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Draft Environmental Release and Occupational Exposure Assessment for Phthalic Anhydride

Technical Support Document for the Draft Risk Evaluation

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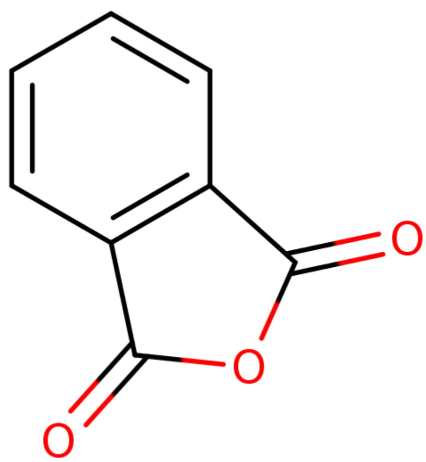

March 2026

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLES

KEY ABBREVIATIONS AND ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
APF	Assigned protection factor
BLS	Bureau of Labor Statistics (U.S.)
CDR	Chemical Data Reporting
CEHD	Chemical Exposure Health Database
CFR	Code of Federal Regulations
COU	Condition of use
CT	Central tendency
EPA	Environmental Protection Agency (U.S.)
ESD	Emission Scenario Document
GS	Generic Scenario
HE	High-end
HVLP	High volume low pressure
LOD	Limit of detection
MWC	Municipal waste combustor
NAICS	North American Industry Classification System
NEI	National Emissions Inventory
NIOSH	National Institute of Occupational Safety and Health
NPDES	National Pollutant Discharge Elimination System
OARS	Occupational Alliance for Risk Science
OECD	Organisation for Economic Co-Operation and Development
OEL	Occupational Exposure Limit
OES	Occupational exposure scenario
ONU	Occupational non-user

OPPT	Office of Pollution Prevention and Toxics (EPA)
OSHA	Occupational Safety and Health Administration (U.S.)
PAPR	Power air-purifying respirator
PBZ	Personal breathing zone
PEL	Permissible Exposure Limit
POTW	Publicly owned treatment works
PPE	Personal protective equipment
PV	Production volume
RCRA	Resource Conservation and Recovery Act
SDS	Safety data sheet
SIC	Standard Industrial Classification
SAR	Supplied-air respirator
SCBA	Self-Contained Breathing Apparatus
STEL	Short-Term Exposure Limit
SUSB	Statistics of U.S. Businesses
TDS	Technical data sheets
TLV	Threshold limit value
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
TSD	Technical support document
TWA	Time-weighted average
U.S.	United States
WEEL	Workplace Environmental Exposure Level
WWT	Wastewater treatment
WWTP	Wastewater treatment plant

SUMMARY

This technical support document (TSD) is part of the *Draft Risk Evaluation for Phthalic Anhydride* (U.S. EPA, 2026c) conducted under the Toxic Substances Control Act (TSCA) (see also public docket, EPA-HQ-OPPT-2018-0459). Phthalic anhydride (CASRN 85-44-9) is a Toxics Release Inventory (TRI)-reportable substance, making it reportable under the Chemical Data Reporting (CDR) rule. This draft TSD/assessment describes the use of reasonably available information to estimate environmental releases of phthalic anhydride and to evaluate occupational exposures. See Appendix C of the *Draft Risk Evaluation for Phthalic Anhydride* (U.S. EPA, 2026c) for a complete list of all the TSDs and supplemental files for phthalic anhydride.

Focus of the Environmental Release and Occupational Exposure Assessment

During scoping, the U.S. Environmental Protection Agency (EPA or the Agency) considered conditions of use (COUs) for phthalic anhydride. Under TSCA, COUs are "the circumstances...under which a chemical substance is intended, known, or reasonably foreseen to be manufactured, processed, distributed in commerce, used or disposed of." The 2020 CDR indicated 250 to 500 million pounds (lb) of phthalic anhydride were manufactured or imported into the United States in 2019 (U.S. EPA, 2020a). Review of preliminary 2024 CDR data indicates that total production volumes for the years 2020 to 2023 are similar to the previously reported range from the 2020 CDR dataset. Therefore, EPA will be utilizing 2020 CDR data to estimate production volumes associated with each occupational exposure scenario (OES; see more below). However, the 2020 and 2024 CDR data were not used for release modeling because EPA has actual release data for phthalic anhydride from TRI and the National Emissions Inventory (NEI). Phthalic anhydride is primarily used as an intermediate chemical for the production of phthalate plasticizers, which are used in manufacturing plastics, paints, coatings, adhesives, sealants, and elastomers, as well as in other applications.

Exposures to workers, consumers, general populations, and ecological species may occur from releases of phthalic anhydride to air, land, and water from industrial and commercial uses of phthalic anhydride and from phthalic anhydride-containing articles. Workers may be exposed to phthalic anhydride while directly handling solid and liquid formulations or during dust- and mist-generating activities. Occupational non-users (ONUs) are those who may work in the vicinity of chemical-related activities but do not handle the chemicals themselves, such as managers or supervisors. It is known that phthalic anhydride rapidly hydrolyzes to *ortho*-phthalic acid, also known as *o*-phthalic acid, in the presence of water. However, phthalic anhydride and products containing phthalic anhydride are produced in the absence of water, otherwise, the chemical would not serve its intended purpose as a monomer for building *ortho*-phthalates. Furthermore, all occupational monitoring studies are measured for the anhydride form rather than the acid, and no industrial or commercial product containing phthalic anhydride listed *o*-phthalic acid as a product component. Therefore, during manufacturing, processing, and industrial/commercial use of products containing phthalic anhydride, workers could experience direct exposures to phthalic anhydride itself and exposures to *o*-phthalic acid from industrial and commercial uses that were not evaluated in this risk evaluation. This draft TSD provides the details of the assessment of the environmental releases and occupational exposures from each COU of phthalic anhydride.

Approach of the Environmental Releases and Occupational Exposures Assessment

EPA evaluated environmental releases of and occupational exposures to phthalic anhydride for each OES. An OES defines a discrete set of activities and conditions for which similar occupational exposures and environmental releases are expected. For each OES with reasonably available data, EPA estimated occupational exposures and environmental releases that are expected to be representative of the entire population of workers and sites across the United States.

EPA evaluated environmental releases of phthalic anhydride 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 2019–2023) and the 2017 and 2020 NEI to identify relevant releases of phthalic anhydride 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 release data, the Agency used a qualitative approach to assess release estimates.

EPA evaluated acute exposures of phthalic anhydride to workers and ONUs for each OES. The Agency used (1) inhalation monitoring data from literature sources, and (2) surrogate dermal exposure monitoring data from different chemicals with similar uses to phthalic anhydride. EPA also used available product information to estimate dermal exposures to workers and ONUs.

Preliminary Results for Environmental Releases and Occupational Exposures

EPA evaluated environmental releases of phthalic anhydride to air, water, and/or land for all OESs assessed in the draft risk evaluation. Detailed environmental release results for each OES to each type of assessed media can be found in Section 3 of this draft TSD. For overall releases, EPA found the greatest quantity of releases to stack air and lesser quantities of release to water and land for phthalic anhydride. EPA also evaluated inhalation and dermal exposures to phthalic anhydride for workers and ONUs for each OES, as appropriate. Detailed inhalation and dermal exposure results for each OES and exposure route can be found in Section 3. For occupational exposures, EPA found the greatest exposure potential from spray applications and from incorporation of phthalic anhydride as a hardener in casting operations.

Uncertainties of this Draft Assessment

EPA acknowledges several sources of uncertainty in this draft assessment. Uncertainty in the monitoring data used to assess environmental releases stems from the accuracy of the reported releases as well as the limitations in representativeness to all U.S. sites. TRI and NEI may not capture all relevant sites due to reporting thresholds and different reporting protocols. More information on the reporting requirements for each database is provided in Section 2.3.3. Furthermore, production volume estimates may not capture all manufacturing and processing facilities due to CDR reporting thresholds. The Agency also used generic EPA models and default input parameter values when site-specific data were not available. Lastly, site-specific differences in occupational use practices and engineering controls cannot be quantified.

For inhalation exposures, the primary uncertainty is the representativeness of the exposure monitoring data toward the true distribution of inhalation concentrations across facilities. Handling phthalic anhydride in its flaked solid form increases the potential for inhalation and dermal exposures to workers due to the generation, translocation, and resuspension of dust particles. Also, the chemical is formulated into paint, coating, and epoxy products that are intended for spray application, representing scenarios with high levels of inhalation and dermal exposure potential. However, if a worker uses proper personal protective equipment (PPE) such as full-face respirators, gloves, or protective clothing while handling phthalic anhydride, inhalation and dermal exposures would be reduced.

Environmental and Exposure Pathways Considered in this Draft Risk Evaluation

EPA assessed environmental releases to air, water, and land to estimate exposures to the general population and ecological species for phthalic anhydride COUs. The environmental release estimates developed by the Agency were used to evaluate the environmental hazards from the presence of phthalic anhydride in the environment and biota. The release estimates were also used to model exposure to the general population and ecological species where environmental monitoring data were not available. EPA also assessed acute exposure to workers and ONUs for each OES, as appropriate. Dermal exposures were considered for all workers but only considered for ONUs with potential exposure to dust deposited on surfaces.

1 INTRODUCTION

1.1 Overview

This TSD accompanies the *Draft Risk Evaluation for Phthalic Anhydride* (U.S. EPA, 2026c) that was conducted under the Frank R. Lautenberg Chemical Safety for the 21st Century Act, which amended TSCA on June 22, 2016. The law includes statutory requirements and deadlines for actions related to conducting risk evaluations of existing chemicals.

Under TSCA section 6(b), EPA 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 non-risk factors, including an unreasonable risk to a potentially exposed or susceptible subpopulation [PESS] 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 also initiated the risk evaluation process for those chemical substances. Phthalic anhydride is one of the chemicals designated as a high priority substance for risk evaluation.

Phthalic anhydride is a common chemical name for a chemical substance that includes the following names: phthalic anhydride (CASRN 85-44-9) and 1,3-isobenzofurandione. Phthalic anhydride is a low volatility solid that is used primarily in the formation of plasticizers, though it is also used in the production of adhesives, sealants, paints, coatings, rubbers, and other materials. All uses are subject to federal and state regulations and reporting requirements (*e.g.*, TRI, CDR). Phthalic anhydride is a TRI-reportable substance, included on the TSCA Inventory, and reported under CDR.

1.2 Scope

EPA assessed environmental releases and occupational exposures for COUs under TSCA as described in Table 1-1 of the *Draft Risk Evaluation for Phthalic Anhydride* (U.S. EPA, 2026c). To estimate environmental releases and occupational exposures, EPA first developed OESs related to the COUs of phthalic anhydride. 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. Releases and 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 below shows mapping between the COUs listed in Table 1-1 of the *Draft Risk Evaluation for Phthalic Anhydride* (U.S. EPA, 2026c) 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 COU categories and subcategories were grouped and assessed together in a single OES to minimize repetitive assessments due to similarities in the processes or lack of differentiating data. In other cases, COU 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. Processing as a reactant
4. Incorporation into formulations, mixtures, or reaction products
5. Plastic compounding
6. Plastic converting
7. Application of paints, coatings, adhesives, and sealants
8. Use of laboratory chemicals
9. Use of lubricants and functional fluids
10. Fabrication or use of final product or articles
11. Disposal and recycling
12. Distribution in commerce

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

COU			OES
Life Cycle Stage	Category	Subcategory	
Manufacturing	Domestic manufacturing	Domestic manufacturing	Manufacturing
	Importing	Importing	Import and repackaging
Processing	Repackaging	Repackaging	Import and repackaging
	Processing as a reactant	Intermediate (all other basic organic chemical manufacturing; Paint and coating manufacturing; Flame retardant manufacturing)	Processing as a reactant
		Intermediate (plastic material and resin manufacturing; construction)	Plastic compounding
		Monomer (plastic material and resin manufacturing)	Plastic compounding
		Monomer (all other basic organic chemical manufacturing)	Processing as a reactant
		Ion exchange agent (all other basic organic chemical manufacturing)	Processing as a reactant
		Pigments (printing ink manufacturing)	Processing as a reactant
		Polymerization promoter (synthetic dye and pigment manufacturing)	Processing as a reactant
		Plasticizer (plastics product manufacturing)	Plastic compounding; Plastic converting
		Plasticizer (adhesive manufacturing; Lubricant additive manufacturing)	Processing as a reactant

COU			OES
Life Cycle Stage	**Category**	**Subcategory**	
Processing	Incorporation into formulations, mixtures, or reaction products	Intermediate (all other basic organic chemical manufacturing; All other basic inorganic chemical manufacturing; Adhesive manufacturing)	Incorporation into formulations, mixtures, or reaction products
		Intermediate (plastic material and resin manufacturing)	Plastic compounding
		Monomer (plastic material and resin manufacturing)	Plastic compounding
		Plasticizers (plastic material and resin manufacturing)	Plastic compounding
		Plasticizers (paint and coating manufacturing)	Incorporation into formulations, mixtures, or reaction products
		Paint additives and coating additives not described by other categories (plastics material and resin manufacturing)	Plastic compounding
		Dyes (synthetic dye and pigment manufacturing)	Incorporation into formulations, mixtures, or reaction products
		Retarder (rubber product manufacturing)	Incorporation into formulations, mixtures, or reaction products
		Flame retardant (plastics product manufacturing)	Plastic compounding; Plastic converting
		Binder (paint and coating manufacturing)	Incorporation into formulations, mixtures, or reaction products
		Hardener (paint and coating manufacturing; Solvent-based paint; adhesive manufacturing; Rubber product manufacturing; Utilities)	Incorporation into formulations, mixtures, or reaction products
		Hardener (epoxy resin casting)	Incorporation into formulations, mixtures, or reaction products (epoxy resin casting hardener)
		Solvent (paint and coating manufacturing)	Incorporation into formulations, mixtures, or reaction products

COU			OES
Life Cycle Stage	Category	Subcategory	
Processing	Incorporation into formulations, mixtures, or reaction products	Solvent (plastic material and resin manufacturing)	Plastic compounding
		Processing aid (paint and coating manufacturing; rubber product manufacturing)	Incorporation into formulations, mixtures, or reaction products
		Pre-catalyst manufacturing	Incorporation into formulations, mixtures, or reaction products
		Polymerization promoter (all other basic organic chemical manufacturing)	Incorporation into formulations, mixtures, or reaction products
	Recycling	Recycling	Disposal and recycling
Disposal	Disposal	Disposal	Disposal and recycling
Distribution in commerce	N/A	N/A	Distribution in commerce
Industrial use	Processing aids, specific to petroleum production	Hydraulic fracturing	Use of lubricants and functional fluids
	Adhesives and sealants	Adhesives and sealants	Application of paints, coatings, adhesives, and sealants (non-spray)
	Paints and coatings	Paints and coatings	Application of paints, coatings, adhesives, and sealants (spray and non-spray)
	Construction products	Construction and building materials covering large surface areas	Fabrication or use of final products or articles (fabrication)
	Metal and electrical products	Machinery, mechanical appliances, electrical/electronic articles	Application of paints, coatings, adhesives, and sealants (non-spray)
	Other	Laboratory chemicals	Use of laboratory chemicals
	Automotive and aerospace products	Transportation equipment manufacturing	Application of paints, coatings, adhesives, and sealants (spray and non-spray)
Commercial uses	Adhesives and sealants	Adhesives and sealants	Application of paints, coatings, adhesives, and sealants (non-spray)

COU			OES
Life Cycle Stage	**Category**	**Subcategory**	
Commercial Use	Fillers	Hardener (*e.g.*, epoxy hardener)	Incorporation into formulations, mixtures, or reaction products (epoxy resin casting hardener)
	Other	Laboratory chemicals	Use of laboratory chemicals
	Transportation equipment manufacturing	Transportation equipment manufacturing	Application of paints, coatings, adhesives, and sealants (spray and non-spray)
	Plastic and rubber products	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard); other (rubber products)	Fabrication or use of final products or articles (routine use)
	Furniture and furnishings	Oil treatment of wood	Application of paints, coatings, adhesives, and sealants (spray and non-spray)
	Paints and coatings	Paints and coatings	Application of paints, coatings, adhesives, and sealants (spray and non-spray)
	Construction products	Construction and building materials covering large surface areas	Fabrication or use of final products or articles (fabrication)
	Metal and electrical products	Machinery, mechanical appliances, electronic/electronic articles	Application of paints, coatings, adhesives, and sealants (non-spray)

The assessment of releases includes quantifying annual and daily releases of phthalic anhydride 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. Releases to water include both direct discharges to surface water (reported by 2 processing facilities), and more commonly, indirect discharges to publicly owned treatment works (POTW) or non-POTW wastewater treatment (WWT) plants (see the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025) for details). 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 phthalic anhydride 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 Phthalic Anhydride* (U.S. EPA, 2026c) describes how these factors were considered when determining exposure and risk.

For workplace exposures, EPA considered exposures to both workers who directly handle phthalic anhydride and ONUs who do not directly handle phthalic anhydride. The Agency evaluated inhalation and dermal exposures to both workers and ONUs where appropriate, and also performed a quantitative assessment of the effect of PPE. The effect of PPE on occupational risk estimates is discussed in the *Draft Risk Evaluation for Phthalic Anhydride* (U.S. EPA, 2026c); the calculations can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b).

2 COMPONENTS OF AN ENVIRONMENTAL RELEASE AND OCCUPATIONAL EXPOSURE ASSESSMENT

EPA describes the assessed COUs for phthalic anhydride in the Section 1.2 of the *Draft Risk Evaluation for Phthalic Anhydride* (U.S. EPA, 2026c), and Table 1-1 maps the phthalic anhydride COUs to 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; process flow diagram including potential release and exposure sources; and process equipment used during the OES.
- **Facility Estimates:** An estimate of the number of sites that use phthalic anhydride for the given OES; the total production volume associated with the OES; per site throughputs/use rates of the chemical; and operating schedules.
- **Environmental Release Assessment:**
    - *Environmental Release Assessment Results:* Estimates of phthalic anhydride releases to surface water, POTW and non-POTW WWT plants, fugitive air, stack air, and land (via a variety of land disposal methods) for the given OES.
- **Occupational Exposure Assessment:**
    - *Worker Activities:* A description of the worker activities, including an assessment of potential occupational 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.

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 phthalic anhydride-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 3.12 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 phthalic anhydride in the 2020 CDR (U.S. EPA, 2020a), NEI (U.S. EPA, 2023a, 2019b), and TRI databases (U.S. EPA, 2023b) 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 are 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. Rely on generic industry data from GSs, ESDs, and other literature sources on typical throughputs/use rates, operating schedules, and the phthalic anhydride production volume used within the OES to estimate the number of facilities.

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. For each OES, EPA provided annual releases, daily releases, and the number of release days per year for each medium of release (*i.e.,* air, water, and land).

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

1. **Quantitative 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. **Qualitative Comparison to Monitoring and Measured Data**
    a. For OESs with low production volumes releases were qualitatively assessed in comparison to the OES(s) with known release data.

EPA provided discrete release data for each OES as reported to TRI in years 2019 to 2023 (U.S. EPA, 2023b) and NEI in years 2017 and 2020 (U.S. EPA, 2023a, 2019b). These data are also summarized in the *Draft Risk Evaluation for Phthalic Anhydride* (U.S. EPA, 2026c).

2.3.1 Identifying Release Sources

EPA performed a literature search to identify process operations that could potentially result in releases of phthalic anhydride to air, water, or land. For each OES, the Agency identified the release sources and the associated media of release. Where phthalic anhydride-specific release sources were unclear or unavailable, EPA referenced relevant ESDs or GSs. Sections 3.1 through 3.12 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. For some facilities, detailed information regarding operating days per year was identified in the NEI database (U.S. EPA, 2023a, 2019b).
2. **Industry-Specific Data:** EPA used industry-specific data from GSs, ESDs, trade publications, or other relevant literature.
3. **Default Assumptions:**
    a. Manufacture of Large-Production Volume (PV) Commodity Chemicals: For the manufacture of large-PV commodity chemicals, EPA used a value of 300 days per year. This assumes the plant runs 6 days per week and 50 weeks per year (with 2 weeks down for turnaround) and always produces the chemical.

    b. Processing and Use: 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 250 days per year to estimate the number of operating days based on the assumption that the facility operates 5 days/week and 50 weeks/year (with 2 weeks for turnaround).

    c. 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.

    d. All Other OESs: Regardless of the facility operating schedule, the chemical of interest is unlikely to be used every day under other OESs. 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 and NEI as annual releases 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 by 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 phthalic anhydride and 10,000 lb for users of phthalic anhydride). EPA makes the reported information publicly available through several platforms and tools. Each facility subject to the rule must report using either the more comprehensive Form R or the simplified Form A. If the volume of chemical manufactured, processed, or otherwise used exceeds 1 million pounds per year (lb/year) or the total annual reportable releases exceed 500 lb/year, facilities must use Form R to 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 eligible to report using Form A are not required to submit annual release and waste management volumes or use/sub-use information. Due to reporting limitations, however, some sites that manufacture, process, or use phthalic anhydride may not be required to 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 R submissions, EPA assessed releases using the reported annual release volumes from each media. For Form A submissions, the reporting threshold for a facility is 500 lb/year total across all release media. To screen for potential downstream risks from Form A submitters, EPA conservatively assumes that all environmental releases from a facility could go to air or that all environmental releases from a facility could go to water (land releases are not considered in downstream analyses of risk). Therefore, for a facility that reports Form A to TRI, it is assumed that the facility may release 500 lb/year to air or the facility could release 500 lb/year to water. For this draft risk evaluation, EPA used TRI data from reporting years 2019 to 2023 to provide a basis for estimating releases from TRI (U.S. EPA, 2023b). Further details on the 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 phthalic anhydride 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.

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 3 years. For the draft risk evaluation, EPA used NEI data for reporting years 2017 and 2020 data to provide a basis for estimating releases (U.S. EPA, 2023a, 2019b).

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 only point source data in the assessment of environmental releases in this risk evaluation since data on area and mobile sources did not provide enough information to categorize into COUs or OESs. 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. Phthalic anhydride is listed as a HAP. Point source facilities include large energy and industrial sites and are reported at the emission unit- and release point-level.

2.3.3.1 Estimating Wastewater Discharges from TRI

Where available, EPA used TRI data from 2019 to 2023 to estimate annual wastewater discharges and the associated daily wastewater discharges. Reviewing data from the 5-year span allowed EPA to perform a more thorough analysis and generate medians and maximums for sites that reported over multiple years.

Annual discharges are reported directly by facilities to TRI. To estimate average daily discharges, EPA used the following steps:

1. Obtain total annual loads from 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 the reporting threshold of 500 lb per year.
3. 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 2019 to 2023 and NEI data from 2017 and 2020 to estimate annual and average daily fugitive and stack air emissions. For air emissions, EPA estimated release patterns (*i.e.,* days per year of release) based on the number of operating days per year. 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.

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. 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 Form A, estimate annual releases using the TRI 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).

2.3.3.3 Estimating Land Disposals from TRI

Where available, EPA used TRI data from 2019 to 2023 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 total aggregated land disposal volume reported in TRI. Reviewing data from the 5-year span allowed the Agency to perform a more thorough analysis for sites that reported over multiple years.

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 then combined totals from all land disposal methods from each facility to estimate a total annual aggregate disposal volume to land. To estimate average daily disposal volumes, the Agency used the following steps:

1. Obtain total annual disposal volumes for each land disposal method for each TRI reporter.
2. Divide the annual disposal volumes for each land disposal method over the number of estimated operating days.
3. Combine totals from all land disposal methods from each facility to estimate a total aggregate disposal volume to land.

2.3.4 Qualitative Release Assessment of Low PV OESs

For some OESs with low PVs, there were no EPA data available to characterize environmental releases. However, the releases from the lower PV uses are expected to be less than the more significant PV uses such as manufacturing and processing. Therefore, the release estimation of low PV OESs were described qualitatively in comparison to the larger PV OESs.

2.4 Occupational Exposure Approach and Methodology

For workplace exposures, EPA considered inhalation and dermal exposures to workers who directly handle phthalic anhydride. EPA also considered reasonably available data relating to inhalation exposures to workers who do not directly handle phthalic anhydride but may be exposed to vapors, particulates, or mists that enter their breathing zone while working in locations near phthalic anhydride handling.

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

EPA used measured or estimated air concentrations and dermal loading concentrations to calculate exposure metrics required for risk assessment. For each OES, EPA provided high-end and central tendency full-shift inhalation exposure concentrations (mg phthalic anhydride/m^3) as well as high-end and central tendency acute dermal exposure levels (mg/cm^2). EPA applied the following hierarchy in selecting data and approaches for assessing occupational exposures:

1. **Monitoring Data**
    a. Personal and directly applicable to OES.
    b. Area and directly applicable to OES.
    c. Personal and potentially applicable or similar to OES.
    d. Area and potentially applicable or similar to OES.
2. **Modeling Approaches**
    a. Surrogate monitoring data.

EPA used the estimated high-end and central tendency, full-shift inhalation exposure concentrations, and acute dermal exposure levels to calculate the exposure metrics required for risk evaluation. Exposure metrics for inhalation and dermal exposures include full-shift inhalation exposure concentrations (mg phthalic anhydride/m^3) and acute dermal exposure levels (mg phthalic anhydride/cm^2).

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, the Agency referenced relevant ESDs or GSs. For manufacturing and processing, EPA identified specific tasks (*e.g.*, bag handling, unclogging baghouse chutes, filling drums with process impurities, cleaning equipment with high solids content) that lead to higher levels of inhalation exposure. Consequently, EPA categorized manufacturing and processing workers that engage in short-term, high exposure tasks as “high exposure” workers. Specifically, high exposure workers are those engaged in short-term, high exposure tasks, as well as routine equipment operations or maintenance. 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 the Occupational Safety and Health Administration (OSHA) and National Institute of Occupational Safety and Health (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 *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances, Version 1.0: A Generic TSCA Systematic Review Protocol with Chemical-Specific Methodologies* (also called the "Draft Systematic Review Protocol") (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 the *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.

EPA primarily used discrete, personal breathing zone measurements that received high ratings through the EPA systematic review process to estimate inhalation exposure concentrations. If representative full-shift personal breathing zone (PBZ) monitoring samples were not available, area samples were used instead. 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 among worker categories. Normally, a primary difference between workers and ONUs is that workers may handle phthalic anhydride and have direct contact with the chemical, while ONUs may work in the general vicinity of workers but do not handle or have direct contact with phthalic anhydride. Generally, potential exposures for ONUs are expected to be lower than those for workers since they may not be exposed to the chemical for an entire 8-hour workday and may be exposed at a lower level. EPA recognizes that job titles and worker activities may vary significantly from site to site; therefore, the Agency typically identifies samples as worker samples unless it is explicitly clear from the job title (*e.g.,* inspectors) or 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 by OSHA compliance officers during monitoring of worker exposures to chemical hazards. OSHA CEHD data are obtained typically from facilities where high workplace exposure levels or potential violations are suspected. OSHA CEHD represents a readily available source of 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 CEHD system and can be accessed online. The database includes PBZ, area, bulk material, wipe, and serum samples. The collected samples are used for comparison to OSHA 8-hour PELs and 15-minute Short-Term Exposure Limits (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 assesses their significance (*e.g.,* by comparing measured concentrations to the regulatory limits).

EPA used the following approach to analyze OSHA CEHD:

1. Downloaded monitoring data for phthalic anhydride from 1992 to 2022: See Section 2.6 for evidence integration notes on targeted years.
2. Organized data by site (*i.e.,* grouped together data collected at the same site).
3. Removed serum samples, bulk samples, wipe samples, and blanks, as these data are not used in EPA's assessment.
4. Assigned each data point to an OES by reviewing 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 and 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. OSHA inspectors may 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.

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

Specific details related to the use of monitoring data for each COU can be found in Sections 3.1.4 through 3.11.4.

2.4.3 Estimating Dermal Exposures

This section summarizes the available dermal exposure data related to phthalic anhydride. Because the health endpoint associated with dermal exposure to phthalic anhydride is dermal sensitization, the relevant exposure metric to estimate risk for phthalic anhydride is the acute dermal exposure level in units of milligrams of phthalic anhydride per square centimeter of exposed skin (mg phthalic anhydride/cm^2). Consequently, EPA quantified the dermal loading of materials being handled (mg product/cm^2), as well as phthalic anhydride weight fraction of the materials being handled (mg phthalic anhydride/mg product), in order to estimate the dermal exposure of phthalic anhydride. Specifically, the dermal exposure of phthalic anhydride (mg phthalic anhydride/cm^2) is the mathematical product of the material dermal loading (mg product/cm^2) and the phthalic anhydride weight fraction of the material being handled (mg phthalic anhydride/mg product). EPA also identified scenarios where dust may be deposited on surfaces because ONUs may experience incidental dermal contact in these scenarios.

EPA used data from Lansink et al. (1996) as surrogate to estimate dermal loading of materials from worker activities associated with handling solid materials. Lansink et al. (1996) conducted an analysis of skin exposure to workers handling calcium carbonate during a variety of activities including collection of the raw material, handling of empty bags, and manual dumping and mixing. Calcium carbonate (chalk) is a powdered material that may be physically similar to the solid form of phthalic anhydride, and the activities evaluated are relevant to the uses of phthalic anhydride in occupational settings. Dermal loading values were measured from cotton gloves worn by the workers, which covered their hands and part of their forearms, to obtain estimates of skin exposure in units of milligrams per day. The study reported the minimum, maximum, geometric mean, and 90th percentile of skin exposure measurements for each activity. For each OES where phthalic anhydride is handled in solid form, EPA identified the activity from Lansink et al. (1996) that is most representative of the OES and used the 50th and 90th percentiles of measurements for central tendency and high-end estimates, respectively, for workers handling phthalic anhydride. For scenarios where ONUs may experience incidental contact with dust deposited on surfaces, EPA used the 10th percentile of data for handling empty bags to represent central tendency and high-end dermal loading values for ONUs.

Although there were no reasonably available chemical-specific dermal loading data identified through the EPA systematic review process for phthalic anhydride, EPA identified two studies that measured dermal loading for similar tasks and materials (UK IOM, 2003; Lansink et al., 1996). Both studies were identified in a detailed analysis of available dermal loading data conducted by Marquart et al. (2006); however, EPA is seeking input on additional data through the public comment of this draft assessment and the risk evaluation. It is important to note that dermal loading estimates for solid materials vary depending on factors including task, physical and chemical properties, and sampling methodology. Lansink et al. (1996) measured ranges of dermal loading (10–90th percentile) of calcium carbonate during collection of raw material (0.13–0.57 mg/cm^2), handling of empty bags (3.0×10^{-2} to 0.56 mg/cm^2), and manual dumping and mixing (0.12–1.6 mg/cm^2). Cotton gloves were used for measuring dermal loading of calcium carbonate by Lansink et al. (1996), and the study states that this may overestimate or underestimate skin adherence. In comparison, Hughson et al. (2003) measured ranges of dermal loading (10–90th percentile) of zinc oxide during manual dumping (3.0×10^{-2} to 0.18 mg/cm^2) and contact with a dusty surface (0.10–0.40 mg/cm^2). Wipe samples were used to collect zinc oxide from bare skin to determine dermal loading values presented by Hughson et al. (2003), and it is noted that this method may underestimate dermal exposure (Marquart et al., 2006). Calcium carbonate and zinc oxide are both solid materials similar in form to phthalic anhydride. However, according to Hughson et al. (2003), zinc oxide tends to agglomerate into larger particles and the material has low adherence to the skin. Furthermore, the density of zinc oxide (5.6 g/cm^3) is greater than the densities of calcium carbonate (2.7 g/cm^3) and phthalic anhydride (1.5 g/cm^3).

Comparing the evaluations of Hughson et al. (2003) and Lansink et al. (1996) for use in the assessment of phthalic anhydride, Lansink et al. (1996) evaluated a wider range of tasks applicable to occupational uses of phthalic anhydride and used a substance with physical and chemical properties that more closely resemble phthalic anhydride. Although there are uncertainties presented by both sets of data, there is greater scientific evidence to support the use of dermal loading data from Lansink et al. (1996) as surrogate for the various occupational uses of phthalic anhydride.

EPA used data from U.S. EPA (1992b) to estimate dermal loading of materials from worker activities associated with handling liquid formulations containing phthalic anhydride. U.S. EPA (1992b) investigated dermal loading from common worker exposures scenarios including rag handling and full hand immersion. EPA utilized the raw data to determine 50th and 95th percentile dermal loading values from rag handling scenarios of 1.4 mg/cm^2 and 2.1 mg/cm^2, respectively, and 50th and 95th percentile dermal loading values from full immersion scenarios of 3.8 mg/cm^2 and 10.3 mg/cm^2, respectively. As described in the ChemSTEER User Guide – Chemical Screening Tool for Exposures and Environmental

Releases (also called the "ChemSTEER Manual") (U.S. EPA, 2015), data from rag handling experiments of U.S. EPA (1992b) are considered relevant for typical occupational tasks such as product sampling, loading/unloading, and cleaning since rag handling is a common activity during these tasks. Also described in the ChemSTEER Manual (U.S. EPA, 2015), data from full immersion experiments of U.S. EPA (1992b) are considered relevant for spray coating scenarios. Spray coating scenarios may lead to significant dermal exposure similar to the immersion scenarios investigated in U.S. EPA (1992b), and this empirically supported by Marquart et al. (2006). Those researchers reported a dermal loading range of 4.15 mg/cm^2 (typical) to 16.6 mg/cm^2 (worst case) based on 25 data points for spraying marine anti-fouling paint, which is similar to spray products within this assessment. Therefore, dermal loading values from liquid immersion measurements are used to estimate dermal loading for tasks such as spray coating.

Product or material concentrations were determined based on CDR reporting and SDS information for products containing phthalic anhydride. Product or material concentrations are described in Section 3.1.1 to Section 3.11.1, and Appendix A contains a list of products that contain phthalic anhydride in the SDS.

2.5 Consideration of Engineering Controls and Personal Protective Equipment

This section contains general information on engineering controls and personal protective equipment. EPA quantitatively estimated 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 Phthalic Anhydride (U.S. EPA, 2026c), and the calculations can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b).

OSHA and NIOSH recommend employers utilize the hierarchy of controls1 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 appropriate respirators to be selected based on the respiratory hazard(s) to which the worker will be exposed, with consideration of 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 (accessed March 26, 2026).

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 (APFs) 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 Protective Clothing

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. EPA did not identify data to justify a specific probability distribution for effective glove use for handling of phthalic anhydride specifically, for a given industry. However, EPA did identify gloves and protective clothing that are most resistant to phthalic anhydride breakthrough. Specifically, the NIOSH Recommendations for Chemical Protective Clothing (NIOSH, 2000) indicates that Silver Shield/4H gloves will prevent breakthrough of phthalic anhydride for up to four hours. After the gloves have been contaminated with phthalic anhydride for four hours, material may penetrate the gloves at a rate greater than 0.1 $\mu g/cm^2/min$. Therefore, Silver Shield/4H gloves may be effective in mitigating occupational dermal exposure, especially if gloves are changed out after 4 hours of contamination. In agreement with the NIOSH Recommendations for Chemical Protective Clothing, the New Jersey Department of Health (NJDH, 2010) also suggests the use of Silver Shield/4H gloves for handling phthalic anhydride. Further, NJDH also suggests the use of Tyvek suits for handling solid phthalic anhydride and Tychem (CPF3, BR, Responder, TK) or Trellchem (HSP, VPS) suits (or equivalent) for handling liquid phthalic anhydride.

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 integrated only 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 prefers measured 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. 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 used 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 NAICS and SOC codes from the Bureau of Labor Statistics (U.S. 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 of facilities for each OES as described in Section 3.1.2 through Section 3.11.2. 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 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 2-2 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. Determine categories of employment relevant to workers and ONUs within each NAICS code.

5. Use market penetration data to estimate the percentage of employees likely to be using phthalic anhydride instead of other chemicals.
6. 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, and/or NEI.
7. Combine the data generated in Steps 1 through 5 to produce an estimate of the number of employees using phthalic anhydride 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 2-2 below contains the relevant NAICS codes and the calculated average number of workers and ONUs identified per site for each OES.

Table 2-2. 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	325613 - Surface Active Agent Manufacturing	22	5
	325998 - All Other Miscellaneous Chemical Product and Preparation Manufacturing	14	5
	325110 - Petrochemical Manufacturing	64	30
	325199 - All Other Basic Organic Chemical Manufacturing	39	18
	Average	**35**	**15**
Import and repackaging	325199 - All Other Basic Organic Chemical Manufacturing	39	18
	325998 - All Other Miscellaneous Chemical Product and Preparation Manufacturing	14	5
	325613 - Surface Active Agent Manufacturing	22	5
	424690 - Other Chemical and Allied Products Merchant Wholesalers	1	0.4
	325211 - Plastics Material and Resin Manufacturing	27	12
	325520 - Adhesive Manufacturing	18	7
	325510 - Paint and Coating Manufacturing	14	5
	Average	**20**	**8**
Processing as a reactant	325510 - Paint and Coating Manufacturing	14	5
	325199 - All Other Basic Organic Chemical Manufacturing	39	18
	325613 - Surface Active Agent Manufacturing	22	5
	325998 - All Other Miscellaneous Chemical Product and Preparation Manufacturing	14	5
	325211 - Plastics Material and Resin Manufacturing	27	12
	325110 - Petrochemical Manufacturing	64	30
	325520 - Adhesive Manufacturing	18	7
	Average	**29**	**12**
Incorporation into formulations, mixtures, or reaction products	325212 - Synthetic Rubber Manufacturing	25	11
	325520 - Adhesive Manufacturing	18	7
	325211 - Plastics Material and Resin Manufacturing	27	12
	325199 - All Other Basic Organic Chemical Manufacturing	39	18
	325510 - Paint and Coating Manufacturing	14	5
	326200 - Rubber Product Manufacturing	42	7

Occupational Exposure Scenario (OES)	Relevant NAICS Codes	Exposed Workers per Site [a]	Exposed ONUs per Site [a]
	325998 - All Other Miscellaneous Chemical Product and Preparation Manufacturing	14	5
	Average	**26**	**10**
Plastic compounding	322220 - Paper Bag and Coated and Treated Paper Manufacturing	35	5
	326113 - Unlaminated Plastics Film and Sheet (except Packaging) Manufacturing	22	6
	325211 - Plastics Material and Resin Manufacturing	27	12
	326100 - Plastics Product Manufacturing	18	5
	325998 - All Other Miscellaneous Chemical Product and Preparation Manufacturing	14	5
	325510 - Paint and Coating Manufacturing	14	5
	Average	**22**	**7**
Plastic converting	326100 - Plastics Product Manufacturing	18	5
	326113 - Unlaminated Plastics Film and Sheet (except Packaging) Manufacturing	22	6
	Average	**20**	**6**
Application of paints, coatings, adhesives, and sealants	337127 - Institutional Furniture Manufacturing	9	7
	337110 - Wood Kitchen Cabinet and Countertop Manufacturing	3	2
	811120 - Automotive Body, Paint, Interior, and Glass Repair	3	0.3
	336900 - Other Transportation Equipment Manufacturing	16	4
	335931 - Current-Carrying Wiring Device Manufacturing	25	9
	337124 - Metal Household Furniture Manufacturing	8	6
	322220 - Paper Bag and Coated and Treated Paper Manufacturing	35	5
	334100 - Computer and Peripheral Equipment Manufacturing	19	27
	334200 - Communications Equipment Manufacturing	13	14
	334300 - Audio and Video Equipment Manufacturing	10	7
	334400 - Semiconductor and Other Electronic Component Manufacturing	30	27
	334500 - Navigational, Measuring, Electromedical, and Control Instruments	17	18
	334600 - Manufacturing and Reproducing Magnetic and Optical Media	5	5
	335100 - Electric Lighting Equipment Manufacturing	17	5
	335300 - Electrical Equipment Manufacturing	28	12
	335900 - Other Electrical Equipment and Component Manufacturing	23	8
	336200 - Motor Vehicle Body and Trailer Manufacturing	40	5
	336300 - Motor Vehicle Parts Manufacturing	51	15
	336400 - Aerospace Product and Parts Manufacturing	75	64

Occupational Exposure Scenario (OES)	Relevant NAICS Codes	Exposed Workers per Site [a]	Exposed ONUs per Site [a]
	336500 - Railroad Rolling Stock Manufacturing	35	15
	336600 - Ship and Boat Building	36	11
	327910 - Abrasive Product Manufacturing	24	5
	Average	**24**	**13**
Use of laboratory chemicals	541713 - Research and Development in Nanotechnology 541714 - Research and Development in Biotechnology 541715 - Research and Development in the Physical, Engineering, and Life Sciences 621511 - Medical Laboratories 541380 - Testing Laboratories		
	Average of NAICS from Use of Laboratory Chemicals GS (U.S. EPA, 2023c)	**3**	**3**
Use of lubricants and functional fluids	213112 - Support Activities for Oil and Gas Operations	9	2
	Average of NAICS from ESD on Chemical Used in Hydraulic Fracturing (OECD, 2024)	**9**	**2**
Fabrication or use of final products or articles	236100 - Residential Building Construction	2	1
	236200 - Nonresidential Building Construction	9	4
	237100 - Utility System Construction	12	3
	237200 - Land Subdivision	1	1
	237300 - Highway, Street, and Bridge Construction	20	4
	237900 - Other Heavy and Civil Engineering Construction	13	3
	337100 - Household and Institutional Furniture Manufacturing	5	4
	337200 - Office Furniture (including Fixtures) Manufacturing	7	3
	Average	**9**	**3**
Disposal and recycling	562213 - Solid Waste Combustors and Incinerators	13	8
	562212 - Solid Waste Landfill	3	2
	562219 - Other Nonhazardous Waste Treatment and Disposal	3	2
	Average	**7**	**4**

[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 2-3 summarizes the number of facilities and total number of exposed workers for all OESs. 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, 2019b), and TRI databases (U.S. EPA, 2023b). Alternatively, for some OESs, the estimated number of facilities is based on typical use rate and overall PV for the OES. Estimates of the total number facilities for all OESs are described in Section 3.1.2 through Section 3.11.2.

Table 2-3. Summary of Total Number of Workers and ONUs Potentially Exposed to Phthalic Anhydride for Each OES

Occupational Exposure Scenario (OES)	Total Exposed Workers [a]	Total Exposed ONUs [a]	Number of Facilities
Manufacturing	280	120	8
Import and repackaging	560–740	224–296	28–37
Processing as a reactant	3,132–9,309	1,296–3,852	108–321
Incorporation into formulations, mixtures, or reaction products	884–4,680	340–1,800	34–180
Plastic compounding	1,034–3,366	329–1,071	47–153
Plastic converting	2,200–6,600	660–1,980	110–330
Application of paints, coatings, adhesives, and sealants	2,592–27,072	1,404–14,664	108–1,128
Laboratory chemicals	6,060–6,780	6,060–6,780	2,020–2,260
Lubricants and functional fluids	<42,192	<9,376	<4,688
Fabrication	N/A		
Disposal and recycling	>154	>88	>22
OES = occupational exposure scenario; ONU = occupational non-user [a] Total exposed across all sites.			

3 ENVIRONMENTAL RELEASE AND OCCUPATIONAL EXPOSURE ASSESSMENTS BY OES

3.1 Manufacturing

The following COUs are captured by this OES: Domestic manufacturing. See the *Draft Risk Evaluation for Phthalic Anhydride* for full list of COUs (U.S. EPA, 2026c).

3.1.1 Process Description

Manufacture of phthalic anhydride is generally accomplished through the catalytic vapor-phase air oxidation of either *o*-xylene or naphthalene. However, because *o*-xylene is a less expensive and produces higher yields than naphthalene, *o*-xylene is more commonly used as feedstock for phthalic anhydride production. In fact, fixed-bed catalytic oxidation of o-xylene is used in more than 90% of phthalic anhydride production operations (Park and Sheehan, 2000; U.S. EPA, 1995). Using either feedstock (*i.e.*, *o*-xylene or naphthalene), phthalic anhydride production begins by mixing a stream of heated, compressed air with the vaporized feedstock in the presence of a catalyst (typically vanadium pentoxide) in a heated reactor (340–385 °C). The heated effluent of the reactor, containing crude phthalic anhydride, then passes through a series of switch condensers that are cooled and heated which allows phthalic anhydride crystals to form and then melt. Next, the crude liquid product passes through a pretreatment phase where there is partial evaporation of water, maleic anhydride, and benzoic acid to yield dehydrated phthalic anhydride. Lastly, the liquid material passes through a vacuum distillation section (one stripper column and one refinement column) to yield pure liquid phthalic anhydride (99.8% purity) in molten form for storage or shipment. Holding tanks and shipment vessels for molten liquid phthalic anhydride are generally maintained at 150 °C. In order to produce solid form phthalic anhydride, the liquid product is dried, flaked, and transferred to bags (standard 25 kg bags or 1 metric ton semi-bulk bags) for storage or shipment (Ridgway et al., 1996; U.S. EPA, 1995; Fawcett, 1970). Phthalic anhydride is typically manufactured in molten liquid or flaked solid form at concentrations of 90 to 100%. Figure 3-1 provides an illustration of the phthalic anhydride manufacturing process.

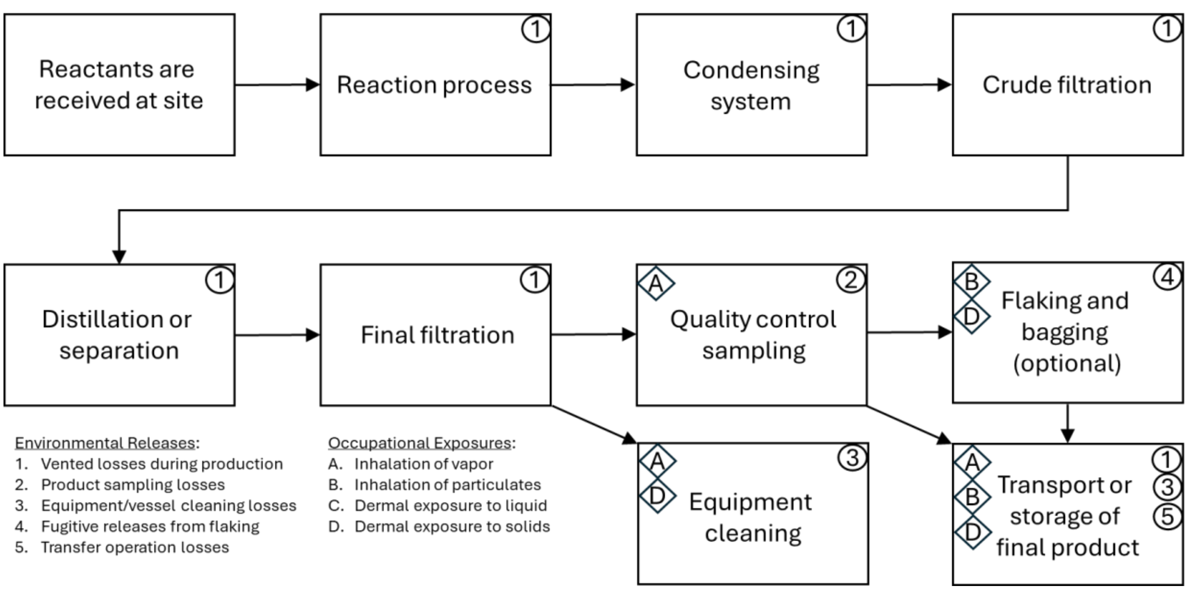

Figure 3-1. Process Flow Diagram for Phthalic Anhydride Manufacturing
Sources: (U.S. EPA, 1995; Agaev et al., 1976; Fawcett, 1970)

3.1.2 Facility Estimates

EPA estimates that there are 8 facilities involved in phthalic anhydride manufacturing based on the 2020 CDR (U.S. EPA, 2020a) and 2019 to 2023 TRI data reporting (U.S. EPA, 2023b). From these data, it is estimated that the annual production volume of phthalic anhydride from domestic manufacturing ranges from 169 to 244 million lb. More detailed information on manufacturing production volume can be found in Appendix B.1.

The number of operating days was determined based on the data reported to the 2017 and 2020 NEI databases (U.S. EPA, 2023a, 2019b), which may contain more detailed information about facility operation schedules. If there were no operation schedule data reported to 2017 or 2020 NEI databases for a facility, it was assumed that the number of operating days was 300 days/year with 6 days/week operations and two full weeks of downtime each operating year. CDR reporters indicated that phthalic anhydride is manufactured primarily in molten liquid form at a concentration of 90 to 100%; however, one company with a maximum production volume of 32,096 lb/year reported manufacturing the material in solid form at a concentration of 1 to 30% (U.S. EPA, 2020a).

Table 3-1. Summary of Facility Estimates for Manufacturing

Total Number of Sites	Sites w/ CBI for PV	Total Annual PV (lb/yr)	Operating Days (day/yr)	Concentration (%)	Physical Form
8	3	168,605,511 243,605,508	300–365	90–100	Liquid or powder
CBI = confidential business information; PV = production volume See Appendix B.1 for more details.					

3.1.3 Release Assessment

3.1.3.1 Environmental Release Assessment Results

Environmental releases of phthalic anhydride are reported to TRI (U.S. EPA, 2023b) and NEI (U.S. EPA, 2023a, 2019b) databases, and EPA used information from these databases to estimate environmental releases of phthalic anhydride to air, water, and land. Specifically, the reporting years 2019 to 2023 were considered for the TRI database and the reporting periods of 2017 and 2020 were considered for the NEI database. EPA preferred and reported the most recent data from the NEI database, and these data are shown in Table 3-2 below. For facilities reporting to TRI in years 2019 to 2023, the highest facility releases and the median facility releases across reporting years for air and land are provided in Table 3-2. The number of release days was assumed to be equal to the number of operation days for a facility. There were no reported releases to water (surface water, POTW, or non-POTW) from manufacturers of TRI in years 2019 to 2023, and all manufacturing facilities reported TRI Form R. Facilities reporting to TRI using 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. Therefore, it is assumed that phthalic anhydride is not released to water from known manufacturing facilities in the United States. For more detailed information regarding environmental releases, see the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).

Table 3-2. Summary of Releases from TRI (2019–2023) and NEI (2017, 2020) for Manufacturing

Type of Air Emission [a], Discharge [b], or Disposal [c]	Estimated Annual Release (kg/site-year) [d]		Estimated Daily Release (kg/site-day) [d]		Number of Facilities [e]	Data Source	Number of Release Days [f]
	Central Tendency	High-End	Central Tendency	High-End			
Stack air	64	2.6E04	0.21	70	8	NEI	300–365
	1.4E03	2.9E04	3.8	80	8	TRI	
Fugitive air	4.6	6.8E03	1.5E−02	19	8	NEI	
	61	1.4E04	0.20	39	8	TRI	
Wastewater	0	0	0	0	8	TRI	
Land	0	2.7E03	0	7.4	8	TRI	

[a] Emissions via stack air and/or fugitive air.
[b] Direct discharge to surface water, indirect discharge to non-POTW, or indirect discharge to POTW. Details on wastewater release streams for each facility are presented in the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).
[c] Land releases were reported to offsite landfills or surface impoundments. See the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025) for more details.
[d] Central tendency values are calculated from the 50th percentile of median reported releases and high-end values are calculated from the 95th percentile of maximum reported releases.
[e] Number of unique facilities reporting releases.
[f] It was assumed that the number of operating days is representative of the number of release days for each facility. Where data were available, EPA used facility-specific operating schedules to estimate number of annual release days. If facility-specific operating schedules were not available, EPA used peer-reviewed literature (*e.g.,* GSs or ESDs) to estimate the number of annual release days.

3.1.4 Occupational Exposure Assessment

3.1.4.1 Worker Activities

During the manufacture of phthalic anhydride, workers that handle the chemical directly (*e.g.*, equipment operators, maintenance workers) are involved with various tasks including product sampling, equipment cleaning and maintenance, container cleaning, and packaging and loading of phthalic anhydride into transport vessels for shipment. When phthalic anhydride is manufactured as a solid flaked material, phthalic anhydride dust can become airborne and workers may experience elevated levels of inhalation exposure to airborne dust. Consequently, EPA distinguished exposures between standard worker activities and high exposure worker activities. Standard worker activities include product sampling, loading finished products for shipment, collection of water samples in the production area, walking the production area, checking for leaks, collection of various readings in the production area, adjustment of valves, and monitoring product flow from the control room. High exposure activities include flaking and bagging phthalic anhydride, unclogging baghouse chutes, filling drums with process impurities, and cleaning equipment with high solids content. Sections 2.5.1 and 2.5.2 provide further details regarding considerations of PPE for handling phthalic anhydride.

ONUs are workers who do not handle the chemical directly but work in proximity to the chemical, such as supervisors, warehouse workers, office engineers, and instrument technicians. Depending on the worker activities, EPA generally expects workers who do not handle the chemical directly (*i.e.*, ONUs) to have lower inhalation and dermal exposures than workers who handle the chemicals directly.

For the worker activities within manufacturing environments, it is expected that workers may be exposed through inhalation of vapors and dust, as well as dermal contact with the solid flaked material. Since dust containing phthalic anhydride may be deposited on surfaces during manufacture, it is possible that workers who do not directly handle the chemical (*i.e.*, ONUs) will also experience dermal exposure through incidental contact with a contaminated surface.

3.1.4.2 Occupational Inhalation Exposure Data

EPA identified several sources of data that quantified the inhalation exposure of phthalic anhydride during manufacture, and the *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994) was used to select the most representative data. Based on the guidelines, EPA preferred discrete, PBZ that received high ratings through the EPA systematic review process. Consequently, the following four studies were selected to estimate inhalation exposure to workers during manufacture of phthalic anhydride: Liss (1983), Cardno ChemRisk (2020), Rietz (1985), and Bookman (2017). Liss (1983) and Rietz (1985) were identified through the EPA systematic review process and the remaining two studies were submitted to EPA as required by section 8(d) of the Toxic Substances Control Act (TSCA). These data were used to estimate full-shift values of occupational exposure for various worker categories as shown in Table 3-3.

Liss (1983) was conducted by NIOSH as a Human Health Evaluation (HHE), and the study examined worker inhalation exposures during manufacturing of phthalic anhydride and subsequent processing of the chemical. The study provides discrete, personal breathing zone measurements for a variety of workers (equipment operators and maintenance) and ONUs (instrument technicians, warehouse workers, office engineers, and supervisors). There were 11 PBZ measurements specific to manufacturing workers, and there were 6 PBZ measurements specific to ONUs throughout the manufacturing and processing facilities investigated. Although some sample measurements are less than 8 hours, it is expected that the measured inhalation exposure values are representative of full-shift exposures. For estimation of exposure measurements below the LOD, EPA followed the *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994). Specifically, the guidelines state that if the geometric standard deviation of the dataset is less than 3.0, nondetectable values should be replaced by the LOD divided by the square root of two. Because the geometric standard deviation of the entire monitoring dataset reported by Liss (1983) was less than 3.0, nondetectable values were replaced by the LOD divided by the square root of two.

Cardno ChemRisk (2020) conducted an occupational exposure monitoring assessment at a phthalic anhydride production facility, and EPA used this data to estimate exposures during standard equipment operation activities, as well as high exposure activities, in the manufacturing workplace. Standard equipment operations included product sampling, loading finished products for shipment, collection of water samples in the production area, walking the production area, checking for leaks, collection of various readings in the production area, adjustment of valves, and monitoring product flow from the control room. High exposure activities included unclogging baghouse chutes, filling drums with process impurities, and cleaning equipment with high solids content. The study reported full-shift PBZ monitoring data, task-based PBZ monitoring data, and full-shift area monitoring data. The full-shift PBZ monitoring data contained associated metadata such as occupation, sample duration, and PPE. EPA used these data for estimating exposures to workers involved in standard equipment operations. Task-based PBZ monitoring data were more limited in utility since the duration of the task-based activities are unknown. There were three task-based activities (*i.e.*, unclogging baghouse chutes, filling drums with process impurities, and cleaning equipment with high solids content) that EPA used for estimating exposures to workers involved in high exposure activities. Although the task durations are unknown for these activities, it is conservatively assumed that higher intensity tasks involving exposures to solid phthalic anhydride will not exceed 2 hours in duration (Nielsen et al., 1988). Therefore, the full-shift exposure values associated with high exposure activities from Cardno ChemRisk (2020) are based on 2 hours of exposure from high exposure activities and 6 hours of exposure at the average exposure concentration of a manufacturing equipment operator or maintenance worker (*i.e.*, 3.4×10^{-2} mg/m^3).

The study also provided full-shift area monitoring data for offices (3 measurements ranging from 1.2×10^{-3} to 3.6×10^{-3} mg/m^3), control rooms (3 measurements ranging from 1.2×10^{-3} to 3.6×10^{-3} mg/m^3), rail tank area (3 measurements ranging from 1.2×10^{-3} to 1.1×10^{-2} mg/m^3), and the laboratory (3 measurements ranging from 2.7×10^{-2} to 5.7×10^{-3} mg/m^3). The study notes that the baghouse is near the entrance to the laboratory and that phthalic anhydride can spread from the baghouse to the laboratory especially during high exposure tasks like unclogging the baghouse chute. The proximity of the baghouse to the laboratory entrance accounts for the seemingly elevated level of phthalic anhydride detected in area monitoring samples within the laboratory, and therefore, these measurements are not representative of typical laboratory exposures. However, the range of phthalic anhydride levels detected in area monitoring samples from the offices, control rooms, and rail tank area (*i.e.*, 1.2×10^{-3} to 1.1×10^{-2} mg/m^3), all relevant to potential ONU exposures, are consistent with the range of PBZ measurements for ONUs (*i.e.*, 2.1×10^{-3} to 1.0×10^{-2} mg/m^3) from the NIOSH HHE conducted by Liss (1983). Since EPA identified high quality PBZ monitoring data for ONUs, and PBZ data are preferred to area data, the area monitoring data from Cardno ChemRisk (2020) were not quantitatively incorporated in the exposure estimates. However, these area monitoring values provide additional support for ONU exposure estimates in this evaluation. Lastly, the Cardno ChemRisk (2020) study indicates that some workers monitored were not wearing respiratory PPE and some workers monitored wore full-face 3M6900 respirators with P100 filters (APF 50). Also, the monitoring study indicates that one worker wore a SCBA respirator with APF 10,000 while unclogging a baghouse chute.

Rietz (1985) examined workers during the handling of bagged phthalic anhydride during mixing and filling operations prior to the production of plastics, and these data were used for estimating inhalation exposure levels for workers engaged in high exposure tasks (i.e., bagging phthalic anhydride in a production facility). A separate study conducted in plants producing alkyd and unsaturated polyester resins (Nielsen et al., 1988) reported that workers may handle bags for up to 30 minutes two times per day, and that filling of larger bags may lead to intermittent dusting that can cause inhalation exposure. The sample durations for inhalation exposure measurements of bag handling activities reported by Rietz (1985) were 1 to 2 hours, and it is expected that a worker will not handle bags of phthalic anhydride for longer than 2 hours per work shift. Therefore, the full-shift exposure values associated with bag handling activities are based on 2 hours of exposure from bag handling and 6 hours of exposure at the average exposure concentration of a manufacturing equipment operator or maintenance worker (i.e., 3.4×10^{-2} mg/m^3). Bookman (2017) supplied inhalation monitoring data for a worker charging super-sacs of solid phthalic anhydride, and a 75-minute PBZ sample resulted in a measurement of 1.3 mg/m3. Since it is expected that exposure from charging super-sacs is similar to exposure from filling super-sacs, EPA has incorporated these data for estimating inhalation exposure levels workers engaged in high exposure tasks (i.e., bagging phthalic anhydride in a production facility). The full-shift exposure values associated with bag handling data reported by Bookman (2017) are based on 1.25 hours of exposure from bag handling and 6.75 hours of exposure at the average exposure concentration of a manufacturing equipment operator or maintenance worker (*i.e.,* 3.4×10^{-2} mg/m^3).

Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b).

Table 3-3. Inhalation Exposure Data for Manufacturing

Source	Data Type	Worker Category	Task or Job Title	Number of Samples	Number of Non-Detects	Measured Concentration (mg/m^3) [a]	Sample Duration (min) [b]	Estimated Full-Shift Exposure (mg/m^3) [c d]
(Rietz, 1985)	Discrete, PBZ	High exposure worker	Bag handling	4	0	0.51–4.9	60–120	0.14–1.2
(Bookman, 2017)	Discrete, PBZ	High exposure worker	Bag handling	1	0	1.33	75	0.22
(Cardno ChemRisk, 2020) [e]	Discrete, PBZ	High exposure worker	Unclogging baghouse chute	1	0	9.9	120 [f]	2.5
		High exposure worker	Cleaning sublimation unit	1	0	1.9	120 [f]	0.51
		High exposure worker	Filling drum with process impurities	1	0	7.9	120 [f]	2.0
		Worker	Equipment operator	15	0	2.8E−03 to 0.14	480 to 662	2.8E−03 to 0.14
(Liss and Hartel, 1983)	Discrete, PBZ	Worker	Equipment operator	7	2	4.0E−03 to 0.19	225–486	4.0E−03 to 0.19
		Worker	Maintenance	4	1	1.1E−02 to 4.2E−02	465–480	1.1E−02 to 4.2E−02
		ONU	Instrument technician	2	2	Non-detect [g]	363–373	2.8E−03
		ONU	Warehouse worker	1	1	Non-detect [h]	459	2.1E−03
		ONU	Office engineer	2	2	Non-detect [g]	409–423	2.8E−03
		ONU	Supervisor	1	0	1.0E−02	429	1.0E−02

[a] Range of measured concentrations does not include non-detectable values.
[b] Sample duration range represents both samples above LOD and samples below LOD.
[c] For equipment operators, instrument technicians, maintenance workers, office engineers, supervisors, and warehouse workers, it is assumed that the inhalation exposure measurements are representative of full-shift exposures (typically 8 hours). For high exposure activities, it is assumed that tasks will not exceed 2 hours in duration and that the worker may be exposed at the average exposure concentration of a manufacturing equipment operator or maintenance worker (*i.e.*, 3.4E−02 mg/m^3) for the remaining duration of a typical 8-hour work shift. For example, full-shift exposure for a manufacturing worker engaged in high exposure activities for a 2-hour duration is calculated as [(2-hour) × (Task concentration (mg/m^3) + (6-hour) × (3.4E−02 mg/m^3)] ÷ (8-hour).
[d] For the purposes of calculating full-shift exposure concentrations, the value of LOD ÷ √2 was used for any samples that were below LOD.
[e] Respirator use is described in the study summary in Section 3.1.4.2.
[f] Task durations were not available, and EPA assumed high exposure tasks may last up to 120 minutes based on available data for similar high exposure tasks.
[g] LOD reported as 4.0×10^{-3} mg/m^3.
[h] LOD reported as 3.0×10^{-3} mg/m^3.

3.1.4.3 Occupational Inhalation Exposure Results

Table 3-4 provides a summary of inhalation exposure results for various worker categories associated with manufacturing. The results are based on full-shift exposure values presented in EPA estimated central tendency (CT) and high-end (HE) exposures using the 50th and 95th percentile values, respectively, from the observed data sets presented in Table 3-3.

Table 3-4. Inhalation Exposure Summary for Manufacturing

Worker Category	Full-shift Exposure (mg/m^3) [a]	
	CT	HE
High exposure worker [b]	0.58	2.3
Worker [c]	1.3E−02	0.13
ONU [d]	2.8E−03	8.2E−03

[a] EPA estimated CT and HE exposure values based on the 50th and 95th percentiles of data presented in Table 3-3.
[b] High exposure workers are those engaged in short-term, high exposure tasks, as well as routine equipment operations or maintenance. For phthalic anhydride production, high exposure tasks include flaking and bagging phthalic anhydride, unclogging baghouse chutes, filling drums with process impurities, and cleaning equipment with high solids content.
[c] Workers include equipment operators and maintenance workers.
[d] ONUs include supervisors, warehouse workers, office engineers, and instrument technicians.

3.1.4.4 Occupational Dermal Exposure Results

During manufacture of phthalic anhydride the material is initially produced in molten liquid form and then stored or transported, or the molten liquid material is processed into a flaked solid material before storage or transport. Because dermal contact with the molten material is unlikely and phthalic anhydride is a solid at room temperature, dermal contact with phthalic anhydride in a manufacturing setting is expected in the solid form primarily.

Lansink et al. (1996) conducted an analysis of skin exposure to workers handling powdered calcium carbonate during a variety of activities including collection of the raw material, handling of empty bags, and manual dumping and mixing. Dermal loading values were assessed using cotton gloves worn by the workers, which covered their hands and part of their forearms, to obtain estimates of skin exposure in units of milligrams per day. The study reported the minimum, maximum, geometric mean, and 90th percentile of skin exposure measurements for each activity.

The manufacture of phthalic anhydride may include high exposure tasks such as flaking and bagging of the raw material. Therefore, the skin exposure measurements reported by Lansink et al. (1996) for the collection of raw materials are considered most representative of potential skin exposure for high exposure tasks during the manufacture of phthalic anhydride. The 50th and 90th percentile values of dermal loading data from raw material collection (*i.e.*, 50th percentile = 476 mg/day, 90th percentile = 1,064 mg/day) are used to estimate central tendency and high-end dermal exposures, respectively, for high exposure workers. Equipment operators and maintenance workers who are not involved in high exposure tasks may also experience dermal exposure during routine tasks since phthalic anhydride may crystalize on equipment surfaces. Therefore, the skin exposure measurements reported by Lansink et al. (1996) for the handling of empty bags are considered most representative of potential skin exposure with phthalic anhydride on equipment surfaces. The 50th and 90th percentile values of dermal loading data from handling empty bags (*i.e.*, 50th percentile = 215 mg/day, 90th percentile = 1,039 mg/day) are used to estimate central tendency and high-end dermal exposures, respectively, for equipment operators and maintenance workers.

Workers in manufacturing facilities that do not handle the chemical directly (*i.e.*, ONUs) may also experience incidental dermal contact with surfaces contaminated with phthalic anhydride dust. Lansink et al. (1996) reports dermal loading for scenarios of handling empty bags, and these data are used as a surrogate for potential dermal loading values for ONUs in manufacturing facilities, such as supervisors, warehouse workers, office engineers, and instrument technicians. Since ONU dermal exposures are generally expected to be at the low end of potential worker dermal exposures, the 10th percentile value of dermal loading data from handling empty bags (*i.e.*, 10th percentile = 55 mg/day) is used to estimate potential dermal exposure for ONUs experiencing incidental contact with dust on surfaces.

The surface area was not explicitly stated in the study by Lansink et al. (1996); however, it was stated that the measurements were reflective of exposure to the hands and part of the forearms. The EPA Exposure Factors Handbook (2011) reports the mean surface area of two adult male hands as 1,070 cm^2 and two adult male arms as 3,140 cm^2. Assuming a surface area of the hands plus one-quarter of the arms (*i.e.*, hands plus part of the forearms), the total surface area of consideration from the Lansink et al. (1996) study can be estimated as 1,855 cm^2. Therefore, converting the skin exposure estimates from Lansink et al. (1996) to dermal loading estimates (mg/cm^2), not accounting for material weight fraction, the central tendency and high-end estimates of dermal loading for high exposures workers become 0.26 mg/cm^2 and 0.57 mg/cm^2, respectively, the central tendency and high-end estimates of dermal loading for equipment operators/maintenance workers become 0.12 mg/cm^2 and 0.56 mg/cm^2, respectively, and dermal loading for ONUs becomes 3.0×10^{-2} mg/cm^2.

Lastly, the concentration of phthalic anhydride during manufacture of the raw material is reported as greater than 90% in the 2020 CDR. Therefore, EPA assumed a concentration of 90% phthalic anhydride for central tendency and 100% phthalic anhydride for high-end estimates of exposure during material manufacture. Table 3-5 provides results of dermal exposure estimates of phthalic anhydride during the manufacturing process. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b), and appropriate forms of dermal PPE can be found in Section 2.5.2 of this document.

Table 3-5. Dermal Exposure Summary for Manufacturing

Worker Category	Dermal Loading (mg product/cm^2)		Phthalic Anhydride Concentration (%)		Dermal Exposure (mg phthalic anhydride/cm^2)	
	CT	HE	CT	HE	CT	HE
High exposure worker [a]	0.26	0.57	90	100	0.23	0.57
Worker [b]	0.12	0.56	90	100	0.10	0.56
ONU [c]	3.0E−02		90		2.7E−02	

[a] High exposure workers are those engaged in short-term, high exposure tasks, as well as routine equipment operations or maintenance. For phthalic anhydride production, high exposure tasks include flaking and bagging phthalic anhydride, unclogging baghouse chutes, filling drums with process impurities, and cleaning equipment with high solids content.
[b] Workers include equipment operators and maintenance workers.
[c] ONUs include supervisors, warehouse workers, office engineers, and instrument technicians.

3.2 Import and Repackaging

The following COUs are captured by this OES: Importing; Repackaging. See the *Draft Risk Evaluation for Phthalic Anhydride* for full list of COUs (U.S. EPA, 2026c).

3.2.1 Process Description

The final phthalic anhydride product can be stored or shipped in either molten liquid or solid flake form. The molten liquid product is typically transported using heated road tankers, and this form is mainly used by customers that handle large amounts of phthalic anhydride (*i.e.*, >2,000 metric tons per year). The liquid product is stored in holding tanks that are heated to 150 °C until the product is used for processing or redistribution (U.S. EPA, 1995). Figure 3-2 provides an illustration of the import process for molten liquid phthalic anhydride. The solid flake form is generally used by customers that handle lesser quantities of phthalic anhydride (*i.e.*, <2,000 metric tons per year), and this form is delivered by truck in standard 25 kg bags (40 bags per pallet) enclosed in shrink wrap or 1 metric ton semi-bulk bags that can be opened from the bottom. However, the semi-bulk bags are not designed for dust-free emptying (Ridgway et al., 1996). Phthalic anhydride is typically imported in molten liquid or flaked solid form at concentrations of 90 to 100%. Figure 3-3 provides an illustration of the import and repackaging process for solid flake phthalic anhydride.

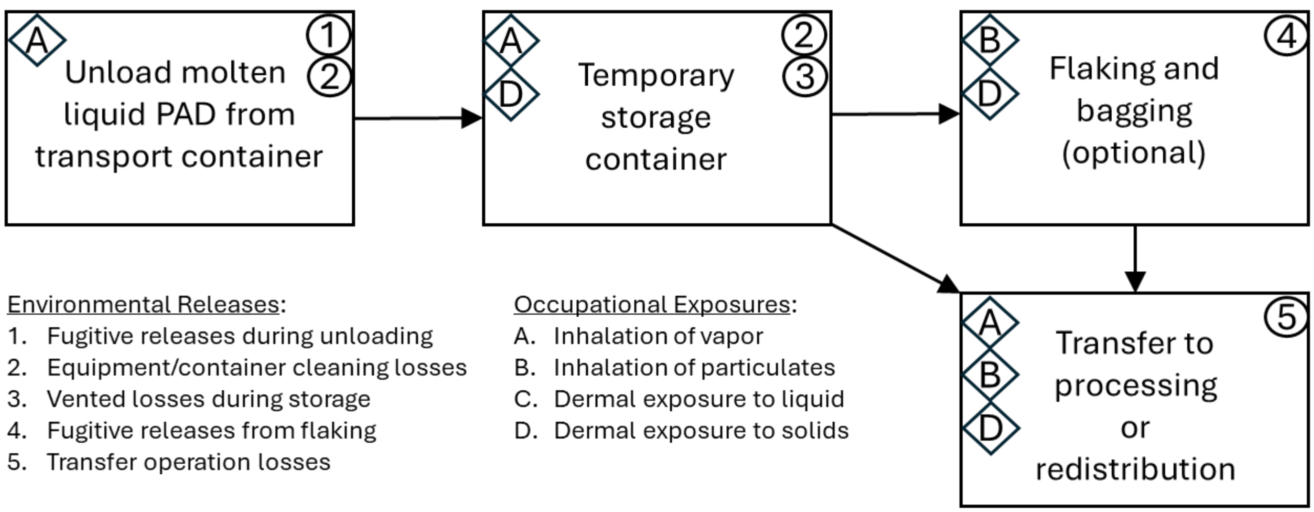

Figure 3-2. Process Flow Diagram for Import and Repackaging of Liquid Molten Phthalic Anhydride

Source: (U.S. EPA, 2022, 1995)

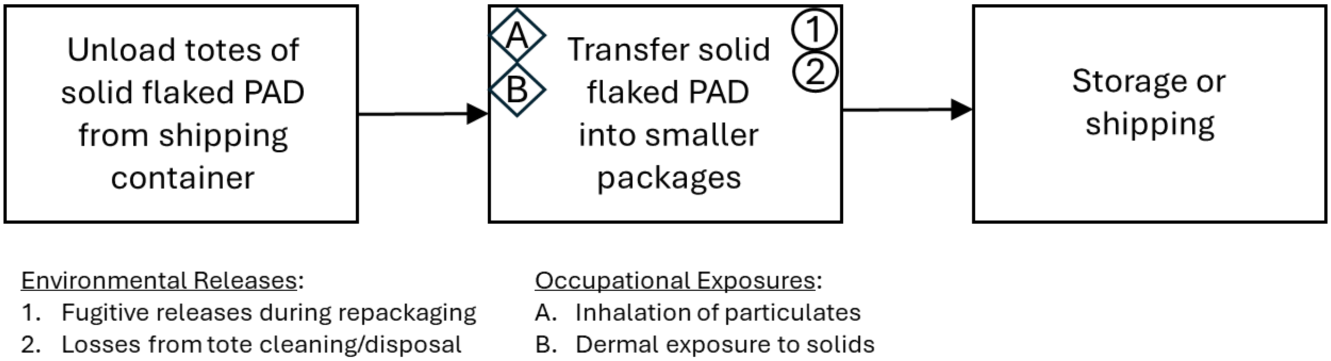

Figure 3-3. Process Flow Diagram for Import and Repackaging of Solid Flaked Phthalic Anydride
Source: (U.S. EPA, 2022, 1995)

3.2.2 Facility Estimates

EPA estimates that there are 28 to 37 facilities involved in phthalic anhydride import and repackaging based on the 2020 CDR (U.S. EPA, 2020a) and 2019 to 2023 TRI data reporting (U.S. EPA, 2023b). From these data, it is estimated that the annual production volume of phthalic anhydride from import and repackaging activities ranges from 81.4 to 256 million lb. More detailed information on import and repackaging production volume can be found in Appendix B.2.

Since there were no operating schedule data identified for facilities importing and repackaging phthalic anhydride, it was assumed that the number of operating days was 260 days/year with based on the Chemical Repackaging GS (U.S. EPA, 2022). CDR reporters indicated that phthalic anhydride is imported primarily in solid form at a concentration of 90 to 100%. However, some importers reported importing in liquid form, and some indicated concentrations less than 90% (U.S. EPA, 2020a).

Table 3-6. Summary of Facility Estimates for Import and Repackaging

Total Number of Sites	Sites w/ CBI for PV	Total Annual PV (lb/yr)	Operating Days (day/yr)	Concentration (%)	Physical Form
28–37	7	81,394,491 256,394,490	260	90–100	Pellets, crystals, powder, or liquid

CBI = confidential business information; PV = production volume
See Appendix B.2 for more details.

3.2.3 Release Assessment

3.2.3.1 Environmental Release Assessment Results

Environmental releases of phthalic anhydride are reported to TRI (U.S. EPA, 2023b) and NEI (U.S. EPA, 2023a, 2019b) databases, but EPA only identified release data of import and repackaging from TRI. Therefore, EPA used information from TRI reporting years 2019 to 2023 to characterize environmental release data. For facilities reporting to TRI in years 2019 to 2023, the highest facility releases and the median facility releases across reporting years for air and water are listed in Table 3-7. The number of release days was assumed to be equal to the number of operation days for a facility. 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). For sites reporting under TRI Form A, it was assumed that the site may be releasing up to 500 lb to air (fugitive and stack) or to water (surface water, POTW, or non-POTW) for purposes of downstream environmental exposure modeling. Facilities reporting to TRI using 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. There were no land releases reported by facilities involved in chemical repackaging, which suggests that releases to land from import and repackaging scenarios are not significant. Therefore, EPA does not characterize releases to land from import and repackaging scenarios in the table below. For more detailed information regarding environmental releases, see the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).

Table 3-7. Summary of Releases from TRI (2019–2023) for Import and Repackaging

Type of Air Emission [a], Discharge [b], or Disposal [c]	Estimated Annual Release (kg/site-year) [d]		Estimated Daily Release (kg/site-day) [d]		Number of Facilities [e]	Data Source	Number of Release Days [f]
	Central Tendency	High-End	Central Tendency	High-End			
Stack air	113	227	0.44	0.87	4	TRI	260
Fugitive air	113	227	0.44	0.87	4	TRI	
Wastewater	113	227	0.44	0.87	4	TRI	
Land	0	0	0	0	4	TRI	

[a] Emissions via stack air and/or fugitive air.
[b] Direct discharge to surface water, indirect discharge to non-POTW, or indirect discharge to POTW. Details on wastewater release streams for each facility are presented in the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).
[c] Land releases may be sent to various locations including on-site underground class 1 wells, on-site and off-site RCRA subtitle C landfills, off-site landfills, other off-site land disposal, and transfers to off-site waste brokers. See the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025) for more details.
[d] Central tendency values are calculated from the 50th percentile of median reported releases and high-end values are calculated from the 95th percentile of maximum reported releases.
[e] Number of unique facilities reporting releases.

3.2.4 Occupational Exposure Assessment

3.2.4.1 Worker Activities

During the import and repackaging of phthalic anhydride, workers that handle the chemical directly (*e.g.*, equipment operators, maintenance workers) are involved with various tasks including product sampling, equipment cleaning and maintenance, container cleaning, and unloading and packaging of phthalic anhydride. When phthalic anhydride is imported or repackaged as a solid flaked material, phthalic anhydride dust can become airborne and workers may experience elevated levels of inhalation exposure to airborne dust. Consequently, EPA distinguished exposures between standard worker activities and high exposure worker activities. Standard worker activities include product sampling, loading or unloading finished products, walking the repackaging area, checking for leaks, collection of various readings in the repackaging area, adjustment of valves, and monitoring product flow from the control room. High exposure activities include flaking and bagging phthalic anhydride, unclogging baghouse chutes, filling drums with process impurities, and cleaning equipment with high solids content. Sections 2.5.1 and 2.5.2 provide further details regarding considerations of PPE for handling phthalic anhydride.

There are some workers who do not directly handle phthalic anhydride but work in proximity to the chemical, such as supervisors, warehouse workers, and office engineers. Generally, EPA expects workers who do not handle the chemical directly to have lower inhalation and dermal exposures than workers who handle the chemicals directly.

For the worker activities within import and repackaging facilities, it is expected that workers may be exposed through inhalation of vapors and dust, as well as dermal contact with the solid flaked material. Since dust containing phthalic anhydride may be deposited on surfaces during import and repackaging, it is possible that workers who do not directly handle the chemical (*i.e.*, ONUs) may also experience dermal exposure through incidental contact with a contaminated surface.

3.2.4.2 Occupational Inhalation Exposure

Due to similarities in worker activities and sources of inhalation exposure between the “Manufacturing” OES and the “Import and repackaging” OES, inhalation exposures are expected to be consistent for these uses. Therefore, the inhalation exposure data for the “Manufacturing” OES described in Section 3.1.4.2 and summarized in Table 3-3, as well as the inhalation exposure results described in Section 3.1.4.3 and summarized in
Table **3-4**, are used as surrogate for estimating inhalation exposures from import and repackaging activities. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b).

3.2.4.3 Occupational Dermal Exposure

Due to similarities in worker activities and sources of dermal exposure between the “Manufacturing” OES and the “Import and repackaging” OES, dermal exposures are expected to be consistent for these uses. Therefore, the dermal exposure estimates for the “Manufacturing” OES described in Section 3.1.4.4 and summarized in Table 3-5, are applicable to the “Import and repackaging” OES. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b), and appropriate forms of dermal PPE can be found in Section 2.5.2 of this document.

3.3 Processing as a Reactant

The following COUs are captured by this OES: Intermediate (all other basic organic chemical manufacturing; paint and coating manufacturing; flame retardant manufacturing); Monomer (all other basic organic chemical manufacturing); Ion exchange agent (all other basic organic chemical manufacturing); Pigments (printing ink manufacturing); Polymerization promoter (synthetic dye and pigment manufacturing); Plasticizer (adhesive manufacturing; lubricant additive manufacturing). See the *Draft Risk Evaluation for Phthalic Anhydride* for full list of COUs (U.S. EPA, 2026c).

3.3.1 Process Description

Phthalic anhydride is a precursor to several plasticizers and is processed as a reactive intermediate, monomer, ion exchange agent, and polymerization promoter. Phthalic anhydride is also processed as a reactant in the manufacture of pigments, paints, and adhesives (U.S. EPA, 2020a). The processing of phthalic anhydride for use in plastic material and resin products is covered under the "Plastic compounding" OES.

Reactive processing of phthalic anhydride begins with transfer of the solid or liquid phthalic anhydride material through tank cars, totes, sacks, or storage vessels on site. It is important to note that phthalic anhydride in molten liquid form is generally maintained at 150 °C. Phthalic anhydride is introduced to reaction components in a mixing vessel and subsequently processed based on the desired product. Once reactive processing is complete, the product is sampled, and if found acceptable, transferred to storage vessels on site or packaged into bottles, small containers, or drums for distribution. The resulting product from reactive processing of phthalic anhydride generally contains small amounts of phthalic anhydride since most of the material is consumed in reaction, and the majority of exposures and releases occur during the transfer and mixing of the initial phthalic anhydride material. Phthalic anhydride is typically processed using molten liquid or flaked solid form at concentrations of 90 to 100%. Potential exposure and release points in the reactive processing use of phthalic anhydride are shown in Figure 3-4, which was modified based on the ESD on Adhesive Formulation (OECD, 2009a).

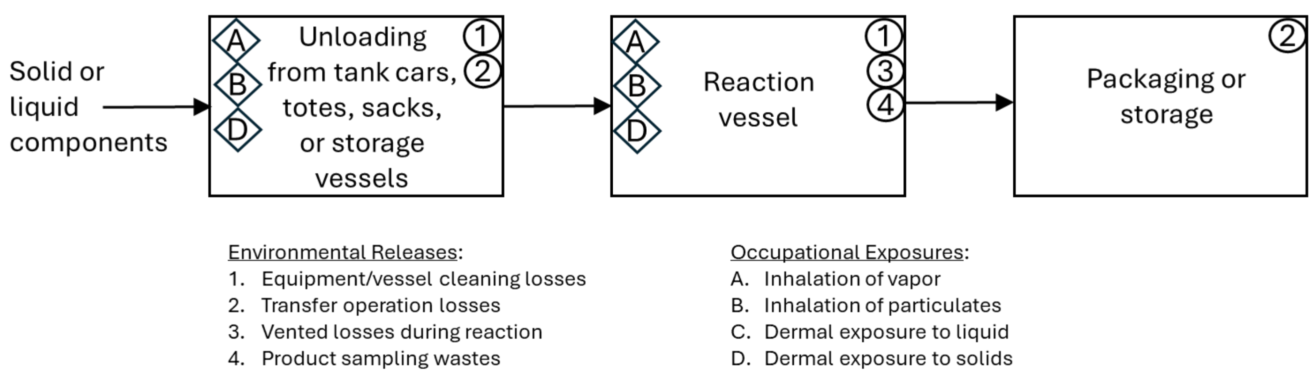

Figure 3-4. Process Flow Diagram for Processing Phthalic Anhydride as a Reactant
Source: (OECD, 2009a)

3.3.2 Facility Estimates

EPA estimates that there are 108 to 321 facilities involved in processing phthalic anhydride as a reactant based on the 2020 CDR data reporting (U.S. EPA, 2020a). From these data, it is estimated that the annual production volume of phthalic anhydride used for processing as a reactant ranges from 72.3 to 201 million lb. More detailed information on production volume used for processing as a reactant can be found in Appendix B.3.

The number of operating days was determined based on the data reported to the 2017 and 2020 NEI databases (U.S. EPA, 2023a, 2019b), which may contain more detailed information about facility operation schedules. If there were no operation schedule data reported to 2017 or 2020 NEI databases for a facility, it was assumed that facilities may operate 5 days/week and 50 weeks/year with 2 weeks of downtime (*i.e.*, 250 operating days/year). CDR reporters indicated that phthalic anhydride may be processed in solid form or molten liquid form, generally at a concentration of 90 to 100%. However, one processor reported that phthalic anhydride was used in liquid form at a concentration of less than 1% (U.S. EPA, 2020a).

Table 3-8. Summary of Facility Estimates for Processing as a Reactant

Total Number of Sites	Total Annual PV (lb/yr)	Operating Days (day/yr)	Concentration (%)	Physical Form
108–321	72,314,019 200,647,351	250–365	90–100	Pellets, crystals, powder, or liquid
See Appendix B.3 for more details.				

3.3.3 Release Assessment

3.3.3.1 Environmental Release Assessment Results

Environmental releases of phthalic anhydride are reported to TRI (U.S. EPA, 2023b) and NEI (U.S. EPA, 2023a, 2019b) databases, and EPA used information from these databases to estimate environmental releases of phthalic anhydride to air, water, and land. Specifically, the reporting years 2019 to 2023 were considered for the TRI database and the reporting periods of 2017 and 2020 were considered for the NEI database. EPA preferred and reported the most recent data from the NEI database, and these data are shown in Table 3-9 below. For facilities reporting to TRI in years 2019 to 2023, the highest facility releases and the median facility releases across reporting years for air, water, and land are provided in Table 3-9. The number of release days was assumed to be equal to the number of operation days for a facility. 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). For sites reporting under TRI Form A, it was assumed that the site may be releasing up to 500 lb to air (fugitive and stack) or to water (surface water, POTW, or non-POTW) for purposes of downstream environmental exposure modeling. Facilities reporting to TRI using 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. For more detailed information regarding environmental releases, see the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).

Table 3-9. Summary of Releases from TRI (2019–2023) and NEI (2017, 2020) for Processing as a Reactant

Type of Air Emission [a], Discharge [b], or Disposal [c]	Estimated Annual Release (kg/site-year) [d]		Estimated Daily Release (kg/site-day) [d]		Number of Facilities [e]	Data Source	Number of Release Days [f]
	Central Tendency	High-End	Central Tendency	High-End			
Stack air	0.14	982	5.0E−04	2.7	39	NEI	250–365
	84	912	0.31	3.3	58	TRI	
Fugitive air	1.3	291	3.7E−03	1.2	39	NEI	
	104	338	0.37	1.4	58	TRI	
Wastewater	2.3	351	9.1E−03	1.4	58	TRI	
Land	0	2.6E03	0	11	58	TRI	

[a] Emissions via stack air and/or fugitive air.
[b] Direct discharge to surface water, indirect discharge to non-POTW, or indirect discharge to POTW. Details on wastewater release streams for each facility are presented in the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).
[c] Land releases were reported to on-site underground class 1 wells, on-site and off-site RCRA subtitle C landfills, off-site landfills, other off-site land disposal, and transfers to off-site waste brokers. See the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025) for more details.
[d] Central tendency values are calculated from the 50th percentile of median reported releases and high-end values are calculated from the 95th percentile of maximum reported releases.
[e] Number of unique facilities reporting releases.
[f] It was assumed that the number of operating days is representative of the number of release days for each facility. Where data were available, EPA used facility-specific operating schedules to estimate number of annual release days. If facility-specific operating schedules were not available, EPA used peer-reviewed literature (*e.g.,* GSs or ESDs) to estimate the number of annual release days.

3.3.4 Occupational Exposure Assessment

3.3.4.1 Worker Activities

While processing phthalic anhydride as a reactant, workers that handle the chemical directly (*e.g.*, equipment operators, maintenance workers) are involved with various tasks including product sampling, equipment cleaning and maintenance, container cleaning, and dumping and mixing phthalic anhydride in mixing vessels. When phthalic anhydride is processed as a solid flaked material, phthalic anhydride dust can become airborne and workers may be exposed to elevated levels airborne dust. Consequently, EPA distinguished exposures between standard worker activities and high exposure worker activities. Standard worker activities include product sampling, loading and unloading products from transport vessels, and operating and cleaning process equipment. High exposure activities include dumping and mixing bags of phthalic anhydride, as well as disposal of the empty bags. Sections 2.5.1 and 2.5.2 provide further details regarding considerations of PPE for handling phthalic anhydride.

ONUs are workers who do not handle the chemical directly but work in proximity to the chemical, such as supervisors, warehouse workers, office engineers, and instrument technicians. Depending on the worker activities, EPA generally expects workers who do not handle the chemical directly (*i.e.*, ONUs) to have lower inhalation and dermal exposures than workers who handle the chemicals directly.

For the worker activities within processing environments, it is expected that workers may be exposed through inhalation of vapors and dust, as well as dermal contact with the solid flaked material. Since dust containing phthalic anhydride may be deposited on surfaces during processing, it is possible that workers who do not directly handle the chemical (*i.e.*, ONUs) will also experience dermal exposure through incidental contact with a contaminated surface.

3.3.4.2 Occupational Inhalation Exposure Data

EPA identified several sources of data that quantified the inhalation exposure of phthalic anhydride during processing, and the *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994) was used to select the most representative data. Based on the guidelines, EPA preferred discrete, personal breathing zone measurements that received high ratings through the EPA systematic review process. Consequently, the following five studies were selected to estimate inhalation exposure to workers during processing of phthalic anhydride: Liss (1983), Griesenbrock (2017), Milford (2018), Rietz (1985), and Bookman (2017). Liss (1983) and Rietz (1985) were identified through the EPA systematic review process and the remaining three studies were submitted to EPA as required by Section 8(d) of TSCA. These data were used to estimate full-shift exposure values of occupational exposure for various worker categories as shown in Table 3-10.

Liss (1983) was conducted by NIOSH as a Human Health Evaluation (HHE), and the study examined worker inhalation exposures during manufacturing of phthalic anhydride and subsequent processing of the chemical. The study provides discrete, personal breathing zone measurements for a variety of worker (equipment operators and maintenance) and ONU (instrument technicians, warehouse workers, office engineers, and supervisors) categories. Although some sample measurements are less than 8 hours, it is expected that the measured inhalation exposure values are representative of full-shift exposures. For estimation of exposure measurements below the LOD, EPA followed the *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994). Specifically, the guidelines state that if the geometric standard deviation of the dataset is less than 3.0, nondetectable values should be replaced by the LOD divided by the square root of two. Because the geometric standard deviation of the entire monitoring dataset reported by Liss (1983) was less than 3.0, nondetectable values were replaced by the LOD divided by the square root of two.

Griesenbrock (2017) reported one full-shift PBZ measurement of a worker unloading phthalic anhydride from a truck, and the measurement was below the LOD. The worker was wearing a full-face respirator with a combination cartridge and a flame-resistance clothing (FRC) uniform. Milford (2018) reported three full-shift PBZ measurements from workers involved in processing phthalic anhydride, and all three measurements were below the LOD. However, the exact worker activities and the worker PPE is not provided in the study report. Since there were no detectable data from these two studies to calculate the geometric standard deviation, EPA conservatively divided the LOD by the square root of two for estimation of exposure levels.

Rietz (1985) examined workers during the handling of bagged phthalic anhydride during mixing and filling operations prior to the production of plastics, and these data were used for estimating inhalation exposure levels for workers processing phthalic anhydride as a reactant. A separate study conducted in plants producing alkyd and unsaturated polyester resins (Nielsen et al., 1988) reported that workers may handle bags for up to 30 minutes two times per day, and that filling of larger bags may lead to intermittent dusting that can cause inhalation exposure. The sample durations for inhalation exposure measurements of bag handling activities reported by Rietz (1985) were 1 to 2 hours, and it is expected that a worker will not handle bags of phthalic anhydride for longer than 2 hours per work shift. Therefore, the full-shift exposure values associated with bag handling activities are based on 2 hours of exposure from bag handling and 6 hours of exposure at the average exposure concentration of a processing equipment operator or maintenance worker (*i.e.*, 1.8×10^{-2} mg/m^3). Bookman (2017) supplied inhalation monitoring data for a worker charging super-sacs of solid phthalic anhydride, and a 75-minute PBZ sample resulted in a measurement of 1.3 mg/m^3. The full-shift exposure values associated with bag handling data reported by Bookman (2017) are based on 1.25 hours of exposure from bag handling and 6.75 hours of exposure at the average exposure concentration of a processing equipment operator or maintenance worker (*i.e.*, 1.8×10^{-2} mg/m^3).

Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b).

Table 3-10. Inhalation Exposure Data for Processing as a Reactant

Source	Data Type	Worker Category	Task or Job Title	Number of Samples	Number of Non-detects	Measured Concentration (mg/m^3) [a]	Sample Duration (min) [b]	Estimated Full-Shift Exposure (mg/m^3) [c d]
(Rietz, 1985)	Discrete, PBZ	High exposure worker	Bag handling	4	0	0.51–4.9	60–120	0.14–1.2
(Bookman, 2017)	Discrete, PBZ	High exposure worker	Bag handling	1	0	1.33	75	0.22
(Griesenbrock, 2017)	Discrete, PBZ	Worker	Equipment operator	1	1	Non-detect	483	1.3E−02
(Milford, 2018)	Discrete, PBZ	Worker	Equipment operator	3	3	Non-detect	595–699	4.9E−03 to 5.7E−03
(Liss and Hartel, 1983)	Discrete, PBZ	Worker	Equipment operator	19	4	5.0E−03 to 1.0E−01	387–486	5.0E−03 to 1.0E−01
		Worker	Maintenance	7	2	1.1E−02 to 4.4E−02	444–480	1.1E−02 to 4.4E−02
		ONU	Instrument technician	2	2	Non-detect [f]	363–373	2.8E−03
		ONU	Warehouse worker	1	1	Non-detect [g]	459	2.1E−03
		ONU	Office engineer	2	2	Non-detect [f]	409–423	2.8E−03
		ONU	Supervisor	1	0	1.0E−02	429	1.0E−02

[a] Range of measured concentrations does not include non-detectable values.
[b] Sample duration range represents both samples above LOD and samples below LOD.
[c] For equipment operators, instrument technicians, maintenance workers, office engineers, supervisors, and warehouse workers, it is assumed that the inhalation exposure measurements are representative of full-shift exposures (typically 8 hours). For high exposure activities, it is assumed that tasks will not exceed 2 hours in duration and that the worker may be exposed at the average exposure concentration of a processing equipment operator or maintenance worker (*i.e.*, 1.8E−02 mg/m^3) for the remaining duration of a typical 8-hour work shift. For example, full-shift exposure for a processing worker engaged in high exposure activities for a 2-hour duration is calculated as [(2-hour) × (Task concentration (mg/m^3) + (6-hour) × (1.8E−02 mg/m^3)] ÷ (8-hour).
[d] For the purposes of calculating full-shift exposure concentrations, the value of LOD ÷ √2 was used for any samples that were below LOD.
[e] Task durations were not available, and EPA assumed high exposure tasks may last up to 120 minutes based on available data for similar high exposure tasks.
[f] LOD reported as 4.0E−03 mg/m^3.
[g] LOD reported as 3.0E10−0^3 mg/m^3.

Occupational Inhalation Exposure Results

Table 3-11 provides a summary of inhalation exposure results for various worker categories associated with processing as a reactant. The results are based on full-shift exposure values presented in Table 3-10. Exposures estimates are calculated from worker categories depending on the size of the dataset for the worker category. For datasets with six or more data points, EPA estimated CT and HE exposures using the 50th and 95th percentile values, respectively, from the observed data sets. For data sets with three to five data points, EPA estimated the central tendency and high-end exposures using the median and maximum values, respectively.

Table 3-11. Inhalation Exposure Summary for Processing as a Reactant

Worker Category	Full-Shift Exposure (mg/m^3) [a]	
	CT	HE
High exposure worker [b]	0.22	1.2
Worker [c]	8.5E−03	5.6E−02
ONU [d]	2.8E−03	8.2E−03

[a] For datasets with 6 or more data points, EPA estimated CT and HE exposures using the 50th and 95th percentile values, respectively, from the data presented in Table 3-10. For data sets with 3–5 data points, EPA estimated the central tendency and high-end exposures using the median and maximum values, respectively, from the data presented in Table 3-10.
[b] High exposure workers are those engaged in short-term, high exposure tasks, as well as routine equipment operations or maintenance. For phthalic anhydride processing, high exposure tasks include dumping and mixing bags of phthalic anhydride, as well as disposal of the empty bags.
[c] Workers include equipment operators and maintenance workers.
[d] ONUs include supervisors, warehouse workers, office engineers, and instrument technicians.

3.3.4.3 Occupational Dermal Exposure Results

Phthalic anhydride is a solid at room temperature. During processing of phthalic anhydride as a reactant, the material may be pumped into mixing vessels as the molten liquid through an automated process or the material may be added manually from bags filled with the flaked solid material. Because dermal contact with the molten material is unlikely and phthalic anhydride is a solid at room temperature, dermal contact with phthalic anhydride in a processing facility is expected in the solid form primarily.

Lansink et al. (1996) conducted an analysis of skin exposure to workers handling powdered calcium carbonate during a variety of activities including collection of the raw material, handling of empty bags, and manual dumping and mixing. Dermal loading values were assessed using cotton gloves worn by the workers, which covered their hands and part of their forearms, to obtain estimates of skin exposure in units of milligrams per day. The study reported the minimum, maximum, geometric mean, and 90th percentile of skin exposure measurements for each activity.

The processing of phthalic anhydride as a reactant may include high exposure tasks such as dumping and mixing of the raw material. Therefore, the skin exposure measurements reported by Lansink et al. (1996) for manual dumping and mixing are considered most representative of potential skin exposure for high exposure tasks during the processing of phthalic anhydride. The 50th and 90th percentile values of dermal loading data from raw material collection (*i.e.*, 50th percentile = 888 mg/day, 90th percentile = 3,046 mg/day) are used to estimate central tendency and high-end dermal exposures, respectively, for high exposure workers. Equipment operators and maintenance workers who are not involved in high exposure tasks may also experience dermal exposure during routine tasks since phthalic anhydride may crystalize on equipment surfaces. Therefore, the skin exposure measurements reported by Lansink et al. (1996) for the handling of empty bags are considered most representative of potential skin exposure with phthalic anhydride on equipment surfaces. The 50th and 90th percentile values of dermal loading data from handling empty bags (*i.e.*, 50th percentile = 215 mg/day, 90th percentile = 1,039 mg/day) are used to estimate central tendency and high-end dermal exposures, respectively, for equipment operators and maintenance workers.

Workers in a processing facility that do not handle the chemical directly (*i.e.*, ONUs) may also experience incidental dermal contact with surfaces contaminated with phthalic anhydride dust. Lansink et al. (1996) reports dermal loading for scenarios of handling empty bags, and these data are used as a surrogate for potential dermal loading values for ONUs in processing facilities, such as supervisors, warehouse workers, office engineers, and instrument technicians. Since ONU dermal exposures are generally expected to be on the low end of potential worker dermal exposures, the 10th percentile value of dermal loading data from handling empty bags (*i.e.*, 10th percentile = 55 mg/day) is used to estimate potential dermal exposure for ONUs experiencing incidental contact with dust on surfaces.

The surface area was not explicitly stated in the study by Lansink et al. (1996); however, it was stated that the measurements were reflective of exposure to the hands and part of the forearms. The EPA Exposure Factors Handbook (2011) reports the mean surface area of two adult male hands as 1,070 cm^2 and two adult male arms as 3,140 cm^2. Assuming a surface area of the hands plus one-quarter of the arms (*i.e.*, hands plus part of the forearms), the total surface area of consideration from the Lansink et al. (1996) study can be estimated as 1,855 cm^2. Therefore, converting the skin exposure estimates from Lansink et al. (1996) to dermal loading estimates (mg/cm^2), not accounting for material weight fraction, the central tendency and high-end estimates of dermal loading for high exposures workers become 0.48 mg/cm^2 and 1.6 mg/cm^2, respectively, the central tendency and high-end estimates of dermal loading for equipment operators/maintenance workers become 0.12 mg/cm^2 and 0.56 mg/cm^2, respectively, and dermal loading for ONUs becomes 3.0×10^{-2} mg/cm^2.

Lastly, the concentration of phthalic anhydride during processing as a reactant is reported as greater than 90% in the 2020 CDR. Therefore, EPA assumed a concentration of 90% phthalic anhydride for central tendency and 100% phthalic anhydride for high-end estimates of exposure during material processing. Table 3-12 provides results of dermal exposure estimates of phthalic anhydride during processing as a reactant. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b), and appropriate forms of dermal PPE can be found in Section 2.5.2 of this document.

Table 3-12. Dermal Exposure Summary for Processing as a Reactant

Worker Category	Dermal Loading (mg product/cm^2)		Phthalic Anhydride Concentration (%)		Dermal Exposure (mg phthalic anhydride/cm^2)	
	CT	HE	CT	HE	CT	HE
High exposure worker [a]	0.48	1.6	90	100	0.43	1.6
Worker [b]	0.12	0.56	90	100	0.10	0.56
ONU [c]	3.0E−02		90		2.7E−02	

[a] High exposure workers are those engaged in short-term, high exposure tasks, as well as routine equipment operations or maintenance. For phthalic anhydride processing, high exposure tasks include dumping and mixing bags of phthalic anhydride, as well as disposal of the empty bags.

Worker Category	Dermal Loading (mg product/cm²)		Phthalic Anhydride Concentration (%)		Dermal Exposure (mg phthalic anhydride/cm²)	
	CT	HE	CT	HE	CT	HE

[b] Workers include equipment operators and maintenance workers.
[c] ONUs include supervisors, warehouse workers, office engineers, and instrument technicians.

3.4 Incorporation into Formulations, Mixtures, or Reaction Products

The following COUs are captured by this OES: Intermediate (all other basic organic chemical manufacturing; all other basic inorganic chemical manufacturing; adhesive manufacturing); Plasticizers (paint and coating manufacturing); Dyes (synthetic dye and pigment manufacturing); Retarder (rubber product manufacturing); Binder (paint and coating manufacturing); Hardener (paint and coating manufacturing; solvent-based paint; adhesive manufacturing; rubber product manufacturing; utilities); Solvent (paint and coating manufacturing); Processing aid (paint and coating manufacturing; rubber product manufacturing); Pre-catalyst manufacturing; Polymerization promoter (all other basic organic chemical manufacturing).

The following COUs are captured by exposure estimates for the incorporation of phthalic anhydride as an epoxy resin casting hardener: Hardener (epoxy resin casting); Fillers (hardener (*e.g.*, epoxy hardener)).

See the *Draft Risk Evaluation for Phthalic Anhydride* for full list of COUs (U.S. EPA, 2026c).

3.4.1 Process Description

Phthalic anhydride is incorporated into formulations, mixtures, or reaction products as an intermediate, plasticizer, paint additive, retarder, binder, hardener, solvent, processing aid, and polymerization promoter (U.S. EPA, 2020a). The processing of phthalic anhydride for use in plastic material and resin products is covered under the “Plastic compounding” OES. Phthalic anhydride is also incorporated as a filler to harden epoxy resin in casting operations for applications such as countertop manufacturing (Tustin et al., 2022; U.S. EPA, 2020a). For this particular incorporative use, raw phthalic anhydride in flaked solid form is mixed with other raw materials such as silica sand, epoxy resin, and pigments, and the mixture is then transferred to a mold and placed in an oven for curing. Once the molds have been cured, the resulting products are transferred to a fabrication area where the materials are cut into the desired shapes.

General incorporative processing of phthalic anhydride typically begins with transfer of the solid or liquid phthalic anhydride material through tank cars, totes, sacks, or storage vessels on site. It is important to note that phthalic anhydride in molten liquid form is generally maintained at 150 °C. Phthalic anhydride is introduced to other component additives in a mixing vessel and subsequently processed based on the desired product. Once processing is complete, the product is sampled, and if found acceptable, transferred to storage vessels on site or packaged into bottles, small containers, or drums for distribution. Phthalic anhydride is typically processed using molten liquid or flaked solid form at concentrations of 90 to 100%. Potential exposure and release points from the incorporation of phthalic anhydride into formulations, mixtures, or reaction products are shown in Figure 3-5, which was modified based on the ESD on Adhesive Formulation (OECD, 2009a).

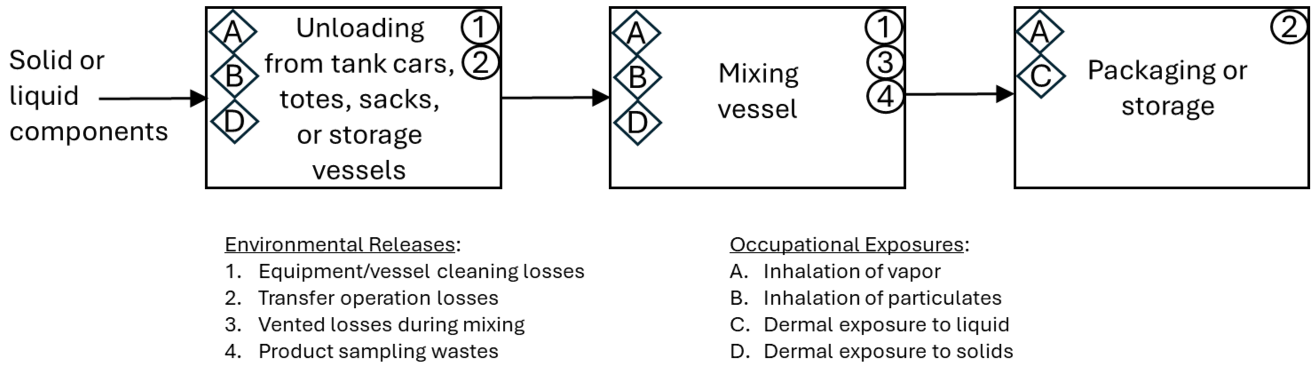

Figure 3-5. Process Flow Diagram for Incorporating Phthalic Anhydride into Formulations, Mixtures, or Reaction Products
Source: (OECD, 2009a)

3.4.2 Facility Estimates

EPA estimates that there are 34 to 180 facilities involved in incorporation of phthalic anhydride into formulations, mixtures, or reaction products based on the 2020 CDR data reporting (U.S. EPA, 2020a). From these data, it is estimated that the annual production volume of phthalic anhydride used for processing as a reactant ranges from 17.4 to 69.1 million lb. More detailed information on production volume used for incorporation into formulations, mixtures, or reaction products can be found in Appendix B.4.

EPA did not identify data on the production schedules of the downstream processing sites. Therefore, it was assumed that facilities may operate 5 days/week and 50 weeks/year with 2 weeks of downtime (*i.e.*, 250 operating days/year). CDR reporters indicated that phthalic anhydride may be processed in solid form or molten liquid form, generally at a concentration of 90 to 100%. However, one processor reported that phthalic anhydride was used in liquid form at a concentration of less than 1% (U.S. EPA, 2020a).

Table 3-13. Summary of Facility Estimates for Incorporation into Formulations, Mixtures, or Reaction Products

Total Number of Sites	Total Annual PV (lb/yr)	Operating Days (day/yr)	Concentration (%)	Physical Form
34–180	17,438,406 69,105,072	250	90–100	Dry powder, other solid, pellets, or large crystals
See Appendix B.4 for more details.				

3.4.3 Release Assessment

3.4.3.1 Environmental Release Assessment Results

Environmental releases of phthalic anhydride are reported to TRI (U.S. EPA, 2023b) and NEI (U.S. EPA, 2023a, 2019b) databases, and EPA used information from these databases to estimate environmental releases of phthalic anhydride to air, water, and land. Specifically, the reporting years 2019 to 2023 were considered for the TRI database and the reporting periods of 2017 and 2020 were considered for the NEI database. EPA preferred and reported the most recent data from the NEI database, and these data are shown in Table 3-14 below. For facilities reporting to TRI in years 2019 to

2023, the highest facility releases and the median facility releases across reporting years for air, water, and land are provided in Table 3-14. The number of release days was assumed to be equal to the number of operation days for a facility. 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). For sites reporting under TRI Form A, it was assumed that the site may be releasing up to 500 lb (227 kg) to air (fugitive and stack) or to water (surface water, POTW, or non-POTW) for purposes of downstream environmental exposure modeling. Facilities reporting to TRI using 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. For more detailed information regarding environmental releases, see the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).

Table 3-14. Summary of Releases from TRI (2019–2023) and NEI (2017, 2020) for Incorporation into Formulations, Mixtures, or Reaction Products

Type of Air Emission [a], Discharge [b], or Disposal [c]	Estimated Annual Release (kg/site-year) [d]		Estimated Daily Release (kg/site-day) [d]		Number of Facilities [e]	Data Source	Number of Release Days [f]
	Central Tendency	High-End	Central Tendency	High-End			
Stack air	0.93	37	3.7E−03	0.15	4	NEI	250
Stack air	1.1	151	4.5E−03	0.60	9	TRI	
Fugitive air	2.3	20	9.1E−03	8.0E−02	4	NEI	
Fugitive air	4.5E−02	153	1.8E−04	0.61	9	TRI	
Wastewater	0	136	0	0.54	9	TRI	
Land	0	1.5E03	0	6.0	9	TRI	

[a] Emissions via stack air and/or fugitive air.
[b] Direct discharge to surface water, indirect discharge to non-POTW, or indirect discharge to POTW. Details on wastewater release streams for each facility are presented in the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).
[c] Land releases were reported to off-site landfills only. See the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025) for more details.
[d] Central tendency values are calculated from the 50th percentile of median reported releases and high-end values are calculated from the 95th percentile of maximum reported releases.
[e] Number of unique facilities reporting releases.

3.4.4 Occupational Exposure Assessment

3.4.4.1 Worker Activities

While incorporating phthalic anhydride into formulations, mixtures, or reaction products, workers that handle the chemical directly (*e.g.*, equipment operators, maintenance workers) are involved with various tasks including product sampling, equipment cleaning and maintenance, container cleaning, and dumping and mixing phthalic anhydride in mixing vessels. When phthalic anhydride is processed as a solid flaked material, phthalic anhydride dust can become airborne and workers may experience elevated levels of inhalation exposure to airborne dust. Consequently, EPA distinguished exposures between standard worker activities and high exposure worker activities. Standard worker activities include product sampling, loading and unloading products from transport vessels, and operating and cleaning process equipment. High exposure activities include dumping and mixing bags of phthalic anhydride, as well as disposal of the empty bags. Sections 2.5.1 and 2.5.2 provide further details regarding considerations of PPE for handling phthalic anhydride.

For the incorporation of phthalic anhydride as a filler to harden epoxy resin mixtures used in casting operations, workers are involved in pouring bags of neat phthalic anhydride to mix with other raw materials before transferring the resulting mixture to a mold for curing. The cured material is then transferred to the fabrication department for downstream operations such as cutting and sanding (Tustin et al., 2022). See Section 3.10 for more information on fabrication of final products containing phthalic anhydride. From the application of phthalic anhydride as a hardener in casting operations, workers may experience inhalation exposure to dust while pouring and mixing phthalic anhyride with other raw materials, and inhalation of vapors may result during the curing process. Also, dermal exposure to the neat solid material may occur while pouring and mixing phthalic anhydride with other raw materials, and ONUs may be exposed to dust deposited on surfaces. The main difference between the incorporation of phthalic anhydride as a filler in casting operations and other incorporative activities is that casting operations have been shown to lead to much higher levels of inhalation exposure (Tustin et al., 2022). However, there were no data provided on the specific engineering controls used in the epoxy resin monitoring evaluations listed in Table 3-15.

3.4.4.2 Occupational Inhalation Exposure

Due to similarities in worker activities and sources of inhalation exposure between the "Incorporation into formulations, mixtures, or reaction products" OES (with the exception of the incorporation of phthalic anhydride as a hardener in epoxy resin mixtures for casting operations) and the "Processing as a reactant" OES, inhalation exposures are expected to be consistent for these uses. Therefore, the inhalation exposure data for the "Processing as a reactant" OES described in Section 3.3.4.2 and summarized in Table 3-10, as well as the inhalation exposure results described in Section 0 and summarized in Table 3-11, are applicable to the "Incorporation into formulations, mixtures, and reaction products" OES. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b).

There is one particular incorporative use of phthalic anhydride that results in higher exposure concentrations (*i.e.*, epoxy resin casting hardener), and there are multiple data sources specific to the incorporation of phthalic anhydride in epoxy resin mixtures for casting materials such as countertop surfaces (see Table 3-15 for references). From TSCA section 8(d) submissions, EPA identified one study that measured full-shift phthalic anhydride levels for workers in a facility that manufactures countertops using phthalic anhydride as a hardener in epoxy resin casting mixtures (Tustin et al., 2022). From EPA's systematic review process, EPA identified PBZ inhalation monitoring data from OSHA inspections for two additional facilities that use phthalic anhydride for institutional furniture manufacturing and laboratory apparatus manufacturing (OSHA, 2019). The exact worker activities of the OSHA data are not clear based on the information provided in the OSHA CEHD, but it is assumed that the data were measured by workers involved in manufacture of countertops using phthalic anhydride as a hardener in epoxy resin casting mixtures based on NAICS codes reported in the OSHA dataset. Sampling times ranged from 85 to 668 minutes, and it is assumed that the measured concentrations are representative of full-shift exposure levels for workers. However, there were no data provided on the specific protection equipment used by workers in the epoxy resin monitoring evaluations listed in Table 3-15. The measured inhalation monitoring data are shown in Table 3-15, and a summary of inhalation exposure estimates are shown in Table 3-16. For the summary of inhalation exposures from the incorporation of phthalic anhydride as a hardener in epoxy resin casting operations (Table 3-16), CT and HE estimates are based on the 50th and 95th percentiles, respectively, of the inhalation data of Tustin et al. (2022) and OSHA (2019) presented in Table 3-15. Generally, EPA expects ONUs to have lower inhalation exposures than workers who handle the chemicals directly. In absence of data specific to ONU inhalation exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs.

Table 3-15. Inhalation Exposure Data for the Incorporation of Phthalic Anhydride as an Epoxy Resin Casting Hardener

Source	Data Type	Worker Category	Task or Job Title	Number of Samples	Measured Concentration (mg/m^3) [a]	Sample Duration (min)
(OSHA, 2019)	Discrete, PBZ	Worker	Institutional furniture manufacturing	12	0.37–14.6	85–668
			Laboratory Apparatus and Furniture	4	7.2–24.9	449–473
(Tustin et al., 2022)	Discrete, PBZ	Worker	Casting department operations	6	1.7–16.5	480

[a] It is assumed that the measured concentrations may persist throughout the duration of an entire work shift.

Table 3-16. Inhalation Exposure Summary for the Incorporation of Phthalic Anhydride as an Epoxy Resin Casting Hardener

Worker Category	Full-Shift Exposure (mg/m^3) [a]	
	CT	HE
Worker	2.8	16.4
ONU [b]	2.8	

[a] EPA estimated CT and HE exposure values based on the 50th and 95th percentiles, respectively, of data presented in Table 3-15.
[b] Worker central tendency exposure was used to estimate potential inhalation exposure to ONUs.

3.4.4.3 Occupational Dermal Exposure

Due to similarities in worker activities and sources of dermal exposure between the “Incorporation into formulations, mixtures, or reaction products” OES (including the incorporation of phthalic anhydride as a hardener in epoxy resin mixtures for casting operations) and the “Processing as a reactant” OES, dermal exposures are expected to be consistent for these uses. Therefore, the dermal exposure estimates described in Section 3.3.4.3 and summarized in Table 3-12 are applicable to the “Incorporation into formulations, mixtures, and reaction products” OES. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b), and appropriate forms of dermal PPE can be found in Section 2.5.2 of this document.

3.5 Plastic Compounding

The following COUs are captured by this OES: Intermediate (plastic material and resin manufacturing; construction); Monomer (plastic material and resin manufacturing); Plasticizer (plastics product manufacturing); Paint additives and coating additives not described by other categories (plastics material and resin manufacturing); Flame retardant (plastics product manufacturing); Solvent (plastic material and resin manufacturing); Plasticizers (plastic material and resin manufacturing). See the *Draft Risk Evaluation for Phthalic Anhydride* for full list of COUs (U.S. EPA, 2026c).

3.5.1 Process Description

Phthalic anhydride is a precursor to several plasticizers and is compounded into plastic material and resin as an intermediate, monomer, plasticizer, solvent, paint additive, and flame retardant. Commercial plastic resins generally contain 1 to 10% phthalic anhydride according to available SDS, and residual quantities may be as low as 0.1% (see Appendix A for product details).

Plastic compounding using phthalic anhydride begins with transfer of the solid or liquid phthalic anhydride material through tank cars, totes, sacks, or storage vessels on site. It is important to note that phthalic anhydride in molten liquid form is generally maintained at 150 °C. The phthalic anhydride material is then introduced to other plastic additive components for blending or compounding, where phthalic anhydride may be partially or fully consumed in reaction depending on the desired product. Once blending or compounding is complete, the resulting stream is transferred to an extruder for shaping into pellets, sheets, film, or pipes. After drying the extrudate, the material is packaged or stored for subsequent plastic product converting. Phthalic anhydride is typically processed using molten liquid or flaked solid form at concentrations of 90 to 100%. Potential exposure and release points from plastic material and resin manufacturing (*i.e.*, plastic compounding) are shown in Figure 3-6, which was modified based on the GS for Use of Additives in Plastic Compounding (U.S. EPA, 2021b).

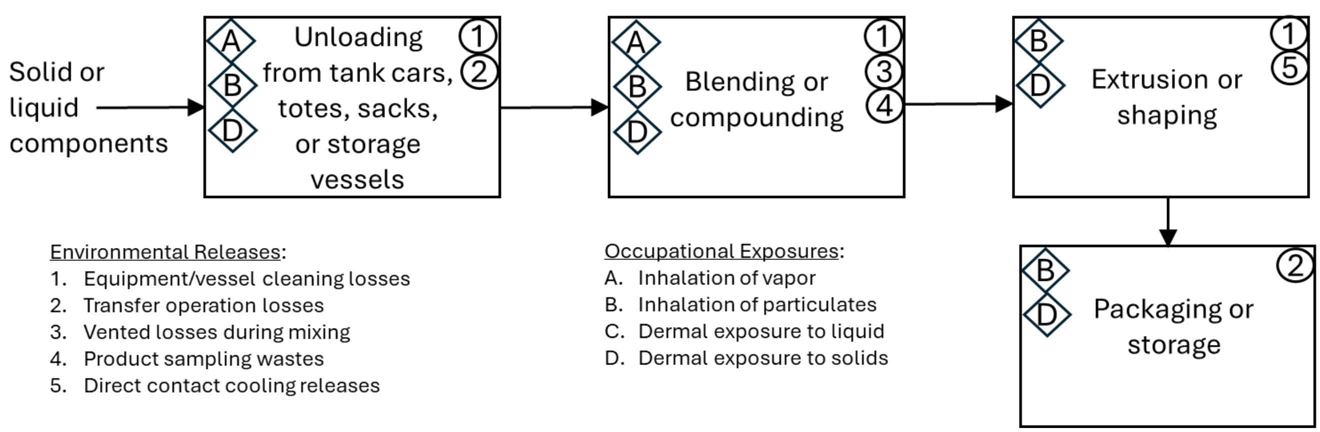

Figure 3-6. Process Flow Diagram for Plastic Compounding
Source: (U.S. EPA, 2021b)

3.5.2 Facility Estimates

EPA estimates that there are 47 to 153 facilities using phthalic anhydride for plastic compounding based on the 2020 CDR data reporting (U.S. EPA, 2020a). From these data, it is estimated that the annual production volume of phthalic anhydride used in plastic compounding ranges from 149 to 219 million lb. More detailed information on production volume used for plastic compounding can be found in Appendix B.5.

The number of operating days was determined based on the data reported to the 2017 and 2020 NEI databases (U.S. EPA, 2023a, 2019b), which may contain more detailed information about facility operation schedules. If there were no operation schedule data reported to 2017 or 2020 NEI databases for a facility, it was assumed that plastic compounding facilities may operate 246 days/year as indicated by the GS for Use of Additives in Plastic Compounding (U.S. EPA, 2021b). CDR reporters indicated that phthalic anhydride may be processed in solid form or molten liquid form, generally at a concentration of 90 to 100% (U.S. EPA, 2020a).

Table 3-17. Summary of Facility Estimates for Plastic Compounding

Total Number of Sites	Total Annual PV (lb/yr)	Operating Days (day/yr)	Concentration (%)	Physical Form
47–153	148,900,733 218,900,733	246–365	90–100	Dry powder, other solid, pellets, large crystals, or liquid
PV = production volume See Appendix B.5 for more details.				

3.5.3 Release Assessment

3.5.3.1 Environmental Release Assessment Results

Environmental releases of phthalic anhydride are reported to TRI (U.S. EPA, 2023b) and NEI (U.S. EPA, 2023a, 2019b) databases, and EPA used information from these databases to estimate environmental releases of phthalic anhydride to air, water, and land. Specifically, the reporting years 2019 to 2023 were considered for the TRI database and the reporting periods of 2017 and 2020 were considered for the NEI database. EPA preferred and reported the most recent data from the NEI database, and these data are shown in Table 3-18 below. For facilities reporting to TRI in years 2019 to 2023, the highest facility releases and the median facility releases across reporting years for air, water, and land are provided in Table 3-18. The number of release days was assumed to be equal to the number of operation days for a facility. 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). For sites reporting under TRI Form A, it was assumed that the site may be releasing up to 500 lb to air (fugitive and stack) or to water (surface water, POTW, or non-POTW) for purposes of downstream environmental exposure modeling. Facilities reporting to TRI using 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. For more detailed information regarding environmental releases, see the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).

Table 3-18. Summary of Releases from TRI (2019–2023) and NEI (2017, 2020) for Plastic Compounding

Type of Air Emission [a], Discharge [b], or Disposal [c]	Estimated Annual Release (kg/site-year) [d]		Estimated Daily Release (kg/site-day) [d]		Number of Facilities [e]	Data Source	Number of Release Days [f]
	Central Tendency	High-End	Central Tendency	High-End			
Stack air	9.7	970	3.3E−02	3.8	46	NEI	246–365
Stack air	61	1.5E03	0.25	6.0	51	TRI	
Fugitive air	6.6	621	2.7E−02	2.3	46	NEI	
Fugitive air	60	903	0.24	3.2	51	TRI	
Wastewater	0	227	0	0.92	51	TRI	
Land	0	2.4E03	0	9.6	51	TRI	

[a] Emissions via stack air and/or fugitive air.
[b] Direct discharge to surface water, indirect discharge to non-POTW, or indirect discharge to POTW. Details on wastewater release streams for each facility are presented in the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).
[c] Land releases were reported to off-site underground class 1 wells, off-site RCRA subtitle C landfills, off-site landfills, other off-site land disposal, and transfers to off-site waste brokers. See the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025) for more details.
[d] Central tendency values are calculated from the 50th percentile of median reported releases and high-end values are calculated from the 95th percentile of maximum reported releases.
[e] Number of unique facilities reporting releases.

3.5.4 Occupational Exposure Assessment

3.5.4.1 Worker Activities

During plastic compounding, workers that handle the chemical directly (*e.g.*, equipment operators, maintenance workers) are involved with various tasks including product sampling, equipment cleaning and maintenance, container cleaning, and dumping and mixing phthalic anhydride in mixing vessels. When phthalic anhydride is processed as a solid flaked material, phthalic anhydride dust can become airborne and workers may be exposed to elevated levels of inhalation exposure to airborne dust. Consequently, EPA distinguished exposures between standard worker activities and high exposure worker activities. Standard worker activities include product sampling, loading and unloading products from transport vessels, and operating and cleaning process equipment. High exposure activities include dumping and mixing bags of phthalic anhydride, as well as disposal of the empty bags. Sections 2.5.1 and 2.5.2 provide further details regarding considerations of PPE for handling phthalic anhydride.

There are some workers who do not directly handle phthalic anhydride but work in proximity to the chemical, such as supervisors, warehouse workers, and office engineers. Generally, EPA expects workers who do not handle the chemical directly to have lower inhalation and dermal exposures than workers who handle the chemicals directly.

For the worker activities within processing facilities, it is expected that workers may be exposed through inhalation of vapors and dust, as well as dermal contact with the solid flaked material. Since dust containing phthalic anhydride may be deposited on surfaces during processing activities, it is possible that workers who do not directly handle the chemical (*i.e.*, ONUs) will also experience dermal exposure through incidental contact with a contaminated surface.

3.5.4.2 Occupational Inhalation Exposure

Due to similarities in worker activities and sources of inhalation exposure between the "Plastic compounding" OES and the "Processing as a reactant" OES, inhalation exposures are expected to be consistent for these uses. Therefore, the inhalation exposure data for the "Processing as a reactant" OES described in Section 3.3.4.2 and summarized in Table 3-10, as well as the inhalation exposure results described in Section 0 and summarized in Table 3-11, are applicable to the "Plastic compounding" OES. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b).

3.5.4.3 Occupational Dermal Exposure

Due to similarities in worker activities and sources of dermal exposure between the "Plastic compounding" OES and the "Processing as a reactant" OES, dermal exposures are expected to be consistent for these uses. Therefore, the dermal exposure estimates described in Section 3.3.4.3 and summarized in Table 3-12 are applicable to the "Plastic compounding" OES. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b), and appropriate forms of dermal PPE can be found in Section 2.5.2 of this document.

3.6 Plastic Converting

The following COUs are captured by this OES: Plasticizer (plastics product manufacturing); Flame retardant (plastics product manufacturing). See the *Draft Risk Evaluation for Phthalic Anhydride* for full list of COUs (U.S. EPA, 2026c).

3.6.1 Process Description

After phthalic anhydride has been incorporated into plastic material or resin, the next step is generally conversion to a plastic product. Phthalic anhydride is utilized as an intermediate, plasticizer, and flame retardant for plastic product manufacturing (U.S. EPA, 2020a). Commercial plastic resins generally contain 1 to 10% phthalic anhydride according to available SDSs, and residual quantities may be as low as 0.1% (see Appendix A for product details). Therefore, the downstream plastic products will be converted with the same concentrations.

Plastic converting begins with the receipt of production of compounded resin, which is then transferred to forming equipment on site. The forming equipment (*e.g.*, extruder, injection molding unit, or blow molding unit) is used to mold or shape the compounded resin based on the desired end product. After the forming/shaping process, the plastic product is trimmed and finished before shipping to downstream users. The excess trimmed material is discarded as solid waste to landfills. Potential exposure and release points from plastic material and resin converting are shown in Figure 3-7, which was modified based on the GS for Additives in Plastics Processing (U.S. EPA, 2004a).

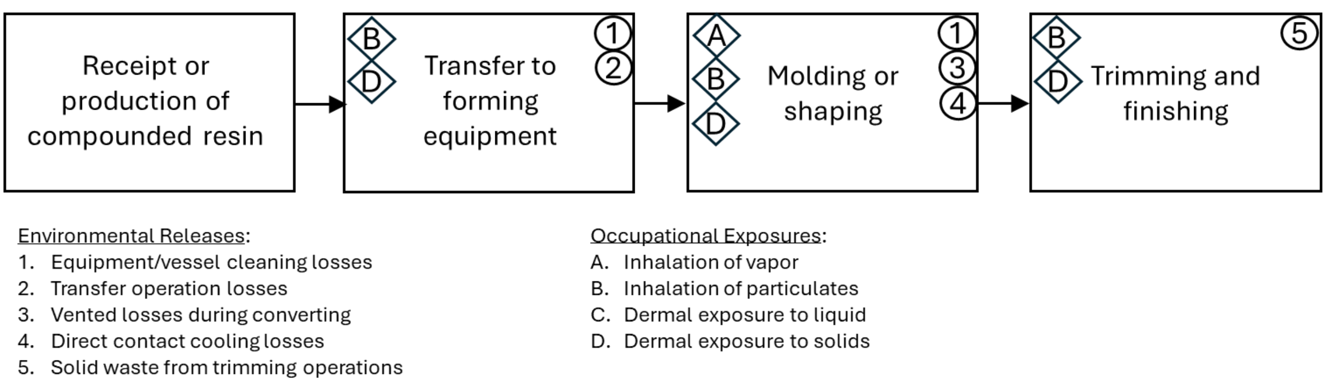

Figure 3-7. Process Flow Diagram for Plastic Converting

Source: (U.S. EPA, 2004a)

3.6.2 Facility Estimates

EPA estimates that there are 110 to 330 facilities converting plastic material with phthalic anhydride based on the 2020 CDR data reporting (U.S. EPA, 2020a). From these data, it is estimated that the annual production volume of phthalic anhydride used in plastic converting ranges from 1.49 to 2.19 million lb. More detailed information on production volume used for plastic converting can be found in Appendix B.6.

The number of operating days was determined based on the data reported to the 2017 and 2020 NEI databases (U.S. EPA, 2023a, 2019b), which may contain more detailed information about facility operation schedules. If there were no operation schedule data reported to 2017 or 2020 NEI databases for a facility, it was assumed that plastic converting facilities may operate 253 days/year as indicated by the Plastic Converting GS (U.S. EPA, 2014).

Table 3-19. Summary of Facility Estimates for Plastic Converting

Total Number of Sites	Total Annual PV (lb/yr)	Operating Days (day/yr)	Concentration (%)	Physical Form
110–330	1,489,007	130–260	0.1–10	Compounded plastic
	2,189,007			
See Appendix B.6 for more details.				

3.6.3 Release Assessment

3.6.3.1 Environmental Release Assessment Results

Environmental releases of phthalic anhydride are reported to TRI (U.S. EPA, 2023b) and NEI (U.S. EPA, 2023a, 2019b) databases; however, EPA only identified releases to air from the NEI database (2017 and 2020 reporting periods) for plastic converting facilities. However, facilities that reported plastic compounding activities to TRI and NEI, shown in Section 3.5, may also be involved with plastic converting. Therefore, it is assumed that releases to water and land from plastic converting activities are less than or equal to releases reported in Section 3.5.3.1. The number of release days was assumed to be equal to the number of operation days for each facility. The air releases reported below in Table 3-20 are for facilities that are engaged in plastic converting only, and EPA reported the most recent NEI data available for each facility.

Table 3-20. Summary of Releases from NEI (2017, 2020) for Plastic Converting

Type of Air Emission [a], Discharge [b], or Disposal [c]	Estimated Annual Release (kg/site-year) [d]		Estimated Daily Release (kg/site-day) [d]		Number of Facilities [e]	Data Source	Number of Release Days [f]
	Central Tendency	High-End	Central Tendency	High-End			
Stack air	90	794	0.36	3.1	4	NEI	
Fugitive air	0	135	0	0.52	4	NEI	130–260
Wastewater, Land	Q [g]	Q [g]	Q [g]	Q [g]	N/A	N/A	

[a] Emissions via stack air and/or fugitive air.
[b] Direct discharge to surface water, indirect discharge to non-POTW, or indirect discharge to POTW. Details on wastewater release streams for each facility are presented in the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).
[c] Land releases may be sent to various locations including on-site underground class 1 wells, on-site and off-site RCRA subtitle C landfills, off-site landfills, other off-site land disposal, and transfers to off-site waste brokers. See the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025) for more details.
[d] Central tendency values are calculated from the 50th percentile of median reported releases and high-end values are calculated from the 95th percentile of maximum reported releases.
[e] Number of unique facilities reporting releases.
[f] It was assumed that the number of operating days is representative of the number of release days for each facility. Where data were available, EPA used facility-specific operating schedules to estimate number of annual release days. If facility-specific operating schedules were not available, EPA used peer-reviewed literature (*e.g.,* GSs or ESDs) to estimate the number of annual release days.
[g] Qualitative assessment – Facilities that reported plastic compounding activities to TRI and NEI may also be involved with plastic converting. Therefore, it is assumed that releases to water and land from plastic converting activities are less than or equal to releases from plastic compounding facilities.

3.6.4 Occupational Exposure Assessment

3.6.4.1 Worker Activities

Plastic converting begins with the transfer of compounded resin to forming equipment. The compounded material is subsequently molded or shaped and then trimmed to create a final product. The most prominent route of worker exposure from plastic converting is inhalation of vapor and dust during the conversion process. Although worker exposures to phthalic anhydride may occur at low levels from dermal contact with dusts generated during the transfer and trimming operations, the extent of potential phthalic anhydride exposure to dust during plastic converting is limited due to the physical properties of the solid compounded material and the low levels of phthalic anhydride in the solid compounded material. When phthalic anhydride is processed into plastic or resin material through the plastic compounding process, the chemical generally functions as a monomer and is largely consumed in reaction to form other plasticizers. The remaining phthalic anhydride entrained in plastic material and resin may range from 0.1 to 10%, but generally EPA assumed that 1% may exist in the final plastic material. Sections 2.5.1 and 2.5.2 provide further details regarding considerations of PPE for handling phthalic anhydride.

3.6.4.2 Occupational Inhalation Exposure Data

EPA identified two sources that quantified the inhalation exposure of phthalic anhydride during plastic converting, and the *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994) was used to select the most representative data. Based on these guidelines, EPA preferred discrete, personal breathing zone measurements that received high ratings through the EPA systematic review process. However, the available sources only provided summary statistics of area monitoring data, and EPA used the summarized area monitoring data from plastic converting activities to estimate potential worker exposures since it was the best available data. Consequently, the following two studies were selected to estimate inhalation exposure to workers during plastic converting: Pfaffli (1986) and Vainiotalo (1990). These data were used to estimate full-shift exposure values of occupational exposure for workers as shown in Table 3-21. Generally, EPA expects ONUs to have lower inhalation exposures than workers who handle the chemicals directly. In absence of data specific to ONU inhalation exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs.

Pfaffli (1986) measured ambient levels of phthalic anhydride from vapor and dust during calendaring (8 samples) and extrusion (6 samples) of PVC plastic material, and the monitoring data were subsequently summarized. However, Pfaffli (1986) did not report discrete PBZ measurements. The stationary sampling equipment was installed facing downwards on stages at a height of 1.5 m for sampling of ambient air at the work site over a 60-minute time duration. The processes of calendaring and extrusion were described as “continuous” by Pfaffli (1986). Although workers may move around in the workspace during their shifts, it is assumed that the measured phthalic anhydride concentrations near the calendaring and extrusion equipment are representative of full-shift worker exposures.

Vainiotalo et al. (1990) measured ambient levels of phthalic anhydride from vapor and dust during calendaring (8 samples), extrusion (16 samples), injection molding (2 samples, both nondetectable), and thermoforming (2 samples), and the monitoring data were subsequently summarized. However, Vainiotalo et al. (1990) did not report discrete data measurements. Static samples were taken at a distance of 0.5 m from the processing machines and 1.5 m from the floor, and samples were collected over a duration of 1.5 to 3 hours. Vainiotalo et al. (1990) indicates that the sample locations are representative of worker breathing zones and sample durations are reflective of 8-hour exposure levels.

The two data measurements for injection molding were both below the LOD as indicated by the mean value reported (*i.e.*, less than 2.0×10^{-5} mg/m^3), and Vainiotalo et al. (1990) did not provide discrete data measurements in the study. Therefore, it was not possible to calculate the geometric standard deviation (GSD) of the dataset. For estimation of exposure measurements below the LOD, EPA follows the *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994) which suggests the replacement of nondetectable values by the LOD divided by square root of two (for GSD < 3.0) or the LOD divided by two (GSD > 3.0). Because it was not possible to determine the geometric standard deviation of the dataset, EPA chose the more conservative option and replaced the nondetectable value by the LOD divided by square root of two.

Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b).

Table 3-21. Inhalation Exposure Data for Plastic Converting

Source	Data Type	Worker Category	Task or Job Title	Number of Samples	Mean Concentration (mg/m^3) [a]	Sample Duration (min)
(Pfaffli, 1986)	Summary, Area	Worker	PVC calendaring	8	3.0E−04	60
			PVC extrusion	6	3.0E−04	60
(Vainiotalo and Pfaffli, 1990)	Summary, Area	Worker	PVC extrusion	16	3.0E−04	180
			PVC calendaring	8	2.0E−04	180
			Injection molding	2	Non-detect [b]	180
			Thermoforming	2	1.0E−04	180

[a] It is assumed that the measured concentrations may persist throughout the duration of an entire work shift.
[b] LOD reported as 2.0E−05 mg/m^3.

3.6.4.3 Occupational Inhalation Exposure Results

The inhalation data for plastic converting are derived from area monitoring data near the processing machines; therefore, the exposure results are relevant for all workers that may be near the processing machines. Table 3-22 provides a summary of inhalation exposure results for workers involved with plastic converting activities. The results are based on inhalation exposure summary data presented in Table 3-21. Because the data points available are mean values from various monitoring samples, EPA calculated the weighted mean across samples to represent the CT and used the maximum value reported as the HE. In absence of data specific to ONU inhalation exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs.

Table 3-22. Inhalation Exposure Summary for Plastic Converting

Worker Category	Full-Shift Exposure (mg/m^3) [a]	
	CT	HE
Worker	2.6E−04	3.0E−04
ONU [b]	2.6E−04	

[a] From data presented in Table 3-21, EPA calculated the weighted mean across samples to represent the central tendency and used the maximum value reported as the high-end.
[b] Worker central tendency exposure was used to estimate potential inhalation exposure to ONUs.

3.6.4.4 Occupational Dermal Exposure Results

When phthalic anhydride is processed into plastic or resin material through the plastic compounding process, the chemical generally functions as a monomer and is largely consumed in reaction to form other plasticizers. Although worker exposures to phthalic anhydride may occur at low levels from dermal contact with dusts generated during the transfer and trimming operations, the extent of potential phthalic anhydride exposure to dust during plastic converting is limited due to the physical properties of the solid compounded material and the low levels of phthalic anhydride in the solid compounded material. Therefore, dermal exposures to phthalic anhydride are expected to be negligible from the plastic converting process. The majority of significant dermal exposures occur during upstream plastic compounding and such exposures are characterized in Section 3.5.4.3.

3.7 Application of Paints, Coatings, Adhesives, and Sealants

The following COUs are captured by *non-spray* application of paints, coatings, adhesives, and sealants exposure estimates: Adhesives and sealants; Paints and coatings; Machinery, mechanical appliances, electrical/electronic articles; Oil treatment of wood; Transportation equipment manufacturing.

The following COUs are captured by the *spray* application of paints and coatings exposure estimates: Paints and coatings; Oil treatment of wood; Transportation equipment manufacturing.

Release estimates for the "Application of paints, coatings, adhesives, and sealants" OES cover all COUs listed above for spray and non-spray applications.

See the *Draft Risk Evaluation for Phthalic Anhydride* for a full list of COUs (U.S. EPA, 2026c).

3.7.1 Process Description

Phthalic anhydride is a plasticizer in paint, coating, adhesive, and sealant products for industrial and commercial use, including dyes and pigment products. For purposes of exposure characterization, EPA has categorized paint, coating, adhesive, and sealant products into two distinct categories: *non-spray application* (*e.g.*, brush, syringe, trowel) and *spray application* (*e.g.*, conventional, airless, and aerosol spray).

Non-Spray Application

Some paint, coating, adhesive, and sealant products containing phthalic anhydride are not intended for spray application. Rather, several of these products are intended for manual application with a brush, roller, trowel, or caulk gun. The liquid or paste product is received on site, transferred to the applicating equipment, and applied to the substrate. 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 material from the applied substrate area (OECD, 2015, 2009b). Non-spray paint, coating, adhesive, and sealant products vary with respect to phthalic anhydride content, with concentrations generally between 0.1 to 25% with a typical concentration of 10% according to product SDSs (see Appendix A for product details).

Spray Application

EPA did not identify any adhesive or sealant products intended for spray application. However, there are known paint and coating products containing phthalic anhydride that are intended for conventional or airless spray application (*e.g.*, Interlac 665). See Appendix A for product details. Before application, the product is mixed thoroughly with power agitation. Thinning may be necessary depending on the spray application equipment specifications. After mixing, the product is transferred to the application equipment and then applied to the substrate. 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 material from the applied substrate area (OECD, 2011, 2009b; U.S. EPA, 2004b).

EPA also identified multiple aerosol spray paint products containing phthalic anhydride (*e.g.*, Harris Metal Primer, Harris T.OV. Varnish). The aerosol spray paint products containing phthalic anhydride are typically sold in an 11-ounce can for use on smaller surface areas. 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. However, it is expected that workers may use up to two cans per day for a total application time of one hour. Sprayable paint and coating products vary with respect to phthalic anhydride content, with concentrations generally between 0.1 to 25% with a typical concentration of 10% according to product SDSs (see Appendix A for product details).

Furthermore, EPA identified several epoxy resin products containing phthalic anhydride (*e.g.*, AC-59, EASYLAM LSE, and Norsodyne H 23100 TA) that may be applied using spray layup methods. Epoxy resins are typically used to create reinforced plastics and surfaces. Spray layup is an application technique that uses mechanical spraying equipment (*e.g.*, conventional spray gun) for depositing resin on layers of reinforcement. Spray layup is generally used for more complex molds and products with greater production rates (U.S. EPA, 2007). Epoxy resin products vary with respect to phthalic anhydride content, with concentrations generally between 1 to 10% according to product SDS (see Appendix A for product details).

Potential exposure and release points from the application of paints, coatings, adhesives, and sealants are shown in Figure 3-8, which was modified based on the ESD on Use of Adhesives (OECD, 2015).

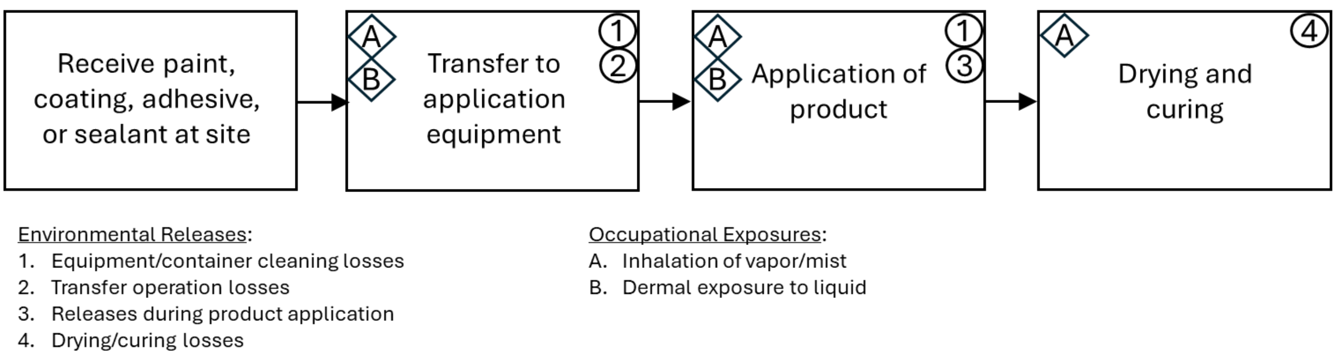

Figure 3-8. Process Flow Diagram for the Application of Paints, Coatings, Adhesives, and Sealants
Source: (OECD, 2015)

3.7.2 Facility Estimates

EPA estimates that there are 108 to 1,128 facilities using paint, coating, adhesive, and sealant materials containing phthalic anhydride based on the 2020 CDR data reporting (U.S. EPA, 2020a) and typical facility throughput described in the ESD on Use of Adhesives and the GS for Spray Coatings in the Furniture Industry (OECD, 2015; U.S. EPA, 2004b). From the CDR data, it is estimated that the annual production volume of phthalic anhydride applied through paint, coating, adhesive, and sealant materials is 3.4 million lb. More detailed information on production volume used for plastic converting can be found in Appendix B.7.

For facilities reporting air releases to the 2017 and 2020 NEI databases (U.S. EPA, 2023a, 2019b), the number of operating days was determined based on the operation schedule data reported. If there were no operation schedule data reported to 2017 or 2020 NEI databases, it is assumed that facilities may operate 5 days/week and 50 weeks/year with 2 weeks of downtime (*i.e.*, 250 operating days/year).

Table 3-23. Summary of Facility Estimates for Application of Paints, Coatings, Adhesives, and Sealants

Total Number of Sites	Total Annual PV (lb/yr)	Operating Days (day/yr)	Concentration (%)	Physical Form
108–1,128	3,355,919	24–365	0.1–25	Liquid or paste
See Appendix B.7 for more details.				

3.7.3 Release Assessment

3.7.3.1 Environmental Release Assessment Results

Environmental releases of phthalic anhydride are reported to TRI (U.S. EPA, 2023b) and NEI (U.S. EPA, 2023a, 2019b) databases, and EPA used information from these databases to estimate environmental releases of phthalic anhydride to air, water, and land. Specifically, the reporting years 2019 to 2023 were considered for the TRI database and the reporting periods of 2017 and 2020 were considered for the NEI database. EPA preferred and reported the most recent data from the NEI database, and these data are shown in Table 3-24 below. For facilities reporting to TRI in years 2019 to 2023, the highest facility releases and the median facility releases across reporting years for air and land are provided in Table 3-24. The number of release days was assumed to be equal to the number of operation days for a facility. There were no releases to water (surface water, POTW, or non-POTW) from facilities engaged in application of paints, coatings, adhesives, and sealants containing phthalic anhydride as reported to TRI in years 2019 to 2023, and all facilities reported via TRI Form R. Facilities reporting to TRI using 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. Therefore, it is assumed that releases of phthalic anhydride to water from the application of paints, coatings, adhesives, and sealants do not significantly contribute to environmental levels of phthalic anhydride. Furthermore, it is important to note that paints, coatings, adhesives, and sealants may be applied through spray application methods (*e.g.*, conventional spray gun) or through non-spray application methods (*e.g.*, brush). However, TRI and NEI databases do not provide the level of detail needed to determine the application method from each facility. Therefore, release estimates for paints, coatings, adhesives, and sealants are expected to be representative of the various application methods for products containing phthalic anhydride. For more detailed information regarding environmental releases, see the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).

Table 3-24. Summary of Releases from TRI (2019–2023) and NEI (2017, 2020) for Application of Paints, Coatings, Adhesives, and Sealants

Type of Air Emission [a], Discharge [b], or Disposal [c]	Estimated Annual Release (kg/site-year) [d]		Estimated Daily Release (kg/site-day) [d]		Number of Facilities [e]	Data Source	Number of Release Days [f]
	Central Tendency	High-End	Central Tendency	High-End			
Stack air	0	176	0	0.83	32	NEI	24–365
Stack air	73	336	0.29	1.3	7	TRI	
Fugitive air	0	88	0	0.32	32	NEI	
Fugitive air	267	1.1E03	1.1	4.4	7	TRI	
Wastewater	0	0	0	0	7	TRI	
Land	0	3.0E03	0	12	7	TRI	

[a] Emissions via stack air and/or fugitive air.
[b] Direct discharge to surface water, indirect discharge to non-POTW, or indirect discharge to POTW. Details on wastewater release streams for each facility are presented in the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).
[c] Land releases were reported to offsite RCRA subtitle C landfills or other offsite landfills. See the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025) for more details.
[d] Central tendency values are calculated from the 50th percentile of median reported releases and high-end values are calculated from the 95th percentile of maximum reported releases.
[e] Number of unique facilities reporting releases.

3.7.4 Occupational Exposure Assessment

3.7.4.1 Worker Activities

Industrial and commercial use of paint, coating, adhesive, and sealant products containing phthalic anhydride may involve a variety of worker tasks including product unloading, container and equipment cleaning, product application, mixing, and curing or drying.

For application of non-spray materials, workers may apply the product manually with a brush, trowel, or roller (OECD, 2015, 2009b). Since phthalic anhydride has low volatility and there are no mists generated during the non-spray applications, it is expected that there may be low levels of vapor exposure near the application area. Workers involved in non-spray applications may experience dermal contact one or more times throughout a work shift. However, since there are no mists deposited on surfaces from non-spray applications, dermal exposure to ONUs is not considered as an exposure route of concern for this population and OES.

For application of sprayable materials, workers may apply the product using conventional, airless, or aerosol spray equipment (OECD, 2011, 2009b; U.S. EPA, 2004b). Spray applications may lead to more significant levels of inhalation exposure, as well as dermal exposure, to workers within the designated application area. Industrial and commercial spray applications are typically conducted in ventilated or enclosed areas (*e.g.*, spray booths), as specified in the *Paint Stripping and Surface Coating NESHAP* [73 FR 1738; January 9, 2008], and ONUs are not expected to experience exposures outside of the controlled application areas. Therefore, inhalation and dermal exposures to ONUs are not exposure routes of concern for this population and OES. Sections 2.5.1 and 2.5.2 provide further details regarding considerations of PPE for handling phthalic anhydride.

3.7.4.2 Occupational Inhalation Exposure Data and Modeling

For purposes of exposure characterization, as mentioned in Section 3.7.1, EPA has categorized paint, coating, adhesive, and sealant products into the following subcategories: *non-spray application* and *spray application*. The inhalation exposure data for each type of application is explained in the paragraphs below. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b).

Non-Spray Application

EPA identified only one study that quantified the inhalation exposure of phthalic anhydride during the non-spray application of phthalic anhydride-containing products; however, the available source only provided summary statistics of area monitoring data. Area monitoring data were collected near the breathing zone of workers, so data are most applicable to workers. Consequently, the study by Pfaffli (1994) was selected to estimate inhalation exposure to workers during non-spray application of paints, coatings, adhesives, and sealants3.7.4.1 as shown in Table 3-25. Generally, EPA expects ONUs to have lower inhalation exposures than workers who handle the chemicals directly. In absence of data specific to ONU inhalation exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs.

Pfaffli (1994) measured phthalic anhydride concentrations in air collected in a powder painting shop during a painting process employing a convection oven. Metal objects were coated with a 50:50 epoxy polyester paint mixture and the process was operated continuously for the whole working day. The facility was equipped with a ventilation system; however, the painting machine did not have local ventilation. Air samples were obtained by stationary sampling units mounted at the height of the workers' breathing zone at various points in the vicinity of the painting machine.

Table 3-25. Inhalation Exposure Data for Non-Spray Application of Paints, Coatings, Adhesives, and Sealants

Source	Data Type	Worker Category	Task or Job Title	Number of Samples	Concentration Range (mg/m^3) [a]	Sample Duration (min)
(Pfaffli, 1994)	Summary, Area	Worker	Coating metal with paint machine	20	1.1E−03 to 2.2E−03	120

[a] It is assumed that the measured concentrations may persist throughout the duration of an entire work shift.

Spray Application

All adhesive and sealant products identified are intended for non-spray application, so the assessment of inhalation exposure from sprayable products is specific to paints and coatings only. EPA did not identify chemical-specific inhalation monitoring data for the use of paints and coatings during systematic review of literature sources. However, EPA estimated inhalation exposures for sprayable paint, coating, and epoxy resin products (conventional, airless, and aerosol spray) using surrogate inhalation monitoring data from the ESD on Coating Application via Spray-Painting in the Automotive Refinishing Industry (OECD, 2011).

The ESD on Coating Application via Spray-Painting in the Automotive Refinishing Industry provides PBZ coating mist concentrations for a variety of booth types (*i.e.*, crossdraft, downdraft, and semi-downdraft) and equipment types (*i.e.*, conventional and high-volume low-pressure spray guns). The 50th and 95th percentile spray mist concentrations across all measurements were 3.38 and 22.1 mg/m^3, respectively. The ESD on Coating Application via Spray-Painting in the Automotive Refinishing Industry also states that a portion of the sprayed product will volatilize and will not be present in the mist. Therefore, it is necessary to estimate the mass fraction of phthalic anhydride in the mist based on the concentration of nonvolatile components. The portion of nonvolatile solids in a spray paint or coating product can range from 0.15 to 0.50 mg chemical/mg coating product (OECD, 2011). EPA used the ESD recommended value of 0.25 mg/mg and the upper bound of the underlying distribution of 0.50 mg/mg for the central tendency and high-end parameters, respectively. Paint, coating, and epoxy resin products vary with respect to phthalic anhydride content, with concentrations generally between 1 to 25% with a typical concentration of 10% according to product SDS (see Appendix A for product details). Table 3-26 shows the parameters used to estimate inhalation exposure from spray applications of paint, coating, and epoxy resin products containing phthalic anhydride, as well as central tendency and high-end estimates of inhalation exposure levels to workers within the spray application area. As described in Section 3.7.4.1, ONUs that are outside of the controlled spray application area (*e.g.*, spray booths) are not expected to experience significant levels of inhalation exposure.

Table 3-26. Input Parameters and Estimated Inhalation Exposure Levels to Workers for Application of Sprayable Paints, Coatings, and Epoxy Resin Products

Parameter	Symbol	Unit	Parameter Value		Rationale/Basis
			Central Tendency	High-End	
Concentration of Mist (Nonvolatile)	C_{mist}	mg nonvolatile / m^3	3.38	22.1	50th and 95th percentile of spray mist data (OECD, 2011)
Phthalic Anhydride Concentration in Product	F_{PAD_prod}	mg phthalic anhydride / mg product	0.1	0.25	Typical and high-end concentrations provided by product SDS. See Appendix A for product details.
Concentration of Nonvolatile Components in the Spray Product	F_{NV_prod}	mg nonvolatile / mg product	0.25	0.5	Range of 0.15–0.50 with typical value of 0.25 (OECD, 2011)
Phthalic Anhydride Concentration of Nonvolatile Components	F_{PAD_NV}	mg phthalic anhydride / mg nonvolatile	0.4	0.5	$F_{PAD\_NV} = F_{PAD\_prod} / F_{NV\_prod}$
Full-shift Exposure Levels of Phthalic Anhydride	C_{PAD}	mg phthalic anhydride / m^3	1.35	11.1	$C_{PAD} = C_{mist} \times F_{PAD\_NV}$

3.7.4.3 Occupational Inhalation Exposure Results

Table 3-27 provides a summary of inhalation exposure results for various application types associated with paints, coatings, adhesives, and sealants. The results below are based on expected full-shift exposure values for workers and ONUs involved in non-spray application of paints, coatings, adhesives, and sealants as presented in Table 3-25 and for workers involved in spray application of paints, coatings, adhesives, and sealants Table 3-26. Exposures estimates for non-spray paint, coating, adhesive, and sealant products are based on the range of measured concentrations presented by Pfaffli (1994). Specifically, the midpoint of the range was used as the CT exposure level for non-spray paint, coating, adhesive, and sealant products, and the maximum reported value was assigned as the HE exposure level. For sprayable paint, coating, and epoxy resin products EPA used surrogate inhalation monitoring data from the ESD on Coating Application via Spray-Painting in the Automotive Refinishing Industry (OECD, 2011), and the 50th and 95th percentile values of mist levels were used to estimate CT and HE exposure levels, respectively.

Table 3-27. Inhalation Exposure Summary for Application of Paints, Coatings, Adhesives, and Sealants

Product Type	Worker Category	Full-shift Exposure (mg/m^3) [a]	
		CT	HE
Non-spray paint, coating, adhesive, or sealant	Worker	1.7E−03	2.2E−03
	ONU [b]	1.7E−03	
Sprayable paint, coating, or epoxy resin	Worker [c]	1.4	11.1

[a] For non-spray paint, coating, adhesive, and sealant products, EPA estimated CT and HE exposures from the midpoint and maximum values, respectively, from the data presented in Table 3-25. For sprayable paint, coating, and epoxy resin products, EPA estimated CT and HE exposures based on the 50th and 95th percentile values, respectively, of mist levels presented in Table 3-26.
[b] For non-spray paints, coatings, adhesives, and sealants, worker central tendency exposure was used to estimate potential inhalation exposure to ONUs.
[c] For spray application of paints, coatings, and epoxy resins, ONUs that are outside of the controlled spray application area are not expected to experience significant levels of inhalation exposure.

3.7.4.4 Occupational Dermal Exposure Results

Paints, coatings, adhesives, and sealants containing phthalic anhydride vary with respect to method of application and phthalic anhydride content as described above in Section 3.7.1. For non-spray products, the materials may be applied with a brush, trowel, or syringe. For sprayable products, the material may be applied with conventional spray guns, airless spray guns, or aerosol cans. Concentrations range from 10 to 25% for both non-spray and sprayable products, but each type of product and application may lead to different levels of occupational dermal exposure. Workers that handle application equipment directly are most vulnerable to dermal exposures. Application of non-spray products are not expected to generate mists that deposit on surfaces, and the application of sprayable products are typically conducted within enclosed areas with ventilated controls, as specified in the *Paint Stripping and Surface Coating NESHAP* [73 FR 1738; January 9, 2008]. Therefore, dermal exposure to ONUs is not considered as an exposure route of concern for this population and OES.

For occupational dermal exposure to liquid paints, coatings, adhesives, and sealant products from spray and non-spray application methods, EPA utilized dermal loading data from common worker exposures scenarios including rag handling and full hand immersion (U.S. EPA, 1992b). As described in the ChemSTEER Manual (U.S. EPA, 2015), data from rag handling experiments of U.S. EPA (1992b) are considered relevant for typical occupational tasks such as product sampling, loading/unloading, and cleaning, whereas data from full immersion experiments of U.S. EPA (1992b) are considered relevant for spray coating scenarios. Therefore, EPA utilized the raw data from rag handling scenarios to determine 50th and 95th percentile dermal loading values of 1.4 mg/cm^2 and 2.1 mg/cm^2, respectively, and these data were applied to non-spray application uses. Also, EPA utilized the raw data from full immersion scenarios to determine 50th and 95th percentile dermal loading values of 3.8 mg/cm^2 and 10.3 mg/cm^2, respectively, and these data were applied to spray application uses. Spray coating scenarios may lead to significant dermal exposure similar to the immersion scenarios investigated in U.S. EPA (1992b), as empirically supported by Marquart et al. (2006). Marquart et al. (2006) reported a dermal loading range of 4.15 mg/cm^2 (typical) to 16.6 mg/cm^2 (worst case) based on 25 data points for spraying marine anti-fouling paint, which is similar to spray products within this assessment. Therefore, dermal loading values from liquid immersion measurements are used to estimate dermal loading for tasks such as spray coating.

Table 3-28 provides estimates of occupational dermal exposure to phthalic anhydride from paint, coatings, adhesive, and sealant products. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b), and appropriate forms of dermal PPE can be found in Section 2.5.2 of this document.

Table 3-28. Dermal Exposure Summary for Application of Paints, Coatings, Adhesives, and Sealants

Worker Category	Product Type	Dermal Loading (mg product/cm^2)		Phthalic Anhydride Concentration (%)		Dermal Exposure (mg Phthalic Anhydride/cm^2)	
		CT	HE	CT	HE	CT	HE
Worker [a]	Non-spray paint, coating, adhesive, or sealant	1.4	2.1	10	25	0.14	0.53
Worker [a]	Sprayable paint, coating, or epoxy resin	3.8	10.3	10	25	0.38	2.6

[a] Dermal exposure to ONUs is not considered as an exposure route of concern for this population and OES.

3.8 Laboratory Chemicals

The following COU is captured by this OES: Laboratory chemicals. See the *Draft Risk Evaluation for Phthalic Anhydride* for full list of COUs (U.S. EPA, 2026c).

3.8.1 Process Description

Phthalic anhydride is a laboratory chemical used at commercial and industrial laboratory sites (ThermoFisher Scientific, 2022). EPA identified relevant SDS that indicate laboratory chemicals containing phthalic anhydride at a concentration of 0.1 to 0.2% for liquid products and concentrations from 90 to 100% for solid products. Based on the GS for Laboratory Chemicals (U.S. EPA, 2023c), EPA expects laboratory chemicals containing phthalic anhydride to arrive at end use sites in 1-gallon bottles for liquid chemicals or in 1 kg containers for solids (U.S. EPA, 2023c). At the end use sites, the lab chemical is transferred to labware and lab equipment for analyses. After analysis, laboratory sites clean containers, labware, and lab equipment and dispose of laboratory waste and unreacted phthalic anhydride-containing laboratory chemicals. Figure 3-9 provides an illustration of the use of laboratory chemicals (U.S. EPA, 2023c).

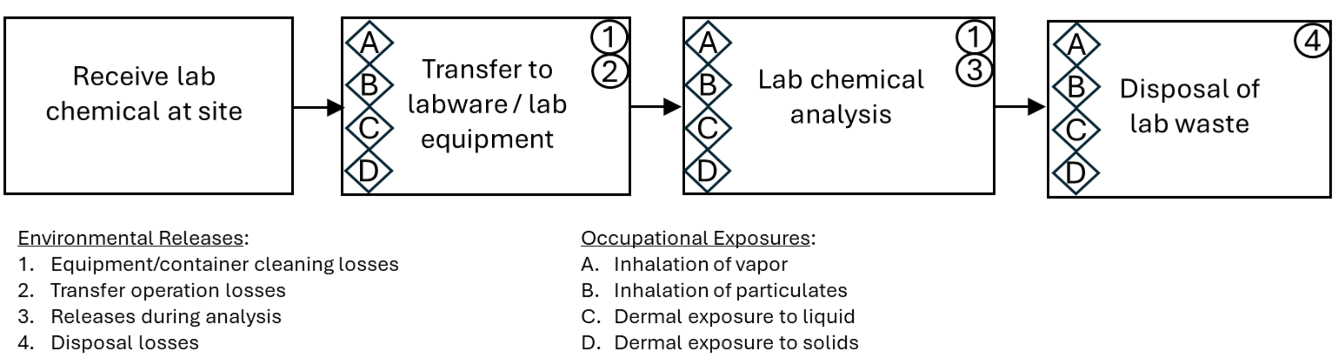

Figure 3-9. Process Flow Diagram for the Use of Laboratory Chemicals
Source: (U.S. EPA, 2023c)

3.8.2 Facility Estimates

EPA estimates that there are 2,020 to 2,260 facilities using phthalic anhydride for laboratory uses based on the 2020 CDR data reporting (U.S. EPA, 2020a) and typical facility throughput described in the GS for the Use of Laboratory Chemicals (U.S. EPA, 2023c). From the CDR data, it is estimated that the annual production volume of phthalic anhydride for laboratory use is 150,000 lb. More detailed information on production volume used for laboratory chemicals can be found in Appendix B.8.

The number of operating days was determined based on the data reported to the 2017 and 2020 NEI databases (U.S. EPA, 2023a, 2019b), which may contain more detailed information about facility operation schedules. If there were no operation schedule data reported to 2017 or 2020 NEI databases for a facility, it was assumed that the number of release days for a laboratory was 260 days/year as indicated by the GS for the Use of Laboratory Chemicals (U.S. EPA, 2023c). SDSs for laboratory chemicals show that phthalic anhydride may exist in low levels for liquid products (*i.e.*, 0.1–0.2%) and higher levels for solid products (*i.e.*, 90–100%). See Appendix A for product details.

Table 3-29. Summary of Facility Estimates for Laboratory Chemicals

Total Number of Sites	Total Annual PV (lb/yr)	Operating Days (day/yr)	Concentration (%)	Physical Form
2,020–2,260	150,000	260–365	90–100 (solid) 0.1–0.2 (liquid)	Solid or liquid formulation
See Appendix B.8 for more details.				

3.8.3 Release Assessment

3.8.3.1 Environmental Release Assessment Results

Environmental releases of phthalic anhydride are reported to TRI (U.S. EPA, 2023b) and NEI (U.S. EPA, 2023a, 2019b) databases. For laboratory facilities using phthalic anhydride, EPA only identified releases to air from the NEI database (2017 and 2020 reporting periods). However, the use of laboratory chemicals is associated with a low production volume (*i.e.*, <0.1% of total annual PV of phthalic anhydride). Therefore, it is expected that releases to water and land from laboratory uses will be less than manufacturing and processing uses and will not significantly contribute to environmental concentrations of phthalic anhydride. The air releases reported below in Table 3-30 are for facilities that are engaged in laboratory activities, and EPA reported the most recent NEI data available for each facility. The number of release days was assumed to be equal to the number of operation days for a facility. For more detailed information regarding environmental releases, see the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).

Table 3-30. Summary of Releases from NEI (2017, 2020) for Laboratory Chemicals

Type of Air Emission [a], Discharge [b], or Disposal [c]	Estimated Annual Release (kg/site-year) [d]		Estimated Daily Release (kg/site-day) [d]		Number of Facilities [e]	Data Source	Number of Release Days [f]
	Central Tendency	High-End	Central Tendency	High-End			
Stack air	0	0.50	0	1.9E−03	5	NEI	260–365
Fugitive air	9.1E−03	0.20	3.5E−05	5.7E−04	5	NEI	
Wastewater, Land	Q [g]	Q [g]	Q [g]	Q [g]	N/A	N/A	

[a] Emissions via stack air and/or fugitive air.
[b] Direct discharge to surface water, indirect discharge to non-POTW, or indirect discharge to POTW. Details on wastewater release streams for each facility are presented in the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).
[c] Land releases may be sent to various locations including on-site underground class 1 wells, on-site and off-site RCRA subtitle C landfills, off-site landfills, other off-site land disposal, and transfers to off-site waste brokers. See the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025) for more details.
[d] Central tendency values are calculated from the 50th percentile of median reported releases and high-end values are calculated from the 95th percentile of maximum reported releases.
[e] Number of unique facilities reporting releases.
[f] It was assumed that the number of operating days is representative of the number of release days for each facility. Where data were available, EPA used facility-specific operating schedules to estimate number of annual release days. If facility-specific operating schedules were not available, EPA used peer-reviewed literature (*e.g.,* GSs or ESDs) to estimate the number of annual release days.
[g] Qualitative assessment – The uses of laboratory chemicals and lubricants/functional fluids are associated with low production volumes (*i.e.*, less than 0.1% of total annual PV of phthalic anhydride). Therefore, it is expected that releases to air, water, and land from these uses are less than manufacturing and processing uses and will not significantly contribute to environmental concentrations of phthalic anhydride.

3.8.4 Occupational Exposure Assessment

3.8.4.1 Worker Activities

Worker exposures to phthalic anhydride may occur through the inhalation of dust or vapor while unloading and transferring laboratory chemicals and during laboratory analysis. Worker dermal exposures may occur during laboratory chemical unloading, container cleaning, labware and labware equipment cleaning, chemical use during laboratory analysis, and disposal of laboratory wastes (U.S. EPA, 2023c), and ONU dermal exposures may occur from incidental contact with phthalic anhydride powder deposited on laboratory surfaces. However, laboratory operations are typically conducted in ventilated areas (*e.g.*, ventilation hoods), and workers and ONUs are not expected to experience exposures outside of the controlled laboratory area. Furthermore, since laboratory facilities generally have strict PPE guidelines, all personnel in laboratory facilities are expected to wear appropriate PPE for handling chemicals such as gloves, goggles, and aprons, and engineering controls such as ventilated hoods are typically used while handling chemicals. Sections 2.5.1 and 2.5.2 provide further details regarding considerations of PPE for handling phthalic anhydride.

3.8.4.2 Occupational Inhalation Exposure Data

EPA identified two sources of data that quantified the inhalation exposure of phthalic anhydride during laboratory activities, and the *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994) was used to select the most representative data. Based on these guidelines, EPA preferred discrete, personal breathing zone measurements that received high ratings through the EPA systematic review process. Consequently, discrete PBZ data from the following studies were selected to estimate inhalation exposure to workers during the use of laboratory chemicals: Liss (1983) and van Tongeren (1995). These data were used to estimate full-shift exposure levels for laboratory workers as shown in Table 3-31. Generally, EPA expects ONUs to have lower inhalation exposures than workers who handle the chemicals directly. In absence of data specific to ONU inhalation exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs.

Liss (1983) was conducted by NIOSH as a Human Health Evaluation (HHE), and the study examined worker inhalation exposures in laboratory facilities where workers were handling phthalic anhydride. Another study conducted by van Tongeren (1995) also measured inhalation exposures to laboratory workers handling phthalic anhydride. Both studies provide discrete, personal breathing zone measurements for a variety of worker categories including laboratory technicians. Although the sample measurements are less than 8 hours in these studies, it is expected that the measured inhalation exposure values are representative of full-shift exposures. There were four PBZ samples evaluated for laboratory workers, and all measurements were above the LOD.

The study by van Tongeren (1995) also reported summary statistics for inhalation exposures to laboratory workers in other laboratory facilities using phthalic anhydride. Results showed an arithmetic mean of 1.5×10^{-2} mg/m^3 from three samples for laboratory workers conducting research and development, an arithmetic mean of 2.5×10^{-3} mg/m^3 from four samples for laboratory workers conducting quality control, an arithmetic mean of 5.0×10^{-4} mg/m^3 from two samples, and an arithmetic mean of 1.8×10^{-3} mg/m^3 from ten samples. These additional summary statistics reported by van Tongeren (1995) are in agreement with the four discrete samples used in evaluation of inhalation exposure to laboratory workers, as shown in Table 3-31 below.

Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b).

Table 3-31. Inhalation Exposure Data for Laboratory Chemicals

Source	Data Type	Worker Category	Task or Job Title	Number of Samples	Measured Concentration (mg/m^3) [a]	Sample Duration (min)
(Liss and Hartel, 1983)	Discrete, PBZ	Worker	Laboratory technician	2	1.1E−02 to 1.9E−02	281–283
(van Tongeren et al., 1995)	Discrete, PBZ	Worker	Laboratory technician	2	5.5E−03 to 3.0E−02	91

[a] It is assumed that the measured concentrations may persist throughout the duration of an entire work shift.

3.8.4.3 Occupational Inhalation Exposure Results

Table 3-32 provides a summary of inhalation exposure results for laboratory workers. The results are based on expected full-shift exposure values presented in Table 3-31. Exposures estimates are calculated depending on the size of the dataset. For data sets with three to five data points, EPA estimated the CT and HE exposures using the median and maximum values, respectively. In absence of data specific to ONU inhalation exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs.

Table 3-32. Inhalation Exposure Summary for Laboratory Chemicals

Worker Category	Full-Shift Exposure (mg/m^3) [a]	
	CT	HE
Worker	1.5E−02	3.0E−02
ONU [b]	1.5E−02	

[a] EPA estimated CT and HE exposure values using the median and maximum values, respectively, of data presented in Table 3-31.
[b] Worker central tendency exposure was used to estimate potential inhalation exposure to ONUs.

3.8.4.4 Occupational Dermal Exposure Results

Laboratory chemicals vary with respect to phthalic anhydride content as described above in Section 3.8.1. For liquid laboratory chemicals, the materials have low concentrations of phthalic anhydride that range from 0.1 to 0.2%. For solid laboratory chemicals, the material may have much higher phthalic anhydride concentrations that range from 90 to 100%. Also, handling the solid material may lead to dust deposited on surfaces, so incidental contact of contaminated surfaces by ONUs was considered in this assessment.

For dermal loading of solid laboratory chemicals, EPA used the work of Lansink et al. (1996) to estimate potential dermal exposures. Lansink et al. (1996) conducted an analysis of skin exposure to workers handling powdered calcium carbonate during a variety of activities including collection of the raw material, handling of empty bags, and manual dumping and mixing. Dermal loading values were assessed using cotton gloves worn by the workers, which covered their hands and part of their forearms, to obtain estimates of skin exposure in units of mg/day. The study reported the minimum, maximum, geometric mean, and 90th percentile of skin exposure measurements for each activity. Laboratory workers typically transfer small quantities of material for evaluations and subsequently dispose of empty bags. Therefore, the skin exposure measurements reported by Lansink et al. (1996) for handling of empty bags (*i.e.*, GM = 215 mg/day, 90th percentile = 1,039 mg/day) are most representative of potential skin exposure for the use of solid laboratory chemicals. EPA selected the geometric mean and 90th percentile of dermal loading estimates from Lansink et al. (1996) to represent central tendency and high-end dermal exposures to workers, respectively. Also, ONUs within the laboratory may experience incidental dermal contact with surfaces contaminated with phthalic anhydride dust. Since ONU dermal exposures are generally expected to be on the low end of potential worker dermal exposures, the 10th percentile value of dermal loading data from handling empty bags (*i.e.*, 10th percentile = 55 mg/day) is used to estimate potential dermal exposure for ONUs in laboratory settings. The surface area was not explicitly stated in the study by Lansink et al. (1996); however, it was stated that the measurements were reflective of exposure to the hands and part of the forearms. The EPA Exposure Factors Handbook (2011) reports the mean surface area of two adult male hands as 1,070 cm^2 and two adult male arms as 3,140 cm^2. Assuming a surface area of the hands plus one-quarter of the arms (*i.e.*, hands plus part of the forearms), the total surface area of consideration from the Lansink et al. (1996) study can be estimated as 1,855 cm^2. Therefore, converting the skin exposure estimates from Lansink et al. (1996) to dermal loading estimates (mg/cm^2), not accounting for material weight fraction, the central tendency and high-end estimates of dermal loading for workers become 0.12 mg/cm^2 and 0.56 mg/cm^2, respectively, and dermal loading for ONUs becomes 3.0×10^{-2} mg/cm^2.

For dermal loading of liquid laboratory chemicals, a study by the U.S. EPA (1992b) investigated dermal loading from common worker exposures scenarios including rag handling. EPA utilized the raw data to determine 50th and 95th percentile dermal loading values from rag handling scenarios of 1.4 mg/cm^2 and 2.1 mg/cm^2, respectively. As described in the ChemSTEER Manual (U.S. EPA, 2015), data from rag handling experiments of U.S. EPA (1992b) are considered relevant for typical occupational tasks such as product sampling, loading/unloading, and cleaning since rag handling is a common activity during these tasks. These data are relevant for the use of laboratory chemicals.

Table 3-33 provides estimates of occupational dermal exposure to phthalic anhydride for laboratory workers handling liquid and solid laboratory chemicals containing phthalic anhydride. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b), and appropriate forms of dermal PPE can be found in Section 2.5.2 of this document.

Table 3-33. Dermal Exposure Summary for Laboratory Chemicals

Worker Category	Dermal Loading (mg product/cm^2)		Phthalic Anhydride Concentration (%)		Dermal Exposure (mg Phthalic Anhydride/cm^2)	
	CT	HE	CT	HE	CT	HE
Worker (liquids)	1.4	2.1	0.1	0.2	1.4E−03	4.2E−03
Worker (solids)	0.12	0.56	90	100	0.10	0.56
ONU (solids)	3.0E−02		90		2.7E−02	

3.9 Lubricants and Functional Fluids

The following COU is captured by this OES: Hydraulic fracturing. See the *Draft Risk Evaluation for Phthalic Anhydride* for full list of COUs (U.S. EPA, 2026c).

3.9.1 Process Description

Phthalic anhydride is used as a functional fluid for processes in hydraulic fracturing as shown in the *Draft Risk Evaluation of Phthalic Anhydride* (U.S. EPA, 2026c). A typical end use site unloads the lubricant/functional fluid when ready for changeout (OECD, 2004). 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. The concentrations of chemical additives in hydraulic fluids may range from 4.0×10^{-2} to 0.5% (OECD, 2024). Figure 3-10 provides an illustration of the expected use of lubricants and functional fluids process (OECD, 2004).

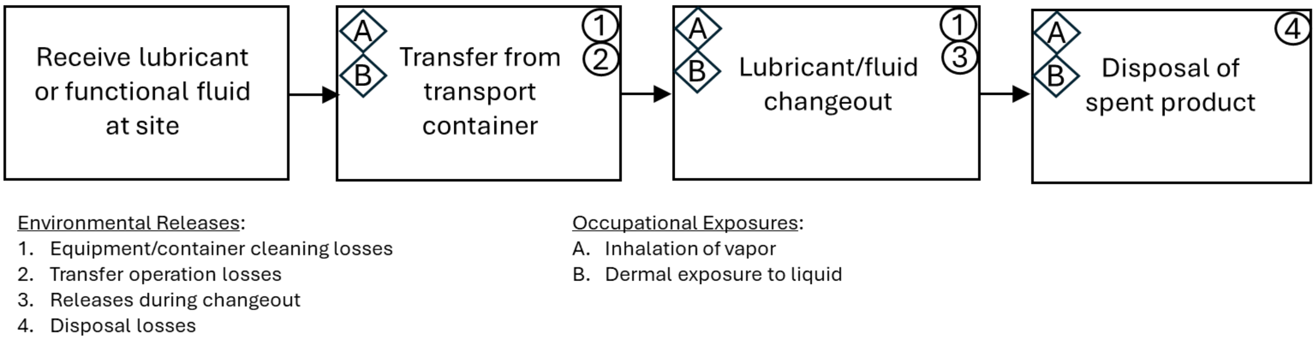

Figure 3-10. Process Flow Diagram for the Use of Lubricants and Functional Fluids
Source: (OECD, 2004)

3.9.2 Facility Estimates

EPA estimates that there are up to 4,688 facilities using lubricants or functional fluids containing phthalic anhydride based on the 2020 CDR data reporting (U.S. EPA, 2020a) and typical facility throughput described in the ESD on Lubricants and Lubricant Additives (OECD, 2004). From the CDR data, it is estimated that the annual production volume of phthalic anhydride in lubricants or functional fluids is 150,000 lb. More detailed information on production volume used in lubricants and functional fluids can be found in Appendix B.9. Since there were no operating schedule data identified for facilities using lubricants or functional fluids containing phthalic anhydride, it was assumed the number of operating days was 250 days/year based on 5 day/week operations and two full weeks of downtime each operating year.

Table 3-34. Summary of Facility Estimates for Lubricants and Functional Fluids

Total Number of Sites	Total Annual PV (lb/yr)	Operating Days (day/yr)	Concentration (%)	Physical Form
<4,688	150,000	250	4.0E–02 to 0.5	Liquid formulation
See Appendix B.9 for more details.				

3.9.3 Release Assessment

3.9.3.1 Environmental Release Assessment Results

Environmental releases of phthalic anhydride are reported to TRI (U.S. EPA, 2023b) and NEI (U.S. EPA, 2023a, 2019b) databases. EPA did not identify any release data from TRI or NEI related to the use of lubricants and functional fluids. However, the use of lubricants and functional fluids is associated with a low production volume (*i.e.*, less than 0.1% of total annual PV of phthalic anhydride). Therefore, it is expected that releases to air, water, and land from the use of lubricants and functional fluids will be less than manufacturing and processing uses and are not expected to significantly contribute to environmental concentrations of phthalic anhydride.

3.9.4 Occupational Exposure Assessment

3.9.4.1 Worker Activities

Workers are potentially exposed to phthalic anhydride 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.

Since phthalic anhydride has low volatility and low concentration in lubricants and functional fluids, and since there are no mists generated during the use of lubricants and functional fluids, it is expected that there may be low levels of vapor exposure near the application area. Workers may also be exposed via dermal contact with low concentration liquids. However, since there are no mists deposited on surfaces from the use of lubricants and functional fluids, dermal exposure to ONUs is not considered as an exposure route of concern for this population and OES. Sections 2.5.1 and 2.5.2 provide further details regarding considerations of PPE for handling phthalic anhydride.

3.9.4.2 Occupational Inhalation Exposure Data

EPA did not identify any reasonably available inhalation data specific to the use of lubricants and functional fluids containing phthalic anhydride. However, inhalation exposure from lubricants and functional fluids would be due to volatilization of phthalic anhydride, similar to scenarios of non-spray application of paints, coatings, adhesives, and sealants. Therefore, it was assumed that inhalation exposure data from phthalic anhydride volatilization measured for non-spray paints, coatings, adhesives, and sealants are suitable surrogate data for estimating inhalation exposures from volatilization of phthalic anhydride during the use of lubricants and functional fluids.

EPA has used monitoring data from a study measuring phthalic anhydride levels during the non-spray application of paints, coatings, adhesives, and sealants (Pfaffli, 1994) as surrogate data for estimating potential inhalation exposures from the use of lubricants and functional fluids. The sole data source provided area summary statistics of 20 data points and received a high rating from EPA's systematic review process. These data were used to estimate full-shift exposure levels for workers handling lubricants and functional fluids as shown in Table 3-35. Generally, EPA expects ONUs to have lower inhalation exposures than workers who handle the chemicals directly. In absence of data specific to ONU inhalation exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b).

Table 3-35. Surrogate Inhalation Exposure Data for Lubricants and Functional Fluids

Source	Data Type	Worker Category	Task or Job Title	Number of Samples	Concentration Range (mg/m^3) [a]	Sample Duration (min)
(Pfaffli, 1994)	Summary, Area	Worker	Coating metal with paint machine	20	1.1E−03 to 2.2E−03	120

[a] It is assumed that the measured concentrations may persist throughout the duration of an entire work shift.

3.9.4.3 Occupational Inhalation Exposure Results

Table 3-36 provides a summary of inhalation exposure results for the use of lubricants and functional fluids. Exposures estimates for the use of lubricants and functional fluids are based on the range of measured concentrations presented by Pfaffli (1994). Specifically, the midpoint of the range was used as the CT exposure level and the maximum reported value was assigned as the HE exposure level. In absence of data specific to ONU inhalation exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs.

Table 3-36. Inhalation Exposure Summary for Lubricants and Functional Fluids

Worker Category	Full-Sshift Exposure (mg/m^3) [a]	
	CT	HE
Worker	1.7E−03	2.2E−03
ONU [b]	1.7E−03	

[a] EPA estimated CT and HE exposures from the midpoint and maximum values, respectively, from the data presented in Table 3-35.
[b] Worker central tendency exposure was used to estimate potential inhalation exposure to ONUs.

3.9.4.4 Occupational Dermal Exposure Results

Lubricants and functional fluids contain low levels of phthalic anhydride, potentially ranging from 4.0×10^{-2} to 0.5% according to the ESD on Chemical Used in Hydraulic Fracturing (OECD, 2024). Uses of lubricants and functional fluids are not expected to generate mists that deposit on surfaces, and dermal exposure to ONUs is not considered as an exposure route of concern for this population and OES.

Regarding dermal loading in occupational settings, a study by the U.S. EPA (1992b) investigated dermal loading from common worker exposures scenarios including rag handling. EPA utilized the raw data to determine 50th and 95th percentile dermal loading values from rag handling scenarios of 1.4 mg/cm^2 and 2.1 mg/cm^2, respectively. As described in the ChemSTEER Manual (U.S. EPA, 2015), data from rag handling experiments of U.S. EPA (1992b) are considered relevant for typical occupational tasks such as product sampling, loading/unloading, and cleaning since rag handling is a common activity during these tasks. These data are relevant for the use of lubricants and functional fluids.

Table 3-37 provides estimates of occupational dermal exposure to phthalic anhydride for workers handling lubricants and functional fluids. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b), and appropriate forms of dermal PPE can be found in Section 2.5.2 of this document.

Table 3-37. Dermal Exposure Summary for Lubricants and Functional Fluids

Worker Category	Dermal Loading (mg product/cm^2)		Phthalic Anhydride Concentration (%)		Dermal Exposure (mg Phthalic Anhydride/cm^2)	
	CT	HE	CT	HE	CT	HE
Worker [a]	1.4	2.1	4.0E–02	0.5	5.6E–04	1.1E−02

[a] Dermal exposure to ONUs is not considered as an exposure route of concern for this population and OES.

3.10 Fabrication or Use of Final Products or Articles

The following COUs are captured by exposure estimates for *routine use* of final products or articles: Other articles with routine, direct contact during normal use including rubber articles; Plastic articles (hard); Other (rubber products).

The following COU is captured by exposure estimates for *fabrication* of final products or articles: Construction and building materials covering large surface areas.

Release estimates for the "Fabrication or use of final products or articles" OES cover all COUs listed above for both fabrication and routine uses.

See the *Draft Risk Evaluation for Phthalic Anhydride* for full list of COUs (U.S. EPA, 2026c).

3.10.1 Process Description

EPA anticipates that phthalic anhydride may be present in a wide array of final articles that are used both commercially and industrially. For purposes of exposure characterization, EPA has categorized fabrication or use of final products or articles into two distinct categories: *routine use* and *fabrication*.

Routine Use

Workers may directly contact rubber or plastic articles that contain phthalic anhydride during routine use of the rubber or plastic articles (*e.g.*, handling rubber or plastic broom while sweeping). Although worker exposures to phthalic anhydride may occur from vapor or dust generated during fabrication operations, the extent of potential phthalic anhydride exposure during routine use is limited due to the physical properties of the solid compounded material. Specifically, phthalic anhydride entrained in solid materials such as rubber or plastic has an exceedingly low affinity for volatilization or surface migration. Therefore, occupational exposures to phthalic anhydride from routine use of final products or articles are expected to be *de minimis*.

Fabrication

Phthalic anhydride is used in construction and building materials such as engineered stone products and resin work surfaces (Ramkissoon et al., 2023; U.S. EPA, 2020a, b; Durcon, 2011). Use cases may include melting articles containing phthalic anhydride and drilling, cutting, grinding, or otherwise shaping articles containing phthalic anhydride. Specifically, a recent study by Ramkissoon et al. (2023) measured phthalic anhydride content of dust generated from dry cutting various engineered stone slabs. However, the study did not provide details on engineering controls or protective equipment. Phthalic anhydride content in the dust ranged from 25.7 to 85.4%.

3.10.2 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 phthalic anhydride-containing article use occurs at many disparate industrial and commercial sites, with different operating conditions. Use cases are expected to include welding or melting articles containing phthalic anhydride and drilling, cutting, grinding, or otherwise shaping articles containing phthalic anhydride, as well as routine use of products or articles containing phthalic anhydride. 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 phthalic anhydride. EPA assumed the number of operating days was 250 days/year based on 5 day/week operations and two full weeks of downtime each operating year.

3.10.3 Release Assessment

3.10.3.1 Environmental Release Assessment Results

EPA did not quantitatively assess environmental releases for this OES due to the lack of reasonably available process-specific and phthalic anhydride-specific data; however, EPA expects releases from this OES to be small and disperse in comparison to other upstream OES, as EPA expects phthalic anhydride to be present in smaller amounts and predominantly remain in the final article, limiting the potential for release. Table 3-38 describes the expected fabrication and use activities that generate releases. All releases are non-quantifiable due to a lack of reasonably available identified process- and product-specific data.

Table 3-38. Release Activities for Fabrication or Use of Final Products or Articles

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
Routine use	Discarding scrapped material or broken equipment	Landfill

3.10.4 Occupational Exposure Assessment

3.10.4.1 Worker Activities

EPA anticipates that phthalic anhydride may be present in a wide array of final articles that are used both commercially and industrially. For purposes of exposure characterization, EPA has categorized fabrication or use of final products or articles into two distinct categories: *fabrication* and *routine use*.

During *routine use* of final products or articles, workers may handle plastic or rubber items (*e.g.*, plastic or rubber broom) containing phthalic anhydride. However, phthalic anhydride entrained in solid materials such as rubber or plastic has an exceedingly low affinity for volatilization or surface migration, and routine uses of such products are unlikely to result in volatilization or surface migration. Consequently, the extent of occupational exposure to phthalic anhydride from routine uses of final products and articles is limited due to the physical properties of the solid compounded material. Therefore, occupational exposures to phthalic anhydride for workers and ONUs are expected to be *de minimis* from the routine use of final products or articles.

During *fabrication* of final products or articles, worker tasks include activities such as cutting, grinding, shaping, drilling, and/or abrasive actions to manipulate a final product or article. Additionally, worker tasks may include activities such as heating or plastic welding. Since phthalic anhydride may volatilize when heated and dust may be generated from abrasive activities, worker and ONU exposures may occur during fabrication of products or articles.

3.10.4.2 Occupational Inhalation Exposure Data

For purposes of exposure characterization, as mentioned in Section 3.10.1, EPA has categorized fabrication or use of final products or articles into the following subcategories: *routine use* and *fabrication*. The inhalation exposure data for each type of use is explained in the paragraphs below. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b).

Routine Use

As mentioned in Section 3.10.4.1, occupational exposures to phthalic anhydride for workers and ONUs are expected to be *de minimis* from the routine use of final products or articles. Specifically, emissions of phthalic anhydride from solid compounded materials such as plastic and rubber are not expected due to the low propensity of volatilization or surface migration. Consequently, EPA does not expect routine use of final products and articles to lead to worker exposures of phthalic anhydride; however, abrasive manipulation of final products or articles (*i.e.*, fabrication) may lead to worker exposures as described below.

Fabrication

EPA identified six sources that quantified the inhalation exposure of phthalic anhydride during fabrication of final products or articles, and the *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994) was used to select the most representative data. Based on these guidelines, the Agency prefers discrete, personal breathing zone measurements that received high ratings through the EPA systematic review process. However, with exception of one OSHA CEHD datapoint and one datapoint presented in a study submitted to EPA under TSCA section 8(d) (Ramkissoon et al., 2023), the available sources only provided summary statistics and area monitoring data. Consequently, EPA used all available monitoring data from fabrication activities to estimate potential worker exposures.

There were three sources identified through EPA's systematic review process that measured personal breathing zone data for workers fabricating materials containing phthalic anhydride, and these studies were used to estimate exposures to the fabrication workers (OSHA, 2019; Pfaffli et al., 2002; Anas et al., 1990). Furthermore, there was one study submitted to EPA under TSCA section 8(d) that measured phthalic anhydride levels while cutting engineered stone materials containing phthalic anhydride, but it was not clear if the data were from a stationary monitor or a personal breathing zone monitor (Ramkissoon et al., 2023). Because significant levels of phthalic anhydride were captured during air monitoring, it is assumed that the measurements were taken near the emission source and in the potential worker breathing zone. Therefore, the inhalation measurements of Ramkissoon *et al*. (2023) were also used to estimate worker exposure levels for fabricating materials containing phthalic anhydride. Lastly, there were two data sources identified through EPA's systematic review process that provided area monitoring data of ambient air in the workplace during PVC welding (Vainiotalo and Pfaffli, 1990; Pfaffli, 1986), and these data represent potential exposure levels to ONUs working near fabrication activities. These six data sources were used to estimate full-shift exposure values of occupational exposure for workers and ONUs as shown in Table 3-39. Although all sample measurements are less than 8 hours, it is expected that the activities may persist throughout the workday and that the measured inhalation exposure values are representative of potential full-shift exposures.

Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b).

Table 3-39. Inhalation Exposure Data for Fabrication of Final Products or Articles

Source	Data Type	Worker Category	Task or Job Title	Number of Samples	Mean Concentration (mg/m^3) [a]	Sample Duration (min)
(OSHA, 2019)	Discrete, PBZ	Worker	Shredding scrap metal	1	3.9E–02	220
(Pfaffli et al., 2002)	Summary, PBZ	Worker	Welding painted metal surface	5	1.6E–02	70
(Anas et al., 1990)	Summary, PBZ	Worker	New construction of ships outfitting	4	0.22	60
		Worker	Shipbreaking (dismantling old ships)	2	8.2E–02	60
(Ramkissoon et al., 2023)	Discrete, PBZ [b]	Worker	Fabricating engineered stone slabs	1	0.32	30
(Pfaffli, 1986)	Summary, Area	ONU	PVC welding	4	5.0E–03	60
(Vainiotalo and Pfaffli, 1990)	Summary, Area	ONU	PVC welding	4	5.0E–03	180

[a] It is assumed that the measured concentrations may persist throughout the duration of an entire work shift.
[b] Sampling methodology unknown. Significant levels of phthalic anhydride indicate that measurements were taken within the personal breathing zone (PBZ) of the fabrication worker.

3.10.4.3 Occupational Inhalation Exposure Results

As mentioned in Section 3.10.4.1, occupational exposures to phthalic anhydride for workers and ONUs are expected to be *de minimis* from the *routine use* of final products or articles; however, worker and ONU exposures are expected for *fabrication* of final products or articles. Table 3-40 provides a summary of inhalation exposure results for fabrication of final products or articles. The results are based on expected full-shift exposure values presented in Table 3-39. Because the data points available are mean values from various monitoring samples, EPA calculated the weighted mean across samples to represent the CT and used the maximum value reported as the HE.

Table 3-40. Inhalation Exposure Summary for Fabrication of Final Products or Articles

Worker Category	Full-Shift Exposure (mg/m^3) [a]	
	CT	HE
Worker	0.11	0.32
ONU	5.0E−03	

[a] From the data presented in Table 3-39, EPA calculated the weighted mean across samples to represent the CT and used the maximum value reported as the HE.

3.10.4.4 Occupational Dermal Exposure Results

As mentioned in Section 3.10.4.1, occupational exposures to phthalic anhydride for workers and ONUs are expected to be *de minimis* from the *routine use* of final products or articles; however, worker and ONU exposures are expected for *fabrication* of final products or articles. Dermal exposure estimates for workers and ONUs during fabrication activities of materials containing phthalic anhydride are described below.

For dermal loading of dust from fabrication activities, EPA used the work of Lansink et al. (1996) to estimate potential dermal exposures. Lansink et al. (1996) conducted an analysis of skin exposure to workers handling powdered calcium carbonate during a variety of activities including collection of the raw material, handling of empty bags, and manual dumping and mixing. Dermal loading values were assessed using cotton gloves worn by the workers, which covered their hands and part of their forearms, to obtain estimates of skin exposure in units of milligrams per day. The study reported the minimum, maximum, geometric mean, and 90th percentile of skin exposure measurements for each activity.

Fabrication activities may generate dust that adheres to the skin, which is similar to contacting a contaminated surface. Therefore, the skin exposure measurements reported by Lansink et al. (1996) for handling of empty bags (*i.e.*, GM = 215 mg/day, 90th percentile = 1,039 mg/day) are most representative of potential skin exposure for the fabrication of final products or articles. EPA selected the geometric mean and 90th percentile of dermal loading estimates from Lansink et al. (1996) to represent central tendency and high-end dermal exposures to workers, respectively. Also, ONUs entering the fabrication area may experience incidental dermal contact with surfaces contaminated with phthalic anhydride dust. Since ONU dermal exposures are generally expected to be on the low end of potential worker dermal exposures, the 10th percentile value of dermal loading data from handling empty bags (*i.e.*, 10th percentile = 55 mg/day) is used to estimate potential dermal exposure for ONUs during the fabrication of final products or articles.

The surface area was not explicitly stated in the study by Lansink et al. (1996); however, it was stated that the measurements were reflective of exposure to the hands and part of the forearms. The EPA Exposure Factors Handbook (2011) reports the mean surface area of two adult male hands as 1,070 cm^2 and two adult male arms as 3,140 cm^2. Assuming a surface area of the hands plus one-quarter of the arms (*i.e.*, hands plus part of the forearms), the total surface area of consideration from the Lansink et al. (1996) study can be estimated as 1,855 cm^2. Therefore, converting the skin exposure estimates from Lansink et al. (1996) to dermal loading estimates (mg/cm^2), not accounting for material weight fraction, the central tendency and high-end estimates of dermal loading for workers become 0.12 mg/cm^2 and 0.56 mg/cm^2, respectively, and dermal loading for ONUs becomes 3.0×10^{-2} mg/cm^2.

Lastly, the concentrations of phthalic anhydride in dusts generated from fabrication activities were measured in a recent study by Ramkissoon et al. (2023). Specifically, the study measured phthalic anhydride content of dust generated from dry cutting various engineered stone slabs, and the resulting phthalic anhydride content data yielded 50th and 95th percentile values of 51.6 and 80.2%, respectively. EPA used the 50th and 95th percentile dust concentrations from these data to estimate central tendency and high-end dermal exposures, respectively.

Table 3-41 provides estimates of occupational dermal exposure to phthalic anhydride for fabrication of final products or articles containing phthalic anhydride. Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b), and appropriate forms of dermal PPE can be found in Section 2.5.2 of this document.

Table 3-41. Dermal Exposure Summary for Fabrication of Final Products or Articles

Worker Category	Dermal Loading (mg product/cm²)		Phthalic Anhydride Concentration (%)		Dermal Exposure (mg Phthalic Anhydride/cm²)	
	CT	HE	CT	HE	CT	HE
Worker	0.12	0.56	51.6	80.2	6.0E−02	0.45
ONU	3.0E−02		51.6		1.5E−02	

3.11 Disposal and recycling

The following COUs are captured by this OES: Disposal; Recycling. See the *Draft Risk Evaluation for Phthalic Anhydride* for full list of COUs (U.S. EPA, 2026c).

3.11.1 Process Description

Each of the conditions of use of phthalic anhydride 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, solid wastes, municipal waste incineration, hazardous waste landfill, municipal waste landfill, or recycling.

Wastewater

Phthalic anhydride may be contained in wastewater discharged to POTW or other non-public treatment works for treatment. Industrial wastewater containing phthalic anhydride discharged to a POTW may be subject to EPA or authorized National Pollutant Discharge Elimination System (NPDES) state pretreatment programs. The assessment of wastewater discharges of phthalic anhydride to POTWs and non-public treatment works is included in each of the condition of use assessments in Section 3.1 through Section 3.10.

Solid Wastes

Solid wastes may meet RCRA's definition of hazardous waste by either being listed as a waste at 40 CFR 261.30 to 261.35 or by meeting waste-like characteristics as defined at 40 CFR 261.20 to 261.24. Solid wastes that are hazardous wastes are regulated under the more stringent requirements of Subtitle C of RCRA, whereas non-hazardous solid wastes are regulated under the less stringent requirements of Subtitle D of RCRA. Phthalic anhydride is included on the list of hazardous wastes pursuant to RCRA section 3001 and is listed under the hazardous waste number U190 in 40 CFR 261.33. The assessment of solid waste discharges of phthalic anhydride is included in each of the condition of use assessments in Section 3.1 through Section 3.10.

Off-site transfers of phthalic anhydride-containing wastes to land disposal, wastewater treatment, incineration, and recycling facilities are expected 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, are recycled off-site, and/or are sent to other or unknown off-site disposal/treatment. See Figure 3-11 below.

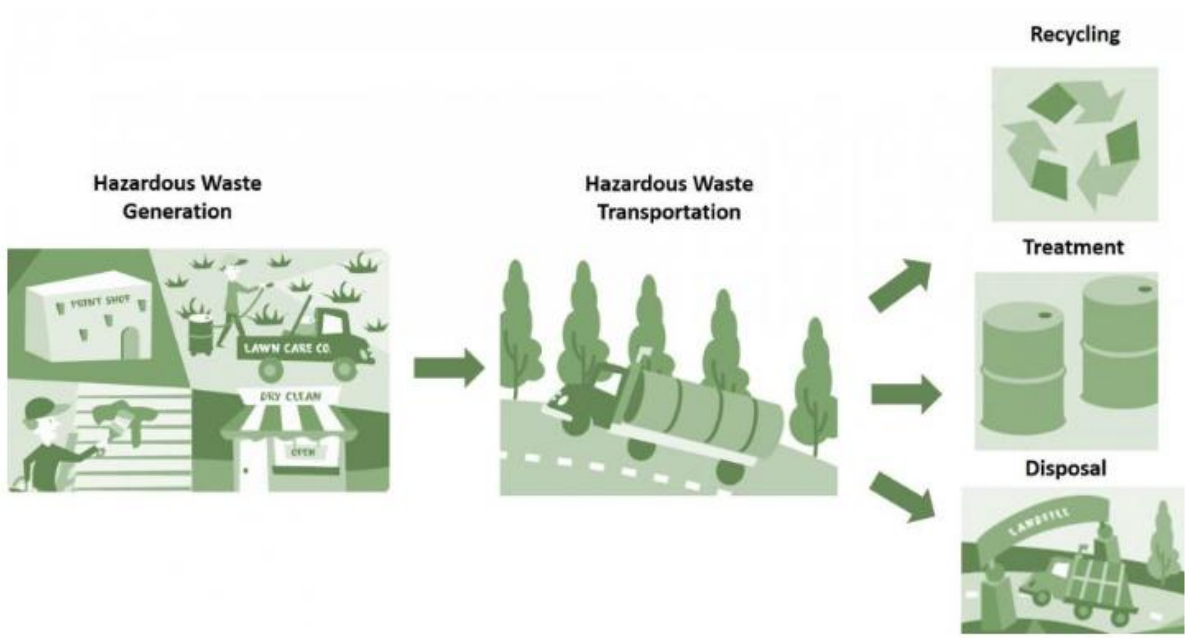

Figure 3-11. Typical Waste Disposal Process
Source: (U.S. EPA, 2019a)

Municipal Waste Incineration

Municipal waste combustors (MWCs) that recover energy are generally located at large facilities and comprised of an enclosed tipping floor and a deep waste storage pit. Typical large MWCs 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 fuel that is 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, is continuously drawn into the combustion unit via one or more forced air fans to serve as the primary combustion air and minimize odors. Dust and lint present in the air is typically captured in filters or other cleaning devices to prevent the clogging of steam coils, which are used to heat the combustion air and help dry higher-moisture inputs (Kitto and Stultz, 1992).

Hazardous Waste Landfill

Phthalic anhydride is present in commercial and consumer products that may be disposed of in landfills, such as Municipal Solid Waste landfills. Design standards for Subtitle C landfills require double liner, double leachate collection and removal systems, leak detection system, run on, runoff, and wind dispersal controls, and a construction quality assurance program. They are also subject to closure and post-closure care requirements including installing and maintaining a final cover, continuing operation of the leachate collection and removal system until leachate is no longer detected, maintaining and monitoring the leak detection and groundwater monitoring system. Bulk liquids may not be disposed in Subtitle C landfills. Subtitle C landfill operators are required to implement an analysis and testing program to ensure adequate knowledge of waste being managed, and to train personnel on routine and emergency operations at the facility. Hazardous waste being disposed in Subtitle C landfills must also meet RCRA waste treatment standards before disposal. See 40 CFR part 264.

Municipal Waste Landfill

Phthalic anhydride is present in commercial and consumer products that may be disposed of in landfills, such as Municipal Solid Waste (MSW) landfills. On-site releases to land from RCRA Subtitle D municipal solid waste landfills or exposures of the general population (including susceptible populations) or terrestrial species from such releases in this TSCA evaluation may occur. While permitted and managed by the individual states, municipal solid waste (MSW) landfills are required by federal regulations to implement some of the same requirements as Subtitle C landfills. MSW landfills generally must have a liner system with leachate collection and conduct groundwater monitoring and corrective action when releases are detected. MSW landfills are also subject to closure and post-closure care requirements and must have financial assurance for funding of any needed corrective actions. MSW landfills have also been designed to allow for the small amounts of hazardous waste generated by households and very small quantity waste generators (less than 220 lb per month). Bulk liquids, such as free solvent, may not be disposed of at MSW landfills. See 40 CFR part 258.

Recycling

EPA identified limited information regarding the recycling of products containing phthalic anhydride but assumed that phthalic anhydride is primarily recycled industrially in the form of phthalic anhydride-containing waste streams.

3.11.2 Facility Estimates

EPA assumes that all phthalic anhydride-containing products from all OES will be disposed of or recycled in some fashion. The concentration of phthalic anhydride in these products varies depending on the type of product and the necessary characteristics of that product. EPA did not identify representative site- or chemical-specific operating data for disposal and recycling (*i.e.*, facility throughput, number of sites, total production volume, operating days, product concentration), as phthalic anhydride-containing wastes occur at all levels of the phthalic anhydride life cycle. EPA expects disposal routes to include POTW and non-publicly owned treatment works; municipal and hazardous waste incineration; and municipal and hazardous waste landfill. Due to a lack of readily available information for this OES, the number of industrial or commercial use sites is unquantifiable and unknown. There were 22 unique sites reporting disposal or recycling activities to TRI (U.S. EPA, 2023b) and NEI (2017 and 2020 reporting periods); however, it is expected there may be more waste or recycling facilities handling phthalic anhydride-containing materials. Consequently, total production volume for disposal and recycling is also unquantifiable, and EPA assumed that each end use site handles a small number of finished articles containing phthalic anhydride.

The number of operating days was determined based on the data reported to the 2017 and 2020 NEI databases (U.S. EPA, 2023a, 2019b), which may contain more detailed information about facility operation schedules. If there were no operation schedule data reported to 2017 or 2020 NEI databases for a facility, it was assumed that the number of release days for a waste handling or recycling facility was 365 days/year based on the waste handling facilities that did report operating schedules to NEI.

3.11.3 Release Assessment

3.11.3.1 Environmental Release Assessment Results

Environmental releases of phthalic anhydride are reported to TRI (U.S. EPA, 2023b) and NEI (U.S. EPA, 2023a, 2019b) databases, and EPA used information from these databases to estimate environmental releases of phthalic anhydride to air, water, and land. Specifically, the reporting years 2019 to 2023 were considered for the TRI database and the reporting periods of 2017 and 2020 were considered for the NEI database. EPA preferred and reported the most recent data from the NEI database, and these data are shown in Table 3-42 below. For facilities reporting to TRI in years 2019 to 2023, the highest facility releases and the median facility releases across reporting years to air and land are provided in Table 3-42. The number of release days was assumed to be equal to the number of operation days for a facility. There were no reported environmental releases to water (surface water, POTW, or non-POTW) from waste handling and recycling facilities from TRI in years 2019 to 2023, and all waste handling and recycling facilities reported to TRI using Form R. Facilities reporting to TRI using 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. Therefore, it is assumed that phthalic anhydride is not significantly released to water from known waste handling and recycling facilities in the United States. For more detailed information regarding environmental releases, see the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).

Table 3-42. Summary of Releases from TRI (2019–2023) and NEI (2017, 2020) for Disposal and Recycling

Type of Air Emission [a], Discharge [b], or Disposal [c]	Estimated Annual Release (kg/site-year) [d]		Estimated Daily Release (kg/site-day) [d]		Number of Facilities [e]	Data Source	Number of Release Days [f]
	Central Tendency	High-End	Central Tendency	High-End			
Stack air	9.1E−02	56	2.5E−04	0.15	15	NEI	260–365
Stack air	3.2E−02	72	8.7E−05	0.20	18	TRI	
Fugitive air	0	29	0	8.0E−02	15	NEI	
Fugitive air	2.7E−02	5.7	7.5E−05	1.6E−02	18	TRI	
Wastewater	0	0	0	0	18	TRI	
Land	0	6.8E03	0	19	18	TRI	

[a] Emissions via stack air and/or fugitive air.
[b] Direct discharge to surface water, indirect discharge to non-POTW, or indirect discharge to POTW. Details on wastewater release streams for each facility are presented in the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025).
[c] Land releases were reported to on-site or off-site underground injection, off-site RCRA subtitle C landfills, other off-site landfills, or off-site waste brokers. See the *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025) for more details.
[d] Central tendency values are calculated from the 50th percentile of median reported releases and high-end values are calculated from the 95th percentile of maximum reported releases.
[e] Number of unique facilities reporting releases.

3.11.4 Occupational Exposure Assessment

3.11.4.1 Worker Activities

As described in Section 3.11.1, waste streams may include the following: wastewater, solid wastes, municipal waste incineration, hazardous waste landfill, municipal waste landfill, or recycling. Since phthalic anhydride has low volatility and low concentration in waste streams, it is expected that there may be low levels of inhalation exposure in waste handling facilities. Furthermore, the extent of dermal exposure to phthalic anhydride from disposal and recycling activities is limited due to the physical properties of the solid compounded material and the low levels of phthalic anhydride in waste streams. Therefore, dermal exposures of phthalic anhydride to workers and ONUs are expected to be *de minimis* from disposal and recycling activities. Sections 2.5.1 and 2.5.2 provide further details regarding considerations of PPE for handling phthalic anhydride.

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 require certain worker safety standards be met. 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 to vapors while working on the tipping floor. Potentially exposed workers include workers stationed on the tipping floor, including front-end loader and crane operators, as well as truck drivers. The potential for dermal exposures is minimized by the use of trucks and cranes to handle the wastes.

Hazardous Waste Incineration

EPA lacks reasonably available information to determine the potential for worker exposures during hazardous waste incineration and 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 may 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.

Recycling

At PVC recycling sites, worker exposures from inhalation may occur during the unloading of bailed PVC, loading of processed phthalic anhydride-containing PVC onto compounding or converting lines or into transport containers, processing of recycled PVC, and equipment cleaning.

3.11.4.2 Occupational Inhalation Exposure Data

EPA identified one source of data that quantified the inhalation exposure of phthalic anhydride during waste handling activities in a phthalic anhydride manufacturing and processing plant, and EPA used these data for estimating the inhalation exposure of workers involved in disposal and recycling activities. Consequently, the following study was selected to estimate inhalation exposure to workers during the disposal and recycling: Liss (1983). These data were used to estimate full-shift exposure levels for workers involved in disposal and recycling activities as shown in Table 3-43. Generally, EPA expects ONUs to have lower inhalation exposures than workers who handle the chemicals directly. In absence of data specific to ONU inhalation exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs.

Liss (1983) was conducted by NIOSH as a Human Health Evaluation (HHE), and the study examined worker inhalation exposures during manufacturing of phthalic anhydride and subsequent processing of the chemical. The study provides discrete, personal breathing zone measurements for a variety of worker categories including waste treatment and boiler operators, and these data were used for estimating inhalation exposures to workers involved in disposal and recycling activities. Although sample measurements are less than 8 hours, it is expected that the measured inhalation exposure values are representative of full-shift exposures. For estimation of exposure measurements below the LOD, EPA followed the *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994). Specifically, the guidelines state that if the geometric standard deviation of the dataset is less than 3.0, nondetectable values should be replaced by the LOD divided by the square root of two. Because the geometric standard deviation of the entire monitoring dataset reported by Liss (1983) was less than 3.0, nondetectable values were replaced by the LOD divided by the square root of two.

Detailed occupational exposure data can be found in the *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b).

Table 3-43. Inhalation Exposure Data for Disposal and Recycling

Source	Data Type	Worker Category	Task or Job Title	Number of Samples	Measured Concentration (mg/m^3)	Sample Duration (min)	Estimated Full-Shift Exposure (mg/m^3) [a]
(Liss and Hartel, 1983)	Discrete, PBZ	Worker	Waste treatment and boiler operation	4	Non-detect	393–436	2.8E−03

[a] For the purposes of calculating full-shift exposure concentrations, the value of LOD/√2 was used for any samples that were below LOD.

3.11.4.3 Occupational Inhalation Exposure Results

Table 3-44 provides a summary of inhalation exposure results for workers and ONUs involved in disposal and recycling. The results are based on expected full-shift exposure values presented in Table 3-43. Exposures estimates are calculated depending on the size of the dataset. For data sets with three to five data points, EPA estimated the CT and HE exposures using the median and maximum values, respectively. However, all data were measured below the LOD for the worker category, and full-shift exposures are estimated as the same for all four measurements. Consequently, CT and HE estimates of inhalation exposure are the same for disposal and recycling activities. In absence of data specific to ONU inhalation exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs.

Table 3-44. Inhalation Exposure Summary for Disposal and Recycling

Worker Category	Full-Sshift Exposure (mg/m^3) [a]	
	CT	HE
Worker	2.8E−03	
ONU [b]	2.8E−03	

[a] EPA estimated the CT and HE exposure values using the median and maximum values, respectively, from the data presented in Table 3-43.
[b] Worker central tendency exposure was used to estimate potential inhalation exposure to ONUs.

3.11.4.4 Occupational Dermal Exposure Results

When phthalic anhydride is processed into final products or articles, the chemical generally functions as a monomer and is largely consumed in reaction to form other plasticizers within the product. Consequently, low levels of phthalic anhydride exist in waste streams, and the chemical is entrained in the solid material. Although worker exposures to phthalic anhydride may occur at low levels from dermal contact with dusts generated during waste handling or recycling operations, the extent of potential phthalic anhydride exposure is limited due to the physical properties of the solid compounded material and the low levels of phthalic anhydride in waste streams. Therefore, dermal exposures to phthalic anhydride are expected to be negligible from disposal and recycling activities. The majority of significant dermal exposures occur during upstream processing, and such exposures are characterized in Section 3.5.4.3.

3.12 Distribution in Commerce

3.12.1 Process Description

For purposes of assessment in this draft risk evaluation, distribution in commerce consists of the transportation associated with the moving of phthalic anhydride or phthalic anhydride-containing products and/or articles between sites manufacturing, processing, and use COUs, or the transportation of phthalic anhydride containing wastes to recycling sites or for final disposal. EPA expects all the phthalic anhydride or phthalic anhydride-containing products and/or articles to be transported in closed system or otherwise to be transported in a form (*e.g.,* articles containing phthalic anhydride) 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 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 scientific evidence conclusions. Release data was primarily sourced from 2019 to 2023 TRI (U.S. EPA, 2023b), 2017 and 2020 NEI (U.S. EPA, 2023a, 2019b). TRI data has a medium data quality rating from EPA's systematic review process and NEI data has a high data quality rating from EPA's systematic review process. Table 4-1 and Table 4-2 provide summaries 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 Rating [b]	Qualitative Assessment [c]	Weight of Scientific Evidence Conclusion
Manufacturing	Air	✓	H	×	Moderate to Robust
	Water	✓	M	×	
	Land	✓	M	×	
Import and repackaging	Air	✓	M	×	Moderate
	Water	✓	M	×	
	Land	✓	M	×	
Processing as a reactant	Air	✓	H	×	Moderate to Robust
	Water	✓	M	×	
	Land	✓	M	×	
Incorporation into formulations, mixtures, or reaction products	Air	✓	H	×	Moderate to Robust
	Water	✓	M	×	
	Land	✓	M	×	
PVC plastics compounding	Air	✓	H	×	Moderate to Robust
	Water	✓	M	×	
	Land	✓	M	×	
PVC plastics converting	Air	✓	H	✓	Moderate
	Water, Land	×	N/A	✓	
Application of paints, coatings, adhesives, and sealants	Air	✓	H	×	Moderate to Robust
	Water	✓	M	×	
	Land	✓	M	×	
Use of laboratory chemicals	Air	✓	H	✓	Moderate
	Water, Land	×	N/A	✓	
Use of lubricants and functional fluids	Air, Water, Land	×	N/A	×	Moderate
Fabrication or use of final products or articles	Air, Water, Land	×	N/A	×	Moderate
Disposal and recycling	Air	✓	H	×	Moderate to Robust
	Water	✓	M	×	
	Land	✓	M	×	

OES	Release Media	Reported Data [a]	Data Quality Rating [b]	Qualitative Assessment [c]	Weight of Scientific Evidence Conclusion

[a] Reported data includes data obtained from EPA databases (*i.e.,* TRI and NEI).
[b] Data quality ratings for reported data are based on EPA systematic review and include ratings Low (L), Medium (M), and High (H)
[c] Where no data were available to estimate releases for an OES, releases were described qualitatively.

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	Environmental releases to air, land, and water were assessed using reported releases from 2019 to 2023 TRI (U.S. EPA, 2023b) and 2017 and 2020 NEI (U.S. EPA, 2023a, 2019b), and these sources received medium and high ratings from EPA's systematic review process, respectively. The assessment of release data from multiple EPA environmental release reporting databases increases confidence in release estimates. Furthermore, these data capture environmental releases from 8 manufacturing sites, which include all sites that reported manufacturing activities to the 2020 CDR. Because the EPA data provide a holistic assessment of releases from manufacturers of phthalic anhydride, there is increased confidence that the release data cover all known manufacturing releases in the United States. However, the most recent manufacturing data at the time of this assessment (*i.e.*, 2020 CDR) and the most recent release data (*i.e.*, 2023 TRI and 2020 NEI) may not capture the current market as manufacturers enter and exit the industry. The lack of manufacturing and release data for the current year creates uncertainty in the assessment. Nevertheless, manufacturing and associated release data remain stable and consistent across the available datasets. As discussed above, the main strength of the analysis includes using industry reported release data to various EPA databases. However, the limitations of the analysis include the uncertainties discussed above, such as the temporal relevancy of the release data compared to the current year. Therefore, considering the strengths and limitations of reasonably available data, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust.
Import and repackaging	Environmental releases to air, land, and water were assessed using reported releases from 2019 to 2023 TRI (U.S. EPA, 2023b), and this source received a medium rating from EPA's systematic review process. Sites reporting releases to TRI using Form A indicate that the sites could potentially release up to 500 lb total to all media; therefore, EPA conservatively assumed that 500 lb were released to each media for purposes of downstream exposure assessment. These values may overestimate releases since the facility would not be releasing the total amount to all media at the same time. This assumption strengthens confidence that the environmental releases evaluated are conservative with respect to the known reporting requirements of TRI. These data capture environmental releases from four import and repackaging sites; however, it was estimated that there may be 28–37 sites involved in import and repackaging of phthalic anhydride. Therefore, there are likely additional sites involved in import and repackaging activities without known or reported release quantities. However, facility releases that are reported to EPA databases are expected to represent the highest release levels throughout the industry since these facilities are exceeding program reporting

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	thresholds. EPA expects the reported releases to reliably estimate the release potential from import and repackaging of phthalic anhydride. As discussed above, the strengths of the analysis includes using industry reported release data to various EPA databases and the conservatism of the assumptions regarding TRI Form A submissions. However, the limitations of the analysis include the uncertainties discussed above, such as not capturing all release sources. Therefore, considering the strengths and limitations of reasonably available data, EPA concluded that the weight of scientific evidence for this assessment is moderate.
Processing as a reactant; Incorporation into formulations, mixtures, or reaction products; Plastic compounding	Environmental releases to air, land, and water were assessed using reported releases from 2019 to 2023 TRI (U.S. EPA, 2023b) and 2017–2020 NEI (U.S. EPA, 2023a, 2019b), and these sources received medium and high ratings from EPA's systematic review process, respectively. The assessment of release data from multiple EPA environmental release reporting databases increases confidence in release estimates. Sites reporting releases to TRI using Form A indicate that the sites could potentially release up to 500 lb total to all media; therefore, EPA conservatively assumed that 500 lb were released to each media for purposes of downstream exposure assessment for these sites. These values may overestimate releases since the facility would not be releasing the total amount to all media at the same time. This assumption strengthens confidence that the environmental releases evaluated are conservative with respect to the known reporting requirements of TRI. These data capture environmental releases from 66 sites that process phthalic anhydride as a reactant; 9 sites that incorporate phthalic anhydride into formulations, mixtures, or reaction products; and 55 sites that are involved in plastic compounding. However, it was estimated that there may be 108–321 sites involved in processing phthalic anhydride as a reactant, 34–180 sites involved in incorporative activities, and 47–153 involved in plastic compounding. Although there are release data for a large number of processing sites, there are likely additional sites involved in processing activities without known or reported release quantities. However, facility releases that are reported to EPA databases are expected to represent the highest release levels throughout the industry since these facilities are exceeding program reporting thresholds. EPA expects the reported releases to reliably estimate the release potential from processing of phthalic anhydride. As discussed above, the strengths of the analysis includes using industry reported release data to various EPA databases, the conservatism of the assumptions regarding TRI Form A submissions, and the large availability of release data for sites processing phthalic anhydride. However, the limitations of the analysis include the uncertainties discussed above, such as not capturing all release sources. Therefore, considering the strengths and limitations of reasonably available data, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust.
Plastic converting	Environmental releases to air were assessed using reported releases from 2017–2020 NEI (U.S. EPA, 2023a, 2019b), and these sources received high ratings from EPA's systematic review process. However, there were only 4 sites identified that reported air releases from plastic converting, and EPA estimated that there may be 110–300 sites involved in plastic converting of materials containing phthalic anhydride. Therefore, there is uncertainty regarding the representativeness of the air release data across all plastic converting sites.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	Furthermore, there were no release data for water or land from plastic converting facilities. Consequently, EPA provided a qualitative assessment of releases for plastic converting activities. Specifically, 55 facilities reported plastic compounding activities to TRI and NEI, and these facilities may also be involved with plastic converting. Therefore, it is assumed that releases to air, water, and land from plastic converting activities are less than or equal to releases reported in by plastic compounding facilities. Because there are robust data reported by plastic compounding facilities, and the assumption that releases from plastic converting facilities are less than or equal to plastic compounding facilities is logical based on the overlap of compounding and converting activities, there is increased confidence in the qualitative assessment of releases from plastic converting facilities. As discussed above, the strengths of the qualitative analysis includes the comparison with robust plastic compounding data. However, the limitations of the analysis include the uncertainties discussed above, such as not capturing all release sources. Therefore, considering the strengths and limitations of reasonably available data, EPA concluded that the weight of scientific evidence for this assessment is moderate.
Application of paints, coatings, adhesives, and sealants	Environmental releases to air, land, and water were assessed using reported releases from 2019–2023 TRI (U.S. EPA, 2023b) and 2017–2020 NEI (U.S. EPA, 2023a, 2019b), and these sources received medium and high ratings from EPA's systematic review process, respectively. The assessment of release data from multiple EPA environmental release reporting databases increases confidence in release estimates. These data capture air releases from 36 sites total (NEI and TRI) and water/land releases from 7 sites (TRI only), and it was estimated that there may be 108–1,128 industrial and commercial sites using paints, coatings, adhesives, sealants containing phthalic anhydride. Therefore, there are likely additional sites involved in paint, coating, adhesive, and sealant application without known or reported release quantities. However, facility releases that are reported to EPA databases are expected to represent the highest release levels throughout the industry since these facilities are exceeding program reporting thresholds. EPA expects the reported releases to reliably estimate the release potential from industrial use of phthalic anhydride. As discussed above, the strengths of the analysis includes using industry reported release data to various EPA databases. However, the limitations of the analysis include the uncertainties discussed above, such as not capturing all release sources. Therefore, considering the strengths and limitations of reasonably available data, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust.
Use of laboratory chemicals	Environmental releases to air were assessed using reported releases from 2017–2020 NEI (U.S. EPA, 2023a, 2019b), and these sources received high ratings from EPA's systematic review process. However, there were only 5 sites identified that reported air releases from laboratories, and EPA estimated that there may be 2,020–2,260 laboratory sites using phthalic anhydride. Therefore, there is uncertainty regarding the representativeness of the air release data across all chemical laboratories. Furthermore, there were no release data for water or land from laboratory facilities. Consequently, EPA provided a qualitative assessment of releases for laboratory activities. Specifically, the use of laboratory chemicals is associated with a low production volume (*i.e.*, <0.1% of total annual PV of phthalic anhydride). Therefore, it is expected that releases to air, water, and land from laboratory uses will be less than manufacturing and processing uses. Because there are robust data reported by manufacturing and

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	processing facilities, and the assumption that releases from laboratory uses are less than releases from manufacturing and processing uses is logical based on the low PV of laboratory use, there is increased confidence in the qualitative assessment of releases from laboratory facilities. As discussed above, the strengths of the qualitative analysis includes the comparison with robust manufacturing and processing data. However, the limitations of the analysis include the uncertainties discussed above, such as not capturing all release sources. Therefore, considering the strengths and limitations of reasonably available data, EPA concluded that the weight of scientific evidence for this assessment is moderate.
Use of lubricants and functional fluids	There were no release data for air, water, or land from facilities using lubricants and functional fluids containing phthalic anhydride. Consequently, EPA provided a qualitative assessment of releases. Specifically, the use of lubricants and functional fluids is associated with a low production volume (*i.e.*, <0.1% of total annual PV of phthalic anhydride). Therefore, it is expected that releases to air, water, and land from uses of lubricants and functional fluids will be less than manufacturing and processing uses. Because there are robust data reported by manufacturing and processing facilities, and the assumption that releases from lubricant and functional fluid uses are less than releases from manufacturing and processing uses is logical based on the low PV of lubricant and functional fluid use, there is increased confidence in the qualitative assessment of releases from facilities using lubricants and functional fluids containing phthalic anhydride. As discussed above, the strengths of the qualitative analysis includes the comparison with robust manufacturing and processing data. However, the limitations of the analysis include the uncertainties discussed above, such as a lack of release data. Therefore, considering the strengths and limitations of reasonably available data, EPA concluded that the weight of scientific evidence for this assessment is moderate.
Fabrication or use of final product or articles	There were no release data for air, water, or land from the fabrication or use of final products or articles containing phthalic anhydride. Consequently, EPA provided a qualitative assessment of releases. Specifically, EPA expects releases from this OES to be small and disperse in comparison to other upstream OESs, as EPA expects phthalic anhydride to be present in smaller amounts and predominantly remain in the final article, limiting the potential for release. Because there are robust data reported from upstream OESs such as manufacturing and processing, and the assumption that releases from fabrication uses are less than releases from upstream OESs is logical based on the low PV of fabrication uses, there is increased confidence in the qualitative assessment of releases from fabrication or final use of products or articles. As discussed above, the strengths of the qualitative analysis includes the comparison with robust data from upstream OESs such as manufacturing and processing. However, the limitations of the analysis include the uncertainties discussed above, such as a lack of release data. Therefore, considering the strengths and limitations of reasonably available data, EPA concluded that the weight of scientific evidence for this assessment is moderate.
Disposal and recycling	Environmental releases to air, land, and water were assessed using reported releases from 2019–2023 TRI (U.S. EPA, 2023b) and 2017–2020 NEI (U.S. EPA, 2023a, 2019b), and these sources received medium and high ratings from EPA's systematic review process, respectively. The assessment of release data from multiple EPA environmental release reporting databases increases confidence in release estimates.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	These data capture environmental releases from 22 disposal and recycling facilities. Although there are release data from a sufficient number of disposal and recyling sites, there are likely additional sites without known or reported release quantities. However, facility releases that are reported to EPA databases are expected to represent the highest release levels throughout the industry since these facilities are exceeding program reporting thresholds. EPA expects the reported releases to reliably estimate the release potential from disposal and recycling of phthalic anhydride. As discussed above, the strengths of the analysis includes using industry reported release data to various EPA databases and the sufficient pool of release data available for disposal and recycling facilities. However, the limitations of the analysis include the uncertainties discussed above, such as not capturing all release sources. Therefore, considering the strengths and limitations of reasonably available data, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust.

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 (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 and Table 4-4 provide summaries of EPA's overall confidence in its occupational exposure estimates for each of the OESs assessed.

2984 **Table 4-3. Summary of Exposure Data for Occupational Exposures by OES**

OES	Data Type [a]	Worker Category	Number of Samples	Number of Non-Detects [b]	Data Quality Rating [c]	Weight of Scientific Evidence Conclusion [d]
Manufacturing	• PBZ • Discrete • Chemical-specific • Use-specific	High exposure worker [e]	8	0	H	Moderate to Robust
		Worker [f]	26	3	H	Robust
		ONU [g]	6	5	H	Moderate to Robust
Import and repackaging	• PBZ • Discrete • Chemical-specific • Surrogate use from manufacturing	High exposure worker [e]	8	0	H	Moderate
		Worker [f]	26	3	H	Moderate to Robust
		ONU [g]	6	5	H	Moderate
Processing as a reactant; Incorporation into formulations, mixtures, or reaction products; Plastic compounding	• PBZ • Discrete • Chemical-specific • Use-specific	High exposure worker [e]	5	0	H	Moderate to Robust
		Worker [f]	30	10	H	Robust
		ONU [g]	6	5	H	Moderate to Robust
Incorporation into formulations, mixtures, or reaction products (epoxy resin casting hardener)	• PBZ • Discrete • Chemical-specific • Use-specific	Worker [h]	22	0	H	Robust
Plastic converting	• Area • Summary • Chemical-specific • Use-specific	Worker [h]	42	2	M	Moderate
Application of paints, coatings, adhesives, and sealants (non-spray)	• Area • Summary • Chemical-specific • Use-specific	Worker [h]	20	0	H	Moderate
Application of paints, coatings, adhesives, and sealants (spray) [i]	• PBZ • Discrete	Worker	88	2	H	Moderate

OES	Data Type [a]	Worker Category	Number of Samples	Number of Non-Detects [b]	Data Quality Rating [c]	Weight of Scientific Evidence Conclusion [d]
	• Surrogate mist levels from various paint/ coating products • Use-specific					
Use of laboratory chemicals	• PBZ • Discrete • Chemical-specific • Use-specific	Worker [h]	4	0	M to H	Moderate to Robust
Use of lubricants and functional fluids	• Area • Summary • Chemical-specific • Surrogate use from non-spray paints, coatings, adhesives, and sealants	Worker [h]	20	0	H	Moderate
Fabrication or use of final products or articles	• PBZ • Discrete and summary • Chemical-specific • Use-specific	Worker	13	0	M to H	Moderate
	• Area • Summary • Chemical-specific • Use-specific	ONU	8	0	M	Moderate
Disposal and recycling	• PBZ • Discrete • Chemical-specific • Use-specific	Worker [h]	4	4	H	Moderate
Dermal exposures (liquids)	• Dermal loading • Discrete • Surrogate chemical [j] • Surrogate use	Worker	240	0	H	Moderate
Dermal exposures (solids)	• Dermal loading	Worker	45	0	H	Moderate

OES	Data Type [a]	Worker Category	Number of Samples	Number of Non-Detects [b]	Data Quality Rating [c]	Weight of Scientific Evidence Conclusion [d]
	• Summary • Surrogate chemical [j] • Use-specific	ONU [k]	14	0	H	Slight to Moderate

[a] Data type may be PBZ inhalation monitoring data (PBZ), inhalation area monitoring data (Area), or dermal loading data (mg/cm^2). The term "surrogate" may be associated with data that were initially measured for a different chemical than phthalic anhydride, but the data were for the same use under investigation. Alternately, the term "surrogate" may be associated with data that were measured for a use of phthalic anhydride that is similar, but different, than the use under investigation. Discrete data were provided as individual data measurements, whereas summary data were provided as statistical parameters (*e.g.,* arithmetic mean, standard deviation, *etc.*) of a dataset.

[b] For datasets that included exposure data reported as below the limit of detection (LOD), EPA estimated exposure concentrations 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 (U.S. EPA, 1994). For datasets with non-detect measurements, LODs are provided in Table 4-4.

[c] Data quality ratings for reported data are based on EPA systematic review and include ratings Low (L), Medium (M), and High (H).

[d] See Table 4-4 for further details on weight of scientific evidence conclusions.

[e] High exposure workers are those engaged in short-term, high exposure tasks, as well as routine equipment operations or maintenance. For phthalic anhydride production, high exposure tasks include flaking and bagging phthalic anhydride, unclogging baghouse chutes, filling drums with process impurities, and cleaning equipment with high solids content.

[f] Workers associated with manufacturing and processing data include equipment operators and maintenance workers.

[g] ONUs associated with manufacturing and processing data include instrument technicians, warehouse workers, office engineers, and supervisors.

[h] When ONU inhalation data were not available, EPA used worker central tendency exposure values to estimate potential inhalation exposures to ONUs. In these cases, exposure estimates for ONUs have reduced confidence in comparison to worker exposure estimates.

[i] Spray applications are expected to occur in enclosed spaces with ventilation controls, as specified in the *Paint Stripping and Surface Coating NESHAP* [73 FR 1738; January 9, 2008], and EPA does not expect exposures to occur outside the application area. Therefore, inhalation and dermal exposures from spray applications were not considered a route of concern for ONUs. See Section 3.7.4 of the *Draft Environmental Release and Occupational Exposure Assessment for Phthalic Anhydride* (U.S. EPA, 2026a) for additional details.

[j] Surrogate data used for dermal loading estimation are described in Section 2.4.3.

[k] Incidental dermal exposures to ONUs were estimated from the 10th percentile of dermal loading data for workers handling empty bags. It is assumed that handling an empty bag leads to similar dermal loading as contacting a surface contaminated with phthalic anhydride dust. See Section 2.4.3 for more details.

2986 **Table 4-4. Summary of Assumptions, Uncertainty, and Overall Confidence in Occupational Exposure Estimates by OES**

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
Manufacturing; Import and repackaging	For assessing inhalation exposures from phthalic anhydride manufacturing and import/repackaging, EPA used personal breathing zone (PBZ) air concentration data sourced from four occupational monitoring studies (Cardno ChemRisk, 2020; Bookman, 2017; Rietz, 1985; Liss and Hartel, 1983). Rietz (1985) and Bookman (2017) reported data for high exposure tasks (*i.e.*, bag handling), Cardno ChemRisk (2020) reported data for equipment operations and high exposure tasks (*i.e.*, unclogging baghouse chutes, filling drums with process impurities, and cleaning equipment with high solids content), and Liss (1983) reported data for equipment operations, maintenance, and ONUs including supervisors, instrument technicians, warehouse workers, and office engineers. All four data sources received high ratings from EPA's systematic review process. Measurements from these studies were also used as surrogate data for estimating inhalation exposure during import and repackaging since worker activities are similar to manufacturing. ***Manufacturing*** The primary strengths of this assessment are based on the underlying data used for inhalation exposure estimation. All data were gathered in phthalic anhydride manufacturing or processing facilities and reported as discrete PBZ monitoring measurements with most associated metadata such as sampling durations and worker activities, and these data received high data quality ratings. For data associated with equipment operators and maintenance workers, there were no factors identified that would lead to a reduction in confidence and the resulting weight of scientific evidence is robust for exposure estimates of equipment operators and maintenance workers. For data associated with high exposure workers, the primary limitation relates to the unknown durations of task-based monitoring samples and EPA assumed up to 2 hours in duration for high exposure tasks. The reduction in confidence from this limitation results in a weight of scientific evidence of moderate to robust for exposure estimates of high exposure workers. For data associated with ONUs (supervisors, instrument technicians, warehouse workers, and office engineers), the primary limitation is the high percentage of non-detectable data. There were 6 data measurements across the 4 ONU worker types, and 5 out of the 6 data measurements were non-detectable (LOD ranged from 3.0E−03 to 4.0 E−03 mg/m^3). However, Cardno ChemRisk (2020) provided full-shift area measurements in offices, control rooms, and rail tank area of a manufacturing facility (9 measurements total ranging from 1.2E−03 to 1.1E−02 mg/m^3), and these measurements are consistent with the range of PBZ measurements for ONUs (*i.e.*, 2.1E−03 to 1.0E−02 mg/m^3) from the NIOSH HHE conducted by Liss (1983). Therefore, the reduction in confidence from this limitation results in a weight of scientific evidence of moderate to robust for exposure estimates of ONUs. ***Import and Repackaging*** EPA did not identify exposure data from import and repackaging facilities. However, because worker activities at import and repackaging facilities are similar to those in manufacturing facilities (*e.g.*, loading, unloading, equipment cleaning, maintenance), EPA used surrogate inhalation monitoring data from manufacturing facilities to estimate exposures at import and repackaging facilities. Although inhalation exposure estimates for import and repackaging activities are based on the same high quality, discrete PBZ monitoring data as manufacturing, there is an additional limitation imposed by the use of surrogate data. Therefore, the confidence is reduced for each worker category, and the resulting weights of scientific evidence for exposure estimates are moderate to robust for equipment operators and maintenance workers and moderate for high exposure workers and ONUs.
Processing as a reactant;	For assessing inhalation exposures from phthalic anhydride processing, EPA used personal breathing zone (PBZ) air concentration data sourced from five occupational monitoring studies (Milford, 2018; Bookman, 2017; Griesenbrock, 2017; Rietz, 1985; Liss and

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
Incorporation into formulations, mixtures, or reaction products; Plastic compounding	Hartel, 1983). Reitz (1985) and Bookman (2017) reported data for high exposure activities (*i.e.*, bag handling), Griesenbrock (2017) and Milford (2018) reported data for equipment operations, and Liss (1983) reported data for equipment operations, maintenance workers, and ONUs including supervisors, instrument technicians, warehouse workers, and office engineers. All five data sources received high ratings from EPA's systematic review process. The primary strengths of this assessment are based on the underlying data used for inhalation exposure estimation. All data were gathered in phthalic anhydride processing facilities and reported as discrete PBZ monitoring measurements with most associated metadata such as sampling durations and worker activities, and these data received high data quality ratings. For data associated with equipment operators and maintenance workers, there were no factors identified that would lead to a reduction in confidence and the resulting weight of scientific evidence is robust for exposure estimates of equipment operators and maintenance workers. For data associated with high exposure workers, the primary limitation relates to the task-based monitoring durations (*i.e.*, 60–120 minutes rather than full-shift). However, the studies provided EPA with adequate data to develop confident full-shift exposure estimates, and the reduction in confidence from this limitation results in a weight of scientific evidence of moderate to robust for exposure estimates of high exposure workers. For data associated with ONUs (supervisors, instrument technicians, warehouse workers, and office engineers), the primary limitation is the high percentage of non-detectable data. There were 6 data measurements across the 4 ONU worker types, and 5 out of the 6 data measurements were non-detectable (LOD ranged from 3.0E−03 to 4.0E−03 mg/m^3). However, Cardno ChemRisk (2020) provided full-shift area measurements in offices, control rooms, and rail tank area of a manufacturing facility (9 measurements total ranging from 1.2E−03 to 1.1 E−02 mg/m^3), and these measurements are consistent with the range of PBZ measurements for ONUs (*i.e.*, 2.1E−03 to 1.0E−02 mg/m^3) from the NIOSH HHE conducted by Liss (1983). Therefore, the reduction in confidence from this limitation results in a weight of scientific evidence of moderate to robust for exposure estimates of ONUs.
Incorporation into formulations, mixtures, or reaction products (epoxy resin casting hardener)	For assessing inhalation exposures from the use of phthalic anhydride in epoxy resin casting operations, EPA used personal breathing zone (PBZ) air concentration data from the OSHA Chemical Exposure Health Data (CEHD) (OSHA, 2019), as well as an inhalation monitoring study from a countertop manufacturing facility (Tustin et al., 2022). Both data sources received high ratings from EPA's systematic review process. The primary strengths of this assessment are based on the underlying data used for inhalation exposure estimation. All data were gathered in epoxy resin casting facilities and reported as discrete PBZ monitoring measurements with most associated metadata such as sampling durations and worker activities, and these data received high data quality ratings. These data measurements were measured for workers within the casting operations department, so the results are applicable to workers in casting operation areas. Since there were no factors identified that would lead to a reduction in confidence, the resulting weight of scientific evidence is robust for exposure estimates of workers within epoxy resin casting operation areas. However, data were not available for inhalation exposure of ONUs, and EPA used central tendency estimates from worker inhalation monitoring data to estimate potential ONU inhalation exposure. Consequently, reduction in confidence from this limitation results in a weight of scientific evidence of moderate for inhalation exposure estimates of ONUs.
Plastic converting	For assessing inhalation exposures of phthalic anhydride from plastic converting, EPA used area concentration data sourced from two studies (Vainiotalo and Pfaffli, 1990; Pfaffli, 1986). Both data sources provided summary statistics and received medium ratings from EPA's systematic review process.

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	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). The primary limitation of these data is the uncertainty of the representativeness of full-shift exposure levels since some measurements were below 8 hours in duration. Furthermore, the best available phthalic anhydride-specific data relevant to plastic converting were provided as summary statistics of area monitoring data rather than discrete PBZ measurements. According to the *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994), discrete PBZ monitoring data are preferred over summary statistics and area monitoring data. Based on the strengths and limitations of the assessment, EPA concluded that the weight of scientific evidence is moderate for inhalation exposure estimates of workers. However, data were not available for inhalation exposure of ONUs, and EPA used central tendency estimates from worker inhalation monitoring data to estimate potential ONU inhalation exposure. Consequently, reduction in confidence from this limitation results in a weight of scientific evidence of slight to moderate for inhalation exposure estimates of ONUs.
Application of paints, coatings, adhesives, and sealants	***Non-Spray Application of Paints, Coatings, Adhesives, and Sealants*** For assessing inhalation exposures of phthalic anhydride from non-spray application of paints, coatings, adhesives, or sealants, EPA used area concentration data sourced from one study (Pfaffli, 1994). The data source provided summary statistics of 20 data points and received a high rating from EPA's systematic review process. 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 OELs. The primary limitation of these data is the uncertainty of the representativeness of full-shift exposure levels since measurements were below 8 hours in duration. Furthermore, the best available phthalic anhydride-specific data relevant to non-spray application of paints, coatings, adhesives, and sealants were provided as summary statistics of area monitoring data rather than discrete PBZ measurements. According to the *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994), discrete PBZ monitoring data are preferred over summary statistics and area monitoring data. Based on the strengths and limitations of the assessment, EPA concluded that the weight of scientific evidence is moderate for inhalation exposure estimates of workers. However, data were not available for inhalation exposure of ONUs, and EPA used central tendency estimates from worker inhalation monitoring data to estimate potential ONU inhalation exposure. Consequently, reduction in confidence from this limitation results in a weight of scientific evidence of slight to moderate for inhalation exposure estimates of ONUs. ***Spray Application of Paints, Coatings, and Epoxy Resins (Conventional, Airless, and Aerosol Spray)*** For inhalation exposure from spray application of paints, coatings, and epoxy resins, EPA used surrogate monitoring data from the ESD on Coating Application via Spray-Painting in the Automotive Refinishing Industry (OECD, 2011), which received a high rating from EPA's systematic review process. EPA also used SDSs and product data sheets from identified phthalic anhydride-containing paint and coating products to identify product concentrations. The strengths of the inhalation assessment include the availability of discrete, highly rated PBZ monitoring data that are use-specific, along with concentration data specific to products containing phthalic anhydride. The primary limitations of the assessment are the lack of phthalic anhydride-specific monitoring data and the representativeness of full-shift exposure levels. Data outlined in

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	the ESD on Coating Application via Spray-Painting in the Automotive Refinishing Industry are representative of mist levels that could be expected at a typical work site during spray applications, but the data are not specific to phthalic anhydride. Furthermore, the monitoring periods were less than 8 hours in duration. Therefore, based on the strengths and limitations of the assessment, EPA concluded that the weight of scientific evidence is moderate for inhalation exposure estimates of workers.
Use of laboratory chemicals	For assessing inhalation exposures of phthalic anhydride from the use of laboratory chemicals, EPA used PBZ air concentration data sourced from 2 studies (van Tongeren et al., 1995; Liss and Hartel, 1983). These studies received medium to high ratings from EPA's systematic review process. There were also summary statistics of PBZ monitoring data for laboratory workers from 19 full-shift measurements provided by van Tongeren (1995). The primary strengths of this assessment are based on the underlying data used for inhalation exposure estimation. All data were gathered in laboratory settings and reported as discrete PBZ monitoring measurements with most associated metadata such as sampling durations and worker activities, and these data received medium to high data quality ratings. The primary limitation of these data is the uncertainty of the representativeness of full-shift exposure levels since discrete PBZ measurements were below 8 hours in duration. Furthermore, there were only four discrete data measurements of laboratory workers provided by the available sources. However, the summary statistics of PBZ monitoring data for laboratory workers from 19 full-shift measurements provided by van Tongeren (1995) show agreement with the four discrete PBZ measurements used in inhalation exposure evaluation. Therefore, the uncertainties of the representativeness of full-shift exposure levels and limited number of discrete data measurements only yield a slight decrease in confidence. Based on the strengths and limitations of the assessment, EPA concluded that the weight of scientific evidence is moderate to robust for inhalation exposure estimates of workers. However, data were not available for inhalation exposure of ONUs, and EPA used central tendency estimates from worker inhalation monitoring data to estimate potential ONU inhalation exposure. Consequently, reduction in confidence from this limitation results in a weight of scientific evidence of moderate for inhalation exposure estimates of ONUs.
Use of lubricants and functional fluids	EPA did not identify any inhalation data specific to the use of lubricants and functional fluids containing phthalic anhydride. However, inhalation exposure from lubricants and functional fluids would be due to volatilization of phthalic anhydride, similar to scenarios of non-spray application of paints, coatings, adhesives, and sealants. Therefore, EPA has used monitoring data from the non-spray application of paints, coatings, adhesives, and sealants (Pfaffli, 1994) as surrogate data for estimating potential inhalation exposures from the use of lubricants and functional fluids. The sole data source provided area summary statistics of 20 data points and received a high rating from EPA's systematic review process. The primary strength of this approach is the use of chemical-specific monitoring data, which is preferrable to other assessment approaches, such as modeling or the use of OELs. However, there are a few uncertainties associated with the assessment. First, the data are not use-specific, and the use of surrogate data leads to uncertainty in the exposure estimates. Second, there is uncertainty in the representativeness of full-shift exposure levels since measurements were below 8 hours in duration. Lastly, data were provided as summary statistics of area monitoring data rather than discrete PBZ measurements. Based on the strengths and limitations of the assessment, EPA concluded that the weight of scientific evidence is moderate for inhalation exposure estimates of workers. However, data were not available for inhalation exposure of ONUs, and EPA used central tendency estimates from worker inhalation monitoring data to estimate potential ONU inhalation exposure. Consequently, reduction in confidence from this limitation results in a weight of scientific evidence of slight to moderate for inhalation exposure estimates of ONUs.

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
Fabrication or use of final products or articles	For assessing inhalation exposure during fabrication or use of final products or articles, EPA used PBZ air concentration data from three sources (OSHA, 2019; Pfaffli et al., 2002; Anas et al., 1990), as well as one additional source that specified the sampling methodology but did not specify whether area or PBZ sampling was used (Ramkissoon et al., 2023). Furthermore, there were two sources of area monitoring data (Vainiotalo and Pfaffli, 1990; Pfaffli, 1986) that are applicable to ONUs in the vicinity of fabrication activities. All data sources received medium or high ratings from EPA's systematic review process. 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 OELs. The primary limitation of these data is the uncertainty regarding the representativeness of full-shift exposure levels since all measurements were below 8 hours in duration. Also, there is uncertainty in the sampling methodology for data presented in Ramkissoon et al. (2023); however, the elevated levels measured during the fabrication of engineered stone indicate that measurements were taken in close proximity to the emission source. Regarding uncertainty in OSHA data, the exact worker activities represented by the discrete PBZ inhalation monitoring data are unclear. Although EPA has high confidence that the data are relevant for the fabrication or final use of products based on the NAICS codes associated with the reporting facilities, OSHA CEHD does not provide information such as worker activities or reason for monitoring. However, due to the elevated levels of the PBZ measurement by OSHA, it is likely that the worker handles the phthalic anhydride-containing materials directly. Therefore, this uncertainty does not significantly impact the level of confidence. Lastly, some worker PBZ data were reported with summary statistics, and the area monitoring data for ONUs were also reported with summary statistics. According to the *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994), discrete PBZ monitoring data are preferred over summary statistics and area monitoring data. Therefore, based on the strengths and limitations of the assessment, EPA concluded that the weight of scientific evidence is moderate for inhalation exposure estimates of workers and ONUs.
Disposal and recycling	EPA identified one source of data that quantified the inhalation exposure of phthalic anhydride during waste handling activities in a phthalic anhydride manufacturing and processing plant (Liss and Hartel, 1983), and these data were used for estimating the inhalation exposure of workers involved in disposal and recycling activities. There were four discrete PBZ monitoring data points presented for waste treatment and boiler operators, and all measurements were below the LOD of 4.0×10^{-3} mg/m^3. However, these data received a high rating from EPA's systematic review process. The primary strengths of this assessment are based on the underlying data used for inhalation exposure estimation. All data were gathered from waste treatment workers in phthalic anhydride manufacturing or processing facilities and reported as discrete PBZ monitoring measurements with all associated metadata such as sampling durations and worker activities, and these data received high data quality ratings. However, the inhalation exposure assessment contains some limitations. First, there are limited data for the OES, and all available data were below the LOD. Because concentrations of phthalic anhydride in waste streams are expected to be low, EPA does not expect significant levels of inhalation exposure from this OES. Nevertheless, inhalation exposure estimates are based on replacement of the LOD as described in the *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994), and this introduces uncertainty in the quantitative inhalation exposure estimates for the OES. Furthermore, there is additional uncertainty regarding the representativeness of full-shift exposure levels since some measurements were below 8 hours in duration. Based on the strengths and limitations of the assessment, EPA concluded that the weight of scientific evidence is moderate for inhalation exposure estimates of workers. However, data were not available for inhalation exposure of ONUs, and EPA used central

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	tendency estimates from worker inhalation monitoring data to estimate potential ONU inhalation exposure. Consequently, reduction in confidence from this limitation results in a weight of scientific evidence of slight to moderate for inhalation exposure estimates of ONUs.
Dermal exposures	EPA assessed dermal exposures (mg/cm^2) of solids containing phthalic anhydride, as well as liquid products containing phthalic anhydride, that a worker may experience for each OES. In order to estimate dermal exposures of phthalic anhydride from worker activities, EPA estimated the overall dermal loading of products from each OES as well as the concentration of phthalic anhydride in the products. For estimating product concentrations of phthalic anhydride, EPA relied on CDR reporting data and product SDS, which both provide highly reliable information regarding product concentration. All product SDS and CDR data received high ratings in EPA's systematic review process, and there are no significant limitations suggested by these data. ***Solids*** The dermal loading of solid materials was estimated using surrogate data from a study on industrial handling of calcium carbonate (Lansink et al., 1996). Specifically, Lansink et al. (1996) conducted an analysis of skin exposure to workers handling powdered calcium carbonate during a variety of activities including collection of the raw material (12 samples), handling of empty bags (14 samples), and manual dumping and mixing (19 samples). Dermal loading values were assessed using cotton gloves worn by the workers, which covered their hands and part of their forearms, to obtain estimates of skin exposure in units of milligrams per day. The study reported the minimum, maximum, geometric mean, and 90th percentile of skin exposure measurements for each activity, and the study received a high rating through EPA's systematic review process. The applicability of the activities from the Lansink et al. (1996) study is a strength in the dermal exposure assessment of solid materials to workers. The primary limitation is that there were only summary statistics available; however, the summary statistics provided a wide range of parameters to assist in understanding the data landscape for each use. Furthermore, these data were used to estimate potential levels of dermal exposure to ONUs with incidental contact on dusty surfaces, and there is uncertainty in the direct applicability of these data for scenarios of incidental contact. The strengths of the dermal exposure assessment to workers include the use of highly rated dermal loading data for applicable worker activities, as well as the use of highly rated concentration data for products containing phthalic anhydride. For solid material handling by workers, the only assessment limitation is related to the use of dermal loading summary statistics rather than discrete data. Furthermore, the surrogate use of worker exposure data for ONU incidental contact imposes additional uncertainty for exposures to ONUs experiencing incidental contact with dusty surfaces. Therefore, based on the strengths and limitations of the assessment, EPA concluded that the weights of scientific evidence for this assessment are moderate for worker exposures and slight to moderate for ONU exposures. ***Liquids*** The dermal loading of liquid materials was estimated using surrogate data from a study on dermal transfer of three different types of oil (*i.e.*, bath oil, mineral oil, and cooking oil) from handling saturated rags and also from full immersion (U.S. EPA, 1992b). Measurements from the handling of saturated rags are applicable to worker tasks such as product sampling, loading/unloading, and cleaning, and measurements from full immersion are applicable to scenarios of spray coating. There were 96 discrete measurements of dermal loading from rag handling and 144 discrete measurements of dermal loading from immersion. The main strength of these

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	data are the robust amount of data measured. However, the study limitations include the type of chemicals used as well as the type of activities investigated. This study received a high rating in EPA's systematic review process. The strengths of the dermal exposure assessment to workers include the use of highly rated dermal loading data for applicable worker activities, as well as the use of highly rated concentration data for products containing phthalic anhydride. The only limitations noted are related to the study of liquid chemical handling. Specifically, the type of liquid materials and activities investigated may introduce uncertainty when used for surrogate chemicals and uses. Therefore, based on the strengths and limitations of the assessment, EPA concluded that the weight of scientific evidence for this assessment is moderate for worker exposures. As described in Section 2.4.3, dermal exposure to liquid materials containing phthalic anhydride is not a route of concern for ONUs based on the use scenarios.

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APPENDICES

Appendix A PRODUCTS CONTAINING PHTHALIC ANHYDRIDE

This section includes a sample of products containing phthalic anhydride. This is not a comprehensive list of products containing phthalic anhydride. In addition, some manufacturers may appear over-represented in Table_Apx A-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.

3136 **Table_Apx A-1. Industrial and Commercial Products Containing Phthalic Anhydride**

Use	Product	Physical Form	Phthalic Anhydride Concentration	Application Method	Source (HERO ID)	SDS Year
Adhesive	Loctite 426 Instant Adhesive	Liquid	0.1–1%	Squeeze tube	6301570	2023
Adhesive	Loctite 435 Rubber Tough Instant Adhesive	Liquid	0.1–1%	Squeeze tube	6301583	2018
Adhesive (cyanoacrylate)	Loctite 4105	Liquid	0.1 to <1%	Squeeze tube	6301581	2023
Adhesive (cyanoacrylate)	Instantbond 120	Liquid	0.1–1% by weight	Squeeze tube	6301618	2020
Adhesive	Instantbond 122	Liquid	0.1–1% by weight	Squeeze tube	6301650	2016
Adhesive (temporary mounting)	Crystalbond 509-1, 509-2, 509-3	Solid resin	60.0–90.0%	Heat and apply to surface for adhesion	6301593	2023
Electronics encapsulant	Lord EP-809 Hardener (Part B)	Liquid	5–10%	Mix and apply	6301654	2017
Acrylic adhesive	VERSILOK 253S	Paste	0.1–0.9%	Caulk tube	12974720	2023
Sealant	3M Aerospace Sealant AC-770 B-2 Catalyst	Liquid	≤1% by weight	Mix and apply	10176505	2023
Primer	Harris Metal Primer Red	Liquid	1.0–10% by weight	Brush or aerosol spray	6301590	2025
Paints and coatings	T.O.V. Varnish	Liquid	10–25% by weight	Brush or aerosol spray	12905622	2025
Paints and coatings	T.O.V. Marine Clear Spar Varnish	Liquid	10–25% by weight	Brush	12905651	2025
Paints and coatings	Interlac 665 Vermelho Seg. 5R4/14	Liquid	1.0–10% by weight	Conventional or airless spray	6301649	2016
Indoor wood treatment	Junckers Rustic Oil, Clear	Liquid	<0.15%	Brush or roller	6301644	2023
Coating compound/surface coating/paint	Marine Finish Satin Sheen	Liquid	2.5–10%	Roller	12907681	2015

Use	Product	Physical Form	Phthalic Anhydride Concentration	Application Method	Source (HERO ID)	SDS Year
Coating compound/surface coating/paint	Original Marine Finish High Gloss	Liquid	2.5–10%	Roller	6584217	2015
Paints and coatings	Südwest Holz-Isolier-Grund	Liquid	≥0.1 to <1% by weight	Brush	6301595	2019
Processing	Phthalic Anhydride	Flaked solid	98–100%	Chemical intermediate	6301571	2019
Epoxy resin	AC-59	Liquid	1.0–10% by weight	Spray-up or Hand lay-up	6301580	2015
Resin for composites	EASYLAM LSE	Liquid	0.1 to <1% by weight	Spray-up or Hand lay-up	6301636	2023
Resin for composites (general purpose, marine, boats)	Norsodyne H 23100 TA	Liquid	<1% by weight	Spray-up or Hand lay-up	6301626	2016
Construction (roofing)	Crystic ROOF Resin	Liquid	≤0.3%	Roller	6301578	2018
Epoxy resin	CoolTherm EP-6029	Liquid	1–5%	Meter/mix/dispense	12974719	2020
Epoxy resin (for elevated temperature curing epoxy adhesive)	SEC1244 B	Liquid	0.1 to <0.5%	Hand lay-up	6301627	2023
Laboratory chemical	Custom 8270 Mix 1	Liquid	0.10%	Mix small amount	6301640	2017
Laboratory chemical	Phthalic Anhydride standard	Liquid	0.20%	Mix small amount	12974718	2015
Laboratory reference material	Semivolatile Mix, 1,000 µg/L in Methylene chloride	Liquid	<0.1%	Mix small amount	6301645	2017
Laboratory chemical	Phthalic Anhydride	Flaked solid	90–100%	Mix small amount	6301610	2025
Laboratory chemical	Phthalic Anhydride	Flaked solid	<100%	Mix small amount	6301605	2022

Appendix B PRODUCTION VOLUMES

B.1 Manufacturing

In the 2020 CDR, there were five domestic manufacturers of phthalic anhydride (CASRN 85-44-9) identified. Three sites with known identity (*i.e.,* Koppers [Cicero, Illinois], Exxon Mobil [Baton Rouge, Louisiana], and Huntsman [Houston, Texas]) reported domestic manufacture, one site with unknown identity reported domestic manufacture, and one site with known identity (*i.e.*, Stepan Company) reported activity as confidential business information (CBI) (U.S. EPA, 2020a). However, data reported to TRI (U.S. EPA, 2023b) indicate that the Stepan Company has manufactured phthalic anhydride at the Elwood, IL site as recently as 2023. Furthermore, TRI data from the years 2019 to 2023 indicate that there are additional sites where phthalic anhydride is manufactured as a byproduct (*i.e.*, BASF (Freeport, TX), Union Carbide (Hahnville, LA), Ascend Performance Materials (Cantonment, FL), and Ineos Joliet (Channahon, IL)) (U.S. EPA, 2023b). It is assumed that one of these additional sites is the CDR reporter that claimed CBI as their identity and that the other three facilities produce phthalic anhydride in quantities less than or equal to the TRI reporting threshold of 25,000 lb.

The 2020 CDR indicates that the national aggregate annual production volume (PV) of phthalic anhydride, including all domestic manufacturing and imports, may range from 250 million to 500 million lb (U.S. EPA, 2020a). In order to represent the known production capacity of each site, EPA used the highest reported annual PV of each site reporting to the 2020 CDR to estimate the total known annual PV of phthalic anhydride in the United States. The summation of the PVs for all manufacture and import sites that did not claim CBI for PV in the 2020 CDR is 235,340,075 lb. As mentioned in the paragraph above, it is also assumed that there are three additional manufacturing sites each producing phthalic anhydride at the TRI threshold of 25,000 lb. Therefore, the total known annual PV of phthalic anhydride is estimated as 235,415,075 lb. The difference between the national aggregate annual PV range and the total known annual PV leaves a remaining range of 14,584,925 to 264,584,924 lb of phthalic anhydride produced or imported, and it is assumed that this range is evenly divided among the 10 manufacture/import sites that claim PV as CBI to the 2020 CDR. Consequently, the range of production volumes associated with each manufacture or import site claiming PV as CBI is 1,458,493 to 26,458,492 lb. The table below provides a breakdown of the various manufacturers of phthalic anhydride and the associated production volumes for the 2020 CDR data.

Table_Apx B-1. Production Volume Data for Manufacturing

Company [a]	Claimed PV as CBI?	Number of Sites	Total Annual PV (lb/yr) [b]	Operating Days (day/yr) [c]	Concentration (%)	Physical Form
Koppers (Cicero, IL)	No	1	164,122,936	365	90–100	Liquid
CBI	No	1	32,096	Unknown	1–30	Powder
Exxon Mobil (Baton Rouge, LA)	Yes	1	1,458,493 26,458,492	364	90–100	Liquid
Huntsman (Houston, TX)	Yes	1	1,458,493 26,458,492	300	90–100	Liquid
Stepan Company (Elwood, IL)	Yes	1	1,458,493 26,458,492	365	CBI	CBI
Sites Under CDR Threshold	N/A	3	75,000	300–365	Unknown	Unknown

Company [a]	Claimed PV as CBI?	Number of Sites	Total Annual PV (lb/yr) [b]	Operating Days (day/yr) [c]	Concentration (%)	Physical Form
Total	3	8	168,605,511 243,605,508	300–365	90–100 (mode)	Liquid or powder

[a] There were 8 total sites reporting manufacturing in TRI years 2019–2023 (*i.e.*, Koppers (Cicero, IL), Exxon Mobil (Baton Rouge, LA), Huntsman (Houston, TX), Stepan Company (Elwood, IL), BASF (Freeport, TX), Union Carbide (Hahnville, LA), Ascend Performance Materials (Cantonment, FL), and Ineos Joliet (Channahon, IL)), and there are 5 total sites reporting to the 2020 CDR. Therefore, it is assumed that there could be 3 manufacturing sites under the CDR threshold of 25,000 lb.
[b] The highest PVs reported to the 2020 CDR were considered for each site in order to represent known production capacities. The difference between the national aggregate annual PV range and the total known annual PV was divided evenly among manufacturing/import sites claiming PV as CBI.
[c] Manufacturing sites without detailed information on operation schedule were assumed to operate 6 days/week, 50 weeks/year.

B.2 Import and Repackaging

In the 2020 CDR, there were 28 importers of phthalic anhydride (CASRN 85-44-9) identified. Four sites listed their activity as either CBI (*i.e.*, Shrieve Chemical Company (Spring, TX)) or "Unknown" (*i.e.*, Stepan Company (Wilmington, NC), Polynt Composites USA (Ennis, TX), Polynt Composites USA (Chatham, VA)) in the 2020 CDR. Shrieve Chemical Company lists their NAICS code as Wholesale Merchants, and there is no indication that the company manufactures phthalic anhydride. Therefore, it was assumed that Shrieve Chemical Company is an importer of the chemical based on the 2020 CDR data. Stepan Company listed their location as CBI; however, the company reports two locations in TRI (U.S. EPA, 2023b), and one of the sites is a manufacturing site in Elwood, IL. Therefore, it was assumed the other site reporting releases of phthalic anhydride by Stepan Company in Wilmington, NC is an importer of the product. The two Polynt Composite sites report NAICS codes related to plastic material and resin manufacturing, so it was assumed that these sites import phthalic anhydride for purposes of plastic material and resin manufacturing. With exception of the four sites mentioned above, the remaining sites reported import of phthalic anhydride in the 2020 CDR (U.S. EPA, 2020a).

The 2020 CDR indicates that the national aggregate annual production volume (PV) of phthalic anhydride, including all domestic manufacturing and imports, may range from 250 million to 500 million lb (U.S. EPA, 2020a). In order to represent the known production capacity of each site, EPA used the highest reported annual PV of each site reporting to the 2020 CDR to estimate the total known annual PV of phthalic anhydride in the United States. The summation of the PVs for all manufacture and import sites that did not claim CBI for PV in the 2020 CDR is 235,340,075 lb. As mentioned in Appendix B.1, it is also assumed that there are three additional manufacturing sites each producing phthalic anhydride at the TRI threshold of 25,000 lb. Therefore, the total known annual PV of phthalic anhydride is estimated as 235,415,075 lb. The difference between the national aggregate annual PV range and the total known annual PV leaves a remaining range of 14,584,925 to 264,584,924 lb of phthalic anhydride produced or imported, and it is assumed that this range is evenly divided among the 10 manufacture/import sites that claim PV as CBI to the 2020 CDR. Consequently, the range of production volumes associated with each manufacture or import site claiming PV as CBI is 1,458,493 to 26,458,492 lb. The table below provides a breakdown of the various importers of phthalic anhydride and the associated production volumes for the 2020 CDR data.

3202 **Table_Apx B-2. Production Volume Data for Import and Repackaging**

Company	Claimed PV as CBI?	Import at Site?	Number of Sites [a]	Total Annual PV (lb/yr) [b]	Conc. (%)	Physical Form
Allnex USA (Alpharetta, GA)	No	No	1–4	785,016	90–100	Liquid
COIM USA (West Deptford, NJ)	No	Yes	1	14,362,983	90–100	Dry Powder
Alphagary Corporation (Leominster, MA)	No	No	1	855,438	90–100	Dry Powder
Pioneer Plastics Corporation (Auburn, ME)	No	Yes	1	376,983	90–100	Dry Powder
Polynt Composites USA (Houston, TX)	No	Yes	1	8,165,820	90–100	Dry Powder
Polynt Composites USA (Forest Park, GA)	No	Yes	1	21,160,604	90–100	Dry Powder
Polynt Composites USA (Carpentersville, IL)	No	Yes	1	1,035,880	90–100	Other Solid
Polynt Composites USA (Ennis, TX)	No	No	1	376,884	Unknown	Unknown
Polynt Composites USA (Chatham, VA)	No	Unknown	1	251,256	Unknown	Unknown
Reichhold LLC 2 (Azusa, CA)	No	Yes	1	3,059,605	90–100	Liquid
Reichhold LLC 2 (Valley Park, MO)	No	Yes	1	2,473,647	90–100	Other Solid
Reichhold LLC 2 (Pensacola, FL)	No	Yes	1	2,214,132	90–100	Other Solid
Reichhold LLC 2 (Jacksonville, FL)	No	Yes	1	41,881	90–100	Other Solid
Reichhold LLC 2 (Morris, IL)	No	Unknown	1	44,091	Unknown	Unknown
Reterra (Houston, TX)	No	Yes	1	5,331,574	90–100	Liquid
Soyventis North America LLC (Fairfield, NJ)	No	No	1	8,105,359	Unknown	Dry Powder
Chempoint (Bellevue, WA)	No	No	1	25,632	Unknown	Dry powder
Lanxess Corporation (Pittsburgh, PA)	No	No	1–3	174,769	90–100	Dry Powder, Other Solid
Colonial Chemical Solutions (Savannah, GA)	No	Unknown	1	209,437	Unknown	Unknown
FRP Services & Co.	No	Unknown	1	502,648	Unknown	Unknown

Company	Claimed PV as CBI?	Import at Site?	Number of Sites [a]	Total Annual PV (lb/yr) [b]	Conc. (%)	Physical Form
(New York, NY)						
Mitsui & Co. (Houston, TX)	No	Unknown	1	1,631,404	Unknown	Unknown
Shrieve Chemical Company (Spring, TX)	Yes	Unknown	1	1,458,493 26,458,492	90–100	Other Solid
Huntsman Corporation (Woodlands, TX)	Yes	No	1	1,458,493 26,458,492	30–60	Pellets, Large Crystals, Liquid
ICC Chemical Corporation (New York, NY)	Yes	No	1	1,458,493 26,458,492	90–100	Pellets or Large Crystals
Posco International (Teaneck, NJ)	Yes	No	1	1,458,493 26,458,492	90–100	Pellets or Large Crystals
The Chemical Company (Jamestown, RI)	Yes	No	1	1,458,493 26,458,492	90–100	Other Solid
Stepan Company (Wilmington, NC)	Yes	Unknown	1	1,458,493 26,458,492	Unknown	Unknown
The Sherwin-Williams Company (Cleveland, OH)	Yes	No	1–5	1,458,493 26,458,492	<1	Liquid
Total	7	10	28–37	81,394,491 256,394,490	90–100 (mode)	Pellets, Crystals, Powder, or Liquid

[a] If the entire chemical PV is imported and used on site, it was assumed that only 1 site is importing the whole PV. However, if it is noted that the chemical is never imported by the reporting entity, it was assumed that the imports occur at 1 unknown site. If there was no indication of the number of import sites, it was assumed that there must be at least 1 import site. Sherwin-Williams reports 5 sites to TRI/NEI, Allnex reports 4 sites to TRI/NEI, and Lanxess reports 3 sites to TRI/NEI.
[b] The highest PVs reported to the 2020 CDR were considered for each site in order to represent known production capacities. The difference between the national aggregate annual PV range and the total known annual PV was divided evenly among manufacturing/import sites claiming PV as CBI.

3203

B.3 Processing as a Reactant

In the 2020 CDR, there were seven companies identified that manufactured or imported phthalic anhydride for the purposes of processing the chemical as a reactant (*i.e.*, Shrieve Chemical Company (Spring, TX), Koppers (Cicero, IL), Exxon Mobil (Baton Rouge, LA), Huntsman (Houston, TX), Stepan Company (Elwood, IL and Wilmington, NC), Posco International (Teaneck, NJ), and The Sherwin-Williams Company (Cleveland, OH)). Sherwin-Williams did not report any identifying information other than NAICS codes, which were related to paint and coating manufacturing. Therefore, it was assumed that the PV associated with Sherwin-Williams was used a reactant based on TRI reporting (U.S. EPA, 2023b). Stepan Company listed their two reporting locations, both associated with processing phthalic anhydride as a reactant, as CBI in the 2020 CDR. However, the company reports two locations in TRI, and it was assumed that these two locations are manufacturing (Elwood, IL) and importing (Wilmington, NC) phthalic anhydride for the purposes of processing the chemical as a reactant (U.S. EPA, 2020a).

The companies listed in the table below reported downstream processing of phthalic anhydride as a reactant in the 2020 CDR. The PVs from the 2020 CDR associated with companies that manufacture or import phthalic anhydride shown in Appendices B.1 and B.2, respectively, were used to determine the PVs associated with companies that manufacture or import phthalic anhydride for the purpose of processing the chemical as a reactant. The number of sites shown in the table below are based on the reported number of downstream processing facilities by each company in the 2020 CDR (U.S. EPA, 2020a).

Table_Apx B-3. Production Volume Data for Processing as a Reactant

Company	Total Annual PV (lb/yr)	Number of Processing Sites	Concentration (%)	Physical Form
Koppers [a] (Cicero, IL)	65,649,174	2–18	90–100	Liquid
Exxon Mobil [b] (Baton Rouge, LA)	1,458,493 26,458,492	1–9	90–100	Liquid
Huntsman [c] (Houston, TX)	636,409 25,636,408	100–249	90–100	Liquid
Stepan Company [d] (Elwood, IL)	583,397 10,583,397	1–9	CBI	CBI
Stepan Company [d] (Wilmington, NC)	583,397 10,583,397	1–9	Unknown	Unknown
The Sherwin-Williams Company [e] (Cleveland, OH)	1,458,493 26,458,492	1–9	< 1	Liquid
Posco International [f] (Teaneck, NJ)	1,458,493 26,458,492	1–9	90–100	Pellets or Large Crystals
Shrieve Chemical Company [g] (Spring, TX)	486,164 8,819,497	1–9	90–100	Other Solid
Total	72,314,019 200,647,351	108–321	90–100 (mode)	Pellets, Crystals, Powder, or Liquid

Company	Total Annual PV (lb/yr)	Number of Processing Sites	Concentration (%)	Physical Form

[a] Koppers reported a maximum annual PV of 164,122,936 lb to the 2020 CDR, where 30% of the PV was processed into synthetic dye and pigments, 10% of the PV was processed into printing ink, and 60% of the PV was processed into plastic products. Synthetic dye and pigment manufacturing and printing ink manufacturing are associated with the "Processing as a reactant" OES, and processing into plastic products is associated with the "Plastic compounding" OES. Koppers reported <10 downstream processing sites associated with synthetic dye and pigment manufacturing, and <10 downstream processing sites associated with printing ink manufacturing in the 2020 CDR.
[b] Exxon Mobil reported PV as CBI to the 2020 CDR, and therefore, PV was calculated as described in Appendix B.1. The number of downstream processing sites was reported as <10 sites to the 2020 CDR, and the entire PV was intended for other basic organic chemical manufacturing.
[c] Huntsman (Houston, TX) reported PV as CBI to the 2020 CDR, and therefore, PV was calculated as described in Appendix B.1. However, Huntsman also reported maximum annual exports in the quantity of 822,084 lb, so the PV related to processing is the difference of the manufactured PV and the exported PV. Huntsman reported 100–249 downstream processing sites, and the entire PV was intended for other basic organic chemical manufacturing.
[d] Stepan Company reported PV as CBI to the 2020 CDR, and therefore, PV was calculated as described in Appendix B.1. Also, Stepan Company reported five different processing uses from 2 CBI entities, and therefore, it was assumed that the entire PV from the two CBI entities was divided evenly among the 5 reported processing uses. There were 2 processing activities reported as processing as a reactant to the 2020 CDR by Stepan Company. The numbers of downstream processing sites were not reported, and it was assumed that there were <10 downstream processing sites are associated with each processing activity. The entire PV associated with processing as a reactant was intended for other basic organic chemical manufacturing.
[e] The Sherwin-Williams Company reported PV as CBI to the 2020 CDR, and therefore, PV was calculated as described in Appendix B.2. The number of downstream processing sites was not reported, and it was assumed that there were <10 downstream processing sites. The entire PV was associated with paint and coating product manufacturing.
[f] Posco International reported PV as CBI to the 2020 CDR, and therefore, PV was calculated as described in Appendix B.2. The number of downstream processing sites was not reported, and it was assumed that there were <10 downstream processing sites. The entire PV was associated with adhesive product manufacturing.
[g] Shrieve Chemical Company reported PV as CBI to the 2020 CDR, and therefore, PV was calculated as described in Appendix B.2. Also, Shrieve Chemical Company reported 3 different processing uses, and therefore, it was assumed that the entire PV from Shrieve Chemical Company was divided evenly among the 3 reported processing uses. There was 1 processing activity reported as processing as a reactant to the 2020 CDR by Shrieve Chemical Company. The numbers of downstream processing sites were not reported, and it was assumed that there were <10 downstream processing sites associated with the activity. The entire PV associated with processing as a reactant was intended for paint and coating product manufacturing.

B.4 Incorporation into Formulations, Mixtures, or Reaction Products

In the 2020 CDR, there were seven companies identified that manufactured or imported phthalic anhydride for the purposes of incorporation into formulations, mixtures, or reaction products (*i.e.*, Shrieve Chemical Company [Spring, Texas], Huntsman [The Woodlands, Texas]), Stepan Company [Elwood, Illinois, or Wilmington, North Carolina], Chempoint [Bellevue, Washington], COIM USA [West Deptford, New Jersey], Lanxess Corporation [Pittsburgh, Pennsylvania], and one site claiming identity as CBI). Stepan Company listed one activity related to incorporation into formulations, mixtures, or reaction products, but the site identity was claimed as CBI. However, Stepan Company reports two locations in TRI (U.S. EPA, 2023b), and it was assumed that one of these two locations (*i.e.*, Elwood, Illinois, or Wilmington, North Carolina) are associated with the reported activity (U.S. EPA, 2020a).

The companies listed in the table below reported incorporation of phthalic anhydride into formulations, mixtures, or reaction products in the 2020 CDR. The PVs from the 2020 CDR associated with companies that manufacture or import phthalic anhydride shown in Appendices B.1 and B.2, respectively, were used to determine the PVs associated with companies that manufacture or import phthalic anhydride for the purpose of incorporating the chemical into formulations, mixtures, or reaction products. The number of sites shown in the table below are based on the reported number of downstream processing facilities by each company in the 2020 CDR (U.S. EPA, 2020a).

Table_Apx B-4. Production Volume Data for Incorporation into Formulations, Mixtures, or Reaction Products

Company	Total Annual PV (lb/yr)	Number of Processing Sites	Concentration (%)	Physical Form
CBI [a]	32,096	25–99	1–30	Dry Powder
COIM USA [b] (West Deptford, NJ)	14,362,983	1–9	90–100	Dry Powder
Lanxess Corporation [c] (Pittsburgh, PA)	3,477	1–9	90–100	Dry Powder, Other Solid
Chempoint [d] (Bellevue, WA)	25,632	2–18	Unknown	Dry Powder
Huntsman [e] (The Woodlands, TX)	1,458,493 26,458,492	2–18	30–60	Pellets or Large Crystals
Stepan Company [f] (Elwood, IL or Wilmington, NC)	583,397 10,583,397	1–9	Unknown	Unknown
Shrieve Chemical Company [g] (Spring, TX)	972,328 17,638,995	2–18	90–100	Other Solid
Total	17,438,406 69,105,072	34–180	90–100 (mode)	Dry Powder, Other Solid, Pellets, or Large Crystals

[a] One site reported identity as CBI but indicated there are 25–99 downstream processing sites and that the chemical is handled in dry powder form with concentrations of 1–30%. The entire PV is associated with paint and coating manufacturing.
[b] COIM USA reported a maximum annual PV of 14,362,983 lb with <10downstream processing sites and that the material is handled in dry powder form with concentrations 90–100%. The entire PV is associated with other organic chemical manufacturing.
[c] Lanxess Corporation reported 2% of their total import volume, excluding 910 lb of reported exports, is intended for use in rubber manufacturing, and the remaining 98% is used for plastic compounding (captured in "Plastic compounding" OES). Lanxess reported downstream processing sites, dry powder material form, and concentrations of 90–100%.
[d] Chempoint reported 2 incorporative activities to the 2020 CDR totaling 25,632 lb. Each activity was reported with <10 downstream processing sites, unknown concentration, and a dry powder material form. Chempoint reported 2% of their total import volume reported to the 2020 CDR is intended as a hardener for use in rubber manufacturing and the remaining 98% is intended as a hardener for adhesive manufacturing.
[e] Huntsman (The Woodlands, TX) reported 2 incorporative activities with PV claimed as CBI. However, the total PV for Huntsman (The Woodlands, TX) was calculated as described in Appendix B.2. Each activity was reported with <10 downstream processing sites with concentrations of 30–60% and material form in pellets or large crystals. Huntsman reported 2% of their total import volume reported to the 2020 CDR is intended for use in utilities and the remaining 98% is intended for use in other inorganic chemical manufacturing.
[f] Stepan Company reported PV as CBI to the 2020 CDR, and therefore, PV was calculated as described in Appendix B.1. Also, Stepan Company reported 5 different processing uses from two CBI entities, and therefore, it was assumed that the entire PV from the 2 CBI entities was divided evenly among the five reported processing uses. There was 1 processing use reported by Stepan Company without an industrial sector description, and it was assumed that the processing activity is related to incorporation into formulations, mixtures, or reaction products. The

Company	Total Annual PV (lb/yr)	Number of Processing Sites	Concentration (%)	Physical Form

numbers of downstream processing sites were not reported, and it was assumed that there were <10 downstream processing sites associated with the incorporative use.
[g] Shrieve Chemical Company reported PV as CBI to the 2020 CDR, and therefore, PV was calculated as described in Appendix B.2. Also, Shrieve Chemical Company reported 3 different processing uses, and therefore, it was assumed that the entire PV from was divided evenly among the 3 reported processing uses. Shrieve Chemical Company reported 2 activities as incorporation into formulations, mixtures, or reaction products. The numbers of downstream processing sites were not reported, and it was assumed that there were <10 downstream processing sites associated with both activities reported as incorporation into formulations, mixtures, or reaction products. The entire PV associated with the 2 incorporative activities reported by Shrieve Chemical Company are related to paint and coating manufacturing.

B.5 Plastic Compounding

In the 2020 CDR, there were 11 companies identified that manufactured or imported phthalic anhydride for the purposes of plastic compounding (*i.e.*, Koppers [Cicero, Illinois], Alphagary Corp. [Leominster, Massachusetts], Allnex USA [Alpharetta, Georgia], ICC Chemical Company [New York, New York], Lanxess Corp. [Pittsburgh, Pennsylvania], Pioneer Plastics Corp. [Auburn, Maine], Polynt Composites USA [Houston, Texas; Forest Park, Georgia; Carpentersville, Illinois; Ennis, Texas; Chatham, Virginia]), Reichhold LLC 2 [Azusa, California; Valley Park, Missouri; Pensacola, Florida; Jacksonville, Florida; Morris, Illinois], Reterra [Houston, Texas], The Chemical Company [Jamestown, Rhode Island]), and Stepan Company (Elwood, Illinois, and Wilmington, North Carolina]. Stepan Company listed their two reporting locations, both associated with plastic compounding, as CBI in the 2020 CDR. However, the company reports two locations in TRI (U.S. EPA, 2023b), and it was assumed that these two locations are manufacturing (Elwood, IL) and importing (Wilmington, NC) phthalic anhydride for the purposes of plastic compounding (U.S. EPA, 2020a).

The companies listed in the table below reported plastic compounding activities in the 2020 CDR. The PVs from the 2020 CDR associated with companies that manufacture or import phthalic anhydride shown in Appendices B.1 and B.2, respectively, were used to determine the PVs associated with companies that manufacture or import phthalic anhydride for the purpose of plastic compounding. The number of sites shown in the table below are based on the reported number of downstream processing facilities by each company in the 2020 CDR (U.S. EPA, 2020a).

Table_Apx B-5. Production Volume Data for Plastic Compounding

Company	Total Annual PV (lb/yr)	Number of Processing Sites	Concentration (%)	Physical Form
Allnex USA [a] (Alpharetta, GA)	785,016	1–9	90–100	Liquid
Koppers [b] (Cicero, IL)	98,473,762	10–24	90–100	Liquid
Alphagary Corporation [c] (Leominster, MA)	855,438	1–9	90–100	Dry Powder
Pioneer Plastics Corporation [d] (Auburn, ME)	376,983	1	90–100	Dry Powder
Polynt Composites USA [e] (Houston, TX)	8,165,820	1	90–100	Dry Powder

Company	Total Annual PV (lb/yr)	Number of Processing Sites	Concentration (%)	Physical Form
Polynt Composites USA [e] (Forest Park, GA)	21,160,604	1	90–100	Dry Powder
Polynt Composites USA [e] (Carpentersville, IL)	1,035,880	1	90–100	Other Solid
Polynt Composites USA [f] (Ennis, TX)	376,884	10–24	Unknown	Unknown
Polynt Composites USA [f] (Chatham, VA)	251,256	10–24	Unknown	Unknown
Reichhold LLC 2 [g] (Azusa, CA)	3,059,605	1	90–100	Liquid
Reichhold LLC 2 [g] (Valley Park, MO)	2,473,647	1	90–100	Other Solid
Reichhold LLC 2 [g] (Pensacola, FL)	2,214,132	1	90–100	Other Solid
Reichhold LLC 2 [g] (Jacksonville, FL)	41,881	1	90–100	Other Solid
Reichhold LLC 2 [h] (Morris, IL)	44,091	1–9	Unknown	Unknown
Reterra [i] (Houston, TX)	5,331,574	1	90–100	Liquid
Lanxess Corporation [j] (Pittsburgh, PA)	170,382	1–9	90–100	Dry Powder, Other Solid
ICC Chemical Corporation [k] (New York, NY)	1,458,493 26,458,492	1–9	90–100	Pellets or Large Crystals
The Chemical Company [l] (Jamestown, RI)	1,458,493 26,458,492	1–9	90–100	Other Solid
Stepan Company [m] (Elwood, IL)	583,397 10,583,397	1–9	CBI	CBI
Stepan Company [m] (Wilmington, NC)	583,397 10,583,397	1–9	CBI	CBI
Total	148,900,733 218,900,733	47–153	90–100 (mode)	Dry Powder, Other Solid, Pellets, Large Crystals, or Liquid

[a] Allnex USA reported a maximum annual PV of 785,016 lb to the 2020 CDR, and the entire PV was intended for plastic compounding activities. Allnex USA reported <10 sites for plastic compounding and liquid material type with concentrations 90–100%.
[b] Koppers reported a maximum annual PV of 164,122,936 lb to the 2020 CDR, where 30% of the PV was processed into synthetic dye and pigments, 10% of the PV was processed into printing ink, and 60% of the PV was processed into plastic products. Synthetic dye and pigment manufacturing and printing ink manufacturing are associated with the "Processing as a reactant" OES, and processing into plastic products is associated with the "Plastic compounding" OES. Koppers reported 10–24 processing sites associated with plastic compounding in the 2020 CDR, with a liquid material type and concentrations 90–100%.
[c] Alphagary Corporation reported a maximum annual PV of 855,438 lb associated with plastic compounding, <10 plastic compounding sites, and dry powder material type with concentrations 90–100%.

Company	Total Annual PV (lb/yr)	Number of Processing Sites	Concentration (%)	Physical Form

[d] Pioneer Plastics Corporation reported a maximum annual PV of 376,983 lb to the 2020 CDR associated with plastic compounding, and the entire PV was used on-site; therefore, it was assumed that all plastic compounding of the reported PV occurred on-site. Pioneer Plastic Corporation also reported use of the dry powder material with concentrations of 90–100%.

[e] Polynt Composites USA (Houston, TX; Forest Park, GA; Carpentersville, IL) reported maximum annual PVs of 8,165,820 lb; 21,160,604 lb; and 1,035,880 lb to the 2020 CDR, respectively, associated with plastic compounding. Each site reported processing of the entire PV on-site; therefore, it was assumed that all plastic compounding of the reported PV occurred on-site. These 3 Polynt sites also reported use of dry powder or other solid material with concentrations of 90–100%.

[f] Polynt Composites USA (Ennis, TX and Chatham, VA) reported maximum annual PVs of 376,884 lb and 251,256 lb to the 2020 CDR, respectively, associated with plastic compounding. These 2 Polynt sites reported 10–24 plastic compounding facilities each, and both sites reported unknown concentrations and physical forms.

[g] Reichhold LLC 2 (Azusa, CA; Valley Park, MO; Pensacola, FL; Jacksonville, FL) reported maximum annual PVs of 3,059,605 lb; 2,473,647 lb; 2,214,132 lb; and 41,881 lb to the 2020 CDR, respectively, associated with plastic compounding. Each site reported processing of the entire PV on-site; therefore, it was assumed that all plastic compounding of the reported PV occurred on-site. These 4 Reichhold sites also reported use of other solid or liquid material with concentrations of 90–100%.

[h] Reichhold LLC 2 (Morris, IL) reported a maximum annual PV of 44,091 lb to the 2020 CDR with unknown use. Therefore, it was assumed the PV is associated with plastic compounding based on the other reporting sites from Reichhold LLC 2. Also, this Reichhold site did not report number of sites, and it was assumed that there were <10 plastic compounding facilities associated with the PV.

[i] Reterra reported a maximum annual PV of 5,331,574 lb to the 2020 CDR, and the entire PV was intended for plastic compounding. This site reported processing of the entire PV on-site; therefore, it was assumed that all plastic compounding of the reported PV occurred on-site. It was also reported that the material is used in liquid form with concentrations 90–100%.

[j] Lanxess reported that 98% of their annual PV, excluding 910 lb of reported exports, is associated with plastic compounding to the 2020 CDR. Also, it was reported that the chemical is used by <10 plastic compounding facilities in dry powder or other solid form with concentrations 90–100%.

[k] ICC Chemical Corporation reported annual PV as CBI to the 2020 CDR, and the entire PV was associated with plastic compounding. Therefore, annual PV was calculated as described in Appendix B.2. Also, it was reported that the chemical is used by <10 plastic compounding facilities in pellet or crystal form with concentrations 90–100%.

[l] The Chemical Company reported annual PV as CBI to the 2020 CDR, and the entire PV was associated with plastic compounding. Therefore, annual PV was calculated as described in Appendix B.2. The number of plastic compounding facilities was not reported to the 2020 CDR, and it was assumed that the chemical is used by <10 plastic compounding facilities. The chemical is used in solid form with concentration 90–100%.

[m] Stepan Company reported PV as CBI to the 2020 CDR, and therefore, PV was calculated as described in Appendix B.1. Also, Stepan Company reported 5 different processing uses from two CBI entities, and therefore, it was assumed that the entire PV from the 2 CBI entities was divided evenly among the 5 reported processing uses. There were two plastic compounding activities reported to the 2020 CDR by Stepan Company. The numbers of downstream processing sites were not reported, and it was assumed that there were <10 downstream processing sites are associated with each plastic compounding activity.

B.6 Plastic Converting

When phthalic anhydride is processed into plastic or resin material through the plastic compounding process, the chemical generally functions as a monomer and is largely consumed in reaction to form other plasticizers. The remaining phthalic anhydride in plastic material and resin may range from 0.1 – 10%, but generally EPA assumed that 1% may exist in the final plastic material. For estimating the PV of phthalic anhydride that is converted to plastic products, and the number facilities converting materials containing phthalic anhydride, EPA used data from the 2020 CDR (U.S. EPA, 2020a) for entities reporting plastic material and resin manufacturing or plastic product manufacturing. It was assumed that each industrial site downstream of the compounding facility was involved in converting the phthalic anhydride-containing plastic material into a final product. The table below shows each compounding facility, the total PV compounded, the total PV converted after reactive compounding, and the number of downstream converting sites that may be handling compounded plastic material containing phthalic anhydride.

Table_Apx B-6. Production Volume Data for Plastic Converting

Company [a]	Annual PV Compounded [b] (lb/yr)	Annual PV Converted (After Compounding) [c] (lb/yr)	Number of Converting Sites [d]
Allnex USA (Alpharetta, GA)	785,016	7,850	1–9
Koppers (Cicero, IL)	98,473,762	984,738	10–24
Alphagary Corporation (Leominster, MA)	855,438	8,554	1–9
Pioneer Plastics Corporation (Auburn, ME)	376,983	3,770	1–9
Polynt Composites USA (Houston, TX)	8,165,820	81,658	10–24
Polynt Composites USA (Forest Park, GA)	21,160,604	211,606	10–24
Polynt Composites USA (Carpentersville, IL)	1,035,880	10,359	1–9
Polynt Composites USA (Ennis, TX)	376,884	3,769	10–24
Polynt Composites USA (Chatham, VA)	251,256	2,513	10–24
Reichhold LLC 2 (Azusa, CA)	3,059,605	30,596	10–24
Reichhold LLC 2 (Valley Park, MO)	2,473,647	24,736	10–24
Reichhold LLC 2 (Pensacola, FL)	2,214,132	22,141	10–24
Reichhold LLC 2 (Jacksonville, FL)	41,881	419	10–24
Reichhold LLC 2 (Morris, IL)	44,091	441	1–9
Reterra (Houston, TX)	5,331,574	53,316	10–24
Lanxess Corporation (Pittsburgh, PA)	170,382	1,704	1–9
ICC Chemical Corporation (New York, NY)	1,458,493	14,585	1–9
	26,458,492	264,585	
The Chemical Company (Jamestown, RI)	1,458,493	14,585	1–9
	26,458,492	264,585	
Stepan Company (Elwood, IL)	583,397	5,834	1–9
	10,583,397	105,834	
Stepan Company (Wilmington, NC)	583,397	5,834	1–9
	10,583,397	105,834	
Total	148,900,733	1,489,007	110–330
	218,900,733	2,189,007	

[a] Companies listed plastic compounding activities in the 2020 CDR.
[b] Maximum annual PVs associated with plastic compounding for each company reporting to the 2020 CDR. If PV was claimed as CBI to the 2020 CDR, then PV was calculated as described in Appendices B.1 and B.2.
[c] It was assumed that phthalic anhydride is largely consumed in reaction to create plasticizers, and that 1% of the compounded PV may exist in the final plastic material.
[d] Number of downstream industrial processing sites reported to the 2020 CDR. If a company reported processing the entire PV on-site, it was assumed that the material was compounded on-site and then distributed to downstream

Company [a]	Annual PV Compounded [b] (lb/yr)	Annual PV Converted (After Compounding) [c] (lb/yr)	Number of Converting Sites [d]
industrial sites for converting. If a site did not report the number of downstream industrial sites to the 2020 CDR, it was assumed that there were <10 downstream processing facilities associated with the PV.			

B.7 Application of Paints, Coatings, Adhesives, and Sealants

CDR provides information regarding manufacturing and processing of a chemical, but information regarding downstream production volume of specific industrial and commercial uses is limited. Consequently, production volume of paints, coatings, adhesives, and sealants containing phthalic anhydride was estimated based on companies that reported the incorporation of phthalic anhydride into formulations, mixtures, or reaction products. More specifically, for companies that reported their use of phthalic anhydride as incorporative and also reported downstream use of paints, coatings, adhesives, or sealants, it was assumed that 10% of their production volume exists in the final paint, coating, adhesive, or sealant product since phthalic anhydride is known to largely react during processing. Also, for any company that reported their use of phthalic anhydride as incorporative and the exact use was uncertain, or if a company reported import without a known use, it was assumed that the company may be using up to 25,000 pounds of phthalic anhydride since this is the threshold value at which a company would be required to specify a particular use. The table below provides a breakdown of PVs by company, as reported or estimated based on the 2020 CDR, that may exist in final paint, coating, adhesive, and sealant products (U.S. EPA, 2020a).

Table_Apx B-7. Production Volume Data for Application of Paints, Coatings, Adhesives, and Sealants

Company	Annual PV (lb/yr) [a]	Incorporative Use	PV in Final Product (lb/yr) [b]
CBI	32,096	Paint and coating manufacturing	3,210
COIM USA (West Deptford, NJ)	14,362,983	Adhesive manufacturing	1,436,298
Chempoint [c] (Bellevue, WA)	25,632	Adhesive manufacturing	2,512
Huntsman (The Woodlands, TX)	1,458,493 26,458,492	All other basic organic chemical manufacturing	25,000
Stepan Company (Elwood, IL or Wilmington, NC)	583,397 10,583,397	CBI	25,000
Shrieve Chemical Company (Spring, TX)	972,328 17,638,995	Paint and coating manufacturing	1,763,899
Colonial Chemical Solutions (Savannah, GA)	209,437	Other chemical and allied products merchant wholesalers	25,000
FRP Services & Co. (New York, NY)	502,648		25,000
Mitsui & Co. (Houston, TX)	1,631,404		25,000

Company	Annual PV (lb/yr) [a]	Incorporative Use	PV in Final Product (lb/yr) [b]
Soyventis North America LLC (Fairfield, NJ)	8,105,359		25,000
		Total	3,355,919

[a] Maximum annual production volumes for each company are based on uses reported to the 2020 CDR as shown in Appendices B.2 and B.4.
[b] Maximum production volumes in final paint, coating, adhesive, and sealant products assumes that 10% of the initial production volume may exist in the final product. If the incorporative use is uncertain, maximum production volume is assumed to be 25,000 lb based on CDR reporting threshold.
[c] Chempoint reported 98% of their total annual PV is intended for adhesive manufacturing.

The maximum PV of phthalic anhydride that is estimated to exist in final paint, coating, adhesive, and sealant products is 3,355,919 lb/yr (1,522,219 kg/yr) as shown in the table above. However, the use rate of paint, coating, adhesive, and sealant products can vary widely depending on the application. The table below shows various uses relevant to paint, coating, adhesive, and sealant products containing phthalic anhydride and the expected use rate for each application type.

Table_Apx B-8. Use Rate for Paint, Coating, Adhesive, and Sealant Products

End-Use Category	Product Use Rate (kg/site-yr)	Source
Computer/electronic and electrical product manufacturing	1,500	(OECD, 2015)
Wood furniture finishing	4,341	(U.S. EPA, 2004b)
Motor and non-motor vehicle, vehicle parts, and tire manufacturing	13,500	(OECD, 2015)
Metal furniture surface coating (medium size operation)	87,100	(U.S. EPA, 2004b)
General assembly	141,198	(OECD, 2015)

The median use rate per site (*i.e.*, 13,500 kg/site-yr) and the maximum use rate per site (*i.e.*, 141,198 kg/site-yr) are used to estimate the range across potential sites that may use paint, coating, adhesive and sealant products containing phthalic anhydride. Assuming a typical product concentration of 10%, the use rate of phthalic anhydride per site is expected to range from 1,350 to 14,120 kg/site-yr. Dividing the total annual PV of phthalic anhydride in paint, coating, adhesive, and sealant products (*i.e.*, 1,522,219 kg/yr) by the range of expected phthalic anhydride use rates per site, it is estimated that there are 108 to 1,128 industrial or commercial sites using phthalic anhydride-containing paint, coating, adhesive, and sealant products.

B.8 Laboratory Chemicals

CDR provides information regarding manufacturing and processing of a chemical, but information regarding downstream production volume of specific industrial and commercial uses is limited. Consequently, production volume of laboratory chemicals was estimated based on companies that may be involved in laboratory chemical production based on reporting to the 2020 CDR (U.S. EPA, 2020a). More specifically, for any company that reported their use of phthalic anhydride as incorporative and the exact use was uncertain, or if a company reported import without a known use, it was assumed that the company may be using up to 25,000 lb of phthalic anhydride for laboratory chemicals since this is the threshold value at which a company would be required to specify a particular use. The table below provides a breakdown of PVs by company, as reported or estimated based on the 2020 CDR, that may exist as laboratory chemicals.

Table_Apx B-9. Production Volume Data for Laboratory Chemicals

Company	Annual PV (lb/yr) [a]	Incorporative Use	PV in Final Product (lb/yr) [b]
Huntsman (The Woodlands, TX)	1,458,493	All other basic organic chemical manufacturing	25,000
	26,458,492		
Stepan Company (Elwood, IL or Wilmington, NC)	583,397	CBI	25,000
	10,583,397		
Colonial Chemical Solutions (Savannah, GA)	209,437	Other chemical and allied products merchant wholesalers	25,000
FRP Services & Co. (New York, NY)	502,648		25,000
Mitsui & Co. (Houston, TX)	1,631,404		25,000
Soyventis North America LLC (Fairfield, NJ)	8,105,359		25,000
Total			150,000

[a] Maximum annual production volumes for each company are based on uses reported to the 2020 CDR as shown in Appendix B.2 and B.4.
[b] Maximum production volume from each entity is assumed to be 25,000 lb based on CDR reporting threshold.

The maximum PV of phthalic anhydride that is estimated to exist in final laboratory chemicals is 150,000 lb/yr (68,039 kg/yr) as shown in the table above. However, the use rate of laboratory chemicals can vary depending on the physical form and use. The GS for the Use of Laboratory Chemicals (U.S. EPA, 2023c) indicates that median use rates for liquid reagents and solid reagents are 2 liters/site-day and 0.255 kilograms/site-day, respectively, and that the default number of operating days for laboratories is 260 days/year. Therefore, annual use rates for liquid and solid laboratory chemicals are estimated as 520 kilogram/site-year (assuming 1 liter equals 1 kilogram) and 66.3 kilograms/site-year, respectively. Assuming an equal number of laboratories are using liquid and solid forms of phthalic anhydride, with liquid concentrations ranging from 0.1 to 0.2% and solid concentrations ranging from 90 to 100%, it is expected that there are approximately 2,020 to 2,260 laboratory sites using phthalic anhydride.

B.9 Lubricants and Functional Fluids

CDR provides information regarding manufacturing and processing of a chemical, but information regarding downstream production volume of specific industrial and commercial uses is limited. Consequently, production volume of lubricants and functional fluids was estimated based on companies that may be involved in lubricant and functional fluid production based on reporting to the 2020 CDR (U.S. EPA, 2020a). More specifically, for any company that reported their use of phthalic anhydride as incorporative and the exact use was uncertain, or if a company reported import without a known use, it was assumed that the company may be using up to 25,000 lb of phthalic anhydride for lubricants and functional fluids since this is the threshold value at which a company would be required to specify a particular use. The table below provides a breakdown of PVs by company, as reported or estimated based on the 2020 CDR, that may exist as lubricants and functional fluids.

Table_Apx B-10. Production Volume Data for Lubricants and Functional Fluids

Company	Annual PV (lb/yr) [a]	Incorporative Use	PV in Final Product (lb/yr) [b]
Huntsman (The Woodlands, TX)	1,458,493	All other basic organic chemical manufacturing	25,000
	26,458,492		
Stepan Company (Elwood, IL or Wilmington, NC)	583,397	CBI	25,000
	10,583,397		
Colonial Chemical Solutions (Savannah, GA)	209,437	Other chemical and allied products merchant wholesalers	25,000
FRP Services & Co. (New York, NY)	502,648		25,000
Mitsui & Co. (Houston, TX)	1,631,404		25,000
Soyventis North America LLC (Fairfield, NJ)	8,105,359		25,000
Total			150,000

[a] Maximum annual production volumes for each company are based on uses reported to the 2020 CDR as shown in Appendix B.2 and B.4.
[b] Maximum production volume from each entity is assumed to be 25,000 lb based on CDR reporting threshold.

The maximum PV of phthalic anhydride that is estimated to exist in final lubricants and functional fluids is 150,000 lb/yr (68,039 kg/yr) as shown in the table above. EPA did not identify site- or phthalic anhydride-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, hydraulic fluids may be used at a rate of up to 2,903 kg/site-year depending on the use (OECD, 2004). Also, the concentration of a chemical additive in hydraulic fluids may be up to 0.5% (OECD, 2024). Therefore, it is estimated that there may be up to 4,688 sites using lubricants and functional fluids containing phthalic anhydride.

Appendix C LIST OF SUPPLEMENTAL DOCUMENTS AND FILES

A list of the supplemental documents that are mentioned in this *Draft Environmental Release and Occupational Exposure Assessment for Phthalic Anhdride*, as well as a brief description of each of these files is provided below. These supplemental documents include spreadsheets that contain environmental release and occupational exposure data and are available in EPA-HQ-OPPT-2018-0459.

1. *Draft Occupational Exposure and Risk Calculator for Phthalic Anhydride* (U.S. EPA, 2026b) – Provides raw occupational inhalation exposure data, occupational dermal exposure data, and exposure and risk estimates for each OES and COU.

2. *Draft Summary of Facility Release Data for Phthalic Anhydride* (U.S. EPA, 2025) – Provides raw environmental release data from TRI (2019–2023) and NEI (2017 and 2020), as well as environmental release summaries for each OES.