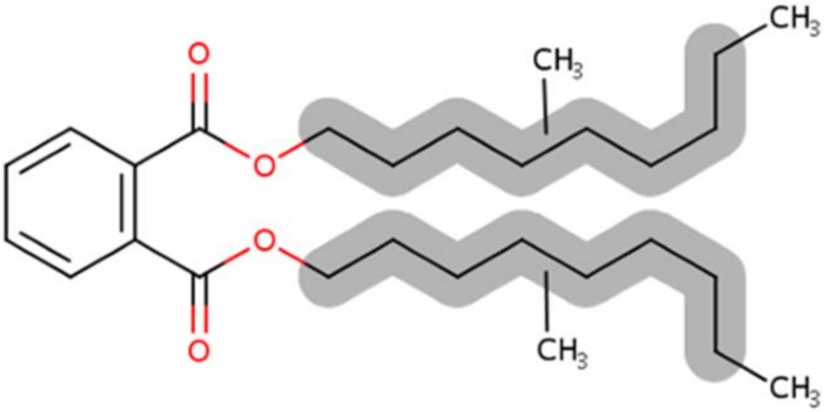
**United States
Environmental Protection Agency**

**May 2024
Office of Chemical Safety and
Pollution Prevention**

Draft Environmental Release and Occupational Exposure Assessment for Diisodecyl Phthalate (DIDP)

Technical Support Document for the Draft Risk Evaluation

CASRNs: 26761-40-0 and 68515-49-1



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ABBREVIATIONS AND ACRONYMS

AC	Acute Exposure Concentration
ACGIH	American Conference of Governmental Industrial Hygienists
AD	Acute Retained Dose
ADD	Average Daily Dose
$ADC_{intermediate}$	Intermediate Average Daily Concentration
AIHA	American Industrial Hygiene Association
APDR	Acute Potential Dermal Dose Rate
APF	Assigned Protection Factor
AT_{acute}	Acute Averaging Time
AT_C	Averaging Time for Cancer Risk
AT_I	Averaging Time for Intermediate Exposure
AWD	Annual Working Days
BLS	Bureau of Labor Statistics
BR	Breathing rate
BW	Body weight
C	Contaminant Concentration in Air
CDR	Chemical Data Reporting
CEB	Chemical Engineering Branch
CEHD	Chemical Exposure Health Database
CFR	Code of Federal Regulations
CPS	Current Population Survey
CPSC	Consumer Product Safety Commission
CT	Central tendency
DD	Dermal Daily Dose
DIDP	Diisodecyl phthalate
DMR	Discharge Monitoring Report
ECETOC TRA	European Centre for Ecotoxicology and Toxicology of Chemicals Targeted Risk Assessment
ED	Exposure duration
EF	Exposure frequency
EF_{int}	Intermediate Exposure Frequency
ELG	Effluent Limitation Guidelines
EPA	United States Environmental Protection Agency
ESD	Emission Scenario Document
ETIMEOFF	Months When Not Working (CPS data)
f	Fractional number of working days per year a worker works
G	Vapor Generation Rate
GS	Generic Scenario
h	Exposure durations
HAP	Hazardous Air Pollutant
HE	High-end
HVLP	High volume low pressure
IADC	Intermediate Average Daily Concentration
ID	Days for intermediate duration
J	Absorptive flux
k	Mixing factor
LADC	Lifetime Average Daily Concentrations
LADD	Lifetime Average Daily Dose

LOD	Limit of detection
LT	Lifetime years for cancer risk
MW	Molecular weight of DIDP
NAICS	North American Industry Classification System
NEI	National Emissions Inventory
NESHAP	National Emissions Standards of Hazardous Air Pollutants
NICNAS	National Industrial Chemicals Notification and Assessment Scheme
NIOSH	National Institute of Occupational Safety and Health
OARS	Occupational Alliance for Risk Science
OD	Operating days
OECD	Organisation for Economic Co-Operation and Development
OEL	Occupational Exposure Limit
OES	Occupational Exposure Scenario
OIS	Occupational Safety and Health Information System
ONU	Occupational non-users
OPPT	Office of Pollution Prevention and Toxics
OSHA	Occupational Safety and Health Administration
OVS	OSHA Versatile Sampler
P	Pressure
PAPR	Power air-purifying respirator
PBZ	Personal breathing zone
PEL	Permissible Exposure Limit
PF	Protection factor
POTW	Publicly owned treatment works
PPE	Personal protective equipment
PV	Production volume
Q	Facility throughput
R	Universal Gas Constant
RD	Release days
REL	Recommended Exposure Limits
$\rho_{product}$	Product density
ρ_{DIDP}	DIDP density
RQ	Reportable Quantity
S	Surface area
SDS	Safety data sheet
SIC	Standard Industrial Classification
SIPP	Survey of Income and Program Participation
SpERC	Specific Emission Release Category
SAR	Supplied-air respirator
SCBA	Self-contained breathing apparatus
SRRP	Source Reduction Research Partnership
SUSB	Statistics of US Businesses
T	Temperature
T_{AGE}	Worker age in SIPP
TDS	Technical data sheets
TJBIND1	Employed Individual Works (SIPP Data)
TLV	Threshold limit value
TMAKMNYR	First Year Worked (SIPP Data)
TRI	Toxics Release Inventory

TSCA	Toxic Substances Control Act
TWA	Time-weighted average
Vm_{DIDP}	Molar volume of DIDP
VP	DIDP vapor pressure
W	Workers
WEEL	Workplace Environmental Exposure Level
WOSE	Weight of scientific evidence
WWT	Wastewater treatment
WY	Working years per Lifetime
S	Surface Area

SUMMARY

This technical document is in support of the TSCA *Draft Risk Evaluation for Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024). DIDP is a common chemical name for the category of chemical substances that includes the following substances: 1,2-benzenedicarboxylic acid, 1,2-diisodecyl ester (CASRN 26761-40-0) and 1,2-benzenedicarboxylic acid, di-C9-11-branched alkyl esters, C10-rich (CASRN 68515-49-1). Both CASRNs contain mainly C10 dialkyl phthalate esters. DIDP is not a Toxics Release Inventory (TRI)-reportable substance; however, it is on the Toxic Substances Control Act (TSCA) Inventory and reported under the CDR rule. This document describes the use of reasonably available information to estimate environmental releases of DIDP and to evaluate occupational exposure to workers. See the draft risk evaluation for a complete list of all the technical support documents for DIDP.

Focus of the Module on Environmental Release and Occupational Exposure Assessment

During scoping, EPA considered all known TSCA uses for DIDP. The 2016 Chemical Data Reporting (CDR) indicated 1-20 million pounds of CASRN 26761-40-0 and 100 to 250 million pounds of CASRN 68515-49-1 were manufactured or imported in the U.S. in 2015 (U.S. EPA, 2019a). The 2020 CDR report indicates a reduction of CASRN 26761-40-0 to less than 1,000,000 lb and an increase of the upper range of CASRN 68515-49-1 to 100 million to 1 billion lb. The largest use of DIDP is as a plasticizer in PVC. Secondary uses are as a plasticizer in adhesives, sealants, paints, coatings, rubbers, non-PVC plastics and other applications.

Exposures to workers, consumers, general populations, and ecological species may occur from industrial, commercial, and consumer uses of DIDP and DIDP-containing articles and releases to air, water, or land. Workers and occupational non-users (ONUs) may be exposed to DIDP during conditions of use such as plastics compounding and converting, paint and coating formulation and application, and the use of inspection fluid/penetrants. Exposure to the general population and ecological species may occur from industrial and commercial releases related to the manufacture, import, processing, distribution, and use of DIDP. The module provides the details of the assessment of the environmental releases and occupational exposures from each condition of use of DIDP.

Approach for Environmental Releases and Occupational Exposures in this Risk Evaluation

EPA evaluated environmental releases of DIDP to air, water, and land from the conditions of use assessed in this risk evaluation. EPA used release data from literature sources where available and used modeling approaches where release data were not available.

EPA evaluated acute, intermediate, and chronic exposures to workers and occupational non-users in association with DIDP conditions of use. EPA used inhalation monitoring data from literature sources where available and exposure models where monitoring data were not available or were deemed insufficient for capturing actual exposure within the condition of use. EPA also used *in vivo* rat absorption data, along with modeling approaches, to estimate dermal exposures to workers.

Results for Environmental Releases and Occupational Exposures in this Risk Evaluation

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

EPA evaluated environmental releases of DIDP to air, water, and/or land for fifteen out of the seventeen OES assessed in this risk evaluation. EPA did not quantitatively assess environmental releases for the other two OES due to the lack of readily available process-specific and DIDP-specific data. The OES with the highest expected release was Manufacturing, followed by Import/Repackaging, and then Non-PVC Compounding. Detailed release results for each OES to each media can be found in Section 3.

EPA also evaluated inhalation and dermal exposures to worker populations, including occupational non-users (ONUs) and females of reproductive age, for each OES. ONUs are those who may work in the vicinity of chemical-related activities but do not handle the chemicals themselves, such as managers or inspectors. Due to the low vapor pressure and low rate of dermal absorption of DIDP, the occupational exposure assessment has shown that inhalation and dermal exposures to DIDP from most industrial and commercial conditions of use (COUs) are also expected to be rather low, with exception of the COU for the Industrial Use of Adhesives and Sealants. Because industrial adhesives and sealants containing DIDP may be applied through high-pressurized spray application, monitoring data show that it is possible for such operations to lead to higher levels of inhalation exposure. Detailed exposure results for each OES and exposure route can be found in Section 3.

Uncertainties of this Risk Evaluation

Uncertainties exist with the monitoring and modeling approaches used to assess DIDP environmental releases and occupational exposures. For example, the lack of DIDP facility production volume data and use of throughput estimates based on CDR reporting thresholds may not be representative of the actual production volume of DIDP used in the U.S. EPA also used generic EPA models and default input parameter values when site-specific data was not available. In addition, site-specific differences in use practices and engineering controls exist, but are largely unknown, this represents another source of variability that EPA could not quantify in the assessment.

Environmental and Exposure Pathways Considered in this Risk Evaluation

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

EPA assessed risks for acute, intermediate, and chronic exposure scenarios in workers (those directly handling DIDP) and occupational non-users (workers not directly involved with the use of DIDP) for DIDP conditions of use. EPA assumed that workers and occupational non-users would be individuals of both sexes (age 16 years and older, including pregnant workers) based upon occupational work permits, although exposures to younger workers in occupational settings cannot be ruled out. An objective of the monitored and modeled inhalation data was to provide separate exposure level estimates for workers and occupational non-users. Dermal exposures were considered for all workers, but only considered for occupational non-users with potential exposure to dust or mist deposited on surfaces.

1 INTRODUCTION

1.1 Overview

On May 24, 2019, EPA received a request from ExxonMobil Chemical Company, through the American Chemical Council's (ACC) High Phthalates Panel (HPP), to conduct a risk evaluation for Diisodecyl Phthalate (CASRNs 26761-40-0 and 68515-49-1) (EPA-HQ-OPPT-2018-0435) under the Frank R. Lautenberg Chemical Safety for the 21st Century Act, the legislation that amended TSCA on June 22, 2016. In December 2019, EPA notified the requesters that the Agency had granted their manufacturer requested risk evaluation for DIDP. Pursuant to 40 CFR 702.37(e)(6)(iv), the requesters had 30 days following the receipt of this notification to withdraw their request. In January of 2020, upon the expiration of this 30-day period, EPA initiated the risk evaluation for DIDP.

DIDP is a common chemical name for the category of chemical substances that includes the following substances: 1,2-benzenedicarboxylic acid, 1,2-diisodecyl ester (CASRN 26761-40-0) and 1,2-benzenedicarboxylic acid, di-C9-11-branched alkyl esters, C10-rich (CASRN 68515-49-1). Both CASRNs contain mainly C10 dialkyl phthalate esters. DIDP is a low volatility liquid that is used primarily as a plasticizer in PVC, though it is also used in adhesives, sealants, paints, coatings, rubbers, non-PVC plastics and other applications. All uses are subject to federal and state regulations and reporting requirements. DIDP is not a Toxics Release Inventory (TRI)-reportable substance; however, it is on the Toxic Substances Control Act (TSCA) Inventory and reported under the CDR rule.

1.2 Scope

EPA assessed environmental releases and occupational exposures for conditions of use as described in Table 2-2 of the *Final Scope of the Risk Evaluation for Diisodecyl Phthalate (DIDP) CASRN 26761-40-0 and 68515-49-1* (U.S. EPA, 2021b). To estimate environmental releases and occupational exposures, EPA first developed Occupational Exposure Scenarios (OES) related to the conditions of use of DIDP. 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. How releases/exposures take place may be similar across multiple condition of uses, or there may be several ways in which releases/exposures takes place for a given condition of use. Table 1-1 shows mapping between the conditions of use in Table 2-2 of the Scope Document to the OES assessed in this report.

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

1. Manufacturing
2. Import and Repackaging
3. Incorporation into Adhesives and Sealants
4. Incorporation into Paints and Coatings
5. Incorporation into Other Formulations, Mixtures, and Reaction Products Not Covered Elsewhere
6. PVC Plastics Compounding
7. PVC Plastics Converting
8. Non-PVC Material Compounding
9. Non-PVC Material Converting

10. Application of Adhesives and Sealants
11. Application of Paints and Coatings
12. Use of Laboratory Chemicals
13. Use of Lubricants and Functional Fluids
14. Use of Penetrants and Inspection Fluids
15. Fabrication and Final Use of Products or Articles
16. Recycling
17. Disposal

Table 1-1. Crosswalk of Conditions of Uses Listed in the Final Scope Document to Occupational Exposure Scenarios Assessed in the Risk Evaluation

Life Cycle Stage	Category	Subcategory	OES
Manufacturing	Domestic manufacturing	Domestic manufacturing	Manufacturing
	Importing	Importing	Import and repackaging
Processing	Repackaging	Repackaging	Import and repackaging
	Incorporation into formulation, mixture, or reaction product	Adhesives and sealants manufacturing	Incorporation into adhesives and sealants
		Laboratory chemicals manufacturing	Incorporation into other formulations, mixtures, or reaction products
		Petroleum lubricating oil manufacturing; Lubricants and lubricant additives manufacturing	Incorporation into other formulations, mixtures, or reaction products
		Surface modifier in paint and coating manufacturing	Incorporation into paints and coatings
		Plastic material and resin manufacturing	PVC plastics compounding; non-PVC material compounding
		Plasticizers (paint and coating manufacturing; colorants (including pigments); rubber manufacturing)	Incorporation into paints and coatings; non-PVC material compounding
		Processing aids, specific to petroleum production (oil and gas drilling, extraction, and support activities)	Incorporation into other formulations, mixtures, or reaction products
		Other (part of the formulation for manufacturing synthetic leather)	PVC plastics compounding; non-PVC material compounding

Life Cycle Stage	Category	Subcategory	OES
	Incorporation into articles	Abrasives manufacturing	Application of adhesives and sealants
		Plasticizers (asphalt paving, roofing, and coating materials manufacturing; construction; automotive products manufacturing, other than fluids; electrical equipment, appliance, and component manufacturing; fabric, textile, and leather products manufacturing; floor coverings manufacturing; furniture and related product manufacturing; plastics product manufacturing; rubber product manufacturing; textiles, apparel, and leather manufacturing; transportation equipment manufacturing; photographic supplies manufacturing; sporting equipment manufacturing)	PVC plastics converting; non-PVC material converting
	Recycling	Recycling	Recycling
Disposal	Disposal	Disposal	Disposal
Distribution in commerce	Distribution in commerce	Distribution in commerce	Distribution in commerce
Industrial uses	Abrasives	Abrasives (surface conditioning and finishing discs; semi-finished and finished goods)	Fabrication or use of final products or articles
	Adhesive and sealants	Adhesives and sealants	Application of adhesives and sealants
	Functional fluids (closed systems)	Functional fluids (closed systems) (SCBA compressor oil)	Use of lubricants and functional fluids
	Lubricant and lubricant additives	Lubricants and lubricant additives	Use of lubricants and functional fluids

Life Cycle Stage	Category	Subcategory	OES
	Solvents (for cleaning or degreasing)	Solvents (for cleaning or degreasing)	Use of lubricants and functional fluids
Commercial uses	Automotive, fuel, agriculture, outdoor use products	Automotive products, other than fluids	Fabrication or use of final products or articles
		Lubricants	Use of lubricants and functional fluids
	Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Application of adhesives and sealants
		Building/construction materials (wire or wiring systems; joint treatment, fire-proof insulation	Fabrication or use of final products or articles
		Electrical and electronic products	Fabrication or use of final products or articles
		Paints and coatings (including surfactants in paints and coatings)	Application of paints and coatings
		Lacquers, stains, varnishes, and floor finishes (as plasticizer)	Application of paints and coatings; Application of adhesives and sealants
	Furnishing, cleaning, treatment/care products	Furniture and furnishings	Fabrication or use of final products or articles
		Construction and building materials covering large surface areas including stone, plaster, cement, glass, and ceramic articles; fabrics, textiles, and apparel (as plasticizer) (Floor coverings (vinyl tiles, PVC-backed carpeting, scraper mats))	Fabrication or use of final products or articles
		Ink, toner, and colorant products	Application of paints and coatings
		PVC film and sheet	Fabrication or use of final products or articles
		Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses)	Fabrication or use of final products or articles
	Other uses	Laboratory chemicals	Use of laboratory chemicals

Life Cycle Stage	Category	Subcategory	OES
		Inspection fluid/penetrant	Use of penetrants and inspection fluids

EPA's assessment of releases includes quantifying annual and daily releases of DIDP to air, water, and land. Releases to air include both fugitive and stack air emissions and emissions resulting from on-site waste treatment equipment, such as incinerators. For purposes of this report, releases to water include both direct discharges to surface water and indirect discharges to publicly owned treatment works (POTW) or non-POTW wastewater treatment (WWT). For purposes of this risk evaluation EPA did not evaluate discharges to POTW and non-POTW WWT using the same methodology as discharges to surface water. 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 DIDP 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 Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024) describes how these factors were considered when determining risk.

For workplace exposures, EPA considered exposures to both workers who directly handle DIDP and occupational non-users (ONUs) who do not directly handle DIDP, but may be exposed to dust, vapors or mists that enter their breathing zone while working in locations near where DIDP handling occurs. EPA evaluated inhalation and dermal exposures to both workers and ONUs.

2 COMPONENTS OF AN OCCUPATIONAL EXPOSURE AND RELEASE ASSESSMENT

EPA describes the assessed conditions of use (COUs) for DIDP in the Section 1.1.2 of the *Draft Risk Evaluation for Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024); however, some COUs differ in terms of specific DIDP processes and associated exposure/release scenarios. Therefore, Table 1-1 provides a crosswalk that maps the DIDP COUs to the more specific OESs. The environmental release and occupational exposure assessments of each OES comprised the following components:

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

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 DIDP-specific process descriptions were unclear or not available, EPA referenced generic process descriptions from literature, including relevant Emission Scenario Documents (ESD) or Generic Scenarios (GS). Sections 3.1 through 3.18 to 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 DIDP in the 2016 and 2020 CDR to an OES (U.S. EPA, 2019a); (U.S. EPA, 2020b). Mapping consists of using facility reported industry sectors (typically reported as either North American Industry Classification System (NAICS) or Standard Industrial Classification (SIC) codes), chemical activity, and processing and use information to assign the most likely OES to each facility.
2. Based on the reporting thresholds and requirements of each data set, evaluate whether the data in the reporting programs is expected to cover most or all the facilities within the OES. If so, EPA assessed the total number of facilities in the OES as equal to the count of facilities mapped to the OES from each data set. If not, EPA proceeded to Step 3.
3. Supplement the available reporting data with U.S. economic and market data using the following steps:
    a. Identify the NAICS codes for the industry sectors associated with the OES.
    b. Estimate total number of facilities using the U.S. Census' Statistics of US Businesses (SUSB) data on total sites by 6-digit NAICS code.
    c. Use market penetration data to estimate the percentage of sites likely to be using DIDP instead of other chemicals.
    d. Combine the data generated in Steps 3.a. through 3.c. to produce an estimate of the number of facilities using DIDP in each 6-digit NAICS code and sum across all applicable NAICS codes to arrive at an estimate of the total number of facilities within the OES. Typically, EPA assumed this estimate encompassed the facilities identified in Step 1; therefore, EPA assessed the total number of facilities for the OES as the total generated from this analysis.
4. If market penetration data required for Step 3.c. are not available, use generic industry data from GSs, ESDs, and other literature sources on typical throughputs/use rates, operating schedules, and the DIDP production volume used within the OES to estimate the number of facilities. In cases where EPA identified a range of operating data in the literature for an OES, EPA used stochastic modeling to provide a range of estimates for the number of facilities within the OES. EPA describes the approaches, equations, and input parameters used in stochastic modeling in the relevant OES sections throughout this report.

2.3 Environmental Releases Approach and Methodology

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

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

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

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

- **Deterministic calculations**: EPA used a combinations of point estimates of each input parameter (*e.g.*, high-end and low-end values) to estimate central tendency and high-end release result. EPA documented the method and rationale for selecting parametric combinations representative of central tendency and high-end releases in the relevant OES subsections in Section 3.
- **Probabilistic (stochastic) calculations**: EPA ran Monte Carlo simulations using the statistical distribution for each input parameter to calculate a full distribution of the final release results. EPA selected the 50th and 95th percentiles of the resulting distribution to represent central tendency and high-end releases, respectively.
- **Combination of deterministic and probabilistic calculations**: EPA had statistical distributions for some parameters and point estimates for the remaining parameters. For example, EPA used Monte Carlo modeling to estimate annual throughputs and emission factors, but only had point estimates of release frequency and production volume. In this case, EPA documented the approach and rationale for combining point estimates with statistical distributions to estimate central tendency and high-end results in the relevant OES subsections in Sections 3.1 through 3.18.

2.3.1 Identifying Release Sources

EPA performed a literature search to identify process operations that could potentially result in releases of DIDP to air, water, or land from each OES. For each OES, EPA identified the release sources and the associated media of release. Where DIDP-specific release sources were unclear or unavailable, EPA referenced relevant ESDs or GSs. Sections 3.1 through 3.18 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:

4. **Facility-specific data:** EPA used facility-specific operating days per year data, if available. Otherwise, EPA used data for other facilities within the same OES, if possible. EPA estimated the operating days per year using one of the following approaches:
    a. If other facilities have known or estimated average daily use rates, EPA calculated the days per year as: Days/year = Estimated Annual Use Rate for the facility (kg/year) / average daily use rate from facilities with available data (kg/day).
    b. If facilities with days per year data do not have known or estimated average daily use rates, EPA used the average number of days per year from the facilities with available data.
5. **Industry-specific data:** EPA used industry-specific data from GSs, ESDs, trade publications, or other relevant literature.
6. **Manufacture of large-production volume (PV) commodity chemicals:** For the manufacture of the large-PV commodity chemicals, EPA used a value of 350 days per year. This assumes the plant runs seven days per week and 50 weeks per year (with two weeks down for turnaround) and always produces the chemical.
7. **Manufacture of lower-PV specialty chemicals:** For the manufacture of lower-PV specialty chemicals, it is unlikely that the plant continuously manufactures the chemical throughout the year. Therefore, EPA used a value of 250 days per year. This assumes the plant manufactures the chemical five days per week and 50 weeks per year (with two weeks down for turnaround).
8. **Other Chemical Plant OES (*e.g.*, processing into formulation and repackaging):** For these OES, EPA assumed that facility does not always use the chemical of interest, even if the facility operates 24/7. Therefore, EPA used a value of 300 days/year, based on the assumption that the facility operates 6 days/week and 50 weeks/year (with 2 weeks for turnaround). However, in instances where the OES uses a low volume of the chemical of interest, EPA used 250 days per year as a lower estimate based on the assumption that the facility operates 5 days/week and 50 weeks/year (with 2 weeks for turnaround).
9. **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 OES) 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, EPA used a value of 365 days per year.
10. **All Other OES:** Regardless of the facility operating schedule, other OES are unlikely to use the chemical of interest every day. Therefore, EPA used a value of 250 days per year for these OES.

2.3.3 Estimating Releases from Models

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

1. Identify release sources and associated release media for each relevant process.
2. Identify or develop model equations for estimating releases from each source.

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

For release models that utilized stochastic calculations, EPA performed a Monte Carlo simulation using the Palisade @Risk software with 100,000 iterations and the Latin Hypercube sampling method. 4.2Appendix E provide detailed descriptions of the model approaches that EPA used for each OES as well as model equations, input parameter values, and associated distributions.

2.3.4 Estimating Releases Using Literature Data

Where available, EPA used data from literature sources to estimate releases. Literature data may include directly measured release data or other information related to release modeling. Therefore, EPA's approach to literature data differed depending on the type of available literature data. For example, if facility-specific release data is available, EPA may use that data to estimate releases for that facility. If facility-specific data is available for a subset of the facilities within an OES, EPA may build a distribution from these data and estimate releases from facilities within the OES using central tendency and high-end values from this distribution. If facility-specific data is unavailable, but industry- or chemical-specific emission factors are available, EPA may use these emission factors to calculate releases for an OES or incorporate the emission factors into release models to develop a distribution of potential releases for the OES. Sections 3.1 through 3.18 provides a detailed description of how EPA incorporated literature data into the release estimates for each OES.

2.4 Occupational Exposure Approach and Methodology

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

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

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

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

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

- **Deterministic calculations:** EPA used combinations of point estimates of each parameter to estimate a central tendency and high-end for each final exposure metric result.
- **Probabilistic (stochastic) calculations:** EPA used Monte Carlo simulations using the full distribution of each parameter to calculate a full distribution of the final exposure metric results and selecting the 50th and 95th percentiles of this resulting distribution as the central tendency and high-end, respectively.
- **Combination of deterministic and probabilistic calculations:** EPA had full distributions for some parameters but point estimates of the remaining parameters. For example, EPA used Monte Carlo modeling to estimate exposure concentrations, but only had point estimates of exposure duration and frequency.

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

For each OES, EPA attempted to provide high-end and central tendency, full-shift time-weighted average (TWA) (typically as an 8-hr TWA) inhalation exposure concentrations as well as high-end and central tendency acute potential dermal dose rates (APDR). EPA applied the following hierarchy in selecting data and approaches for assessing occupational exposures:
Monitoring data:
    a. Personal and directly applicable to the OES
    b. Area and directly applicable to the OES
    c. Personal and potentially applicable or similar to the OES
    d. Area and potentially applicable or similar to the OES

7. Modeling approaches:
    a. Surrogate monitoring data
    b. Fundamental modeling approaches
    c. Statistical regression modeling approaches
8. Occupational exposure limits:
    a. Company-specific occupational exposure limits (OELs) (for site-specific exposure assessments, *e.g.*, there is only one manufacturer who provides their internal OEL to EPA, but the manufacturer does not provide monitoring data)
    b. Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PEL)

   c. Voluntary limits (*i.e.*, American Conference of Governmental Industrial Hygienists [ACGIH] Threshold Limit Values [TLV], National Institute for Occupational Safety and Health [NIOSH] Recommended Exposure Limits [REL], Occupational Alliance for Risk Science (OARS) workplace environmental exposure level (WEEL) [formerly by AIHA])

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

2.4.1 Identifying Worker Activities

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

2.4.2 Number of Workers and Occupational Non-users

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

2.4.3 Estimating Inhalation Exposures

2.4.3.1 Inhalation Monitoring Data

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

Exposures are calculated from the monitoring data sets provided in the sources depending on the size of the data set. For data sets with six or more data points, EPA estimated central tendency and high-end exposures using the 50th and 95th percentile values from the observed data set, respectively. 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. For data sets with two data points, EPA presented the midpoint and the maximum value. Finally, EPA presented data sets with only one data point as-is. For data sets including exposure data that were reported as below the limit of detection (LOD), EPA estimated the exposure concentrations for these data following guidance in EPA's *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994). EPA combined the exposure data from all studies applicable to a given occupational exposure scenario into a single data set.

For exposure assessment, personal breathing zone (PBZ) monitoring data and applicable area monitoring data were used to determine the TWA exposure concentration. Table 2-1 presents the data quality rating of monitoring data that EPA used to assess occupational exposures. EPA evaluated monitoring data using the evaluation strategies laid out in the *Application of Systematic Review in TSCA Risk Evaluations* (U.S. EPA, 2021a).

Table 2-1. Data Evaluation of Sources Containing Occupational Exposure Monitoring Data

Source Reference	Data Type	Data Quality Rating	Occupational Exposure Scenario(s)
(ExxonMobil, 2022a)	PBZ Monitoring	Medium	Manufacturing
(Porras et al., 2020);	Area Monitoring	Medium	PVC Plastics Converting
(Irwin, 2022)	PBZ Monitoring	Medium	PVC Plastics Converting

2.4.3.2 Inhalation Exposure Modeling

Where inhalation exposures are expected for an OES, but monitoring data were either unavailable or EPA determined that the monitoring data did not sufficiently capture the exposures for an OES, EPA attempted to utilize models to estimate inhalation exposures. These models apply deterministic calculations, stochastic calculations, or a combination of both deterministic and stochastic calculations to estimate inhalation exposures. EPA used the following steps to estimate exposures for each OES:

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

For exposure models that utilize stochastic calculations, EPA performed a Monte Carlo simulation using the Palisade @Risk software with 100,000 iterations and the Latin Hypercube sampling method.

Appendix E provides detailed descriptions of the model approaches used for each OES, model equations, and input parameter values and associated distributions.

2.4.4 Estimating Dermal Exposures

This section summarizes the available dermal absorption data related to DIDP (Section 2.4.4.1), the interpretation of the dermal absorption data (Section 2.4.4.1.1), dermal absorption modeling efforts (Section 2.4.4.2), and uncertainties associated with dermal absorption estimation (Section 2.4.4.3). Dermal data were sufficient to characterize occupational dermal exposures to liquids or formulations containing DIDP (Section 2.4.4.1); however, dermal data were not sufficient to estimate dermal exposures to solids or articles containing DIDP. Therefore, modeling efforts described in Section 2.4.4.2 were utilized to estimate dermal exposures to solids or articles containing DIDP. Dermal exposures to vapors are not expected to be significant due to the extremely low volatility of DIDP, and therefore, are not included in the dermal exposure assessment of DIDP. The flux-based dermal exposure approach used for estimating occupational dermal exposures to DIDP is further explained in Appendix D.

2.4.4.1 Dermal Absorption Data

Dermal absorption data related to DIDP are limited. Specifically, EPA identified only one study directly related to the dermal absorption of DIDP (Elsisi et al., 1989), which was an *in vivo* absorption study using male F344 rats. For each *in vivo* dermal absorption experiment, neat DIDP was applied to a freshly shaven area of 1.3 cm^2 in doses ranging from 5 – 8 mg/cm^2 and the site of application was covered with a perforated cap. Urine and feces were collected and analyzed every 24 hours for a duration of 7 days, and at the end of the seventh day, each rat was killed and all remaining contents (tissues, organs, *etc.*) were analyzed. Results of the study showed the average percent absorption of DIDP (both into and through the skin) over the 7-day period was 1.5% and the average material recovery was 82%. However, OECD 156 (2022) guidelines suggest that material recovery from dermal absorption testing of non-volatile compounds should be 90 – 110%. Because the material recovery of DIDP fell outside the recommended recovery range, OECD 156 (2022) guidelines suggest the following normalization of the percent absorption.

$$\text{Normalized Percent Absorption of DIDP} = (100/82) \times (1.5\%) = 1.8\%$$

OECD 156 (2022) states that this approach of normalizing percent absorption assumes that losses occurred in all matrices equally, which is reasonable considering the duration of the experiment and the fact that the cap was perforated.

Though there are no direct points of comparison for absorption of neat DIDP, there was an analogous *in vivo* dermal absorption study conducted for neat DINP (Midwest Research Institute, 1983). For each *in vivo* dermal absorption experiment, neat DINP was applied to a freshly shaven area of 3 cm x 4 cm at a dose of 8 mg/cm^2 and the site of application was covered with a Styrofoam cup lined with aluminum foil. After 7 days of monitoring, the average percent absorption of DINP (both through and into the skin) was 3.06% and the average material recovery was 96.55%. Because it is expected that DINP is slightly more absorptive than DIDP due to the slightly shorter alkyl chain length of DINP compared to DIDP, the results of the study from the Midwest Research Institute (1983) provide additional credence to the results of DIDP absorption from Elsisi (1989).

2.4.4.1.1 Dermal Absorption Data Interpretation

With respect to interpretation of the DIDP dermal absorption data reported in Elsisi (1989), it is important to consider the relationship between the applied dermal load and the rate of dermal absorption. Specifically, the work of Kissel (2011) suggests the dimensionless term N_{derm} to assist with interpretation of dermal absorption data. The term N_{derm} represents the ratio of the experimental load (*i.e.*, application dose) to the steady-state absorptive flux for a given experimental duration as shown in the following equation.

Equation 2-1. Relationship Between Applied Dermal Load and Rate of Dermal Absorption

$$N_{derm} = \frac{experimental\ load\ (\frac{mass}{area})}{steady - state\ flux\ \left(\frac{mass}{area * time}\right) \times\ experimental\ duration\ (time)}$$

Kissel (2011) indicates that high values of N_{derm} (>> 1) suggest that supply of the material is in surplus and that the dermal absorption is considered “flux-limited,” whereas lower values of N_{derm} indicate that absorption is limited by the experimental load and would be considered “delivery-limited.” Furthermore, Kissel (2011) indicates that values of percent absorption for flux-limited scenarios are highly dependent on the dermal load and should not be assumed transferable to conditions outside of the experimental conditions. Rather, the steady-state absorptive flux should be utilized for estimating dermal absorption of flux-limited scenarios.

Using an estimate of 1.8% absorption of 5 – 8 mg/cm^2 of DIDP over a 7-day period, a range of potential steady-state fluxes of neat DIDP is calculated as 5.36×10^{-4} to 8.57×10^{-4} $mg/cm^2/hr$. The application of N_{derm} to the DIDP dermal absorption data reported in Elsisi (1989) is shown below.

$$N_{derm} = \frac{8\ mg/cm^2}{8.57\ \mathrm{E} - 04 \frac{mg}{cm^2 \cdot hr} \times\ 7\ days\ \times 24 \frac{hr}{day}} = 56$$

Because N_{derm} >> 1 for the experimental conditions of Elsisi (1989), it is shown that the absorption of DIDP is considered flux-limited even at finite doses (*i.e.*, less than 10 $\mu L/cm^2$ (OECD, 2004c)) and that percent absorption should not be considered transferrable across exposure conditions. The range of estimated steady-state fluxes of DIDP presented in this section, based on the results of Elsisi (1989), is representative of exposures to liquid materials or formulations only. Dermal exposures to liquids containing DIDP are characterized in Appendix D. Regarding dermal exposures to solids containing DIDP, there were no available data and dermal exposures to solids are modeled as described in Section 2.4.4.2.

2.4.4.2 Dermal Absorption Modeling

It is expected that dermal exposure to solid matrices would result in far less absorption, but there are no studies that report dermal absorption of DIDP from a solid matrix. For cases of dermal absorption of DIDP from a solid matrix, EPA assumes that DIDP will first migrate from the solid matrix to a thin layer of moisture on the skin surface. Therefore, absorption of DIDP from solid matrices is considered limited by aqueous solubility and is estimated using an aqueous absorption model as described below.

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

Equation 2-2. Dermal Absorption Dose During Absorption Event

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

Where:

DA_{event} = Dermally absorbed dose during absorption event t_{abs} (mg/cm^2)
FA = Effect of stratum corneum on quantity absorbed = 0.68 [see Exhibit A-5 of U.S. EPA (2004b)]
K_p = Permeability coefficient = 0.0071cm/hr (calculated using CEM (U.S. EPA, 2023a))
S_w = Water solubility = 0.33 mg/L [Mean value determined from the following studies: (NLM, 2020; EC/HC, 2017; ECJRC, 2003a; NTP-CERHR, 2003; Letinski et al., 2002; Howard et al., 1985; SRC, 1983)]
t_{lag} = $0.105*10^{0.0056MW} = 0.105*10^{0.0056*446.68}$ = 33.3 hours [calculated from A.4 of U.S. EPA (2004b)]
t_{abs} = Duration of absorption event (hours)

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

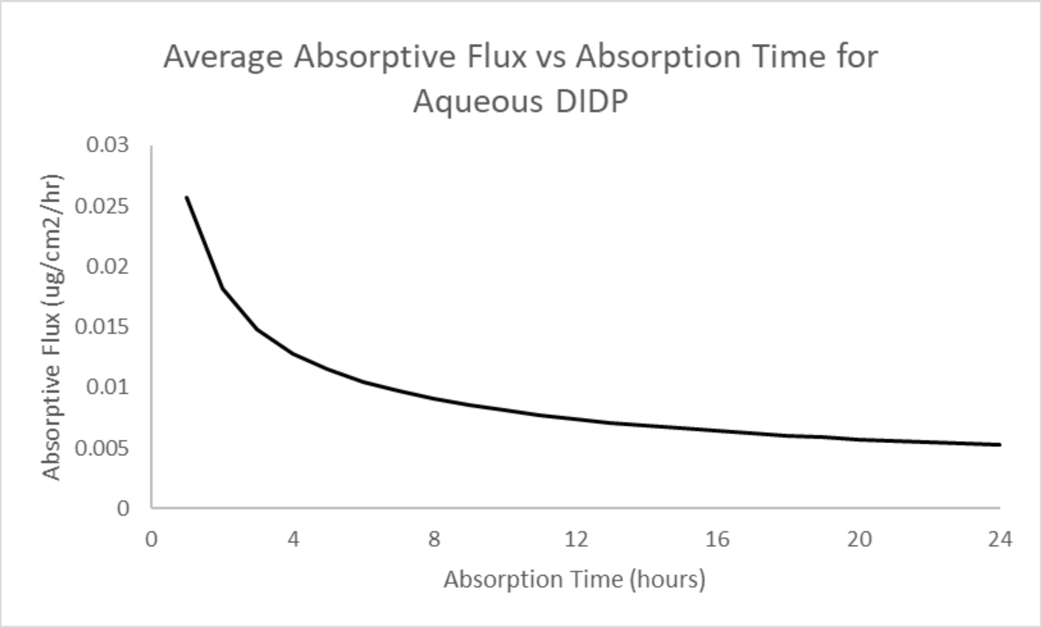

Figure 2-1. Average Absorptive Flux Absorbed into and through Skin as Function of Absorption Time

Figure 2-1 shows that the average absorptive flux for aqueous DIDP is expected to vary between 0.005 and 0.025 µg/cm^2/hr for durations between 1-hour and 1-day, and the average absorptive flux for an 8-hr exposure is 0.00899 µg/cm^2/hr. The estimation of average flux of aqueous material through and into the skin is dependent on the duration of absorption and must be determined based on the scenario under assessment. The range of estimated steady-state fluxes of DIDP presented in this section, based on modeling from (U.S. EPA, 2004b), is considered representative of dermal exposures to solid materials or articles containing DIDP. Dermal exposures to solids containing DIDP are characterized in Appendix D.

2.4.4.3 Uncertainties in Dermal Absorption Estimation

As noted above in Section 2.4.4.1, EPA identified only one set of experimental data related to the dermal absorption of neat DIDP (Elsisi et al., 1989). This dermal absorption study was conducted *in vivo* using male F344 rats. There have been additional studies conducted to determine the difference in dermal absorption between rat skin and human skin. Specifically, Scott (1987) examined the difference in dermal absorption between rat skin and human skin for four different phthalates (*i.e.*, DMP, DEP, DBP, and DEHP) using *in vitro* dermal absorption testing. Results from the *in vitro* dermal absorption experiments showed that rat skin was more permeable than human skin for all four phthalates examined. For example, rat skin was up to 30 times more permeable than human skin for DEP, and rat skin was up to 4 times more permeable than human skin for DEHP. Though there is uncertainty regarding the magnitude of difference between dermal absorption through rat skin vs. human skin for DIDP, EPA is confident that the *in vivo* dermal absorption data using male F344 rats (Elsisi et al., 1989) provides an upper bound of dermal absorption of DIDP based on the findings of Scott (1987).

Another source of uncertainty regarding the dermal absorption of DIDP from products or formulations stems from the varying concentrations and co-formulants that exist in products or formulations containing DIDP. For purposes of this risk evaluation, EPA assumes that the absorptive flux of neat DIDP measured from *in vivo* rat experiments serves as an upper bound of potential absorptive flux of chemical into and through the skin for dermal contact with all liquid products or formulations, and that the modeled absorptive flux of aqueous DIDP serves as an upper bound of potential absorptive flux of chemical into and through the skin for dermal contact with all solid products. However, dermal contact with products or formulations that have lower concentrations of DIDP may exhibit lower rates of flux since there is less material available for absorption. Conversely, co-formulants or materials within the products or formulations may lead to enhanced dermal absorption, even at lower concentrations. Therefore, it is uncertain whether the products or formulations containing DIDP would result in decreased or increased dermal absorption. Based on the available dermal absorption data for DIDP, EPA has made assumptions that result in exposure assessments that are the most human health protective in nature.

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

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

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

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

2.5 Consideration of Engineering Controls and Personal Protective Equipment

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

2.5.1 Respiratory Protection

OSHA's Respiratory Protection Standard (29 CFR 1910.134) requires employers in certain industries to address workplace hazards by implementing engineering control measures and, if these are not feasible, providing respirators that are applicable and suitable for the purpose intended. Respirator selection provisions are provided in section 1910.134(d) and require that appropriate respirators be selected based on the respiratory hazard(s) to which the worker will be exposed and 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 2-2) and refer to the level of respiratory protection that a respirator or class of respirators is expected to provide to employees when the employer implements a continuing, effective respiratory protection program according to the requirements of OSHA's Respiratory Protection Standard.

If respirators are necessary in atmospheres that are not immediately dangerous to life or health, workers must use NIOSH-certified air-purifying respirators or NIOSH-approved supplied-air respirators with the appropriate APF. Respirators that meet these criteria include air-purifying respirators with organic vapor cartridges. Respirators must meet or exceed the required level of protection listed in Table 2-2. 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 2-2. Assigned Protection Factors for Respirators in OSHA Standard 29 CFR 1910.134

Type of Respirator	Quarter Mask	Half Mask	Full Facepiece	Helmet/ Hood	Loose-Fitting Facepiece
1. Air-Purifying Respirator	5	10	50	--	--
2. Power Air-Purifying Respirator (PAPR)	--	50	1,000	25/1,000	25
3. Supplied-Air Respirator (SAR) or Airline Respirator					
• Demand mode	--	10	50	--	--
• Continuous flow mode	--	50	1,000	25/1,000	25

Type of Respirator	Quarter Mask	Half Mask	Full Facepiece	Helmet/ Hood	Loose-Fitting Facepiece
• Pressure-demand or other positive-pressure mode	--	50	1,000	--	--
4. Self-Contained Breathing Apparatus (SCBA)					
• Demand mode	--	10	50	50	--
• Pressure-demand or other positive-pressure mode (*e.g.*, open/closed circuit)	--	--	10,000	10,000	--
Source: 29 CFR 1910.134(d)(3)(i)(A)					

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

NIOSH and BLS estimated that about 619,400 sites used respirators for voluntary or required purposes (including emergency and non-emergency uses). About 281,800 sites (45 percent) used respirators for required purposes in the 12 months prior to the survey. NIOSH and BLS estimated that the 281,800 sites that used respirators for required purposes constituted approximately 4.5 percent of all private industry sites in the United States at that time (NIOSH, 2003).
The survey found that the sites that required respirator use had the following respirator program characteristics (NIOSH, 2003):

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

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

Of the sites that used respirators for a required purpose within the 12 months prior to the survey, NIOSH and BLS found (NIOSH, 2003):

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

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

- A majority use dust masks, 76 percent overall and varying from 56 to 88 percent across industry sectors;

- Varying fractions use half-mask respirators, 52 percent overall and varying from 26 to 66 percent across industry sectors; and
- Varying fractions use full-facepiece respirators, 23 percent overall and varying from 4 to 33 percent across industry sectors.

Table 2-3 summarizes the number and percent of all private industry sites and employees that used respirators for a required purpose within the 12 months prior to the survey and includes a breakdown by industry sector (NIOSH, 2003).

Table 2-3. Number and Percent of Sites and Employees Using Respirators within 12 Months Prior to Survey

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

2.5.2 Glove Protection

Data on the frequency of effective glove use (*i.e.*, the proper use of effective gloves) in industrial settings is very limited. An initial literature review suggests that there is unlikely to be sufficient data to justify a specific probability distribution for effective glove use for DIDP or a given industry. Instead, EPA explored the impact of effective glove use by considering different percentages of effectiveness (*e.g.*, 25 percent vs. 50 percent effectiveness).

EPA also made assumptions about glove use and associated protection factors. When workers wear gloves, they may be exposed to DIDP-based products that penetrate the gloves. This may occur though seepage at the cuff from improper donning of the gloves. When workers do not wear gloves, they are exposed through direct dermal contact with DIDP-based products.

Gloves only offer barrier protection until the chemical breaks through the glove material. Using a conceptual model, Cherrie (2004) proposed a glove workplace protection factor, defined as the ratio of estimated uptake through the hands without gloves to the estimated uptake though the hands while wearing gloves. This protection factor is driven by flux, and thus the protection factor varies with time. The ECETOC TRA model represents the glove protection factor as a fixed, assigned value equal to 5, 10, or 20 (Marquart et al., 2017). Like the APR for respiratory protection, the inverse of the protection factor is the fraction of the chemical that penetrates the glove. Table 2-4 presents dermal doses without glove use, with the potential impacts of these protection factors presented as what-if scenarios in the dermal exposure summary.

Table 2-4. Glove Protection Factors for Different Dermal Protection Strategies

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

2.6 Evidence Integration for Environmental Releases and Occupational Exposures

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

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

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

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. EPA estimated OES-specific assessment approaches where supporting data existed and documented uncertainties where supporting data were only applicable for broader assessment approaches.

3 ENVIRONMENTAL RELEASE AND OCCUPATIONAL EXPOSURE ASSESSMENTS BY OES

3.1 Manufacturing

3.1.1 Process Description

At a typical manufacturing site, DIDP is formed through the reaction of phthalic anhydride and isodecyl alcohol using an acid catalyst. The alkyl esters of DIDP are a mixture of branched hydrocarbon isomers in the C9 through C11 ranges, comprised primarily of C10 isomers of decyl esters (U.S. EPA, 2021b). Typical manufacturing operations consist of reaction, followed by crude filtration, where the product is distilled or separated, and final filtration. Manufacturing operations may also include quality control sampling of the DIDP product. Additionally, manufacturing operations include equipment cleaning/reconditioning and product transport to other areas of the manufacturing facility or offsite shipment for downstream processing or use. No changes to chemical composition occur during transportation (ExxonMobil, 2022a). Figure 3-1 provides an illustration of the manufacturing process.

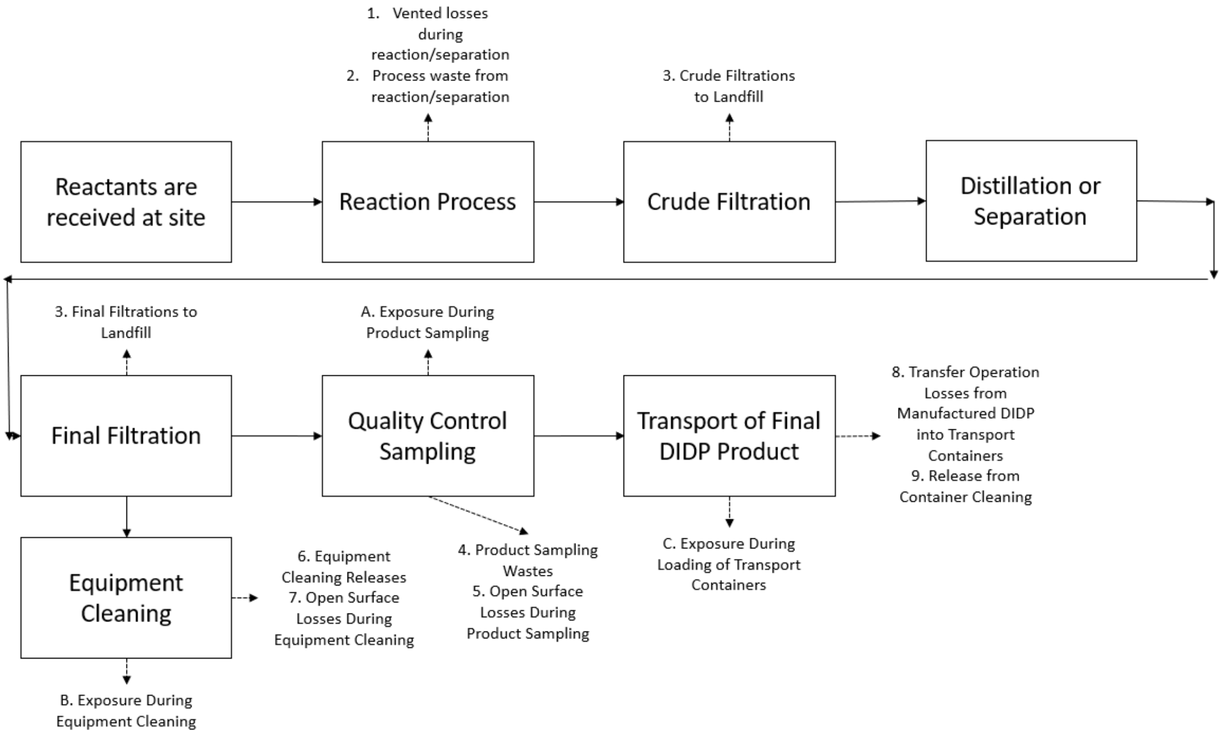

Figure 3-1. Manufacturing Flow Diagram (ExxonMobil, 2022b)

3.1.2 Facility Estimates

In the 2020 CDR, three sites reported domestic manufacturing of DIDP CASRN 68515-49-1. A fourth site, Teknor Apex in Brownsville, TN, did not report any activity specific to DIDP but did report their overall site activity for their NAICS code as "manufacture"; therefore, EPA assessed this site as a domestic manufacturer of DIDP. Troy Chemical in Phoenix, AZ reported a production volume of 20,507 kg for the 2020 CDR reporting years of 2016-2019. The remaining three sites reported their production volumes as CBI (U.S. EPA, 2020a). No sites reported domestic manufacturing of DIDP under CASRN 26761-40-0. EPA did not identify other data on current manufacturing sites or volumes from systematic review.

EPA evaluated the production volume for sites that claimed this information as CBI by subtracting known production volumes from other manufacturing and import sites from the total DIDP production volume reported to the 2020 CDR. EPA considered production volumes for both import and manufacturing sites because the annual DIDP production volumes in the CDR include both domestic manufacture and importation.[1] The 2020 CDR reported a range of national production volume for DIDP, therefore EPA provided the manufacturing production volume as a range. EPA split the remaining production volume range evenly across all sites that reported this information as CBI. The calculated production volume range for the three unknown manufacturing sites under the CASRN 68515-49-1 was 7,556,455 to 75,595,310 kg per average site per year. No production volume was calculated for CASRN 26761-40-0 because no sites reporting any manufacture activity for this CASRN.

EPA did not identify information from systematic review for general site throughputs; site throughput information was estimated through Monte Carlo Modeling, with a 50th to 95th percentile range of 230,977-401,073 kg/site-day. A published report from ExxonMobil indicated a continuous half year operation dedicated to the manufacture of DIDP. Therefore, EPA assessed 180 days per year of continuous DIDP manufacturing operations (ExxonMobil, 2022b). The ExxonMobil report also indicated that DIDP is transported via marine vessels, rail cars, and trucks to/from the ExxonMobil facility. Based on CDR and systematic review information, DIDP is manufactured in liquid form at a concentration of 90–100% (ExxonMobil, 2022b; U.S. EPA, 2020a; NICNAS, 2015; ECJRC, 2003a).

3.1.3 Release Assessment

3.1.3.1 Environmental Release Points

ExxonMobil provided EPA with a walkthrough presentation of their Baton Rouge manufacturing facility and identified non-air releases but did not quantify releases to protect their CBI claim on production volume. Each release point and suspected fugitive air release points were assigned a default EPA model to quantify potential releases. EPA expects stack air releases from vented losses to air during process operations, and fugitive air releases from sampling, equipment cleaning, and container loading. EPA expects releases to onsite wastewater treatment, incineration, or landfill from equipment cleaning, process wastes, and sampling wastes. EPA expects landfill release from crude and final filtration steps, and onsite wastewater release from container cleaning. Fugitive emissions may occur at loading racks and container filling from equipment leaks and displaced vapor as containers are filled.

3.1.3.2 Environmental Release Assessment Results

Table 3-1. Summary of Modeled Environmental Releases for Manufacture of DIDP

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
45,211 lb production volume	Fugitive Air	4.60E−05	1.53E−04	180		2.56E−07	8.52E−07
	Stack Air	2.05E01				1.14E−01	
	Wastewater to Onsite Treatment or	2.62	4.73			1.05E−01	1.89E−01

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[1] For specific values of the known site production volumes belonging to the Import OES, see the Import process description (Section 3.2).

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
	Discharge to POTW						
	Onsite Wastewater, Incineration, or Landfill	7.84E01	1.03E02			2.70	2.84
	Landfill	1.25E02	2.16E02			1.30	2.25
16,659,131-166,659,131 lb. production volume	Fugitive Air	7.64E−04	1.31E−03	180		4.24E−06	7.47E−06
	Stack Air	4.16E04	7.22E04			2.31E02	4.01E02
	Wastewater to Onsite Treatment or Discharge to POTW	4.85E03	1.27E04			1.93E02	5.06E02
	Onsite Wastewater, Incineration, or Landfill	1.61E04	3.20E04			4.69E03	8.14E03
	Landfill	8.34E04				8.69E02	

3.1.4 Occupational Exposure Assessment

3.1.4.1 Workers Activities

During manufacturing, worker exposures to DIDP occur during product sampling. Additionally, worker exposures may occur via inhalation of vapors or dermal contact with liquids during equipment cleaning, container cleaning, and packaging and loading of DIDP into transport containers for shipment. Workers that manufacture DIDP at ExxonMobil sites wear standard PPE during filtration; however, EPA did not identify additional information on the extent to which engineering controls and required PPE are used at any other manufacturing sites or throughout the remainder of the process at ExxonMobil sites (ExxonMobil, 2022b).

ONUs include employees (*e.g.*, supervisors, managers) that work at the manufacturing facility, but do not directly handle DIDP. Generally, EPA expects ONUs to have lower inhalation and dermal exposures than workers who handle the chemicals directly. For the worker activities within the Manufacturing OES, it is expected that workers are exposed through inhalation of vapors and dermal contact with concentrated liquids. However, ONUs are not expected to encounter dermal contact with liquids containing DINP; therefore, only inhalation exposures were estimated for ONUs under the Manufacturing OES.

3.1.4.2 Numbers of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016);(U.S. Census Bureau, 2015) to estimate the number of workers and ONUs that are potentially exposed to DIDP during the manufacturing of DIDP. This approach involved the identification of relevant Standard Occupational Classification (SOC) codes within the BLS data for select NAICS codes. Section 2.4.2 provides additional details on the methodology that EPA used to estimate the number of workers and ONUs per site. EPA assigned the NAICS codes 325110, 325199, and 325998 for this OES, based on the "Emission Scenario Document on the Chemical Industry" and CDR reported NAICS codes for DIDP manufacturers (U.S. EPA, 2020a; OECD, 2011c). Table 3-2 summarizes the per site estimates for this OES. As discussed in Section 3.1.2, EPA did not identify site-specific data for the number of facilities in the United States that manufacture DIDP.

Table 3-2. Estimated Number of Workers Potentially Exposed to DIDP During the Manufacturing of DIDP

NAICS Code	Number of Sites	Exposed Workers per Site[a]	Total Number of Exposed Workers	Exposed ONUs per Site[a]	Total Number of Exposed ONUs
325510 – Petrochemical Manufacturing	1	64	64	30	30
325199 – All Other Basic Organic Chemical Manufacturing	2	39	77	18	36
325998 – All Other Miscellaneous Chemical Product and Preparation Manufacturing	1	14	14	5	5
Total/Average	4	39	155	18	71

[a] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer.

3.1.4.3 Occupational Inhalation Exposure Results

EPA identified inhalation monitoring data for the manufacture of DIDP during systematic review of literature sources. EPA used monitoring data provided in an exposure study conducted by ExxonMobil at their DIDP manufacturing site to estimate inhalation exposure for this OES (ExxonMobil, 2022a). ExxonMobil collected PBZ samples via an American Industrial Hygiene Association (AIHA) validated method involving polytetrafluoroethylene (PTFE) Teflon filters, extraction with acetonitrile, and high-performance liquid chromatography (HPLC) analysis with UV detection. The study took PBZ samples from plasticizer assistant operators, laboratory technicians, maintenance operators (ExxonMobil, 2022a). EPA used the samples taken during filter change-out from maintenance operators to represent this OES, as this activity was determined to best represent the activities that occur during manufacturing. The study included two PBZ data points for DIDP. Both data points were below the limit of detection (LOD). Therefore, EPA could not create a full distribution of monitoring results to use in estimating central tendency and high-end exposures. To estimate high-end exposures to workers, EPA use the LOD reported in the study. To estimate central tendency worker exposure, EPA used half of the LOD.

Table 3-3 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during the manufacture of DIDP. The central tendency and high-end exposures use 180 days per year as the exposure frequency based on industry-provided information on operating days (ExxonMobil, 2022b). Specifically, ExxonMobil indicated that DIDP is manufactured in continuous, half-year campaigns. However, it is uncertain whether this captures actual worker schedules and exposures at that and other manufacturing sites.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration (mg/m^3)	3.6E−02	7.2E−02
	Acute Dose (AD) (mg/kg/day)	4.5E−03	9.0E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.3E−03	6.6E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.2E−03	4.4E−03
Female of Reproductive Age	8-hr TWA Exposure Concentration (mg/m^3)	3.6E−02	7.2E−02
	Acute Dose (AD) (mg/kg/day)	5.0E−03	9.9E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.6E−03	7.3E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.5E−03	4.9E−03
ONU	8-hr TWA Exposure Concentration (mg/m^3)	3.6E−02	3.6E−02
	Acute Dose (AD) (mg/kg/day)	4.5E−03	4.5E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.3E−03	3.3E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.2E−03	2.2E−03

EPA compared the exposures in Table 3-3 to a Monte Carlo simulation for the OES. In this simulation, EPA applied the *EPA Mass Balance Inhalation Model* to all release points with inhalation exposure potential (*e.g.*, those with fugitive air releases) and estimated an 8-hour TWA assuming no exposure occurred outside of the manufacturing activities. The *EPA/OPPT Mass Balance Inhalation Model* estimates a worker inhalation exposure to an estimated concentration of chemical vapors within the worker's breathing zone using a one box model. The model estimates the amount of chemical inhaled by a worker during an activity in which the chemical has volatilized and the airborne concentration of the chemical vapor is estimated as a function of the source vapor generation rate or the saturation level of the chemical in air. Within the simulation, workers were expected to be exposed to DIDP during product sampling, equipment cleaning, and loading of DIDP into transport containers.

EPA used a Monte Carlo simulation to capture variability in the following model input parameters: production rate, DIDP concentration, air speed, diameter of openings, saturation factor, container size, loss fractions, mixing factor, and ventilation rate. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts and exposure concentrations for this OES.

For the modeled scenario using average production volumes across all the CDR sites that reported CBI PVs, the results of this analysis were within two orders of magnitude of the high-end and central tendency inhalation exposure estimates developed from ExxonMobil's study. For the modeled scenario using the one reported PV, the exposure concentrations were much lower, due to the PV being 3-4 orders of magnitude lower. The comparable simulation results justify the use of the ExxonMobil monitoring data for this OES. Table 3-4 presents the central tendency and high-end (50th and 95th percentile) 8-hr TWA exposure concentrations for each simulation.

Table 3-4. Summary of Modeled Worker Inhalation Exposures for Manufacture of DIDP

Modeled Scenario	Central Tendency 8h-TWA (mg/m3)	High-End 8h-TWA (mg/m3)
Production Volume 1: Troy Chemical Corp.	9.5E−06	5.0E−05
Average PV Across all Sites with CBI PVs	1.2E−04	4.5E−04

3.1.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various "Exposure Concentration Types" from Table 3-5 are explained in Appendix B. Because dermal exposures to workers may occur in the neat liquid form during manufacturing of DIDP, EPA assessed the absorptive flux of DIDP according to dermal absorption data of neat DIDP (see Appendix D.2.1.1 for details). Table 3-5 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for both average adult workers and female workers of reproductive age. Because there are no dust or mist expected to be deposited on surfaces from this OES, dermal exposures to ONUs from contact with surfaces were not assessed. Dermal exposure parameters are described in Appendix D.

Table 3-5. Summary of Estimated Worker Dermal Exposures for the Manufacturing of DIDP

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.7	7.3
	Acute (AD, mg/kg-day)	4.6E−02	9.2E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	6.7E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.3E−02	4.5E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.1	6.1
	Acute (AD, mg/kg-day)	4.2E−02	8.4E−02
	Intermediate (IADD, mg/kg-day)	3.1E−02	6.2E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.1E−02	4.2E−02

3.1.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-6.

Table 3-6. Summary of Estimated Worker Aggregate Exposures for Manufacture of DIDP

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	5.0E−02	0.10
	Intermediate (IADD, mg/kg-day)	3.7E−02	7.4E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.5E−02	5.0E−02
Female of Reproductive Age	Acute (AD, mg/kg-day)	4.7E−02	9.4E−02
	Intermediate (IADD, mg/kg-day)	3.5E−02	6.9E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.3E−02	4.6E−02
ONU	Acute (AD, mg/kg-day)	4.5E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	3.3E−03	3.3E−03
	Chronic, Non-cancer (ADD, mg/kg-day)	2.2E−03	2.2E−03

3.2 Import and Repackaging

3.2.1 Process Description

At a typical import and repackaging site, DIDP arrives via water, air, land, or intermodal shipment on oceangoing chemical tankers, rail cars, tank trucks, or intermodal tank containers (U.S. EPA, 2021b). Sites unload the import containers and transfer DIDP into smaller containers (drums or rail cars) for downstream processing, use within the facility, or offsite use. Operations may include quality control sampling of DIDP product and equipment cleaning. No changes to chemical composition occur during transportation (U.S. EPA, 2022a). Figure 3-2 provides an illustration of the import and repackaging process.

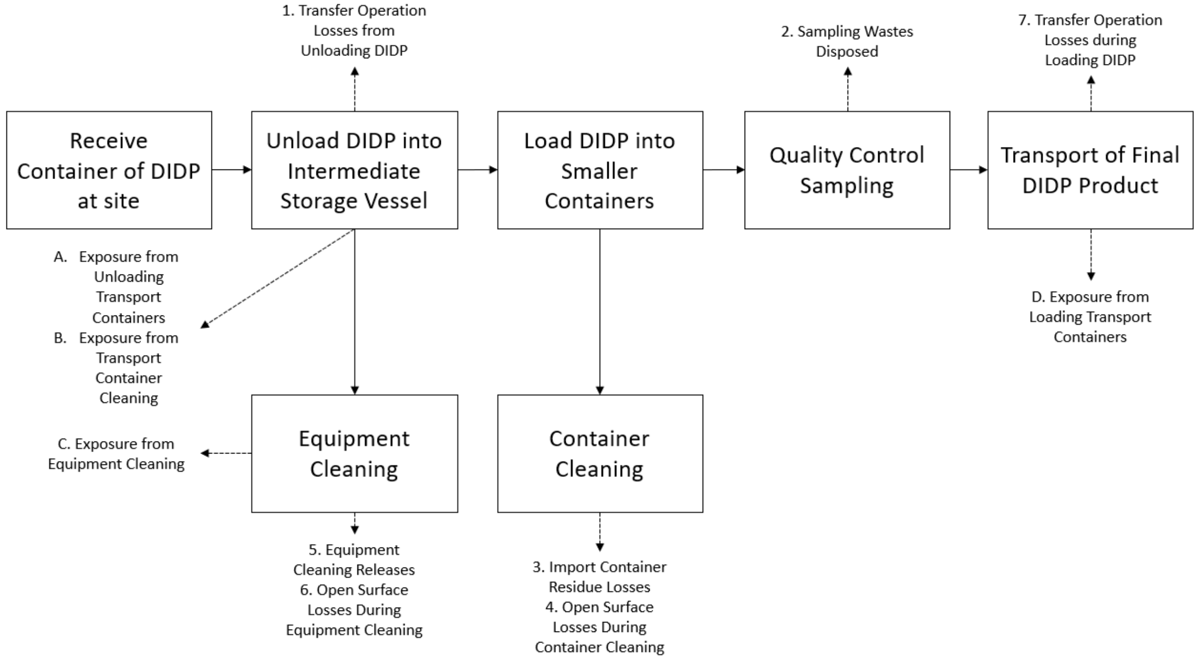

Figure 3-2. Import and Repackaging Flow Diagram (U.S. EPA, 2022a)

3.2.2 Facility Estimates

In the 2020 CDR, eight sites reported import and repackaging of DIDP CASRN 26761-40-0. Five out of the eight sites that reported import activity provided a non-CBI production volume for the reporting years of 2016-2019, with the other three sites reporting their production volumes as CBI (U.S. EPA, 2020a). Table 3-7 provides the location and reported production volume for DIDP CASRN 26761-40-0 import sites.

Table 3-7: Production Volume of DIDP CASRN 26761-40-0 Import and Repackaging Sites, 2020 CDR

DIDP Import Site, Site Location	2019 Reported Production Volume of DIDP CASRN 26761-40-0 (kg/year)
LG Hausys America, Adairsville, GA	11,895
Harwick Standard Distribution, Akron, OH	19,447
Tremco Inc., Beachwood, OH	362,965
Akrochem Corp., Stow, OH	6,616
Chemspec LTD., Uniontown, OH	23,801
3M Company, St. Paul, MN	CBI
LG Chemical America, Atlanta, GA	CBI
ICC Chemical Corporation, New York, NY	CBI

In the 2020 CDR, three sites reported the import of DIDP CASRN 68515-49-1, with all three sites reporting their DIDP production volume as CBI (U.S. EPA, 2020a). EPA did not identify other information on current DIDP import sites or volumes from systematic review.

EPA evaluated the production volume for sites that claimed this information as CBI by subtracting known production volumes of other manufacturing and import sites from the total DIDP production volume reported to the 2020 CDR. The 2020 CDR reported a range of national production volume for DIDP for CASRN 68515-49-1 and a maximum production volume value for DIDP CASRN 26761-40-0; therefore, EPA provided the import production volume as a range. EPA considered production volumes for both import and manufacturing sites because the annual DIDP production volumes in the CDR include both domestic manufacture and importation.[2] EPA split the remaining production volume range evenly across all sites that reported this information as CBI. For CASRN 26761-40-0, the calculated production volume for sites that reported this information as CBI was 9,623 kg/site-year. For CASRN 68515-49-1, the calculated production volume for sites that reported this information as CBI ranged from 7,556,455 to 75,595,310 kg/site-year.

EPA did not identify information from systematic review for import site operating days; therefore, EPA assessed the total number of operating days for DIDP import as 174-260 days per year based on the length of worker shifts described in the 2022 GS on *Chemical Repackaging* (U.S. EPA, 2022a). Import and repackaging facilities operate 24 hours/day, 7 days/week (*i.e.*, multiple shifts). However, EPA capped the total number of operating days, so as not to exceed estimated site throughputs. Based on CDR reports, DIDP is imported in liquid, pellets or large crystals, dry powder, or other solid forms with concentrations ranging from 1-100% DIDP (U.S. EPA, 2020a). EPA did not identify chemical- or site-specific information on site throughputs; site throughput information was estimated through Monte Carlo Modeling, with a 50th to 95th percentile range of 46-55 kg/site-day.

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[2] For CDR-reported production volumes for the Manufacturing OES, see the Manufacturing Process Description (section 3.1).

3.2.3 Release Assessment

3.2.3.1 Environmental Release Points

EPA assigned release points based on the 2022 GS on *Chemical Repackaging* (U.S. EPA, 2022a) and used default models to quantify releases from each identified release point. Release points include fugitive air releases from loading and unloading, container cleaning, and equipment cleaning as well as releases to onsite wastewater treatment, discharges to POTW, and waste disposal from sampling, container residue, and equipment cleaning.

3.2.3.2 Environmental Release Assessment Results

Table 3-8. Summary of Modeled Environmental Releases for Import and Repackaging of DIDP

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
26,223 lbs production volume	Fugitive Air	2.98E−07	4.18E−07	208	260	4.71E−08	6.13E−08
	Wastewater to Onsite Treatment, Discharge to POTW, or Landfill	6.84E01	2.36E02			1.57	1.81
42,873 lb production volume	Fugitive Air	7.72E−07	9.99E−07	208	260	1.00E−07	1.05E−07
	Wastewater to Onsite Treatment, Discharge to POTW, or Landfill	9.80E01	1.25E02			2.31	2.86
800,201 lb production volume	Fugitive Air	1.19E−06	2.73E−06	208	260	2.17E−08	4.08E−08
	Wastewater to Onsite Treatment, Discharge to POTW, or Landfill	1.56E03	2.00E03			4.17E01	5.16E01
14,585 lb production volume	Fugitive Air	2.49E−07	3.35E−07	208	260	4.69E−08	6.10E−08
	Wastewater to Onsite Treatment, Discharge to POTW, or Landfill	1.06E02	1.38E02			1.09	1.50
52,472 lb production volume	Fugitive Air	8.57E−07	1.13E−06	208	260	1.01E−07	1.06E−07
	Wastewater to Onsite Treatment, Discharge to POTW, or Landfill	1.20E02	1.54E02			2.82	3.51
21,215 lb production volume	Fugitive Air	4.34E−07	6.30E−07	208	260	7.38E−08	1.01E−07
	Wastewater to Onsite Treatment, Discharge to POTW, or Landfill	1.18E02	1.99E02			1.39	1.83
16,659,131-166,659,131 lb production volume	Fugitive Air	5.06E−04	1.41E−03	208	260	2.45E−06	6.99E−06
	Wastewater to Onsite Treatment, Discharge to POTW, or Landfill	6.44E04	1.36E05			4.12E03	7.98E03

3.2.4 Occupational Exposure Assessment

3.2.4.1 Workers Activities

During import and repackaging, worker exposures to DIDP occur when transferring DIDP from the import vessels (*e.g.*, chemical tankers, rail cars, intermodal tank containers) into smaller containers. Worker exposures also occur via inhalation of vapors or dermal contact with liquids when cleaning import vessels, loading and unloading DIDP, sampling, and cleaning equipment. EPA did not find any information on the extent to which engineering controls and worker PPE are used at facilities that repackage DIDP from import vessels into smaller containers.

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

3.2.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB specific (**U.S. BLS, 2016**; **U.S. Census Bureau, 2015**) to estimate the number of workers and ONUs that are potentially exposed to DIDP during DIDP import and repackaging. This approach involved the identification of relevant SOC codes within the BLS data for select NAICS codes. Section 2.4.2 provides additional details on the methodology that EPA used to estimate the number of workers and ONUs per site. EPA assigned the NAICS codes 322220, 325211, 325510, 325520, 326113, 424690, and 444120 for this OES, based on the *Chemical Repackaging Generic Scenario* and CDR reported NAICS codes for DIDP importers (**U.S. EPA, 2022a**, **2020a**). Table 3-9 summarizes the per site estimates for this OES. As discussed in Section 3.2.2, EPA did not identify site-specific data for the number of facilities in the United States that import and repackage DIDP.

Table 3-9. Estimated Number of Workers Potentially Exposed to DIDP during Import and Repackaging

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers	Exposed Occupational Non-users per Site[b]	Total Number of Exposed ONUs
322220 – Paper Bag and Coated and Treated Paper Manufacturing	2	35	70	5	9
325211 – Plastic Material and Resin Manufacturing	1	27	27	12	12
325510 – Paint and Coating Manufacturing	2	14	29	5	11
325520 – Adhesive Manufacturing	1	18	18	7	7
326113 – Unlaminated Plastics Film and Sheet (except Packaging) Manufacturing	0	22	0	6	0

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers	Exposed Occupational Non-users per Site[b]	Total Number of Exposed ONUs
424690 – Other Chemical and Allied Products Merchant Wholesalers	5	1	6	0.4	2
444120 – Paint and Wallpaper Stores	0	0.16	0	0.02	0
Total/Average	11	17	151	5	41

[a] Number of sites for MFG and Import are based on reported NAICS code for each site. Some NAICS codes had 0 sites reporting under them in CDR, but they are none-the-less included here because the reporting thresholds for CDR do not provide for a 100% capture of the industry.

[b] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as "0" are left unrounded.

3.2.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for import and repackaging from systematic review of literature sources. However, EPA estimated inhalation exposures for this OES using monitoring data for DIDP exposures during manufacturing (ExxonMobil, 2022a). EPA expects that inhalation exposures during manufacturing are greater than inhalation exposures during import and repackaging.

EPA used surrogate monitoring data from an exposure study conducted by ExxonMobil at their DIDP manufacturing site to estimate inhalation exposure for this OES. ExxonMobil collected PBZ samples via an AIHA validated method involving PTFE Teflon filters, extraction with acetonitrile, and HPLC analysis with UV detection. ExxonMobil took PBZ samples from plasticizer assistant operators, laboratory technicians, maintenance operators (ExxonMobil, 2022b). EPA used the samples taken during filter change-out from maintenance operators to represent this OES, as this activity was determined to best represent the activities that occur during manufacturing. The study included two PBZ data points for DIDP. Both data points were below the LOD. Therefore, EPA could not create a full distribution of monitoring results to use in estimating central tendency and high-end exposures. To estimate high-end exposures to workers, EPA use the LOD reported in the study. To estimate central tendency worker exposure, EPA used half of the LOD.

Table 3-10 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during the import and repackaging of DIDP. The high-end exposures are based on 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days. The central tendency exposures use 208 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment.

Table 3-10. Summary of Estimated Worker Inhalation Exposures for Import and Repackaging of DIDP

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration (mg/m^3)	3.6E−02	7.2E−02
	Acute Dose (AD) (mg/kg/day)	4.5E−03	9.0E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.3E−03	6.6E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.6E−03	6.2E−03
Female of Reproductive Age	8-hr TWA Exposure Concentration (mg/m^3)	3.6E−02	7.2E−02
	Acute Dose (AD) (mg/kg/day)	5.0E−03	9.9E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.6E−03	7.3E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.8E−03	6.8E−03
ONU	8-hr TWA Exposure Concentration (mg/m^3)	3.6E−02	3.6E−02
	Acute Dose (AD) (mg/kg/day)	4.5E−03	4.5E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.3E−03	3.3E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.6E−03	3.1E−03

3.2.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-11 are explained in Appendix B. Because dermal exposures to workers may occur in the neat liquid form during import and/or repackaging of DIDP, EPA assessed the absorptive flux of DIDP according to dermal absorption data of neat DIDP (see Appendix D.2.1.1 for details). Table 3-11 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for both average adult workers and female workers of reproductive age. Because there are no dust or mist expected to be deposited on surfaces from this OES, dermal exposures to ONUs from contact with surfaces were not assessed. Dermal exposure parameters are described in Appendix D.

Table 3-11. Summary of Estimated Worker Dermal Exposures for Import and Repackaging of DIDP

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.7	7.3
	Acute (AD, mg/kg-day)	4.6E−02	9.2E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	6.7E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.6E−02	6.3E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.1	6.1
	Acute (AD, mg/kg-day)	4.2E−02	8.4E−02
	Intermediate (IADD, mg/kg-day)	3.1E−02	6.2E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.4E−02	5.8E−02

3.2.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B to arrive at the aggregate worker and ONU exposure estimates in Table 3-12.

Table 3-12. Summary of Estimated Worker Aggregate Exposures for Import and Repackaging of DIDP

Modeled Scenario	**Exposure Concentration Type (mg/kg/day)**	**Central Tendency**	**High-End**
Average Adult Worker	Acute (AD, mg/kg-day)	5.0E−02	0.10
	Intermediate (IADD, mg/kg-day)	3.7E−02	7.4E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−02	6.9E−02
Female of Reproductive Age	Acute (AD, mg/kg-day)	4.7E−02	9.4E−02
	Intermediate (IADD, mg/kg-day)	3.5E−02	6.9E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.7E−02	6.5E−02
ONU	Acute (AD, mg/kg-day)	4.5E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	3.3E−03	3.3E−03
	Chronic, Non-cancer (ADD, mg/kg-day)	2.6E−03	3.1E−03

3.3 Incorporation into Adhesives and Sealants

3.3.1 Process Description

The *Final Use Report for Diisodecyl Phthalate (DIDP) (1,2-Benzenedicarboxylic acid, 1,2-diisodecyl ester and 1,2-Benzenedicarboxylic acid, di-C9-11-branched alkyl esters, C10-rich) (CASRN 26761-40-0 and 68515-49-1)* states DIDP's use as a plasticizer for *Processing, incorporation into formulation, mixture, or reaction product, "adhesive manufacturing"* (U.S. EPA, 2021c).

DIDP is a plasticizer in adhesive and sealant products for industrial and commercial use, including polymer sealants and industrial adhesives (see Appendix F for EPA identified DIDP-containing products for this OES). Based on the 2009 *ESD on the Manufacture of Adhesives*, a typical adhesive incorporation site receives and unloads DIDP into adhesive and sealant formulations in industrial mixing vessels as a batch blending or mixing process, with no reactions or chemical changes occurring to the plasticizer (*i.e.*, DIDP) during the mixing process. Blending or mixing operations can take up to 8 hours a day. Process operations may also include quality control sampling. EPA expects that sites will load DIDP-containing products into bottles, small containers, or drums depending on the product type. Incorporation sites may dispose of off-specification product when the adhesive product does not meet quality or desired standards (OECD, 2009a). Figure 3-3 provides an illustration of the adhesive and sealant manufacturing process.

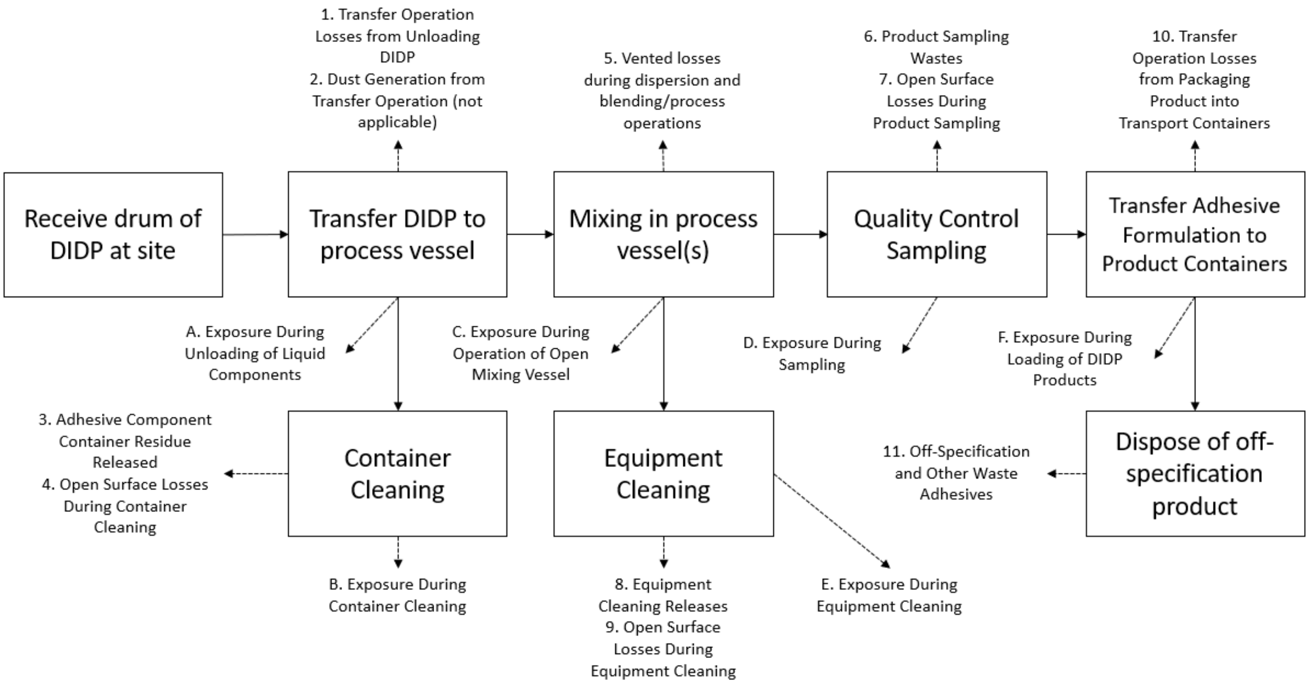

Figure 3-3. Incorporation into Adhesives and Sealants Flow Diagram (OECD, 2009a)

3.3.2 Facility Estimates

In the 2020 CDR, two sites reported adhesive and sealant manufacturing for DIDP, one of which reported their production volume as CBI. EPA did not identify any other data on sites that use DIDP in adhesives and sealants or production volumes from systematic review. Therefore, EPA attempted to develop a representative production volume range for DIDP processed into adhesive and sealant products.

To estimate the low-end of the production volume range, EPA assumed that sites that reported a CBI production volume processed a minimum of 25,000 lb (11,340 kg) into adhesive and sealant products based on the CDR reporting thresholds. The one site that provided a non-CBI production volume, Tremco Inc. in Beachwood, OH, did not indicate the percentage of its yearly production volume associated with adhesive and sealant manufacture (U.S. EPA, 2020a). Therefore, EPA assumed that the site processed 100% of its 362,965 kg production volume into adhesive and sealant products. This resulted in a minimum production volume of 374,305 kg/year for this OES.

EPA estimated the high-end production volume and number of sites from systematic review due to the limitations of CDR reporting for downstream processes and uses. The 2003 *DIDP Risk Assessment* published by the European Union estimates a PV of approximately 1.1% to non-polymer uses (ECJRC, 2003a). The 1.1 % to non-polymer uses is split equally between paints/coatings, adhesives/sealants, and inks, which is 0.37% for each. The American Chemistry Council indicated that the use rate of DIDP in the EU is similar to the use rate in the United States (ACC, 2020a). EPA calculated the high-end production volume of DIDP in adhesives and sealants as 0.37% of the yearly production volume or 1,679,970 kg/year accounting for both CASRN (Note: 0.37% of the low-end national production volume of DIDP was less than the minimum volume reported from CDR; therefore, EPA calculated the minimum production volume as described above). The total production volume range for incorporation into adhesives and sealants was 374,305–1,679,970 kg/year.

EPA did not identify operating information for this OES (*i.e.*, batch size or number of batches per year); EPA assumed a 4,000 kg batch size and 250 batches per year based on and the 2009 *ESD on the Manufacture of Adhesives* (OECD, 2009a). This is equivalent to a facility throughput of DIDP of 1,000-750,000 kg-DIDP/site-year based on a DIDP concentration in the Adhesive/ Sealant product of 0.1-60% (see Appendix F for EPA identified DIDP-containing products for this OES). Additionally, EPA assumed the number of operating days was equivalent to the number of batches per year or 250 days/year of 24 hour/day, 7 day/week (*i.e.*, multiple shifts) operations for the given site throughput scenario. Incorporation sites receive DIDP in drums and totes ranging in size from 20-100 gallons with DIDP concentrations of 30-60% (U.S. EPA, 2020a). Sites receive DIDP as either a liquid or solid paste that is then incorporated as a liquid, with material in drums transferred to mixing vessels during formulation (OECD, 2009a). EPA estimated the total number of sites that manufacture DIDP-containing adhesives and sealants using a Monte Carlo model (see Appendix E.4 for details). The 50th-95th percentile range of the number of sites was 6 to 50 sites. In contrast, the 2020 CDR identified two incorporation sites.

3.3.3 Release Assessment

3.3.3.1 Environmental Release Points

EPA assigned release points based on the 2009 *ESD on the Manufacture of Adhesives* (OECD, 2009a). EPA assigned default models to quantify release from each release point and suspected fugitive air release point. EPA expects fugitive air releases from unloading of DIDP containers, container cleaning, sampling, and equipment cleaning. EPA expects stack air releases from vented losses during process operations and packaging into transport containers. EPA expects releases to wastewater, incineration, or landfill from container residue, sampling, equipment cleaning, and off-specification trimming.

3.3.3.2 Environmental Release Assessment Results

Table 3-13. Summary of Modeled Environmental Releases for Incorporation into Adhesives and Sealants

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
825,201-3,703,700 lb production volume	Fugitive Air	1.66E−06	8.32E−06	250		6.63E−09	3.35E−08
	Stack Air	1.43E−06	2.01E−05			5.70E−09	8.04E−08
	Wastewater, Incineration, or Landfill	1.04E04	2.71E04			4.16E01	1.08E02

3.3.4 Occupational Exposure Assessment

3.3.4.1 Workers Activities

During the formulation of adhesives and sealants containing DIDP, worker exposures may occur when transferring DIDP from transport containers into process vessels, taking QC samples, and packaging formulated products into containers. Worker exposures may also occur via inhalation of vapor or dermal contact with liquids when cleaning residuals from transport containers or process vessels (OECD, 2009a). EPA did not identify information on engineering controls or worker PPE used at DIDP-containing adhesive and sealant formulation facilities.

For this OES, ONUs may include supervisors, managers, and other employees that work in the formulation area but do not directly contact DIDP that is received or processed onsite or handle the formulated product. ONUs are potentially exposed through the inhalation route while in the working area. However, dermal exposures to ONUs are not expected for this OES.

3.3.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs that are potentially exposed to DIDP during the incorporation of DIDP into adhesives and sealants. This approach involved the identification of relevant SOC codes within the BLS data for select NAICS codes. Section 2.4.2 provides additional details on the methodology that EPA used to estimate the number of workers and ONUs per site. EPA assigned the NAICS code 325520 – Adhesive Manufacturing for this OES, based on the CDR reported NAICS codes for incorporation into adhesives or sealants (U.S. EPA, 2020a). Table 3-14 summarizes the per site estimates for this OES. As discussed in Section 3.3.2, EPA did not identify site-specific data for the number of facilities in the United States that incorporate DIDP into adhesives and sealants.

Table 3-14. Estimated Number of Workers Potentially Exposed to DIDP during Incorporation into Adhesives and Sealants

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed ONUs per Site[b]	Total Number of Exposed ONUs[a]
325520 – Adhesive Manufacturing	6-50	18	108-903	7	41-338

[a] The result is expressed as a range between the central tendency and the high-end value representing the 50th and 95th percentile results

[b] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as "0" are left unrounded.

3.3.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for the incorporation of DIDP into adhesives and sealants during systematic review. However, EPA estimated inhalation exposures for this OES using monitoring data for DIDP and DINP exposures during plastics converting. EPA expects that inhalation exposures during plastics converting are comparable to inhalation exposures during incorporation into adhesives and sealants.

The p-chem properties (*e.g.*, molecular weight and vapor pressure) of diisodecyl phthlate and di(2-propylheptyl) phthalate are quite similar, and vapor inhalation monitoring data for DIDP were lacking.

Therefore, EPA used surrogate monitoring data for di(2-propylheptyl) phthalate provided in an exposure study conducted by SP Porras et al. (2020) in a PVC-coated cable manufacturing facility to estimate worker vapor inhalation exposures to DIDP for this OES. Inhalation exposures during PVC-coated cable manufacturing occur when di(2-propylheptyl) phthalate additives are incorporated into the plastic coating, and EPA expects that these exposures are comparable to inhalation exposures to DIDP during adhesive and sealant manufacturing. The subject facility in the SP Porras *et al.* study sometimes used DIDP as a plasticizer for manufacturing PVC-coated cables, but the facility was using di(2-propylheptyl) phthalate as the plasticizer on the day that sampling occurred (Porras et al., 2020). The study personnel collected stationary samples using the OVS sampler type, which measures a combination of vapor and particulate phases. SP Porras *et al.* collected two samples at cooling points near extruders and provided results as a single 8-hour TWA value for di(2-propylheptyl) phthalate, which was 0.03 mg/m^3. Since the study conducted sampling near a high-temperature extruder, EPA expects that the monitoring data represents vapor concentrations of di(2-propylheptyl) phthalate from heated material as opposed to particulates containing the phthalate. To estimate ONU exposures for this OES, EPA used surrogate DINP monitoring data provided in an exposure study conducted by Irwin *et al.* at a PVC roofing manufacturing site (Irwin, 2022) (hereinafter referred to as “Irwin 2022 study”). Irwin *et al.* collected PBZ samples with an unspecified sampling method. The study included one PBZ sample for ONU exposure to airborne oil mists (Irwin, 2022). This sample was below the LOD. Therefore, EPA could not create a full distribution of monitoring results to use in estimating central tendency and high-end exposures. To estimate high-end exposures to ONUs, EPA use the LOD reported in the study. To estimate central tendency ONU exposure, EPA used half of the LOD.

Table 3-15 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during the incorporation into adhesives and sealants. The central tendency and high-end exposures use 250 days per year as the exposure frequency since the 50th and 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days.

Table 3-15. Summary of Estimated Worker Inhalation Exposures for Incorporation into Adhesives and Sealants

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−02	3.0E−02
	Acute Dose (AD) (mg/kg/day)	3.8E−03	3.8E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	2.8E−03	2.8E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.6E−03	2.6E−03
Female of Reproductive Age	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−02	3.0E−02
	Acute Dose (AD) (mg/kg/day)	4.1E−03	4.1E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.0E−03	3.0E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.8E−03	2.8E−03
ONU	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−04	6.0E−04
	Acute Dose (AD) (mg/kg/day)	3.8E−05	7.5E−05

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	2.8E−05	5.5E−05
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.6E−05	5.1E−05

3.3.4.4 Occupational Dermal Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various "Exposure Concentration Types" from Table 3-16 are explained in Appendix B. Because dermal exposures to workers may occur in a concentrated liquid form during the incorporation of DIDP into adhesives and sealants, EPA assessed the absorptive flux of DIDP according to dermal absorption data of neat DIDP (see Appendix D.2.1.1 for details). Table 3-16 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for both average adult workers and female workers of reproductive age. Because there are no dust or mist expected to be deposited on surfaces from this OES, dermal exposures to ONUs from contact with surfaces were not assessed. Dermal exposure parameters are described in Appendix D.

Table 3-16. Summary of Estimated Worker Dermal Exposures for Incorporation into Adhesives and Sealants

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.7	7.3
	Acute (AD, mg/kg-day)	4.6E−02	9.2E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	6.7E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.1E−02	6.3E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.1	6.1
	Acute (AD, mg/kg-day)	4.2E−02	8.4E−02
	Intermediate (IADD, mg/kg-day)	3.1E−02	6.2E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−02	5.8E−02

3.3.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-17.

Table 3-17. Summary of Estimated Worker Aggregate Exposures for Incorporation into Adhesives and Sealants

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	5.0E−02	9.5E−02
	Intermediate (IADD, mg/kg-day)	3.6E−02	7.0E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.4E−02	6.5E−02
	Acute (AD, mg/kg-day)	4.6E−02	8.8E−02

Female of Reproductive Age	Intermediate (IADD, mg/kg-day)	3.4E−02	6.5E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.2E−02	6.1E−02
ONU	Acute (AD, mg/kg-day)	3.8E−05	7.5E−05
	Intermediate (IADD, mg/kg-day)	2.8E−05	5.5E−05
	Chronic, Non-cancer (ADD, mg/kg-day)	2.6E−05	5.1E−05

3.4 Incorporation into Paints and Coatings

3.4.1 Process Description

DIDP is a plasticizer in paint and coating products for industrial and commercial use, including paints and colorants (see Appendix F for EPA identified DIDP-containing products for this OES). A typical incorporation site receives and unloads DIDP into industrial mixing vessels as a batch blending or mixing process, with no reactions or chemical changes occurring to the plasticizer (*i.e.*, DIDP) during the mixing process. Blending or mixing operations can take up to eight hours a day. Process operations may include quality control sampling. In the case of waterborne coatings, the formulator will transfer the blended formulation through an in-line filter. Following formulation, incorporation sites will load DIDP-containing products into bottles, small containers, or drums depending on the product type. Sites may dispose of off-specification product when the product does not meet quality or desired standards (U.S. EPA, 2014a). Figure 3-4 provides an illustration of the paint and coating manufacturing process.

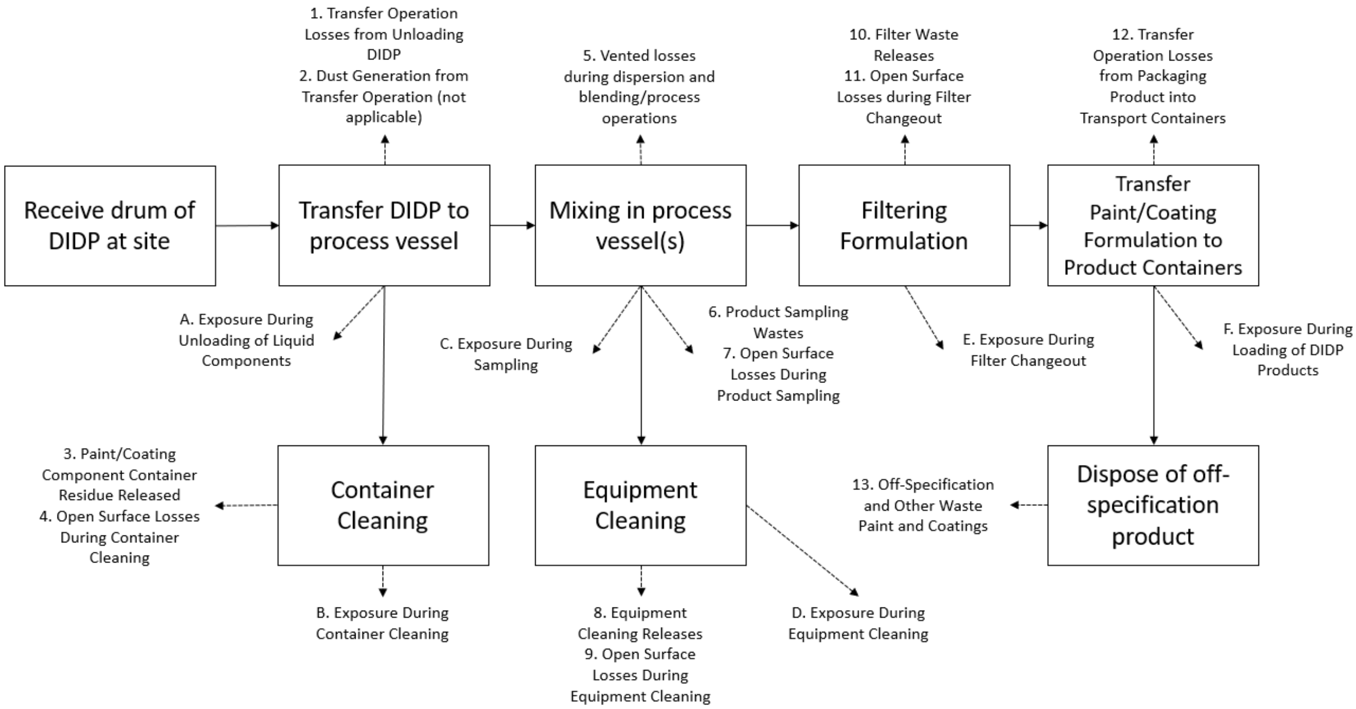

Figure 3-4. Incorporation into Paints and Coatings Flow Diagram (U.S. EPA, 2014a)

3.4.2 Facility Estimates

In the 2020 CDR, four sites reported paint and coating manufacturing, three of which claimed their production volume as CBI. The one site that provided a non-CBI production volume, Troy Chemical Corp. in Florham Park, NJ, reported that 100% of this production volume was allocated to paint and coating manufacturing (U.S. EPA, 2020a). However, EPA estimated the total production volume and the number of sites from systematic review due to the limitations of CDR reporting for downstream processes and uses. The 2003 *DIDP Risk Assessment* published by the European Union estimates a PV of approximately 1.1% to non-polymer uses (ECJRC, 2003a). The 1.1 % to non-polymer uses is split equally between paints/coatings, adhesives/sealants, and inks, which is 0.37% for each. The American Chemistry Council indicated that the use rate of DIDP in the EU is similar to the use rate in the United States (ACC, 2020a). EPA calculated the production volume of DIDP in paints and coatings as 0.37% of the total DIDP production volume reported to CDR for both CASRN. The 2020 CDR reported a range of national production volume for DIDP; therefore, EPA provided the paint and coating production volume as a range. The total production volume for incorporation into paints and coatings was 169,485-1,679,970 kg/year.

EPA did not identify paint and coating site operating data (*i.e.*, batch size or number of batches per year); EPA assumed 5,030 kg per batch and 250 batches per year based on the 2014 GS on the *Formulation of Waterborne Coatings* (U.S. EPA, 2014a). This corresponds to a facility throughput of DIDP of 160-800,000 kg-DIDP/site-year based on a DIDP concentration in the paint/coating product of 0.01-5%. Additionally, EPA assumed that the number of operating days was equivalent to the number of batches manufactured per year, or 250 days/year of 24 hour/day, 7 day/week operations (*i.e.*, multiple shifts) for the given site throughput scenario. Incorporation sites receive DIDP in drums and totes ranging in size from 20-100 gallons with DIDP concentrations of 1-90% (see Appendix F for EPA identified DIDP-containing products for this OES) (U.S. EPA, 2020a). Sites receive DIDP as either a liquid or solid paste that is then incorporated into paints and coatings as a liquid, with material in drums transferred to mixing vessels during formulation (U.S. EPA, 2014a). EPA estimated the total number of sites that manufacture DIDP-containing paints and coatings using a Monte Carlo model (see Appendix E.5 for details). The 50th-95th percentile range of the number of sites was 6-38 sites. In contrast, the 2020 CDR identified four incorporation sites.

3.4.3 Release Assessment

3.4.3.1 Environmental Release Points

EPA assigned release points based on the 2014 *GS on the Formulation of Waterborne Coatings* (U.S. EPA, 2014a). EPA assigned a default model to quantify releases from each identified release point and fugitive air release point. EPA expects fugitive air releases from unloading DIDP containers, container cleaning, sampling, equipment cleaning, and filter replacements. EPA expects stack air releases from vented losses during process operations and from packaging paints and coatings into transport containers. EPA expects releases to wastewater, incineration, or landfill from container residue, sampling, equipment cleaning, filter wastes, and off-specification wastes.

3.4.3.2 Environmental Release Assessment Results

Table 3-18. Summary of Modeled Environmental Releases for Incorporation into Paints and Coatings

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
373,650-3,703,700 lb production volume	Fugitive Air	1.11E−06	3.99E−06	250		4.46E−09	1.59E−08
	Stack Air	1.32E−07	1.28E−06			5.27E−10	5.12E−09
	Wastewater, Incineration, or Landfill	8.37E03	2.71E04			3.35E01	1.08E02

3.4.4 Occupational Exposure Assessment

3.4.4.1 Worker Activities

During the formulation of paints and coatings that contain DIDP, worker exposures to DIDP vapors may occur when packaging paint and coating products. Worker exposures may also occur via inhalation of vapors or dermal contact with liquids when unloading DIDP, cleaning transport containers, product sampling, equipment cleaning, and during filter media change out (U.S. EPA, 2014a). EPA did not identify information on engineering controls or worker PPE used at DIDP-containing paint and coating formulation sites.

ONUs include supervisors, managers, and other employees that work in the formulation area but do not directly contact DIDP received or processed onsite or handle the formulated product. ONUs are potentially exposed through the inhalation route while in the working area. However, dermal exposures to ONUs are not expected for this OES.

3.4.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs that are potentially exposed to DIDP during the incorporation of DIDP into paints and coatings. This approach involved the identification of relevant

SOC codes within the BLS data for select NAICS codes. Section 2.4.2 provides additional details on the methodology that EPA used to estimate the number of workers and ONUs per site. EPA assigned the NAICS codes 325320, 325510, 325613, 325998, and 444120 for this OES based on the *Generic Scenario on the Formulation of Waterborne Coatings* and CDR reported NAICS codes for incorporation into paints and coatings (U.S. EPA, 2020a, 2014a). Table 3-19 summarizes the per site estimates for this OES. As discussed in Section 3.4.2, EPA did not identify site-specific data on the number of facilities in the United States that incorporate DIDP into paints and coatings.

Table 3-19. Estimated Number of Workers Potentially Exposed to DIDP during Incorporation into Paints and Coatings

NAICS Code	Number of Sites[b]	Exposed Workers per Site[a]	Total Number of Exposed Workers[b]	Exposed Occupational Non-users per Site[a]	Total Number of Exposed ONUs[b]
325320 – Pesticide and Other Agricultural Chemical Manufacturing	N/A	25	N/A	7	N/A
325510 – Paint and Coating Manufacturing		14		5	
325613 – Surface Active Agent Manufacturing		22		5	
325998 – All Other Miscellaneous Chemical Product and Preparation		14		5	
444120 – Paint and Wallpaper Stores		0.16		0.02	
Total/Average	6-38	15	91-576	4	27-170

[a] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as "0" are left unrounded.

[b] The result is expressed as a range between the central tendency and the high-end value representing the 50th and 95th percentile results. Results were not assessed by NAICS code for this scenario due to a lack of NAICS-specific number of sites data.

3.4.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for the incorporation of DIDP into paints and coatings during systematic review. However, EPA estimated inhalation exposures for this OES using monitoring data for DIDP and DINP exposures during plastics converting. EPA expects that inhalation exposures during plastics converting are comparable to inhalation exposures during the incorporation of DIDP into paints and coatings.

The p-chem properties (*e.g.*, molecular weight and vapor pressure) of diisodecyl phthlate and di(2-propylheptyl) phthalate are quite similar, and vapor inhalation monitoring data for DIDP were lacking. Therefore, EPA used surrogate monitoring data for di(2-propylheptyl) phthalate provided in an exposure study conducted by SP Porras *et al.* (2020) in a PVC-coated cable manufacturing facility to estimate worker vapor inhalation exposures to DIDP for this OES. Inhalation exposures during PVC-coated cable manufacturing occur when di(2-propylheptyl) phthalate additives are incorporated into the plastic coating, and EPA expects that these exposures are comparable to inhalation exposures to DIDP during paint and coating manufacturing. The subject facility in the SP Porras *et al.* study sometimes used DIDP as a plasticizer for manufacturing PVC-coated cables, but the facility was using di(2-propylheptyl) phthalate as the plasticizer on the day that sampling occurred (Porras et al., 2020). The study personnel collected stationary samples using the OVS sampler type, which measures a combination of vapor and particulate phases. SP Porras *et al.* collected two samples at cooling points near extruders and provided results as a single 8-hour TWA value for di(2-propylheptyl) phthalate, which was 0.03 mg/m^3. Since the study conducted sampling near a high-temperature extruder, EPA expects that the monitoring data represents vapor concentrations of di(2-propylheptyl) phthalate from heated material as opposed to particulates containing the phthalate.

To estimate ONU exposures for this OES, EPA used surrogate DINP monitoring data provided in an exposure study conducted by Irwin *et al.* at a PVC roofing manufacturing site (Irwin, 2022) (hereinafter referred to as “Irwin 2022 study”). Irwin *et al.* collected PBZ samples with an unspecified sampling method. The study included one PBZ sample for ONU exposure to airborne oil mists (Irwin, 2022). This data point was below the LOD. Therefore, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To estimate high-end exposures to ONUs, EPA used the LOD reported in this study. To estimate central tendency ONU exposures, EPA used half of the LOD.

Table 3-20 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during incorporation into paints and coatings. The central tendency and high-end exposures use 250 days per year as the exposure frequency since the 50th and 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days.

Table 3-20. Summary of Estimated Worker Inhalation Exposures for Incorporation into Paints and Coatings

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−02	3.0E−02
	Acute Dose (AD) (mg/kg/day)	3.8E−03	3.8E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	2.8E−03	2.8E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.6E−03	2.6E−03
Female of Reproductive Age	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−02	3.0E−02
	Acute Dose (AD) (mg/kg/day)	4.1E−03	4.1E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.0E−03	3.0E−03

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.8E−03	2.8E−03
ONU	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−04	6.0E−04
	Acute Dose (AD) (mg/kg/day)	3.8E−05	7.5E−05
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	2.8E−05	5.5E−05
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.6E−05	5.1E−05

3.4.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-21 are explained in Appendix B. Because dermal exposures to workers may occur in a concentrated liquid form during the incorporation of DIDP into paints and coatings, EPA assessed the absorptive flux of DIDP according to dermal absorption data of neat DIDP (see Appendix D.2.1.1 for details). Table 3-21 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for both average adult workers and female workers of reproductive age. Because there are no dust or mist expected to be deposited on surfaces from this OES, dermal exposures to ONUs from contact with surfaces were not assessed. Dermal exposure parameters are described in Appendix D.

Table 3-21. Summary of Estimated Worker Dermal Exposures for Incorporation into Paints and Coatings

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.7	7.3
	Acute (AD, mg/kg-day)	4.6E−02	9.2E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	6.7E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.1E−02	6.3E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.1	6.1
	Acute (AD, mg/kg-day)	4.2E−02	8.4E−02
	Intermediate (IADD, mg/kg-day)	3.1E−02	6.2E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−02	5.8E−02

3.4.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-22.

Table 3-22. Summary of Estimated Worker Aggregate Exposures for Incorporation into Paints and Coatings

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	5.0E−2	9.5E−02
	Intermediate (IADD, mg/kg-day)	3.6E−02	7.0E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.4E−02	6.5E−02
Female of Reproductive Age	Acute (AD, mg/kg-day)	4.6E−02	8.8E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	6.5E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.2E−02	6.1E−02
ONU	Acute (AD, mg/kg-day)	3.8E−05	7.5E−05
	Intermediate (IADD, mg/kg-day)	2.8E−05	5.5E−05
	Chronic, Non-cancer (ADD, mg/kg-day)	2.6E−05	5.1E−05

3.5 Incorporation into Other Formulations, Mixtures, and Reaction Products Not Covered Elsewhere

3.5.1 Process Description

"Incorporation into other formulations, mixtures, and reaction products" is broad and includes formulation of asphalt, hydraulic fluids, lubricants, penetrants, and other products. EPA expects that each use case is small; therefore, EPA assessed exposures as a group rather than individually. While EPA identified limited information on the formulation of these types of products, EPA expects that formulation follows the same processes regardless of end product type. Based on the 2014 *GS on the Formulation of Waterborne Coatings*, EPA expects that a typical site will unload DIDP and incorporate it into other formulations, mixture, and reaction products within industrial mixing vessels, using a batch blending or mixing process, with no reactions or chemical changes occurring to DIDP during the mixing process. Blending or mixing operations can take up to eight hours a day. Process operations may include quality control sampling and incorporation sites may transfer the blended formulation through an in-line filter. Following formulation, sites will load DIDP-containing products into bottles, small containers, or drums depending on the product type. Sites may dispose of off-specification product when the product does not meet quality or desired standards (U.S. EPA, 2014a). Figure 3-5 provides an illustration of the other formulations manufacturing process.

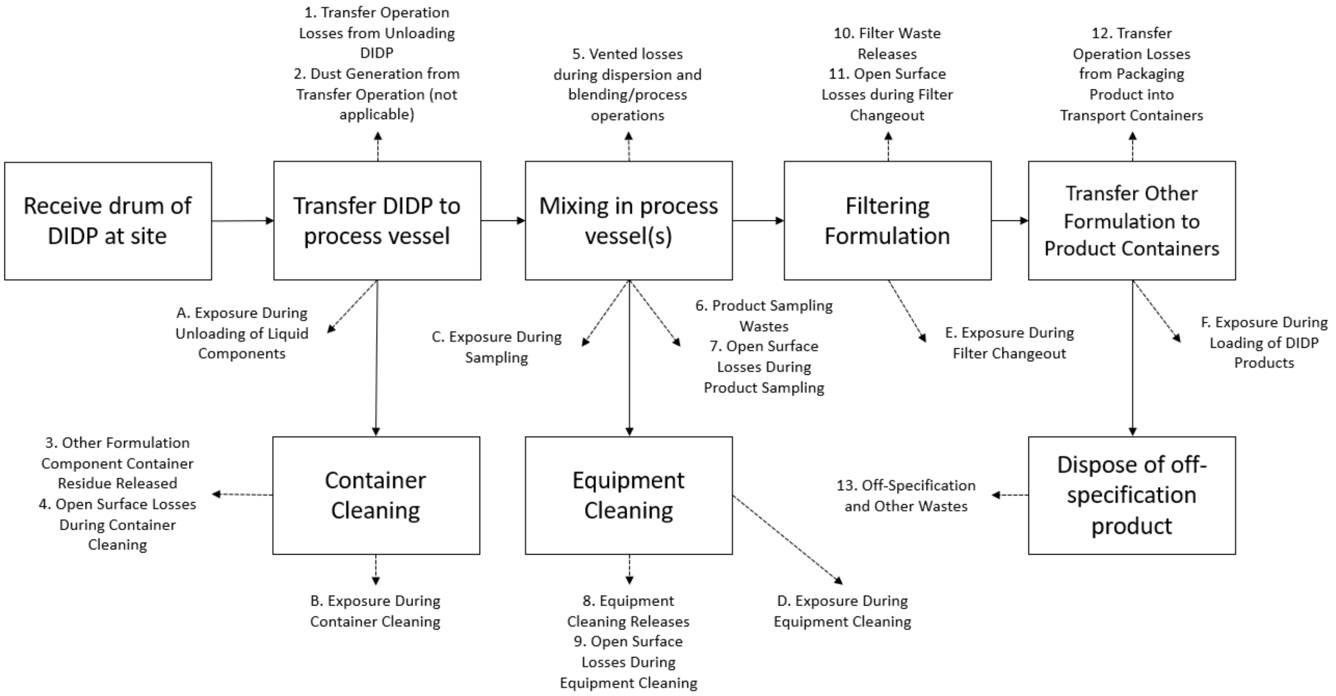

Figure 3-5. Incorporation into Other Formulations, Mixtures, and Reaction Products Flow Diagram (U.S. EPA, 2014a)

3.5.2 Facility Estimates

The 2020 CDR has one entry for “Incorporation into other formulations, mixtures, and reaction products” for Lanxess Solutions in Fords, NJ, which the site reported as “Petroleum Lubricating Oil and Grease Manufacturing; Lubricating Agent” (U.S. EPA, 2020a). However, EPA estimated the total production volume and the number of sites from systematic review due to the limitations of CDR reporting for downstream processes and uses. The 2003 *DIDP Risk Assessment* published by the European Union estimates a PV of approximately 1.1% to non-polymer uses (ECJRC, 2003a). The 1.1 % to non-polymer uses is split equally between paints/coatings, adhesives/sealants, and inks, which is 0.37% for each. The American Chemistry Council indicated that the use rate of DIDP in the EU is similar to the use rate in the United States (ACC, 2020a). As a result, EPA calculated the production volume of DIDP in other formulations, mixtures, and reaction products as 0.37% of the yearly production volume of DIDP for both CASRN reported to CDR. The total production volume for other formulations was 169,485-1,679,970 kg/year.

EPA did not identify other formulation operating information (*i.e.*, batch size or number of batches per year); EPA assumed 5,030 kg/batch and 250 batches/year based on the 2014 *ESD on the Formulation of Waterborne Coatings* (U.S. EPA, 2014a). This corresponds to a DIDP facility throughput of 12,575-1,131,750 kg-DIDP/site-year based on DIDP product concentrations of 1-90% (see Appendix F for EPA identified DIDP-containing products for this OES). Additionally, EPA assumed that the number of operating days is equivalent to the number of batches per year, or 250 days/year with 24 hour/day and 7 day/week operations (*i.e.*, multiple shifts) for the given site throughput scenario. According to CDR reports, other formulation sites receive DIDP in drums and totes ranging in size from 20-100 gallons with DIDP concentrations of 30-90% (U.S. EPA, 2020a). These sites receive DIDP as either a liquid or a solid paste that is then incorporated into other formulations as a liquid, with material in drums transferred to mixing vessels during formulation (U.S. EPA, 2014a). EPA estimated the total number of sites that manufacture other formulations using a Monte Carlo model (see Appendix E.6 for details). The 50th-95th percentile range of the number of sites was 1-2 sites. In contrast to 2020 CDR reports, in which a sole incorporation site was identified.

3.5.3 Release Assessment

3.5.3.1 Environmental Release Points

EPA assigned release points based on the 2014 *GS on the Formulation of Waterborne Coatings* (U.S. EPA, 2014a). EPA assigned default models to quantify potential releases from each release point and suspected fugitive air release point. EPA expects fugitive air releases from unloading of DIDP containers, container cleaning, sampling, equipment cleaning, and filter replacements. EPA expects stack air releases from vented losses during process operations and from packaging products into transport containers. EPA expects releases to wastewater, incineration, or landfill from container residue, sampling and equipment cleaning wastes, filter wastes, and off-specification wastes.

3.5.3.2 Environmental Release Assessment Results

Table 3-23. Summary of Modeled Environmental Releases for Incorporation into Other Formulations, Mixtures, and Reaction Products

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
373,650-3,703,700 lb production volume	Fugitive Air	1.03E−04	2.61E−04	250		4.13E−07	1.04E−06
	Stack Air	2.66E−05	1.24E−04			1.06E−07	4.97E−07
	Wastewater, Incineration, or Landfill	2.14E04	2.20E04			7.39E02	1.29E03

3.5.4 Occupational Exposure Assessment

3.5.4.1 Worker Activities

During the formulation of other articles that contain DIDP, worker exposures to DIDP vapors may occur when packaging final products. Worker exposures may also occur via inhalation of vapors or dermal contact with liquids when unloading DIDP, cleaning transport containers, product sampling, equipment cleaning, and during filter media change out (U.S. EPA, 2014a). EPA did not identify information on engineering controls or workers PPE used at other formulation sites.

ONUs include supervisors, managers, and other employees that work in the formulation area but do not directly contact DIDP received or processed onsite or handle of formulated product. ONUs are potentially exposed through the inhalation route while in the working area. However, dermal exposures to ONUs are not expected for this OES.

3.5.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs potentially exposed to DIDP during the incorporation of DIDP into other formulations, mixtures, or reaction products not covered elsewhere. This approach involved the identification of relevant SOC codes within the BLS data for select NAICS codes. Section 2.4.2 provides additional details on the methodology that EPA used to estimate the number of workers and ONUs per site. EPA assigned the NAICS codes 325110 and 325199 for this OES based on the *Generic Scenario on the Formulation of Waterborne Coatings* and CDR reported NAICS codes for incorporation into paints and coatings (U.S. EPA, 2020a, 2014a). Table 3-24 summarizes the per site estimates for this OES. As discussed in Section 3.5.2, EPA did not identify site-specific data for the number of facilities in the United States that incorporate DIDP into other formulations, mixtures, or reaction products not covered elsewhere.

Table 3-24. Estimated Number of Workers Potentially Exposed to DIDP during Incorporation into Other Formulations, Mixtures, or Reaction Products not Covered Elsewhere

NAICS Code	Number of Sites[b]	Exposed Workers per Site[a]	Total Number of Exposed Workers[b]	Exposed ONUs per Site[a]	Total Number of Exposed ONUs[b]
325110 – Petrochemical Manufacturing	N/A	64	N/A	30	N/A
325199 – All Other Basic Organic Chemical Manufacturing		39		18	
Total/Average	1-2	51	51-102	24	24-48

[a] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as "0" are left unrounded.

[b] The result is expressed as a range between the central tendency and the high-end value representing the 50th and 95th percentile results. Results were not assessed by NAICS code for this scenario.

3.5.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for the incorporation of DIDP into other formulations, mixtures, and reaction products from systematic review. However, EPA estimated inhalation exposures for this OES using monitoring data for DIDP and DIN exposures during plastics converting. EPA expects that inhalation exposures during plastics converting are comparable to inhalation exposures during incorporation into other formulations, mixtures, and reaction products.

The p-chem properties (*e.g.*, molecular weight and vapor pressure) of diisodecyl phthlate and di(2-propylheptyl) phthalate are quite similar, and vapor inhalation monitoring data for DIDP were lacking. Therefore, EPA used surrogate monitoring data for di(2-propylheptyl) phthalate provided in an exposure study conducted by SP Porras *et al.* (2020) in a PVC-coated cable manufacturing facility to estimate worker vapor inhalation exposures to DIDP for this OES. Inhalation exposures during PVC-coated cable manufacturing occur when di(2-propylheptyl) phthalate additives are incorporated into the plastic coating, and EPA expects that these exposures are comparable to inhalation exposures to DIDP during formulation manufacturing. The subject facility in the SP Porras *et al.* study sometimes used DIDP as a plasticizer for manufacturing PVC-coated cables, but the facility was using di(2-propylheptyl) phthalate as the plasticizer on the day that sampling occurred (Porras et al., 2020). The study personnel collected stationary samples using the OVS sampler type, which measures a combination of vapor and particulate phases. SP Porras *et al.* collected two samples at cooling points near extruders and provided results as a single 8-hour TWA value for di(2-propylheptyl) phthalate, which was 0.03 mg/m^3. Since the study conducted sampling near a high-temperature extruder, EPA expects that the monitoring data represents vapor concentrations of di(2-propylheptyl) phthalate from heated material as opposed to particulates containing the phthalate. To estimate ONU exposures for this OES, EPA used surrogate DINP monitoring data provided in an exposure study conducted by Irwin *et al.* at a PVC roofing manufacturing site (Irwin, 2022) (hereinafter referred to as "Irwin 2022 study"). Irwin *et al.* collected PBZ samples with an unspecified sampling method. The study included one PBZ sample for ONU exposures to airborne oil mists (Irwin, 2022). This data point was below the LOD. Therefore, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To estimate high-end exposures to ONUs, EPA use the LOD reported in the study. To estimate central tendency ONU exposure, EPA used half of the LOD.

Table 3-25 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during incorporation into other formulations, mixtures, and reaction products not covered elsewhere. The central tendency and high-end exposures use 250 days per year as the exposure frequency since the 50th and 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days.

Table 3-25. Summary of Estimated Worker Inhalation Exposures for Incorporation into Other Formulations, Mixtures, and Reaction Products Not Covered Elsewhere

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−02	3.0E−02
	Acute Dose (AD) (mg/kg/day)	3.8E−03	3.8E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	2.8E−03	2.8E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.6E−03	2.6E−03
Female of Reproductive Age	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−02	3.0E−02
	Acute Dose (AD) (mg/kg/day)	4.1E−03	4.1E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.0E−03	3.0E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.8E−03	2.8E−03
ONU	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−04	6.0E−04
	Acute Dose (AD) (mg/kg/day)	3.8E−05	7.5E−05
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	2.8E−05	5.5E−05
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.6E−05	5.1E−05

3.5.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-26 are explained in Appendix B. Because dermal exposures to workers may occur in a concentrated liquid form during the incorporation of DIDP into other formulations, mixtures, and reaction products, EPA assessed the absorptive flux of DIDP according to dermal absorption data of neat DIDP (see Appendix D.2.1.1 for details). Table 3-26 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for both average adult workers and female workers of reproductive age. Because there are no dust or mist expected to be deposited on surfaces from this OES, dermal exposures to ONUs from contact with surfaces were not assessed. Dermal exposure parameters are described in Appendix D.

Table 3-26. Summary of Estimated Worker Dermal Exposures for Incorporation into Other Formulations, Mixtures, and Reaction Products Not Covered Elsewhere

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.7	7.3
	Acute (AD, mg/kg-day)	4.6E−02	9.2E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	6.7E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.1E−02	6.3E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.1	6.1
	Acute (AD, mg/kg-day)	4.2E−02	8.4E−02
	Intermediate (IADD, mg/kg-day)	3.1E−02	6.2E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−02	5.8E−02

3.5.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-27.

Table 3-27. Summary of Estimated Worker Aggregate Exposures for Incorporation into Other Formulations, Mixtures, or Reaction Products Not Covered Elsewhere

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	5.0E−2	9.5E−02
	Intermediate (IADD, mg/kg-day)	3.6E−02	7.0E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.4E−02	6.5E−02
Female of Reproductive Age	Acute (AD, mg/kg-day)	4.6E−02	8.8E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	6.5E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.2E−02	6.1E−02
ONU	Acute (AD, mg/kg-day)	3.8E−05	7.5E−05
	Intermediate (IADD, mg/kg-day)	2.8E−05	5.5E−05

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
	Chronic, Non-cancer (ADD, mg/kg-day)	2.6E−05	5.1E−05

3.6 PVC Plastics Compounding

3.6.1 Process Description

PVC Plastics Compounding involves the mixing of the polymer with the plasticizer and other chemical such as, fillers and heat stabilizers. The plasticizer needs to be absorbed into the particle to impart flexibility to the polymer. For PVC Plastics Compounding scenarios, compounding occurs through mixing of ingredients to produce a powder (dry blending) or a liquid (Plastisol blending) (ACC, 2020b, c). The most common process for dry blending involves heating the ingredients in a high intensity mixer and transfer to a cold mixer. The Plastisol blending is done at ambient temperature using specific mixers that allow for the breakdown of the PVC agglomerates and the absorption of the plasticizer into the resin particle. The 2020 and 2012 CDR reports use of this chemical as a plasticizer in plastic material and resin manufacturing (U.S. EPA, 2020a, 2019a).

As mentioned above, DIDP is used as a plasticizer in PVC including vinyl barriers and castable PVC plastics adhesives (see Appendix F for EPA identified DIDP-containing products for this OES). EPA expects that a typical compounding site receives DIDP as a pure liquid at 25°C in drums and totes ranging in size from 20-100 gallons (U.S. EPA, 2021e). The site unloads and transfers DIDP into mixing vessels to produce a compounded resin masterbatch. Following completion of the masterbatch, the site transfers the solid resin to an extruder that shapes and sizes the plastic and packages the final product for shipment to downstream conversion sites after cooling. Figure 3-6 provides an illustration of the PVC plastic compounding process (U.S. EPA, 2021e).

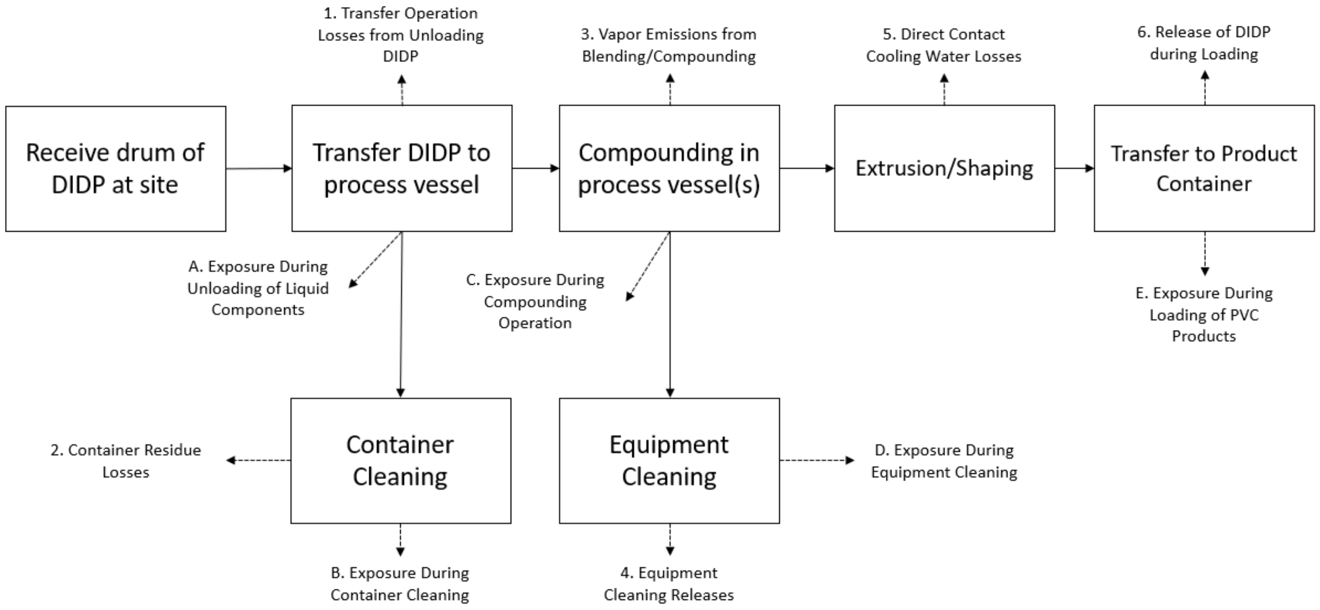

Figure 3-6. PVC Plastics Compounding Flow Diagram (U.S. EPA, 2021e)

3.6.2 Facility Estimates

In the 2020 CDR, seven sites reported using DIDP as a plasticizer for several industrial sectors including plastic product manufacturing and plastic material and resin manufacturing. Two sites provided a non-CBI production volume, whereas five sites indicated that their production volume was CBI. Due to the limitations of CDR reporting data for downstream processes and uses, EPA relied on data from the European Union and the American Chemistry Council to estimate the total production volume. The 2003 *DIDP Risk Assessment* published by the European Union stated that the use rate of DIDP in PVC plastics is equal to 95.75% of the annual chemical production volume (ECJRC, 2003a). The American Chemistry Council indicated that the use rate of DIDP in the EU is similar to the use rate in the United States (ACC, 2020a). As a result, EPA calculated the production volume of DIDP in PVC plastics compounding as 95.75% of the yearly production volume of DIDP under both CASRN or 43,859,857-434,749,009 kg/year. The 2020 CDR reported the national production volume of DIDP as a range; therefore, EPA also provided the plastics compounding production volume as a range. In addition, the Royal Society of Chemistry published a book chapter that stated that, "In 2008, more than 5 million tonnes of phthalates were used as plasticizers worldwide. Of the phthalates used 16% are used in North America… In 2008 DINP and DIDP had a market share of 38% and 21%, respectively" (Koch and Angerer, 2011). The annual North American DIDP production volume used in PVC plastics based on these market share values is 160,000,000 DIDP kg/year, which is generally consistent with the production volume range calculated based on the 2020 CDR data and EU Risk Assessment.

The American Chemistry Council provided information on the concentration of DIDP in different types of PVC plastic products, as shown in Table 3-28 (ACC, 2020a).

Table 3-28. DIDP Concentration for Different PVC Products

Product Type	Concentration Range by Weight
Wire and Cable	25% DIDP
Film and Sheet	20-45% DIDP

Product Type	Concentration Range by Weight
Other	10-40% DIDP

EPA did not identify site- or chemical-specific operating data for PVC plastics compounding (*i.e.*, facility production rate, number of batches, or operating days); EPA estimated an annual facility DIDP throughput of 1,489,327-4,146,286 kg/site-year based on the 2021 *Generic Scenario on Plastic Compounding* throughput of plastic additives, the mass fraction of DIDP in PVC products, and the mass fraction of all additives in compounded plastic resin (U.S. EPA, 2021e). EPA estimated the total number of PVC plastics compounding sites using a Monte Carlo model (see Appendix E.7 for details). The 50th-95th percentile range of the number of sites was 98-195 sites. In contrast three of the seven sites from the 2020 CDR reported their number of downstream sites as Not Known or Reasonably Ascertained (NKRA). The other four sites each reported a total number of downstream sites less than ten. EPA assessed the total number of operating days of 148-264 days/year, with 24 hour/day, 7 day/week (*i.e.*, multiple shifts) operations for the given site throughput scenario. Additionally, EPA assumed the number of batches per site per year was equivalent to the number of operating days, or one batch per day.

3.6.3 Release Assessment

3.6.3.1 Environmental Release Points

EPA assigned release points based on the 2021 *Generic Scenario on Plastic Compounding* (U.S. EPA, 2021e). EPA assigned a default model to quantify releases at each release point and suspected fugitive air release point. EPA expects fugitive or stack air releases from unloading plastic additives and process operations. EPA expects releases to wastewater, incineration, or landfill from container residues and equipment cleaning wastes. EPA expects releases to wastewater from direct contact cooling. Sites may utilize air capture technology. If a site uses air capture technology, EPA expects dust releases from product loading to be controlled and released to disposal facilities for incineration or landfill. EPA expects that the remaining uncontrolled dust is released to stack air. If the site does not use air control technology, EPA expects releases to fugitive air, wastewater, incineration, or landfill as described above.

3.6.3.2 Environmental Release Assessment Results

Table 3-29. Summary of Modeled Environmental Releases for PVC Plastics Compounding

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
96,695,434-958,457,500 lb production volume	Fugitive or Stack Air	7.18E03	3.10E04	223	254	3.29E01	1.45E02
	Fugitive Air, Wastewater, Incineration, or Landfill	1.81E04	5.87E04			8.29E01	2.73E02
	Wastewater, Incineration, or Landfill	9.36E04	1.41E05			4.29E02	6.80E02
	Wastewater	2.38E04	3.38E04			1.09E02	1.64E02

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
	Incineration or Landfill	4.83E03	2.39E04			2.21E01	1.11E02

3.6.4 Occupational Exposure Assessment

3.6.4.1 Worker Activities

Worker exposures during the compounding process may occur via inhalation of DIDP-containing dusts. Dermal exposures to liquids may occur during equipment cleaning. Worker exposures may also occur via dermal contact with liquids and inhalation of vapors during DIDP unloading and loading and transport container cleaning (U.S. EPA, 2021e). EPA did not identify information on engineering controls or worker PPE used at plastics compounding sites.

ONUs include supervisors, managers, and other employees that work in the formulation area but do not directly contact DIDP received or processed onsite or handle compounded product. ONUs are potentially exposed through the inhalation route while in the working area. Also, dermal exposures from contact with surfaces where dust has been deposited were assessed for ONUs.

3.6.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs that are potentially exposed to DIDP during PVC plastics compounding. This approach involved the identification of relevant SOC codes within the BLS data for the select NAICS codes. Section 2.4.2 provides additional details on the methodology EPA used to estimate the number of workers and ONUs per site. EPA assigned the NAICS code 326100 – Plastics Product Manufacturing for this OES based on the CDR reported NAICS codes for PVC plastics compounding (U.S. EPA, 2020a). Table 3-30 summarizes the per site estimates for this OES. As discussed in Section 3.6.2, EPA did not identify site-specific data for the number of facilities in the United States that compound PVC plastics.

Table 3-30. Estimated Number of Workers Potentially Exposed to DIDP during PVC Plastics Compounding

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed Occupational Non-users per Site[b]	Total Number of Exposed ONUs[a]
326100 – Plastics Product Manufacturing	98-195	18	1,798-3,578	5	509-1,012

[a] The result is expressed as a range between the central tendency and the high-end value representing the 50th and 95th percentile results.

[b] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as "0" are left unrounded.

3.6.4.3 Occupational Inhalation Exposure Results

EPA did not identify chemical-specific or OES-specific inhalation monitoring data for DIDP. EPA estimated aggregate (*i.e.*, vapor and dust) worker inhalation exposures using both the surrogate monitoring data for di(2-propylheptyl) phthalate during PVC-coated cable manufacturing and the Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR) (U.S. EPA, 2021d).

The p-chem properties (*e.g.*, molecular weight and vapor pressure) of diisodecyl phthlate and di(2-propylheptyl) phthalate are quite similar, and vapor inhalation monitoring data for DIDP were lacking. Therefore, EPA used surrogate monitoring data for di(2-propylheptyl) phthalate provided in an exposure study conducted by SP Porras *et al.* (2020) in a PVC-coated cable manufacturing facility to estimate worker vapor inhalation exposures to DIDP for this OES. Inhalation exposures during PVC-coated cable manufacturing occur when di(2-propylheptyl) phthalate additives are incorporated into the plastic coating, and EPA expects that these exposures are comparable to inhalation exposures to DIDP during PVC material compounding. The subject facility in the SP Porras *et al.* study sometimes used DIDP as a plasticizer for manufacturing PVC-coated cables, but the facility was using di(2-propylheptyl) phthalate as the plasticizer on the day that sampling occurred (Porras et al., 2020). The study personnel collected stationary samples using the OVS sampler type, which measures a combination of vapor and particulate phases. SP Porras *et al.* collected two samples at cooling points near extruders and provided results as a single 8-hour TWA value for di(2-propylheptyl) phthalate, which was 0.03 mg/m^3. Since the study conducted sampling near a high-temperature extruder, EPA expects that the monitoring data represents vapor concentrations of di(2-propylheptyl) phthalate from heated material as opposed to particulates containing the phthalate. For this reason, EPA decided to aggregate the surrogate monitoring data from SP Porras *et al.* (2020) with particulate inhalation exposure model estimates (discussed below).

DIDP is present in PVC materials (U.S. CPSC, 2015), so EPA expects worker inhalation exposures to DIDP via exposure to particulates of PVC materials. Therefore, EPA estimated worker inhalation exposures during PVC compounding using the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d). Model approaches and parameters are described in Appendix E.16. In the model, EPA used a subset of the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* data that came from facilities with NAICS codes starting with 326 (Plastics and Rubber Manufacturing) to estimate PVC particulate concentrations in the air. EPA used the maximum expected concentration of DIDP in PVC plastic products to estimate the concentration of DIDP in particulates of PVC material. For this OES, EPA selected 45 percent by mass as the highest expected DIDP concentration based on the estimated plasticizer concentrations in flexible PVC given by the *Use of Additives in Plastic Compounding Generic Scenario* (U.S. EPA, 2021e). The estimated exposures assume that DIDP is present in particulates of the PVC material at this fixed concentration throughout the working shift. The *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* uses an 8-hour TWA for particulate concentrations by assuming exposures outside the sample duration are zero. For example, if exposure was measured at 5 mg/m^3 over a 7-hour duration, the 8-hr TWA exposure value would be 4.375 mg/m^3.

EPA assumes that the worker is exposed to DIDP in the form of PVC particulates and DIDP vapors. EPA aggregated estimates from the surrogate monitoring data and the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d) to address these two physical forms of DIDP for the full 8-hour work shift. EPA added the 8-hour TWA concentration from the monitoring data and exposure estimates from the model to aggregate the exposures. EPA used the number of operating days determined in the release assessment for this OES to estimate exposure frequency, with a maximum exposure frequency of 250 working days per year.

Table 3-31 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during PVC plastics compounding. The high-end exposures use 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days. The central tendency exposures use 223 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment.

To estimate ONU exposure for this OES, EPA used surrogate DINP monitoring data provided in an exposure study conducted by Irwin *et al.* at a PVC roofing manufacturing site (Irwin, 2022) (hereinafter referred to as "Irwin 2022 study"). The study collected data via PBZ samples with an unspecified sampling method. The study included one PBZ sample for ONU exposure to airborne oil mists (Irwin, 2022). This data point was below the LOD. Therefore, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To estimate high-end exposures to ONUs, EPA used the LOD reported in the study. To estimate central tendency ONU exposures, EPA used half of the LOD. Appendix B describes the approach for estimating AD, IADD, and ADD.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration to Vapors (mg/m^3)	3.0E−02	3.0E−02
	8-hr TWA Exposure Concentration to Dust (mg/m^3)	0.10	2.1
	Acute Dose (AD) (mg/kg/day)	1.7E−02	0.27
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	1.2E−02	0.20
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	1.0E−02	0.18
Female of Reproductive Age	8-hr TWA Exposure Concentration to Vapors (mg/m^3)	3.0E−02	3.0E−02
	8-hr TWA Exposure Concentration to Dust (mg/m^3)	0.10	2.1
	Acute Dose (AD) (mg/kg/day)	1.8E−02	0.30
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	1.4E−02	0.22
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	1.1E−02	0.20
ONU	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−04	6.0E−04
	8-hr TWA Exposure Concentration to Dust (mg/m^3)	0.10	0.10
	Acute Dose (AD) (mg/kg/day)	1.3E−02	1.3E−02
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	9.5E−03	9.5E−03

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	7.9E−03	8.9E−03

3.6.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-32 are explained in Appendix B. Because dermal exposures of DIDP to workers may occur in the neat form during PVC plastics compounding, EPA assessed the absorptive flux of DIDP according to dermal absorption data of neat DIDP (see Appendix D.2.1.1 for details). Also, since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Dermal exposure to workers is generally expected to be greater than dermal exposure to ONUs. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure. Therefore, worker central tendency exposure values for dermal contact with solids containing DIDP were assumed representative of ONU dermal exposure.

Table 3-32 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for average adult workers, female workers of reproductive age, and ONUs. Dermal exposure parameters are described in Appendix D.

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

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.7	7.3
	Acute (AD, mg/kg-day)	4.6E−02	9.2E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	6.7E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.8E−02	6.3E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.1	6.1
	Acute (AD, mg/kg-day)	4.2E−02	8.4E−02
	Intermediate (IADD, mg/kg-day)	3.1E−02	6.2E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.6E−02	5.8E−02
ONU	Dose Rate (APDR, mg/day)	3.8E−02	3.8E−02
	Acute (AD, mg/kg-day)	4.8E−04	4.8E−04
	Intermediate (IADD, mg/kg-day)	3.5E−04	3.5E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−04	3.3E−04

3.6.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-33.

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

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	6.3E−02	0.36
	Intermediate (IADD, mg/kg-day)	4.6E−02	0.26
	Chronic, Non-cancer (ADD, mg/kg-day)	3.8E−02	0.25
Female of Reproductive Age	Acute (AD, mg/kg-day)	6.1E−02	0.38
	Intermediate (IADD, mg/kg-day)	4.4E−02	0.28
	Chronic, Non-cancer (ADD, mg/kg-day)	3.7E−02	0.26
ONU	Acute (AD, mg/kg-day)	1.3E−02	1.3E−02
	Intermediate (IADD, mg/kg-day)	9.9E−03	9.9E−03
	Chronic, Non-cancer (ADD, mg/kg-day)	8.2E−03	9.2E−03

3.7 PVC Plastics Converting

3.7.1 Process Description

DIDP is used as a plasticizer in PVC plastics, including vinyl barriers and castable PVC plastic (see Appendix F for EPA identified DIDP-containing products for this OES). EPA expects that DIDP will arrive at a typical converting site as a solid in containers ranging in size from 5-1000 gallons (U.S. EPA, 2004a). A typically converting site will unload DIDP in solid form, as a masterbatch, from PVC plastic compounding sites where it is transferred to a shaping unit operation such as an extruder, injection molding unit, or blow molding unit to achieve the final product shape. The converting site may trim excess material from the final plastic product after it cools. Figure 3-7 provides an illustration of the plastic converting process (U.S. EPA, 2004a).

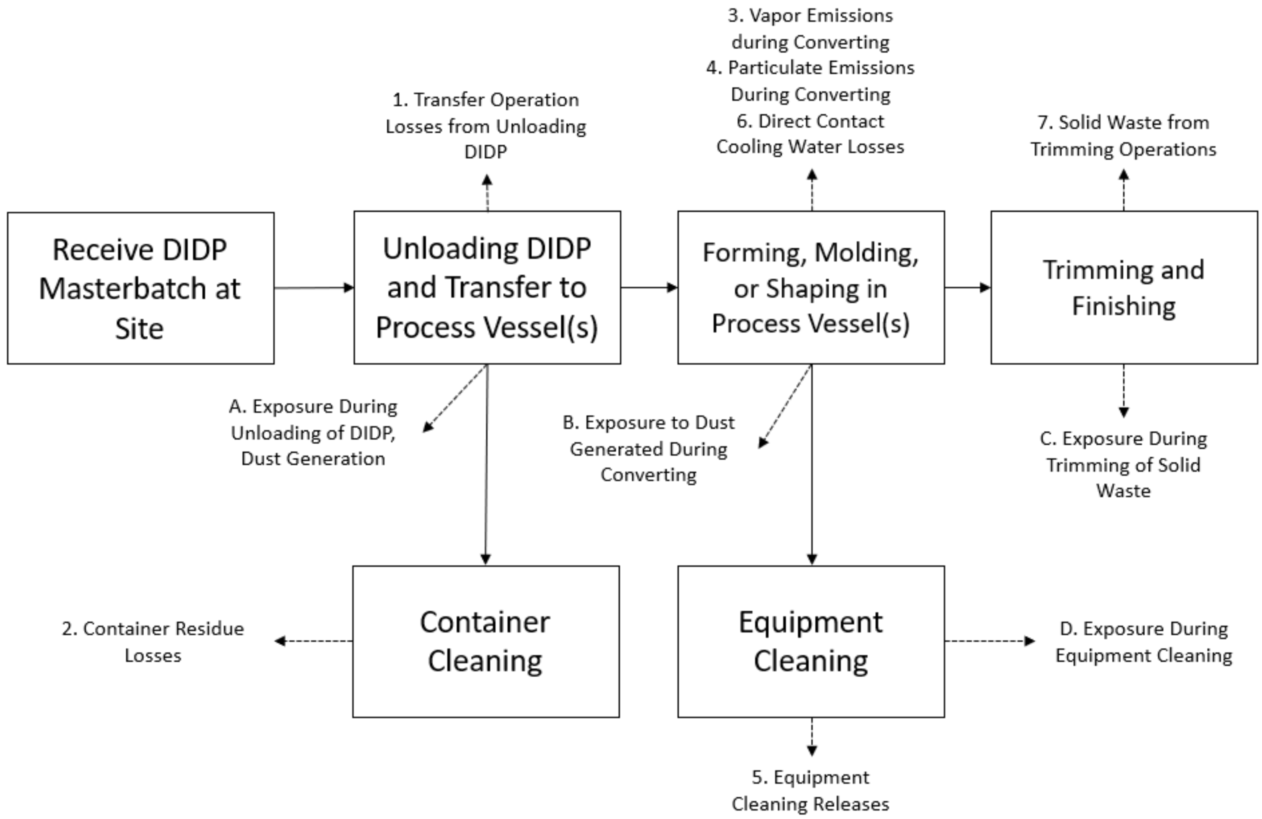

Figure 3-7. PVC Plastics Converting Flow Diagram (U.S. EPA, 2004a)

It is important to note that the Manufacturer request for risk evaluation: Diisodecyl phthalate (DIDP) and Final Use Report for Diisodecyl Phthalate (DIDP) (1,2-Benzenedicarboxylic acid, 1,2-diisodecyl ester and 1,2-Benzenedicarboxylic acid, di-C9-11-branched alkyl esters, C10-rich) (CASRN 26761-40-0 and 68515-49-1) reported use of DIDP in inks and colorants (U.S. EPA, 2021c, 2019b). The Processing ,incorporation into articles, "ink, toner, and colorant products manufacturing" COU describes the incorporation of DIDP-containing colorants into material such as, polyurethane or plastisol. Plastisol mixed with DIDP-containing colorants are applied through processes such as dipping, roto-molding, or slush molding to produce coated fabrics, vinyl sealants, wall coverings, toys, and sporting goods (ACC, 2020b). DIDP is also present in colorants used to color two-part polyurethane, foam, and epoxy resin systems used for production of prototypes, miniature models, and taxidermy (U.S. EPA, 2021c).

3.7.2 Facility Estimates

Since converting occurs immediately downstream of compounding, EPA expects the production volume for PVC plastic converting to be identical to the production volume for the PVC plastics compounding OES. The production volume of DIDP for use in PVC plastics compounding under both CASRN was 43,859,857-434,749,009 kg/year (see Section 3.6 for details).

The American Chemistry Council provided information on the concentration of DIDP in different types of PVC products as shown in Table 3-28 (ACC, 2020a).

EPA did not identify PVC plastic converting site operating data (*i.e.*, facility production rate, number of batches, or operating days); EPA estimated an annual facility DIDP throughput of 68,542-182,547 kg/site-year based on the 2004 *Generic Scenario on Plastics Converting* throughput of plastic additives, the mass fraction of DIDP in PVC products, and the mass fraction of all additives in plastic resin (U.S. EPA, 2004a). EPA estimated the total number of PVC plastics converting sites using a Monte Carlo model (see Appendix E.8 for details). The 50th-95th percentile range of the number of sites was 2,128-4,237 sites. In contrast to the 2020 CDR, in which three of the seven sites reported their number of downstream sites as NKRA, while the other four sites each reported a total number of downstream sites less than ten. EPA assessed the total number of operating days as 137-254 days/year, of 24 hour/day, 7 day/week (*i.e.*, multiple shifts) operations for the given site throughput scenario. Additionally, EPA assumed the number of batches completed per site per year was equivalent to the number of operating days, or one completed batch per day.

3.7.3 Release Assessment

3.7.3.1 Environmental Release Points

EPA assigned release points based on the 2004 *Generic Scenario on Plastic Converting* (U.S. EPA, 2004a). EPA assigned default models to quantify releases from each release point and suspected fugitive air release point. EPA expects fugitive or stack air releases and particulate emissions to fugitive air, wastewater, incineration, or landfill from converting operations. EPA expects releases to wastewater, incineration, or landfill from container residues, and equipment cleaning. EPA expects releases to wastewater from direct contact cooling and incineration, and landfill releases from solid waste trimming. Converting sites may utilize air capture technology. If a site uses air capture technology, EPA expects dust releases from plastic unloading to be controlled and released to disposal facilities for incineration or landfill; The site would release the remaining uncontrolled dust to stack air. If the site does not use air control technology, EPA expects plastic unloading releases to fugitive air, wastewater, incineration, or landfill as described above.

3.7.3.2 Environmental Release Assessment Results

Table 3-34. Summary of Modeled Environmental Releases for PVC Plastics Converting

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
96,695,434-958,457,500 lb production volume	Fugitive or Stack Air	3.35E02	1.43E03	219	251	1.57	6.86
	Fugitive Air, Wastewater, Incineration, or Landfill	8.40E02	2.71E03			3.94	1.30E01
	Wastewater, Incineration, or Landfill	3.28E03	4.66E03			1.54E01	2.35E01
	Wastewater	1.10E03	1.55E03			5.14	7.84
	Incineration or Landfill	3.05E03	4.50E03			1.43E01	2.28E01

3.7.4 Occupational Exposure Assessment

3.7.4.1 Worker Activities

Workers are potentially exposed to DIDP via dust inhalation during the converting process and via dermal contact with liquids during equipment cleaning. Additionally, workers may be exposed to DIDP via dermal contact with liquids and inhalation of vapors during unloading and loading, transport container cleaning, and trimming of excess plastic (U.S. EPA, 2021f). EPA did not identify information on engineering controls or worker PPE used at plastics converting sites.

ONUs include supervisors, managers, and other employees that work in the formulation area but do directly contact DIDP that is received or processed onsite or handle the finished product. ONUs are potentially exposed through the inhalation route while in the working area. Also, dermal exposures from contact with surfaces where dust has been deposited were assessed for ONUs.

3.7.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs per site that are potentially exposed to DIDP during PVC plastics converting. This approach involved the identification of relevant SOC codes withing the BLS data for select NAICS codes. Section 2.4.2 provides additional details regarding the methodology that EPA used to estimate the number of workers and ONUs per site. EPA assigned the NAICS code 326100 – Plastics Product Manufacturing for this OES based on the CDR reported NAICS codes for PVC plastics converting (U.S. EPA, 2020a). Table 3-35 summarizes the per site estimates for this OES. As discussed in Section 3.7.2, EPA did not identify site-specific data for the number of facilities in the United States that convert PVC plastics.

Table 3-35. Estimated Number of Workers Potentially Exposed to DIDP during PVC Plastics Converting

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed Occupational Non-users per Site[b]	Total Number of Exposed ONUs[a]
326100 – Plastics Product Manufacturing	2,128-4,237	18	39,044-77,739	5	11,049-22,000

[a] The result is expressed as a range between the central tendency and the high-end value representing the 50th and 95th percentile results.

[b] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as "0" are left unrounded.

3.7.4.3 Occupational Inhalation Exposure Results

EPA identified one study with surrogate monitoring data collected during plastics converting at a cable coating facility; however, as described below, the study had several limitations. Therefore, EPA estimated aggregate (*i.e.*, vapor and dust) worker inhalation exposures using both the cable coating surrogate monitoring data and the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d).

The p-chem properties (*e.g.*, molecular weight and vapor pressure) of diisodecyl phthlate and di(2-propylheptyl) phthalate are quite similar, and vapor inhalation monitoring data for DIDP were lacking. Therefore, EPA used surrogate monitoring data for di(2-propylheptyl) phthalate provided in an exposure study conducted by SP Porras *et al.* (2020) in a PVC-coated cable manufacturing facility to estimate worker vapor inhalation exposures to DIDP for this OES. Inhalation exposures during PVC-coated cable manufacturing occur when di(2-propylheptyl) phthalate additives are incorporated into the plastic coating, and EPA expects that these exposures are comparable to inhalation exposures to DIDP during

PVC plastics converting. The subject facility in the SP Porras *et al.* study sometimes used DIDP as a plasticizer for manufacturing PVC-coated cables, but the facility was using di(2-propylheptyl) phthalate as the plasticizer on the day that sampling occurred (Porras et al., 2020). The study personnel collected stationary samples using the OVS sampler type, which measures a combination of vapor and particulate phases. SP Porras *et al.* collected two samples at cooling points near extruders and provided results as a single 8-hour TWA value for di(2-propylheptyl) phthalate, which was 0.03 mg/m^3. Since the study conducted sampling near a high-temperature extruder, EPA expects that the monitoring data represents vapor concentrations of di(2-propylheptyl) phthalate from heated material as opposed to particulates containing the phthalate. For this reason, EPA decided to aggregate the surrogate monitoring data from SP Porras *et al.* (2020) with particulate inhalation exposure model estimates (discussed below).

DIDP is present in PVC materials (U.S. CPSC, 2015), so EPA expects worker inhalation exposures to DIDP via exposure to particulates of PVC materials. Therefore, EPA estimated worker inhalation exposures during PVC plastic converting using the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d). Model approaches and parameters are described in Appendix E.16. In the model, EPA used a subset of the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* data that came from facilities with NAICS codes starting with 326 (Plastics and Rubber Manufacturing) to estimate PVC plastic particulate concentrations in the air. EPA used the highest expected concentration of DIDP in PVC plastic products to estimate the concentration of DIDP in particulates. For this OES, EPA selected 45 percent by mass as the maximum expected DIDP concentration, based on the estimated plasticizer concentrations in flexible PVC given by the *Use of Additives in Plastic Compounding Generic Scenario* (U.S. EPA, 2021e). The estimated exposures assume that DIDP is present in particulates of the PVC plastic at this fixed concentration throughout the working shift. The *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* uses an 8-hour TWA for particulate concentrations, by assuming exposures outside the sample duration are zero. Exposures during individual worker activities are not determined using this model.

EPA assumed that the worker is exposed to DIDP in the form of PVC plastic particulates and DIDP vapors. EPA aggregated estimates from the surrogate monitoring data and the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d) to address these two physical forms of DIDP for the full 8-hour work shift. EPA added the 8-hour TWA from the monitoring data and exposure estimates from the model to aggregate the exposures. EPA used the number of operating days determined in the release assessment for this OES to estimate exposure frequency, with a maximum exposure frequency of 250 working days per year.

Table 3-36 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during PVC plastics converting. The high-end exposures use 250 days per year as the exposure frequency, since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days. The central tendency exposures use 219 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment.

To estimate ONU exposure for this OES, EPA used surrogate DINP monitoring data provided in an exposure study conducted by Irwin *et al.* at a PVC roofing manufacturing site (Irwin, 2022) (hereinafter referred to as “Irwin 2022 study”). Irwin *et al.* collected PBZ samples using an unspecified sampling method. The study included one PBZ sample for ONU exposure to airborne oil mists (Irwin, 2022). This data point was below the LOD. Therefore, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To estimate high-end exposures to ONUs, EPA used the LOD reported in the study. To estimate central tendency ONU exposures, EPA used half of the LOD. EPA does not expect ONU exposures to dusts during PVC plastics converting. Appendix B describes the approach for estimating AD, IADD, and ADD.

Table 3-36. Summary of Estimated Worker Inhalation Exposures for PVC Plastics Converting

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration to Vapors (mg/m^3)	3.0E−02	3.0E−02
	8-hr TWA Exposure Concentration to Dust (mg/m^3)	0.10	2.1
	Acute Dose (AD) (mg/kg/day)	1.7E−02	0.27
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	1.2E−02	0.20
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	1.0E−02	0.18
Female of Reproductive Age	8-hr TWA Exposure Concentration to Vapors (mg/m^3)	3.0E−02	3.0E−02
	8-hr TWA Exposure Concentration to Dust (mg/m^3)	0.10	2.1
	Acute Dose (AD) (mg/kg/day)	1.8E−02	0.30
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	1.4E−02	0.22
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	1.1E−02	0.20
ONU	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−04	6.0E−04
	8-hr TWA Exposure Concentration to Dust (mg/m^3)	0.10	0.10
	Acute Dose (AD) (mg/kg/day)	1.3E−02	1.3E−02
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	9.5E−03	9.5E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	7.8E−03	8.9E−03

3.7.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-37 are explained in Appendix B. Because dermal exposures of DIDP to workers is expected to occur through contact with solids or articles for this OES, EPA assessed the absorptive flux of DIDP according to dermal absorption modeling approach for solids outlined in Appendix D.2.1.2. Also, since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Dermal exposure to workers is generally expected to be greater than dermal exposure to ONUs. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure. Therefore, worker central tendency exposure values for dermal contact with solids containing DIDP were assumed representative of ONU dermal exposure.

Table 3-37 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for average adult workers, female workers of reproductive age, and ONUs. Dermal exposure parameters are described in Appendix D.

Table 3-37. Summary of Estimated Worker Dermal Exposures for PVC Plastics Converting

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.9E−02	7.7E−02
	Acute (AD, mg/kg-day)	4.8E−04	9.6E−04
	Intermediate (IADD, mg/kg-day)	3.5E−04	7.1E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−04	6.6E−04
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.2E−02	6.4E−02
	Acute (AD, mg/kg-day)	4.4E−04	8.8E−04
	Intermediate (IADD, mg/kg-day)	3.2E−04	6.5E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	2.7E−04	6.1E−04
ONU	Dose Rate (APDR, mg/day)	3.9E−02	3.9E−02
	Acute (AD, mg/kg-day)	4.8E−04	4.8E−04
	Intermediate (IADD, mg/kg-day)	3.5E−04	3.5E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−04	3.3E−04

3.7.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-38.

Table 3-38. Summary of Estimated Worker Aggregate Exposures for PVC Plastics Converting

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.7E−02	0.27
	Intermediate (IADD, mg/kg-day)	1.3E−02	0.20
	Chronic, Non-cancer (ADD, mg/kg-day)	1.0E−02	0.18
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.9E−02	0.30
	Intermediate (IADD, mg/kg-day)	1.4E−02	0.22
	Chronic, Non-cancer (ADD, mg/kg-day)	1.1E−02	0.20
ONU	Acute (AD, mg/kg-day)	1.3E−02	1.3E−02
	Intermediate (IADD, mg/kg-day)	9.9E−03	9.9E−03
	Chronic, Non-cancer (ADD, mg/kg-day)	8.1E−03	9.2E−03

3.8 Non-PVC Material Compounding

3.8.1 Process Description

The 2021 *Scope of the Risk Evaluation for Diisodecyl Phthalate* (U.S. EPA, 2021b) and CDR reports for plastic material and resin manufacturing indicate DIDP use in non-PVC polymers, such as rubber, vinyl resins, cellulose ester plastics, and flexible fibers (see Appendix F for EPA identified DIDP-containing products for this OES) (U.S. EPA, 2021b, 2020a; ECJRC, 2003a); however, EPA did not identify specific non-PVC polymer products that contain DIDP from the data sources that underwent systematic review.

EPA expects that a typical non-PVC material compounding site operates similar to a PVC plastic compounding site. Based on the 2021 *Generic Scenario on Plastic Compounding*, typical compounding sites receive DIDP as a pure liquid at 25°C in drums and totes ranging from 20-1,000 gallons in size. Typical compounding sites receive and unload DIDP and transfer it into mixing vessels to produce a compounded resin masterbatch. Following completion of the masterbatch, sites transfer the solid resin to extruders that shape and size the plastic and package the final product for shipment to downstream conversion sites after cooling (U.S. EPA, 2021e). Figure 3-8 provides an illustration of the plastic compounding process (U.S. EPA, 2021e).

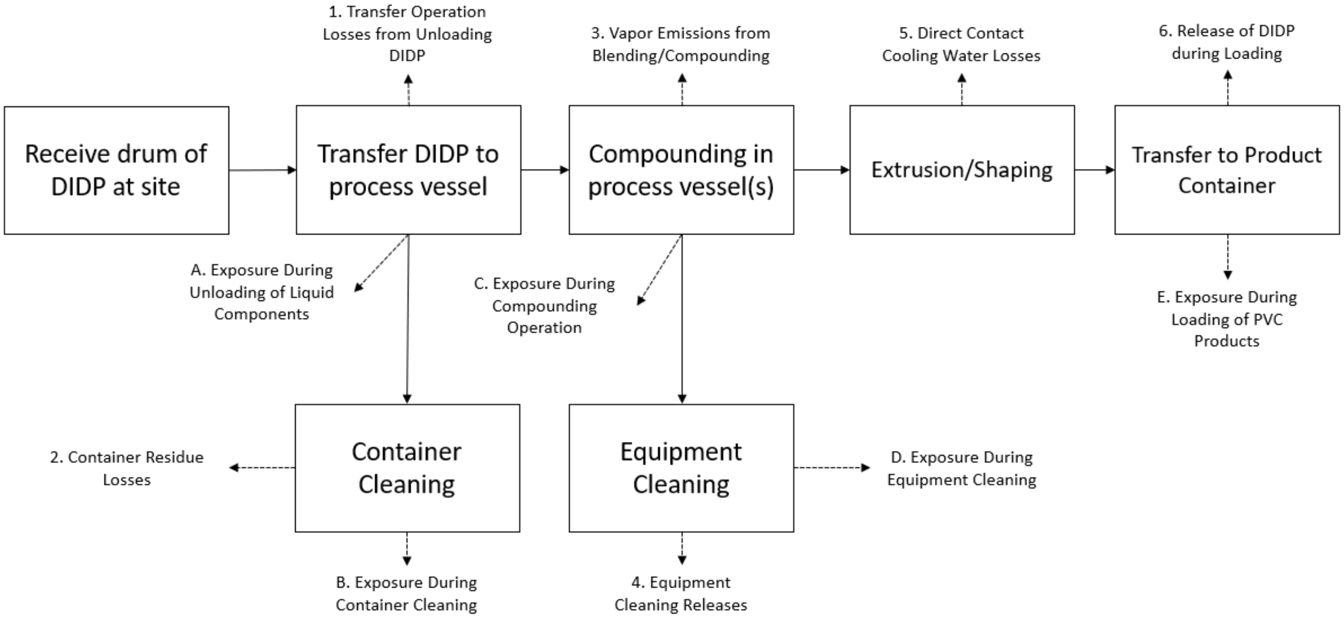

Figure 3-8. Non-PVC Material Compounding Flow Diagram

Note that some materials, such as rubbers, may consolidate the compounding and converting operation as described in the SpERC Fact Sheet on Rubber Production and Processing. Figure 3-9 provides an illustration of the rubbers formulation process (ESIG, 2020; OECD, 2004a). However, it is the rate of consolidated operations for non-PVC materials is unknown; therefore, EPA assessed all formulations as separate compounding and converting steps. Figure 3-9 provides an illustration of the consolidated process.

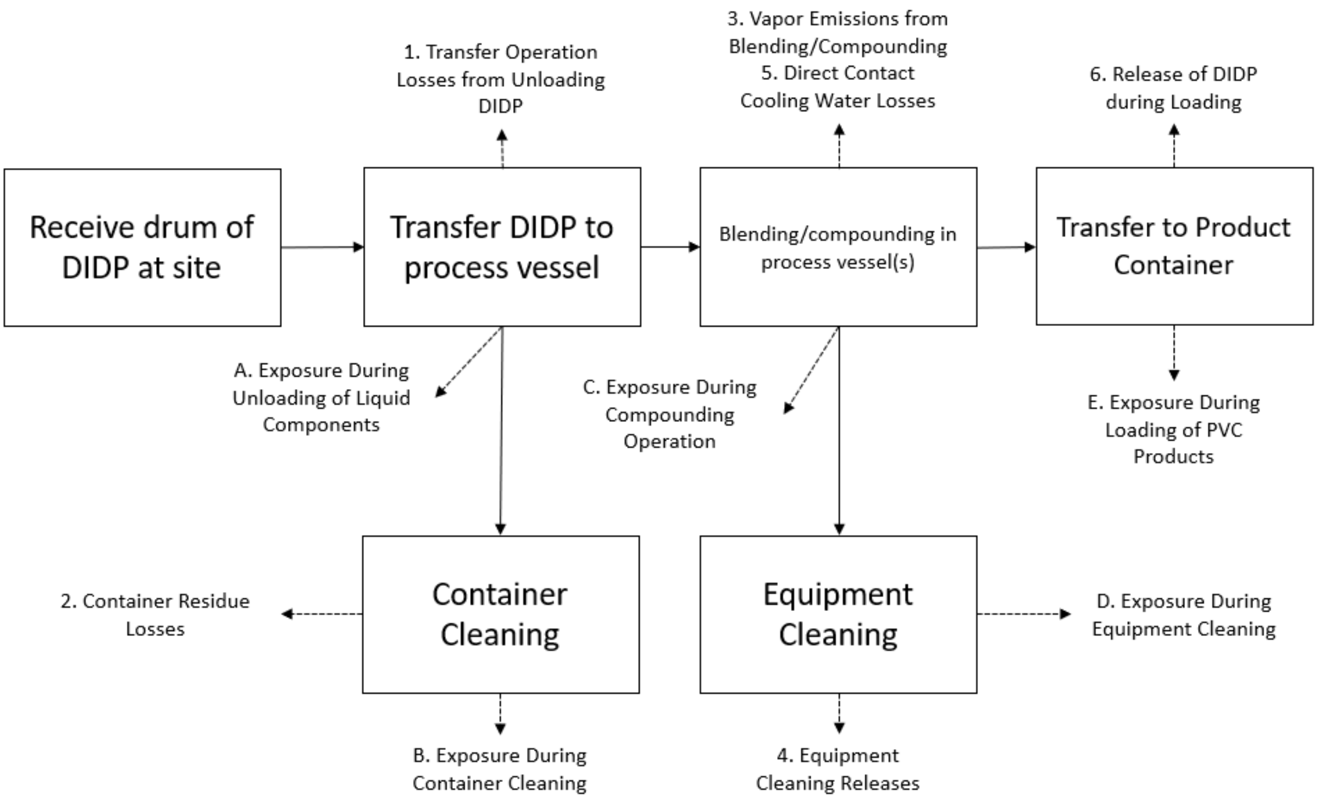

Figure 3-9. Consolidated Compounding and Converting Flow Diagram

3.8.2 Facility Estimates

In the 2020 CDR two sites reported a production volume for the formulation of rubbers OES. Many sites reported plastic compounding activity; however, CDR does not allow reporters to specify PVC and non-PVC Plastics compounding. Therefore, EPA assessed all plastic compounding sites as PVC compounding based on the majority use case. Due to additional limitations associated with using CDR data for downstream processes, EPA relied on data from the European Union and the American Chemistry Council to assess the total production volume. The 2003 *DIDP Risk Assessment* published by the European Union stated that the downstream use rate in the other category, including non-PVC plastic and rubber manufacturing is equal to 3.2% of the annual chemical production volume (ECJRC, 2003a). The American Chemistry Council indicated that the use rate of DIDP in the EU is similar to the use rate in the United States (ACC, 2020a). The 2020 CDR reported a national production volume range for DIDP; therefore, EPA provided the formulation of rubbers and non-PVC polymers production volume as a range using the EU defined percentage of non-PVC polymer DIDP use. Since EPA was unable to further refine this production volume into non-PVC polymer and rubber formulation, the OES were assessed together due to similarities in their respective production processes. EPA calculated the production volume of DIDP under both CASRN as 1,465,812 to 14,529,471 kg/year.

EPA did not identify site- or DIDP-specific non-PVC material compounding operating data (*i.e.*, facility production rate, number of batches, or operating days). EPA assessed non-PVC material compounding operating data based on PVC compounding operating data, as the operations are expected to be similar. EPA based the DIDP facility use rate on the 2021 *Generic Scenario on Plastic Compounding* product throughput of plastic additives. EPA also considered the 2004 *ESD on Additives in the Rubber Industry* but determined the plastics compound GS to be more representative of the whole OES (OECD, 2004a).

The GS based the facility use rate on the mass fraction of DIDP in non-PVC products, and the mass fraction of all additives in compounded plastic resin (U.S. EPA, 2021e). The estimated annual facility DIDP throughput was 1,489,327-4,146,286 kg/site-year. The GS estimated the total number of operating days as 148-300 days/year, with 24 hour/day, 7 day/week (*i.e.*, multiple shifts) operations for the given site throughput scenario. The number of batches completed per site year was equivalent to the number of operating days, or one batch per day (U.S. EPA, 2021e). EPA estimated the total number of sites that participate in non-PVC plastic compounding using a Monte Carlo model (see Appendix E.9 for details). The 50th-95th percentile range of the number of sites was 4-9. In contrast to 2020 CDR reports, in which one site reported the number of industrial use sites as NKRA and the other site reported a total number of industrial sites to be less than 10.

3.8.3 Release Assessment

3.8.3.1 Environmental Release Points

EPA assigned release points based on the 2021 *Generic Scenario on Plastic Compounding* (U.S. EPA, 2021e). EPA assigned default models to quantify releases from each release point and suspected fugitive air release point. EPA expects fugitive or stack air releases from unloading plastic additives, and process operations. EPA expects releases to wastewater, incineration, or landfill from container residues and equipment cleaning wastes. EPA expects releases to wastewater from direct contact cooling. Sites may utilize air capture technology. If a site uses air capture technology, EPA expects dust releases from product loading to be controlled and released to disposal facilities for incineration or landfill. EPA expects the remaining uncontrolled dust to be released to stack air. If the site does not use air control technology, EPA expects releases to fugitive air, wastewater, incineration, or landfill as described above.

3.8.3.2 Environmental Release Assessment Results

Table 3-39. Summary of Modeled Environmental Releases for Non-PVC Material Compounding

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
96,695,434-958,457,500 lb production volume	Fugitive or Stack Air	9.99E03	3.37E04	234	280	4.39E01	1.44E02
	Fugitive Air, Wastewater, Incineration, or Landfill	8.67E02	2.97E03			3.80	1.27E01
	Wastewater, Incineration, or Landfill	2.08E05	3.97E05			9.07E02	1.66E03
	Wastewater	1.87E04	2.70E04			8.25E01	1.07E02
	Incineration or Landfill	1.45E04	4.41E04			6.35E01	1.87E02

3.8.4 Occupational Exposure Assessment

3.8.4.1 Worker Activities

Worker exposures to DIDP dust may occur through inhalation during the compounding process, while dermal exposures to liquids may occur during equipment cleaning. Worker exposures may also occur via dermal contact with liquids and inhalation of vapors during unloading and loading of DIDP and transport container cleaning (U.S. EPA, 2021e). EPA did not identify information on engineering controls or worker PPE used at plastics compounding sites.

ONUs include supervisors, managers, and other employees that work in the formulation area but do not directly contact DIDP that is received or processed onsite or handle of compounded product. ONUs are potentially exposed through the inhalation route while in the working area. Also, dermal exposures from contact with surfaces where dust has been deposited were assessed for ONUs.

3.8.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs per site that are potentially exposed to DIDP during the compounding of non-PVC material. This approach involved the identification of relevant SOC codes within the BLS data for select NAICS codes. Section 2.4.2 provides additional details regarding the methodology that EPA used to estimate the number of workers and ONUs per site. EPA assigned the NAICS codes 325212, 326200, and 424690 for this OES based on the "Generic Scenario on the Use of Additives in Plastic Compounding" and CDR reported NAICS codes for non-PVC material compounding (U.S. EPA, 2021e, 2020a). Table 3-40 summarizes the per site estimates for this OES. As addressed in Section 3.8.2, EPA did not identify site-specific data for the number of facilities in the United States that compound non-PVC material.

Table 3-40. Estimated Number of Workers Potentially Exposed to DIDP during Non-PVC Material Compounding

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed ONUs per Site[b]	Total Number of Exposed ONUs[a]
325212 – Synthetic Rubber Manufacturing	N/A	25	N/A	11	N/A
326200 – Rubber Product Manufacturing		42		7	
424690 – Other Chemical and Allied Products Merchant Wholesalers		1		0.4	
Total/Average	4-9	23	90-203	6	24-54

[a] The result is expressed as a range between the central tendency and the high-end value. Results were not assessed by NAICS code for this scenario.

[b] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as "0" are left unrounded.

3.8.4.3 Occupational Inhalation Exposure Results

EPA did not identify chemical-specific or OES-specific inhalation monitoring data for DIDP. EPA estimated aggregate (*i.e.*, vapor and dust) worker inhalation exposures using DIDP monitoring data collected at a PVC-coated cable manufacturing facility and the Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR) (U.S. EPA, 2021d).

The p-chem properties (*e.g.*, molecular weight and vapor pressure) of diisodecyl phthlate and di(2-propylheptyl) phthalate are quite similar, and vapor inhalation monitoring data for DIDP were lacking. Therefore, EPA used surrogate monitoring data for di(2-propylheptyl) phthalate provided in an exposure study conducted by SP Porras *et al.* (2020) in a PVC-coated cable manufacturing facility to estimate worker vapor inhalation exposures to DIDP for this OES. Inhalation exposures during PVC-coated cable manufacturing occur when di(2-propylheptyl) phthalate additives are incorporated into the plastic coating, and EPA expects that these exposures are comparable to inhalation exposures to DIDP during non-PVC material compounding. The subject facility in the SP Porras *et al.* study sometimes used DIDP as a plasticizer for manufacturing PVC-coated cables, but the facility was using di(2-propylheptyl) phthalate as the plasticizer on the day that sampling occurred (Porras et al., 2020). The study personnel collected stationary samples using the OVS sampler type, which measures a combination of vapor and particulate phases. SP Porras *et al.* collected two samples at cooling points near extruders and provided results as a single 8-hour TWA value for di(2-propylheptyl) phthalate, which was 0.03 mg/m^3. Since the study conducted sampling near a high-temperature extruder, EPA expects that the monitoring data represents vapor concentrations of di(2-propylheptyl) phthalate from heated material as opposed to particulates containing the phthalate. For this reason, EPA decided to aggregate the surrogate monitoring data from SP Porras *et al.* (2020) with particulate inhalation exposure model estimates (discussed below).

DIDP is present in non-PVC materials (U.S. CPSC, 2015), so EPA expects worker inhalation exposures to DIDP via exposure to particulates of non-PVC materials. Therefore, EPA estimated worker inhalation exposures during non-PVC material compounding using the Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR) (U.S. EPA, 2021d). Model approaches and parameters are described in Appendix E.16. In the model, EPA used a subset of the Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR) data that came from facilities with NAICS codes starting with 326 (Plastics and Rubber Manufacturing) to estimate non-PVC material particulate concentrations in the air. EPA used the highest expected concentration of DIDP in non-PVC plastic products to estimate the concentration of DIDP present in the particulates of non-PVC material. For this OES, EPA selected 20 percent by mass as the maximum expected DIDP concentration based on the Emission Scenario Document on Additives in Rubber Industry (OECD, 2004a). The estimated exposures assume that DIDP is present in particulates of the non-PVC material at this fixed concentration throughout the working shift. The Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR) estimates an 8-hour TWA for particulate concentrations by assuming exposures outside the sample duration are zero. Exposures during individual worker activities are not determined using this model.

EPA assumed that the worker is exposed to DIDP in the form of non-PVC material particulates and DIDP vapors. EPA aggregated estimates from the surrogate monitoring data and the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d) to address these two physical forms of DIDP for the full 8-hour work shift. EPA added the 8-hour TWA concentration from the monitoring data and the exposure estimates from the model to aggregate the exposures. EPA used the number of operating days determined in the release assessment for this OES to estimate exposure frequency, with a maximum exposure frequency of 250 working days per year.

Table 3-41 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during non-PVC material compounding. The high-end exposures use 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days. The central tendency exposures use 234 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Appendix B describes the approach for estimating AD, IADD, and ADD.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−02	3.0E−02
	8-hr TWA Exposure Concentration to Dust (mg/m^3)	4.6E−02	0.94
	Acute Dose (AD) (mg/kg/day)	9.5E−03	0.12
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	7.0E−03	8.9E−02
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	6.1E−03	8.3E−02
Female of Reproductive Age	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−02	3.0E−02
	8-hr TWA Exposure Concentration to Dust (mg/m^3)	4.6E−02	0.94
	Acute Dose (AD) (mg/kg/day)	1.0E−02	0.13
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	7.7E−03	9.8E−02
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	6.7E−03	9.2E−02
ONU	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−04	6.0E−04
	8-hr TWA Exposure Concentration to Dust (mg/m^3)	4.6E−02	4.6E−02
	Acute Dose (AD) (mg/kg/day)	5.8E−03	5.8E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	4.2E−03	4.3E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	3.7E−03	4.0E−03

3.8.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-42 are explained in Appendix B. Because dermal exposures of DIDP to workers may occur in the neat form during non-PVC material compounding, EPA assessed the absorptive flux of DIDP according to dermal absorption data of neat DIDP (see Appendix D.2.1.1 for details). Also, since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Dermal exposure to workers is generally expected to be greater than dermal exposure to ONUs. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure. Therefore, worker central tendency exposure values for dermal contact with solids containing DIDP were assumed representative of ONU dermal exposure.

Table 3-42 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for average adult workers, female workers of reproductive age, and ONUs. Dermal exposure parameters are described in Appendix D.

Table 3-42. Summary of Estimated Worker Dermal Exposures for Non-PVC Material Compounding

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.7	7.3
	Acute (AD, mg/kg-day)	4.6E−02	9.2E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	6.7E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−02	6.3E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.1	6.1
	Acute (AD, mg/kg-day)	4.2E−02	8.4E−02
	Intermediate (IADD, mg/kg-day)	3.1E−02	6.2E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.7E−02	5.8E−02
ONU	Dose Rate (APDR, mg/day)	3.9E−02	3.9E−02
	Acute (AD, mg/kg-day)	4.8E−04	4.8E−04
	Intermediate (IADD, mg/kg-day)	3.5E−04	3.5E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	3.1E−04	3.3E−04

3.8.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-43.

Table 3-43. Summary of Estimated Worker Aggregate Exposures for Non-PVC Material Compounding

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	5.5E−02	0.21
	Intermediate (IADD, mg/kg-day)	4.1E−02	0.16
	Chronic, Non-cancer (ADD, mg/kg-day)	3.5E−02	0.15
Female of Reproductive Age	Acute (AD, mg/kg-day)	5.3E−02	0.22
	Intermediate (IADD, mg/kg-day)	3.9E−02	0.16
	Chronic, Non-cancer (ADD, mg/kg-day)	3.4E−02	0.15
ONU	Acute (AD, mg/kg-day)	6.3E−03	6.3E−03
	Intermediate (IADD, mg/kg-day)	4.6E−03	4.6E−03
	Chronic, Non-cancer (ADD, mg/kg-day)	4.0E−03	4.3E−03

3.9 Non-PVC Material Converting

3.9.1 Process Description

The 2021 *Scope of the Risk Evaluation for Diisodecyl Phthalate* (U.S. EPA, 2021b) and CDR reports in plastic material and resin manufacturing indicates DIDP use in non-PVC polymers, such as rubber, vinyl resins, cellulose ester plastics, and flexible fibers (see Appendix F for EPA identified DIDP-containing products for this OES) (U.S. EPA, 2021b, 2020a; ECJRC, 2003a); however, EPA did not identify specific DIDP-containing products from the data sources that underwent systematic review.

EPA expects that typical non-PVC material converting site operates similar to PVC plastic converting sites. A typical converting site receives and unloads DIDP in solid form, as a masterbatch, from compounding sites. The converting sites then transfers the masterbatch to a shaping unit operation such as an extruder, injection molding unit, or blow molding unit to achieve the final product shape. The converting site may trim excess material from the final product after it cools. Figure 3-10 provides an illustration of the non-PVC material converting process (U.S. EPA, 2021e).

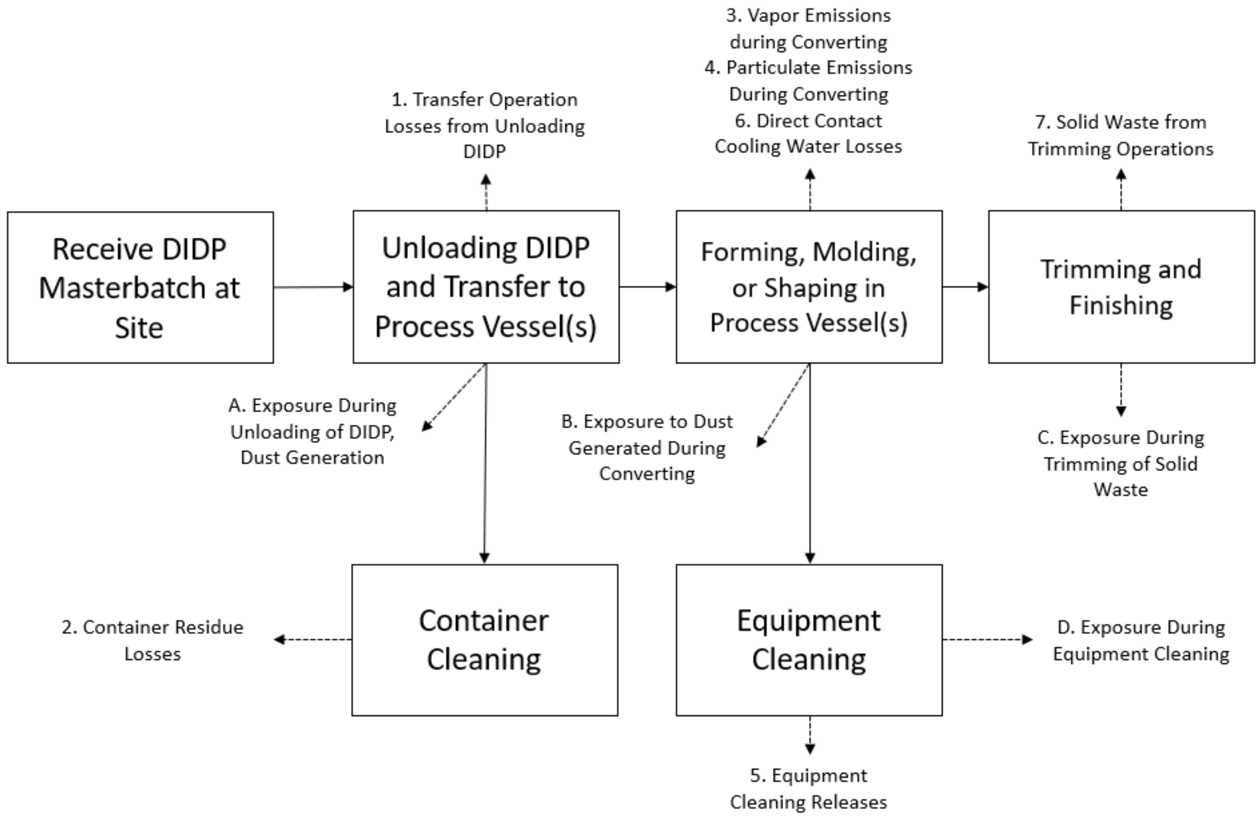

Figure 3-10. Non-PVC Material Converting Flow Diagram (U.S. EPA, 2004a)

3.9.2 Facility Estimates

Since converting occurs immediately downstream of compounding, EPA expects the production volume for non-PVC material converting to be identical to the production volume for the non-PVC material compounding OES. The production volume of DIDP for use in non-PVC material converting under both CASRN is 1,465,812-14,529,471 kg/year (see Section 3.8.2 for details).

EPA did not identify site- or chemical-specific plastic converting operating data (*i.e.*, facility production rate, number of batches, or operating days). EPA based the DIDP facility use rate on the 2021 *Revised*

Generic Scenario on Plastic Converting product throughput of plastic additives, the mass fraction of DIDP in non-PVC products, and the mass fraction of all additives in plastic resin. The estimated annual facility DIDP throughput is 68,542-190,822 kg/site-year. The GS estimated the total number of operating days as 137-254 days/year, with 24 hour/day, 7 day/week (*i.e.*, multiple shifts) operations for the given site throughput scenario. The number of batches per site year was equivalent to the number of operating days, or one batch per day (U.S. EPA, 2021e). EPA estimated the total number of sites that participate in non-PVC material converting using a Monte Carlo model (see Appendix E.10 for details). The 50th-95th percentile range of the number of sites was 178-212. In contrast to 2020 CDR reports one site reported the number of industrial use sites as Not Known or Reasonably Ascertainable (NKRA) and the other site reported a total number of industrial sites to be less than 10.

3.9.3 Release Assessment

3.9.3.1 Environmental Release Points

EPA assigned release points based on the 2021 *Revised Generic Scenario on Plastic Converting* (U.S. EPA, 2021e). EPA assigned default models to quantify releases from each release point and suspected fugitive air release point. EPA expects fugitive or stack air releases and particulate emissions to fugitive air, wastewater, incineration, or landfill from converting operations. EPA expects releases to wastewater, incineration, or landfill from container residues, and equipment cleaning. EPA expects releases to wastewater from direct contact cooling and incineration or landfill releases from solid waste trimming. Sites may utilize air capture technology. If a site uses air capture technology, EPA expects dust releases from plastic unloading to be controlled and released to disposal facilities for incineration or landfill. EPA expects the remaining uncontrolled dust to be released to stack air. If the site does not use air control technology, EPA expects releases to fugitive air, wastewater, incineration, or landfill as described above.

3.9.3.2 Environmental Release Assessment Results

Table 3-44. Summary of Modeled Environmental Releases for Non-PVC Material Converting

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
96,695,434-958,457,500 lb production volume	Fugitive or Stack Air	2.37E02	8.05E02	219	251	1.11	3.86
	Fugitive Air, Wastewater, Incineration, or Landfill	2.30E01	7.35E01			1.08E−01	3.53E−01
	Wastewater, Incineration, or Landfill	1.50E03	2.58E03			7.79	1.41E01
	Wastewater	4.38E02	6.66E02			2.05	3.31
	Incineration or Landfill	1.47E03	2.47E03			6.89	1.23E01

3.9.4 Occupational Exposure Assessment

3.9.4.1 Worker Activities

Worker exposures to DIDP dust may occur via inhalation during the converting process. Dermal exposures may occur during equipment cleaning. Additionally, worker exposures may occur via dermal contact with liquids and inhalation of vapors during DIDP unloading and loading, transport container cleaning, and trimming of excess plastic (U.S. EPA, 2021f). EPA did not identify information on engineering controls or worker PPE used at plastics converting sites.

ONUs include supervisors, managers, and other employees that may work in the formulation area but do not directly contact DIDP that is received or processed onsite or handle the finished converted product. ONUs are potentially exposed through the inhalation route while in the working area. Also, dermal exposures from contact with surfaces where dust has been deposited were assessed for ONUs.

3.9.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs per site that are potentially exposed to DIDP during the converting of non-PVC material. This approach involved the identification of relevant SOC codes within the BLS data for select NAICS codes. Section 2.4.2 provides additional details regarding the methodology that EPA used to estimate the number of workers and ONUs per site. EPA assigned the NAICS codes 325212, 326200, and 424690 for this OES based on the "Generic Scenario on the Use of Additives in the Thermoplastic Converting Industry" and CDR reported NAICS codes for non-PVC material converting (U.S. EPA, 2020a, 2014d). Table 3-45 summarizes the per site estimates for this OES. As addressed in Section 3.9.2, EPA did not identify site-specific data for the number of facilities in the United States that convert non-PVC material.

Table 3-45. Estimated Number of Workers Potentially Exposed to DIDP during Non-PVC Material Converting

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed ONUs per Site[a]	Total Number of Exposed ONUs[a]
325212 – Synthetic Rubber Manufacturing	N/A	25	N/A	11	N/A
326200 – Rubber Product Manufacturing		42		7	
424690 – Other Chemical and Allied Products Merchant Wholesalers		1		0.4	
Total/Average	178-212	23	4,016-4,783	6	1,068-1,272

[a] The result is expressed as a range between the central tendency and the high-end value. Results were not assessed by NAICS code for this scenario.

[b] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as "0" are left unrounded.

3.9.4.3 Occupational Inhalation Exposure Results

EPA identified one study with surrogate monitoring data for plastics converting processes from a cable coating facility; however, the study had several limitations as discussed below. Additionally, the cables in the study were coated with PVC, so the data was not OES-specific for non-PVC converting. Therefore, EPA estimated aggregate (*i.e.*, vapor and dust) worker inhalation exposures using both the surrogate monitoring data and the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d).

The p-chem properties (*e.g.*, molecular weight and vapor pressure) of diisodecyl phthlate and di(2-propylheptyl) phthalate are quite similar, and vapor inhalation monitoring data for DIDP were lacking. Therefore, EPA used surrogate monitoring data for di(2-propylheptyl) phthalate provided in an exposure study conducted by SP Porras *et al.* (2020) in a PVC-coated cable manufacturing facility to estimate worker vapor inhalation exposures to DIDP for this OES. Inhalation exposures during PVC-coated cable manufacturing occur when di(2-propylheptyl) phthalate additives are incorporated into the plastic coating, and EPA expects that these exposures are comparable to inhalation exposures to DIDP during non-PVC material converting. The subject facility in the SP Porras *et al.* study sometimes used DIDP as a plasticizer for manufacturing PVC-coated cables, but the facility was using di(2-propylheptyl) phthalate as the plasticizer on the day that sampling occurred (Porras et al., 2020). The study personnel collected stationary samples using the OVS sampler type, which measures a combination of vapor and particulate phases. SP Porras *et al.* collected two samples at cooling points near extruders and provided results as a single 8-hour TWA value for di(2-propylheptyl) phthalate, which was 0.03 mg/m^3. Since the study conducted sampling near a high-temperature extruder, EPA expects that the monitoring data represents vapor concentrations of di(2-propylheptyl) phthalate from heated material as opposed to particulates containing the phthalate. For this reason, EPA decided to aggregate the surrogate monitoring data from SP Porras *et al.* (2020) with particulate inhalation exposure model estimates (discussed below).

DIDP is present in non-PVC materials (U.S. CPSC, 2015), so EPA expects worker inhalation exposures to DIDP via exposure to particulates of non-PVC materials. Therefore, EPA estimated worker inhalation exposures during non-PVC plastic converting using the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d). Model approaches and parameters are described in Appendix E.16. In the model, EPA used a subset of the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* data that came from facilities with NAICS codes starting with 326 (Plastics and Rubber Manufacturing) to estimate non-PVC particulate concentrations in the air. EPA used the highest expected concentration of DIDP in non-PVC plastic products to estimate the concentration of DIDP present in particulates. For this OES, EPA selected 20 percent by mass as the maximum expected DIDP concentration based on the *Emission Scenario Document on Additives in the Rubber Industry* (OECD, 2004a). The estimated exposures assume that DIDP is present in particulates of the non-PVC plastic at this fixed concentration throughout the working shift. The *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* uses an 8-hour TWA for particulate concentrations, by assuming exposures outside the sample duration are zero. Exposures during individual worker activities are not determined using this model.

EPA assumed that the worker is exposed to DIDP in the form of non-PVC plastic particulates and DIDP vapors. EPA aggregated estimates from the surrogate monitoring data and the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d) to address these two physical forms of DIDP for the full 8-hour work shift. EPA added the 8-hour TWA from the monitoring data and exposure estimates from the model to aggregate the exposures. EPA used the number of operating days determined in the release assessment for this OES to estimate exposure frequency, with a maximum exposure frequency of 250 working days per year.

Table 3-46 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during non-PVC material converting. The high-end exposures use 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days. The central tendency exposures use 219 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Appendix B describes the approach for estimating AD, IADD, and ADD.

Table 3-46. Summary of Estimated Worker Inhalation Exposures for Non-PVC Material Converting

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−02	3.0E−02
	8-hr TWA Exposure Concentration to Dust (mg/m^3)	4.6E−02	0.94
	Acute Dose (AD) (mg/kg/day)	9.5E−03	0.12
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	7.0E−03	8.9E−02
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	5.7E−03	8.3E−02
Female of Reproductive Age	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−02	3.0E−02
	8-hr TWA Exposure Concentration to Dust (mg/m^3)	4.6E−02	0.94
	Acute Dose (AD) (mg/kg/day)	1.0E−02	0.13
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	7.7E−03	9.8E−02
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	6.3E−03	9.2E−02
ONU	8-hr TWA Exposure Concentration (mg/m^3)	3.0E−04	6.0E−04
	8-hr TWA Exposure Concentration to Dust (mg/m^3)	4.6E−02	4.6E−02
	Acute Dose (AD) (mg/kg/day)	5.8E−03	5.8E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	4.2E−03	4.3E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	3.5E−03	4.0E−03

3.9.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-47 are explained in Appendix B. Because dermal exposures of DIDP to workers is expected to occur through contact with solids or articles for this OES, EPA assessed the absorptive flux of DIDP according to dermal absorption modeling approach for solids outlined in Appendix D.2.1.2. Also, since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Dermal exposure to workers is generally expected to be greater than dermal exposure to ONUs. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure. Therefore, worker central tendency exposure values for dermal contact with solids containing DIDP were assumed representative of ONU dermal exposure.

Table 3-47 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for average adult workers, female workers of reproductive age, and ONUs. Dermal exposure parameters are described in Appendix D.

Table 3-47. Summary of Estimated Worker Dermal Exposures for Non-PVC Material Converting

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.9E−02	7.7E−02
	Acute (AD, mg/kg-day)	4.8E−04	9.6E−04
	Intermediate (IADD, mg/kg-day)	3.5E−04	7.1E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−04	6.6E−04
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.2E−02	6.4E−02
	Acute (AD, mg/kg-day)	4.4E−04	8.8E−04
	Intermediate (IADD, mg/kg-day)	3.2E−04	6.5E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	2.7E−04	6.1E−04
ONU	Dose Rate (APDR, mg/day)	3.9E−02	3.9E−02
	Acute (AD, mg/kg-day)	4.8E−04	4.8E−04
	Intermediate (IADD, mg/kg-day)	3.5E−04	3.5E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−04	3.3E−04

3.9.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-48.

Table 3-48. Summary of Estimated Worker Aggregate Exposures for Non-PVC Material Converting

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.0E−02	0.12
	Intermediate (IADD, mg/kg-day)	7.3E−03	9.0E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	6.0E−03	8.4E−02
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.1E−02	0.13
	Intermediate (IADD, mg/kg-day)	8.0E−03	9.9E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	6.6E−03	9.2E−02
ONU	Acute (AD, mg/kg-day)	6.3E−03	6.3E−03
	Intermediate (IADD, mg/kg-day)	4.6E−03	4.6E−03
	Chronic, Non-cancer (ADD, mg/kg-day)	3.8E−03	4.3E−03

3.10 Application of Adhesives and Sealants

3.10.1 Process Description

DIDP is a plasticizer in adhesive and sealant products for industrial and commercial use, including polymer sealants and industrial adhesives and may arrive at end use sites in containers ranging in size from 1-5 gallons at concentrations of 0.1-75% DIDP (see Appendix F for EPA identified DIDP-containing products for this OES). The application site transfers the Adhesive/ Sealant from the shipping container to the application equipment, such as a caulk gun or syringe, and applies the sealant to the substrate ([OECD, 2015a](#)). Application methods include bead, roll, and syringe application. Application may occur over the course of an 8-hour workday for 1 or 2 days at a given site, accounting for drying or curing times and additional coats where necessary. The site may trim excess Adhesive/ Sealant from the applied substrate area. Figure 3-11 provides an illustration of the process of applying adhesives and sealants ([OECD, 2015a](#)).

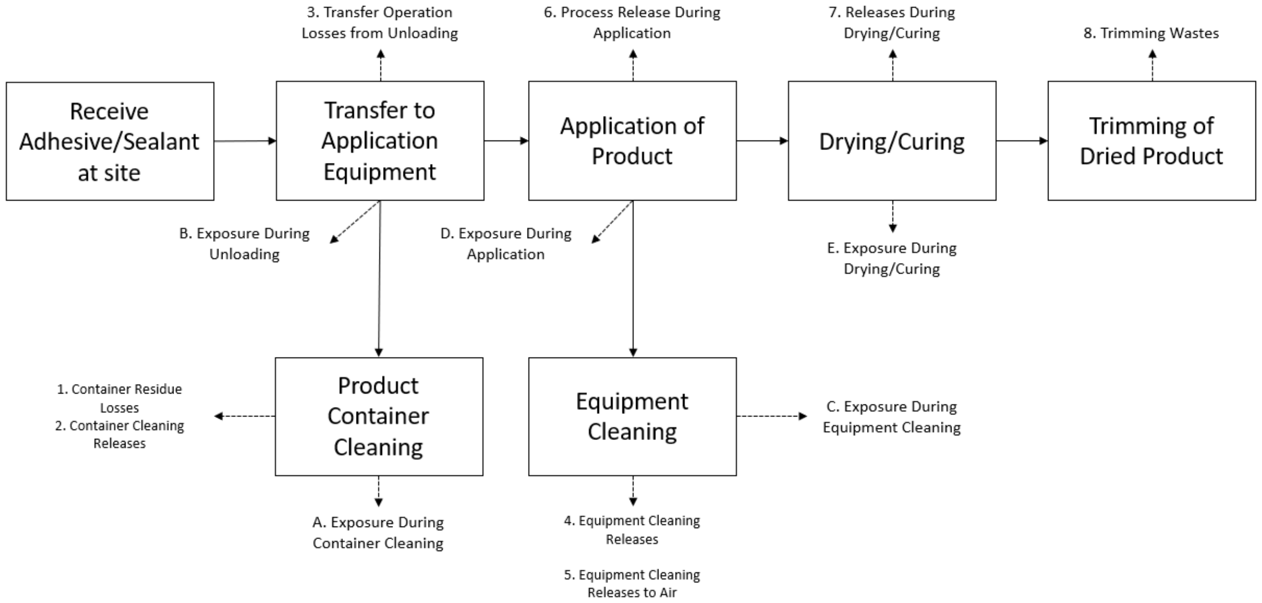

Figure 3-11. Application of Adhesives and Sealants Flow Diagram

In industrial settings, workers may apply adhesives and sealants by automated or mechanical spraying in facilities where exposure controls can be expected to be in place; however, products containing DIDP that are categorized as spray adhesives have not currently been identified by EPA. Workers may apply adhesives and sealants in commercial settings such as in construction. Most commonly, the products containing DIDP are applied using a syringe, caulk gun or spread on the surface using a trowel. According to the *Manufacturer Request for Risk Evaluation: Diisodecyl Phthalate (DIDP)*, less than 5 percent of DIDP is used in non-PVC applications such as those associated with adhesives and sealants ([U.S. EPA, 2019b](#)). *Final Scope of the Risk Evaluation for Diisodecyl Phthalate (DIDP)* states that DIDP is used as a plasticizer in the manufacture of industrial adhesives and sealant end products; however, DIDP is primarily used in commercial and consumer end products (concentrations ranging from 1 to 60 percent) such as automotive interiors, undercoats, electrical products, and plastic products ([U.S. EPA, 2021b](#)).

3.10.2 Facility Estimates

Since the application of adhesives and sealants occurs immediately downstream of incorporation into adhesive and sealants, EPA expects the same production volume for the two OES. The production volume for adhesives and sealants use under both CASRN was 374,305 to 1,679,970 kg/year (see Section 3.3.2 for details).

EPA did not identify site- or chemical-specific adhesive and sealant application operating data (*i.e.*, facility use rates, operating days). However, the 2015 *ESD on the Use of Adhesives* estimated an adhesive use rate of 2,300-141,498 kg/site-year. Based on DIDP concentration in the product of 0.1-75%, EPA estimated a DIDP use rate 2.3-106,124 kg/site-year. Additionally, the ESD estimated the number of operating days as 50-365 days/year of 8 hour/day operations for the given throughput scenario (OECD, 2015a). EPA did not identify estimates on the number of sites that may apply adhesive and sealant products containing DIDP. Therefore, EPA estimated the total number of application sites that use DIDP-containing adhesives and sealants using a Monte Carlo model (see Appendix E.11 for details). The 50th-95th percentile range of the number of sites was 84-1,056.

3.10.3 Release Assessment

3.10.3.1 Environmental Release Points

EPA assigned release points based on the 2015 *ESD on the Use of Adhesives* (OECD, 2015a). EPA assigned default models to quantify releases from each release point and suspected fugitive air release point. EPA expects fugitive air releases from unloading of adhesives, container cleaning, equipment cleaning, and drying or curing processes. EPA expects releases to wastewater, incineration, or landfill from small container residue, equipment cleaning waste, adhesive application process waste, and trimming waste.

3.10.3.2 Environmental Release Assessment Results

Table 3-49. Summary of Modeled Environmental Releases for Application of Adhesives and Sealants

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
825,201-3,703,700 lb production volume	Fugitive or Stack Air	2.06E−06	7.71E−06	232	325	9.80E−09	3.24E−08
	Wastewater, Incineration, or Landfill	5.66E02	2.80E03			2.61	1.45E01

3.10.4 Occupational Exposure Assessment

3.10.4.1 Worker Activities

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

ONUs include supervisors, managers, and other employees that work in the application area but do not directly contact adhesives or sealants or handle or apply products. ONUs are potentially exposed via inhalation while present in the application area. Also, dermal exposures from contact with surfaces where mist has been deposited were assessed for ONUs.

3.10.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs per site that are potentially exposed to DIDP during the application of adhesives and sealants. This approach involved the identification of relevant SOC codes within the BLS data for select NAICS codes. Section 2.4.2 provides additional details regarding the methodology that EPA used to estimate the number of workers and ONUs per site. EPA assigned the NAICS codes 322220, 334100, 334200, 334300, 334400, 334500, 334600, 335100, 335200, 335300, 335900, 336100, 336200, 336300, 336400, 336500, 336600, 336900, and 327910 for this OES based on the *Emission Scenario Document on the Use of Adhesives* and CDR reported NAICS codes for application of adhesives and sealants (U.S. EPA, 2020a; OECD, 2015b). Table 3-50 summarizes the per site estimates for this OES. As discussed in Section 3.10.4.2, EPA did not identify site-specific data for the number of facilities in the United States that apply adhesives and sealants.

Table 3-50. Estimated Number of Workers Potentially Exposed to DIDP during Application of Adhesives and Sealants

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed Occupational Non-users per Site[b]	Total Number of Exposed ONUs[a]
322220 – Paper Bag and Coated and Treated Paper Manufacturing	N/A	35	N/A	5	N/A
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	
335200 – Household Appliance Manufacturing		102		20	

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed Occupational Non-users per Site[b]	Total Number of Exposed ONUs[a]
335300 – Electrical Equipment Manufacturing		28		12	
335900 – Other Electrical Equipment and Component Manufacturing		23		8	
336100 – Motor Vehicle Manufacturing		447		59	
336200 – Motor Vehicle Body and Trailer Manufacturing		40		5	
336300 – Motor Vehicle Parts Manufacturing		51		15	
336400 – Aerospace Product and Parts Manufacturing		75		64	
336500 – Railroad Rolling Stock Manufacturing		35		15	
336600 – Ship and Boat Building		36		11	
336900 – Other Transportation Equipment Manufacturing		16		4	
327910 – Abrasive Product Manufacturing		24		5	
Total/Average	84-1,056	54	4,523-56,857	17	1,433-18,012

[a] The result is expressed as a range between the central tendency and the high-end value. Results were not assessed by NAICS code for this scenario.

[b] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as “0” are left unrounded.

3.10.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for the use of adhesives and sealants use during systematic review of literature sources. However, EPA estimated inhalation exposures for this OES using the Automotive Refinishing Spray Coating Mist Inhalation Model from the ESD on Coating Application via Spray-Painting in the Automotive Refinishing Industry (OECD, 2011a).

Although adhesives and sealants can be applied in a variety of ways, EPA assesses exposures using spray application to encompass high-end exposures during this OES. The Automotive Refinishing Spray

Coating Mist Inhalation Model estimates worker inhalation exposure based on the concentration of the chemical of interest in the nonvolatile portion of the sprayed product and the concentration of over sprayed mist/particles (OECD, 2011a). The model is based on PBZ monitoring data for mists during automotive refinishing. EPA used the 50th and 95th percentile mist concentration along with the concentration of DIDP in the adhesives and sealants to estimate the central tendency and high-end inhalation exposures, respectively.

Table 3-51 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during the use of adhesives and sealants. The high-end exposures use 250 days per year as the exposure frequency since the 95th percentiles of operating days in the release assessment exceeded 250 days per year, which is the expected maximum number of working days. The central tendency exposures use 232 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Appendix B describes the approach for estimating AD, IADD, and ADD.

Table 3-51. Summary of Estimated Worker Inhalation Exposures for Application of Adhesives and Sealants

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration (mg/m^3)	0.14	22
	Acute Dose (AD) (mg/kg/day)	1.7E−02	2.8
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	1.2E−02	2.0
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	1.1E−02	1.9
Female of Reproductive Age	8-hr TWA Exposure Concentration (mg/m^3)	0.14	22
	Acute Dose (AD) (mg/kg/day)	1.9E−02	3.1
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	1.4E−02	2.2
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	1.2E−02	2.1
ONU	8-hr TWA Exposure Concentration (mg/m^3)	0.14	0.14
	Acute Dose (AD) (mg/kg/day)	1.7E−02	1.7E−02
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	1.2E−02	1.2E−02
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	1.1E−02	1.2E−02

3.10.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-52 are explained in Appendix B. Because dermal exposures of DIDP to workers may occur in a concentrated liquid form during the application of adhesives or sealants, EPA assessed the absorptive flux of DIDP according to dermal absorption data of neat DIDP (see Appendix D.2.1.1 for details). Also, since there may be mist deposited on surfaces from this OES, dermal exposures to ONUs from contact with mist on surfaces were assessed. Dermal exposure to workers is generally expected to be greater than dermal exposure to ONUs. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure. Therefore, worker central tendency exposure values for dermal contact with liquids containing DIDP were assumed representative of ONU dermal exposure.

Table 3-52 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for average adult workers, female workers of reproductive age, and ONUs. Dermal exposure parameters are described in Appendix D.

Table 3-52. Summary of Estimated Worker Dermal Exposures for Application of Adhesives and Sealants

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.7	7.3
	Acute (AD, mg/kg-day)	4.6E−02	9.2E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	6.7E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−02	6.3E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.1	6.1
	Acute (AD, mg/kg-day)	4.2E−02	8.4E−02
	Intermediate (IADD, mg/kg-day)	3.1E−02	6.2E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.7E−02	5.8E−02
ONU	Dose Rate (APDR, mg/day)	3.7	3.7
	Acute (AD, mg/kg-day)	4.6E−02	4.6E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	3.4E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−02	3.1E−02

3.10.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-53.

Table 3-53. Summary of Estimated Worker Aggregate Exposures for Application of Adhesives and Sealants

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	6.3E−02	2.9
	Intermediate (IADD, mg/kg-day)	4.6E−02	2.1
	Chronic, Non-cancer (ADD, mg/kg-day)	4.0E−02	2.0
Female of Reproductive Age	Acute (AD, mg/kg-day)	6.1E−02	3.1
	Intermediate (IADD, mg/kg-day)	4.5E−02	2.3
	Chronic, Non-cancer (ADD, mg/kg-day)	3.9E−02	2.1
ONU	Acute (AD, mg/kg-day)	6.3E−02	6.3E−02
	Intermediate (IADD, mg/kg-day)	4.6E−02	4.6E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	4.0E−02	4.3E−02

3.11 Application of Paints and Coatings

3.11.1 Process Description

DIDP is a plasticizer in paint and coating products for industrial and commercial use, including paints and colorant products. Paint and coating products containing DIDP may arrive at end use sites in containers ranging from 5-20 gallons in size with DIDP concentrations of 0.01-5% (see Appendix F for identified product information). Application sites transfer the paint/coating product from the shipping container to the application equipment and apply the coating to the substrate (U.S. EPA, 2014b; OECD, 2009c; U.S. EPA, 2004d). Application methods for DIDP-containing paints and coatings include spray, brush, and trowel coating. EPA did not identify information on the prevalence of these various application methods. Manual spray equipment includes air (*e.g.*, low volume/high pressure), air-assisted, and airless spray systems (U.S. EPA, 2014b; OECD, 2009c; U.S. EPA, 2004d). End use sites may utilize spray booth capture technologies when performing spray applications (OECD, 2011a). DIDP will remain in the dried/cured coating as an additive following application to the substrate. Applications may occur over the course of an 8-hour workday for 1 or 2 days at a given site, accounting for multiple coats and typical drying or curing times. Figure 3-12 provides an illustration of the spray application of paints and coatings (U.S. EPA, 2014b; OECD, 2011b, 2009c; U.S. EPA, 2004d).

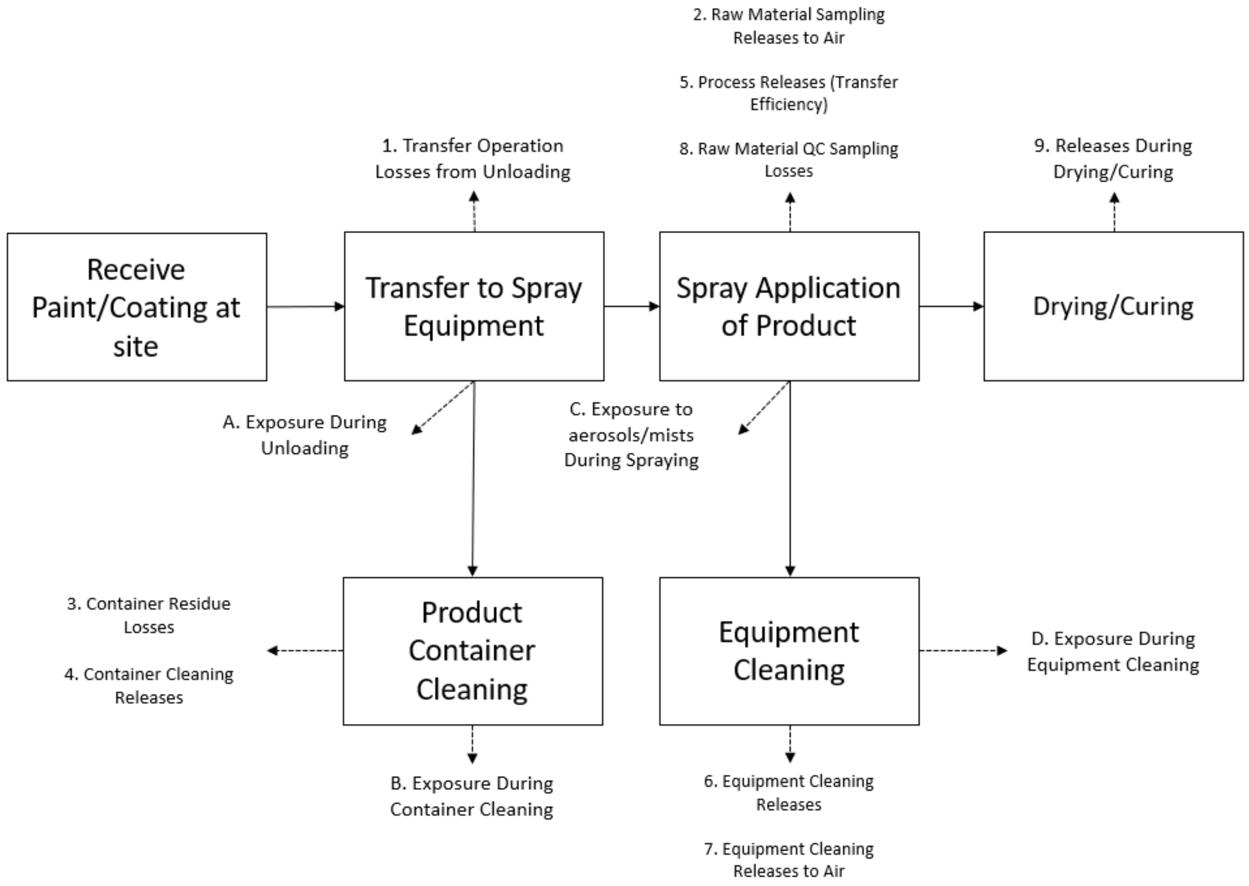

Figure 3-12. **Application of Paints and Coatings Flow Diagram**

3.11.2 Facility Estimates

Since application of paints and coatings occurs immediately downstream of incorporation into paints and coatings, EPA expects these OES to have the same production volume. The production volume for paint and coating use under both CASRN was 169,485-1,679,970 kg/year (see Section 3.4 for details).

EPA did not identify site- or chemical-specific paint and coating use operating data (*e.g.*, facility use rates, operating days). EPA based the facility use rate on the 2011 *ESD on Radiation Curable Coatings, Inks and Adhesives*, the 2011 *ESD on Coating Application via Spray-Painting in the Automotive Finishing Industry*, the 2004 *GS on Spray Coatings in the Furniture Industry*, and the European Council of the Paint, Printing Ink, and Artist's Colours Industry (CEPE) *SpERC Factsheet for Industrial Application of Coatings and Inks by Spraying*. The ESDs, GSs, and SpERC estimated coating use rates of 2,694-446,600 kg/site-year. Based on a DIDP concentration in the paints and coatings of 0.01-5%, EPA estimated a DIDP use rate of 0.26-22,330 kg/site-year. Additionally, the ESDs, GSs, and SpERC estimated the number of operating days as 225-300 days/year with 8 hour/day operations (CEPE, 2020; OECD, 2011a, b; U.S. EPA, 2004c). EPA did not identify estimates of the number of sites that may apply paint and coating products containing DIDP. Therefore, EPA estimated the total number of application sites that use DIDP-containing paints and coatings using a Monte Carlo model (see Appendix E.10 for details). The 50th to 95th percentile range of the number of sites was 222 to 1,242.

3.11.3 Release Assessment

3.11.3.1 Environmental Release Points

EPA assigned release points based on the 2011 *ESD on Radiation Curable Coatings, Inks and Adhesives* (OECD, 2011b). EPA assigned default models to quantify releases from each release point and suspected fugitive air release point. EPA expects fugitive air releases from unloading, sampling, container cleaning, and equipment cleaning. EPA expects wastewater, incineration, or landfill releases from container residue losses, equipment cleaning, and sampling. Sites may utilize overspray control technology to prevent additional air releases during spray application. If a site uses overspray control technology, EPA expects stack air releases of approximately 10% of process related operational losses. EPA expects the site to release the remaining 90% of operational losses to wastewater, landfill, or incineration. If the site does not use control technology, EPA expects the site to release all process related operational losses to fugitive air, wastewater, incineration, or landfill in unknown percentages.

3.11.3.2 Environmental Release Assessment Results

Table 3-54. Summary of Modeled Environmental Releases for Application of Paints and Coatings

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
373,650-3,703,700 lb production volume Control Technology	Fugitive Air	6.75E−07	1.79E−06	257	287	2.62E−09	6.90E−09
	Stack Air	1.64E02	5.22E02			6.34E−01	2.04
	Wastewater, Incineration, or Landfill	1.62E03	5.06E03			6.29	1.98E01
	Fugitive Air	6.75E−07	1.79E−06	257	287	2.62E−09	6.87E−09

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
373,650-3,703,700 lb production volume No Control Technology	Wastewater, Incineration, or Landfill	1.44E02	3.99E02			5.58E−01	1.55
	Unknown	1.63E03	5.23E03			6.32	2.04E01

3.11.4 Occupational Exposure Assessment

3.11.4.1 Worker Activities

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

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

3.11.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs per site that are potentially exposed to DIDP during the application of paints and coatings. This approach involved the identification of relevant SOC codes within the BLS data for select NAICS codes. Section 2.4.2 provides further details regarding the methodology that EPA used to estimate the number of workers and ONUs per site. EPA assigned the NAICS codes 332431, 334416, 335931, 337124, 337214, 337127, 337215, 337122, 337211, 337212, 337110, and 811120 for this OES based on the *Emission Scenario Documents for the Coating Industry and Automotive Refinishing* as well as the *Generic Scenario on Spray Coatings in the Furniture Industry* (OECD, 2011a, 2009c; U.S. EPA, 2004d). Table 3-55 summarizes the per site estimates for this OES. As described in Section 3.11.2, EPA did not identify site-specific data for the number of facilities in the United States that apply DIDP-containing paints and coatings.

3232 **Table 3-55. Estimated Number of Workers Potentially Exposed to DIDP during Application of**
3233 **Paints and Coatings**

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed ONUs per Site[b]	Total Number of Exposed ONUs[a]
332431 – Metal Can Manufacturing	N/A	31	N/A	11	N/A
335931 – Current-Carrying Wiring Device Manufacturing		25		9	
337124 – Metal Household Furniture Manufacturing		8		6	
337214 – Office Furniture (except wood) Manufacturing		22		9	
337127 – Institutional Furniture Manufacturing		9		7	
337215 – Showcase, Partition, Shelving, and Locker Manufacturing		8		4	
337122 – Nonupholstered Wood Household Furniture Manufacturing		3		2	
337211 – Wood Office Furniture Manufacturing		9		4	
337212 – Custom Architectural Woodwork and Millwork Manufacturing		5		2	
337110 – Wood Kitchen Cabinet and Countertop Manufacturing		3		2	
811120 – Automotive Body, Paint, Interior, and Glass Repair		6		1	
Total/Average	222-1,242	12	2,615-14,631	5	1,140-6,375

[a] The result is expressed as a range between the central tendency and the high-end value. Results were not assessed by NAICS code for this scenario.

[b] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as "0" are left unrounded.

3.11.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for the use of paints and coatings use during systematic review of literature sources. However, EPA estimated inhalation exposures for this OES using the Automotive Refinishing Spray Coating Mist Inhalation Model from the ESD on Coating Application via Spray-Painting in the Automotive Refinishing Industry (OECD, 2011a).

Although paints and coatings can be applied in a variety of ways, EPA assesses exposures using spray application to encompass high-end exposures during this OES. The Automotive Refinishing Spray Coating Mist Inhalation Model estimates worker inhalation exposure based on the concentration of the chemical of interest in the nonvolatile portion of the sprayed product and the concentration of over sprayed mist/particles (OECD, 2011a). The model is based on PBZ monitoring data for mists during automotive refinishing. EPA used the 50th and 95th percentile mist concentration along with the concentration of DIDP in the paint to estimate the central tendency and high-end inhalation exposures, respectively.

Table 3-56 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during the use of paints and coatings. The central tendency and high-end exposures use 250 days per year as the exposure frequency since the 50th and 95th percentiles of operating days in the release assessment exceeded 250 days per year, which is the expected maximum number of working days. Appendix B describes the approach for estimating AD, IADD, and ADD.

Table 3-56. Summary of Estimated Worker Inhalation Exposures for Application of Paints and Coatings

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration (mg/m^3)	0.14	22
	Acute Dose (AD) (mg/kg/day)	1.7E−02	0.28
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	1.2E−02	0.20
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	1.2E−02	0.19
Female of Reproductive Age	8-hr TWA Exposure Concentration (mg/m^3)	0.14	22
	Acute Dose (AD) (mg/kg/day)	1.9E−02	0.31
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	1.4E−02	0.22
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	1.3E−02	0.21
ONU	8-hr TWA Exposure Concentration (mg/m^3)	0.14	0.14
	Acute Dose (AD) (mg/kg/day)	1.7E−02	1.7E−02
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	1.2E−02	1.2E−02
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	1.2E−02	1.2E−02

3.11.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-57 are explained in Appendix B. Because dermal exposures of DIDP to workers may occur in a concentrated liquid form during the application of paints or coatings, EPA assessed the absorptive flux of DIDP according to dermal absorption data of neat DIDP (see Appendix D.2.1.1 for details). Also, since there may be mist deposited on surfaces from this OES, dermal exposures to ONUs from contact with mist on surfaces were assessed. Dermal exposure to workers is generally expected to be greater than dermal exposure to ONUs. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure. Therefore, worker central tendency exposure values for dermal contact with liquids containing DIDP were assumed representative of ONU dermal exposure.

Table 3-57 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for average adult workers, female workers of reproductive age, and ONUs. Dermal exposure parameters are described in Appendix D.

Table 3-57. Summary of Estimated Worker Dermal Exposures for Application of Paints and Coatings

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.7	7.3
	Acute (AD, mg/kg-day)	4.6E−02	9.2E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	6.7E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.1E−02	6.3E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.1	6.1
	Acute (AD, mg/kg-day)	4.2E−02	8.4E−02
	Intermediate (IADD, mg/kg-day)	3.1E−02	6.2E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−02	5.8E−02
ONU	Dose Rate (APDR, mg/day)	3.7	3.7
	Acute (AD, mg/kg-day)	4.6E−02	4.6E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	3.4E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.1E−02	3.1E−02

3.11.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-58.

Table 3-58. Summary of Estimated Worker Aggregate Exposures for Application of Paints and Coatings

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	6.3E−02	0.37
	Intermediate (IADD, mg/kg-day)	4.6E−02	0.27
	Chronic, Non-cancer (ADD, mg/kg-day)	4.3E−02	0.25
	Acute (AD, mg/kg-day)	6.1E−02	0.39

Female of Reproductive Age	Intermediate (IADD, mg/kg-day)	4.5E−02	0.29
	Chronic, Non-cancer (ADD, mg/kg-day)	4.2E−02	0.27
ONU	Acute (AD, mg/kg-day)	6.3E−02	6.3E−02
	Intermediate (IADD, mg/kg-day)	4.6E−02	4.6E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	4.3E−02	4.3E−02

3.12 Use of Laboratory Chemicals

3.12.1 Process Description

DIDP is a laboratory chemical used at commercial laboratory sites. Laboratory chemicals containing DIDP arrive at end use sites in containers ranging in size from 0.5-1 gallons or 0.5-1 kg, depending on the chemical form (see Appendix F for EPA identified DIDP-containing products for this OES). The end use site transfers the chemical to labware and lab equipment for analyses. After analysis, laboratory sites clean containers, labware, and lab equipment and dispose of laboratory waste and unreacted DIDP-containing laboratory chemicals. Figure 3-13 provides an illustration of the use of laboratory chemicals (U.S. EPA, 2023c).

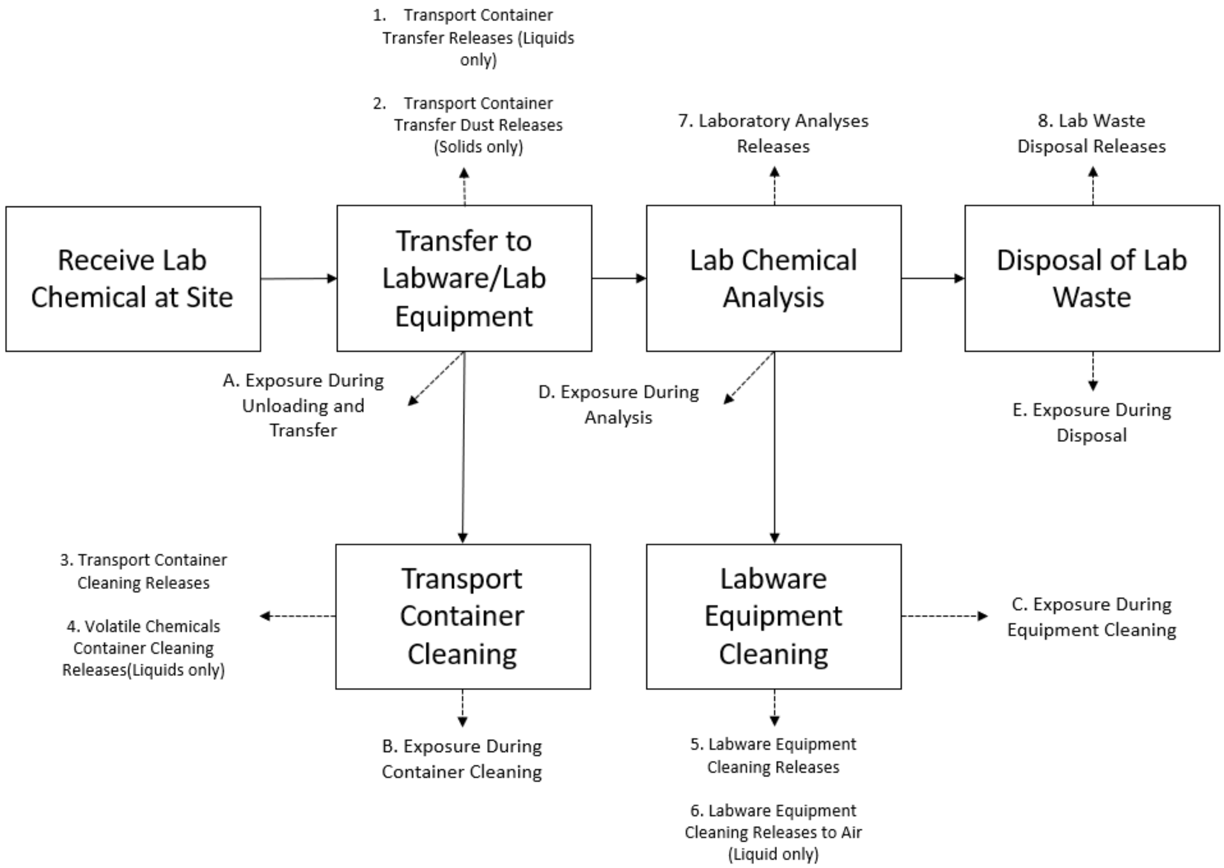

Figure 3-13. Use of Laboratory Chemicals Flow Diagram

3.12.2 Facility Estimates

No sites reported the use of DIDP-containing laboratory chemicals in the 2020 CDR. Instead, EPA assumed that a portion the DIDP production volume from each CDR reporting site may be used in laboratory chemicals. Specifically, EPA estimated the total production volume of DIDP in laboratory chemicals using the CDR reporting threshold limits of either 25,000 pounds (11,340 kg) or 5% of a site's reported production volume, whichever value was smaller. EPA considered every site that reported using DIDP to CDR, regardless of assigned OES. EPA assumed that sites that claimed their production volume as CBI used 25,000 pounds of DIDP-containing laboratory chemicals annually. Table 3-59 lists the sites and associated production volumes that EPA considered in calculating the total production volume for this OES (U.S. EPA, 2020a). The total production volume for this OES was 94,832 kg/year.

Table 3-59. CDR Reported Site Information for Use in Calculation of Laboratory Chemicals Production Volume

CASRN	Site Name	Site Location	Reported Production Volume (kg/year)	Threshold Limit Used	Production Volume Added to Total[3] (kg/year)
26761-40-0	3M	St. Paul, MN	CBI	11,340 kg	11,340
26761-40-0	LG Hausys, Inc.	Adairsville, GA	11,895	5%	595
26761-40-0	Harwick Standard Distribution Corp.	Akron, OH	19,447	5%	972
26761-40-0	LG Chem, Inc.	Atlanta, GA	CBI	11,340 kg	11,340
26761-40-0	Tremco Inc.	Beachwood, OH	362,965	11,340 kg	11,340
26761-40-0	Akrochem Corp.	Stow, OH	6,616	5%	331
26761-40-0	Chemspec, Ltd.	Uniontown, OH	23,801	5%	1,190
68515-49-1	3M	St. Paul, MN	CBI	11,340 kg	11,340
68515-49-1	ExxonMobil BR Chemical Plant	Baton Rouge, LA	CBI	11,340 kg	11,340
68515-49-1	Lanxess Solutions, Inc.	Fords, NJ	CBI	11,340 kg	11,340
68515-49-1	The Sherwin-Williams Co.	Cleveland, OH	CBI	11,340 kg	11,340
68515-49-1	Sika Corp.	Lyndhurst, NJ	CBI	11,340 kg	11,340
68515-49-1	Troy Chemical Corp.	Phoenix, AZ	20,507	5%	1,025

EPA did not identify site- or chemical-specific operating data for laboratory use of DIDP (*i.e.*, facility throughput, operating days, number of sites). For solid products, the 2023 *GS on The Use of Laboratory Chemicals* provides an estimated throughput of 0.33 kg/site-day for solid laboratory chemicals. Based on the mass fraction of DIDP in the laboratory chemical of 0.03 kg/kg, EPA estimated a daily facility DIDP use rate of 0.01 kg/site-day. For liquid products, the 2023 GS provided an estimated throughput of 0.017-4 L/site-day for liquid laboratory chemicals. Based on the concentration of DIDP in liquid laboratory chemicals of 90-100%, (see Appendix F for EPA identified DIDP-containing products for this OES) and the DIDP density of 0.9634 kg/L, EPA estimated a daily facility use rate of laboratory chemicals using Monte Carlo modeling, resulting in a 50th-95th percentile range of 1.83-3.47 kg/site-day.

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[3] Values reported are rounded to the nearest whole number value, the sum of the column exceeds the reported production volume by 1 kg due to rounding effects.

Additionally, the GS estimated the number of operating days as 174-260 days/year, with 8 hour/day operations (U.S. EPA, 2023c). EPA did not identify estimates of the number of sites that use laboratory chemicals containing DIDP. Therefore, EPA estimated the total number of sites that use DIDP-containing laboratory chemicals using a Monte Carlo model (see Appendix E.12 for details). The 50th-95th percentile range of the number of sites was 225-2,095 for the liquid use case. Based on the use rate, modeling results for number of sites exceeded the maximum indicated in the GS; therefore, EPA assessed the maximum number of sites of 36,873 as a bounding estimate. (U.S. EPA, 2023c).

3.12.3 Release Assessment

3.12.3.1 Environmental Release Points

EPA assigned release points based on the 2023 *GS on the Use of Laboratory Chemicals* (U.S. EPA, 2023c). EPA assigned default models to quantify releases from each release point and suspected fugitive air release point. Laboratory sites may use a combination of solid and liquid laboratory chemicals, but for release estimate EPA assumed each site used either the liquid or solid form of the DIDP-containing laboratory chemical. In the liquid laboratory chemical use case, EPA expects fugitive or stack air releases from unloading containers, container cleaning, labware cleaning, and during laboratory analysis. In the solid laboratory chemical use case, EPA expects sites to release dust emissions from unloading to stack air, incineration, or landfill. In both use cases, EPA expects wastewater, incineration, or landfill releases from container cleaning wastes, labware equipment cleaning wastes, and laboratory wastes.

3.12.3.2 Environmental Release Assessment Results

Table 3-60. Summary of Modeled Environmental Releases for Use of Laboratory Chemicals

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
209,068 lb production volume Liquid Laboratory Chemicals	Fugitive or Stack Air	4.47E−07	7.80E−07	235	258	1.94E−09	3.31E−09
	Wastewater, Incineration, or Landfill	4.20E02	8.22E02			1.83	3.47
209,068 lb production volume Solid Laboratory Chemicals	Stack Air	2.82E−02	6.17E−02	260		1.08E−04	2.37E−04
	Wastewater, Incineration, or Landfill	2.54	2.55			9.83E−03	9.88E−03

3.12.4 Occupational Exposure Assessment

3.12.4.1 Worker Activities

Worker exposures to DIDP may occur through the inhalation of solid powders while unloading and transferring laboratory chemicals and during laboratory analysis. Inhalation exposures to DIDP vapor and dermal exposure to liquid and solid chemicals 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). EPA did not find information on the extent to which laboratories that use DIDP-containing chemicals also use engineering controls and worker PPE.

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

3.12.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs per site that are potentially exposed to DIDP during the use of laboratory chemicals. This approach involved the identification of relevant SOC codes within the BLS data for select NAICS codes. Section 2.4.2 provides further details regarding the methodology that EPA used for estimating the number of workers and ONUs per site. EPA assigned the NAICS codes 541380, 541713, 541714, 541715, and 621511 for this OES based on the Generic Scenario on the Use of Laboratory Chemicals (U.S. EPA, 2023c). Table 3-61 summarizes the per site estimates for this OES. NAICS codes 541713, 541714, and 541715 were all excluded from the table as they lacked worker data. As described in Section 3.12.2, EPA did not identify site-specific data for the number of facilities in the United States that use DIDP-containing laboratory chemicals.

Table 3-61. Estimated Number of Workers Potentially Exposed to DIDP during Use of Laboratory Chemicals

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed Occupational Non-users per Site[b]	Total Number of Exposed ONUs[a]
541380 – Testing Laboratories	N/A	2	N/A	17	N/A
621511 – Medical Laboratories		0.1		0.2	
Total/Average (Liquid)	225-2,095	1	223-2,075	9	1,964-18,290
Total/Average (Solid)	36,873	1	36,517	9	321,917

[a] The result is expressed as a range between the central tendency and the high-end value. Results were not assessed by NAICS code for this scenario.

[b] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as "0" are left unrounded.

3.12.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for the use of laboratory chemicals during systematic review of literature sources. However, EPA estimated inhalation exposures for this OES using monitoring data for DIDP exposures during manufacturing (ExxonMobil, 2022a) and the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d). EPA expects that inhalation exposures during manufacturing are greater than inhalation exposures expected during use of laboratory chemicals and serve as a reasonable bounding estimate.

For exposure to liquid laboratory chemicals, EPA used surrogate monitoring data provided in an exposure study conducted by ExxonMobil at their DIDP manufacturing site to estimate inhalation exposures for this OES. The ExxonMobil exposure study collected data via PBZ samples via an AIHA validated method involving PTFE Teflon filters, extraction with acetonitrile, and HPLC analysis with UV detection. ExxonMobil took PBZ samples from plasticizer assistant operators, laboratory technicians, and maintenance operators (ExxonMobil, 2022a). EPA used the samples taken during filter change-out from maintenance workers to represent this OES, as this activity was determined to best represent the activities that occur during manufacturing. EPA also used these samples to evaluate laboratory worker exposures. The study included two PBZ data points for DIDP. Both data points were below the LOD. Therefore, EPA could not create a full distribution of monitoring results to use in estimating central tendency and high-end exposures. To estimate high-end exposures to workers exposures, EPA use the LOD reported in the study. To estimate central tendency worker exposure, EPA used half of the LOD.

DIDP is present in solid laboratory chemicals (see Appendix F for DIDP-containing product data), so EPA expects worker inhalation exposures to DIDP via exposure to particulates of laboratory chemicals. Therefore, EPA estimated worker inhalation exposures during the use of laboratory chemicals using the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d). Model approaches and parameters are described in Appendix E.16. In the model, EPA used a subset of the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* data that came from facilities with NAICS codes starting with 54 (Professional, Scientific, and Technical Services) to estimate particulate concentrations in the air. EPA used the highest expected concentration of DIDP in laboratory chemicals to estimate the concentration of DIDP in particulates. For this OES, EPA selected 3 percent by mass as the highest expected DIDP concentration based on identified DIDP-containing products applicable to this OES (see Appendix F). EPA assumed that DIDP is present in particulates of solid laboratory chemicals at this fixed concentration throughout the working shift. The *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* uses an 8-hour TWA for particulate concentrations, by assuming exposures outside the sample duration are zero. This model does not determine exposures during individual worker activities.

EPA assumed that the worker is exposed to DIDP in the form of solid particulates and DIDP vapors. EPA used estimates from the monitoring data and the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d) to separately address these two physical forms of DIDP for the full 8-hour work shift. EPA used the number of operating days determined in the release assessment for this OES to estimate exposure frequency, with a maximum exposure frequency of 250 working days per year.

Table 3-62 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during the use of laboratory chemicals. The high-end and central tendency exposures to solid laboratory chemicals use 250 days per year as the exposure frequency since the 95th and 50th percentiles of operating days in the release assessment exceeded 250 days per year, which is the expected maximum number of working days. The high-end and central tendency exposures to liquid laboratory chemicals use 235 days per year and 250 days per year, respectively, as the exposure frequencies. Appendix B describes the approach for estimating AD, IADD, and ADD.

3422 3423 **Table 3-62. Summary of Estimated Worker Inhalation Exposures for Use of Laboratory Chemicals**

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker – Liquids	8-hr TWA Exposure Concentration (mg/m^3)	3.6E−02	7.2E−02
	Acute Dose (AD) (mg/kg/day)	4.5E−03	9.0E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.3E−03	6.6E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.9E−03	6.2E−03
Average Adult Worker – Solids	8-hr TWA Exposure Concentration to Dust (mg/m^3)	5.7E−03	8.1E−02
	Acute Dose (AD) (mg/kg/day)	7.1E−04	1.0E−02
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	5.2E−04	7.4E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	4.9E−04	6.9E−03
Female of Reproductive Age - Liquids	8-hr TWA Exposure Concentration (mg/m^3)	3.6E−02	7.2E−02
	Acute Dose (AD) (mg/kg/day)	5.0E−03	9.9E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.6E−03	7.3E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	3.2E−03	6.8E−03
Female of Reproductive Age - Solids	8-hr TWA Exposure Concentration to Dust (mg/m^3)	5.7E−03	8.1E−02
	Acute Dose (AD) (mg/kg/day)	7.9E−04	1.1E−02
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	5.8E−04	8.2E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	5.4E−04	7.7E−03
ONU – Liquids	8-hr TWA Exposure Concentration (mg/m^3)	3.6E−03	3.6E−03
	Acute Dose (AD) (mg/kg/day)	4.5E−03	4.5E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.3E−03	3.3E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.9E−03	3.1E−03
ONU - Solids	8-hr TWA Exposure Concentration to Dust (mg/m^3)	5.7E−03	5.7E−03
	Acute Dose (AD) (mg/kg/day)	7.1E−04	7.1E−04
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	5.2E−04	5.2E−04
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	4.9E−04	4.9E−04

3.12.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various "Exposure Concentration Types" from Table 3-63 are explained in Appendix B. Because dermal exposures to workers may occur in the neat liquid form or solid form during the use of DIDP in laboratory settings, EPA assessed the absorptive flux of DIDP according to both dermal absorption data of neat DIDP (Appendix D.2.1.1) and dermal modeling results for solid materials (Appendix D.2.1.2). Also, since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Dermal exposure to workers is generally expected to be greater than dermal exposure to ONUs. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure. Therefore, worker central tendency exposure values for dermal contact with solids containing DIDP were assumed representative of ONU dermal exposure.

Table 3-63 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for average adult workers, female workers of reproductive age, and ONUs. Dermal exposure parameters are described in Appendix D.

Table 3-63. Summary of Estimated Worker Dermal Exposures for Use of Laboratory Chemicals

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker - Liquids	Dose Rate (APDR, mg/day)	3.7	7.3
	Acute (AD, mg/kg-day)	4.6E−02	9.2E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	6.7E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.0E−02	6.3E−02
Female of Reproductive Age - Liquids	Dose Rate (APDR, mg/day)	3.1	6.1
	Acute (AD, mg/kg-day)	4.2E−02	8.4E−02
	Intermediate (IADD, mg/kg-day)	3.1E−02	6.2E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.7E−02	5.8E−02
Average Adult Worker - Solids	Dose Rate (APDR, mg/day)	3.9E−02	7.7E−02
	Acute (AD, mg/kg-day)	4.8E−04	9.6E−04
	Intermediate (IADD, mg/kg-day)	3.5E−04	7.1E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	3.3E−04	6.6E−04
Female of Reproductive Age - Solids	Dose Rate (APDR, mg/day)	3.2E−02	6.4E−02
	Acute (AD, mg/kg-day)	4.4E−04	8.8E−04
	Intermediate (IADD, mg/kg-day)	3.2E−04	6.5E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	3.0E−04	6.1E−04
ONU - Solids	Dose Rate (APDR, mg/day)	3.9E−02	3.9E−02
	Acute (AD, mg/kg-day)	4.8E−04	4.8E−04
	Intermediate (IADD, mg/kg-day)	3.5E−04	3.5E−04

Worker Population	Exposure Concentration Type	Central Tendency	High-End
	Chronic, Non-cancer (ADD, mg/kg-day)	3.3E−04	3.3E−04

3.12.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-64.

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

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker - Liquids	Acute (AD, mg/kg-day)	5.0E−02	0.10
	Intermediate (IADD, mg/kg-day)	3.7E−02	7.4E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.2E−02	6.9E−02
Female of Reproductive Age - Liquids	Acute (AD, mg/kg-day)	4.7E−02	9.4E−02
	Intermediate (IADD, mg/kg-day)	3.5E−02	6.9E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.0E−02	6.5E−02
ONU - Liquids	Acute (AD, mg/kg-day)	4.5E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	3.3E−03	3.3E−03
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−03	3.1E−03
Average Adult Worker - Solids	Acute (AD, mg/kg-day)	1.2E−03	1.1E−02
	Intermediate (IADD, mg/kg-day)	8.8E−04	8.1E−03
	Chronic, Non-cancer (ADD, mg/kg-day)	8.2E−04	7.6E−03
Female of Reproductive Age - Solids	Acute (AD, mg/kg-day)	1.2E−03	1.2E−02
	Intermediate (IADD, mg/kg-day)	9.0E−04	8.8E−03
	Chronic, Non-cancer (ADD, mg/kg-day)	8.4E−04	8.3E−03
ONU - Solids	Acute (AD, mg/kg-day)	1.2E−03	1.2E−03
	Intermediate (IADD, mg/kg-day)	8.8E−04	8.8E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	8.2E−04	8.2E−04

3.13 Use of Lubricants and Functional Fluids

3.13.1 Process Description

DIDP is incorporated in lubricants and functional fluids for air compressors and found in functional fluids for heat exchanger processes in both commercial and industrial processes (see Appendix F for EPA identified DIDP-containing products for this OES). A typical end use site unloads the lubricant/functional fluid when ready for changeout (OECD, 2004b). Sites incorporate the product into the system with a frequency ranging from once every 3 months to once every 5 years. After changeout, sites clean the transport containers and equipment, and dispose of used fluid. Figure 3-14 provides an illustration of the expected use of lubricants and functional fluids process (OECD, 2004b).

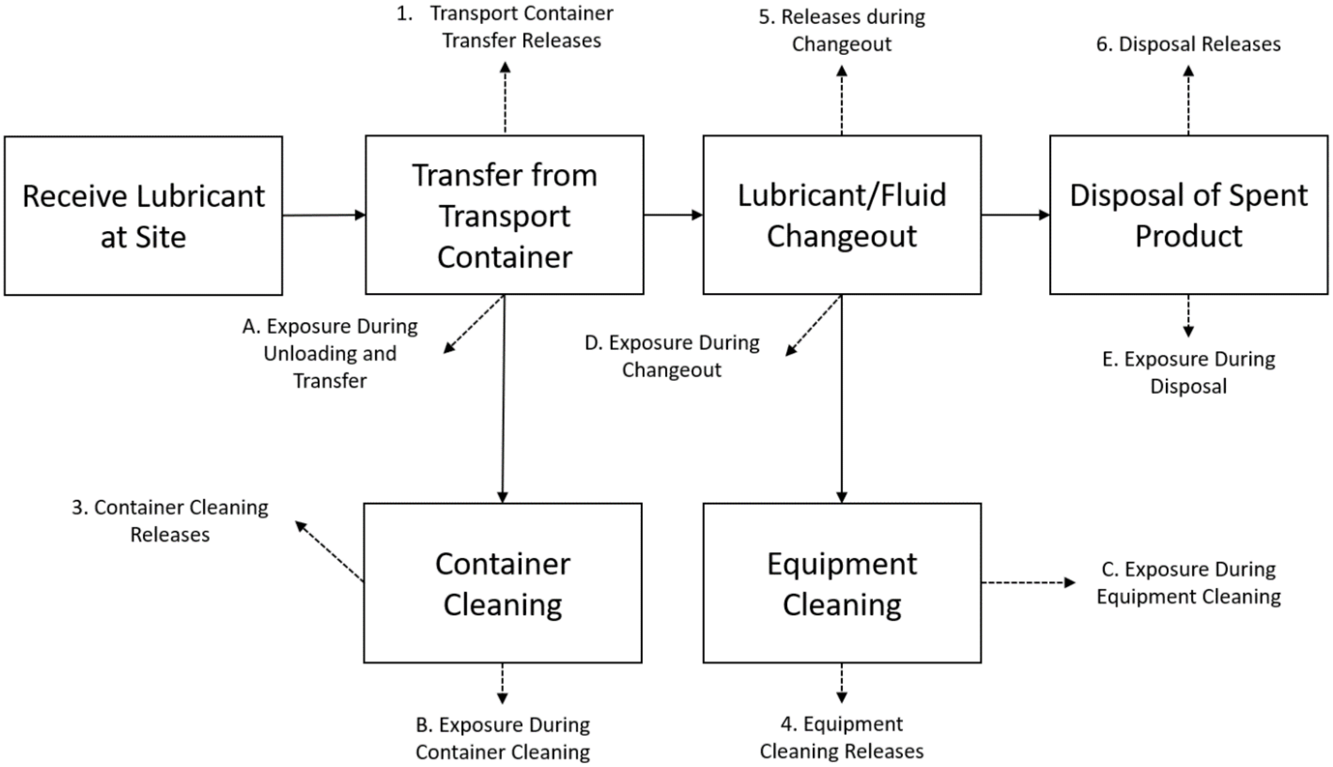

Figure 3-14. Use of Lubricants and Functional Fluids Flow Diagram

3.13.2 Facility Estimates

No sites reported the use of DIDP-containing lubricants or functional fluids to the 2020 CDR (U.S. EPA, 2020a). The American Chemistry Council indicated that the use rate of DIDP in the EU is similar to the use rate in the United States (ACC, 2020a), however, the 2003 *DIDP Risk Assessment* published by the European Union (ECJRC, 2003a) did not estimate a production volume for lubricants and functional fluids. The smallest PV breakdown the EU risk assessment provided was 1.1% for inks, adhesives/sealants, and paints. Based on minimal data for the "lubricants and functional fluids" breakdown, EPA uses one third of the 1.1% as an estimate for lubricants and functional fluid. As a result, EPA calculated the production volume of DIDP in lubricants as 0.37% of the total DIDP production volume reported to CDR for both CASRN. The 2020 CDR reported a national production volume range for DIDP; therefore, EPA provided the lubricant and functional fluid production volume as a range. The resulting total production volume was 169,485-1,679,970 kg/year.

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

The ESD provides an estimate of 1-4 changeouts per year for different types of hydraulic fluids, and EPA assumed each changeout occurs over the course of 1 day. Based on this relationship, the EPA assessed 1-4 operating days per year. Based on this operating day distribution, the 50th and 95th percentile range of the resulting product use rate was 921-2,903 kg/site-year. EPA did not identify any estimates of the number of sites that may use lubricants/functional fluids containing DIDP. Therefore, EPA estimated the total number of sites that use DIDP-containing lubricants/functional fluids using a Monte Carlo model (see Appendix E.12 for details). The 50th-95th percentile range of the number of sites was 2,596-18,387 sites.

3.13.3 Release Assessment

3.13.3.1 Environmental Release Points

EPA assigned release points based on the 2004 *ESD on Lubricants and Lubricant Additives* (OECD, 2004b). EPA assigned default models to quantify releases from each release point and suspected fugitive air release. EPA expects releases to wastewater, landfill, or incineration from the use of equipment. Releases to wastewater, landfill, and incineration from fuel blending activities are expected from fluid changeouts.

3.13.3.2 Environmental Release Assessment Results

Table 3-65. Summary of Modeled Environmental Releases for Use of Lubricants and Functional Fluids

Modeled Scenario	**Environmental Media**	**Annual Release (kg/site-yr)**		**Number of Release Days**		**Daily Release (kg/site-day)**	
		Central Tendency	**High-End**	**Central Tendency**	**High-End**	**Central Tendency**	**High-End**
373,650-3,703,700 lb production volume	Wastewater	1.61E02	7.60E02	2	4	7.29E01	2.69E02
	Landfill	7.06E01	3.60E02			3.21E01	1.30E02
	Recycling	2.56	1.72E01			1.19	6.31
	Fuel Blending (Incineration)	5.70E01	3.83E02			2.64E01	1.40E02

3.13.4 Occupational Exposure Assessment

3.13.4.1 Worker Activities

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

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

3.13.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs per site that are potentially exposed to DIDP during the use of lubricants and functional fluids. This approach involved the identification of relevant SOC codes within the BLS data for the select NAICS codes. Section 2.4.2 provides further details regarding the methodology that EPA used to estimate the number of workers and ONUs per site. EPA assigned the

NAICS codes 336100, 336200, 336300, 336400, 336500, 336600, 336900, and 811100 for this OES based on the *Emission Scenario Document on Lubricants and Lubricant Additives* (OECD, 2004b). Table 3-66 summarizes the per site estimates for this OES. As described in Section 3.13.2, EPA did not identify site-specific data for the number of facilities in the United States that use DIDP-containing lubricants and functional fluids.

Table 3-66. Estimated Number of Workers Potentially Exposed to DIDP during Use of Lubricants and Functional Fluids

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed Occupational Non-users per Site[b]	Total Number of Exposed ONUs[a]
336100 – Motor Vehicle Manufacturing	N/A	447	N/A	59	N/A
336200 – Motor Vehicle Body and Trailer Manufacturing		40		5	
336300 – Motor Vehicle Parts Manufacturing		51		15	
336400 – Aerospace Product and Parts Manufacturing		75		64	
336500 – Railroad Rolling Stock Manufacturing		35		15	
336600 – Ship and Boat Building		36		11	
336900 – Other Transportation Equipment Manufacturing		16		4	
811100 – Automotive Repair and Maintenance		6		1	
Total/Average	2,596-18,387	88	228,779-1,620,403	22	56,176-397,887

[a] The result is expressed as a range between the central tendency and the high-end value. Results were not assessed by NAICS code for this scenario.

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed Occupational Non-users per Site[b]	Total Number of Exposed ONUs[a]

[b] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as “0” are left unrounded.

3.13.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for use of lubricants and functional fluids during systematic review of literature sources. However, EPA estimated inhalation exposures for this OES using monitoring data for DIDP exposures during manufacturing (ExxonMobil, 2022a). EPA expects that inhalation exposures during manufacturing are greater than inhalation exposures expected during use of lubricants and functional fluids and serve as reasonable bounding estimates.

EPA used surrogate monitoring data provided in an exposure study conducted by ExxonMobil at their DIDP manufacturing site to estimate inhalation exposure for this OES. ExxonMobil collected PBZ samples via an AIHA validated method involving PTFE Teflon filters, extraction with acetonitrile, and HPLC analysis with UV detection. ExxonMobil took PBZ samples from plasticizer assistant operators, laboratory technicians, maintenance operators (ExxonMobil, 2022a). EPA used the samples taken during filter change-out from maintenance workers to represent this OES, as this activity was determined to best represent the activities that occur during manufacturing. The study included two PBZ data points for DIDP. Both data points were below the LOD. Therefore, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To estimate high-end worker exposures, EPA used the LOD reported in the study. To estimate central tendency worker exposure, EPA used half of the LOD.

Table 3-67 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during use of lubricants and functional fluids. The high-end exposures use 4 days per year as the exposure frequency based on the 95th percentile of operating days from the release assessment. The central tendency exposures use 2 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Appendix B describes the approach for estimating AD, IADD, and ADD.

Table 3-67. Summary of Estimated Worker Inhalation Exposures for Use of Lubricants and Functional Fluids

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration (mg/m^3)	3.6E−02	7.2E−02
	Acute Dose (AD) (mg/kg/day)	4.5E−03	9.0E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.0E−04	1.2E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.5E−05	9.9E−05
	8-hr TWA Exposure Concentration (mg/m^3)	3.6E−02	7.2E−02
	Acute Dose (AD) (mg/kg/day)	5.0E−03	9.9E−03

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Female of Reproductive Age	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.3E−04	1.3E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.7E−05	1.1E−04
ONU	8-hr TWA Exposure Concentration (mg/m^3)	3.6E−02	3.6E−02
	Acute Dose (AD) (mg/kg/day)	4.5E−03	4.5E−03
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	3.0E−04	6.0E−04
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	2.5E−05	4.9E−05

3.13.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-68 are explained in Appendix B. Because dermal exposures to workers may occur in a concentrated liquid form during the use of lubricants and functional fluids, EPA assessed the absorptive flux of DIDP according to dermal absorption data of neat DIDP (see Appendix D.2.1.1 for details). Table 3-68 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for both average adult workers and female workers of reproductive age. Because there are no dust or mist expected to be deposited on surfaces from this OES, dermal exposures to ONUs from contact with surfaces were not assessed. Dermal exposure parameters are described in Appendix D.

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

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.7	7.3
	Acute (AD, mg/kg-day)	4.6E−02	9.2E−02
	Intermediate (IADD, mg/kg-day)	3.1E−03	1.2E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.5E−04	1.0E−03
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.1	6.1
	Acute (AD, mg/kg-day)	4.2E−02	8.4E−02
	Intermediate (IADD, mg/kg-day)	2.8E−03	1.1E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.3E−04	9.2E−04

3.13.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-69.

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

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	5.0E−02	0.10
	Intermediate (IADD, mg/kg-day)	3.4E−03	1.3E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.8E−04	1.1E−03
Female of Reproductive Age	Acute (AD, mg/kg-day)	4.7E−02	9.4E−02
	Intermediate (IADD, mg/kg-day)	3.1E−03	1.3E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.6E−04	1.0E−03
ONU	Acute (AD, mg/kg-day)	4.5E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	3.0E−04	6.0E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	2.5E−05	4.9E−05

3.14 Use of Penetrants and Inspection Fluids

3.14.1 Process Description

DIDP is present in inspection fluids or penetrants that are commercially used to reveal surface defects (*e.g.*, cracks, folds, pitting, etc.), typically on metal parts (see Appendix F for EPA identified DIDP-containing products for this OES). EPA assessed aerosol-based penetrants and non-aerosol penetrants as separate processes with unique release points. EPA expects that sites receive non-aerosol penetrants in bottles, cans, or drums, ranging in size from 0.08-55 gallons, with the maximum container size based on the ESD default for drums and the minimum based on a 10.5-ounce aerosol product can (OECD, 2011d). The site transfers the non-aerosol penetrant from transport containers into process vessels and applies the product using brushing and/or immersion. EPA expects that non-aerosol penetrant application occurs over the course of an 8-hour workday A typical site that uses aerosol penetrants receives cans of penetrant and an operator sprays the aerosol penetrant and disposes of the used aerosol can. EPA expects the operator to apply the aerosol in non-steady, instantaneous bursts at the start of each job, and allow the penetrant to remain on the surface as it reveals defects before eventually wiping it away. EPA expects that the penetrant product is self-contained and does not require transfer or cleaning from shipping containers or application equipment for this OES. Figure 3-15 and Figure 3-16 provide illustrations of the use of inspection fluids or penetrants for the non-aerosol and aerosol use cases respectively (OECD, 2011d).

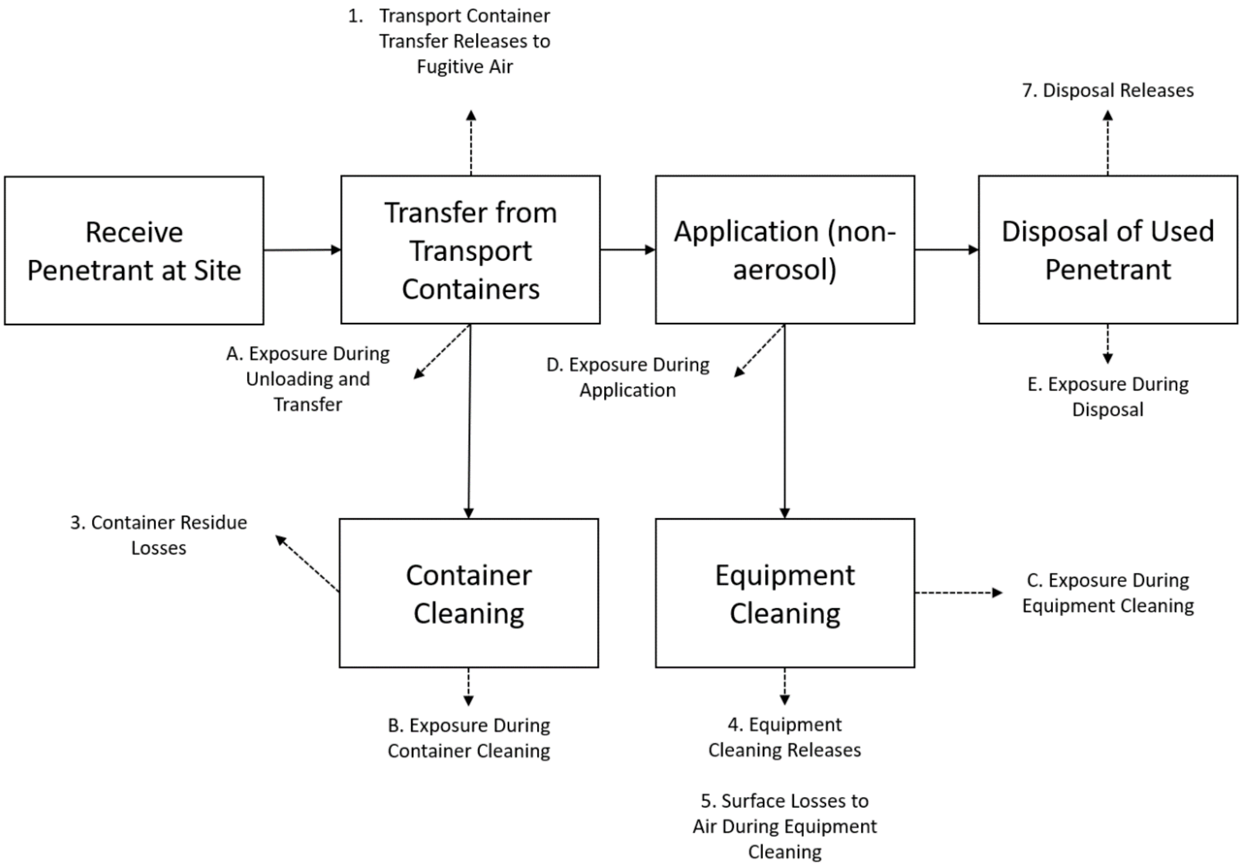

Figure 3-15. Use of Penetrants and Inspection Fluids Flow Diagram Non-Aerosol Use

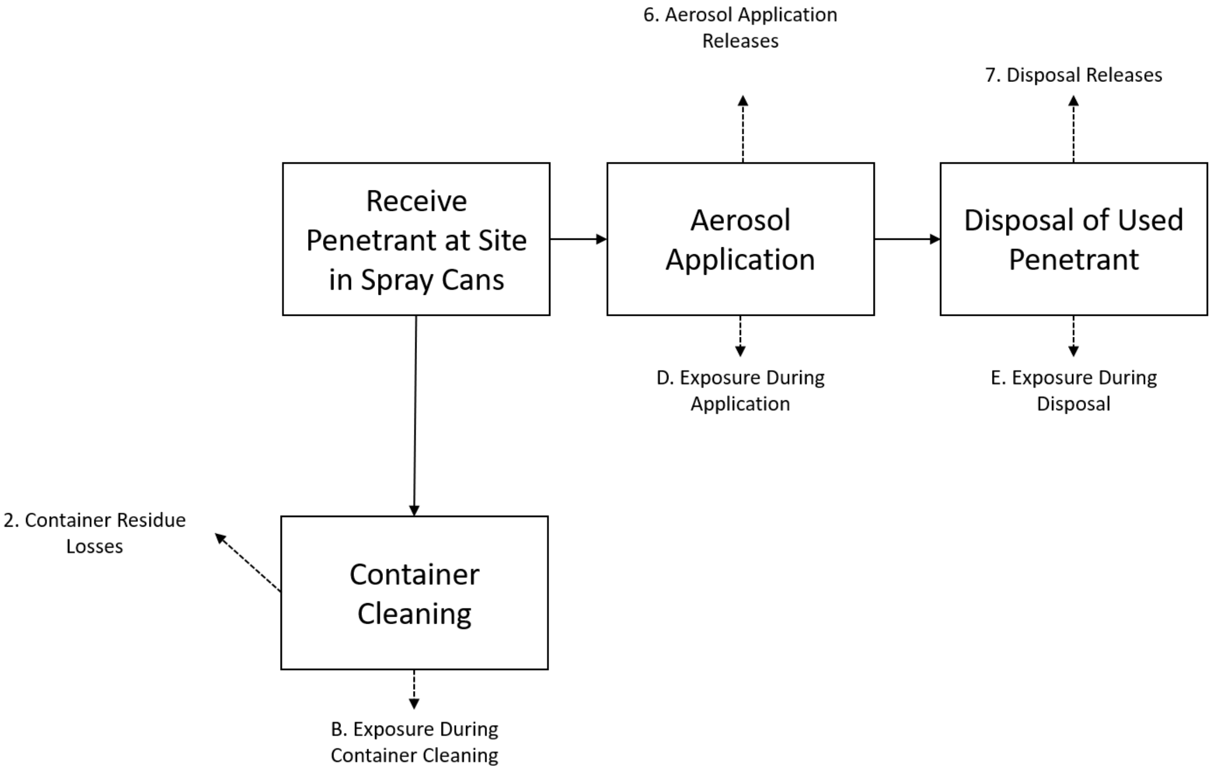

Figure 3-16. Use of Penetrants and Inspection Fluids Flow Diagram Aerosol Use

3.14.2 Facility Estimates

No site reported the use of DIDP-containing inspection fluids or penetrants to the 2020 CDR. EPA estimated the total production volume using the CDR reporting threshold limits of either 25,000 pounds (11,430 kg) or 5% of a site's reported production volume, whichever value was smaller (U.S. EPA, 2020a). EPA considered every site that reported to CDR, regardless of assigned OES. EPA assumed that sites that claimed their production volume as CBI used 25,000 pounds of DIDP annually. Table 3-70 provides each reported site and the associated production volume for use in calculating the total production volume (U.S. EPA, 2020a). This resulted in a total production volume for this OES across both CASRN of 94,832 kg/year.

Table 3-70. CDR Reported Site Information for Use in Calculation of Use of Penetrants and Inspection Fluids Production Volume

CASRN	Site Name	Site Location	Reported Production Volume (kg/year)	Threshold Limit Used	Production Volume Added to Total[4] (kg/year)
26761-40-0	3M	St. Paul, MN	CBI	11,340 kg	11,340
26761-40-0	LG Hausys, Inc.	Adairsville, GA	11,895	5%	595
26761-40-0	Harwick Standard Distribution Corp.	Akron, OH	19,447	5%	972
26761-40-0	LG Chem, Inc.	Atlanta, GA	CBI	11,340 kg	11,340
26761-40-0	Tremco Inc.	Beachwood, OH	362,965	11,340 kg	11,340
26761-40-0	Akrochem Corp.	Stow, OH	6,616	5%	331
26761-40-0	Chemspec, Ltd.	Uniontown, OH	23,801	5%	1,190
68515-49-1	3M	St. Paul, MN	CBI	11,340 kg	11,340
68515-49-1	ExxonMobil BR Chemical Plant	Baton Rouge, LA	CBI	11,340 kg	11,340
68515-49-1	Lanxess Solutions, Inc.	Fords, NJ	CBI	11,340 kg	11,340
68515-49-1	The Sherwin-Williams Co.	Cleveland, OH	CBI	11,340 kg	11,340
68515-49-1	Sika Corp.	Lyndhurst, NJ	CBI	11,340 kg	11,340
68515-49-1	Troy Chemical Corp.	Phoenix, AZ	20,507	5%	1,025

EPA did not identify site- or DIDP-specific inspection fluid/penetrant site operating data (*i.e.*, batch size or number of batches per year) from systematic review; therefore, EPA assessed the daily DIDP facility throughput of $1.67 \times 10^{-2} – 3.34 \times 10^{-2}$ kg/site-day based on a penetrant product throughput of eight 10.5 oz cans per day (one can of product per hour), and a concentration of DIDP in inspection fluid/penetrant products of 10-20% (See Appendix F for product data). EPA assessed the number of operating days using the 2011 *ESD on the Use of Metalworking Fluids*, which cites general averages for facilities with a range of 246-249 operating days/year of 8 hour/day, 5 days/week operations up to the operating days for the given site throughput scenario (OECD, 2011d). EPA assessed the total number of sites that use DIDP-containing inspection fluids/penetrants using a Monte Carlo model that considered the total production volume for this OES and the annual DIDP facility throughput of 4.10-8.31 kg/site-year. The 50th- 95th percentile range of the number of sites was 15,315-21,892.

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[4] Values reported are rounded to the nearest whole number value, the sum of the column exceeds the reported production volume by 1 kg due to rounding effects.

3.14.3 Release Assessment

3.14.3.1 Environmental Release Points

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

3.14.3.2 Environmental Release Assessment Results

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

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
209,068 lb production volume Aerosol Based	Fugitive Air	9.10E−01	1.19	247	249	3.68E−03	4.80E−03
	Wastewater, Incineration, or Landfill	5.23	6.80			2.14E−02	2.77E−02
209,068 lb production volume Non-aerosol Based	Fugitive Air	6.09E−07	1.13E−06	247	249	2.46E−09	4.57E−09
	Wastewater, Incineration, or Landfill	5.72	7.78			2.50E−02	3.25E−02

3.14.4 Occupational Exposure Assessment

3.14.4.1 Worker Activities

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

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

3.14.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs per site that are potentially exposed to DIDP during the use of penetrants and inspection fluids. This approach involved the identification of relevant SOC codes within the BLS data for select NAICS codes. Section 2.4.2 provides further details regarding the methodology that EPA used to estimate the number of workers and ONUs per site. EPA assigned the NAICS codes 332100, 332200, 332300, 332400, 332500, 332600, 332700, 332800, 332900, 333100, 333200, 333300, 333400, and 333900 for this OES based on the *Emission Scenario Document on the Use of Metalworking Fluids* (OECD, 2011d). Table 3-72 summarizes the per site estimates for this OES. As described in Section 3.14.2, EPA did not identify site-specific data for the number of facilities in the United States that use DIDP-containing penetrants and inspection fluids.

Table 3-72. Estimated Number of Workers Potentially Exposed to DIDP during Use of Penetrants and Inspection Fluids

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed ONUs per Site[b]	Total Number of Exposed ONUs[a]
332100 – Forging and Stamping	N/A	10	N/A	4	N/A
332200 – Cutlery and Handtool Manufacturing		25		9	
332300 – Architectural and Structural Metals Manufacturing		5		2	
332400 – Boiler, Tank, and Shipping Container Manufacturing		17		13	
332500 – Hardware Manufacturing		12		4	
332600 – Spring and Wire Product Manufacturing		10		3	
332700 – Machine Shops; Turned Product; and Screw, Nut, and Bolt		2		1	
332800 – Coating, Engraving, and Heat-Treating Metals		8		2	
332900 – Other Fabricated Metal Product Manufacturing		12		5	
333100 – Agriculture, Construction, and Mining Machinery Manufacturing		20		9	
333200 – Industrial Machinery Manufacturing		8		6	
333300 – Commercial and Service Industry		14		6	

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed ONUs per Site[b]	Total Number of Exposed ONUs[a]
Machinery Manufacturing					
333400 – HVAC and Commercial Refrigeration Equipment		31		8	
333900 – Other General Purpose Machinery Manufacturing		13		6	
Total/Average	15,315-21,892	13	203,772-291,282	6	85,651-122,433

[a] The result is expressed as a range between the central tendency and the high-end value. Results were not assessed by NAICS code for this scenario.

[b] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as "0" are left unrounded.

3.14.4.3 Occupational Inhalation Exposure Results

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

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

Table 3-73 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during the use of penetrants and inspection fluids. The high-end exposures use 249 days per year as the exposure frequency based on the 95th percentile of operating days from the release assessment. The central tendency exposures use 247 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Appendix B describes the approach for estimating AD, IADD, and ADD.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration (mg/m^3)	1.5	5.6
	Acute Dose (AD) (mg/kg/day)	0.19	0.70
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	0.14	0.51
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	0.13	0.47
Female of Reproductive Age	8-hr TWA Exposure Concentration (mg/m^3)	1.5	5.6
	Acute Dose (AD) (mg/kg/day)	0.21	0.77
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	0.15	0.56
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	0.14	0.52
ONU	8-hr TWA Exposure Concentration (mg/m^3)	5.1E−02	0.38
	Acute Dose (AD) (mg/kg/day)	6.4E−03	4.7E−02
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	4.7E−03	3.5E−02
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	4.3E−03	3.2E−02

3.14.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-74 are explained in Appendix B. Because dermal exposures of DIDP to workers may occur in a concentrated liquid form during the use of penetrants or inspection fluids, EPA assessed the absorptive flux of DIDP according to dermal absorption data of neat DIDP (see Appendix D.2.1.1 for details). Also, since there may be mist deposited on surfaces from this OES, dermal exposures to ONUs from contact with mist on surfaces were assessed. Dermal exposure to workers is generally expected to be greater than dermal exposure to ONUs. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure. Therefore, worker central tendency exposure values for dermal contact with liquids containing DIDP were assumed representative of ONU dermal exposure.

Table 3-74 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for average adult workers, female workers of reproductive age, and ONUs. Dermal exposure parameters are described in Appendix D.

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

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.7	7.3
	Acute (AD, mg/kg-day)	4.6E−02	9.2E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	6.7E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.1E−02	6.3E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.1	6.1
	Acute (AD, mg/kg-day)	4.2E−02	8.4E−02
	Intermediate (IADD, mg/kg-day)	3.1E−02	6.2E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−02	5.7E−02
ONU	Dose Rate (APDR, mg/day)	3.7	3.7
	Acute (AD, mg/kg-day)	4.6E−02	4.6E−02
	Intermediate (IADD, mg/kg-day)	3.4E−02	3.4E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.1E−02	3.1E−02

3.14.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-75.

Table 3-75. Summary of Estimated Worker Aggregate Exposures for Use of Penetrants and Inspection Fluids

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	0.24	0.79
	Intermediate (IADD, mg/kg-day)	0.17	0.58
	Chronic, Non-cancer (ADD, mg/kg-day)	0.16	0.53
Female of Reproductive Age	Acute (AD, mg/kg-day)	0.25	0.85
	Intermediate (IADD, mg/kg-day)	0.18	0.62
	Chronic, Non-cancer (ADD, mg/kg-day)	0.17	0.58
ONU	Acute (AD, mg/kg-day)	5.2E−02	9.3E−02
	Intermediate (IADD, mg/kg-day)	3.8E−02	6.8E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	3.5E−02	6.3E−02

3.15 Fabrication and Final Use of Products or Articles

3.15.1 Process Description

EPA expects DIDP to be present in a wide array of different final articles that are used both commercially and industrially, including automotive care products, abrasives, heat-resistant electric cords, interior leather for cars, roofing sheets, synthetic leather, tool handles, and hoses (see Appendix F for EPA identified DIDP-containing products for this OES) (U.S. CPSC, 2015). Also, the *Manufacturer Request for Risk Evaluation: Diisodecyl Phthalate (DIDP)*, submission states that DIDP is used in general purpose plasticizers for PVC used in building and construction materials such as vinyl tiles, resilient flooring, PVC-backed carpeting, scraper mats, and wall coverings (U.S. EPA, 2019b). These uses may require the worker handle, shape/cut, and install the DIDP-containing products.

DIDP is present in products that are used for surface conditioning, which is a COU considered under the "Fabrication and Final Use of Products or Articles" OES. Specifically, the COU of *Industrial use, – abrasives, "abrasives (surface conditioning and finishing discs; semi-finished and finished goods)*" is describing the use of finished, abrasive articles by workers to smooth surfaces, after the incorporation of DIDP into the article. According to the *Final Scope of the Risk Evaluation for Diisodecyl Phthalate (DIDP), s*urface conditioning is needed for such task as smoothing a surface prior to the application of paints and coatings or blending parting lines on cast parts. DIDP is present at low concentrations (less than 1.5 percent) in the line of non-woven abrasives supplied by Superior Abrasives (U.S. EPA, 2021b). DIDP is also present in abrasive products at concentrations ranging from 1 to 8 percent with applications as an abrasive system for semi-finished and finished goods (EPA-HQ-OPPT-2018-0435-0012).

Also, data reported to the 2020 CDR indicates DIDP is used in a variety of automotive products (U.S. EPA, 2020a). According to the *Manufacturer request for risk evaluation: Diisodecyl Phthalate (DIDP)*, DIDP is primarily used as a plasticizer in automotive products such as upholstery and interior finishes (*e.g.*, synthetic leather for car interiors), interior PVC skins (dashboards and shift boot covers), window glazing (urethane glass bonding adhesives and PVC window encapsulate), body-side molding, automotive undercoating, molded interior applications, insulation for wire and cable and wire harnesses (U.S. EPA, 2019b). However, the applications of any adhesives (*e.g.*, window glazing) or sealants (*e.g.*, automotive undercoating) are covered under the OES for "Application of Adhesives and Sealants".

Lastly, regarding the commercial COU for furnishing, cleaning, treatment/care products – furniture and furnishings, this COU is describing workers handling furniture and furnishings that already contain DIDP and are transforming materials into final products. There is little product data to support this use other than the 2012 CDR reported use of DIDP in commercial furniture and furnishings not covered elsewhere and the *Final Scope of the Risk Evaluation for Diisodecyl Phthalate (DIDP)*. (U.S. EPA, 2019a, b)). Information for products that have DIDP incorporated into an adhesive and sealant chemical or paint and coating that is used in the manufacture of furniture has not been currently identified.

3.15.2 Facility Estimates

EPA identified multiple products for the fabrication and final use of products or articles OES. The concentration of DIDP in these products varies depending on the type of product and the necessary characteristics of that product. Therefore, EPA used the concentration from a single product, plastic vinyl flooring, to represent this scenario, with DIDP at a concentration ranging from 9-32% (WA DOE, 2020). 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 DIDP-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 DIDP; drilling, cutting, grinding, or otherwise shaping articles containing DIDP; and the general use of DIDP-containing abrasives. 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 DIDP. EPA assumed the number of operating days was 250 days/year with 5 day/week operations and two full weeks of downtime each operating year.

3.15.3 Release Assessment

3.15.3.1 Environmental Release Points

EPA did not quantitatively assess environmental releases for this OES due to the lack of readily available process-specific and DIDP-specific data; however, EPA expects releases from this OES to be small and disperse in comparison to other upstream OES, as EPA expects DIDP to be present in smaller amounts and predominantly remain in the final article, limiting the potential for release. Table 3-76 describes the expected fabrication and use activities that generate releases. All releases are non-quantifiable due to a lack of identified process- and product- specific data.

Table 3-76. Release Activities for Fabrication/Use of Final Articles Containing DIDP

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

3.15.4 Occupational Exposure Assessment

3.15.4.1 Worker Activities

During fabrication and final use of products or articles, worker exposures to DIDP may occur via dermal contact while handling and shaping articles containing DIDP additives. Worker exposures may also occur via particulate inhalation during activities such as cutting, grinding, shaping, drilling, and/or abrasive actions that generate particulates from the product. Additionally, DIDP vapor inhalation exposure may occur during heating or plastic welding. EPA did not identify chemical-specific information on engineering controls and worker PPE used at final product or article formulation or use sites. Based on the presence of DIDP as an additive within solid articles or products, EPA expects particulate inhalation exposures to be higher than vapor exposures for this OES.

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

3.15.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs per site that are potentially exposed to DIDP during the fabrication and final use of products or articles. This approach involved the identification of relevant SOC codes within the BLS data for select NAICS codes. Section 2.4.2 provides further details regarding the methodology EPA used to estimating the number of workers and ONUs per site. EPA assigned the NAICS codes 236100, 236200, 237100, 237200, 237300, 237900, 337100, and 337200 for this OES based on NAICS codes that matched the relevant COUs for this scenario. Table 3-77 summarizes the per site estimates for this OES. As discussed in Section 3.15.2, EPA did not identify site-specific data for the number of facilities in the United States that fabricate or use final products or articles that contain DIDP.

Table 3-77. Estimated Number of Workers Potentially Exposed to DIDP during the Fabrication and Final Use of Products or Articles

NAICS Code	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
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
Total/Average	9	3

[a] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as "0" are left unrounded.

3.15.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data to assess exposures to DIDP during fabrication and final use of products or articles containing DIDP. Based on the presence of DIDP as an additive in products (U.S. CPSC, 2015), EPA assessed worker inhalation exposures to DIDP as an exposure to particulates of final products. Therefore, EPA estimated worker inhalation exposures during fabrication and final use of products using the Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR) (U.S. EPA, 2021d). Model approaches and parameters are described in Appendix E.16.

In the model, EPA used a subset of the Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR) (U.S. EPA, 2021d) data from facilities with NAICS codes starting with 337 (Furniture and Related Product Manufacturing) to estimate final product particulate concentrations in the air. Particulate exposures across end-use industries may include trimming, cutting, and/or abrasive actions on the DIDP-containing product, and EPA expects similar actions during furniture and related products manufacturing. EPA used the highest expected concentration of DIDP in final products to estimate the concentration of DIDP in the particulates. For this OES, EPA selected 45 percent by mass as the highest expected DIDP concentration based on the estimated plasticizer concentrations in relevant products given by the Use of Additives in Plastic Compounding Generic Scenario (U.S. EPA, 2021e). The estimated exposures assume that DIDP is present in particulates at this fixed concentration throughout the working shift.

The *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d) estimates an 8-hour TWA for particulate concentrations by assuming exposures outside the sample duration are zero. The model does not determine exposures during individual worker activities. EPA used the number of operating days estimated in the release assessment for this OES to estimate exposure frequency.

Table 3-78 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposure to DIDP during fabrication and final use of products. The high-end and central tendency exposures both use 250 days per year as the exposure frequency based on the 95th and 50th percentiles of operating days in the release assessment. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DIDP in the form of product particulates and does not account for other potential inhalation exposure routes, such as from vapors.

Table 3-78. Summary of Estimated Worker Inhalation Exposures for Fabrication and Final Use of Products or Articles

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration to Dust (mg/m^3)	9.0E−02	0.81
	Acute Dose (AD) (mg/kg/day)	1.1E−02	0.10
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	8.3E−03	7.4E−02
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	7.7E−03	6.9E−02
Female of Reproductive Age	8-hr TWA Exposure Concentration to Dust (mg/m^3)	9.0E−02	0.81
	Acute Dose (AD) (mg/kg/day)	1.2E−02	0.11
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	9.1E−03	8.2E−02
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	8.5E−03	7.7E−02
ONU	8-hr TWA Exposure Concentration to Dust (mg/m^3)	9.0E−02	9.0E−02
	Acute Dose (AD) (mg/kg/day)	1.1E−02	1.1E−02
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	8.3E−03	8.3E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	7.7E−03	7.7E−03

3.15.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-79 are explained in Appendix B. Because dermal exposures of DIDP to workers is expected to occur through contact with solids or articles for this OES, EPA assessed the absorptive flux of DIDP according to dermal absorption modeling approach for solids outlined in Appendix D.2.1.2. Also, since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Dermal exposure to workers is generally expected to be greater than dermal exposure to ONUs. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure.

Therefore, worker central tendency exposure values for dermal contact with solids containing DIDP were assumed representative of ONU dermal exposure.

Table 3-79 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for average adult workers, female workers of reproductive age, and ONUs. Dermal exposure parameters are described in Appendix D.

Table 3-79. Summary of Estimated Worker Dermal Exposures for Fabrication and Final Use of Products or Articles

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.9E−02	7.7E−02
	Acute (AD, mg/kg-day)	4.8E−04	9.6E−04
	Intermediate (IADD, mg/kg-day)	3.5E−04	7.1E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	3.3E−04	6.6E−04
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.2E−02	6.4E−02
	Acute (AD, mg/kg-day)	4.4E−04	8.8E−04
	Intermediate (IADD, mg/kg-day)	3.2E−04	6.5E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	3.0E−04	6.1E−04
ONU	Dose Rate (APDR, mg/day)	3.9E−02	3.9E−02
	Acute (AD, mg/kg-day)	4.8E−04	4.8E−04
	Intermediate (IADD, mg/kg-day)	3.5E−04	3.5E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	3.3E−04	3.3E−04

3.15.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-80.

Table 3-80. Summary of Estimated Worker Aggregate Exposures for Fabrication and Final Use of Products or Articles

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.2E−02	0.10
	Intermediate (IADD, mg/kg-day)	8.6E−03	7.5E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	8.0E−03	7.0E−02
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.3E−02	0.11
	Intermediate (IADD, mg/kg-day)	9.4E−03	8.3E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	8.8E−03	7.7E−02
ONU	Acute (AD, mg/kg-day)	1.2E−02	1.2E−02
	Intermediate (IADD, mg/kg-day)	8.6E−03	8.6E−03
	Chronic, Non-cancer (ADD, mg/kg-day)	8.0E−03	8.0E−03

3.16 Recycling

3.16.1 Process Description

DIDP is primarily recycled industrially in the form of DIDP-containing PVC waste streams, including roofing membranes, vinyl window frame profiles, and carpet squares. Based on a report by Sika Corporation, all roofing membrane recycling is completed using mechanical recycling technology, in the form of scrap regrinding and recycling (Irwin, 2022). While chemical/feedstock recycling is possible, EPA did not identify any market share data indicating chemical/feedstock recycling processes for DIDP-containing waste streams.

The Association of Plastic Recyclers reported recycled PVC arrives at a typical recycling site tightly baled as crushed finished articles ranging from 240 – 453 kg (APR, 2023). The bales are unloaded into process vessels, where the DIDP is grinded and separated from non-PVC fractions using electrostatic separation, washing/floatation, or air/jet separation. Following cooling of grinded PVC, that the site transfers the product to feedstock storage for use in the plastics compounding or converting line or loaded into containers for shipment to downstream use sites. Figure 3-17 provides an illustration of the PVC recycling process (U.S. EPA, 2021e).

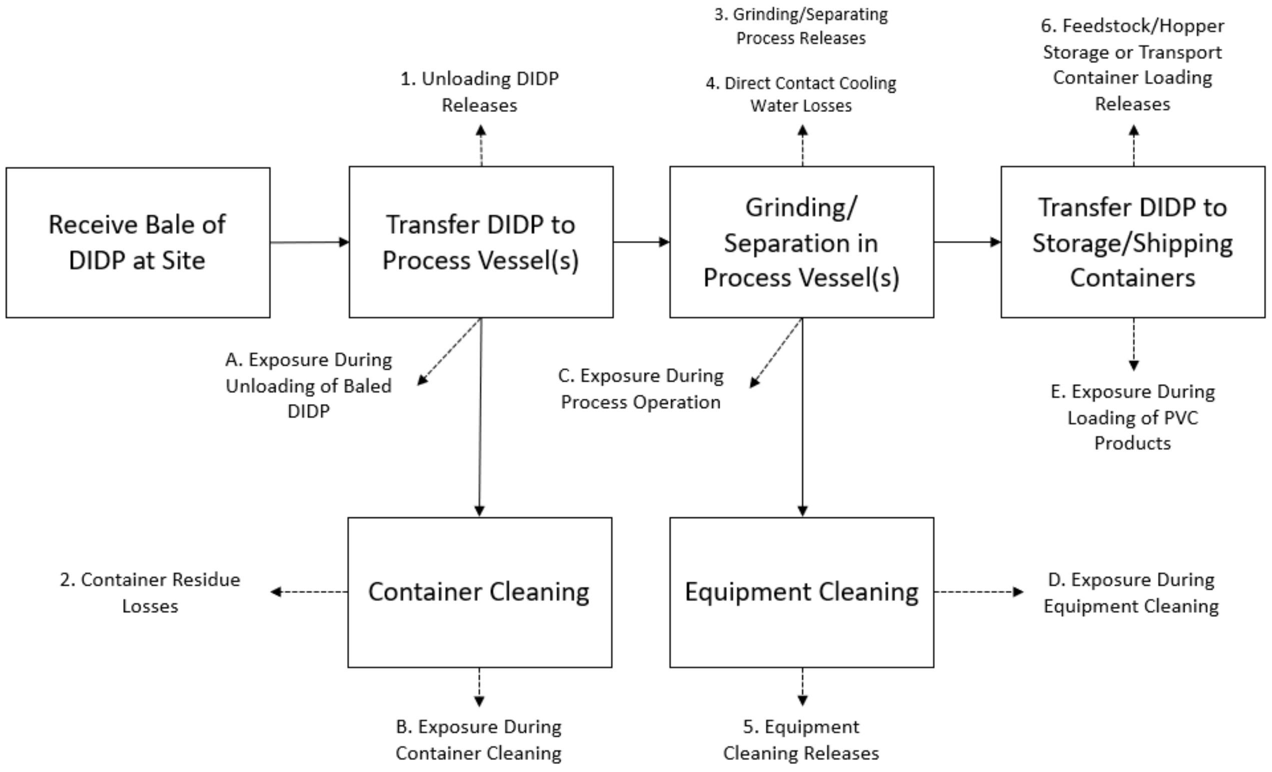

Figure 3-17. DIDP-Containing PVC Recycling Flow Diagram

3.16.2 Facility Estimates

ENF Recycling (ENF Plastic, 2024) estimated a total of 228 plastics recyclers operating in the United States of which 58 accept PVC wastes for recycling. It is unclear if the total number of sites includes some or all circular recycling sites – facilities where new PVC can be manufactured from recycled and virgin materials on the same site. A notice by the Sika Corporation indicated the use of sites with in-house post-consumer roofing membrane grinding capabilities (Irwin, 2022). Such sites would be identified primarily by the manufactured product, however compounding site parameters and release estimates are based on generic values specified in the Plastics Compounding GS and would thus incorporate all PVC material streams; recycled or virgin production (U.S. EPA, 2021e).

The Quantification and Evaluation of Plastic Waste in the United States estimated that of the 699 kilotons of PVC waste managed in 2019, 3% was recycled or 20,970,000 kg-PVC (Milbrandt et al., 2022). The 2010 technical report on the *Evaluation of New Scientific Evidence Concerning DINP and DIDP* estimated the fraction of DIDP-containing PVC used in the overall PVC market as 9.78% (ECHA, 2010). As a result, EPA calculated the use rate of recycled PVC plastics containing DIDP as 9.78% of the yearly recycled production volume of PVC or 2,050,866 kg/year. This is comparable to the estimated production volume of DIDP-containing PVC of 43,859,857 – 434,749,009 kg/year. Plastics compounding sites may engage in the reformulation of plastics from recycled plastic products. The 2021 *Generic Scenario on Plastics Compounding* estimated that the mass fraction of DIDP used as a plasticizer in PVC was 10 – 45% (U.S. EPA, 2021e), and EPA expects the 2021 GS to be representative of PVC recycling activities and their associated releases. EPA estimated the production volume of DIDP in PVC plastic recycled as 205,087 – 922,890 kg based on the use rate of DIDP-containing PVC in the overall market and the mass fraction of DIDP used as plasticizer in PVC. The GS estimated the total number of operating days of 148 – 264 days/year, with 24 hour/day, 7 day/week (*i.e.*, multiple shifts) operations for the given site throughput scenario (U.S. EPA, 2021e).

3.16.3 Release Assessment

3.16.3.1 Environmental Release Points

EPA assigned release points based on the 2021 *Generic Scenario on Plastic Compounding* (U.S. EPA, 2021e). EPA assigned default models to quantify releases from each release point and suspected fugitive air release. EPA does not expect recycling sites to utilize air pollution capture and control technologies. EPA expects fugitive air, wastewater, incineration, or landfill releases from unloading and loading, general recycling processing, container residue losses, and equipment cleaning. EPA expects wastewater releases from direct contact cooling and storage or loading of recycled plastic. EPA expects stack air releases expected from storage or loading of recycled plastic.

3.16.3.2 Environmental Release Assessment Results

Table 3-81. Summary of Modeled Environmental Releases for Recycling

Modeled Scenario	Environmental Media	Annual Release (kg/site-yr)		Number of Release Days		Daily Release (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	Central Tendency
452,139 - 2,034,624 lb production volume	Stack Air	5.00	1.01E02	223	254	2.33E−02	4.68E−01
	Fugitive Air, Wastewater, Incineration, or Landfill	3.60E02	6.68E02			1.84	3.36
	Wastewater	1.71E02	3.62E02			7.80E−01	1.70

3.16.4 Occupational Exposure Assessment

3.16.4.1 Worker Activities

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

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

3.16.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs per site that are potentially exposed to DIDP during recycling and disposal. This approach involved the identification of relevant SOC codes within the BLS data for select NAICS codes. Section 2.4.2 provides further details regarding the methodology EPA used to estimate the number of workers and ONUs per site. EPA assigned the NAICS codes 562212, 562213, and 562219 for this OES based on the NAICS codes that related to the process description in Section 3.15.1. Table 3-82 summarizes the per site estimates for this OES. As described in Section 3.15.2, EPA did not identify site-specific data for the number of facilities in the United States that recycle and dispose of DIDP-containing materials.

Table 3-82. Estimated Number of Workers Potentially Exposed to DIDP during Recycling and Disposal

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed Occupational Non-users per Site[b]	Total Number of Exposed ONUs[a]
562212 – Solid Waste Landfill	N/A	7	N/A	4	N/A
562213 – Solid Waste Combustors and Incinerators		27		15	
562219 – Other Nonhazardous Waste Treatment and Disposal		6		3	
Total/Average	58	13	754	7	432

[a] Results were not assessed by NAICS code for this scenario.

[b] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as "0" are left unrounded.

3.16.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data to assess exposures to DIDP during recycling processes. Based on the presence of DIDP as an additive in plastics (U.S. CPSC, 2015), EPA assessed worker inhalation exposures to DIDP as an exposure to particulates of recycled plastic materials. Therefore, EPA estimated worker inhalation exposures during recycling using the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d). Model approaches and parameters are described in Appendix E.16.

In the model, EPA used a subset of the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d) data that came from facilities with the NAICS code starting with 56 (Administrative and Support and Waste Management and Remediation Services) to estimate plastic particulate concentrations in the air. EPA used the highest expected concentration of DIDP in recyclable plastic products to estimate the concentration of DIDP present in particulates. For this OES, EPA selected 45 percent by mass as the highest expected DIDP concentration based on the estimated plasticizer concentrations in flexible PVC given by the *Use of Additives in Plastic Compounding Generic Scenario* (U.S. EPA, 2021e). The estimated exposures assume that DIDP is present in particulates of the plastic at this fixed concentration throughout the working shift.

The *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d) estimates an 8-hour TWA for particulate concentrations by assuming exposures outside the sample duration are zero. The model does not determine exposures during individual worker activities. EPA used the number of operating days estimated in the release assessment for this OES to estimate exposure frequency, with a maximum exposure frequency of 250 working days per year.

Table 3-83 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during recycling. The high-end exposures use 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum number of working days. The central tendency exposures use 223 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DIDP in the form of plastic particulates and does not account for other potential inhalation exposure routes, such as from the inhalation of vapors.

Table 3-83. Summary of Estimated Worker Inhalation Exposures for Recycling

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration to Dust (mg/m^3)	0.11	1.6
	Acute Dose (AD) (mg/kg/day)	1.4E−02	0.20
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	9.9E−03	0.14
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	8.2E−03	0.13

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Female of Reproductive Age	8-hr TWA Exposure Concentration to Dust (mg/m^3)	0.11	1.6
	Acute Dose (AD) (mg/kg/day)	1.5E−02	0.22
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	1.1E−02	0.16
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	9.1E−03	0.15
ONU	8-hr TWA Exposure Concentration to Dust (mg/m^3)	0.11	0.11
	Acute Dose (AD) (mg/kg/day)	1.4E−02	1.4E−02
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	9.9E−03	9.9E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	8.2E−03	9.2E−03

3.16.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-84 are explained in Appendix B. Because dermal exposures of DIDP to workers is expected to occur through contact with solids or articles for this OES, EPA assessed the absorptive flux of DIDP according to dermal absorption modeling approach for solids outlined in Appendix D.2.1.2. Also, since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Dermal exposure to workers is generally expected to be greater than dermal exposure to ONUs. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure. Therefore, worker central tendency exposure values for dermal contact with solids containing DIDP were assumed representative of ONU dermal exposure.

Table 3-84 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for average adult workers, female workers of reproductive age, and ONUs. Dermal exposure parameters are described in Appendix D.

Table 3-84. Summary of Estimated Worker Dermal Exposures for Recycling

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.9E−02	7.7E−02
	Acute (AD, mg/kg-day)	4.8E−04	9.6E−04
	Intermediate (IADD, mg/kg-day)	3.5E−04	7.1E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−04	6.6E−04
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.2E−02	6.4E−02
	Acute (AD, mg/kg-day)	4.4E−04	8.8E−04
	Intermediate (IADD, mg/kg-day)	3.2E−04	6.5E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	2.7E−04	6.1E−04
ONU	Dose Rate (APDR, mg/day)	3.9E−02	3.9E−02

Worker Population	Exposure Concentration Type	Central Tendency	High-End
	Acute (AD, mg/kg-day)	4.8E−04	4.8E−04
	Intermediate (IADD, mg/kg-day)	3.5E−04	3.5E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−04	3.3E−04

3.16.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-85.

Table 3-85. Summary of Estimated Worker Aggregate Exposures for Recycling

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.4E−02	0.20
	Intermediate (IADD, mg/kg-day)	1.0E−02	0.15
	Chronic, Non-cancer (ADD, mg/kg-day)	8.5E−03	0.14
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.5E−02	0.22
	Intermediate (IADD, mg/kg-day)	1.1E−02	0.16
	Chronic, Non-cancer (ADD, mg/kg-day)	9.4E−03	0.15
ONU	Acute (AD, mg/kg-day)	1.4E−02	1.4E−02
	Intermediate (IADD, mg/kg-day)	1.0E−02	1.0E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	8.5E−03	9.6E−03

3.17 Disposal

3.17.1 Process Description

Each of the conditions of use of DIDP may generate waste streams of the chemical that are collected and transported to third-party sites for disposal, treatment, or recycling. Wastes of DIDP that are generated during a condition of use and sent to a third-party site for treatment, disposal, or recycling may include the following:

Wastewater: DIDP may be contained in wastewater discharged to POTW or other, non-public treatment works for treatment. Industrial wastewater containing DIDP discharged to a POTW may be subject to EPA or authorized NPDES state pretreatment programs. The assessment of wastewater discharges to POTWs and non-public treatment works of DIDP is included in each of the condition of use assessments in Sections 3.1 through 3.16.

Solid Wastes: Solid wastes are defined under RCRA as any material that is discarded by being: abandoned; inherently waste-like; a discarded military munition; or recycled in certain ways (certain instances of the generation and legitimate reclamation of secondary materials are exempted as solid wastes under RCRA). Solid wastes may subsequently meet RCRA’s definition of hazardous waste by either being listed as a waste at 40 CFR §§ 261.30 to 261.35 or by meeting waste-like characteristics as defined at 40 CFR §§ 261.20 to 261.24. Solid wastes that are hazardous wastes are regulated under the more stringent requirements of Subtitle C of RCRA, whereas non-hazardous solid wastes are regulated under the less stringent requirements of Subtitle D of RCRA. DIDP is not listed as a toxic chemical as specified in Subtitle C of RCRA, and not subject to hazardous waste regulation. However, solid wastes containing DIDP may require regulation if the waste leaches constituents, specified in the toxicity characteristic leaching procedure (TLCP), in excess of the regulatory limit. This could include toxins such as lead and cadmium, which are used as stabilizers in PVC. The assessment of solid waste discharges of DIDP is included in each of the condition of use assessments in Sections 3.1 through 3.16.

Off-site transfers of DIDP and DIDP-containing substances 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 3-18.

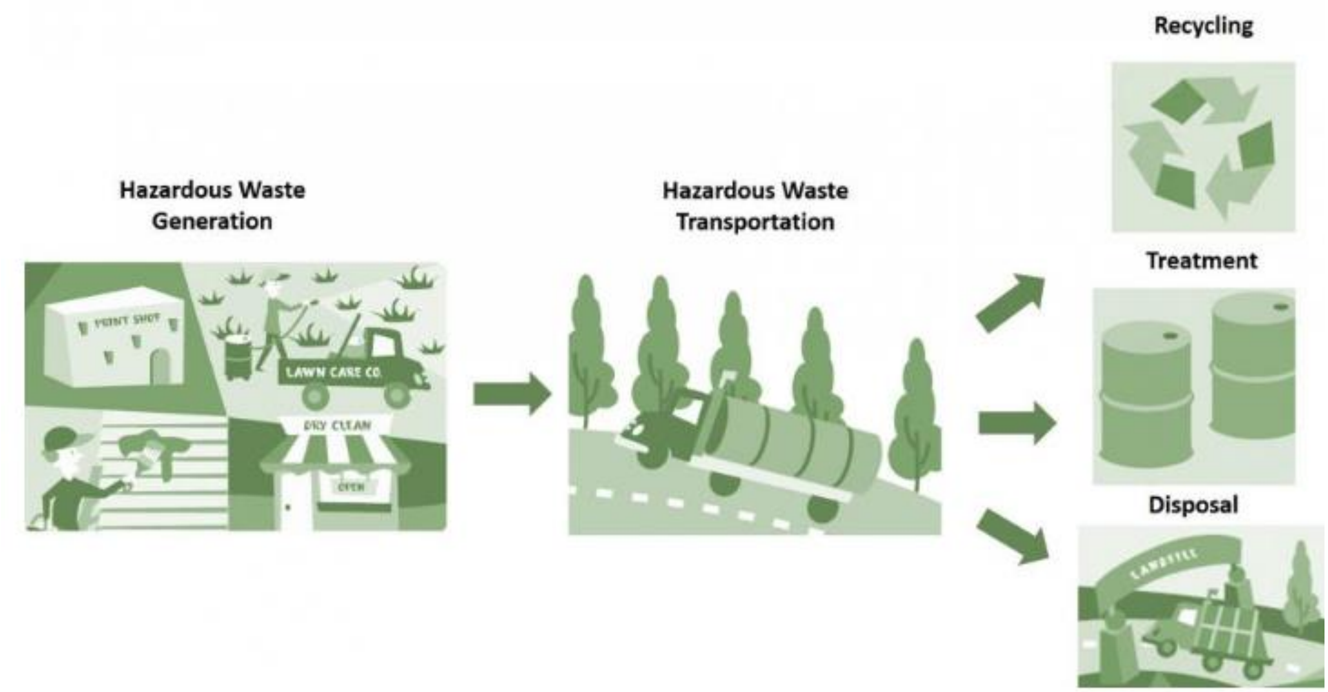

Figure 3-18. Typical Waste Disposal Process

Source: (U.S. EPA, 2017) (https://www.epa.gov/hw/learn-basics-hazardous-waste)

Municipal Waste Incineration

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

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

Tipping floor operations may generate dust. Air from the enclosed tipping floor, however, is continuously drawn into the combustion unit via one or more forced air fans to serve as the primary combustion air and minimize odors. Dust and lint present in the air is typically captured in filters or other cleaning devices to prevent the clogging of steam coils, which are used to heat the combustion air and help dry higher-moisture inputs.[5]

Hazardous Waste Incineration

Commercial scale hazardous waste incinerators are generally two-chamber units, a rotary kiln followed by an afterburner, that accept both solid and liquid waste. Liquid wastes are pumped through pipes and are fed to the unit through nozzles that atomize the liquid for optimal combustion. Solids may be fed to the kiln as loose solids gravity fed to a hopper, or in drums or containers using a conveyor[6,7].

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

Smaller scale units that burn municipal solid waste or hazardous waste (such as infectious and hazardous waste incinerators at hospitals) may require more direct handling of the materials by facility personnel. Units that are batch-loaded require the waste to be placed on the grate prior to operation and may involve manually dumping waste from a container or shoveling waste from a container onto the grate. See Figure 3-19 for a typical incineration process.

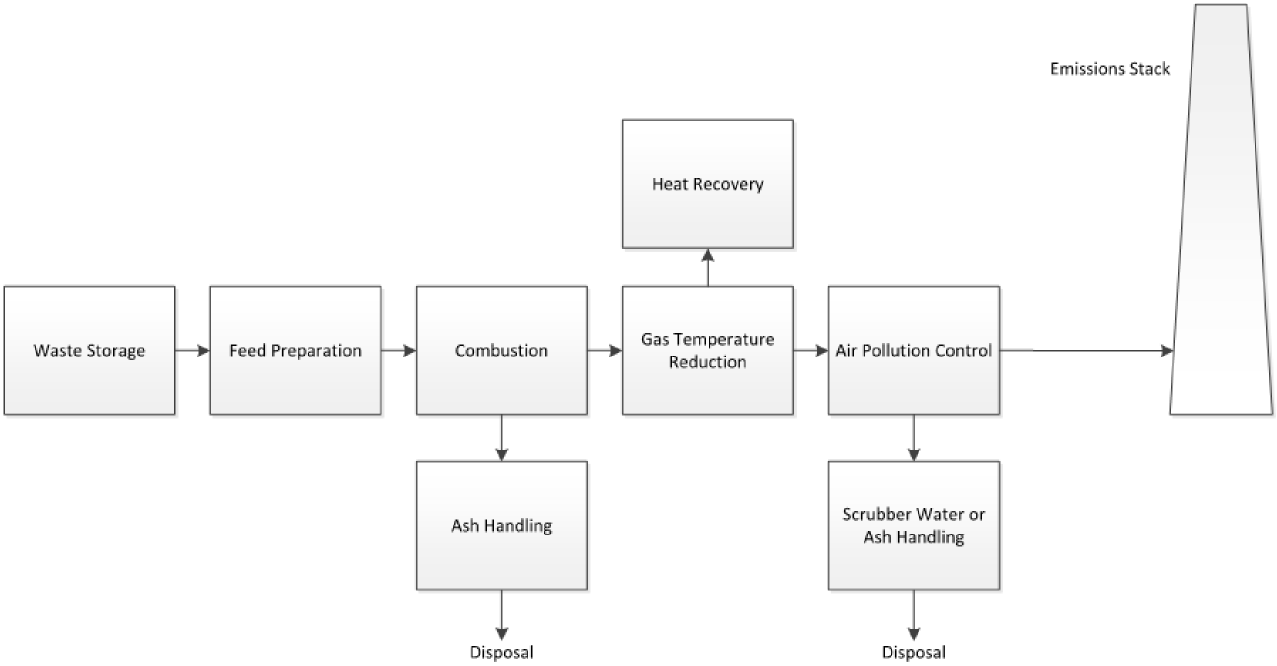

Figure 3-19.Typical Industrial Incineration Process

Municipal Waste Landfill

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[5] J.B. Kitto, Eds., Steam: Its Generation and Use, 40th Edition, Babcock and Wilcox/American Boiler Manufacturers Association, 1992.

[6] Environmental Technology Council’s Hazardous Waste Resource Center; http://www.etc.org/advanced-technologies/high-temperature-incineration.aspx

[7] Incineration Services; Heritage; https://www.heritage-enviro.com/services/incineration/

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

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

Hazardous Waste Landfill

Hazardous waste landfills are excavated or engineered sites specifically designed for the final disposal of non-liquid hazardous wastes. Design standards for these landfills require double liner, double leachate collection and removal systems, leak detection system, run on, runoff and wind dispersal controls, and construction quality assurance program.[8] There are also requirements for closure and post-closure, such as the addition of a final cover over the landfill and continued monitoring and maintenance. These standards and requirements prevent potential contamination of groundwater and nearby surface water resources. Hazardous waste landfills are regulated under Part 264/265, Subpart N.

3.17.2 Facility Estimates

EPA assumes that all DIDP-containing products from all OES will be disposed of in some fashion. The concentration of DIDP 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 this OES (*i.e.*, facility throughput, number of sites, total production volume, operating days, product concentration), as DIDP-containing wastes occur at all levels of the DIDP 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. 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 DIDP. EPA assumed the number of operating days was 250 days/year with 5 day/week operations and two full weeks of downtime each operating year.

3.17.3 Release Assessment

3.17.3.1 Environmental Release Points

EPA did not quantitatively assess environmental releases for this OES due to the lack of readily available process-specific and DIDP-specific data; however, EPA expects releases from this OES to be small and disperse in comparison to other upstream OES, as EPA expects DIDP to be present in smaller amounts and predominantly remain in the disposed article, solution, or material, limiting the potential for release. Releases to all media are possible and all releases are non-quantifiable due to a lack of identified process- and product- specific data.

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

3.17.4 Occupational Exposure Assessment

3.17.4.1 Worker Activities

At waste disposal sites, workers are potentially exposed via dermal contact with waste containing DIDP or via inhalation of DIDP vapor or dust. Depending on the concentration of DIDP in the waste stream, the route and level of exposure may be similar to that associated with container unloading activities. See 3.2.4.1 for the assessment of worker exposure from chemical unloading activities.

Municipal Waste Incineration

At municipal waste incineration facilities, there may be one or more technicians present on the tipping floor to oversee operations, direct trucks, inspect incoming waste, or perform other tasks as warranted by individual facility practices. These workers may wear protective gear such as gloves, safety glasses, or dust masks. Specific worker protocols are largely up to individual companies, although state or local regulations may 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

More information is needed 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.[9]

3.17.4.2 Number of Workers and Occupational Non-users

EPA used data from the BLS and the U.S. Census' SUSB (U.S. BLS, 2016; U.S. Census Bureau, 2015) to estimate the number of workers and ONUs per site that are potentially exposed to DIDP during recycling and disposal. This approach involved the identification of relevant SOC codes within the BLS data for select NAICS codes. Section 2.4.2 provides further details regarding the methodology EPA used to estimate the number of workers and ONUs per site. EPA assigned the NAICS codes 562212, 562213, and 562219 for this OES based on the NAICS codes that related to the process description in Section 3.17.1. Table 3-86 summarizes the per site estimates for this OES. As described in Section 3.17.2, EPA did not identify site-specific data for the number of facilities in the United States that recycle and dispose of DIDP-containing materials.

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

Table 3-86. Estimated Number of Workers Potentially Exposed to DIDP during Recycling and Disposal

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers[a]	Exposed Occupational Non-users per Site[b]	Total Number of Exposed ONUs[a]
562212 – Solid Waste Landfill	N/A	7	N/A	4	N/A
562213 – Solid Waste Combustors and Incinerators		27		15	
562219 – Other Nonhazardous Waste Treatment and Disposal		6		3	
Total/Average	58	13	754	7	432

[a] Results were not assessed by NAICS code for this scenario.

[b] Number of workers and occupational non-users per site are calculated by dividing the total number of exposed workers or occupational non-users by the total number of establishments for a given NAICS code. The number of workers and occupational non-users are rounded to the nearest integer. Values which would otherwise be displayed as "0" are left unrounded.

3.17.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data to assess exposures to DIDP during disposal processes. Based on the presence of DIDP as an additive in plastics (U.S. CPSC, 2015), EPA assessed worker inhalation exposures to DIDP as an exposure to particulates of discarded plastic materials. Therefore, EPA estimated worker inhalation exposures during disposal using the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d). Model approaches and parameters are described in Appendix E.16.

In the model, EPA used a subset of the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d) data that came from facilities with the NAICS code starting with 56 (Administrative and Support and Waste Management and Remediation Services) to estimate plastic particulate concentrations in the air. EPA used the highest expected concentration of DIDP in plastic products to estimate the concentration of DIDP present in particulates. For this OES, EPA selected 45 percent by mass as the highest expected DIDP concentration based on the estimated plasticizer concentrations in flexible PVC given by the *Use of Additives in Plastic Compounding Generic Scenario* (U.S. EPA, 2021e). The estimated exposures assume that DIDP is present in particulates of the plastic at this fixed concentration throughout the working shift.

The *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d) estimates an 8-hour TWA for particulate concentrations by assuming exposures outside the sample duration are zero. The model does not determine exposures during individual worker activities. EPA used the number of operating days estimated in the release assessment for this OES to estimate exposure frequency, with a maximum exposure frequency of 250 working days per year.

Table 3-87 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DIDP during disposal. The high-end exposures use 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum number of working days. The central tendency exposures use 223 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DIDP in the form of plastic particulates and does not account for other potential inhalation exposure routes, such as from the inhalation of vapors.

Table 3-87. Summary of Estimated Worker Inhalation Exposures for Disposal

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	8-hr TWA Exposure Concentration to Dust (mg/m^3)	0.11	1.6
	Acute Dose (AD) (mg/kg/day)	1.4E−02	0.20
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	9.9E−03	0.14
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	8.2E−03	0.13
Female of Reproductive Age	8-hr TWA Exposure Concentration to Dust (mg/m^3)	0.11	1.6
	Acute Dose (AD) (mg/kg/day)	1.5E−02	0.22
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	1.1E−02	0.16
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	9.1E−03	0.15
ONU	8-hr TWA Exposure Concentration to Dust (mg/m^3)	0.11	0.11
	Acute Dose (AD) (mg/kg/day)	1.4E−02	1.4E−02
	Intermediate Non-cancer Exposures (IADD) (mg/kg/day)	9.9E−03	9.9E−03
	Chronic Average Daily Dose, Non-cancer Exposures (ADD) (mg/kg/day)	8.2E−03	9.2E−03

3.17.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix D. The various “Exposure Concentration Types” from .

Table 3-88 are explained in Appendix B. Because dermal exposures of DIDP to workers is expected to occur through contact with solids or articles for this OES, EPA assessed the absorptive flux of DIDP according to dermal absorption modeling approach for solids outlined in Appendix D.2.1.2. Also, since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Dermal exposure to workers is generally expected to be greater than dermal exposure to ONUs. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure. Therefore, worker central tendency exposure values for dermal contact with solids containing DIDP were assumed representative of ONU dermal exposure..

Table 3-88 summarizes the Acute Potential Dose Rate (APDR), the Acute Dose (AD), the Intermediate Average Daily Dose (IADD), and the Average Daily Dose (ADD) for average adult workers, female workers of reproductive age, and ONUs. Dermal exposure parameters are described in Appendix D.

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

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	3.9E−02	7.7E−02
	Acute (AD, mg/kg-day)	4.8E−04	9.6E−04
	Intermediate (IADD, mg/kg-day)	3.5E−04	7.1E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−04	6.6E−04
Female of Reproductive Age	Dose Rate (APDR, mg/day)	3.2E−02	6.4E−02
	Acute (AD, mg/kg-day)	4.4E−04	8.8E−04
	Intermediate (IADD, mg/kg-day)	3.2E−04	6.5E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	2.7E−04	6.1E−04
ONU	Dose Rate (APDR, mg/day)	3.9E−02	3.9E−02
	Acute (AD, mg/kg-day)	4.8E−04	4.8E−04
	Intermediate (IADD, mg/kg-day)	3.5E−04	3.5E−04
	Chronic, Non-cancer (ADD, mg/kg-day)	2.9E−04	3.3E−04

3.17.4.5 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix B.3 to arrive at the aggregate worker and ONU exposure estimates in Table 3-89.

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

Modeled Scenario	Exposure Concentration Type (mg/kg/day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.4E−02	0.20
	Intermediate (IADD, mg/kg-day)	1.0E−02	0.15
	Chronic, Non-cancer (ADD, mg/kg-day)	8.5E−03	0.14
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.5E−02	0.22
	Intermediate (IADD, mg/kg-day)	1.1E−02	0.16
	Chronic, Non-cancer (ADD, mg/kg-day)	9.4E−03	0.15
ONU	Acute (AD, mg/kg-day)	1.4E−02	1.4E−02
	Intermediate (IADD, mg/kg-day)	1.0E−02	1.0E−02
	Chronic, Non-cancer (ADD, mg/kg-day)	8.5E−03	9.6E−03

3.18 Distribution in Commerce

3.18.1 Process Description

Distribution in commerce involves loading and unloading activities (throughout various life cycle stages), transit activities, temporary storage, warehousing, and spill cleanup of DIDP. Loading and unloading activities are generally interpreted as part of distribution in commerce; however, the releases and exposures resulting from these activities are covered within each individual OES where the activity occurs (*i.e.*, unloading of imported DIDP is covered under the import OES). Similarly, tank cleaning activities which occur after unloading of DIDP are also assessed as part of individual OESs where the activity occurs.

Some worker activities associated with distribution in commerce (*e.g.*, loading and unloading) are expected to be similar to other OESs such as manufacturing or import; however, it is also expected that workers involved in distribution in commerce spend less time exposed to DIDP than workers in manufacturing or import facilities since only part of the workday is spent in an area with potential exposure. In conclusion, occupational exposures associated with the distribution in commerce COU are expected to be less than other COUs including manufacturing and import.

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). For example, EPA used moderate to categorize measured release data from a limited number of sources, such that there is a limited number of data points that may not cover most or all the sites within the OES. EPA used slight to describe limited information that does not sufficiently cover all sites within the OES, and for which the assumptions and uncertainties are not fully known or documented. See EPA's *Application of Systematic Review in TSCA Risk Evaluations* (U.S. EPA, 2021a) for additional information on weight of scientific evidence conclusions.

Table 4-1 provides a summary of EPA's overall confidence in its inhalation exposure estimates for each OES.

Table 4-1. Summary of Assumptions, Uncertainty, and Overall Confidence in Release Estimates by OES

OES	Weight of Scientific Evidence Conclusion in Release Estimates
Manufacturing	EPA found limited chemical specific data for the manufacturing OES and assessed environmental releases using models and model parameters derived from CDR, the *2023 Methodology for Estimating Environmental Releases from Sampling Wastes* (U.S. EPA, 2023b), and sources identified through systematic review (including industry supplied data). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, with media of release assessed using assumptions from EPA/OPPT models and industry supplied data. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than a discrete value. Additionally, Monte Carlo modeling uses a large number of data points (simulation runs) and considers the full distributions of input parameters. EPA used facility-specific DIDP manufacturing volumes for all facilities that reported this information to CDR and DIDP-specific operating parameters derived using data with a high data quality ranking from a current U.S. manufacturing site to provide more accurate estimates than the generic values provided by the EPA/OPPT models. The primary limitation of EPA's approach is the uncertainty in the representativeness of release estimates toward the true distribution of potential releases. In addition, EPA lacks DIDP facility production volume data for some DIDP manufacturing sites that claim this information as CBI for the purposes of CDR reporting; therefore, throughput estimates for these sites are based on the CDR reporting threshold of 25,000 lbs (*i.e.*, not all potential sites represented) and an annual DIDP production volume range that spans an order of magnitude. Additional limitations include uncertainties in the representativeness of the industry-provided operating parameters and the generic EPA/OPPT models for all DIDP manufacturing sites. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, and the assessment provides a plausible estimate of releases considering the strengths and limitations of the reasonably available data.
Import and Repackaging	EPA found limited chemical specific data for the import and repackaging OES and assessed releases to the environment using the assumptions and values from the *Chemical Repackaging GS*, which the systematic review process rated high for data quality (U.S. EPA, 2022a). EPA also referenced the *2023 Methodology for Estimating Environmental Releases from Sampling Wastes* (U.S. EPA, 2023b) and used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment. EPA assessed the media of release using assumptions from the ESD and EPA/OPPT models. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases at sites than discrete value. Additionally, Monte Carlo modeling uses a high number of data points (simulation runs) and the full distributions of input parameters. EPA used facility specific DIDP import volumes for all facilities that reported this information to CDR. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, because the default values in the ESD are generic, there is uncertainty in the representativeness of these generic site estimates in characterizing actual releases from real-world sites that import and repackage DIDP. In addition, EPA lacks DIDP facility import volume data for some CDR-reporting import and repackaging sites that claim this information as CBI; therefore, throughput estimates for these sites are based on the CDR reporting threshold of 25,000 lbs (*i.e.*, not all potential sites represented) and an annual DIDP production volume range that spans an order of magnitude. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, and the assessment provides a plausible estimate of releases, considering the strengths and limitations of the reasonably available data.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
Incorporation into Adhesives and Sealants	EPA found limited chemical specific data for the incorporation into adhesives and sealants OES and assessed releases to the environment using the *ESD on the Formulation of Adhesives*, which has a high data quality rating based on the systematic review process (OECD, 2009a). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment and assessed the media of release using assumptions from the ESD and EPA/OPPT models. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases at sites than a discrete value. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DIDP-specific data on concentrations in adhesive and sealant products in the analysis to provide more accurate estimates than the generic values provided by the ESD. EPA based the production volume for the OES on use rates cited by the ACC (2020a) and referenced the *2003 EU Risk Assessment Report* (ECJRC, 2003a) for the expected U.S. DIDP use rates per use scenario. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the default values in the ESD may not be representative of actual releases from real-world sites that incorporate DIDP into adhesives and sealants. In addition, EPA lacks data on DIDP-specific facility production volume and number of formulation sites; therefore, EPA based throughput estimates on CDR which has a reporting threshold of 25,000 lbs (*i.e.*, not all potential sites represented) and an annual DIDP production volume range that spans an order of magnitude. The respective share of DIDP use for each OES (as presented in the *EU Risk Assessment Report*) may differ from actual conditions adding additional uncertainty to estimated releases. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, and the assessment provides a plausible estimate of releases, considering the strengths and limitations of the reasonably available data.
Incorporation into Paints and Coatings	EPA found limited chemical specific data for the incorporation into paints and coatings OES and assessed releases to the environment using the *Draft GS for the Formulation of Waterborne Coatings*, which has a medium data quality rating based on systematic review (U.S. EPA, 2014a). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment and assessed the media of release using assumptions from the GS and EPA/OPPT models. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than a discrete value. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DIDP-specific data on concentrations in paint and coating products to provide more accurate estimates of DIDP concentrations than the generic values provided by the GS. EPA based the production volume for the OES on rates cited by the ACC (2020a) and referenced the *2003 EU Risk Assessment Report* (ECJRC, 2003a) for the expected U.S. DIDP use rates per use scenario. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the GS are specific to waterborne coatings and may not be representative of releases from real-world sites that incorporate DIDP into paints and coatings, particularly for sites formulating other coating types (*e.g.*, solvent-borne coatings). In addition, EPA lacks data on DIDP-specific facility production volume and number of formulation sites; therefore, EPA based throughput estimates on CDR which has a reporting threshold of 25,000 lbs (*i.e.*, not all potential sites represented) and an annual DIDP production volume range that spans an order of

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	magnitude. The share of DIDP use for each OES presented in the *EU Risk Assessment Report* may differ from actual conditions adding some uncertainty to estimated releases. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, and the assessment provides a plausible estimate of releases, considering the strengths and limitations of the reasonably available data.
Incorporation into Other Formulations, Mixtures, and Reaction Products Not Covered Elsewhere	EPA found limited chemical specific data for the incorporation into other formulations, mixtures, and reaction products not covered elsewhere OES and assessed releases to the environment using the *Draft GS for the Formulation of Waterborne Coatings*, which has a medium data quality rating based on systematic review process (U.S. EPA, 2014a). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, and media of release using assumptions from the GS and EPA/OPPT models. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than discrete values. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DIDP-specific data on concentrations in other formulation, mixture, and reaction products in the analysis to provide more accurate estimates than the generic values provided by the GS. The safety and product data sheets that EPA obtained these values from have high data quality ratings based on the systematic review process. EPA based the production volume for the OES on rates cited by the ACC (2020a) and referenced the *2003 EU Risk Assessment Report* (ECJRC, 2003a) for the expected U.S. DIDP use rates per use scenario. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the ESD are based on the formulation of paints and coatings and may not represent releases from real-world sites that incorporate DIDP into other formulations, mixtures, or reaction products. In addition, EPA lacks data on DIDP-specific facility production volume and number of formulation sites; therefore, EPA based the throughput estimates on CDR which has a reporting threshold of 25,000 lbs (*i.e.*, not all potential sites represented) and an annual DIDP production volume range that spans an order of magnitude. Finally, the share of DIDP use for each OES presented in the *EU Risk Assessment Report* may differ from actual conditions adding some uncertainty to estimated releases. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, and the assessment provides a plausible estimate of releases, considering the strengths and limitations of the reasonably available data.
PVC Plastics Compounding	EPA found limited chemical specific data for the PVC plastics compounding OES and assessed releases to the environment using the *Revised Draft GS for the Use of Additives in Plastic Compounding*, which has a medium data quality rating based on systematic review (U.S. EPA, 2021e). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, and media of release using assumptions from the GS and EPA/OPPT models. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than discrete values. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DIDP-specific data on concentrations in different DIDP-containing PVC plastic products and PVC-specific additive throughputs in the analysis. These data provide more accurate estimates than the generic values provided by the GS. The safety and product data sheets that EPA obtained these values from have high data quality ratings based on systematic review. EPA based production volumes for the OES on rates cited by the ACC (2020a) and referenced the *2003 EU Risk Assessment Report* (ECJRC, 2003a) for the expected U.S. DIDP use rates per use scenario.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the ESD consider all types of plastic compounding and may not represent releases from real-world sites that compound DIDP into PVC plastic raw material. In addition, EPA lacks data on DIDP-specific facility production volume and number of compounding sites; therefore, EPA estimated throughput based on CDR which has a reporting threshold of 25,000 lbs (*i.e.*, not all potential sites represented) and an annual DIDP production volume range that spans an order of magnitude. The respective share of DIDP use for each OES presented in the *EU Risk Assessment Report* may differ from actual conditions adding some uncertainty to estimated releases. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, and the assessment provides a plausible estimate of releases, considering the strengths and limitations of the reasonably available data.
PVC Plastics Converting	EPA found limited chemical specific data for the PVC plastics converting OES and assessed releases to the environment using the *Revised Draft GS on the Use of Additives in the Thermoplastics Converting Industry*, which has a medium data quality rating based on systematic review (U.S. EPA, 2021f). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, and media of release using assumptions from the GS and EPA/OPPT models. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values is more likely to capture actual releases than discrete values. Monte Carlo also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DIDP-specific data on concentrations in different DIDP-containing PVC plastic products and PVC-specific additive throughputs in the analysis. These data provide more accurate estimates than the generic values provided by the GS. The safety and product data sheets that EPA used to obtain these values have high data quality ratings based on systematic review. EPA based the production volume for the OES on rates cited by the ACC (2020a) and referenced the *2003 EU Risk Assessment Report* (ECJRC, 2003a) for the expected U.S. DIDP use rates per use scenario. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the ESD are based on all types of thermoplastics converting sites and processes and may not represent actual releases from real-world sites that convert DIDP-containing PVC raw material into PVC articles using a variety of methods, such as extrusion or calendaring. In addition, EPA lacks data on DIDP-specific facility production volume and number of converting sites; therefore, EPA estimated throughput based on CDR which has a reporting threshold of 25,000 lbs (*i.e.*, not all potential sites represented) and an annual DIDP production volume range that spans an order of magnitude. The respective share of DIDP use for each OES presented in the *EU Risk Assessment Report* may differ from actual conditions adding some uncertainty to estimated releases. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, and the assessment provides a plausible estimate of releases, considering the strengths and limitations of the reasonably available data.
Non-PVC Material Compounding	EPA found limited chemical specific data for the non-PVC material compounding OES and assessed releases to the environment using the *Revised Draft GS for the Use of Additives in Plastic Compounding* and the *ESD on Additives in the Rubber Industry*. Both sources have a medium data quality rating based on the systematic review process (U.S. EPA, 2021e; OECD, 2004a). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, and media of release using assumptions from the GS, ESD, and EPA/OPPT models. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than discrete values.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DIDP-specific concentration data for different DIDP-containing rubber products in the analysis. These data provide more accurate estimates than the generic values provided by the GS and ESD. The safety and product data sheets that EPA obtained these values from have high data quality ratings based on systematic review. EPA based the production volume for the OES on rates cited by the ACC (2020a) and referenced the *2003 EU Risk Assessment Report* (ECJRC, 2003a) for the expected U.S. DIDP use rates per use scenario. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the GS and ESD are based on all types of plastic compounding and rubber manufacturing, and the DIDP-specific concentration data only consider rubber products. As a result, these values may not be representative of actual releases from real-world sites that compound DIDP into non-PVC material. In addition, EPA lacks data on DIDP-specific facility production volume and number of compounding sites; therefore, EPA estimated throughput based on CDR which has a reporting threshold of 25,000 lbs (*i.e.*, not all potential sites represented) and an annual DIDP production volume range that spans an order of magnitude. The respective share of DIDP use for each OES presented in the *EU Risk Assessment Report* may differ from actual conditions adding some uncertainty to estimated releases. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, and the assessment provides a plausible estimate of releases, considering the strengths and limitations of the reasonably available data.
Non-PVC Material Converting	EPA found limited chemical specific data for the non-PVC material converting OES and assessed releases to the environment using the *Revised Draft GS on the Use of Additives in the Thermoplastics Converting Industry* and the *ESD on Additives in the Rubber Industry*. Both documents have a medium data quality rating based on systematic review (U.S. EPA, 2021f; OECD, 2004a). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, and media of release using assumptions from the GS, ESD, and EPA/OPPT models. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than discrete values. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DIDP-specific data on concentrations in different DIDP-containing rubber products in the analysis. These data provide more accurate estimates than the generic values provided by the GS and ESD. The safety and product data sheets that EPA obtained these values from have high data quality ratings based on the systematic review process. EPA based the production volume for the OES on rates cited by the ACC (2020a) and referenced the *2003 EU Risk Assessment Report* (ECJRC, 2003a) for the expected U.S. DIDP use rates per use scenario. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the GS and ESD consider all types of plastic converting and rubber manufacturing sites, and the DIDP-specific concentration data only considers rubber products. As a result, these generic site estimates may not represent actual releases from real-world sites that convert DIDP containing non-PVC material into finished articles. In addition, EPA lacks data on DIDP-specific facility production volume and number of converting sites; therefore, EPA based throughput estimates on values from industry SpERC documents, CDR data (which has a reporting threshold of 25,000 lbs (*i.e.*, not all potential sites represented), and an annual DIDP production volume range that spans an order of

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	magnitude. The share of DIDP use for each OES presented in the *EU Risk Assessment Report* may differ from actual conditions adding some uncertainty to estimated releases. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, and the assessment provides a plausible estimate of releases, considering the strengths and limitations of the reasonably available data.
Application of Adhesives and Sealants	EPA found limited chemical specific data for the application of adhesives and sealants OES and assessed releases to the environment using the *ESD on the Use of Adhesives*, which has a medium data quality rating based on systematic review (OECD, 2015a). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, and media of release using assumptions from the ESD and EPA/OPPT models. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than discrete values. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DIDP-specific data on concentration and application methods for different DIDP-containing adhesives and sealant products in the analysis. These data provide more accurate estimates than the generic values provided by the ESD. The safety and product data sheets from which these values were obtained have high data quality ratings from the systematic review process. EPA based OES PV on rates cited by the ACC (2020a), which references the *2003 EU Risk Assessment Report* (ECJRC, 2003a) for the expected U.S. DIDP use rates per use scenario. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the ESD may not represent releases from real-world sites that incorporate DIDP into adhesives and sealants. In addition, EPA lacks data on DIDP-specific facility use volume and number of use sites; therefore, EPA based throughput estimates on values from industry SpERC documents, CDR data (which has a reporting threshold of 25,000 lbs (*i.e.*, not all potential sites represented), and an annual DIDP production volume range that spans an order of magnitude. The respective share of DIDP use for each OES as presented in the *EU Risk Assessment Report* may differ from actual conditions adding some uncertainty to estimated releases. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, and the assessment provides a plausible estimate of releases, considering the strengths and limitations of reasonably available data.
Application of Paints and Coatings	EPA found limited chemical specific data for the application of paints and coatings OES and assessed releases to the environment using the *ESD on the Application of Radiation Curable Coatings, Inks and Adhesives*, the *GS on Coating Application via Spray Painting in the Automotive Refinishing Industry*, the *GS on Spray Coatings in the Furniture Industry*. These documents have a medium data quality rating based on the systematic review process (U.S. EPA, 2014b; OECD, 2011b; U.S. EPA, 2004d). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment. EPA assessed media of release using assumptions from the ESD, GS, and EPA/OPPT models and a default assumption that all paints and coatings are applied via spray application. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than discrete values. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DIDP-specific data on concentration and application methods for different DIDP-containing paints and coatings in the analysis. These data provide more accurate estimates than the generic values provided by the GS and ESDs. The safety and product data sheets that EPA obtained these values from have high data quality ratings based on the systematic review process. EPA based production volumes for these

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	OES on rates cited by the ACC (2020a) and referenced the *2003 EU Risk Assessment Report* (ECJRC, 2003a) for the expected U.S. DIDP use rates per use scenario. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the GS and ESDs may not represent releases from real-world sites that incorporate DIDP into paints and coatings. Additionally, EPA assumes spray applications of the coatings, which may not be representative of other coating application methods. In addition, EPA lacks data on DIDP-specific facility use volume and number of use sites; therefore, EPA based throughput estimates on values from industry SpERC documents, CDR data (which has a reporting threshold of 25,000 lbs (*i.e.*, not all potential sites represented), and an annual DIDP production volume range that spans an order of magnitude. The share of DIDP use for each OES presented in the *EU Risk Assessment Report* may differ from actual conditions adding some uncertainty to estimated releases. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, and the assessment provides a plausible estimate of releases, considering the strengths and limitations of reasonably available data
Use of Laboratory Chemicals	EPA found limited chemical specific data for the use of laboratory chemicals OES and assessed releases to the environment using the *Draft GS on the Use of Laboratory Chemicals*, which has a high data quality rating based on systematic review (U.S. EPA, 2023c). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, and media of release using assumptions from the GS and EPA/OPPT models for solid and liquid DIDP materials. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than discrete values. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. EPA used SDSs from identified laboratory DIDP products to inform product concentration and material states. EPA believes the primary limitation to be the uncertainty in the representativeness of values toward the true distribution of potential releases. In addition, EPA lacks data on DIDP laboratory chemical throughput and number of laboratories; therefore, EPA based the number of laboratories and throughput estimates on stock solution throughputs from the *Draft GS on the Use of Laboratory Chemicals* and on CDR reporting thresholds. Additionally, because no entries in CDR indicate a laboratory use case and there were no other sources to estimate the volume of DIDP used in this OES, EPA developed a high-end bounding estimate based on the CDR reporting threshold, which by definition is expected to over-estimate the average release case. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, and the assessment provides a plausible estimate of releases, considering the strengths and limitations of reasonably available data.
Use of Lubricants and Functional Fluids	EPA found limited chemical specific data for the use of lubricants and functional fluids OES and assessed releases to the environment using the *ESD on the Lubricant and Lubricant Additives*, which has a medium data quality rating based on systematic review (OECD, 2004b). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, and media of release using assumptions from the ESD and EPA/OPPT models. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than discrete values. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DIDP-specific data on concentration and uses of different DIDP-containing lubricants and functional fluid products in the analysis. These data provide more accurate estimates than the generic

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	values provided by the ESD. The safety and product data sheets that EPA used to obtain these values have high data quality ratings based on systematic review. EPA based production volumes for the OES on rates cited by the ACC (2020a) and referenced the *2003 EU Risk Assessment Report* (ECJRC, 2003a) for the expected U.S. DIDP use rates per use scenario. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the ESD may not represent releases from real-world sites using DIDP-containing lubricants and functional fluids. In addition, EPA lacks information on the specific facility use rate of DIDP-containing products and number of use sites; therefore, EPA estimated the number of sites and throughputs based on CDR, which has a reporting threshold of 25,000 lbs (*i.e.*, not all potential sites represented), and an annual DIDP production volume range that spans an order of magnitude. The respective share of DIDP use for each OES presented in the *EU Risk Assessment Report* may differ from actual conditions adding some uncertainty to estimated releases. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, and the assessment provides a plausible estimate of releases in consideration of the strengths and limitations of reasonably available data.
Use of Penetrants and Inspection Fluids	EPA found limited chemical specific data for the use of penetrants and inspection fluids OES and assessed releases to the environment using the *ESD on the Use of Metalworking Fluids*, which has a medium data quality rating based on systematic review (OECD, 2011d). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, and media of release using assumptions from the ESD, and EPA/OPPT models. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than discrete values. Monte Carlo modeling also consider a large number of data points (simulation runs) and the full distributions of input parameters. Because there were no DIDP-containing penetrant products identified, EPA assessed an aerosol and non-aerosol application method based on surrogate DINP-specific penetrant data which also provided DINP concentration. The safety and product data sheets that EPA used to obtain these values have high data quality ratings based on systematic review and provide more accurate estimates than the generic values provided by the ESD. EPA based production volumes for the OES on rates cited by the ACC (2020a) and referenced the *2003 EU Risk Assessment Report* (ECJRC, 2003a) for the expected U.S. DIDP use rates per use scenario. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the ESD and the surrogate material parameters may not be representative of releases from real-world sites that use DIDP-containing inspection fluids and penetrants. Additionally, because no entries in CDR indicate this OES use case and there were no other sources to estimate the volume of DIDP used in this OES, EPA developed a high-end bounding estimate based on CDR reporting threshold, which by definition is expected to over-estimate the average release case. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, and the assessment provides a plausible estimate of releases, considering the strengths and limitations of reasonably available data.
Fabrication and Final Use of Products or Articles	No data were available to estimate releases for this OES and there were no suitable surrogate release data or models. This release is described qualitatively.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
Recycling and Disposal	EPA found limited chemical specific data for the recycling and disposal OES. EPA assessed releases to the environment from recycling activities using the *Revised Draft GS for the Use of Additives in Plastic Compounding* as surrogate for the recycling process. The GS has a medium data quality rating based on systematic review (U.S. EPA, 2021e). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, and media of release using assumptions from the GS and EPA/OPPT models. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than discrete values. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DIDP-specific data on concentrations in different DIDP-containing PVC plastic products in the analysis to provide more accurate estimates than the generic values provided by the GS. The safety and product data sheets that EPA used to obtain these values have high data quality ratings based on systematic review. EPA referenced the *Quantification and evaluation of plastic waste in the United States*, which has a medium quality rating based on systematic review (Milbrandt et al., 2022), to estimate the rate of PVC recycling in the U.S. and applied it to DIDP PVC market share to define an approximate recycling volume of PVC containing DIDP. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the GS represent all types of plastic compounding sites and may not represent sites that recycle PVC products containing DIDP. In addition, EPA lacks DIDP-specific PVC recycling rates and facility production volume data; therefore, EPA based throughput estimates on PVC plastics compounding data and U.S. PVC recycling rates, which are not specific to DIDP, and may not accurately reflect current U.S. recycling volume. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, yet the assessment still provides a plausible estimate of releases, considering the strengths and limitations of the reasonably available data.

4.2 Occupational Exposures

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

Table 4-2 provides a summary of EPA's overall confidence in its inhalation and dermal exposure estimates for each of the Occupational Exposure Scenarios assessed.

4276 **Table 4-2. Summary of Assumptions, Uncertainty, and Overall Confidence in Inhalation Exposure Estimates by OES**

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
Manufacturing	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the full-shift TWA inhalation exposure estimates for the Manufacturing OES. The primary strength is the use of directly applicable monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used PBZ air concentration data to assess inhalation exposures, with the data source having a high data quality rating from the systematic review process (ExxonMobil, 2022a). Data from these sources were DIDP-specific from a DIDP manufacturing facility, though it is uncertain whether the measured concentrations accurately represent the entire industry. A further strength of the data is that it was compared against an EPA developed Monte Carlo model and the data points from ExxonMobil were found to be more protective. The primary limitations of these data include the uncertainty of the representativeness of these data toward the true distribution of inhalation concentrations in this scenario, that the data come from one industry-source, and that 100% of the data for both workers and ONUs from the source were reported as below the LOD. EPA also assumed 8 exposure hours per day and 180 exposure days per year based on a manufacturing site reporting half-year DIDP campaign runs (ExxonMobil, 2022a); it is uncertain whether this captures actual worker schedules and exposures at that and other manufacturing sites. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate to robust and provides a plausible estimate of exposures.
Import and Repackaging	EPA used surrogate manufacturing data to estimate worker inhalation exposures due to limited data. Import and repackaging inhalation exposures were estimated using the manufacturing inhalation exposure as a surrogate. The primary strength is the use of monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used PBZ air concentration data to assess inhalation exposures, with the data source having a high data quality rating from the systematic review process (ExxonMobil, 2022a). Data from these sources were DIDP-specific from a DIDP manufacturing facility, though it is uncertain whether the measured concentrations accurately represent the entire industry. The primary limitations of these data include the uncertainty of the representativeness of these data toward this OES and the true distribution of inhalation concentrations in this scenario; that the data come from one industry-source; and that 100% of the data for both workers and ONUs from the source were reported as below the LOD. The high-end exposures are based on 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days. The central tendency exposures use 208 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Also, it was assumed that each worker is potentially exposed for 8 hours per workday; however, it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
Incorporation into Adhesives and Sealants	EPA used surrogate data to estimate worker inhalation exposures due to limited data. Incorporation into adhesives and sealants exposures were estimated using the PVC plastics converting OES inhalation exposure as a surrogate estimate. The primary strength is the use of monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	both PBZ and stationary air concentration data to assess inhalation exposures. The PBZ data are surrogate for an ONU exposed to DINP and the area sample is a DPHP sample taken adjacent to two extruders in plastic cable manufacturing. Both data sources have a high data quality rating from the systematic review process (Irwin, 2022; Porras et al., 2020). Data from these sources are specific to a PVC plastic converting facility, though it is uncertain whether the measured concentrations accurately represent the entire industry. The primary limitations of these data include the uncertainty of the representativeness of these data toward the true distribution of inhalation concentrations in this scenario, that the data come from one datapoint from each source, and that 100% of the data for both workers and ONUs from the source were reported as below the LOD. EPA also assumed 8 exposure hours per day and 250 exposure days per year based on continuous DIDP exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
Incorporation into Paints and Coatings	EPA used surrogate data to estimate worker inhalation exposures due to limited data. Incorporation into paints and coatings exposures were estimated using the PVC plastics converting OES inhalation exposure as a surrogate estimate. The primary strength is the use of monitoring data, which is preferrable to other assessment approaches such as modeling or the use of OELs. EPA used both PBZ and stationary air concentration data to assess inhalation exposures. The PBZ data are surrogate for an ONU exposed to DINP and the area sample is a DPHP sample taken adjacent to two extruders in plastic cable manufacturing. Both data sources have a high data quality rating from the systematic review process (Irwin, 2022; Porras et al., 2020). Data from these sources are specific to a PVC plastic converting facility, though it is uncertain whether the measured concentrations accurately represent the entire industry. The primary limitations of these data include the uncertainty of the representativeness of these data toward the true distribution of inhalation concentrations in this scenario, that the data come from one datapoint from each source, and that 100% of the data for both workers and ONUs from the source were reported as below the LOD. EPA also assumed 8 exposure hours per day and 250 exposure days per year based on continuous DIDP exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
Incorporation into Other Formulations, Mixtures, and Reaction Products Not	EPA used surrogate data to estimate worker inhalation exposures due to limited data. Incorporation into other formulations, mixtures, and reaction products not covered elsewhere exposures were estimated using the PVC plastics converting OES inhalation exposure as a surrogate estimate. The primary strength is the use of monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used both PBZ and stationary air concentration data to assess inhalation exposures. The PBZ data are surrogate for an ONU exposed to DINP and the area sample is a DPHP sample taken adjacent to two extruders in plastic cable manufacturing. Both data sources have a high data quality rating from the systematic review process (Irwin,

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
Covered Elsewhere	2022; Porras et al., 2020). Data from these sources are specific to a PVC plastic converting facility, though it is uncertain whether the measured concentrations accurately represent the entire industry. The primary limitations of these data include the uncertainty of the representativeness of these data toward the true distribution of inhalation concentrations in this scenario, that the data come from one datapoint from each source, and that 100% of the data for both workers and ONUs from the source were reported as below the LOD. EPA also assumed 8 exposure hours per day and 250 exposure days per year based on continuous DIDP exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
PVC Plastics Compounding	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hr TWA inhalation exposure estimates. EPA used surrogate data to estimate worker inhalation exposures due to limited data. PVC plastics compounding exposures were estimated using the PVC plastics converting OES inhalation exposure as a surrogate bounding estimate. The primary strength is the use of monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used both PBZ and stationary air concentration data to assess inhalation exposures. The PBZ data are surrogate from for an ONU exposed to DINP and the area sample is a DPHP sample taken adjacent to two extruders in plastic cable manufacturing. Both data sources have a high data quality rating from the systematic review process (Irwin, 2022; Porras et al., 2020). Data from these sources are specific to a PVC plastic converting facility, though it is uncertain whether the measured concentrations accurately represent the entire industry. Compounding activities are also expected to generate dust from the solid product; therefore, EPA incorporated the Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR) into the assessment to estimate worker inhalation exposure to solid particulate. The respirable PNOR range was refined using OSHA CEHD data sets, which the systematic review process rated high for data quality (OSHA, 2020). EPA estimated the highest expected concentration of DIDP in plastic using industry provided data on DIDP concentration in PVC, which were also rated high for data quality in the systematic review process. The primary limitations of these data include the uncertainty of the representativeness of the monitoring data and PNOR model toward the true distribution of inhalation concentrations in this scenario, that the monitoring data come from one datapoint from each source, that 100% of the data for both workers and ONUs from the source were reported as below the LOD, and that the OSHA CEHD data are not specific to DIDP. The high-end exposures are based on 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days. The central tendency exposures use 223 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Also, it was assumed that each worker is potentially exposed for 8 hours per workday; however, it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
PVC Plastics Converting	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the full-shift TWA inhalation exposure estimates for the PVC Plastics Converting OES. The primary strength is the use of directly applicable monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used both PBZ and stationary air concentration data to assess inhalation exposures. The PBZ data are surrogate from for an ONU exposed to DINP and the area sample is a DPHP sample taken adjacent to two extruders in plastic cable manufacturing. Both data sources have a high data quality rating from the systematic review process (Irwin, 2022; Porras et al., 2020). Data from these sources are specific to a PVC plastic converting facility, though it is uncertain whether the measured concentrations accurately represent the entire industry. Converting activities are also expected to generate dust from the solid product; therefore, EPA incorporated the Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR) into the assessment to estimate worker inhalation exposure to solid particulate. The respirable PNOR range was refined using OSHA CEHD data sets, which the systematic review process rated high for data quality (OSHA, 2020). EPA estimated the highest expected concentration of DIDP in plastic using industry provided data on DIDP concentration in PVC, which were also rated high for data quality in the systematic review process. The primary limitations of these data include the uncertainty of the representativeness of the monitoring data and PNOR model toward the true distribution of inhalation concentrations in this scenario, that the monitoring data come from one datapoint from each source, that 100% of the data for both workers and ONUs from the source were reported as below the LOD, and that the OSHA CEHD data are not specific to DIDP. The high-end exposures are based on 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days. The central tendency exposures use 219 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Also, it was assumed that each worker is potentially exposed for 8 hours per workday; however, it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
Non-PVC Material Compounding	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hr TWA inhalation exposure estimates. EPA used surrogate data to estimate worker inhalation exposures due to limited data. Non-PVC material compounding exposures were estimated using the PVC plastics converting OES inhalation exposure as a surrogate bounding estimate. The primary strength is the use of monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used both PBZ and stationary air concentration data to assess inhalation exposures. The PBZ data are surrogate from for an ONU exposed to DINP and the area sample is a DPHP sample taken adjacent to two extruders in plastic cable manufacturing. Both data sources have a high data quality rating from the systematic review process (Irwin, 2022; Porras et al., 2020). Data from these sources are specific to a PVC plastic converting facility, though it is uncertain whether the measured concentrations accurately represent the entire industry. Compounding activities are also expected to generate dust from the solid product; therefore, EPA incorporated the Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR) into the assessment to estimate worker inhalation exposure to solid particulate. The respirable PNOR range was refined using OSHA

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	CEHD data sets, which the systematic review process rated high for data quality (OSHA, 2020). EPA estimated the highest expected concentration of DIDP in plastic using industry provided data on DIDP concentration in PVC, which were also rated high for data quality in the systematic review process. The primary limitations of these data include the uncertainty of the representativeness of the monitoring data and PNOR model toward the true distribution of inhalation concentrations in this scenario, that the monitoring data come from one datapoint from each source, that 100% of the data for both workers and ONUs from the source were reported as below the LOD, and that the OSHA CEHD data are not specific to DIDP. The high-end exposures are based on 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days. The central tendency exposures use 234 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Also, it was assumed that each worker is potentially exposed for 8 hours per workday; however, it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
Non-PVC Material Converting	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hr TWA inhalation exposure estimates. EPA used surrogate data to estimate worker inhalation exposures due to limited data. Non-PVC material converting exposures were estimated using the PVC plastics converting OES inhalation exposure as a surrogate bounding estimate. The primary strength is the use of monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used both PBZ and stationary air concentration data to assess inhalation exposures. The PBZ data are surrogate from for an ONU exposed to DINP and the area sample is a DPHP sample taken adjacent to two extruders in plastic cable manufacturing. Both data sources have a high data quality rating from the systematic review process (Irwin, 2022; Porras et al., 2020). Data from these sources are specific to a PVC plastic converting facility, though it is uncertain whether the measured concentrations accurately represent the entire industry. Converting activities are also expected to generate dust from the solid product; therefore, EPA incorporated the Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR) into the assessment to estimate worker inhalation exposure to solid particulate. The respirable PNOR range was refined using OSHA CEHD data sets, which the systematic review process rated high for data quality (OSHA, 2020). EPA estimated the highest expected concentration of DIDP in plastic using industry provided data on DIDP concentration in PVC, which were also rated high for data quality in the systematic review process. The primary limitations of these data include the uncertainty of the representativeness of the monitoring data and PNOR model toward the true distribution of inhalation concentrations in this scenario, that the monitoring data come from one datapoint from each source, that 100% of the data for both workers and ONUs from the source were reported as below the LOD, and that the OSHA CEHD data are not specific to DIDP. The high-end exposures are based on 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days. The central tendency exposures use 219 days per year as the exposure frequency based on the 50th percentile of operating days

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	from the release assessment. Also, it was assumed that each worker is potentially exposed for 8 hours per workday; however, it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
Application of Adhesives and Sealants	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hr TWA inhalation exposure estimates. EPA used surrogate monitoring data from the *ESD on Coating Application via Spray-Painting in the Automotive Refinishing Industry*, which the systematic review process rated high for data quality, to estimate inhalation exposures (OECD, 2011a). EPA used SDSs and product data sheets from identified DIDP-containing adhesives and sealant products to identify product concentrations. The primary limitation is the lack of DIDP-specific monitoring data, with the ESD serving as a surrogate source of monitoring data representing the level of exposure that could be expected at a typical work site for the given spray application method. EPA assumes spray applications of the adhesives and sealants, so the estimates may not be representative of exposure during other application methods. Additionally, it is uncertain whether the substrates bonded, and products used to generate the surrogate data are representative of those associated with DIDP-containing adhesives and sealants. EPA only assessed mist exposures to DIDP over a full 8-hour work shift to estimate the level of exposure, though other activities may result in vapor exposures other than mist and application duration may be variable depending on the job site. The high-end exposures are based on 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days. The central tendency exposures use 232 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Also, it was assumed that each worker is potentially exposed for 8 hours per workday; however, it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
Application of Paints and Coatings	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hr TWA inhalation exposure estimates. EPA used surrogate monitoring data from the *ESD on Coating Application via Spray-Painting in the Automotive Refinishing Industry*, which the systematic review process rated high for data quality, to estimate inhalation exposures (OECD, 2011a). EPA used SDSs and product data sheets from identified DIDP-containing products to identify product concentrations. The primary limitation is the lack of DIDP-specific monitoring data, with the ESD serving as a surrogate source of monitoring data representing the level of exposure that could be expected at a typical work site for the given spray application method. EPA assumes spray applications of the coatings, so the estimates may not be representative of exposure during other coating application methods. Additionally, it is uncertain whether the substrates coated, and products used to generate the surrogate data are representative of those associated with DIDP-containing coatings. EPA only assessed mist exposures to DIDP over a full 8-hour work shift to estimate the level of exposure, though other activities may result in vapor exposures other than mist and application duration may be variable

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	depending on the job site. EPA assessed 250 days of exposure per year based on workers applying coatings on every working day, however, application sites may use DIDP-containing coatings at much lower or variable frequencies. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
Use of Laboratory Chemicals	EPA used surrogate data to estimate worker vapor inhalation exposures due to limited data. Use of laboratory chemicals inhalation exposures were estimated using the manufacturing inhalation exposure as a surrogate bounding estimate. The primary strength is the use of monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used PBZ air concentration data to assess inhalation exposures, with the data source having a high data quality rating from the systematic review process (ExxonMobil, 2022a). Data from these sources were DIDP-specific from a DIDP manufacturing facility, though it is uncertain whether the measured concentrations accurately represent the entire industry. The primary limitations of these data include the uncertainty of the representativeness of these data toward this OES and the true distribution of inhalation concentrations in this scenario; that the data come from one industry-source; and that 100% of the data for both workers and ONUs from the source were reported as below the LOD. The high-end and central tendency exposures to solid laboratory chemicals use 250 days per year as the exposure frequency since the 95th and 50th percentiles of operating days in the release assessment exceeded 250 days per year, which is the expected maximum number of working days. The high-end and central tendency exposures to liquid laboratory chemicals use 235 days per year and 250 days per year, respectively, as the exposure frequencies. Also, it was assumed that each worker is potentially exposed for 8 hours per workday; however, it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
Use of Lubricants and Functional Fluids	EPA used surrogate data to estimate worker inhalation exposures due to limited data. Use of lubricants and functional fluids inhalation exposures were estimated using the manufacturing inhalation exposure as a surrogate bounding estimate. The primary strength is the use of monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used PBZ air concentration data to assess inhalation exposures, with the data source having a high data quality rating from the systematic review process (ExxonMobil, 2022a). Data from these sources were DIDP-specific from a DIDP manufacturing facility, though it is uncertain whether the measured concentrations accurately represent the entire industry. The primary limitations of these data include the uncertainty of the representativeness of these data toward this OES and the true distribution of inhalation concentrations in this scenario; that the data come from one industry-source; and that 100% of the data for both workers and ONUs from the source were reported as below the LOD. The high-end exposures use 4 days per year as the exposure frequency based on the 95th percentile of operating days from the release assessment. The central tendency exposures use 2 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Also, it was assumed that each worker is potentially exposed for 8 hours per workday; however, it is uncertain whether this captures actual worker schedules and exposures.

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
Use of Penetrants and Inspection Fluids	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hr TWA inhalation exposure estimates. EPA utilized a near-field/far-field approach (AIHA, 2009), and the inputs to the model were derived from references that received ratings of medium-to-high for data quality in the systematic review process. EPA combined this model with Monte Carlo modeling to estimate occupational exposures in the near-field (worker) and far-field (ONU) inhalation exposures. A strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential exposure values is more likely than a discrete value to capture actual exposure at sites, the high number of data points (simulation runs), and the full distributions of input parameters. EPA identified and used a DINP-containing penetrant/inspection fluid product as surrogate to estimate concentrations, application methods, and use rate. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. EPA lacks facility and DIDP-specific product use rates, concentrations, and application methods, therefore, estimates are made based on surrogate DINP-containing product. EPA only found one product to represent this use scenario, however, and its representativeness of all DIDP-containing penetrants and inspection fluids is not known. The high-end exposures use 249 days per year as the exposure frequency based on the 95th percentile of operating days from the release assessment. The central tendency exposures use 247 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Also, it was assumed that each worker is potentially exposed for 8 hours per workday; however, it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
Fabrication and Final Use of Products or Articles	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hr TWA inhalation exposure estimates. EPA utilized the Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR) to estimate worker inhalation exposure to solid particulate. The respirable PNOR range was refined using OSHA CEHD data sets, which the systematic review process rated high for data quality (OSHA, 2020). EPA estimated the highest expected concentration of DIDP in plastic using industry provided data on DIDP concentration in PVC, which were also rated high for data quality in the systematic review process. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Additionally, the representativeness of the CEHD data set and the identified DIDP concentrations in plastics for this specific fabrication and final use of products or articles is uncertain. EPA lacks facility and DIDP-containing product fabrication and use rates, methods, and operating times and EPA assumed eight exposure hours per day and 250 exposure days per year based on continuous DIDP exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures.

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
Recycling and Disposal	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hr TWA inhalation exposure estimates. EPA utilized the Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR) to estimate worker inhalation exposure to solid particulate. The respirable PNOR range was refined using OSHA CEHD data sets, which the systematic review process rated high for data quality (OSHA, 2020). EPA estimated the highest expected concentration of DIDP in plastic using industry provided data on DIDP concentration in PVC, which were also rated high for data quality in the systematic review process. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Additionally, the representativeness of the CEHD data set and the identified DIDP concentrations in plastics for this specific recycling end-use is uncertain. The high-end exposures use 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum number of working days. The central tendency exposures use 223 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Also, it was assumed that each worker is potentially exposed for 8 hours per workday; however, it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
Dermal – Liquids	EPA used *in vivo* rat absorption data for neat DIDP (Elsisi et al., 1989) to estimate occupational dermal exposures to workers since exposures to the neat material or concentrated formulations are possible for occupational scenarios. Because rat skin generally has greater permeability than human skin (Scott et al., 1987), the use of *in vivo* rat absorption data is assumed to be a conservative assumption. Also, it is acknowledged that variations in chemical concentration and co-formulant components affect the rate of dermal absorption. However, it is assumed that absorption of the neat chemical serves as a reasonable upper bound across chemical compositions and the data received a medium rating through EPA's systematic review process. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and that the chemical is contacted at least once per day. Because DIDP has low volatility and low absorption, it is possible that the chemical remains on the surface of the skin after a dermal contact until the skin is washed. Therefore, absorption of DIDP from occupational dermal contact with materials containing DIDP may extend up to 8 hours per day (U.S. EPA, 1991a). For average adult workers, the surface area of contact was assumed equal to the area of one hand (*i.e.*, 535 cm^2), or two hands (*i.e.*, 1,070cm^2), for central tendency exposures, or high-end exposures, respectively (U.S. EPA, 2011). The standard sources for exposure duration and area of contact received high ratings through EPA's systematic review process. The occupational dermal exposure assessment for contact with liquid materials containing DIDP was based on dermal absorption data for the neat material, as well as standard occupational inputs for exposure duration and area of contact, as described above.

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	Based on the strengths and limitations of these inputs, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of occupational dermal exposures.
Dermal – Solids	EPA used dermal modeling of aqueous materials (U.S. EPA, 2023a, 2004b) to estimate occupational dermal exposures of workers and ONUs to solid materials as described in Appendix D.2.1.2. However, the modeling approach for determining the aqueous permeability coefficient was used outside the range of applicability given the p-chem parameters of DIDP. Also, it is acknowledged that variations in chemical concentration and co-formulant components affect the rate of dermal absorption. However, it is assumed that absorption of aqueous DIDP serves as a reasonable upper bound for the dermal absorption of DIDP from solid matrices, and the modeling approach received a medium rating through EPA's systematic review process. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and that the chemical is contacted at least once per day. Because DIDP has low volatility and low absorption, it is possible that the chemical remains on the surface of the skin after a dermal contact until the skin is washed. Therefore, absorption of DIDP from occupational dermal contact with materials containing DIDP may extend up to 8 hours per day (U.S. EPA, 1991a). For average adult workers, the surface area of contact was assumed equal to the area of one hand (*i.e.*, 535 cm^2), or two hands (*i.e.*, 1,070cm^2), for central tendency exposures, or high-end exposures, respectively (U.S. EPA, 2011). The standard sources for exposure duration and area of contact received high ratings through EPA's systematic review process. The occupational dermal exposure assessment for contact with solid materials containing DIDP was based on dermal absorption modeling of aqueous DIDP, as well as standard occupational inputs for exposure duration and area of contact, as described above. Based on the strengths and limitations of these inputs, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of occupational dermal exposures.

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APPENDICES

Appendix A EXAMPLE OF ESTIMATING NUMBER OF WORKERS AND OCCUPATIONAL NON-USERS

This appendix summarizes the methods that EPA used to estimate the number of workers who are potentially exposed to DIDP in each of its conditions of use. The method consists of the following steps:

1. Check relevant emission scenario documents (ESDs) and Generic Scenarios (GSs) for estimates on the number of workers potentially exposed.
2. Identify the NAICS codes for the industry sectors associated with each condition of use.
3. Estimate total employment by industry/occupation combination using the Bureau of Labor Statistics' Occupational Employment Statistics (OES) data (U.S. BLS, 2016).
4. Refine the OES estimates where they are not sufficiently granular by using the U.S. BLS (2016) Statistics of U.S. Businesses (SUSB) data on total employment by 6-digit NAICS.
5. Estimate the percentage of employees likely to be using DIDP instead of other chemicals (*i.e.*, the market penetration of DIDP in the condition of use).
6. Estimate the number of sites and number of potentially exposed employees per site.
7. Estimate the number of potentially exposed employees within the condition of use.

Step 1: Identifying Affected NAICS Codes

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

- Querying the U.S. Census Bureau's *NAICS Search* tool using keywords associated with each condition of use to identify NAICS codes with descriptions that match the condition of use.
- Referencing EPA Generic Scenarios (GS's) and Organisation for Economic Co-operation and Development (OECD) Emission Scenario Documents (ESDs) for a condition of use to identify NAICS codes cited by the GS or ESD.
- Reviewing CDR data for the chemical, identifying the industrial sector codes reported for downstream industrial uses, and matching those industrial sector codes to NAICS codes using Table D-2 provided in the CDR reporting instructions (U.S. EPA, 2019a).

Each condition of use section in the main body of this report identifies the NAICS codes EPA identified for the respective condition of use.

Step 2: Estimating Total Employment by Industry and Occupation

U.S. BLS (2016) OES data provide employment data for workers in specific industries and occupations. The industries are classified by NAICS codes (identified previously), and occupations are classified by Standard Occupational Classification (SOC) codes.

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

Table_Apx A-1. SOCs With Worker and ONU Designation for All COUs Except Dry Cleaning

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

W = worker designation; O = ONU designation

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

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

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

After identifying relevant NAICS and SOC codes, EPA used BLS data to determine total employment by industry and by occupation based on the NAICS and SOC combinations. For example, there are 110,640 employees associated with 4-digit NAICS 8123 (*Drycleaning and Laundry Services*) and SOC 51-6010 (*Laundry and Dry-Cleaning Workers*).

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

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

The third step in EPA's methodology was to further refine the employment estimates by using total employment data in the (U.S. Census Bureau, 2015) SUSB. In some cases, BLS OES's occupation-specific data are only available at the 4-digit or 5-digit NAICS level, whereas the SUSB data are available at the 6-digit level (but are not occupation-specific). Identifying specific 6-digit NAICS will ensure that only industries with potential DIDP exposure are included. As an example, OES data are available for the 4-digit NAICS 8123 *Drycleaning and Laundry Services*, which includes the following 6-digit NAICS:

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

In this example, only NAICS 812320 may be of interest. The Census data allow EPA to calculate employment in the specific 6-digit NAICS of interest as a percentage of employment in the BLS 4-digit NAICS.

The 6-digit NAICS 812320 comprises 46 percent of total employment under the 4-digit NAICS 8123. This percentage can be multiplied by the occupation-specific employment estimates given in the BLS OES data to further refine our estimates of the number of employees with potential exposure. Table_Apx A-3. illustrates this granularity adjustment for NAICS 812320.

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

NAICS	SOC CODE	SOC Description	Occupation Designation	Employment by SOC at 4-digit NAICS level	% of Total Employment	Estimated Employment by SOC at 6-digit NAICS level
8123	41-2000	Retail Sales Workers	O	44,500	46.0%	20,459
8123	49-9040	Industrial Machinery Installation, Repair, and Maintenance Workers	W	1,790	46.0%	823
8123	49-9070	Maintenance and Repair Workers, General	W	3,260	46.0%	1,499
8123	49-9090	Miscellaneous Installation, Maintenance, and Repair Workers	W	1,080	46.0%	497
8123	51-6010	Laundry and Dry-Cleaning Workers	W	110,640	46.0%	50,867
8123	51-6020	Pressers, Textile, Garment, and Related Materials	W	40,250	46.0%	18,505
8123	51-6030	Sewing Machine Operators	O	1,660	46.0%	763
8123	51-6040	Shoe and Leather Workers	O	Not Reported for this NAICS Code		
8123	51-6050	Tailors, Dressmakers, and Sewers	O	2,890	46.0%	1,329
8123	51-6090	Miscellaneous Textile, Apparel, and Furnishings Workers	O	0	46.0%	0
Total Potentially Exposed Employees				**206,070**		**94,740**
Total Workers						**72,190**
Total Occupational Non-users						**22,551**

W = worker; O = occupational non-user

Note: numbers may not sum exactly due to rounding

Source: U.S. BLS (2016), U.S. Census Bureau (2015)

Step 4: Estimating the Percentage of Workers Using DIDP Instead of Other Chemicals

In the final step, EPA accounted for the market share by applying a factor to the number of workers determined in Step 3. This accounts for the fact that DIDP may be only one of multiple chemicals used for the applications of interest. EPA did not identify market penetration data for any conditions of use. In the absence of market penetration data for a given condition of use, EPA assumed DIDP may be used at up to all sites and by up to all workers calculated in this method as a bounding estimate. This assumes a market penetration of 100 percent. Market penetration is discussed for each condition of use in the main body of this report.

Step 5: Estimating the Number of Workers per Site

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

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

EPA then estimated the total number of establishments by obtaining the number of establishments reported in the U.S. Census Bureau's SUSB (U.S. Census Bureau, 2015) data at the 6-digit NAICS level.

EPA then summed the number of workers and occupational non-users over all occupations within a NAICS code and divided these sums by the number of establishments in the NAICS code to calculate the average number of workers and occupational non-users per site.

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

EPA estimated the number of workers and occupational non-users potentially exposed to DIDP and the number of sites that use DIDP in a given condition of use through the following steps:

1. Obtaining the total number of establishments by:
    a. Obtaining the number of establishments from SUSB (U.S. Census Bureau, 2015) at the 6-digit NAICS level (Step 5) for each NAICS code in the condition of use and summing these values; or
    b. Obtaining the number of establishments from the TRI, DMR, NEI, or literature for the condition of use.
2. Estimating the number of establishments that use DIDP by taking the total number of establishments from 1a and multiplying it by the market penetration factor from Step 4.
3. Estimating the number of workers and occupational non-users potentially exposed to DIDP by taking the number of establishments calculated in 1b and multiplying it by the average number of workers and ONUs per site from Step 5.

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

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

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

EPA used AD to estimate acute risks (*i.e.*, risks occurring as a result of exposure for less than one day) from workplace inhalation exposures for, per Equation B-1.

Equation B-1.

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

Where:

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

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

Equation B-2.

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

Where:

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

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

Equation B-3.

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

Where:

ADD = Average daily dose for chronic non-cancer risk calculations
EF = Exposure frequency (day/yr)

WY = Working years per lifetime (yr) – used in the denominator for ADD

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

EPA used AD to estimate acute risks from workplace dermal exposures using Equation B-4.

Equation B-4.

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

Where:

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

EPA used IADD to estimate intermediate risks from workplace dermal exposures using Equation B-5.

Equation B-5.

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

Where:

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

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

Equation B-6.

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

Where:

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

B.3 Calculating Aggregate Exposure

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

Equation B-7.

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

Where:

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

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

B.4 Acute, Intermediate, and Chronic (Non-cancer) Equation Inputs

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

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

Parameter Name	Symbol	Value	Unit
Exposure Duration	ED	8	hr/day
Breathing Rate	BR	1.25	m^3/hr
Exposure Frequency	EF	2–250[a]	days/yr
Exposure Frequency, Intermediate	EF_{int}	22	days
Days for Duration, Intermediate	ID	30	days
Working years	WY	31 (50th percentile) 40 (95th percentile)	years
Body Weight	BW	80 (average adult worker) 72.4 (female of reproductive age)	kg

[a] Depending on OES

B.4.1 Exposure Duration (ED)

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

B.4.2 Breathing Rate

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

B.4.3 Exposure Frequency (EF)

EPA generally used a maximum exposure frequency of 250 days per year. However, for some OES where a range of exposure frequency was possible, EPA used probabilistic modeling to estimate exposures and the associated exposure frequencies, resulting in exposure frequencies below 250 days per year. The relevant sections of this report describe EPA's estimation of exposure frequency and the associated distributions for each OES.

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

Equation B-8.

$$EF = AWD \times f$$

Where:

EF = exposure frequency, the number of days per year a worker is exposed to the chemical (day/yr)
AWD = annual working days, the number of days per year a worker works (day/yr)
f = fractional number of annual working days during which a worker is exposed to the chemical (unitless)

BLS (2018) provides data on the total number of work hours and total number of employees by each industry NAICS code. BLS provides these data from the 3- to 6-digit NAICS level (where 3-digit NAICS are less granular and 6-digit NAICS are the most granular). Dividing the total, annual hours worked by the number of employees yields the average number of hours worked per employee per year for each NAICS.

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

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

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

Equation B-9.

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

B.4.5 Intermediate Duration (ID)

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

B.4.6 Working Years (WY)

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

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

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

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

The U.S. Census' (2016a) Survey of Income and Program Participation (SIPP) provides information on *lifetime tenure with all employers*. SIPP is a household survey that collects data on income, labor force participation, social program participation and eligibility, and general demographic characteristics through a continuous series of national panel surveys of between 14,000 and 52,000 households (Census, 2016b). EPA analyzed the 2008 SIPP Panel Wave 1, a panel that began in 2008 and covers the interview months of September 2008 through December 2008 (Census, 2016a-b). For this panel, lifetime tenure data are available by Census Industry Codes, which can be cross walked with NAICS codes. SIPP data include fields for the industry in which each surveyed, employed individual works (TJBIND1); worker age (TAGE); and years of work experience *with all employers* over the surveyed individual's lifetime[10] Census household surveys use different industry codes than the NAICS codes, so EPA converted these industry codes to NAICS using a published crosswalk (Census Bureau, 2012b). EPA calculated the average tenure for the following age groups: 1) workers aged 50 and older; 2) workers aged 60 and older; and 3) workers of all ages employed at time of survey. EPA used tenure data for age group "50 and older" to determine the high-end lifetime working years, because the sample size in this age group is often substantially higher than the sample size for age group "60 and older". For some industries, the number of workers surveyed, or the *sample size*, was too small to provide a reliable representation of the worker tenure in that industry. Therefore, EPA excluded data where the sample size is less than five from our analysis.

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

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

Industry Sectors	Working Years			
	Average	50th Percentile	95th Percentile	Maximum
Manufacturing sectors (NAICS 31–33)	35.7	36	39	40
Non-manufacturing sectors (NAICS 42–81)	36.1	36	39	44

Source: Census Bureau, 2016a.
Note: Industries where sample size is less than five are excluded from this analysis.

BLS CPS data provide the median years of tenure that wage and salary workers had been with their current employer. Table_Apx B-3 presents CPS data for all demographics (men and women) by age group from 2008 to 2012. To estimate the low-end value for number of working years, EPA used the

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

most recent (2014) CPS data for workers aged 55 to 64 years, which indicates a median tenure of 10.4 years with their current employer. The use of this low-end value represents a scenario where workers are only exposed to the chemical of interest for a portion of their lifetime working years, as they may change jobs or move from one industry to another throughout their career.

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

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

B.4.7 Body Weight (BW)

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

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

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

C.1 Inhalation Exposures

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

Calculating AD_{HE}:

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

$$AD_{HE} = \frac{2.1\ \frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr}}{80\ kg} = 0.27\ \frac{\frac{mg}{kg}}{day}$$

Calculating $IADD_{HE}$:

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

$$IADD_{HE} = \frac{2.1\ \frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr} \times 22\,\frac{days}{year}}{80\ kg \times 30\,\frac{days}{year}} = 0.20\ \frac{\frac{mg}{kg}}{day}$$

Calculating ADD_{HE}:

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

$$ADD_{HE} = \frac{2.1\ \frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr} \times 250\,\frac{days}{year} \times 40\ years}{80\ kg \times 365\,\frac{days}{year} \times 40\ years} = 0.18\,\frac{\frac{mg}{kg}}{day}$$

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

Calculating AD_{CT}:

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

$$AD_{CT} = \frac{0.13\,\frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr}}{80\;kg} = 1.7 \times 10^{-2}\;\frac{\frac{mg}{kg}}{day}$$

Calculating IADD$_{CT}$:

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

$$IADD_{CT} = \frac{0.13\,\frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr} \times 22\,\frac{days}{year}}{80\;kg \times 30\,\frac{days}{year}} = 1.2 \times 10^{-2}\;\frac{\frac{mg}{kg}}{day}$$

Calculating ADD$_{CT}$:

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

$$ADD_{CT} = \frac{0.13\,\frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr} \times 223\,\frac{days}{year} \times 31\;years}{80\;kg \times 365\,\frac{days}{year} \times 31\;years} = 1.0 \times 10^{-2}\,\frac{\frac{mg}{kg}}{day}$$

C.2 Dermal Exposures

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

Calculating AD$_{HE}$:

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

$$AD_{HE} = \frac{7.3\,\frac{mg}{day}}{80\;kg} = 9.2 \times 10^{-2}\,\frac{mg}{kg\text{-}day}$$

Calculate IADD$_{HE}$:

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

$$IADD_{HE} = \frac{7.3\,\frac{mg}{day} \times 22\,\frac{day}{yr}}{80\ kg \times 30\,\frac{day}{yr}} = 6.7 \times 10^{-2}\,\frac{mg}{kg\text{-}day}$$

Calculate ADD$_{HE}$ (non-cancer):

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

$$ADD_{HE} = \frac{7.3\,\frac{mg}{day} \times 250\,\frac{day}{yr} \times 40\ years}{80\ kg \times 365\,\frac{day}{yr} \times 40\ years} = 6.3 \times 10^{-2}\,\frac{mg}{kg\text{-}day}$$

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

Calculating AD$_{CT}$:

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

$$AD_{CT} = \frac{3.7\,\frac{mg}{day}}{80\ kg} = 4.6 \times 10^{-2}\,\frac{mg}{kg\text{-}day}$$

Calculating IADD$_{CT}$:

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

$$IADD_{CT} = \frac{3.7\,\frac{mg}{day} \times 22\,\frac{days}{yr}}{80\ kg \times 30\,\frac{days}{yr}} = 3.4 \times 10^{-2}\,\frac{mg}{kg\text{-}day}$$

Calculate ADD$_{CT}$ (non-cancer):

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

$$ADD_{CT} = \frac{3.7\,\frac{mg}{day} \times 223\,\frac{days}{yr} \times 31\ years}{80\ kg \times 365\,\frac{day}{yr} \times 31\ years} = 2.8 \times 10^{-2}\,\frac{mg}{kg\text{-}day}$$

Appendix D DERMAL EXPOSURE ASSESSMENT METHOD

D.1 Dermal Dose Equation

As described in Section 2.4.4, occupational dermal exposures to DIDP are characterized using a flux-based approach to dermal exposure estimation. Therefore, EPA used Equation D-1 to estimate the acute potential dose rate (APDR) from occupational dermal exposures. The APDR (units of mg/day) characterizes the quantity of chemical that is potentially absorbed by a worker on a given workday.

Equation D-1.

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

Where:

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

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

D.2 Parameters of the Dermal Dose Equation

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

Table_Apx D-1. Summary of Dermal Dose Equation Values

Input Parameter	Symbol	Value	Unit	Rationale
Absorptive Flux	J	Dermal Contact with Liquids: 8.57E−04 Dermal Contact with Solids: 8.99E−06	mg/cm^2/hr	See Appendix D.2
Surface Area	S	Workers: 535 (central tendency) 1,070 (high-end) Females of reproductive age: 445 (central tendency) 890 (high-end)	cm^2	See Appendix D.2.2
Absorption time	t_{abs}	8	hr	See Appendix D.2.3
Glove Protection Factor	PF	1; 5; 10; or 20	unitless	See Appendix D.2.4

D.2.1 Absorptive Flux

D.2.1.1 Dermal Contact with Liquids or Formulations Containing DIDP

As described in Section 2.4.4.1, the work of Elsisi (1989) shows that the steady-state absorptive flux of neat DIDP ranges from 5.36E−04 to 8.57E−04 mg/cm^2/hr. Because the individual data were not available from Elsisi (1989), EPA has chosen the upper-bound value of flux of 8.57E−04 mg/cm^2/hr as the representative value for occupational dermal exposure assessment of the contact with liquids or formulations containing DIDP. Though it is possible that lower concentration materials exhibit higher fluxes than the neat material due to the properties of the vehicle of absorption, the flux of the neat material serves as a reasonable upper bound of potential flux across concentrations. Using flowchart presented in Figure 3 in OECD 156 (OECD, 2011e), it is suggested that an exposure assessor should use dermal absorption data from a realistic surrogate formulation or material if there are no data on absorption of the exact material under investigation. Because there are only dermal absorption data for neat DIDP, and workers are reasonably exposed to the neat material or concentrated formulations, EPA considers the dermal absorption of neat DIDP to be representative across chemical concentrations.

Using the work of Kissel (2011) to interpret the absorption data from Elsisi (1989), it was determined that dermal absorption of DIDP may be flux-limited, even for finite doses (*i.e.*, less than 10 µL/cm^2 for liquids (OECD, 2004c)). Therefore, the steady-state flux (*i.e.*, 8.57E−04 mg/cm^2/hr) reported by Elsisi *et al.* was assumed for the duration of chemical retention on the skin, which is expected to last up to 8 hours in occupational settings. However, it is also important to consider the magnitude of dermal loading of DIDP in occupational settings to ensure there is enough material present on the skin to support the assumption of the steady-state flux for an 8-hour shift. For contact with liquids in occupational settings, EPA assumes a range of dermal loading of 0.7 – 2.1 mg/cm^2 (U.S. EPA, 1992b) for tasks such as product sampling, loading/unloading, and cleaning as shown in the ChemSTEER Manual (U.S. EPA, 2015). More specifically, EPA has utilized the raw data of the U.S. EPA (1992b) study to determine a central tendency (50th percentile) dermal loading value of 1.4 mg/cm^2 and a high-end (95th percentile) dermal loading value of 2.1 mg/cm^2 for dermal exposure to liquids. For scenarios where liquid immersion occurs, EPA assumes a range of dermal loading of 1.3 – 10.3 mg/cm^2 (U.S. EPA, 1992b) for tasks such as spray coating as shown in the ChemSTEER Manual (U.S. EPA, 2015). More specifically, EPA has utilized the raw data of the U.S. EPA (1992b) study to determine a central tendency (50th percentile) value of 3.8 mg/cm^2 and a high-end (95th percentile) value of 10.3 mg/cm^2 for scenarios aligned with dermal immersion in liquids.

The high-end absorptive flux of DIDP reported by Elsisi (1989) would result in maximum absorption of 6.86E−03 mg/cm^2 over an 8-hour period. Therefore, the high-end dermal exposure estimate for liquids containing DIDP is quite reasonable with respect to the amount of material that may be available for absorption in an occupational setting.

D.2.1.2 Dermal Contact with Solids or Articles Containing DIDP

As described in Section 2.4.4.2, the average absorptive flux of DIDP from solid matrices is expected to vary between 0.005 and 0.025 µg/cm^2/hr for durations between 1-hour and 1-day based on aqueous absorption modeling from U.S. EPA (2004b). Using Equation 2-2 from Section 2.4.4.2, the average absorptive flux of DIDP over an 8-hour exposure period was calculated as 8.99E−06 mg/cm^2/hr. Because it is assumed that DIDP must first migrate from the solid matrix to a thin film of moisture on the surface of the skin, and that solubility of DIDP by the moisture layer limits absorption, the 8-hr time weighted average (TWA) aqueous flux value of 8.99E−06 mg/cm^2/hr was chosen as a representative value for dermal exposures to solids or articles containing DIDP.

Using the work of Kissel (2011) to interpret the dermal modeling results for aqueous DIDP, it was determined that dermal absorption of DIDP may be flux-limited, even for finite doses (*i.e.*, typically 1 to 5 mg/cm^2 for solids(OECD, 2004c)). Therefore, the 8-hr TWA flux (*i.e.*, 8.99E−06 mg/cm^2/hr) of aqueous DIDP was assumed for the duration of chemical retention on the skin, which is expected to last up to 8 hours in occupational settings. However, it is also important to consider the magnitude of dermal loading of DIDP in occupational settings to ensure there is enough material present on the skin to support the assumption of the steady-state flux for an 8-hour shift. For contact with solids or powders in occupational settings, EPA generally assumes a range of dermal loading of 900 – 3,100 mg/day (50th – 95th percentile from Lansink *et al.* (1996)) as shown in the ChemSTEER manual (U.S. EPA, 2015). For contact with materials such as solder/pastes in occupational settings, EPA assumes a range of dermal loading of 450 – 1,100 mg/day (50th – 95th percentile from Lansink *et al.* (1996)) as shown in the ChemSTEER Manual (U.S. EPA, 2015).

The average absorptive flux of DIDP for an 8-hour absorption period, as determined through modeling efforts (U.S. EPA, 2023a, 2004b), would result in maximum absorption of 7.19E−05 mg/cm^2 over an 8-hour period. Therefore, the high-end dermal exposure estimate for solids containing DIDP is quite reasonable with respect to the amount of material that may be available for absorption in an occupational setting.

D.2.2 Surface Area

Regarding surface area of occupational dermal exposure, EPA assumed a high-end value of 1070 cm^2 for male workers and 890 cm^2 for female workers. These high-end occupational dermal exposure surface area values are based on the mean two-hand surface area for adults of age 21 or older from Chapter 7 of EPA’s *Exposure Factors Handbook* (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).

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

D.2.3 Absorption Time

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

D.2.4 Glove Protection Factors

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

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

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

Table_Apx D-2 presents the PF values from ECETOC TRA model (Version 3). In the exposure data used to evaluate the ECETOC TRA model, (Marquart et al., 2017) reported that the observed glove protection factor was 34, compared to PF values of 5 or 10 used in the model.

Table_Apx D-2. Exposure Control Efficiencies and Protection Factors for Different Dermal Protection Strategies from ECETOC TRA v3

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

Appendix E MODEL APPROACHES AND PARAMETERS

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

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

E.1 EPA/OPPT Standard Models

This appendix section discusses the standard models used by EPA to estimate environmental releases of chemicals and occupational inhalation exposures. All the models presented in this section are models that were previously developed by EPA and are not the result of any new model development work for this risk evaluation. Therefore, this appendix does not provide the details of the derivation of the model equations which have been provided in other documents such as the *ChemSTEER User Guide* (U.S. EPA, 2015), *Chemical Engineering Branch Manual for the Preparation of Engineering Assessments, Volume 1* (U.S. EPA, 1991b), *Evaporation of pure liquids from open surfaces* (Arnold and Engel, 2001), *Evaluation of the Mass Balance Model Used by the References Environmental Protection Agency for Estimating Inhalation Exposure to New Chemical Substances* (Fehrenbacher and Hummel, 1996), and *Releases During Cleaning of Equipment* (Associates, 1988). The models include loss fraction models as well as models for estimating chemical vapor generation rates used in subsequent model equations to estimate the volatile releases to air and occupational inhalation exposure concentrations. The parameters in the equations of this appendix section are specific to calculating environmental releases and occupational inhalation exposures to DIDP.

The *EPA/OPPT Penetration Model* estimates releases to air from evaporation of a chemical from an open, exposed liquid surface. This model is appropriate for determining volatile releases from activities that are performed indoors or when air velocities are expected to be less than or equal to 100 feet per minute. The *EPA/OPPT Penetration Model* calculates the average vapor generation rate of the chemical from the exposed liquid surface using the following equation:

Equation E-1.

$$G_{activity} = \frac{(8.24 \times 10^{-8}) * (MW_{DIDP}^{0.835}) * F_{correction\_factor} * VP * \sqrt{Rate_{air\_speed}} * (0.25\pi D_{opening}^{2}) \sqrt[4]{\frac{1}{29} + \frac{1}{MW_{DIDP}}}}{T^{0.05} * \sqrt{D_{opening}} * \sqrt{P}}$$

Where:

$G_{activity}$ = Vapor generation rate for activity [g/s]
MW_{DIDP} = DIDP molecular weight [g/mol]

$F_{correction\_factor}$ = Vapor pressure correction factor [unitless]
VP = DIDP vapor pressure [torr]
$Rate_{air\_speed}$ = Air speed [cm/s]
$D_{opening}$ = Diameter of opening [cm]
T = Temperature [K]
P = Pressure [torr]

The *EPA/OPPT Mass Transfer Coefficient Model* estimates releases to air from the evaporation of a chemical from an open, exposed liquid surface. This model is appropriate for determining this type of volatile release from activities that are performed outdoors or when air velocities are expected to be greater than 100 feet per minute. The *EPA/OPPT Mass Transfer Coefficient Model* calculates the average vapor generation rate of the chemical from the exposed liquid surface using the following equation:

Equation E-2.

$$G_{activity} = \frac{(1.93 \times 10^{-7}) * \left(MW_{DIDP}{}^{0.78}\right) * F_{correction\_factor} * VP * Rate_{air\_speed}^{0.78} * (0.25\pi D_{opening}^{2})\sqrt[3]{\frac{1}{29} + \frac{1}{MW_{DIDP}}}}{T^{0.4} D_{opening}^{0.11} (\sqrt{T} - 5.87)^{2/3}}$$

Where:

$G_{activity}$ = Vapor generation rate for activity [g/s]
MW_{DIDP} = DIDP molecular weight [g/mol]
$F_{correction\_factor}$ = Vapor pressure correction factor [unitless]
VP = DIDP vapor pressure [torr]
$Rate_{air\_speed}$ = Air speed [cm/s]
$D_{opening}$ = Diameter of opening [cm]
T = Temperature [K]

The EPA's *Office of Air Quality Planning and Standards (OAQPS) AP-42 Loading Model* estimates releases to air from the displacement of air containing chemical vapor as a container/vessel is filled with a liquid. This model assumes that the rate of evaporation is negligible compared to the vapor loss from the displacement and is used as the default for estimating volatile air releases during both loading activities and unloading activities. This model is used for unloading activities because it is assumed while one vessel is being unloaded another is assumed to be loaded. The *EPA/OAQPS AP-42 Loading Model* calculates the average vapor generation rate from loading or unloading using the following equation:

Equation E-3.

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

Where:

$G_{activity}$ = Vapor generation rate for activity [g/s]
$F_{saturation\_factor}$ = Saturation factor [unitless]
MW_{DIDP} = DIDP molecular weight [g/mol]
$V_{container}$ = Volume of container [gal/container]
$F_{correction\_factor}$ = Vapor pressure correction factor [unitless]
VP = DIDP vapor pressure [torr]
$RATE_{fill}$ = Fill rate of container [containers/hr]

R = Universal gas constant [L*torr/mol-K]
T = Temperature [K]

For each of the vapor generation rate models, the vapor pressure correction factor ($F_{correction\_factor}$) can be estimated using Raoult's Law and the mole fraction of DIDP in the liquid of interest. However, in most cases, EPA did not have data on the molecular weights of other components in the liquid formulations; therefore, EPA approximated the mole fraction using the mass fraction of DIDP in the liquid of interest. Using the mass fraction of DIDP to estimate mole fraction does create uncertainty in the vapor generation rate model. If other components in the liquid of interest have similar molecular weights as DIDP, then mass fraction is a reasonable approximation of mole fraction. However, if other components in the liquid of interest have much lower molecular weights than DIDP, the mass fraction of DIDP will be an overestimate of the mole fraction. If other components in the liquid of interest have much higher molecular weights than DIDP, the mass fraction of DIDP will underestimate the mole fraction.

If calculating an environmental release, the vapor generation rate calculated from one of the above models (Equation E-1, Equation E-2, and Equation E-3) is then used along with an operating time to calculate the release amount:

Equation E-4.

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

Where:

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

In addition to the vapor generation rate models, EPA uses various loss fraction models to calculate environmental releases, including the following:

- EPA/OPPT Small Container Residual Model
- EPA/OPPT Drum Residual Model
- EPA/OPPT Bulk Transport Residual Model
- EPA/OPPT Multiple Process Vessel Residual Model
- EPA/OPPT Single Process Vessel Residual Model
- EPA/OPPT Solid Residuals in Transport Containers Model
- March 2023 Methodology for Estimating Environmental Releases from Sampling Waste

The loss fraction models apply a given loss fraction to the overall throughput of DIDP for the given process. The loss fraction value or distribution of values differs for each model; however, each model follows the same general equation based on the approaches described for each OES:

Equation E-5.

$$Release\_Year_{activity} = PV * F_{activity\_loss}$$

Where:

$Release\_Year_{activity}$ = DIDP released for activity per site-year [kg/site-yr]
PV = Production volume throughput of DIDP [kg/site-yr]
$F_{activity\_loss}$ = Loss fraction for activity [unitless]

The *EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders* estimates a loss fraction of dust that may be generated during the transferring/unloading of solid powders. This model can be used to estimate a loss fraction of dust both when the facility does not employ capture technology (*i.e.*, local exhaust ventilation, hoods) or dust control/removal technology (*i.e.*, cyclones, electrostatic precipitators, scrubbers, or filters), and when the facility does employ capture and/or control/removal technology. The model explains that when dust is uncaptured, the release media is fugitive air, water, incineration, or landfill. When dust is captured but uncontrolled, the release media is to stack air. When dust is captured and controlled, the release media is to incineration or landfill. The *EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders* calculates the amount of dust not captured, captured but not controlled, and both captured and controlled, using the following equations (U.S. EPA, 2021d):

Equation E-6.

$$\mathbf{Elocal_{dust\_not\_captured}} = \mathbf{Elocal_{dust\_generation}} * \left(\mathbf{1} - \mathbf{F_{dust\_capture}}\right)$$

Where:

$Elocal_{dust\_not\_captured}$ = Daily amount emitted from transfers/unloading that is not captured [kg not captured/site-day]

$Elocal_{dust\_generation}$ = Daily release of dust from transfers/unloading [kg generated/site-day]

$F_{dust\_capture}$ = Capture technology efficiency [kg captured/kg generated]

Equation E-7.

$$Elocal_{dust\_cap\_uncontrol} = Elocal_{dust\_generation} * F_{dust\_capture} * \left(1 - F_{dust\_control}\right)$$

Where:

$Elocal_{dust\_cap\_uncontrol}$ = Daily amount emitted from control technology from transfers/unloading [kg not controlled/site-day]

$Elocal_{dust\_generation}$ = Daily release of dust from transfers/unloading [kg generated/site-day]

$F_{dust\_capture}$ = Capture technology efficiency [kg captured/kg generated]

$F_{dust\_control}$ = Control technology removal efficiency [kg controlled/kg captured]

Equation E-8.

$$Elocal_{dust\_cap\_control} = Elocal_{dust\_generation} * F_{dust\_capture} * F_{dust\_control}$$

Where:

$Elocal_{dust\_cap\_control}$ = Daily amount captured and removed by control technology from transfers/unloading [kg controlled/site-day]

$Elocal_{dust\_generation}$ = Daily release of dust from transfers/unloading [kg generated/site-day]

$F_{dust\_capture}$ = Capture technology efficiency [kg captured/kg generated]

$F_{dust\_control}$ = Control technology removal efficiency [kg controlled/kg captured]

The *EPA/OPPT Mass Balance Inhalation Model* estimates a worker inhalation exposure to an estimated concentration of chemical vapors within the worker's breathing zone using a one box model. The model estimates the amount of chemical inhaled by a worker during an activity in which the chemical has volatilized and the airborne concentration of the chemical vapor is estimated as a function of the source vapor generation rate or the saturation level of the chemical in air. First, the applicable vapor generation rate model (Equation E-1, Equation E-2, and Equation E-3) is used to calculate the vapor generation rate for the given activity. With this vapor generation rate, the *EPA/OPPT Mass Balance Inhalation Model* calculates the volumetric concentration of DIDP using the following equation:

Equation E-9.

$$Cv_{activity} = Minimum: \begin{cases} \left[\dfrac{170{,}000 * T * G_{activity}}{MW_{DIDP} * Q * k}\right] \\ \left[\dfrac{1{,}000{,}000ppm * F_{correction\_factor} * VP}{P}\right] \end{cases}$$

Where:

$Cv_{activity}$ = Exposure activity volumetric concentration [ppm]
$G_{activity}$ = Exposure activity vapor generation rate [g/s]
MW_{DIDP} = DIDP molecular weight [g/mol]
Q = Ventilation rate [ft^3/min]
k = Mixing factor [unitless]
T = Temperature [K]
$F_{correction\_factor}$ = Vapor pressure correction factor [unitless]
VP = DIDP vapor pressure [torr]
P = Pressure [torr]

Mass concentration can be estimated by multiplying the volumetric concentration by the molecular weight of DIDP and dividing by molar volume at standard temperature and pressure.

EPA uses the above equations in the DIDP environmental release and occupational exposure models, and EPA references the model equations by model name and/or equation number within Appendix E.

E.2 Manufacturing Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases and occupational exposures for DIDP during the manufacturing OES. This approach utilizes the *Virtual Tour of the Exxon Mobil Baton Rouge Chemical Plant DIDP/DIDP Production Facility* (ExxonMobil virtual tour) (ExxonMobil, 2022b) and CDR data (U.S. EPA, 2020a) combined with Monte Carlo simulation (a type of stochastic simulation).

Based on ExxonMobil's virtual tour (ExxonMobil, 2022b), EPA identified the following release sources from manufacturing operations:

- Release source 1: Vented Losses to Air During Reaction/Separations/Other Process Operations.
- Release source 2: Process Waste from Reaction/Separations/Other Process Operations.
- Release source 3: Crude and Final Filtrations.
- Release source 4: Product Sampling Wastes.
- Release source 5: Open Surface Losses to Air During Product Sampling.
- Release source 6: Equipment Cleaning Wastes.
- Release source 7: Open Surface Losses to Air During Equipment Cleaning.
- Release source 8: Transfer Operation Losses to Air from Packaging Manufactured DIDP into Transport Containers.
- Release source 9: Container Cleaning Wastes.

Environmental releases for DIDP during manufacturing are a function of DIDP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: production rate, DIDP concentration, air speed, diameter of openings, saturation factor, container size, and loss fractions. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts and exposure concentrations for this OES.

E.2.1 Model Equations

Table_Apx E-1 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the manufacturing OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix E.2.2. The Monte Carlo simulation calculated the total DIDP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th percentile and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx E-1. Models and Variables Applied for Release Sources in the Manufacturing OES

Release source	Model(s) Applied	Variables Used
Release source 1: Vented Losses to Air During Reaction/Separations/Other Process Operations.	See Equation E-10	Q_{DIDP_day}; F_{DIDP_SPERC}
Release source 2: Process Waste from Reaction/Separations/Other Process Operations.	See Equation E-11	Q_{DIDP_day}; WS_{DIDP}
Release source 3: Crude and Final Filtrations.	See Equation E-12	Q_{DIDP_day}; $LF_{filtration}$
Release source 4: Product Sampling Wastes.	*March 2023 Methodology for Estimating Environmental Releases from Sampling Waste* (Appendix E.1)	Q_{DIDP_day}; $LF_{sampling}$
Release source 5: Open Surface Losses to Air During Product Sampling.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; MW; VP; $RATE_{air\_speed}$; $D_{sampling}$; T; P Operating Time: $OH_{sampling}$
Release source 6: Equipment Cleaning Wastes.	*EPA/OPPT Multiple Process Vessel Residual Model* (Appendix E.1)	Q_{DIDP_day}; LF_{equip_clean}
Release source 7: Open Surface Losses to Air During Equipment Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; MW; VP; $RATE_{air\_speed}$; D_{equip_clean}; T; P Operating Time: OH_{equip_clean}

Release source	Model(s) Applied	Variables Used
Release source 8: Transfer Operation Losses to Air from Packaging Manufactured DIDP into Transport Containers.	*EPA/OAQPS AP-42 Loading Model* (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; VP; f_{sat}; MW; R; T; $RATE_{fill\_drum}$ Operating Time: $N_{prodcont\_yr}$; $RATE_{fill\_cont}$; $RATE_{fill\_drum}$; OD
Release source 9: Container Cleaning Wastes.	*EPA/OPPT Bulk Transport Residual Model* (Appendix E.1)	Q_{DIDP_day}; LF_{bulk}

Release source 1 daily release (Vented Losses to Air During Reaction/Separations/Other Process Operations) is calculated using the following equation:

Equation E-10.

$$Release\_perDay_{RP1} = Q_{DIDP\_day} * F_{DIDP\_SPERC}$$

Where:

$Release\_perDay_{RP1}$ = DIDP released for release source 1 [kg/site-day]
Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
F_{DIDP_SPERC} = Loss fraction for unit operations [unitless]Release source 2 daily release (Process Waste from Reaction/Separations/Other Process Operations) is calculated using the following equation:

Equation E-11.

$$Release\_perDay_{RP2} = Q_{DIDP_{day}} * \frac{WS_{DIDP}}{1000}$$

Where:

$Release\_perDay_{RP2}$ = DIDP released for release source 2 [kg/site-day]
Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
WS_{DIDP} = Water solubility for DIDP [g/L]

Release source 3 daily release (Crude and Final Filtrations) is calculated using the following equation. Note that this release point is calculated differently for the site with a known production volume, and for the other three sites that claimed their production volumes (PVs) as CBI:

Equation E-12.

$$Release\_perDay_{RP3} = Q_{DIDP_{day}} * LF_{filtration} \text{ (1 site with known PV)}$$

or

$$Release\_perDay_{RP3} = Q_{filtration\_release} \text{ (3 sites with CBI PVs)}$$

Where:

$Release\_perDay_{RP3}$ = DIDP released for release source 3 [kg/site-day]
Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
$LF_{filtration}$ = Loss fraction for filtration [unitless]

$Q_{filtration\_release}$ = Estimated daily filtration releases from ExxonMobil virtual tour [kg/site-day]

E.2.2 Model Input Parameters

Table_Apx E-2 summarizes the model parameters and their values for the Manufacturing Monte Carlo simulation. Additional explanations of EPA’s selection of the distributions for each parameter are provided after Table_Apx E-2.

5401 **Table_Apx E-2. Summary of Parameter Values and Distributions Used in the Manufacturing Models**

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Facility Production Rate – Known Site 1	PV	kg/site-yr	20,507	—	—	—	—	See Section E.2.4
Facility Production Rate – Unknown Sites	PV	kg/site-yr	75,595,310	7556454.71	75595310.2	—	Uniform	See Section E.2.4
Manufactured DIDP Concentration	F_{DIDP}	kg/kg	0.995	0.9	1	0.995	Triangular	See Section E.2.7
Air Speed	$RATE_{air\_speed}$	ft/min	19.7	2.56	398	—	Lognormal	See Section E.2.8
Diameter of Sampling Opening	$D_{sampling}$	cm	2.5	2.5	10	2.5	Triangular	See Section E.2.9
Diameter of Equipment Opening	D_{equip_clean}	cm	92	—	—	—	—	See Section E.2.9
Saturation Factor	f_{sat}	dimensionless	0.5	0.5	1.45	0.5	Triangular	See Section E.2.10
Drum Size	V_{drum}	gal	55	20	100	55	Triangular	See Section E.2.11
Bulk Container Size	V_{cont}	gal	20000	5000	20000	20000	Triangular	See Section E.2.11
Bulk Container Loss Fraction	LF_{bulk}	kg/kg	0.0007	0.0002	0.002	0.0007	Triangular	See Section E.2.12
Loss Fraction for Filtration Releases (PV1)	$LF_{filtration}$	kg/kg	0.0207	0.00207	0.0207	—	Uniform	See Section E.2.13

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Fraction of DIDP Lost During Sampling - 1 (Q_{DIDP_day} < 50 kg/site-day)	$F_{sampling\_1}$	kg/kg	0.02	0.002	0.02	0.02	Triangular	See Section E.2.14
Fraction of DIDP Lost During Sampling - 2 (Q_{DIDP_day} 50-200 kg/site-day)	$F_{sampling\_2}$	kg/kg	0.005	0.0006	0.005	0.005	Triangular	See Section E.2.14
Fraction of DIDP Lost During Sampling - 3 (Q_{DIDP_day} 200-5000 kg/site-day)	$F_{sampling\_3}$	kg/kg	0.004	0.0005	0.004	0.004	Triangular	See Section E.2.14
Fraction of DIDP Lost During Sampling - 4 (Q_{DIDP_day} > 5000 kg/site-day)	$F_{sampling\_4}$	kg/kg	0.0004	0.00008	0.0004	0.0004	Triangular	See Section E.2.14
Number of Sites	Ns	sites	4	—	—	—	—	See Section E.2.3
Operating Days	OD	days/yr	180	—	—	—	—	See Section E.2.15

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Vapor Pressure at 25C	VP	mmHg	5.28E−07	—	—	—	—	Physical property
Vapor Pressure at 140F	VP_{140}	mmHg	5.21E−05	—	—	—	—	Physical property
Vapor Pressure at 250F	VP_{250}	mmHg	6.16E−03	—	—	—	—	Physical property
Vapor Pressure at 375F	VP_{375}	mmHg	0.283	—	—	—	—	Physical property
Molecular Weight	MW	g/mol	446.68	—	—	—	—	Physical property
Gas Constant	R	atm-cm3/gmol-L	82.05	—	—	—	—	Universal constant
Process Operation Emission Factor	F_{DIDP_SPERC}	kg/kg	0.001	—	—	—	—	See Section E.2.16
Water Solubility of DIDP	WS_{DIDP}	g/L	0.00028	—	—	—	—	Physical property
Exxon Filtration Release Amount	$Q_{filtration\_release}$	kg/day	869	—	—	—	—	See Section E.2.13
Temperature	T	K	298	—	—	—	—	Process parameter
Pressure	P	atm	1	—	—	—	—	Process parameter
Equipment cleaning loss fraction	LF_{equip_clean}	kg/kg	0.02	—	—	—	—	See Section E.2.17
Drum Fill Rate	$RATE_{fill\_drum}$	drums/hr	20	—	—	—	—	See Section E.2.18

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Bulk Container Fill Rate	$RATE_{fill\_cont}$	containers/hr	1	—	—	—	—	See Section E.2.18
Density of DIDP	RHO	kg/L	0.9634	—	—	—	—	Physical property
Mixing Factor	F_{mixing}	dimensionless	0.5	0.1	1	0.5	Triangular	See Section E.2.19

E.2.3 Number of Sites

EPA used 2020 CDR data (U.S. EPA, 2020a) to identify the number of sites that manufacture DIDP. In CDR, four sites reported domestic manufacturing of DIDP. Table_Apx E-3 presents the names and locations of these sites.

Table_Apx E-3. Sites Reporting to CDR for Domestic Manufacture of DIDP

Facility Name	Facility Location
Troy Chemical Corp.	Phoenix, AZ
ExxonMobil	Baton Rouge, LA
LANXESS Solutions	Fords, NJ
Teknor Apex	Brownsville, TN

E.2.4 Throughput Parameters

EPA ran the Monte Carlo model once to estimate releases and exposures from the single site with a known production volume, and once to estimate releases and exposures from the other three sites that claimed their production volumes (PVs) as CBI. EPA used 2020 CDR data (U.S. EPA, 2020a) to identify annual facility PV for each site. Out of the four sites that reported domestic manufacturing of DIDP in CDR, only one site provided a production volume. Troy Chemical Corporation reported 45,211 pounds (20,507 kg) of DIDP manufactured.

For the other three sites, EPA used a uniform distribution set within the national PV range for each CASRN (DIDP encompasses two CASRNs). EPA calculated the bounds of the range by taking the total PV range in CDR and subtracting out the PVs that belonged to known sites (both MFG and import). Then, for each bound of the PV range for the remaining unknown sites, EPA divided the value by the number of unknown sites for each CASRN. CDR estimates a total national DIDP PV of 100,000,000 to 1,000,000,000 lb Based on the known PVs from importers and manufacturers, the total PV associated with the three sites with CBI PVs is 16,659,131 to 166,659,131 lbs/site-yr. Based on this (while converting pounds to kilograms), EPA set a uniform distribution with lower bound of 7,556,455 kg/site-yr, and an upper bound of 75,595,310 kg/site-yr.

The daily throughput of DIDP is calculated using Equation E-13 by dividing the annual production volume by the number of operating days. The number of operating days is determined according to Section E.2.15.

Equation E-13.

$$Q_{DIDP\_day} = \frac{PV}{OD}$$

Where:

Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
PV = Annual production volume [kg/site-yr]
OD = Operating days (see Section E.2.15) [days/yr]

E.2.5 Number of Containers Per Year

The number of manufactured DIDP product containers filled by a site per year is calculated using the following equation:

Equation E-14.

$$N_{prodcont\_yr} = \frac{PV}{RHO * \left(3.79\ \frac{L}{gal}\right) * V_{drum/cont}}$$

Where:

$N_{prodcont\_yr}$ = Annual number of product containers [container/site-year]

$V_{drum/cont}$ = Product container volume (see Section E.2.11) [gal/container]

PV = Facility production rate (see Section E.2.4) [kg/site-year]

RHO = DIDP density [kg/L]

E.2.6 Operating Hours

EPA estimated operating hours using ExxonMobil's virtual tour (ExxonMobil, 2022b), and through calculation from other parameters. Worker activities with operating hours provided from ExxonMobil's virtual tour include product sampling, equipment cleaning, and loading.

For product sampling (release point 5), ExxonMobil stated via their virtual tour that one hr/day is spent on product sampling (ExxonMobil, 2022b). This is consistent with the default value provided in the *ChemSTEER User Guide* (U.S. EPA, 2015).

For equipment cleaning (release point 7), the *ChemSTEER User Guide* provides an estimate of four hours per day for cleaning multiple vessels (U.S. EPA, 2015).

The operating hours for loading of DIDP into transport containers (release point 8) is calculated based on the number of product containers filled at the site and the fill rate using the following equation:

Equation E-15.

$$Time_{RP8} = \frac{N_{prodcont\_yr}}{RATE_{fill\_drum/cont} * OD}$$

Where:

$Time_{RP8}$ = Operating time for release point 8 [hrs./site-day]

$RATE_{fill\_drum/cont}$ = Fill rate of container, dependent on volume (see Section E.2.18) [containers/hr]

$N_{prodcont\_yr}$ = Annual number of product containers (see Section E.2.5) [containers/site-year]

OD = Operating days (see Section E.2.15) [days/site-year]

E.2.7 Manufactured DIDP Concentration

For the site that provided details in CDR (Troy Chemical Corporation), EPA used the manufactured concentration range reported in CDR (U.S. EPA, 2020a) to make a uniform distribution of 1-30% DIDP.

CDR Data from the remaining three sites indicated a concentration range of 90-100% DIDP (U.S. EPA, 2020a). According to the Australian Assessment Report, DIDP is manufactured at or above 99.5%. In addition, during ExxonMobil's virtual tour of the DIDP/DINP production facility, the company indicates a concentration of 99.6% DIDP. Based on this information, EPA modeled the manufactured DIDP concentration for the other three sites using a triangular distribution with a lower bound of 90%, upper bound of 100%, and mode of 99.5%.

E.2.8 Air Speed

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

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

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

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

E.2.9 Diameters of Opening

The *ChemSTEER User Guide* indicates diameters for the openings for various vessels that may hold liquids in order to calculate vapor generation rates during different activities (U.S. EPA, 2015). For equipment cleaning operations, the *ChemSTEER User Guide* indicates a single default value of 92 cm (U.S. EPA, 2015).

For sampling activities, the *ChemSTEER User Guide* indicates that the typical diameter of opening for vaporization of the liquid is 2.5 cm (U.S. EPA, 2015). Additionally, the *ChemSTEER User Guide* provides ten cm as a high-end value for the diameter of opening during sampling (U.S. EPA, 2015). The underlying distribution of this parameter is not known; therefore, EPA assigned a triangular distribution based on the estimated lower bound, upper bound, and mode of the parameter. EPA assigned the value of 2.5 cm as a lower bound for the parameter and ten cm as the upper bound based on the values provided in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA also assigned 2.5 cm as the mode diameter value for sampling liquids based on the typical value described in *ChemSTEER User Guide* (U.S. EPA, 2015).

E.2.10 Saturation Factor

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

E.2.11 Container Size

For the site with a known PV, (Troy Chemical Corporation), EPA assumed that manufactured DIDP was packaged into drums, based on the reported PV of 20,507 kg/site-yr. According to the *ChemSTEER User Guide*, drums are defined as containing between 20 and 100 gallons of liquid, and the default drum size is 55 gallons (U.S. EPA, 2015). Therefore, EPA modeled drum size using a triangular distribution with a lower bound of 20 gallons, an upper bound of 100 gallons, and a mode of 55 gallons.

For the other three sites, EPA assumed that DIDP was packaged into bulk containers, based on the larger PV range of 7,556,455 to 75,595,310 kg/site-yr. According to ExxonMobil's virtual tour (ExxonMobil, 2022b), DIDP is transported via marine vessels (58.5%), rail cars (28.5%), and trucks (13%) at the facility. According to the *ChemSTEER User Guide* (U.S. EPA, 2015), the default tank truck size is 5,000 gallons, and the default rail car size is 20,000 gallons. Therefore, EPA modeled bulk container size using a triangular distribution with a lower bound of 5,000 gallons, an upper bound of 20,000 gallons, and a mode of 20,000 gallons. The mode was set at 20,000 gallons since ExxonMobil listed that the majority of transport methods were rail cars or marine vessels.

E.2.12 Bulk Container Residue Loss Fraction

EPA paired the data from the PEI Associates Inc. study (Associates, 1988) such that the residuals data for emptying tanks by gravity-draining was aligned with the default central tendency and high-end values from the *EPA/OPPT Bulk Transport Residual Model*. For unloading tanks by gravity-draining in the PEI Associates Inc. study, EPA found that the average percent residual from the pilot-scale experiments showed a range of 0.02 percent to 0.19 percent and an average of 0.06 percent (Associates, 1988). The *EPA/OPPT Bulk Transport Residual Model* from the *ChemSTEER User Guide* (U.S. EPA, 2015) recommends a default central tendency loss fraction of 0.07 percent and a high-end loss fraction of 0.2 percent.

The underlying distribution of the loss fraction parameter for bulk containers is not known; therefore, EPA assigned a triangular distribution, since triangular distributions require least assumptions and are completely defined by range and mode of a parameter. EPA assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the *EPA/OPPT Bulk Transport Residual Model* in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study for emptying tanks by gravity-draining (Associates, 1988).

E.2.13 Filtration Loss Fraction

For the three sites with unknown PVs, EPA used estimates from ExxonMobil's virtual tour (ExxonMobil, 2022b) to estimate environmental releases from filtration losses. In the virtual tour, ExxonMobil stated that during DIDP/DINP production, crude filtration losses are 397 kg/day, and final filtration losses are 472 kg/day, for a total of 869 kg/day for filtration losses. As the PV of ExxonMobil is expected to be on the same scale as the PV estimate for the three unknown sites, this release estimate of 869 kg/day is used directly.

For the site with a known PV (Troy Chemical Corporation), EPA did not expect the ExxonMobil filtration loss estimates to be accurate due to the smaller PV of DIDP. Therefore, EPA developed a uniform distribution of loss fractions from ExxonMobil's filtration loss estimates. EPA divided 869 kg/day by the range of daily production volumes for the sites with CBI PVs. This resulted in a uniform distribution of filtration loss fractions with a lower bound of 2.07E−03 kg/kg and an upper bound of 2.07E−02 kg/kg.

E.2.14 Sampling Loss Fraction

Sampling loss fractions were estimated using the *March 2023 Methodology for Estimating Environmental Releases from Sampling Wastes* (U.S. EPA, 2023b). In this methodology, EPA completed a search of over 300 IRERs completed in the years 2021 and 2022 for sampling release data, including a similar proportion of both PMNs and Low Volume Exemptions (LVEs). Of the searched IRERs, 60 data points for sampling release loss fractions, primarily for sampling releases from submitter-controlled sites (~75% of IRERs), were obtained. The data points were analyzed as a function of the chemical daily throughput and industry type. This analysis showed that the sampling loss fraction generally decreased as the chemical daily throughput increased. Therefore, the methodology provides guidance for selecting a loss fraction based on chemical daily throughput. Table_Apx E-4 presents a summary of the chemical daily throughputs and corresponding loss fractions.

Table_Apx E-4. Sampling Loss Fraction Data from the March 2023 Methodology for Estimating Environmental Releases from Sampling Waste

Chemical Daily Throughput (kg/site-day) ($Q_{chem\_site\_day}$)	Number of Data Points	Sampled Quantity (kg chemical/day)		Sampling Loss Fraction ($LF_{sampling}$)	
		50th Percentile	95th Percentile	50th Percentile	95th Percentile
<50	13	0.03	0.20	0.002	0.02
50 to <200	10	0.10	0.64	0.0006	0.005
200 to <5,000	25	0.37	3.80	0.0005	0.004
≥5,000	10	1.36	6.00	0.00008	0.0004
All	58	0.20	5.15	0.0005	0.008

For each range of daily throughputs, EPA estimated sampling loss fractions using a triangular distribution of the 50th percentile value as the lower bound, and the 95th percentile value as the upper bound and mode. The sampling loss fraction distribution was chosen based on the calculation of daily throughput, as shown in Section E.2.4.

E.2.15 Operating Days

According to ExxonMobil's virtual tour (ExxonMobil, 2022b), DIDP production occurs continuously for half a year (180 days). The other half year is dedicated to DINP production. EPA used this value as a constant for the number of operating days for DIDP production.

E.2.16 Process Operations Emission Factor

In order to estimate releases from reactions, separations, and other process operations, EPA used an emission factor from the European Solvents Industry Group (ESIG). According to the ESD on Plastic Additives, the processing temperature during manufacture of plasticizers is 375°F (OECD, 2009b). At this temperature, DIDP has a vapor pressure of 37.8 Pa. ESIG's Specific Environmental Release

Category for Industrial Substance Manufacturing (solvent-borne) states that a chemical with a vapor pressure between 10-100 Pa will have an emission factor of 0.001 (ESIG, 2012). Therefore, EPA used this emission factor as a constant value for process operation releases.

E.2.17 Equipment Cleaning Loss Fraction

EPA used the *EPA/OPPT Multiple Process Residual Model* to estimate the releases from equipment cleaning. The *EPA/OPPT Multiple Process Residual Model*, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015), provides an overall loss fraction of 2 percent from equipment cleaning.

E.2.18 Container Fill Rates

The *ChemSTEER User Guide* (U.S. EPA, 2015) provides a typical fill rate of 20 containers per hour for containers with 20 to 100 gallons of liquid and a typical fill rate of one container per hour for containers with over 10,000 gallons of liquid.

E.2.19 Mixing Factor

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

E.3 Import and Repackaging Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DIDP during the import and repackaging OES. This approach utilizes the *Generic Scenario for Chemical Repackaging* (U.S. EPA, 2022a) and CDR data (U.S. EPA, 2020a) combined with Monte Carlo simulation (a type of stochastic simulation).

Based on the GS, EPA identified the following release sources from import and repackaging operations:

- Release source 1: Transfer Operation Losses to Air from Unloading DIDP.
- Release source 2: Product Sampling Wastes.
- Release source 3: Container Cleaning Wastes.
- Release source 4: Open Surface Losses to Air During Container Cleaning.
- Release source 5: Equipment Cleaning Wastes.
- Release source 6: Open Surface Losses to Air During Equipment Cleaning.
- Release source 7: Transfer Operation Losses to Air from Loading DIDP.

Environmental releases for DIDP during import and repackaging are a function of DIDP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: production rate, operating days, DIDP concentration, air speed, saturation factor, container size, and loss fractions. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.3.1 Model Equations

Table_Apx E-5 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the import and repackaging OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix E.3.2. The Monte Carlo simulation calculated the total DIDP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th percentile and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx E-5. Models and Variables Applied for Release Sources in the Import and Repackaging OES

Release source	Model(s) Applied	Variables Used
Release source 1: Transfer Operation Losses to Air from Unloading DIDP.	*EPA/OAQPS AP-42 Loading Model* (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; VP; f_{sat}; MW; R; T ; V_{tote}; $RATE_{fill\_tote}$; V_{rail}; $RATE_{fill\_rail}$ Operating Time: $N_{tote/rail\_unload\_yr}$; $RATE_{fill\_tote}$; $RATE_{fill\_rail}$; OD
Release source 2: Product Sampling Wastes.	*March 2023 Methodology for Estimating Environmental Releases from Sampling Waste* (Appendix E.1)	Q_{DIDP_day}; $LF_{sampling}$
Release source 3: Container Cleaning Wastes.	*EPA/OPPT Bulk Transport Residual Model* (Appendix E.1)	Q_{DIDP_day}; LF_{bulk}
Release source 4: Open Surface Losses to Air During Container Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; MW; VP; $RATE_{air\_speed}$; $D_{cont\_clean\_tote}$; $D_{cont\_clean\_rail}$; T; P Operating Time: $N_{tote/rail\_unload\_yr}$; $RATE_{fill\_tote}$; $RATE_{fill\_rail}$; OD
Release source 5: Equipment Cleaning Wastes	*EPA/OPPT Multiple Process Vessel Residual Model* (Appendix E.1)	Q_{DIDP_day}; LF_{equip_clean}
Release source 6: Open Surface Losses to Air During Equipment Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; MW; VP; $RATE_{air\_speed}$; D_{equip_clean}; T; P Operating Time: OH_{equip_clean}
Release source 7: Transfer Operation Losses to Air from Loading DIDP.	*EPA/OAQPS AP-42 Loading Model* (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; VP; f_{sat}; MW; R; T; V_{drum}; $RATE_{fill\_drum}$; V_{rail}; $RATE_{fill\_rail}$ Operating Time: $N_{drum/rail\_load\_yr}$; $RATE_{fill\_drum}$; $RATE_{fill\_rail}$; OD

E.3.2 Model Input Parameters

Table_Apx E-6 summarizes the model parameters and their values for the Import and Repackaging Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after Table_Apx E-6.

5670 **Table_Apx E-6. Summary of Parameter Values and Distributions Used in the Import and Repackaging Model**

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Facility Production Rate	PV	kg/site-yr	Multiple distributions based on CDR data.			—	Uniform	See Section E.3.4
Operating Days	OD	days/yr	208	174	260	—	Discrete	See Section E.3.7
Manufactured DIDP Concentration	F_{DIDP}	kg/kg	Multiple distributions based on CDR data.				Triangular	See Section E.3.8
Air Speed	$RATE_{air\_speed}$	ft/min	19.7	2.56	398	—	Lognormal	See Section E.3.9
Saturation Factor	f_{sat}	dimensionless	0.5	0.5	1.45	0.5	Triangular	See Section E.3.10
Drum Size	V_{drum}	gal	55	20	100	55	Triangular	See Section E.3.11
Tote Size	V_{tote}	gal	550	100	1000	550	Triangular	See Section E.3.11
Rail Car Size	V_{rail}	gal	20000	10000	20000	20000	Triangular	See Section E.3.11
Bulk Container Loss Fraction	LF_{bulk}	kg/kg	0.0007	0.0002	0.002	0.0007	Triangular	See Section E.3.12
Fraction of DIDP Lost During Sampling - 1 ($Q_{DIDP\_day} < 50$ kg/site-day)	$F_{sampling\_1}$	kg/kg	0.02	0.002	0.02	0.02	Triangular	See Section E.3.13
Fraction of DIDP Lost During Sampling - 2 (Q_{DIDP_day} 50-200 kg/site-day)	$F_{sampling\_2}$	kg/kg	0.005	0.0006	0.005	0.005	Triangular	See Section E.3.13
Fraction of DIDP Lost During Sampling - 3 (Q_{DIDP_day} 200-5000 kg/site-day)	$F_{sampling\_3}$	kg/kg	0.004	0.0005	0.004	0.004	Triangular	See Section E.3.13
Fraction of DIDP Lost During Sampling - 4 ($Q_{DIDP\_day} > 5000$ kg/site-day)	$F_{sampling\_4}$	kg/kg	0.0004	0.00008	0.0004	0.0004	Triangular	See Section E.3.13
Number of Sites	Ns	sites	11	—	—	—	—	See Section E.3.3

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Diameter of Tote Opening	$D_{cont\_clean\_tote}$	cm	5.08	—	—	—	—	See Section E.3.14
Diameter of Rail Car Opening	$D_{cont\_clean\_rail}$	cm	7.6	—	—	—	—	See Section E.3.14
Diameter of Opening for Equipment Cleaning	D_{equip_clean}	cm	92	—	—	—	—	See Section E.3.14
Vapor Pressure at 25C	VP	mmHg	5.28E−07	—	—	—	—	Physical property
Molecular Weight	MW	g/mol	446.68	—	—	—	—	Physical property
Gas Constant	R	atm-cm3/gmol-L	82.05	—	—	—	—	Universal constant
Temperature	T	K	298	—	—	—	—	Process parameter
Pressure	P	atm	1	—	—	—	—	Process parameter
Equipment cleaning loss fraction	LF_{equip_clean}	kg/kg	0.02	—	—	—	—	See Section E.3.15
Drum Fill Rate	$RATE_{fill\_drum}$	drums/hr	20	—	—	—	—	See Section E.3.16
Tote Fill Rate	$RATE_{fill\_tote}$	totes/hr	20	—	—	—	—	See Section E.3.16
Rail Car Fill Rate	$RATE_{fill\_cont}$	rail car/hr	1	—	—	—	—	See Section E.3.16
Density of DIDP	RHO	kg/L	0.9634	—	—	—	—	Physical property

E.3.3 Number of Sites

EPA used 2020 CDR data (U.S. EPA, 2020a) to identify the number of sites that import DIDP. In CDR, 10s sites reported importing DIDP. Table_Apx E-7 presents the names and locations of these sites.

Table_Apx E-7. Sites Reporting to CDR for Domestic Manufacture of DIDP

Facility Name	Facility Location
L.G. Hausys America, Inc.	Adairsville, GA
Harwick Standard Distribution Corp.	Akron, OH
Tremco Incorporated	Beachwood, OH
Akrochem Corp.	Stow, OH
Chemspec, Ltd.	Uniontown, OH
ICC Chemical Corp.	New York, NY
3M Company	St. Paul, MN
The Sherwin-Williams Company	Cleveland, OH
Sika Corp.	Lyndhurst, NJ
LG Chem America, Inc.	Atlanta, GA

E.3.4 Throughput Parameters

EPA ran seven unique scenarios for the import and repackaging OES: one unique scenario for each of the sites with known PVs, one scenario to estimate releases from three sites with CBI PVs for CASRN 26761-40-0, and one scenario to estimate releases from three sites with CBI PVs for CASRN 68515-49-1. Note that 3M Company reported manufacture of both CASRNs, so this site is included with both CBI estimates. EPA used 2020 CDR data (U.S. EPA, 2020a) to identify annual facility PVs for each site. Out of the 11 sites that reported importing DIDP in CDR, five sites provided a production volume. Table_Apx E-8 presents the known facilities and their DIDP production volumes.

Table_Apx E-8. Sites with Known Production Volumes in CDR

Facility Name	Facility Location	Production Volume (lbs)
LG Huasys America, Inc.	Adairsville, GA	26,223
Harwick Standard Distribution Corporation	Akron, OH	42,873
Tremco Incorporated	Beachwood, OH	800,201
Akrochem Corporation	Stow, OH	14,585
Chemspec, Ltd.	Uniontown, OH	52,472

For the other five sites, EPA used a uniform distribution set within the national PV range for each CASRN (DIDP encompasses two CASRNs). EPA calculated the bounds of the uniform distribution by taking the total PV range in CDR and subtracting out the known PVs (both MFG and import). Then, for each adjusted bound of the CDR range, EPA divided this value by the number of sites with CBI PVs for each CASRN.

For CASRN 26761-40-0, CDR estimates a total national DIDP PV of <1,000,000 lb EPA used this as a maximum value. Based on the known PVs from importers and manufacturers, the total PV associated with the remaining three sites with CBI PVs is 63,646 lb When divided equally among the three sites, this resulted in an estimated PV of 21,215 lbs (9,623 kg).

For CASRN 68515-49-1, CDR estimates a total national DIDP PV of 100,000,000 to 1,000,000,000 lb Based on the known PVs from importers and manufacturers, the total PV associated with the three sites with CBI PVs is 16,659,131 to 166,659,131 lbs/site-yr. Based on this (while converting pounds to kilograms), EPA set a uniform distribution with lower bound of 7,556,455 kg/site-yr, and an upper bound of 75,595,310 kg/site-yr.

The daily throughput of DIDP is calculated using Equation E-16 by dividing the annual production volume by the number of operating days. The number of operating days is determined according to Section E.3.7.

Equation E-16.

$$Q_{DIDP\_day} = \frac{PV}{OD}$$

Where:

Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
PV = Annual production volume [kg/site-yr]
OD = Operating days (see Section E.3.7) [days/yr]

E.3.5 Number of Containers per Year

The number of imported DIDP totes or rail cars unloaded by a site per year is calculated using the following equation:

Equation E-17.

$$N_{tote/rail\_unload\_yr} = \frac{PV}{RHO * \left(3.79\ \frac{L}{gal}\right) * V_{tote/rail}}$$

Where:

$V_{tote/rail}$ = Product container volume (see Section E.3.11) [gal/container]
PV = Facility production rate (see Section E.3.4) [kg/site-year]
RHO = DIDP density [kg/L]
$N_{tote/rail\_unload\_yr}$ = Annual number of totes or rail cars [tote or rail car/site-year]

The number of DIDP drums or rail cars loaded by a site per year is calculated using the following equation:

Equation E-18.

$$N_{drum/rail\_load\_yr} = \frac{PV}{RHO * \left(3.79\ \frac{L}{gal}\right) * V_{drum/rail}}$$

Where:

$V_{drum/rail}$ = Product container volume (see Section E.3.11) [gal/container]
PV = Facility production rate (see Section E.3.4) [kg/site-year]
RHO = DIDP density [kg/L]
$N_{drum/rail\_load\_yr}$ = Annual number of drums or rail cars [drum or rail car/site-year]

E.3.6 Operating Hours

EPA estimated operating hours or hours of duration using data provided from the *ChemSTEER User Guide* (U.S. EPA, 2015) and/or through calculation from other parameters. Release points with operating hours provided from the *ChemSTEER User Guide* include unloading, container cleaning, equipment cleaning, and loading into transport containers.

For unloading and container cleaning (release points 1 and 4), the operating hours are calculated based on the number of imported totes or rail cars unloaded at the site and the unloading rate using the following equation:

Equation E-19.

$$OH_{RP1/RP4} = \frac{N_{tote/rail\_unload\_yr}}{RATE_{fill\_tote/rail} * OD}$$

Where:

$OH_{RP1/RP4}$ = Operating time for release points 1 and 4 [hrs/site-day]
$RATE_{fill\_tote/rail}$ = Fill rate of container, dependent on volume (see Section E.3.16) [containers/hr]
$N_{tote/rail\_unload\_yr}$ = Annual number of totes or rail cars (see Section E.3.5) [tote or rail car/site-year]
OD = Operating days (see Section E.3.7) [days/site-year]

For equipment cleaning (release point 6), the *ChemSTEER User Guide* provides an estimate of four hours per day for cleaning multiple vessels (U.S. EPA, 2015).

For loading into transport containers (release point 7), the operating hours are calculated based on number of product containers filled per year, or on remaining time after accounting for container unloading. The operating hours are calculated using the following equation:

Equation E-20.

$$OH_{RP7} = \frac{N_{drum/rail\_load\_yr}}{RATE_{fill\_drum/rail} * OD}$$

Where:

OH_{RP7} = Operating time for release point 7 [hrs/site-day]
$RATE_{fill\_drum/rail}$ = Fill rate of container, dependent on volume (see Section E.3.16) [containers/hr]
$N_{drum/rail\_load\_yr}$ = Annual number of drums or rail cars (see Section E.3.5) [drum or rail car/site-year]
OD = Operating days (see Section E.3.7) [days/site-year]

E.3.7 Operating Days

EPA assessed the number of operating days associated with import and repackaging using employment data obtained through the U.S. BLS Occupational Employment Statistics (U.S. BLS, 2016). Per the U.S. BLS website, operating duration for each NAICS code is assumed as a 'year-round, full-time' hours figure of 2,080 hours (U.S. BLS, 2016). Therefore, dividing this time by an assumed working duration of 8-12 hours/day yields a number of operating days between 174-260 days/year. In order to account for differences in operating days, EPA assumed three types of shift durations with corresponding operating days per year: 8-hour, 10-hour, and 12-hour shifts. These shift durations correspond to 260, 208, and 174 operating days per year, respectively. Therefore, EPA used a discrete distribution with equal probability for each shift length/operating days combination to model this parameter.

E.3.8 Manufactured DIDP Concentration

For the five sites that had non-CBI production volumes in CDR, their DIDP concentration ranges were also listed in CDR. For each site, EPA used a uniform distribution with the upper and lower bounds as presented in Table_Apx E-9.

Table_Apx E-9. Sites with Known DIDP Concentrations in CDR

Facility Name	Facility Location	DIDP Concentration (%)
LG Huasys America, Inc.	Adairsville, GA	30-60
Harwick Standard Distribution Corporation	Akron, OH	90-100
Tremco Incorporated	Beachwood, OH	1-30
Akrochem Corporation	Stow, OH	30-60
Chemspec, Ltd.	Uniontown, OH	90-100

CDR Data from the remaining six sites indicated a concentration range of 1-100% DIDP (U.S. EPA, 2020a). According to the Australian Assessment Report and the European Risk Report for DIDP (NICNAS, 2015; ECJRC, 2003a), neat DIDP is typically handled at 99% or higher. Based on this information, EPA modeled the manufactured DIDP concentration for the other six sites using a triangular distribution with a lower bound of 1%, upper bound of 100%, and mode of 99%.

E.3.9 Air Speed

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

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

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

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

E.3.10 Saturation Factor

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

E.3.11 Container Size

EPA assessed container size based on the PV of each model run. For example, a site with a PV of over 100 million kg would likely use rail cars for transportation, as the volume would require an unreasonable number of smaller drums. Drums, totes, and rail cars were all used in this model. According to the *ChemSTEER User Guide*, drums are defined as containing between 20 and 100 gallons of liquid, and the default drum size is 55 gallons (U.S. EPA, 2015). Therefore, EPA modeled drum size using a triangular distribution with a lower bound of 20 gallons, an upper bound of 100 gallons, and a mode of 55 gallons. Totes are defined as containing between 100 and 1,000 gallons, with a default of 550 gallons. Therefore, EPA modeled tote size using a triangular distribution with a lower bound of 100 gallons, an upper bound of 1,000 gallons, and a mode of 550 gallons. Rail cars are defined as containing 10,000 or more gallons. The default rail car size is 20,000 gallons (U.S. EPA, 2015). Therefore, EPA modeled rail car size using a triangular distribution with a lower bound of 10,000 gallons and an upper bound and mode of 20,000 gallons.

E.3.12 Bulk Container Residue Loss Fraction

EPA paired the data from the PEI Associates Inc. study (Associates, 1988) such that the residuals data for emptying tanks by gravity-draining was aligned with the default central tendency and high-end values from the *EPA/OPPT Bulk Transport Residual Model*. For unloading tanks by gravity-draining in the PEI Associates Inc. study, EPA found that the average percent residual from the pilot-scale experiments showed a range of 0.02 percent to 0.19 percent and an average of 0.06 percent (Associates, 1988). The *EPA/OPPT Bulk Transport Residual Model* from the *ChemSTEER User Guide* (U.S. EPA, 2015) recommends a default central tendency loss fraction of 0.07 percent and a high-end loss fraction of 0.2 percent.

The underlying distribution of the loss fraction parameter for bulk containers is not known; therefore, EPA assigned a triangular distribution, since triangular distributions require least assumptions and are completely defined by range and mode of a parameter. EPA assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the *EPA/OPPT Bulk Transport Residual Model* in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study for emptying tanks by gravity-draining (Associates, 1988).

E.3.13 Sampling Loss Fraction

Sampling loss fractions were estimated using the *March 2023 Methodology for Estimating Environmental Releases from Sampling Wastes* (U.S. EPA, 2023b). In this methodology, EPA completed a search of over 300 IRERs completed in the years 2021 and 2022 for sampling release data, including a similar proportion of both PMNs and Low Volume Exemptions (LVEs). Of the searched IRERs, 60 data points for sampling release loss fractions, primarily for sampling releases from submitter-controlled sites (~75% of IRERs), were obtained. The data points were analyzed as a function of the chemical daily throughput and industry type. This analysis showed that the sampling loss fraction generally decreased as the chemical daily throughput increased. Therefore, the methodology provides guidance for selecting a loss fraction based on chemical daily throughput. Table_Apx E-10 presents a summary of the chemical daily throughputs and corresponding loss fractions.

Table_Apx E-10. Sampling Loss Fraction Data from the March 2023 Methodology for Estimating Environmental Releases from Sampling Waste

Chemical Daily Throughput (kg/site-day) ($Q_{chem\_site\_day}$)	Number of Data Points	Sampled Quantity (kg chemical/day)		Sampling Loss Fraction ($LF_{sampling}$)	
		50th Percentile	95th Percentile	50th Percentile	95th Percentile
<50	13	0.03	0.20	0.002	0.02
50 to <200	10	0.10	0.64	0.0006	0.005
200 to <5,000	25	0.37	3.80	0.0005	0.004
≥5,000	10	1.36	6.00	0.00008	0.0004
All	58	0.20	5.15	0.0005	0.008

For each range of daily throughputs, EPA estimated sampling loss fractions using a triangular distribution of the 50th percentile value as the lower bound, and the 95th percentile value as the upper bound and mode. The sampling loss fraction distribution was chosen based on the calculation of daily throughput, as shown in Section E.3.4

E.3.14 Diameters of Opening

The *ChemSTEER User Guide* indicates diameters for the openings for various vessels that may hold liquids in order to calculate vapor generation rates during different activities (U.S. EPA, 2015). For equipment cleaning operations, the *ChemSTEER User Guide* indicates a single default value of 92 cm (U.S. EPA, 2015).

For container cleaning activities, the *ChemSTEER User Guide* indicates a single default value of 5.08 cm for containers less than 5,000 gallons, and 7.6 cm for containers greater than or equal to 5,000 gallons (U.S. EPA, 2015).

E.3.15 Equipment Cleaning Loss Fraction

EPA used the *EPA/OPPT Multiple Process Residual Model* to estimate the releases from equipment cleaning. The *EPA/OPPT Multiple Process Residual Model*, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015), provides an overall loss fraction of 2 percent from equipment cleaning.

E.3.16 Container Fill Rates

The *ChemSTEER User Guide* (U.S. EPA, 2015) provides a typical fill rate of 20 containers per hour for containers with 20 to 100 gallons of liquid and a typical fill rate of one container per hour for containers with over 10,000 gallons of liquid.

E.4 Incorporation into Adhesives and Sealants Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DIDP during the incorporation into adhesives and sealants OES. This approach utilizes the *Emission Scenario Document on Adhesive Formulation* (OECD, 2009a) and CDR data (U.S. EPA, 2020a) combined with Monte Carlo simulation (a type of stochastic simulation).

Based on the ESD, EPA identified the following release sources from incorporation into adhesives and sealants:

- Release source 1: Transfer Operation Losses to Air from Unloading Adhesive Component.
- Release source 2: Dust Generation from Transfer Operations.
- Release source 3: Container Cleaning Wastes.
- Release source 4: Open Surface Losses to Air During Container Cleaning.
- Release source 5: Vented Losses to Air During Dispersion and Blending.
- Release source 6: Product Sampling Wastes.
- Release source 7: Open Surface Losses to Air During Product Sampling.
- Release source 8: Equipment Cleaning Wastes.
- Release source 9: Open Surface Losses to Air During Equipment Cleaning.
- Release source 10: Transfer Operation Losses to Air from Packaging Adhesive/ Sealant into Transport Containers.
- Release source 11: Off-Spec and Other Waste Adhesive.

Environmental releases for DIDP during incorporation into adhesives and sealants are a function of DIDP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: production volume, DIDP concentrations, air speed, saturation factor, container size, loss fractions, diameters of openings, and operating durations. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.4.1 Model Equations

Table_Apx E-11 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the incorporation into adhesives and sealants OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix E.4.2. The Monte Carlo simulation calculated the total DIDP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th percentile and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx E-11. Models and Variables Applied for Release Sources in the Incorporation into Adhesives and Sealants OES

Release source	Model(s) Applied	Variables Used
Release source 1: Transfer Operation Losses to Air from Unloading Adhesive Component.	*EPA/OAQPS AP-42 Loading Model* (Appendix E.1)	Vapor Generation Rate: F_{DIDP_import}; VP; f_{sat}; MW; R; T; $RATE_{fill\_drum\_tote}$ Operating Time: Q_{DIDP_year}; V_{cont}; $RATE_{fill\_drum\_tote}$; RHO; OD
Release source 2: Dust Generation from Transfer Operations.	Not Assessed for liquid DIDP.	N/A
Release source 3: Container Cleaning Wastes.	*EPA/OPPT Drum Residual Model* (Appendix E.1)	Q_{DIDP_year}; LF_{drum}; V_{cont}; RHO; OD
Release source 4: Open Surface Losses to Air During Container Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP_import}; MW; VP; $RATE_{air\_speed}$; D_{cont_clean}; T; P Operating Time: Q_{DIDP_year}; V_{cont}; $RATE_{fill\_drum\_tote}$; RHO; OD
Release source 5: Vented Losses to Air During Dispersion and Blending.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP_final}; MW; VP; $RATE_{air\_speed}$; D_{blend}; T; P Operating Time: Q_{DIDP_year}; Q_{batch}; OD
Release source 6: Product Sampling Wastes.	*March 2023 Methodology for Estimating Environmental Releases from Sampling Waste* (Appendix E.1)	Q_{DIDP_day}; $LF_{sampling}$
Release source 7: Open Surface Losses to Air During Product Sampling.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP_final}; MW; VP; $RATE_{air\_speed}$; $D_{sampling}$; T; P Operating Time: $OH_{sampling}$
Release source 8: Equipment Cleaning Wastes.	*EPA/OPPT Multiple Process Vessel Residual Model* (Appendix E.1)	Q_{DIDP_day}; LF_{equip_clean}
Release source 9: Open Surface Losses to Air During Equipment Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP_final}; MW; VP; $RATE_{air\_speed}$; D_{equip_clean}; T; P Operating Time: OH_{equip_clean}
Release source 10: Transfer Operation Losses to Air from Packaging Adhesive/ Sealant into Transport Containers.	*EPA/OAQPS AP-42 Loading Model (*Appendix E.1)	Vapor Generation Rate: F_{DIDP_final}; VP; f_{sat}; MW; R; T; $V_{cont\_packaged}$; $RATE_{fill\_cont}$; $RATE_{fill\_drum\_tote}$; OD;

Release source	Model(s) Applied	Variables Used
		Operating Time: PV; $V_{cont\_packaged}$; $RATE_{fill\_cont}$; RHO; OD; Q_{DIDP_year}; V_{cont}; $RATE_{fill\_drum\_tote}$; $RATE_{fill\_adjusted}$
Release source 11: Off-Spec and Other Waste Adhesive.	See Equation E-21	Q_{DIDP_day}; $LF_{offspec}$

Release source 11 daily release (Off-Spec and Other Waste Adhesive) is calculated using the following equation:

Equation E-21.

$$Release\_perDay_{RP11} = Q_{DIDP\_day} * LF_{offspec}$$

Where:

$Release\_perDay_{RP11}$ = DIDP released for release source 11 [kg/site-day]
Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
$LF_{offspec}$ = Loss fraction for off-spec and waste adhesive [unitless]

E.4.2 Model Input Parameters

Table_Apx E-12 summarizes the model parameters and their values for the Incorporation into Adhesives and Sealants Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after Table_Apx E-12.

Table_Apx E-12. Summary of Parameter Values and Distributions Used in the Incorporation into Adhesives and Sealants Model

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Total PV of DIDP at All Sites	PV_{total}	kg/yr	1,679,970	374,305	1,679,970	—	Uniform	See Section E.4.3
Initial DIDP Concentration	F_{DIDP_import}	kg/kg	0.6	0.3	0.6	—	Uniform	See Section E.4.7
Final DIDP Concentration	F_{DIDP_final}	kg/kg	0.01	0.001	0.6	0.01	Triangular	See Section E.4.8
Air Speed	$RATE_{air\_speed}$	ft/min	19.7	2.56	398	—	Lognormal	See Section E.4.9
Saturation Factor	f_{sat}	dimensionless	0.5	0.5	1.45	0.5	Triangular	See Section E.4.10
Import Container Size	V_{cont}	gal	55	20	100	55	Triangular	See Section E.4.11
Drum Residual Loss Fraction	LF_{drum}	kg/kg	0.025	0.017	0.03	0.025	Triangular	See Section E.4.12
Fraction of DIDP Lost During Sampling - 1 ($Q_{DIDP\_day} < 50$ kg/site-day)	$F_{sampling\_1}$	kg/kg	0.02	0.002	0.02	0.02	Triangular	See Section E.4.13
Fraction of DIDP Lost During Sampling - 2 (Q_{DIDP_day} 50-200 kg/site-day)	$F_{sampling\_2}$	kg/kg	0.005	0.0006	0.005	0.005	Triangular	See Section E.4.13
Fraction of DIDP Lost During Sampling - 3 (Q_{DIDP_day} 200-5000 kg/site-day)	$F_{sampling\_3}$	kg/kg	0.004	0.0005	0.004	0.004	Triangular	See Section E.4.13

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Fraction of DIDP Lost During Sampling - 4 (Q_{DIDP_day} > 5000 kg/site-day)	$F_{sampling\_4}$	kg/kg	0.0004	0.00008	0.0004	0.0004	Triangular	See Section E.4.13
Diameter of Opening-Blending	D_{blend}	cm	10	10	168.92	—	Uniform	See Section E.4.14
Diameter of Opening – Sampling	$D_{sampling}$	cm	2.5	2.5	10	—	Uniform	See Section E.4.14
Hours per Batch for Equipment Cleaning	$OH_{batch\_equip\_clean}$	hours/batch	4	1	4	4	Triangular	See Section E.4.15
Packaged Container Size	$V_{cont\_packaged}$	gal	55	0.10	100	55	Triangular	See Section E.4.11
Vapor Pressure at 25C	VP	mmHg	5.28E−07	—	—	—	—	Physical property
Molecular Weight	MW	g/mol	446.68	—	—	—	—	Physical property
Gas Constant	R	atm-cm3/gmol-L	82.05	—	—	—	—	Universal constant
Density of DIDP	RHO	kg/L	0.9634	—	—	—	—	Physical property
Temperature	T	K	298	—	—	—	—	Process parameter
Pressure	P	atm	1	—	—	—	—	Process parameter
Operating Days	OD	days/yr	250	—	—	—	—	See Section E.4.16
Batch Size	Q_{batch}	kg/batch	4000	—	—	—	—	See Section E.4.17
Drum and Tote Fill Rate	$RATE_{fill\_drum\_tote}$	containers/hr	20	—	—	—	—	See Section E.4.18
Small Container Fill Rate	$RATE_{fill\_cont}$	containers/hr	60	—	—	—	—	See Section E.4.18

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Diameter of Opening – Container Cleaning	D_{cont_clean}	cm	5.08	—	—	—	—	See Section E.4.14
Diameter of Opening – Equipment Cleaning	D_{equip_clean}	cm	92	—	—	—	—	See Section E.4.14
Sampling Duration	$OH_{sampling}$	hr/day	1	—	—	—	—	See Section E.4.6
Equipment Cleaning Loss Fraction	LF_{equip_clean}	kg/kg	0.02	—	—	—	—	See Section E.4.19
Off-Spec and Waste Loss Fraction	$LF_{offspec}$	kg/kg	0.01	—	—	—	—	See Section E.4.20

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E.4.3 Number of Sites

Per 2020 U.S. Census Bureau data for NAICS code 32552 (Adhesives Manufacturing), there are 540 Adhesive/ Sealant formulation sites (U.S. BLS, 2016). Therefore, this value is used as a bounding limit, not to be exceeded by the calculation. Number of sites is calculated using the following equation.:

Equation E-22.

$$N_s = \frac{PV}{Q_{DIDP\_year}}$$

Where:

N_s = Number of sites [sites]
PV = Production volume (see Section E.4.4) [kg/year]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.4.4) [kg/site-yr]

E.4.4 Throughput Parameters

EPA estimated the total production volume for all sites using a uniform distribution with a lower bound of 374,305 kg/yr and an upper bound of 1,679,970 kg/yr.

The lower bound is based on CDR data (U.S. EPA, 2020a). Three entries in CDR list adhesive and sealant use as the expected end use for DIDP. However, two entries are for the same company (Sika Corporation). Tremco Incorporated did not report how much of their PV is used in adhesives and sealants, but there were no other entries from this company in CDR. Therefore, EPA assumed 100% of the site's PV is used in adhesives and sealants. The two entries for Sika Corporation list the PV as CBI. For their two sites, EPA assumes a combined PV of 25,000 lbs based on the reporting threshold for reporting processing and use information in CDR. Therefore, EPA calculates the lower bound for national PV used in adhesive and sealants as the sum of the non-CBI PV (800,201 lbs or 362,965 kg) and the combined site CDR threshold PV (25,000 lb. or 11,340 kg) for a total of 374,305 kg/yr used in adhesives and sealants.

The upper bound is based on CDR data (U.S. EPA, 2020a) and the 2003 European Union Risk Assessment on DIDP (ECJRC, 2003b). The EU Risk Assessment found that only 1.1% of the DIDP produced goes to non-PVC, non-polymer end use categories. As this Risk Evaluation includes three OESs that fall under this category, EPA assumes that each category accounts for an equal amount to this percentage (*i.e.*, 0.37% each). CDR states that the total U.S. national production volume of DIDP is 1.001 billion lbs/yr. Multiplying this figure by 0.37% results in 3,703,700 lbs/yr (1,679,970 kg/yr).

The annual throughput of DIDP is calculated using Equation E-23 by multiplying batch size by the concentration of DIDP in the final adhesive product and by operating days. Batch size is determined according to Section E.4.17 and operating days is determined according to Section E.4.16. EPA assumes the number of batches is equal to the number of operating days.

Equation E-23.

$$Q_{DIDP\_year} = Q_{batch} * OD * F_{DIDP_{final}} * N_{batch\_day}$$

Where:

Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
Q_{batch} = Adhesive/ Sealant batch size (see Section E.4.17) [kg/batch]

OD = Operating days (see Section E.4.16) [days/yr]
F_{DIDP_final} = Concentration of DIDP in final Adhesive/ Sealant (see Section E.4.8) [kg/kg]
N_{batch_day} = Number of batches per day of Adhesive/ Sealant (default of 1) [batch/day]

The daily throughput of DIDP is calculated using Equation E-24 by dividing the annual production volume by the number of operating days. The number of operating days is determined according to Section E.4.16.

Equation E-24.

$$Q_{DIDP\_day} = \frac{Q_{DIDP\_year}}{OD}$$

Where:

Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
OD = Operating days (see Section E.4.16) [days/yr]

E.4.5 Number of Containers per Year

The number of DIDP raw material containers received and unloaded by a site per year is calculated using the following equation:

Equation E-25.

$$N_{cont\_unload\_yr} = \frac{Q_{DIDP\_year}}{RHO * \left(3.79\ \frac{L}{gal}\right) * V_{cont}}$$

Where:

V_{cont} = Import container volume (see Section E.4.11) [gal/container]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.4.3) [kg/site-yr]
RHO = DIDP density [kg/L]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded [container/site-year]

The number of product containers loaded by a site per year is calculated using the following equation:

Equation E-26.

$$N_{cont\_load\_yr} = \frac{Q_{DIDP\_year}}{RHO * \left(3.79\ \frac{L}{gal}\right) * V_{cont\_packaged}}$$

Where:

$V_{cont\_packaged}$ = Product container volume (see Section E.4.11) [gal/container]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.4.3) [kg/site-yr]
RHO = DIDP density [kg/L]
$N_{cont\_load\_yr}$ = Annual number of containers loaded [container/site-year]

E.4.6 Operating Hours

EPA estimated operating hours or hours of duration using data provided from the *ESD for Adhesive Formulation* (OECD, 2009a), *ChemSTEER User Guide* (U.S. EPA, 2015), and/or through calculation from other parameters. Release points with operating hours provided from these sources include unloading, container cleaning, blending/process operations, product sampling, equipment cleaning, and loading into transport containers.

For unloading and container cleaning (release points 1 and 4), the operating hours are calculated based on the number of containers unloaded at the site and the unloading rate using the following equation:

Equation E-27.

$$OH_{RP1/RP4} = \frac{N_{cont\_unload\_yr}}{RATE_{fill\_drum\_tote} * OD}$$

Where:

$OH_{RP1/RP4}$ = Operating time for release points 1 and 4 [hrs/site-day]
$RATE_{fill\_drum\_tote}$ = Fill rate of drums and totes (see Section E.4.18) [containers/hr]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded (see Section E.4.5) [container/site-year]
OD = Operating days (see Section E.4.16) [days/site-year]

For blending/process operations (release point 5), the *ESD for Adhesive Formulation* (OECD, 2009a) recommends using the following equation:

Equation E-28.

$$OH_{RP5} = \left(\frac{Q_{DIDP\_year}}{Q_{batch} * OD}\right) * 8\frac{hrs}{day}$$

Where:

OH_{RP5} = Operating time for release point 5 [hrs/site-day]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.4.3) [kg/site-yr]
Q_{batch} = Average batch size (see Section E.4.17) [kg/batch]
OD = Operating days (see Section E.4.16) [days/site-year]

For product sampling (release point 7), the *ChemSTEER User Guide* (U.S. EPA, 2015) indicates a value of 1 hour/day.

For equipment cleaning (release point 9), the *ESD for Adhesive Formulation* (OECD, 2009a) provides an estimate of four hours per batch based on the value for cleaning multiple vessels from the *ChemSTEER User Guide* (U.S. EPA, 2015). The *ESD for Adhesive Formulation* also states that a case study conducted by the Pollution Prevention Assistance Division indicated a range of equipment cleaning times between one and three hours per batch. The underlying distribution of this parameter is not known; therefore, EPA assigned a triangular distribution based on a lower bound, upper bound, and mode for equipment cleaning operating hours. EPA assigned the lower bound as one hour based on the lower end cleaning time observed in the case study (OECD, 2009a) and the upper bound as four hours based on the *ChemSTEER User Guide* default value for this worker activity. For the mode, EPA assigned four hours based on the *ESD for Adhesive Formulation* (OECD, 2009a). EPA calculated the equipment cleaning operating hours using the following equation:

Equation E-29.

$$OH_{RP9} = \left(\frac{Q_{DIDP\_year}}{Q_{batch} * OD}\right) * OH_{batch\_equip\_clean}$$

Where:

OH_{RP9} = Operating time for release point 9 [hrs/site-day]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.4.3) [kg/site-yr]
Q_{batch} = Average batch size (see Section E.4.17) [kg/batch]
OD = Operating days (see Section E.4.16) [days/site-year]
$OH_{batch\_equip\_clean}$ = Duration for batch equipment cleaning (see Section E.4.6) [hrs/batch]

For loading into transport containers (release point 10), the operating hours are calculated based on number of product containers filled per year unless the operating hours per day exceeds 24 hours. If the total operating hours exceeds 24 hours, the duration for loading containers is estimated as the remaining time after accounting for container unloading. The operating hours are calculated using the following equation:

Equation E-30.

$$OH_{RP10} = \begin{cases} \dfrac{N_{cont\_load\_yr}}{RATE_{fill\_cont} * OD}, & \dfrac{N_{cont\_load\_yr}}{RATE_{fill\_cont} * OD} \leq [24 - OH_{RP1/RP4}] \\ 24 - OH_{RP1/RP4}, & \dfrac{N_{cont\_load\_yr}}{RATE_{fill\_cont} * OD} > [24 - OH_{RP1/RP4}] \end{cases}$$

Where:

OH_{RP10} = Operating time for release point 10 [hrs/site-day]
$RATE_{fill\_cont}$ = Fill rate of containers (see Section E.4.18) [containers/hr]
$N_{cont\_load\_yr}$ = Annual number of containers loaded (see Section E.4.5) [container/site-year]
OD = Operating days (see Section E.4.16) [days/site-year]
$OH_{RP1/RP4}$ = Operating time for release points 1 and 4 [hrs/site-day]

E.4.7 Initial DIDP Concentration

EPA modeled the initial DIDP concentration using a uniform distribution with a lower bound of 30% and upper bound of 60% based on information reported in the 2020 CDR by sites indicating DIDP use in adhesives and sealants (U.S. EPA, 2020a).

E.4.8 Final DIDP Concentration

EPA modeled final DIDP concentration in adhesives and sealants using a triangular distribution with a lower bound of 0.1%, upper bound of 60%, and mode of 1%. The upper bound is based on the upper bound for imported DIDP concentration. The concentration of DIDP in the adhesive or sealant cannot be higher than the concentration of neat DIDP that was imported. The lower bound and mode is based on compiled SDS information for adhesives and sealant products containing DIDP. EPA did not have information on the prevalence or market share of different Adhesive/ Sealant products in commerce; therefore, EPA assumed a triangular distribution of concentrations. From the compiled data, the minimum concentration was 0.1% and the mode of high-end product concentrations was 1% (see Appendix F for EPA identified DIDP-containing products for this OES)

E.4.9 Air Speed

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

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

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

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

E.4.10 Saturation Factor

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

E.4.11 Container Size

EPA assumed that adhesive and sealant manufacturing sites would receive DIDP in drums. According to the *ESD for Adhesive Formulation* (OECD, 2009a), 55-gallon drums are expected to be the default container size for adhesives and sealant components. According to the *ChemSTEER User Guide*, drums are defined as containing between 20 and 100 gallons of liquid, and the default drum size is 55 gallons (U.S. EPA, 2015). Therefore, EPA modeled import container size using a triangular distribution with a lower bound of 20 gallons, an upper bound of 100 gallons, and a mode of 55 gallons.

For packaging of adhesives and sealants after production, EPA identified products in bottles as small as 0.1 gallons, in small containers, and in drums. According to the *ESD for Adhesive Formulation* (OECD, 2009a), 55-gallon drums are expected to be the default container size for finished adhesives and sealants. Therefore, EPA modeled finished adhesive container size using a triangular distribution with a lower bound of 0.1 gallons, an upper bound of 100 gallons, and a mode of 55 gallons.

E.4.12 Drum Residue Loss Fraction

EPA paired the data from the PEI Associates Inc. study (Associates, 1988) such that the residuals data for emptying drums by pumping was aligned with the default central tendency and high-end values from the *EPA/OPPT Drum Residual Model*. For unloading drums by pumping in the PEI Associates Inc. study, EPA found that the average percent residual from the pilot-scale experiments showed a range of 1.7 percent to 4.7 percent and an average of 2.6 percent. The *EPA/OPPT Drum Residual Model* from the ChemSTEER User Guide recommends a default central tendency loss fraction of 2.5 percent and a high-end loss fraction of 3.0 percent (U.S. EPA, 2015).

The underlying distribution of the loss fraction parameter for drums is not known; therefore, EPA assigned a triangular distribution, since triangular distributions require least assumptions and are completely defined by range and mode of a parameter. EPA assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the *EPA/OPPT Drum Residual Model* in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study (Associates, 1988) for emptying drums by pumping.

E.4.13 Sampling Loss Fraction

Sampling loss fractions were estimated using the *March 2023 Methodology for Estimating Environmental Releases from Sampling Wastes* (U.S. EPA, 2023b). In this methodology, EPA completed a search of over 300 IRERs completed in the years 2021 and 2022 for sampling release data, including a similar proportion of both PMNs and Low Volume Exemptions (LVEs). Of the searched IRERs, 60 data points for sampling release loss fractions, primarily for sampling releases from submitter-controlled sites (~75% of IRERs), were obtained. The data points were analyzed as a function of the chemical daily throughput and industry type. This analysis showed that the sampling loss fraction generally decreased as the chemical daily throughput increased. Therefore, the methodology provides guidance for selecting a loss fraction based on chemical daily throughput. Table_Apx E-13 presents a summary of the chemical daily throughputs and corresponding loss fractions.

Table_Apx E-13. Sampling Loss Fraction Data from the March 2023 Methodology for Estimating Environmental Releases from Sampling Waste

Chemical Daily Throughput (kg/site-day) ($Q_{chem\_site\_day}$)	Number of Data Points	Sampled Quantity (kg chemical/day)		Sampling Loss Fraction ($LF_{sampling}$)	
		50th Percentile	95th Percentile	50th Percentile	95th Percentile
<50	13	0.03	0.20	0.002	0.02
50 to <200	10	0.10	0.64	0.0006	0.005
200 to <5,000	25	0.37	3.80	0.0005	0.004
≥5,000	10	1.36	6.00	0.00008	0.0004
All	58	0.20	5.15	0.0005	0.008

For each range of daily throughputs, EPA estimated sampling loss fractions using a triangular distribution of the 50th percentile value as the lower bound, and the 95th percentile value as the upper bound and mode. The sampling loss fraction distribution was chosen based on the calculation of daily throughput, as shown in Section E.4.3.

E.4.14 Diameters of Opening

The *ChemSTEER User Guide* indicates diameters for the openings for various vessels that may hold liquids in order to calculate vapor generation rates during different activities (U.S. EPA, 2015). For equipment cleaning operations, the *ChemSTEER User Guide* indicates a single default value of 92 cm (U.S. EPA, 2015).

For container cleaning activities, the *ChemSTEER User Guide* indicates a single default value of 5.08 cm for containers less than 5,000 gallons (U.S. EPA, 2015).

For sampling liquid product, sampling liquid raw material, or general liquid sampling, the *ChemSTEER User Guide* indicates that the typical diameter of opening for vaporization of the liquid is 2.5 cm (U.S. EPA, 2015). Additionally, the *ChemSTEER User Guide* provides ten cm as a high-end value for the diameter of opening during sampling (U.S. EPA, 2015). The underlying distribution of this parameter is not known; therefore, EPA assigned a triangular distribution based on the estimated lower bound, upper bound, and mode of the parameter. EPA assigned the value of 2.5 cm as a lower bound for the parameter and ten cm as the upper bound based on the values provided in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA also assigned 2.5 cm as the mode diameter value for sampling liquids based on the typical value described in *ChemSTEER User Guide* (U.S. EPA, 2015).

For blending operations, the *ESD for Adhesive Formulation* (OECD, 2009a)and *GS for Formulation of Waterborne Coatings* (U.S. EPA, 2014a) assumes a closed vessel with a 4-inch diameter process vent, corresponding to ten cm in diameter. In addition, EPA considered the potential for open process vessels used for blending as mentioned in both the *ESD for Adhesive Formulation* (OECD, 2009a) and *GS for Formulation of Waterborne Coatings* (U.S. EPA, 2014a), with diameters of the open vessel calculated based on the batch volume for the simulation iteration and the assumption in the ESD and GS of a one-to-one height to diameter ratio for the process vessel. The underlying distribution of this parameter is not known; therefore, EPA assigned a triangular distribution defined by an estimated lower bound, upper bound, and mode of the parameter. EPA assigned the value of ten cm for both the lower bound and mode of the triangular distribution as the recommended value by the *ESD for Adhesive Formulation* (OECD, 2009a) and *GS for Formulation of Waterborne Coatings* (U.S. EPA, 2014a). For the upper bound value of the triangular distribution, EPA assigned an equation calculating the diameter of an open process vessel with a one-to-one height to diameter ratio and fixed batch volume of approximately 1,000 gallons based on the batch size discussed in Section E.4.17:

Equation E-31.

$$D_{blending\_max} = \left[\frac{4 * V_{batch} * 3785.41\,\frac{cm^3}{gal}}{\pi}\right]^{1/3}$$

E.4.15 Hours per Batch for Equipment Cleaning

The *ESD for Adhesive Formulation* (OECD, 2009a) cites a cleaning time per batch of one to four hours and suggests that a value of four hours per cleaning be used for model defaults. Therefore, EPA modeled this parameter via a triangular distribution with a lower bound of one hour/batch, upper bound of four hours/batch, and mode of four hours/batch.

E.4.16 Operating Days

EPA was unable to identify DIDP-specific information for operating days in the production of adhesives and sealants. Therefore, EPA assumes a constant value of 250 days/yr, which assumes the production sites operate five days per week and 50 weeks per year, with two weeks down for turnaround.

E.4.17 Batch Size

The *ESD for Adhesive Formulation* (OECD, 2009a) cites a default batch size of 4,000 kg adhesive per batch with an approximate batch volume of 1,000 gallons.

E.4.18 Container Fill Rates

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

To account for situations where operating times for container unloading and loading exceeded a 24-hour period in the simulation, EPA applied an equation to determine a corrected fill rate that would replace the deterministic values provided in the *ChemSTEER User Guide*. The equation for the corrected fill rate in cases where operating time for unloading and loading is greater than 24 hours is included below. EPA only used the corrected fill rate for loading product containers (release point 10).

Equation E-32.

$$if\ 24 < (OH_{RP1/RP4} + OH_{RP10}), RATE_{fill\_adjusted} = \frac{N_{cont\_load\_yr}}{(24 - OH_{RP1/RP4}) * OD}$$

Where:

$RATE_{fill\_adjusted}$ = Corrected fill rate for product containers [containers/hr]
$N_{cont\_load\_yr}$ = Annual number of product containers [containers/site-year]
OH_n = Operating time for release point “n” [hrs/site-day]
OD = Operating days [days/site-year]

E.4.19 Equipment Cleaning Loss Fraction

EPA used the *EPA/OPPT Multiple Process Residual Model* to estimate the releases from equipment cleaning. The *EPA/OPPT Multiple Process Residual Model*, as detailed in the ChemSTEER User Guide (U.S. EPA, 2015) provides an overall loss fraction of 2 percent from equipment cleaning.

E.4.20 Off-Spec Loss Fraction

The *ESD for Adhesive Formulation* (OECD, 2009a) and *GS for Formulation of Waterborne Coatings* (U.S. EPA, 2014a) provides a loss fraction of one percent of throughput disposed from off-specification material during manufacturing. The one percent default loss fraction was provided as an estimate from a Source Reduction Research Partnership (SRRP) study referenced in the *ESD for Adhesive Formulation* (OECD, 2009a).

E.5 Incorporation into Paints and Coatings Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DIDP during the incorporation into paints and coatings OES. This approach utilizes the *Generic*

Scenario for Formulation of Waterborne Coatings (U.S. EPA, 2014a) and CDR data (U.S. EPA, 2020a) combined with Monte Carlo simulation (a type of stochastic simulation).

Based on the ESD, EPA identified the following release sources from incorporation into paints and coatings:

- Release source 1: Transfer Operation Losses to Air from Unloading Paint Component.
- Release source 2: Dust Generation from Transfer Operations.
- Release source 3: Container Cleaning Wastes.
- Release source 4: Open Surface Losses to Air During Container Cleaning.
- Release source 5: Vented Losses to Air During Blending/Process Operations.
- Release source 6: Product Sampling Wastes.
- Release source 7: Open Surface Losses to Air During Product Sampling.
- Release source 8: Equipment Cleaning Wastes.
- Release source 9: Open Surface Losses to Air During Equipment Cleaning.
- Release source 10: Filter Waste Losses.
- Release source 11: Open Surface Losses to Air During Filter Media Replacement.
- Release source 12: Transfer Operation Losses to Air from Packaging Paint/Coating into Transport Containers.
- Release source 13: Off-Spec and Other Waste Paint/Coatings.

Environmental releases for DIDP during incorporation into paints and coatings are a function of DIDP’s physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: production volume and rate, DIDP concentrations, air speed, saturation factor, container size, loss fractions, diameters of openings, and operating durations. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.5.1 Model Equations

Table_Apx E-14 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the incorporation into paints and coatings OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix E.5.2. The Monte Carlo simulation calculated the total DIDP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th percentile and 95th percentile values to estimate the central tendency and high-end releases, respectively.

6332 **Table_Apx E-14. Models and Variables Applied for Release Sources in the Incorporation into**
6333 **Paints and Coatings OES**

Release Source	Model(s) Applied	Variables Used
Release source 1: Transfer Operation Losses to Air from Unloading Paint Component.	*EPA/OAQPS AP-42 Loading Model* (Appendix E.1)	Vapor Generation Rate: F_{DIDP_import}; VP; f_{sat}; MW; R; T; V_{cont}; $RATE_{fill\_drum\_tote}$ Operating Time: Q_{DIDP_year}; V_{cont}; $RATE_{fill\_drum\_tote}$; RHO; OD
Release source 2: Dust Generation from Transfer Operations.	Not Assessed for liquid DIDP.	N/A
Release source 3: Container Cleaning Wastes.	*EPA/OPPT Drum Residual Model* (Appendix E.1)	LF_{drum}; V_{cont}; Q_{DIDP_year}; V_{cont}; RHO; OD
Release source 4: Open Surface Losses to Air During Container Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP_import}; MW; VP; $RATE_{air\_speed}$; D_{cont_clean}; T; P Operating Time: Q_{DIDP_year}; V_{cont}; $RATE_{fill\_drum\_tote}$; RHO; OD
Release source 5: Vented Losses to Air During Blending/Process Operations.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP_final}; MW; VP; $RATE_{air\_speed}$; D_{blend}; T; P Operating Time: Q_{DIDP_year}; Q_{DIDP_batch}; OD
Release source 6: Product Sampling Wastes.	*March 2023 Methodology for Estimating Environmental Releases from Sampling Waste* (Appendix E.1)	Q_{DIDP_day}; $LF_{sampling}$
Release source 7: Open Surface Losses to Air During Product Sampling.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP_final}; MW; VP; $RATE_{air\_speed}$; $D_{sampling}$; T; P Operating Time: $OH_{sampling}$
Release source 8: Equipment Cleaning Wastes.	*EPA/OPPT Multiple Process Vessel Residual Model* (Appendix E.1)	Q_{DIDP_day}; LF_{equip_clean}
Release source 9: Open Surface Losses to Air During Equipment Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP_final}; MW; VP; $RATE_{air\_speed}$; D_{equip_clean}; T; P Operating Time: $OH_{batch\_equip\_clean}$; Q_{DIDP_year}; Q_{DIDP_batch}; OD

Release Source	Model(s) Applied	Variables Used
Release source 10: Filter Waste Losses.	No available data or models for estimation. Estimate on a case-by-case basis.	N/A
Release source 11: Open Surface Losses to Air During Filter Media Replacement	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP_final}; MW; VP; $RATE_{air\_speed}$; D_{filter}; T; P Operating Time: OH_{filter}
Release source 12: Transfer Operation Losses to Air from Packaging Paint/Coating into Transport Containers.	*EPA/OAQPS AP-42 Loading Model* (Appendix E.1)	Vapor Generation Rate: F_{DIDP_final}; VP; f_{sat}; MW; R; T; $V_{cont\_packaged}$ Operating Time: Q_{DIDP_year}; $V_{cont\_packaged}$; $RATE_{fill\_cont}$; RHO; OD; $RATE_{fill\_adjusted}$
Release source 13: Off-Spec and Other Waste Paint/Coating.	See Equation E-33	Q_{DIDP_day}; $LF_{offspec}$

Release source 13 daily release (Off-Spec and Other Waste Adhesive) is calculated using the following equation:

Equation E-33.

$$Release\_perDay_{RP13} = Q_{DIDP\_day} * LF_{offspec}$$

Where:

$Release\_perDay_{RP13}$ = DIDP released for release source 13 [kg/site-day]

Q_{DIDP_day} = Facility throughput of DIDP (see Section E.5.3) [kg/site-day]

$LF_{offspec}$ = Loss fraction for off-spec and waste adhesive (see Section E.5.20) [unitless]

E.5.2 Model Input Parameters

Table_Apx E-15 summarizes the model parameters and their values for the Incorporation into Paints and Coatings Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after Table_Apx E-15.

Table_Apx E-15. Summary of Parameter Values and Distributions Used in the Incorporation into Paints and Coatings Model

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Total PV of DIDP at All Sites	PV_{total}	kg/yr	1,679,970	169,485	1,679,970	—	Uniform	See Section E.5.3
Initial DIDP Concentration	F_{DIDP_import}	kg/kg	0.9	0.01	0.9	—	Uniform	See Section E.5.7
Final DIDP Concentration	F_{DIDP_final}	kg/kg	0.01	0.0001	0.05	0.01	Triangular	See Section E.5.8
Air Speed	$RATE_{air\_speed}$	ft/min	19.7	2.56	398	—	Lognormal	See Section E.5.9
Saturation Factor	f_{sat}	dimensionless	0.5	0.5	1.45	0.5	Triangular	See Section E.5.10
Import Container Size	V_{cont}	gal	55	20	100	55	Triangular	See Section E.5.11
Drum Residual Loss Fraction	LF_{drum}	kg/kg	0.025	0.017	0.03	0.025	Triangular	See Section E.5.12
Fraction of DIDP Lost During Sampling - 1 ($Q_{DIDP\_day} < 50$ kg/site-day)	$F_{sampling\_1}$	kg/kg	0.02	0.002	0.02	0.02	Triangular	See Section E.5.13
Fraction of DIDP Lost During Sampling - 2 (Q_{DIDP_day} 50-200 kg/site-day)	$F_{sampling\_2}$	kg/kg	0.005	0.0006	0.005	0.005	Triangular	See Section E.5.13
Fraction of DIDP Lost During Sampling - 3 (Q_{DIDP_day} 200-5000 kg/site-day)	$F_{sampling\_3}$	kg/kg	0.004	0.0005	0.004	0.004	Triangular	See Section E.5.13

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Fraction of DIDP Lost During Sampling - 4 (Q_{DIDP_day} > 5000 kg/site-day)	$F_{sampling\_4}$	kg/kg	0.0004	0.00008	0.0004	0.0004	Triangular	See Section E.5.13
Diameter of Opening-Blending	D_{blend}	cm	10	10	168.92	—	Uniform	See Section E.5.14
Diameter of Opening – Sampling	$D_{sampling}$	cm	2.5	2.5	10	—	Uniform	See Section E.5.14
Hours per Batch for Equipment Cleaning	$OH_{batch\_equip\_clean}$	hours/batch	4	1	4	4	Triangular	See Section E.5.6
Packaged Container Size	$V_{cont\_packaged}$	gal	1	0.10	20	1	Triangular	See Section E.5.11
Overall Paint/Coating Production Rate	Q_{paint}	kg/site-yr	16,000,000	1,600,000	16,000,000	—	Uniform	See Section E.5.15
Vapor Pressure at 25C	VP	mmHg	5.28E−07	—	—	—	—	Physical property
Molecular Weight	MW	g/mol	446.68	—	—	—	—	Physical property
Gas Constant	R	atm-cm3/gmol-L	82.05	—	—	—	—	Universal constant
Density of DIDP	RHO	kg/L	0.9634	—	—	—	—	Physical property
Temperature	T	K	298	—	—	—	—	Process parameter
Pressure	P	atm	1	—	—	—	—	Process parameter
Operating Days	OD	days/yr	250	—	—	—	—	See Section E.5.16

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Batch Size	Q_{batch}	kg/batch	5,030	—	—	—	—	See Section E.5.17
Drum and Tote Fill Rate	$RATE_{fill\_drum\_tote}$	containers/hr	20	—	—	—	—	See Section E.5.18
Small Container Fill Rate	$RATE_{fill\_cont}$	containers/hr	60	—	—	—	—	See Section E.5.18
Diameter of Opening – Container Cleaning	D_{cont_clean}	cm	5.08	—	—	—	—	See Section E.5.14
Diameter of Opening – Equipment Cleaning	D_{equip_clean}	cm	92	—	—	—	—	See Section E.5.14
Diameter of Opening – Filter Media Replacement	D_{filter}	cm	182.4	—	—	—	—	See Section E.5.14
Sampling Duration	$OH_{sampling}$	hr/day	1	—	—	—	—	See Section E.5.6
Filter Media Replacement Duration	OH_{filter}	hr/day	1	—	—	—	—	See Section E.5.6
Equipment Cleaning Loss Fraction	LF_{equip_clean}	kg/kg	0.02	—	—	—	—	See Section E.5.19
Off-Spec and Waste Loss Fraction	$LF_{offspec}$	kg/kg	0.012	—	—	—	—	See Section E.5.20

E.5.3 Number of Sites

Per 2020 U.S. Census Bureau data for NAICS code 32551 (Paint and Coating Manufacturing), there are 1,131 paint/coating formulation sites (U.S. BLS, 2016). Therefore, this value is used as a bounding limit, not to be exceeded by the calculation. Number of sites is calculated using the following equation.:

Equation E-34.

$$N_s = \frac{PV}{Q_{DIDP\_year}}$$

Where:

N_s = Number of sites [sites]
PV = Production volume (see Section E.4.4) [kg/year]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.4.4) [kg/site-yr]

E.5.4 Throughput Parameters

EPA estimated the total production volume for all sites using a uniform distribution with a lower bound of 169,485 kg/yr and an upper bound of 1,679,970 kg/yr.

The upper and lower bounds are based on CDR data (U.S. EPA, 2020a) and the 2003 European Union Risk Assessment on DIDP (ECJRC, 2003b). The 2003 EU Risk Assessment found that 1.1% of the DIDP produced goes to non-PVC, non-polymer end use categories. As this Risk Evaluation includes three OESs that are non-PVC, non-polymer end uses, EPA assumes that each OES accounts for an equal amount to this percentage (*i.e.*, 0.37% each). CDR states that the total U.S. national PV of DIDP is a range of 100,986,354 lbs/yr to 1.001 billion lbs/yr. Multiplying these figures by 0.37% results in 373,650 lb./yr (169,485 kg/yr) to 3,703,700 lbs/yr (1,679,970 kg/yr).

The annual throughput of DIDP is calculated using Equation E-35 by multiplying overall paint and coating production rate by the concentration of DIDP in the final paint or coating product. Overall paint and coating production rate is determined according to Section E.5.15 and concentration of DIDP in the final article is determined according to Section E.5.8.

Equation E-35.

$$Q_{DIDP\_year} = Q_{paint} * F_{DIDP_{final}}$$

Where:

Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
Q_{paint} = Overall paint/coating production rate (see Section E.5.15) [kg/site-yr]
$F_{DIDP_{final}}$ = Concentration of DIDP in final paint/coating (see Section E.5.8) [kg/kg]

The daily throughput of DIDP is calculated using Equation E-36 by dividing the annual production volume by the number of operating days. The number of operating days is determined according to Section E.5.16.

Equation E-36.

$$Q_{DIDP\_day} = \frac{Q_{DIDP\_year}}{OD}$$

Where:

Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
OD = Operating days (see Section E.5.16) [days/yr]

E.5.5 Number of Containers per Year

The number of DIDP raw material containers received and unloaded by a site per year is calculated using the following equation:

Equation E-37.

$$N_{cont\_unload\_yr} = \frac{Q_{DIDP\_year}}{RHO * \left(3.79\ \frac{L}{gal}\right) * V_{cont}}$$

Where:

V_{cont} = Import container volume (see Section E.5.11) [gal/container]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.5.3) [kg/site-yr]
RHO = DIDP density [kg/L]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded [container/site-year]

The number of product containers loaded by a site per year is calculated using the following equation:

Equation E-38.

$$N_{cont\_load\_yr} = \frac{Q_{DIDP\_year}}{RHO * \left(3.79\ \frac{L}{gal}\right) * V_{cont\_packaged}}$$

Where:

$V_{cont\_packaged}$ = Product container volume (see Section E.5.11) [gal/container]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.5.3) [kg/site-yr]
RHO = DIDP density [kg/L]
$N_{cont\_load\_yr}$ = Annual number of containers loaded [container/site-year]

E.5.6 Operating Hours

EPA estimated operating hours or hours of duration using data provided from the *GS for Formulation of Waterborne Coatings* (U.S. EPA, 2014a), *ESD for Adhesive Formulation* (OECD, 2009a), *ChemSTEER User Guide* (U.S. EPA, 2015), and/or through calculation from other parameters. Release points with operating hours provided from these sources include unloading, container cleaning, blending/process operations, product sampling, equipment cleaning, filter media replacement, and loading into transport containers.

For unloading and container cleaning (release points 1 and 4), the operating hours are calculated based on the number of containers unloaded at the site and the unloading rate using the following equation:

Equation E-39.

$$OH_{RP1/RP4} = \frac{N_{cont\_unload\_yr}}{RATE_{fill\_drum\_tote} * OD}$$

Where:

$OH_{RP1/RP4}$ = Operating time for release points 1 and 4 [hrs/site-day]
$RATE_{fill\_drum\_tote}$ = Fill rate of drums and totes (see Section E.5.18) [containers/hr]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded (see Section E.5.5) [container/site-year]
OD = Operating days (see Section E.5.16) [days/site-year]

For blending/process operations (release point 5), the *ESD for Adhesive Formulation* (OECD, 2009a) recommends using the following equation:

Equation E-40.

$$OH_{RP5} = \left(\frac{Q_{DIDP\_year}}{Q_{batch} * OD}\right) * 8\,\frac{hrs}{day}$$

Where:

OH_{RP5} = Operating time for release point 5 [hrs/site-day]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.5.3) [kg/site-yr]
Q_{batch} = Average batch size (see Section E.5.17) [kg/batch]
OD = Operating days (see Section E.5.16) [days/site-year]

For product sampling (release point 7), the *ChemSTEER User Guide* (U.S. EPA, 2015) indicates a value of one hour/day.

For equipment cleaning (release point 9), the *ESD for Adhesive Formulation* (OECD, 2009a) provides an estimate of four hours per batch based on the value for cleaning multiple vessels from the *ChemSTEER User Guide* (U.S. EPA, 2015). The *ESD for Adhesive Formulation* also states that a case study conducted by the Pollution Prevention Assistance Division indicated a range of equipment cleaning times between one and three hours per batch. The underlying distribution of this parameter is not known; therefore, EPA assigned a triangular distribution based on a lower bound, upper bound, and mode for equipment cleaning operating hours. EPA assigned the lower bound as one hour based on the lower end cleaning time observed in the case study (OECD, 2009a) and the upper bound as four hours based on the *ChemSTEER User Guide* default value for this worker activity. For the mode, EPA assigned four hours based on the *ESD for Adhesive Formulation* (OECD, 2009a). EPA calculated the equipment cleaning operating hours using the following equation:

Equation E-41.

$$OH_{RP9} = \left(\frac{Q_{DIDP\_year}}{Q_{batch} * OD}\right) * OH_{batch\_equip\_clean}$$

Where:

OH_{RP9} = Operating time for release point 9 [hrs/site-day]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.5.3) [kg/site-yr]
Q_{batch} = Average batch size (see Section E.5.17) [kg/batch]
OD = Operating days (see Section E.5.16) [days/site-year]
$OH_{batch\_equip\_clean}$ = Batch duration for equipment cleaning (see Section E.5.6) [hrs/batch]

For filter media changeout (release point 11), the *ChemSTEER User Guide* (U.S. EPA, 2015) indicates a single value of one hour/day.

For loading into transport containers (release point 12), the operating hours are calculated based on number of product containers filled per year unless the operating hours per day exceeds 24 hours. If the total operating hours exceeds 24 hours, the duration for loading containers is estimated as the remaining time after accounting for container unloading. The operating hours are calculated using the following equation:

Equation E-42.

$$OH_{RP12} = \begin{cases} \frac{N_{cont\_load\_yr}}{RATE_{fill\_cont} * OD}, & \frac{N_{cont\_load\_yr}}{RATE_{fill\_cont} * OD} \leq [24 - OH_{RP1/RP4}] \\ 24 - OH_{RP1/RP4}, & \frac{N_{cont\_load\_yr}}{RATE_{fill\_cont} * OD} > [24 - OH_{RP1/RP4}] \end{cases}$$

Where:

OH_n = Operating time for release point "n" [hrs/site-day]
$RATE_{fill\_cont}$ = Fill rate of containers, dependent on volume (see Section E.5.18) [containers/hr]
$N_{cont\_load\_yr}$ = Annual number of containers loaded (see Section E.5.5) [container/site-year]
OD = Operating days (see Section E.5.16) [days/site-year]

E.5.7 Initial DIDP Concentration

EPA modeled the initial DIDP concentration using a uniform distribution with a lower bound of 1% and upper bound of 90% based on information reported in the 2020 CDR by sites indicating DIDP use in paints and coatings (U.S. EPA, 2020a).

E.5.8 Final DIDP Concentration

EPA modeled final DIDP concentration in paints and coatings using a triangular distribution with a lower bound of 0.01%, upper bound of 5%, and mode of 1%. This is based on compiled SDS information for paint and coating products containing DIDP. The lower and upper bounds represent the minimum and maximum reported concentrations in the SDSs. The mode represents the mode of all range endpoints reported in the SDSs. (see Appendix F for EPA identified DIDP-containing products for this OES).

E.5.9 Air Speed

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

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

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

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

E.5.10 Saturation Factor

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

E.5.11 Container Size

EPA assumed that paint and coating manufacturing sites would receive DIDP in drums. According to the *ChemSTEER User Guide*, drums are defined as containing between 20 and 100 gallons of liquid, and the default drum size is 55 gallons (U.S. EPA, 2015). Therefore, EPA modeled import container size using a triangular distribution with a lower bound of 20 gallons, an upper bound of 100 gallons, and a mode of 55 gallons.

For packaging of paints and coatings after production, EPA identified products in bottles as small as 0.1 gallons, and in small containers as large as 20 gallons. However, 1-gallon containers are the default packaged container size. Therefore, EPA modeled finished paint/coating container size using a triangular distribution with a lower bound of 0.1 gallons, an upper bound of 20 gallons, and a mode of one gallon.

E.5.12 Drum Residue Loss Fraction

EPA paired the data from the PEI Associates Inc. study (Associates, 1988) such that the residuals data for emptying drums by pumping was aligned with the default central tendency and high-end values from the *EPA/OPPT Drum Residual Model*. For unloading drums by pumping in the PEI Associates Inc. study, EPA found that the average percent residual from the pilot-scale experiments showed a range of 1.7 percent to 4.7 percent and an average of 2.6 percent. The *EPA/OPPT Drum Residual Model* from the *ChemSTEER User Guide* recommends a default central tendency loss fraction of 2.5 percent and a high-end loss fraction of 3.0 percent (U.S. EPA, 2015).

The underlying distribution of the loss fraction parameter for drums is not known; therefore, EPA assigned a triangular distribution, since triangular distributions require least assumptions and are completely defined by range and mode of a parameter. EPA assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the *EPA/OPPT Drum Residual Model* in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study (Associates, 1988) for emptying drums by pumping.

E.5.13 Sampling Loss Fraction

Sampling loss fractions were estimated using the *March 2023 Methodology for Estimating Environmental Releases from Sampling Wastes* (U.S. EPA, 2023b). In this methodology, EPA completed a search of over 300 IRERs completed in the years 2021 and 2022 for sampling release data, including a similar proportion of both PMNs and Low Volume Exemptions (LVEs). Of the searched IRERs, 60 data points for sampling release loss fractions, primarily for sampling releases from submitter-controlled sites (~75% of IRERs), were obtained. The data points were analyzed as a function of the chemical daily throughput and industry type. This analysis showed that the sampling loss fraction generally decreased as the chemical daily throughput increased. Therefore, the methodology provides guidance for selecting a loss fraction based on chemical daily throughput. Table_Apx E-16 presents a summary of the chemical daily throughputs and corresponding loss fractions.

Table_Apx E-16. Sampling Loss Fraction Data from the March 2023 Methodology for Estimating Environmental Releases from Sampling Waste

Chemical Daily Throughput (kg/site-day) ($Q_{chem\_site\_day}$)	Number of Data Points	Sampled Quantity (kg chemical/day)		Sampling Loss Fraction ($LF_{sampling}$)	
		50th Percentile	95th Percentile	50th Percentile	95th Percentile
<50	13	0.03	0.20	0.002	0.02
50 to <200	10	0.10	0.64	0.0006	0.005
200 to <5,000	25	0.37	3.80	0.0005	0.004
≥5,000	10	1.36	6.00	0.00008	0.0004
All	58	0.20	5.15	0.0005	0.008

For each range of daily throughputs, EPA estimated sampling loss fractions using a triangular distribution of the 50th percentile value as the lower bound, and the 95th percentile value as the upper bound and mode. The sampling loss fraction distribution was chosen based on the calculation of daily throughput, as shown in Section E.4.3

E.5.14 Diameters of Opening

The *ChemSTEER User Guide* indicates diameters for the openings for various vessels that may hold liquids in order to calculate vapor generation rates during different activities (U.S. EPA, 2015). For equipment cleaning operations, the *ChemSTEER User Guide* indicates a single default value of 92 cm (U.S. EPA, 2015). For container cleaning activities, the *ChemSTEER User Guide* indicates a single default value of 5.08 cm for containers less than 5,000 gallons (U.S. EPA, 2015). For filter media replacement, the *ChemSTEER User Guide* indicates a single default value of 182.4 cm.

For sampling liquid product, sampling liquid raw material, or general liquid sampling, the *ChemSTEER User Guide* indicates that the typical diameter of opening for vaporization of the liquid is 2.5 cm (U.S.

EPA, 2015). Additionally, the *ChemSTEER User Guide* provides ten cm as a high-end value for the diameter of opening during sampling (U.S. EPA, 2015). The underlying distribution of this parameter is not known; therefore, EPA assigned a triangular distribution based on the estimated lower bound, upper bound, and mode of the parameter. EPA assigned the value of 2.5 cm as a lower bound for the parameter and ten cm as the upper bound based on the values provided in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA also assigned 2.5 cm as the mode diameter value for sampling liquids based on the typical value described in *ChemSTEER User Guide* (U.S. EPA, 2015).

For blending operations, the *ESD for Adhesive Formulation* (OECD, 2009a)and *GS for Formulation of Waterborne Coatings* (U.S. EPA, 2014a) assumes a closed vessel with a 4-inch diameter process vent, corresponding to ten cm in diameter. In addition, EPA considered the potential for open process vessels used for blending as mentioned in both the *ESD for Adhesive Formulation* (OECD, 2009a) and *GS for Formulation of Waterborne Coatings* (U.S. EPA, 2014a), with diameters of the open vessel calculated based on the batch volume for the simulation iteration and the assumption in the ESD and GS of a one-to-one height to diameter ratio for the process vessel. The underlying distribution of this parameter is not known; therefore, EPA assigned a triangular distribution defined by an estimated lower bound, upper bound, and mode of the parameter. EPA assigned the value of ten cm for both the lower bound and mode of the triangular distribution as the recommended value by the *ESD for Adhesive Formulation* (OECD, 2009a) and *GS for Formulation of Waterborne Coatings* (U.S. EPA, 2014a). For the upper bound value of the triangular distribution, EPA assigned an equation calculating the diameter of an open process vessel with a one-to-one height to diameter ratio and fixed batch volume of approximately 1,000 gallons based on the batch size discussed in Section E.5.17:

Equation E-43.

$$D_{blending\_max} = \left[\frac{4 * V_{batch} * 3785.41 \frac{cm^3}{gal}}{\pi} \right]^{1/3}$$

E.5.15 Overall Paint/Coating Production Rate

The *GS for Formulation of Waterborne Coatings* (U.S. EPA, 2014a) provides two estimates for overall paint/coating production rates. For architectural coatings, the GS estimates 16 million kg of coatings/site-yr. For special purpose coatings, the GS estimates 1.6 million kg of coatings/site-yr. Therefore, EPA modeled this parameter with a uniform distribution with a lower bound of 1.6 million kg/site-yr and an upper bound of 16 million kg/site-yr.

E.5.16 Operating Days

EPA was unable to identify DIDP-specific information for operating days in the production of adhesives and sealants. The *GS for Formulation of Waterborne Coatings* (U.S. EPA, 2014a) assumes a constant value of 250 days/yr, which assumes the production sites operate five days per week and 50 weeks per year, with two weeks down for turnaround.

E.5.17 Batch Size

The *GS for Formulation of Waterborne Coatings* (U.S. EPA, 2014a) cites a default batch size of 5,030 kg coatings per batch with an approximate batch volume of 1,000 gallons.

E.5.18 Container Fill Rates

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

To account for situations where operating times for container unloading and loading exceeded a 24-hour period in the simulation, EPA applied an equation to determine a corrected fill rate that would replace the deterministic values provided in the *ChemSTEER User Guide*. The equation for the corrected fill rate in cases where operating time for unloading and loading is greater than 24 hours is included below. EPA only used the corrected fill rate for loading product containers (release point 10).

Equation E-44.

$$if\ 24 < (OH_{RP1/RP4} + OH_{RP12}), RATE_{fill\_adjusted} = \frac{N_{cont\_load\_yr}}{(24 - OH_{RP1/RP4}) * OD}$$

Where:

$RATE_{fill\_adjusted}$ = Corrected fill rate for product containers [containers/hr]
$N_{cont\_load\_yr}$ = Annual number of product containers [containers/site-year]
OH_n = Operating time for release point “n” [hrs/site-day]
OD = Operating days [days/site-year]

E.5.19 Equipment Cleaning Loss Fraction

EPA used the *EPA/OPPT Multiple Process Residual Model* to estimate the releases from equipment cleaning. The *EPA/OPPT Multiple Process Residual Model*, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015) provides an overall loss fraction of two percent from equipment cleaning.

E.5.20 Off-Spec Loss Fraction

The *GS for Formulation of Waterborne Coatings* (U.S. EPA, 2014a) provides a loss fraction of 1.2 percent of throughput disposed from off-specification material during manufacturing. This 1.2 percent default loss fraction was provided as an estimate from a Source Reduction Research Partnership (SRRP) study referenced in the *GS for Formulation of Waterborne Coatings* (U.S. EPA, 2014a).

E.6 Incorporation into Other Formulations, Mixtures, and Reaction Products Not Covered Elsewhere Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DIDP during the incorporation into other formulations, mixtures, and reaction products not covered elsewhere OES. This approach utilizes the same equations and assumptions presented for Incorporation into Paints and Coatings in Appendix E.5. Therefore, only the parameters that differ between approaches, which includes concentration of DIDP in the raw material and final product DIDP concentrations, will be presented in this section for brevity.

E.6.1 Import DIDP Concentration

EPA modeled the imported DIDP concentration using a uniform distribution with a lower bound of 30% and upper bound of 90% based on information reported in the 2020 CDR by sites indicating DIDP use in other formulations, mixtures, and reaction products (U.S. EPA, 2020a).

E.6.2 Final DIDP Concentration

EPA modeled final DIDP concentration in other articles using a triangular distribution with a lower bound of 0.1%, upper bound of 90%, and mode of 20%. The upper bound is based on the imported DIDP concentration. The concentration of DIDP in the adhesive or sealant cannot be higher than the concentration of neat DIDP that was imported. The lower bound and mode is based on compiled SDS information for adhesives and sealant products containing DIDP. From the compiled data, the minimum concentration was 0.1% and the mode was 20%. The mode represents the mode of all high-end values of the concentration ranges found in SDSs.

E.7 Non-PVC Plastics Materials Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DIDP during the Non-PVC Plastics Material Compounding and Non-PVC Plastics Material Converting OESs. This approach utilizes the *Generic Scenario for the Use of Additives in Plastic Compounding* (U.S. EPA, 2021e), the 2021 *Use of Additives in Plastics Converting Draft Generic Scenario* (U.S. EPA, 2021f), *Emission Scenario Document on Additives in Rubber Industry* (OECD, 2004a), and CDR data (U.S. EPA, 2020a) combined with Monte Carlo simulation (a type of stochastic simulation).

Based on the GS, EPA identified the following release sources from non-PVC plastics materials compounding:

- Release source 1: Transfer Operation Losses to Air from Unloading Plastics Additives.
- Release source 2: Container Cleaning Wastes.
- Release source 3: Open Surface Losses to Air During Compounding.
- Release source 4: Equipment Cleaning Wastes.
- Release source 5: Direct Contact Cooling Water Losses.
- Release source 6: Transfer Operations Losses to Air from Loading Compounded Plastic.

Based on the GS, EPA identified the following release sources from non-PVC plastics materials converting:

- Release source 1: Transfer Operation Losses to Air from Unloading Plastics Additives.
- Release source 2: Container Cleaning Wastes.
- Release source 3: Vapor Emissions from Converting.
- Release source 4: Particulate Emissions from Converting.
- Release source 5: Equipment Cleaning Wastes.
- Release source 6: Direct Contact Cooling Water Losses.
- Release source 7: Solid Wastes from Trimming Operations.

Environmental releases for DIDP during non-PVC plastics materials production are a function of DIDP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: production volume, DIDP concentrations, operating days, air speed, saturation factor, container size, loss fractions, and dust control/capture efficiencies. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.7.1 Model Equations

Table_Apx E-17 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the non-PVC plastics materials OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix E.7.2. The Monte Carlo simulation calculated the total DIDP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th percentile and 95th percentile values to estimate the central tendency and high-end releases, respectively.

6733 **Table_Apx E-17. Models and Variables Applied for Release Sources in the Non-PVC Plastics**
6734 **Materials OES**

Release source	Model(s) Applied	Variables Used
Plastics compounding		
Release source 1: Transfer Operation Losses to Air from Unloading Plastics Additives.	*EPA/OAQPS AP-42 Loading Model* (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; VP; f_{sat}; MW; R; T; V_{drum}; V_{tote}; $RATE_{fill\_drum\_tote}$ Operating Time: Q_{DIDP_year}; V_{drum}; $RATE_{fill\_drum\_tote}$; V_{tote}; RHO; OD_{comp}
Release source 2: Container Cleaning Wastes.	*EPA/OPPT Drum Residual Model* or *EPA/OPPT Bulk Transport Residual Model*, based on container size (Appendix E.1)	Q_{DIDP_year}; LF_{drum}; V_{cont}; LF_{bulk}; V_{bulk} RHO; OD_{comp}
Release source 3: Open Surface Losses to Air During Compounding.	See Equation E-45	Q_{DIDP_day}; $F_{vapor\_emissions}$
Release source 4: Equipment Cleaning Wastes.	*EPA/OPPT Multiple Process Vessel Residual Model* (Appendix E.1)	Q_{DIDP_day}; LF_{equip_clean}
Release source 5: Direct Contact Cooling Water Losses.	See Equation E-47	Q_{DIDP_day}; $F_{cooling\_water}$
Release source 6: Transfer Operations Losses to Air from Loading Compounded Plastic.	*EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders* (Appendix E.1)	Q_{DIDP_day}; $F_{dust\_generation}$; $F_{dust\_capture}$; $F_{dust\_control}$
Plastics Converting		
Release source 1: Transfer Operation Losses to Air from Unloading Plastics Additives.	*EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders* (Appendix E.1)	Q_{DIDP_day}; $F_{dust\_generation}$; $F_{dust\_capture}$; $F_{dust\_control}$
Release source 2: Container Cleaning Wastes.	*EPA/OPPT Solid Residuals in Transport Containers Model* (Appendix E.1)	Q_{DIDP_year}; LF_{cont}; V_{cont}; RHO; $N_{cont\_unload\_day}$; OD_{conv}
Release source 3: Vapor Emissions from Converting.	See Equation E-45	Q_{DIDP_day}; $F_{vapor\_emissions}$
Release source 4: Particulate Emissions from Converting.	See Equation E-46	Q_{DIDP_day}; $F_{particulate\_emissions}$
Release source 5: Equipment Cleaning Wastes.	*EPA/OPPT Multiple Process Vessel Residual Model* (Appendix E.1)	Q_{DIDP_day}; LF_{equip_clean}

Release source	Model(s) Applied	Variables Used
Release source 6: Direct Contact Cooling Water Losses.	See Equation E-47	$Q_{DIDP\_day}; F_{cooling\_water}$
Release source 7: Solid Wastes from Trimming Operations.	See Equation E-48	$Q_{DIDP\_day}; F_{trimming}$

Compounding and converting release source 3 daily release (Open Surface Losses to Air During Compounding/Converting) is calculated using the following equation:

Equation E-45.

$$Release\_perDay_{RP3} = Q_{DIDP\_day} * F_{vapor\_emissions}$$

Where:

$Release\_perDay_{RP3}$ = DIDP released for release source 3 [kg/site-day]
Q_{DIDP_day} = Facility throughput of DIDP (see Section E.7.3) [kg/site-day]
$F_{vapor\_emissions}$ = Fraction of DIDP lost from volatilization during compounding/converting operations (see Section E.7.21) [kg/kg]

Converting release source 4 daily release (Particulate Emissions from Converting) is calculated using the following equation:

Equation E-46.

$$Release\_perDay_{RP4} = Q_{DIDP\_day} * F_{particulate\_emissions}$$

Where:

$Release\_perDay_{RP4}$ = DIDP released for release source 4 [kg/site-day]
Q_{DIDP_day} = Facility throughput of DIDP (see Section E.7.3) [kg/site-day]
$F_{particulate\_emissions}$ = Fraction of DIDP lost as particulates during converting operations (see Section E.7.16) [kg/kg]

Compounding and converting release source 5 daily release (Direct Contact Cooling Water Losses) is calculated using the following equation:

Equation E-47.

$$Release\_perDay_{RP5} = Q_{DIDP\_day} * F_{cooling\_water}$$

Where:

$Release\_perDay_{RP5}$ = DIDP released for release source 5 [kg/site-day]
Q_{DIDP_day} = Facility throughput of DIDP (see Section E.7.3) [kg/site-day]
$F_{cooling\_water}$ = Cooling water loss fraction (see Section E.7.19) [kg/kg]

Converting release source 7 daily release (Solid Wastes from Trimming Operations) is calculated using the following equation:

Equation E-48.

$$Release\_perDay_{RP7} = Q_{DIDP\_day} * F_{trimming}$$

Where:

$Release\_perDay_{RP7}$ = DIDP released for release source 7 [kg/site-day]
Q_{DIDP_day} = Facility throughput of DIDP (see Section E.7.3) [kg/site-day]

$F_{trimming}$ = Trimming loss fraction (see Section E.7.23) [kg/kg]

E.7.2 Model Input Parameters

Table_Apx E-18 and summarizes the model parameters and their values for the Non-PVC Plastics Materials Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after Table_Apx E-18.

Table_Apx E-18. Summary of Parameter Values and Distributions Used in the Non-PVC Plastics Materials Model

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Total PV of DIDP at all Sites	PV_{total}	kg/yr	14,529,471	1,465,812	14,529,471	—	Uniform	See Section E.7.3
Initial DIDP Concentration	F_{DIDP_import}	kg/kg	1	0.3	1	1	Triangular	See Section E.7.9
Plastic DIDP Concentration	F_{DIDP}	kg/kg	0.2	0.1	0.2	—	Uniform	See Section E.7.10
Operating Days - Compounding	OD_{comp}	days/yr	246	147	301	246	Triangular	See Section E.7.11
Operating Days - Converting	OD_{conv}	days/yr	253	136	255	253	Triangular	See Section E.7.11
Saturation Factor	f_{sat}	dimensionless	0.5	0.5	1.45	0.5	Triangular	See Section E.7.12
Drum Container Size	V_{drum}	gal	55	20	100	55	Triangular	See Section E.7.13
Tote Container Size	V_{tote}	gal	550	100	1,000	550	Triangular	See Section E.7.13
Solid Container Size	V_{cont}	gal	7	7	132	7	Triangular	See Section E.7.13
Drum Residual Loss Fraction	LF_{drum}	kg/kg	0.025	0.017	0.03	0.025	Triangular	See Section E.7.14
Bulk Container Loss Fraction	LF_{bulk}	kg/kg	0.07	0.02	0.2	0.07	Triangular	See Section E.7.14
Fraction of chemical lost during transfer of solid powders	$F_{dust\_generation}$	kg/kg	0.0050	0.000006	0.045	0.005	Triangular	See Section E.7.15
Capture efficiency for	$F_{dust\_capture}$	kg/kg	0.9630	0.931	1	0.963	Triangular	See Section E.7.15

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
dust capture methods								
Control efficiency for dust control methods	$F_{dust\_control}$	kg/kg	Multiple distributions depending on control type.				Triangular	See Section E.7.15
Fraction of DIDP lost as particulates during converting processes	$F_{particulate\_emissions}$	kg/kg	0.00006	0.00002	0.0001	0.00006	Triangular	See Section E.7.16
Mass fraction of all additives in the compounded plastic resin	$F_{additives\_resin}$	kg/kg	0.49	0.49	0.87	—	Uniform	See Section E.7.5
Annual use rate of all plastic additives	$Q_{additives\_yr}$	kg/site-yr	198,773	—	—	—	—	See Section E.7.6
Vapor Pressure at 25C	VP	mmHg	5.28E−07	—	—	—	—	Physical property
Molecular Weight	MW	g/mol	446.68	—	—	—	—	Physical property
Gas Constant	R	atm-cm3/gmol-L	82.05	—	—	—	—	Universal constant
Density of DIDP	RHO	kg/L	0.9634	—	—	—	—	Physical property
Temperature	T	K	298	—	—	—	—	Process parameter
Pressure	P	atm	1	—	—	—	—	Process parameter

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Drum and Tote Fill Rate	$RATE_{fill\_drum\_tote}$	containers/hr	20	—	—	—	—	See Section E.7.17
Small Container Fill Rate	$RATE_{fill\_cont}$	containers/hr	60	—	—	—	—	See Section E.7.17
Tank Truck Fill Rate	$RATE_{fill\_truck}$	containers/hr	2	—	—	—	—	See Section E.7.17
Rail Car Fill Rate	$RATE_{fill\_rail}$	containers/hr	1	—	—	—	—	See Section E.7.17
Equipment Cleaning Loss Fraction	LF_{equip_clean}	kg/kg	0.02	—	—	—	—	See Section E.7.18
Cooling Water Loss Fraction	$F_{cooling\_water}$	kg/kg	0.01	—	—	—	—	See Section E.7.19
Rubber Production Rate	Q_{rubber}	kg/day	55,000	—	—	—	—	See Section E.7.20
Fraction of the chemical of interest lost from volatilization during forming and molding processes (open process)	$F_{vapor\_emissions\_open}$	kg/kg	0.00010	—	—	—	—	See Section E.7.21
Fraction of the chemical of interest lost from volatilization during forming and molding	$F_{vapor\_emissions\_closed}$	kg/kg	0.00002	—	—	—	—	See Section E.7.21

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
processes (closed process)								
Solid container loss fraction	LF_{cont}	kg/kg	0.01	—	—	—	—	See Section E.7.22
Trimming loss fraction	$F_{trimming}$	kg/kg	0.025	—	—	—	—	See Section E.7.23

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E.7.3 Number of Sites

Number of sites is calculated using the following equation.:

Equation E-49.

$$N_s = \frac{PV}{Q_{DIDP_{year}}}$$

Where:

N_s = Number of sites [sites]
PV = Production volume (see Section E.7.4) [kg/year]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.7.4) [kg/site-yr]

E.7.4 Throughput Parameters

EPA estimated the total production volume for all sites using a uniform distribution with a lower bound of 1,465,812 kg/yr and an upper bound of 14,529,471 kg/yr. This is based on CDR data (U.S. EPA, 2020a) and the *2003 European Union Risk Assessment on DIDP* (ECJRC, 2003b).

The upper and lower bounds are based on CDR data (U.S. EPA, 2020a) and the 2003 European Union Risk Assessment on DIDP (ECJRC, 2003b). The 2003 EU Risk Assessment found that 3.2% of the DIDP produced is used in non-PVC polymers. CDR states that the total U.S. national PV of DIDP is in the range of 100,986,354 lbs/yr to 1.001 billion lbs/yr. Multiplying these figures by 3.2% results in 3,231,563 lb./yr (1,465,812 kg/yr) to 32,032,000 lbs/yr (14,529,471 kg/yr). This production range is used for both non-PVC plastic compounding and converting, since EPA assumes 100% of the compounded plastic goes to the converting process.

For compounding, the annual throughput of DIDP is calculated using Equation E-50 by multiplying daily rubber production rate by operating days and the concentration of DIDP in the final article. Daily rubber production rate is determined according to Section E.7.20, operating days is determined according to Section E.7.11, and concentration of DIDP in the final article is determined according to Section E.7.10.

Equation E-50.

$$Q_{DIDP\_year} = Q_{rubber} * F_{DIDP} * OD_{comp}$$

Where:

Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
Q_{rubber} = Overall non-PVC plastic material production rate (see Section E.7.20) [kg/site-day]
F_{DIDP} = Concentration of DIDP in final plastic/rubber (see Section E.7.10) [kg/kg]
OD_{comp} = Operating days for compounding (see Section E.7.11) [days/yr]

For converting, the annual throughput of DIDP is calculated using Equation E-51 by multiplying the annual use rate of all plastics additives by the concentration of DIDP in the final article and dividing by the mass fraction of all additives in the compounded plastic resin. Annual use rate of all plastics additives is determined according to Section E.7.6, concentration of DIDP in the final article is determined according to Section E.7.10, and mass fraction of all additives in compounded resin is determined according to Section E.7.5.

Equation E-51.

$$Q_{DIDP\_year} = \frac{Q_{additives\_yr} * F_{DIDP}}{F_{additives\_resin}}$$

Where:

Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
$Q_{additives\_yr}$ = Annual use rate of all plastic additives (see Section E.7.6) [kg/site-yr]
F_{DIDP} = Concentration of DIDP in final plastic/rubber (see Section E.7.10) [kg/kg]
$F_{additives\_resin}$ = Mass fraction of all additives in the compounded plastic resin (see Section E.7.5) [kg/kg]

For both compounding and converting, the daily throughput of DIDP is calculated using Equation E-52 by dividing the annual production volume by the number of operating days. The number of operating days is determined according to Section E.7.11.

Equation E-52.

$$Q_{DIDP\_day} = \frac{Q_{DIDP\_year}}{OD_{comp/conv}}$$

Where:

Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
$OD_{comp/conv}$ = Operating days for either compounding or converting (based on the specific OES assessed) (see Section E.7.11) [days/yr]

E.7.5 Mass Fraction of All Additives in Compounded Plastic Resin

EPA modeled the mass fraction of additives in compounded plastic resin using a uniform distribution with a lower bound of 0.49 and an upper bound of 0.87. This is based on the 2021 *Use of Additives in Plastics Converting Draft Generic Scenario* (U.S. EPA, 2021f). The GS provides a range of 0.49 to 0.87 for the fraction of additives in flexible PVC. While this OES is for non-PVC products, EPA used these values as a surrogate for non-PVC plastics.

E.7.6 Annual Use Rate of All Plastic Additives During Converting

The 2021 *Use of Additives in Plastics Converting Draft Generic Scenario* (U.S. EPA, 2021f) estimates that the annual facility use rate of all plastic additives is 198,773 kg additives/site-yr. This was calculated by dividing the annual U.S. demand for plastics additives by the number of sites estimated in the GS.

E.7.7 Number of Containers per Year

The number of DIDP raw material containers received and unloaded by a site per year is calculated using the following equation:

Equation E-53.

$$N_{cont\_unload\_yr} = \frac{Q_{DIDP\_year}}{RHO * \left(3.79\,\frac{L}{gal}\right) * V_{drum/tote}}$$

Where:

$V_{drum/tote}$ = Import container volume (see Section E.7.13) [gal/container]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.7.10) [kg/site-yr]
RHO = DIDP density [kg/L]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded [container/site-year]

E.7.8 Operating Hours

EPA estimated operating hours or hours of duration using data provided from the *2021 Use of Additives in Plastic Compounding Draft Generic Scenario* (U.S. EPA, 2021e), 2021 *Use of Additives in Plastics Converting Draft Generic Scenario* (U.S. EPA, 2021f), *ChemSTEER User Guide* (U.S. EPA, 2015), and/or through calculation from other parameters. Release points with operating hours provided from these sources include unloading, compounding, converting, and loading into transport containers.

For unloading during compounding and converting, (release point 1), the operating hours are calculated based on the number of containers unloaded at the site and the unloading rate using the following equation:

Equation E-54.

$$OH_{RP1} = \frac{N_{cont\_unload\_yr}}{RATE_{fill\_drum\_tote} * OD}$$

Where:

OH_{RP1} = Operating time for release point 1 [hrs/site-day]
$RATE_{fill\_drum\_tote}$ = Fill rate of drums and totes (see Section E.7.17) [containers/hr]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded (see Section E.7.7) [container/site-year]
OD = Operating days (see Section E.7.11) [days/yr]

For compounding and converting operations (release point 3 for compounding, 3 & 4 for converting), EPA assumes compounding and converting occurs for the entirety of a work-shift and assigns a duration of eight hours/day.

E.7.9 Initial DIDP Concentration

EPA modeled the initial DIDP concentration using a triangular distribution with a lower bound of 30%, upper bound of 100%, and mode of 100% based on information reported in the 2020 CDR by sites indicating DIDP use in non-PVC plastics (U.S. EPA, 2020a).

E.7.10 Final DIDP Concentration

EPA modeled final DIDP concentration in non-PVC plastics using a uniform distribution with a lower bound of 10% and upper bound of 20%. This is based on the *Emission Scenario Document on Additives in Rubber Industry* (OECD, 2004a). The ESD states that rubber additives are expected to be present at 10-20% for rubber products.

E.7.11 Operating Days

For compounding, EPA modeled the operating days per year using a triangular distribution with a lower bound of 148 days/yr, an upper bound of 300 days/yr, and a mode of 246 days/yr. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 148-300 days/yr. The lower bound is based on the *2014 Plastics Compounding Draft Generic Scenario* (U.S. EPA, 2014c). The report states that a typical range of 148-264 days/yr are assumed. The upper bound is based on ESIG's *Specific Environmental Release Category for Rubber Production and Processing* (ESIG, 2020). The SpERC indicates a default of 300 days/yr for rubber manufacturing. The mode is based on the *2021 Generic Scenario for the Use of Additives in Plastic Compounding* (U.S. EPA, 2021e), which states that 246 days/yr should be used as a default.

For converting, EPA modeled the operating days per year using a triangular distribution with a lower bound of 137 days/yr, an upper bound of 254 days/yr, and a mode of 253 days/yr. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 137-254 days/yr. The lower and upper bounds are based on the *2014 Use of Additives in the Thermoplastic Converting Industry Draft GS* (U.S. EPA, 2014d), which states 137-254 days/yr should be assumed. The mode is based on the 2021 *Use of Additives in Plastics Converting Draft Generic Scenario* (U.S. EPA, 2021f), which states that an average value of 253 days/yr should be used as a default.

E.7.12 Saturation Factor

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

E.7.13 Container Size

EPA assumed that non-PVC plastic manufacturing sites would receive DIDP in drums or totes. According to the *ChemSTEER User Guide*, drums are defined as containing between 20 and 100 gallons of liquid, and the default drum size is 55 gallons (U.S. EPA, 2015). Totes are defined as containing between 100 and 1,000 gallons, and the default tote size is 550 gallons. EPA modeled triangular distributions for each container type using these values, with the lower and upper bounds corresponding to the range of volumes for each container type, and the mode corresponding to the default container size for each container type.

For packaging of compounded plastics, EPA modeled solid containers using a triangular distribution with a lower bound and mode of 25 kg and upper bound of 500 kg. This is based on the 2021 *Use of Additives in Plastics Converting Draft Generic Scenario* (U.S. EPA, 2021f), which states that compounded plastics in pellet form are routinely shipped in containers ranging from 25 kg bags to 500 kg gaylords. EPA converted the mass of the container to volume assuming a compounded plastic density of 1 kg/L. The volumetric distribution contains a lower bound and mode of 7 gallons, and an upper bound of 132 gallons.

E.7.14 Container Residue Loss Fractions

For drums, EPA paired the data from the PEI Associates Inc. study (Associates, 1988) such that the residuals data for emptying drums by pumping was aligned with the default central tendency and high-end values from the *EPA/OPPT Drum Residual Model*. For unloading drums by pumping in the PEI Associates Inc. study, EPA found that the average percent residual from the pilot-scale experiments showed a range of 1.7 percent to 4.7 percent and an average of 2.6 percent. The *EPA/OPPT Drum Residual Model* from the ChemSTEER User Guide recommends a default central tendency loss fraction of 2.5 percent and a high-end loss fraction of 3.0 percent (U.S. EPA, 2015).

The underlying distribution of the loss fraction parameter for drums is not known; therefore, EPA assigned a triangular distribution, since triangular distributions require least assumptions and are completely defined by range and mode of a parameter. EPA assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the *EPA/OPPT Drum Residual Model* in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study (Associates, 1988) for emptying drums by pumping.

For bulk containers, EPA paired the data from the PEI Associates Inc. study (Associates, 1988) such that the residuals data for emptying tanks by gravity-draining was aligned with the default central tendency and high-end values from the *EPA/OPPT Bulk Transport Residual Model*. For unloading tanks by gravity-draining in the PEI Associates Inc. study, EPA found that the average percent residual from the pilot-scale experiments showed a range of 0.02 percent to 0.19 percent and an average of 0.06 percent (Associates, 1988). The *EPA/OPPT Bulk Transport Residual Model* from the *ChemSTEER User Guide* (U.S. EPA, 2015) recommends a default central tendency loss fraction of 0.07 percent and a high-end loss fraction of 0.2 percent.

The underlying distribution of the loss fraction parameter for bulk containers is not known; therefore, EPA assigned a triangular distribution, since triangular distributions require least assumptions and are completely defined by range and mode of a parameter. EPA assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the *EPA/OPPT Bulk Transport Residual Model* in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study for emptying tanks by gravity-draining (Associates, 1988).

E.7.15 Dust Generation Loss Fraction, Dust Capture Efficiency, and Dust Control Efficiency

The *EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders* (Dust Release Model) compiled data for loss fractions of solids from various sources in addition to the capture and removal efficiencies for control technologies in order to estimate releases of dust to the environment. Dust releases estimated from the model are based on three different parameters: the initial loss fraction, the fraction captured by the capture technology, and the fraction removed/controlled by the control technology. The underlying distributions for each of these parameters is not known; therefore, EPA assigned triangular distributions, since triangular distribution requires least assumptions and is completely defined by range and mode of a parameter.

EPA assigned the range and mode for each of the three parameters using the data presented in the Dust Release Model. For the initial loss fraction, EPA assigned a range of 6.0E−06 to 0.045 with a mode of 0.005 by mass. EPA assigned the mode based on the recommended default value for the parameter in

the Dust Release Model. The range of initial loss fraction values comes from the range of values compiled from various sources and considered in the development of the Dust Release Model (U.S. EPA, 2021d).
For the fraction captured, EPA assigned a range of 0.931 to 1.0 with a mode of 0.963 by mass. EPA assigned the range for the fraction captured based on the minimum and maximum estimated capture efficiencies listed in the data compiled for the Dust Release Model. EPA assigned the mode for the fraction captured based on the average of all lower bound estimated capture efficiency values for all capture technologies presented in the model (U.S. EPA, 2021d).

For the fraction removed/controlled, the *2021 Generic Scenario for the Use of Additives in Plastic Compounding* (U.S. EPA, 2021e) and 2021 *Use of Additives in Plastics Converting Draft Generic Scenario* (U.S. EPA, 2021f) state that many facilities collect fugitive dust emissions in filters or utilize wet scrubbers. Therefore, EPA used two triangular distributions: a distribution for filter efficiency, and a distribution for wet scrubber efficiency. Each control technology distribution has an equal probability of being selected during each iteration of the simulation. The triangular distribution for filter efficiency has a lower bound of 0.97, upper bound of 0.99999, and mode of 0.99. The triangular distribution for wet scrubber efficiency has a lower bound of 0.20, upper bound of 0.995, and mode of 0.55. These distributions are based on the minimum, maximum, and default values presented for each control technology in the Dust Release Model (U.S. EPA, 2021d).

E.7.16 Fraction of DIDP Lost as Particulates During Converting Processes

EPA modeled the loss fraction of particulate DIDP during converting using a triangular distribution with a lower bound of 2.0E−05 kg/kg, upper bound of 1.0E−04 kg/kg, and mode of 6.0E−05 kg/kg. This is based on the 2021 *Use of Additives in Plastics Converting Draft Generic Scenario* (U.S. EPA, 2021f). The GS presents loss fractions for three types of converting: open process (1.0E−04 kg/kg), partially open process (6.0E−05 kg/kg), or closed process (2.0E−05 kg/kg). EPA used these loss fractions to build the triangular distribution based on magnitude of the values, with the loss fraction for a partially open process being the central value. The distribution does not reflect prevalence of each type of process in the industry.

E.7.17 Container Fill Rates

The *ChemSTEER User Guide* (U.S. EPA, 2015) provides typical fill rates of one container per hour for containers over 10,000 gallons of liquid; two containers per hour for containers with 1,000 to 10,000 gallons of liquid; 20 containers per hour for containers with 20 to 100 gallons of liquid; and 60 containers per hour for containers with less than 20 gallons of liquid.

E.7.18 Equipment Cleaning Loss Fraction

EPA used the *EPA/OPPT Multiple Process Residual Model* to estimate the releases from equipment cleaning. The *EPA/OPPT Multiple Process Residual Model*, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015), provides an overall loss fraction of two percent from equipment cleaning.

E.7.19 Cooling Water Loss Fraction

The *2021 Generic Scenario for the Use of Additives in Plastic Compounding* (U.S. EPA, 2021e) and 2021 *Use of Additives in Plastics Converting Draft Generic Scenario* (U.S. EPA, 2021f) state that the if direct contact cooling water is used for compounding/converting, that the *EPA/OPPT Single Vessel Residual Model* should be used to estimate releases. The *EPA/OPPT Single Vessel Residual Model*, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015), provides an overall loss fraction of one percent residual in equipment. This model is intended for equipment; however, in the context of losses to contact cooling water, using this model assumes one percent of the batch size remains available on plastic resin (*e.g.*, extruded pellets, granules) being cooled and is transferred to the cooling water, which is discharged from the site (U.S. EPA, 2014d).

E.7.20 Rubber Production Rate

The *Emission Scenario Document on Additives in Rubber Industry* (OECD, 2004a) provides a point source estimate for all rubber manufacturing, with a default production rate of 55,000 kg/day, which is based on a 1999 German Rubber Industry study.

E.7.21 Fraction of DIDP Lost from Volatilization During Forming and Molding Processes

The 2021 *Use of Additives in Plastics Converting Draft Generic Scenario* (U.S. EPA, 2021f) provides a breakdown of vapor emission rates during converting. The loss rates are based on plastic additive type and volatility of the chemical. DIDP is a plasticizer with a low volatility (less than 0.2 torr at 200°C). According to the GS, a loss rate of 0.01% is expected for open processes, and a loss rate of 0.002% is expected for closed processes. Within the Monte Carlo model, each loss rate has an equal probability of being selected during each iteration of the simulation.

E.7.22 Solid Container Loss Fraction

EPA used the *EPA/OPPT Solid Residuals in Transport Containers Model* to estimate residual releases from solid container cleaning. The *EPA/OPPT Solid Residuals in Transport Containers Model*, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015), provides an overall loss fraction of one percent from container cleaning.

E.7.23 Trimming Loss Fraction

The 2021 *Use of Additives in Plastics Converting Draft Generic Scenario* (U.S. EPA, 2021f) recommends a default trimming loss fraction of 0.025 kg/kg.

E.8 PVC Plastics Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DIDP during the PVC Plastics Compounding and PVC Plastics Converting OESs. This approach utilizes the same equations and assumptions presented for non-PVC plastics materials in Appendix E.7. Therefore, only the parameters that differ between approaches, including throughput parameters, DIDP concentrations, and dust control efficiency, will be presented in this Section for brevity.

E.8.1 Throughput Parameters

EPA estimated the total production volume for all sites using a uniform distribution with a lower bound of 43,859,857 kg/yr and an upper bound of 434,749,009 kg/yr. This is based on CDR data (U.S. EPA, 2020a) and the *2003 European Union Risk Assessment on DIDP* (ECJRC, 2003b). The EU Risk Assessment found that 95.75% of the DIDP produced is used in PVC polymers. CDR states that the total U.S. national PV of DIDP is in the range of 100,986,354 lbs/yr to 1.001 billion lbs/yr. Multiplying these figures by 95.75% % results in 96,695,434 lb./yr (43,859,857 kg/yr) to 958,457,500 lbs/yr (434,749,009 kg/yr). This production range is used for both PVC plastic compounding and converting, since EPA assumes 100% of the compounded plastic goes to the converting process.

For compounding and converting, the annual throughput of DIDP is calculated using Equation E-55 by multiplying annual use rate of all plastic additives by mass fraction of DIDP in the compounded plastic resin and dividing by the mass fraction of all additives in the compounded plastic resin. Annual use rate of all plastic additives is determined according to Section E.8.5 for compounding and Section E.7.6 for converting. Mass fraction of DIDP in the compounded plastic resin is determined according to Section

E.8.3, and mass fraction of all additives in the compounded plastic resin is determined according to Section E.7.5.

Equation E-55.

$$Q_{DIDP\_year} = \frac{Q_{additives\_yr} * F_{chem\_resin}}{F_{additives\_resin}}$$

Where:

Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
$Q_{additives\_yr}$ = Annual use rate of all plastic additives (see Section E.8.5) [kg/site-yr]
F_{chem_resin} = Mass fraction of DIDP in the compounded plastic resin (see Section E.8.3) [kg/kg]
$F_{additives\_resin}$ = Mass fraction of all additives in the compounded plastic resin (see Section E.7.5) [kg/kg]

E.8.2 Plastic DIDP Concentration

EPA modeled final DIDP concentration in PVC plastics using a uniform distribution with a lower bound of 10% and upper bound of 45%. This is based on a presentation by the American Chemistry Council (ACC) on DIDP and DINP Product Life cycles (ACC, 2020a). The ACC indicated that DIDP is present in PVC wire and cable at 25%, in PVC film and sheets at 20-45%, and in other PVC products at 10-40%. Therefore, EPA used the lower bound and upper bound of the provided ranges to create a uniform distribution.

E.8.3 Fraction of DIDP in Compounded Plastic Resin

EPA modeled the mass fraction of DIDP in compounded plastic resin using a uniform distribution with a lower bound of 0.3 and an upper bound of 0.45. This is based on the *Generic Scenario for the Use of Additives in Plastic Compounding* (U.S. EPA, 2021e). The GS provides a range of 0.3-0.45 for the typical weight fraction of plasticizers in rigid PVC.

E.8.4 Dust Capture and Control Efficiency

The *EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders* (Dust Release Model) compiled data for loss fractions of solids from various sources in addition to the capture and removal efficiencies for control technologies in order to estimate releases of dust to the environment. Dust releases estimated from the model are based on three different parameters: the initial loss fraction, the fraction captured by the capture technology, and the fraction removed/controlled by the control technology. The underlying distributions for each of these parameters is not known; therefore, EPA assigned triangular distributions, since triangular distribution requires least assumptions and is completely defined by range and mode of a parameter. Section E.7.15 provides the distribution for the initial loss fraction.

For the fraction captured, EPA assigned a range of 0 to 1.0 with a mode of 0.321 by mass. EPA assigned the range for the fraction captured based on the minimum and maximum estimated capture efficiencies listed in the data compiled for the Dust Release Model. EPA assigned the mode for the fraction captured based on the average of all lower bound estimated capture efficiency values for all capture technologies presented in the model with a safety factor of three applied according to the model.

For the fraction removed/controlled, EPA assigned a range of 0 to 1.0 with a mode of 0.26 by mass. EPA assigned the range for the fraction controlled based on the minimum and maximum estimated control efficiencies listed in the data compiled for the Dust Release Model. EPA assigned the mode for the fraction controlled based on the average of all lower bound estimated control efficiency values for all control technologies presented in the model with a safety factor of three applied according to the model.

E.8.5 Annual Use Rate of All Plastic Additives During Compounding

The *Generic Scenario for the Use of Additives in Plastic Compounding* (U.S. EPA, 2021e) estimates that the annual facility use rate of all plastic additives at compounding sites is 4,319,048 kg additives/site-yr. This was calculated by dividing the annual U.S. demand for plastics additives by the number of sites estimated in the GS.

E.9 Application of Adhesives and Sealants Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DIDP during the application of adhesives and sealants OES. This approach utilizes the *Emission Scenario Document on Use of Adhesives* (OECD, 2015b) combined with Monte Carlo simulation (a type of stochastic simulation).

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

- Release source 1: Container Cleaning Wastes.
- Release source 2: Open Surface Losses to Air During Container Cleaning.
- Release source 3: Transfer Operation Losses from Unloading Adhesive Formulation.
- Release source 4: Equipment Cleaning Wastes.
- Release source 5: Open Surface Losses to Air During Equipment Cleaning.
- Release source 6: Process Releases During Adhesive Application.
- Release source 7: Open Surface Losses to Air During Curing/Drying.
- Release source 8: Trimming Wastes

Environmental releases for DIDP during use of adhesives and sealants are a function of DIDP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: production volume, product throughput, DIDP concentrations, air speed, saturation factor, container size, loss fractions, and operating days. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.9.1 Model Equations

Table_Apx E-19 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the use of adhesives and sealants OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix E.9.2. The Monte Carlo simulation calculated the total DIDP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th percentile and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx E-19. Models and Variables Applied for Release Sources in the Application of Adhesives and Sealants OES

Release source	Model(s) Applied	Variables Used
Release source 1: Container Cleaning Wastes.	*EPA/OAQPS AP-42 Small Container Residual Model* (Appendix E.1)	Q_{DIDP_year}; $F_{residue}$; V_{cont}; RHO; OD; F_{DIDP}
Release source 2: Open Surface Losses to Air During Container Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; MW; VP; $RATE_{air\_speed}$; D_{cont_clean}; T; P Operating Time: $RATE_{fill\_cont}$; RHO; V_{cont}; Q_{DIDP_year}
Release source 3: Transfer Operation Losses from Unloading Adhesive Formulation.	*EPA/OAQPS AP-42 Loading Model* (Appendix E.1))	Vapor Generation Rate: F_{DIDP}; VP; f_{sat}; MW; R; T ; $RATE_{fill\_cont}$; V_{cont} Operating Time: $RATE_{fill\_cont}$; RHO; V_{cont}; Q_{DIDP_year}
Release source 4: Equipment Cleaning Wastes.	*EPA/OPPT Multiple Process Vessel Residual Model* (Appendix E.1)	Q_{DIDP_day}; $F_{equipment\_cleaning}$
Release source 5: Open Surface Losses to Air During Equipment Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; MW; VP; $RATE_{air\_speed}$; D_{equip_clean}; T; P Operating Time: OH_{equip_clean}
Release source 6: Process Releases During Adhesive Application.	Unable to estimate due to lack of substrate surface area data.	N/A
Release source 7: Open Surface Losses to Air During Curing/Drying.	Unable to estimate due to the required data for release estimation of volatilization during curing not being available.	N/A
Release source 8: Trimming Wastes.	See Equation E-56	Q_{DIDP_day}; $F_{trimming}$

Release source 8 daily release (Trimming Wastes) is calculated using the following equation:

Equation E-56.

$$Release\_perDay_{RP8} = Q_{DIDP\_day} * F_{trimming}$$

Where:

$Release\_perDay_{RP8}$ = DIDP released for release source 8 [kg/site-day]
Q_{DIDP_day} = Facility throughput of DIDP (see Section E.9.3) [kg/site-day]
$F_{trimming}$ = Fraction of DIDP released as trimming waste (see Section E.9.13) [kg/kg]

E.9.2 Model Input Parameters

Table_Apx E-20 summarizes the model parameters and their values for the Application of Adhesives and Sealants Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after Table_Apx E-20.

Table_Apx E-20. Summary of Parameter Values and Distributions Used in the Application of Adhesives and Sealants Model

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Annual Facility Throughput of Adhesive/ Sealant	$Q_{product\_yr}$	kg/yr	13,500	2,300	141,498	13,500	Triangular	See Section E.9.3
Adhesive/ Sealant DIDP Concentration	F_{DIDP}	kg/kg	0.01	0.001	0.6	0.01	Triangular	See Section E.9.7
Operating Days	OD	days/yr	250	49	366	260	Triangular	See Section E.9.8
Air Speed	$RATE_{air\_speed}$	ft/min	19.7	2.56	398	–	Lognormal	See Section E.9.9
Saturation Factor	f_{sat}	dimensionless	0.5	0.5	1.45	0.5	Triangular	See Section E.9.10
Small Container Volume	V_{cont}	gal	1	1	5	1	Triangular	See Section E.9.11
Small Container Residual Loss Fraction	$F_{residue}$	kg/kg	0.003	0.0003	0.006	0.003	Triangular	See Section E.9.12
Fraction of DIDP Released as Trimming Waste	$F_{trimming}$	kg/kg	0.04	0	0.04	0.04	Triangular	See Section E.9.13
Vapor Pressure at 25C	VP	mmHg	5.28E−07	–	–	–	–	Physical property
Molecular Weight	MW	g/mol	446.68	–	–	–	–	Physical property
Gas Constant	R	atm-cm3/gmol-L	82.05	–	–	–	–	Universal constant
Density of DIDP	RHO	kg/L	0.9634	–	–	–	–	Physical property
Temperature	T	K	298	–	–	–	–	Process parameter
Pressure	P	atm	1	–	–	–	–	Process parameter
Small Container Fill Rate	$RATE_{fill\_cont}$	containers/hr	60	–	–	–	–	See Section E.9.14

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Diameter of Opening – Container Cleaning	D_{cont_clean}	cm	5.08	–	–	–	–	See Section E.9.15
Diameter of Opening – Equipment Cleaning	D_{equip_clean}	cm	92	–	–	–	–	See Section E.9.15
Operating Hours for Equipment Cleaning	OH_{equip_clean}	hr/day	1	–	–	–	–	See Section E.9.6
Equipment Cleaning Loss Fraction	$F_{equipment\_cleaning}$	kg/kg	0.02	–	–	–	–	See Section E.9.16

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E.9.3 Number of Sites

Per 2020 U.S. Census Bureau data for the NAICS codes identified in the *Emission Scenario Document on Use of Adhesives* (OECD, 2015b), there are 10,144 adhesive and sealant use sites (U.S. BLS, 2016). Therefore, this value is used as a bounding limit, not to be exceeded by the calculation. Number of sites is calculated using the following equation.:

Equation E-57.

$$N_s = \frac{PV}{Q_{DIDP_{year}}}$$

Where:

N_s = Number of sites [sites]
PV = Production volume (see Section E.9.4) [kg/year]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.9.4) [kg/site-yr]

E.9.4 Throughput Parameters

The annual throughput of adhesive and sealant product is modeled using a triangular distribution with a lower bound of 2,300 kg/yr, an upper bound of 141,498 kg/yr, and mode of 13,500 kg/yr. This is based on the *Emission Scenario Document on Use of Adhesives* (OECD, 2015b). The ESD provides default adhesive use rates based on end-use category. EPA compiled the end-use categories that were relevant to downstream uses for adhesives and sealants. The relevant end-use categories included general assembly, motor and non-motor vehicle, vehicle parts, and tire manufacturing (except retreading), and computer/electronic and electrical product manufacturing. The lower and upper bound adhesive use rates for these categories was 2,300 to 141,498 kg/yr. The mode is based on the ESD default for unknown end-use markets.

The annual throughput of DIDP in adhesives/sealants is calculated using Equation E-58 by multiplying the annual throughput of all adhesives and sealants by the concentration of DIDP in the adhesives/sealants.

Equation E-58.

$$Q_{DIDP\_year} = Q_{product\_yr} * F_{DIDP}$$

Where:

Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
$Q_{product\_yr}$ = Facility annual throughput of all Adhesive/ Sealant [kg/batch]
F_{DIDP} = Concentration of DIDP in Adhesive/ Sealant (see Section E.9.8) [kg/kg]

The daily throughput of DIDP is calculated using Equation E-59 by dividing the annual production volume by the number of operating days. The number of operating days is determined according to Section E.9.8.

Equation E-59.

$$Q_{DIDP\_day} = \frac{Q_{DIDP\_year}}{OD}$$

Where:

Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
OD = Operating days (see Section E.9.8) [days/yr]

E.9.5 Number of Containers per Year

The number of DIDP raw material containers received and unloaded by a site per year is calculated using the following equation:

Equation E-60.

$$N_{cont\_unload\_yr} = \frac{Q_{DIDP\_year}}{RHO * \left(3.79\ \frac{L}{gal}\right) * V_{cont}}$$

Where:

V_{cont} = Import container volume (see Section E.9.11) [gal/container]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.9.3) [kg/site-yr]
RHO = DIDP density [kg/L]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded [container/site-year]

E.9.6 Operating Hours

EPA estimated operating hours or hours of duration using data provided from the *Emission Scenario Document on Use of Adhesives* (OECD, 2015b), *ChemSTEER User Guide* (U.S. EPA, 2015), and/or through calculation from other parameters. Release points with operating hours provided from these sources include container cleaning and equipment cleaning.

For container cleaning and unloading (release points 2 and 3), the operating hours are calculated based on the number of containers unloaded at the site and the unloading rate using the following equation:

Equation E-61.

$$OH_{RP2/RP3} = \frac{N_{cont\_unload\_yr}}{RATE_{fill\_cont} * OD}$$

Where:

$OH_{RP2/RP3}$ = Operating time for release points 2 and 3 [hrs/site-day]
$RATE_{fill\_cont}$ = Container fill rate (see Section E.9.14) [containers/hr]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded (see Section E.9.5) [container/site-year]
OD = Operating days (see Section E.9.8) [days/site-year]

For equipment cleaning (release point 5), the *ChemSTEER User Guide* (U.S. EPA, 2015) states that the default operating hours for equipment cleaning is one hour/batch multiplied by the number of batches per day. Per the *Emission Scenario Document on Use of Adhesives* (OECD, 2015b), the default number of batches per day is one. Therefore, EPA assumes that equipment cleaning occurs for one hour/day.

E.9.7 Adhesive/ Sealant DIDP Concentration

EPA modeled DIDP concentration in adhesives and sealants using a triangular distribution with a lower bound of 0.1%, upper bound of 60%, and mode of 1%. The upper bound is based on the upper bound for imported DIDP concentration. The concentration of DIDP in the adhesive or sealant cannot be higher than the concentration of DIDP in the final formulation. The lower bound and mode is based on compiled SDS information for adhesives and sealant products containing DIDP. EPA did not have information on the prevalence or market share of different Adhesive/ Sealant products in commerce; therefore, EPA assumed a triangular distribution of concentrations. From the compiled data, the minimum concentration was 0.1% and the mode of high-end product concentrations was 1% (see Appendix F for EPA identified DIDP-containing products for this OES).

E.9.8 Operating Days

EPA modeled the operating days per year using a triangular distribution with a lower bound of 50 days/yr, an upper bound of 365 days/yr, and a mode of 260 days/yr. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 50-365 days/yr. This is based on the *Emission Scenario Document on Use of Adhesives* (OECD, 2015b). The ESD provides operating days for several end-use categories, as listed in Section E.9.3. The range of operating days for the end-use categories is 50-365 days/yr. The mode of the distribution is based on the ESD's default of 260 days/yr for unknown or general use cases.

E.9.9 Air Speed

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

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

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

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

E.9.10 Saturation Factor

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

E.9.11 Container Size

EPA assumed that use sites would receive adhesives and sealants in bottles. According to the *ChemSTEER User Guide*, bottles are defined as containing between one and five gallons of liquid, and the default bottle size is one gallon (U.S. EPA, 2015). Therefore, EPA modeled container size using a triangular distribution with a lower bound and mode of one gallon, an upper bound of five gallons.

E.9.12 Small Container Residue Loss Fraction

EPA paired the data from the PEI Associates Inc. study (Associates, 1988) such that the residuals data for emptying drums by pouring was aligned with the default central tendency and high-end values from the *EPA/OPPT Small Container Residual Model*. For unloading drums by pouring in the PEI Associates Inc. study (Associates, 1988), EPA found that the average percent residual from the pilot-scale experiments showed a range of 0.03 percent to 0.79 percent and an average of 0.32 percent. The *EPA/OPPT Small Container Residual Model* from the *ChemSTEER User Guide* (U.S. EPA, 2015) recommends a default central tendency loss fraction of 0.3 percent and a high-end loss fraction of 0.6 percent.

The underlying distribution of the loss fraction parameter for small containers is not known; therefore, EPA assigned a triangular distribution, since triangular distributions require least assumptions and are completely defined by range and mode of a parameter. EPA assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the *EPA/OPPT Small Container Residual Model* in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study (Associates, 1988) for emptying drums by pouring.

E.9.13 Fraction of DIDP Released as Trimming Waste

EPA modeled the fraction of DIDP released as trimming waste using a uniform distribution with a lower bound of 0 and upper bound of 0.04. This is based on the *Emission Scenario Document on Use of Adhesives* (OECD, 2015b). The ESD states that trimming losses should only be assessed if trimming losses are expected for the end-use being assessed. Since not all adhesive and sealant end uses will result in trimming losses, EPA assigned a lower bound of 0. The upper bound is based on the ESD's default waste fraction of 0.04 kg chemical in trimmings/kg chemical applied.

E.9.14 Container Unloading Rates

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

E.9.15 Diameters of Opening

The *ChemSTEER User Guide* indicates diameters for the openings for various vessels that may hold liquids in order to calculate vapor generation rates during different activities (U.S. EPA, 2015). For equipment cleaning operations, the *ChemSTEER User Guide* indicates a single default value of 92 cm (U.S. EPA, 2015).

For container cleaning activities, the *ChemSTEER User Guide* indicates a single default value of 5.08 cm for containers less than 5,000 gallons (U.S. EPA, 2015).

E.9.16 Equipment Cleaning Loss Fraction

EPA used the *EPA/OPPT Multiple Process Residual Model* to estimate the releases from equipment cleaning. The *EPA/OPPT Multiple Process Residual Model*, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015) provides an overall loss fraction of two percent from equipment cleaning.

E.10 Application of Paints and Coatings Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DIDP during the application of paints and coatings OES. This approach utilizes the *Emission Scenario Document on Coating Application via Spray-Painting in the Automotive Refinishing Industry* (OECD, 2011a), *Emission Scenario Document on the Coating Industry (Paints, Lacquers, and Varnishes)* (OECD, 2009c), and *Emission Scenario Document on the Application of Radiation Curable Coatings, Inks, and Adhesives via Spray, Vacuum, Roll, and Curtain Coating* (OECD, 2011b) combined with Monte Carlo simulation (a type of stochastic simulation).

Based on the ESD, EPA identified the following release sources from the application of paints and coatings:

- Release source 1: Transfer Operation Losses to Air from Unloading Paint.
- Release source 2: Open Surface Losses to Air During Raw Material Sampling.
- Release source 3: Container Cleaning Wastes.
- Release source 4: Open Surface Losses to Air During Container Cleaning.
- Release source 5: Process Releases During Operations.
- Release source 6: Equipment Cleaning Wastes.
- Release source 7: Open Surface Losses to Air During Equipment Cleaning.
- Release source 8: Raw Material Sampling Wastes.

Environmental releases for DIDP during the application of paints and coatings are a function of DIDP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: production volume, throughput, DIDP concentrations, air speed, saturation factor, container size, loss fractions, diameters of openings, and operating days. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.10.1 Model Equations

Table_Apx E-21 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the application of paints and coatings OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix E.10.2. The Monte Carlo simulation calculated the total DIDP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th percentile and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx E-21. Models and Variables Applied for Release Sources in the Application of Paints and Coatings OES

Release source	Model(s) Applied	Variables Used
Release source 1: Transfer Operation Losses to Air from Unloading Paint.	*EPA/OAQPS AP-42 Loading Model* (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; VP; f_{sat}; MW; R; T; V_{cont}; $RATE_{fill\_cont}$ Operating Time: Q_{DIDP_year}; $RATE_{fill\_cont}$; V_{cont}; RHO; F_{DIDP}; OD
Release source 2: Open Surface Losses to Air During Raw Material Sampling.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; MW; VP; $RATE_{air\_speed}$; $D_{sampling}$; T; P Operating Time: $OH_{sampling}$
Release source 3: Container Cleaning Wastes.	*EPA/OAQPS AP-42 Small Container Residual Model* (Appendix E.1)	Q_{DIDP_day}; $F_{residue}$
Release source 4: Open Surface Losses to Air During Container Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; MW; VP; $RATE_{air\_speed}$; D_{cont_clean}; T; P Operating Time: Q_{DIDP_year}; $RATE_{fill\_cont}$; V_{cont}; RHO; F_{DIDP}; OD
Release source 5: Process Releases During Operations.	See Equation E-62 through Equation E-66	Q_{DIDP_day}; $F_{transfer\_eff}$; $F_{capture\_eff}$; $F_{solidrem\_eff}$; OD
Release source 6: Equipment Cleaning Wastes.	*EPA/OPPT Multiple Process Vessel Residual Model* (Appendix E.1)	Q_{DIDP_day}; LF_{equip_clean}
Release source 7: Open Surface Losses to Air During Equipment Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; MW; VP; $RATE_{air\_speed}$; D_{equip_clean}; T; P Operating Time: OH_{equip_clean}
Release source 8: Raw Material Sampling Wastes.	*March 2023 Methodology for Estimating Environmental Releases from Sampling Waste* (Appendix E.1)	Q_{DIDP_day}; $LF_{sampling}$

Release source 5 (Process Releases During Operations) is partitioned out by release media. In order to calculate the releases to each media, the total release is calculated first using the following equation:

Equation E-62.

$$Release\_perDay_{RP5\_total} = Q_{DIDP\_day} * (1 - F_{transfer\_eff})$$

Where:

$Release\_perDay_{RP5\_total}$ = DIDP released for release source 5 to all release media

[kg/site-day]

Q_{DIDP_day} = Facility throughput of DIDP (see Section E.10.3) [kg/site-day]

$F_{transfer\_eff}$ = Paint/coating transfer efficiency fraction (see Section E.10.15) [unitless]

Transfer efficiency is determined according to Section E.10.15. The percent of release 5 that is released to water is calculated using the following equation:

Equation E-63.

$$\%_{water} = F_{capture\_eff} * \left(1 - F_{solidrem\_eff}\right)$$

Where:

$\%_{water}$ = Percent of release 5 that is released to water [unitless]

$F_{capture\_eff}$ = Booth capture efficiency for spray-applied Paints/ Coatings (see Section E.10.18) [kg/kg]

$F_{solidrem\_eff}$ = Fraction of solid removed in the spray mist of sprayed Paints/ Coatings (see Section E.10.19) [kg/kg]

Booth capture efficiency is determined according to Section E.10.18 and solid removal efficiency is determined according to Section E.10.19. The percent of release 5 that is released to air is calculated using the following equation:

Equation E-64.

$$\%_{air} = \left(1 - F_{capture\_eff}\right)$$

Where:

$\%_{air}$ = Percent of release 5 that is released to air [unitless]

$F_{capture\_eff}$ = Booth capture efficiency for spray-applied Paints/ Coatings (see Section E.10.18) [kg/kg]

The percent of release 5 that is released to land is calculated using the following equation:

Equation E-65.

$$\%_{land} = F_{capture\_eff} * F_{solidrem\_eff}$$

Where:

$\%_{land}$ = Percent of release 5 that is released to land [unitless]

$F_{capture\_eff}$ = Booth capture efficiency for spray-applied Paints/ Coatings (see Section E.10.18) [kg/kg]

$F_{solidrem\_eff}$ = Fraction of solid removed in the spray mist of sprayed Paints/ Coatings (see Section E.10.19) [kg/kg]

Finally, the release amounts to each media are calculated using the following equation:

Equation E-66.

$$Release\_perDay_{RP5\_media} = Release\_perDay_{RP5\_total} * \%_{media}$$

Where:

$Release\_perDay_{RP5\_media}$ = Amount of release 5 that is released to water, air, or land

[kg/site-day]

$Release\_perDay_{RP5\_total}$ = DIDP released for release source 5 to all release media [kg/site-day]

$\%_{media}$ = Percent of release 5 that is released to water, air, or land [unitless]

E.10.2 Model Input Parameters

Table_Apx E-22 summarizes the model parameters and their values for the Application of Paints and Coatings Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after Table_Apx E-22.

7486 **Table_Apx E-22. Summary of Parameter Values and Distributions Used in the Application of Paints and Coatings Model**

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Annual Facility Throughput of Paint/Coating	Q_{coat_yr}	kg/site-yr	225,000	2,694	446,600	225,000	Triangular	See Section E.10.3
Paint/Coating DIDP Concentration	F_{DIDP}	kg/kg	0.01	0.001	0.05	0.01	Triangular	See Section E.10.7
Operating Days	OD	days/yr	250	225	300	250	Triangular	See Section E.10.8
Air Speed	$RATE_{air\_speed}$	ft/min	19.7	2.56	398	—	Lognormal	See Section E.10.9
Saturation Factor	f_{sat}	dimensionless	0.5	0.5	1.45	0.5	Triangular	See Section E.10.10
Container Size	V_{cont}	gal	5	5	20	5	Triangular	See Section E.10.11
Small Container Loss Fraction	$F_{residue}$	kg/kg	0.003	0.003	0.006	0.003	Triangular	See Section E.10.12
Fraction of DIDP Lost During Sampling – 1 ($Q_{DIDP\_day} < 50$ kg/site-day)	$F_{sampling\_1}$	kg/kg	0.02	0.002	0.02	0.02	Triangular	See Section E.10.13
Fraction of DIDP Lost During Sampling – 2 (Q_{DIDP_day} 50-200 kg/site-day)	$F_{sampling\_2}$	kg/kg	0.005	0.0006	0.005	0.005	Triangular	See Section E.10.13
Fraction of DIDP Lost During Sampling – 3 (Q_{DIDP_day} 200-5000 kg/site-day)	$F_{sampling\_3}$	kg/kg	0.004	0.0005	0.004	0.004	Triangular	See Section E.10.13

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Fraction of DIDP Lost During Sampling – 4 (Q_{DIDP_day} > 5000 kg/site-day)	$F_{sampling\_4}$	kg/kg	0.0004	0.00008	0.0004	0.0004	Triangular	See Section E.10.13
Diameter of Opening – Sampling	$D_{sampling}$	cm	2.5	2.5	10	—	Uniform	See Section E.10.14
Transfer Efficiency Fraction	$F_{transfer\_eff}$	unitless	0.65	0.2	0.8	0.65	Triangular	See Section E.10.15
Vapor Pressure at 25C	VP	mmHg	5.28E−07	—	—	—	—	Physical property
Molecular Weight	MW	g/mol	446.68	—	—	—	—	Physical property
Gas Constant	R	atm-cm3/gmol-L	82.05	—	—	—	—	Universal constant
Density of DIDP	RHO	kg/L	0.9634	—	—	—	—	Physical property
Temperature	T	K	298	—	—	—	—	Process parameter
Pressure	P	atm	1	—	—	—	—	Process parameter
Small Container Fill Rate	$RATE_{fill\_cont}$	containers/hr	60	—	—	—	—	See Section E.10.16
Diameter of Opening – Container Cleaning	D_{cont_clean}	cm	5.08	—	—	—	—	See Section E.10.14
Diameter of Opening – Equipment Cleaning	D_{equip_clean}	cm	92	—	—	—	—	See Section E.10.14

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Sampling Duration	$OH_{sampling}$	hr/day	1	—	—	—	—	See Section E.10.6
Equipment Cleaning Duration	OH_{equip_clean}	hr/day	4	—	—	—	—	See Section E.10.6
Equipment Cleaning Loss Fraction	LF_{equip_clean}	kg/kg	0.02	—	—	—	—	See Section E.10.17
Capture Efficiency for Spray Booth	$F_{capture\_eff}$	kg/kg	0.9	—	—	—	—	See Section E.10.18
Fraction of Solid Removed in Spray Mist	$F_{solidrem\_eff}$	kg/kg	1	—	—	—	—	See Section E.10.19

E.10.3 Number of Sites

Per 2020 U.S. Census Bureau data for the NAICS codes identified in the *Emission Scenario Document on Coating Application via Spray-Painting in the Automotive Refinishing Industry* (OECD, 2011a), *Emission Scenario Document on the Coating Industry (Paints, Lacquers, and Varnishes)* (OECD, 2009c), and *Emission Scenario Document on the Application of Radiation Curable Coatings, Inks, and Adhesives via Spray, Vacuum, Roll, and Curtain Coating* (OECD, 2011b), there are 83,456 paints and coatings use sites (U.S. BLS, 2016). Therefore, this value is used as a bounding limit, not to be exceeded by the calculation. Number of sites is calculated using the following equation.:

Equation E-67.

$$N_s = \frac{PV}{Q_{DIDP_{year}}}$$

Where:

N_s = Number of sites [sites]
PV = Production volume (see Section E.9.4) [kg/year]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.9.4) [kg/site-yr]

E.10.4 Throughput Parameters

The annual throughput of paint and coating product is modeled using a triangular distribution with a lower bound of 2,694 kg/yr, an upper bound of 446,600 kg/yr, and mode of 225,000 kg/yr. The lower bound is based on the *Emission Scenario Document on the Application of Radiation Curable Coatings, Inks, and Adhesives via Spray, Vacuum, Roll, and Curtain Coating* (OECD, 2011b). The ESD provides a range of 2,694-265,000 kg of radiation curable coatings produced per site, per year. The lower bound was taken from this range. The upper bound is based on the *Generic Scenario for Spray Coatings in the Furniture Industry* (U.S. EPA, 2004d). The GS provides a range of 5,000 to 446,000 liters of furniture coatings used per year based on plant size, with an assumption of 1 kg/L as the density of the coating. The upper bound was taken from this range and using the assumed coating density. The mode is based on CEPE's *SpERC Industrial application of coatings by spraying* (CEPE, 2020). The factsheet provides a production rate of 1,000 kg/day for 225 days/yr, for a total of 225,000 kg/yr.

The annual throughput of DIDP in the Paints and Coatings OES is calculated using Equation E-68 by multiplying the annual throughput of all paints and coatings by the concentration of DIDP found in the paints and coatings.

Equation E-68.

$$Q_{DIDP\_year} = Q_{coat\_yr} * F_{DIDP}$$

Where:

Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
Q_{coat_yr} = Facility annual throughput of all Paints/ Coatings [kg/site-yr]
F_{DIDP} = Concentration of DIDP in Paints/ Coatings (see Section E.10.7) [kg/kg]

The daily throughput of DIDP is calculated using Equation E-69 by dividing the annual production volume by the number of operating days. The number of operating days is determined according to Section E.10.8.

Equation E-69.

$$Q_{DIDP\_day} = \frac{Q_{DIDP\_year}}{OD}$$

Where:

Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
OD = Operating days (see Section E.10.8) [days/yr]

E.10.5 Number of Containers per Year

The number of DIDP raw material containers received and unloaded by a site per year is calculated using the following equation:

Equation E-70.

$$N_{cont\_unload\_yr} = \frac{Q_{DIDP\_year}}{RHO * \left(3.79\,\frac{L}{gal}\right) * V_{cont}}$$

Where:

V_{cont} = Container volume (see Section E.10.11) [gal/container]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.10.3) [kg/site-yr]
RHO = DIDP density [kg/L]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded [container/site-year]

E.10.6 Operating Hours

EPA estimated operating hours or hours of duration using data provided from the *ChemSTEER User Guide* (U.S. EPA, 2015) and/or through calculation from other parameters. Release points with operating hours provided from these sources include unloading, product sampling, and equipment cleaning.

For unloading (release point 1), the operating hours are calculated based on the number of containers unloaded at the site and the unloading rate using the following equation:

Equation E-71.

$$OH_{RP1/RP4} = \frac{N_{cont\_unload\_yr}}{RATE_{fill\_cont} * OD}$$

Where:

$OH_{RP1/RP4}$ = Operating time for release points 1 and 4 [hrs/site-day]
$RATE_{fill\_cont}$ = Container fill rate (see Section E.10.16) [containers/hr]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded (see Section E.10.5) [container/site-year]
OD = Operating days (see Section E.10.8) [days/site-year]

For product sampling (release point 2), the *ChemSTEER User Guide* (U.S. EPA, 2015) indicates a single value of one hour/day.

For equipment cleaning (release point 7), the *ChemSTEER User Guide* provides an estimate of four hours per day for cleaning multiple vessels (U.S. EPA, 2015).

E.10.7 Paint/Coating DIDP Concentration

EPA modeled final DIDP concentration in paints and coatings using a triangular distribution with a lower bound of 0.01%, upper bound of 5%, and mode of 1%. This is based on compiled SDS information for paint and coating products containing DIDP. The lower and upper bounds represent the minimum and maximum reported concentrations in the SDSs. The mode represents the mode of all range endpoints reported in the SDSs (see Appendix F for EPA identified DIDP-containing products for this OES).

E.10.8 Operating Days

EPA modeled the operating days per year using a triangular distribution with a lower bound of 225 days/yr, an upper bound of 300 days/yr, and a mode of 250 days/yr. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 225-300 days/yr. The lower bound is based on ESIG's *Specific Environmental Release Category Factsheet for Industrial Application of Coatings by Spraying* (CEPE, 2020). The factsheet estimates 225 days/yr as the number of emission days. The upper bound is based on the European Risk Report for DIDP (ECJRC, 2003a) which provided a default of 300 days/yr. The mode is based on the *Generic Scenario for Automobile Spray Coating* (U.S. EPA, 1996) which estimates 250 days/yr, based on five days/week operation that takes place 50 weeks/yr.

E.10.9 Air Speed

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

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

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

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

E.10.10 Saturation Factor

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

E.10.11 Container Size

EPA assumed that paint and coating use sites would receive DIDP in small containers. According to the *ChemSTEER User Guide*, small containers are defined as containing between 5 and 20 gallons of liquid, and the default drum size is 5 gallons (U.S. EPA, 2015). Therefore, EPA modeled import container size using a triangular distribution with a lower bound of 5 gallons, an upper bound of 20 gallons, and a mode of 5 gallons.

E.10.12 Small Container Loss Fraction

EPA paired the data from the PEI Associates Inc. study (Associates, 1988) such that the residuals data for emptying drums by pouring was aligned with the default central tendency and high-end values from the *EPA/OPPT Small Container Residual Model*. For unloading drums by pouring in the PEI Associates Inc. study (Associates, 1988), EPA found that the average percent residual from the pilot-scale experiments showed a range of 0.03 percent to 0.79 percent and an average of 0.32 percent. The *EPA/OPPT Small Container Residual Model* from the *ChemSTEER User Guide* (U.S. EPA, 2015) recommends a default central tendency loss fraction of 0.3 percent and a high-end loss fraction of 0.6 percent.

The underlying distribution of the loss fraction parameter for small containers is not known; therefore, EPA assigned a triangular distribution, since triangular distributions require least assumptions and are completely defined by range and mode of a parameter. EPA assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the *EPA/OPPT Small Container Residual Model* in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study (Associates, 1988) for emptying drums by pouring.

E.10.13 Sampling Loss Fraction

Sampling loss fractions were estimated using the *March 2023 Methodology for Estimating Environmental Releases from Sampling Wastes* (U.S. EPA, 2023b). In this methodology, EPA completed a search of over 300 IRERs completed in the years 2021 and 2022 for sampling release data, including a similar proportion of both PMNs and Low Volume Exemptions (LVEs). Of the searched IRERs, 60 data points for sampling release loss fractions, primarily for sampling releases from submitter-controlled sites (~75% of IRERs), were obtained. The data points were analyzed as a function of the chemical daily throughput and industry type. This analysis showed that the sampling loss fraction generally decreased as the chemical daily throughput increased. Therefore, the methodology provides guidance for selecting a loss fraction based on chemical daily throughput. Table_Apx E-23 presents a summary of the chemical daily throughputs and corresponding loss fractions.

Table_Apx E-23. Sampling Loss Fraction Data from the March 2023 Methodology for Estimating Environmental Releases from Sampling Waste

Chemical Daily Throughput (kg/site-day) ($Q_{chem\_site\_day}$)	Number of Data Points	Sampled Quantity (kg chemical/day)		Sampling Loss Fraction ($LF_{sampling}$)	
		50th Percentile	95th Percentile	50th Percentile	95th Percentile
<50	13	0.03	0.20	0.002	0.02
50 to <200	10	0.10	0.64	0.0006	0.005
200 to <5,000	25	0.37	3.80	0.0005	0.004
≥5,000	10	1.36	6.00	0.00008	0.0004
All	58	0.20	5.15	0.0005	0.008

For each range of daily throughputs, EPA estimated sampling loss fractions using a triangular distribution of the 50th percentile value as the lower bound, and the 95th percentile value as the upper bound and mode. The sampling loss fraction distribution was chosen based on the calculation of daily throughput, as shown in Section E.10.3.

E.10.14 Diameters of Opening

The *ChemSTEER User Guide* indicates diameters for the openings for various vessels that may hold liquids in order to calculate vapor generation rates during different activities (U.S. EPA, 2015). For equipment cleaning operations, the *ChemSTEER User Guide* indicates a single default value of 92 cm (U.S. EPA, 2015). For container cleaning activities, the *ChemSTEER User Guide* indicates a single default value of 5.08 cm for containers less than 5,000 gallons (U.S. EPA, 2015).

For sampling liquid product, sampling liquid raw material, or general liquid sampling, the *ChemSTEER User Guide* indicates that the typical diameter of opening for vaporization of the liquid is 2.5 cm (U.S. EPA, 2015). Additionally, the *ChemSTEER User Guide* provides ten cm as a high-end value for the diameter of opening during sampling (U.S. EPA, 2015). The underlying distribution of this parameter is not known; therefore, EPA assigned a triangular distribution based on the estimated lower bound, upper bound, and mode of the parameter. EPA assigned the value of 2.5 cm as a lower bound for the parameter and ten cm as the upper bound based on the values provided in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA also assigned 2.5 cm as the mode diameter value for sampling liquids based on the typical value described in *ChemSTEER User Guide* (U.S. EPA, 2015).

E.10.15 Transfer Efficiency Fraction

EPA modeled transfer efficiency fraction using a triangular distribution with a lower bound of 0.2, an upper bound of 0.8, and a mode of 0.65. The lower bound and mode are based on the *EPA/OPPT Automobile OEM Overspray Loss Model.* Per the model, the transfer efficiency varies based on the type of spray gun used. For high volume, low pressure (HVLP) spray guns, the default transfer efficiency is 0.65. For conventional spray guns, the default transfer efficiency is 0.2 by mass. Across all spray technologies, the *ESD on Coating Industry* (OECD, 2009c) estimates a transfer efficiency of 30-80 percent. Therefore, EPA used 0.8 as the upper bound.

E.10.16 Small Container Unloading Rate

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

E.10.17 Equipment Cleaning Loss Fraction

EPA used the *EPA/OPPT Multiple Process Residual Model* to estimate the releases from equipment cleaning. The *EPA/OPPT Multiple Process Residual Model*, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015), provides an overall loss fraction of two percent from equipment cleaning.

E.10.18 Capture Efficiency for Spray Booth

The *Emission Scenario Document on the Application of Radiation Curable Coatings, Inks, and Adhesives via Spray, Vacuum, Roll, and Curtain Coating* (OECD, 2011b) uses the *EPA/OPPT Automobile Refinish Coating Overspray Loss Model* to estimate releases from spray coating. This model assumes a spray booth capture efficiency of 90%.

E.10.19 Fraction of Solid Removed in Spray Mist

The *Emission Scenario Document on the Application of Radiation Curable Coatings, Inks, and Adhesives via Spray, Vacuum, Roll, and Curtain Coating* (OECD, 2011b) uses the *EPA/OPPT Automobile Refinish Coating Overspray Loss Model* to estimate releases from spray coating. This model assumes a solid removal efficiency of 100%.

E.11 Use of Laboratory Chemicals Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DIDP during the use of laboratory chemicals OES. This approach utilizes the *Generic Scenario on Use of Laboratory Chemicals* (U.S. EPA, 2023c) and CDR data (U.S. EPA, 2020a) combined with Monte Carlo simulation (a type of stochastic simulation).

Based on the GS, EPA identified the following release sources from use of laboratory chemicals:

- Release source 1: Transfer Operation Losses to Air from Unloading Laboratory Chemicals.
- Release source 2: Dust Emissions from Transferring Powders.
- Release source 3: Container Cleaning Wastes.
- Release source 4: Open Surface Losses to Air During Container Cleaning.
- Release source 5: Equipment Cleaning Wastes.
- Release source 6: Open Surface Losses to Air During Equipment Cleaning.
- Release source 7: Releases During Laboratory Analysis.
- Release source 8: Laboratory Waste Disposal.

Environmental releases for DIDP during the use of laboratory chemicals are a function of DIDP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: facility throughput, operating days, DIDP concentrations, air speed, saturation factor, container size, loss fractions, and diameters of openings. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.11.1 Model Equations

Table_Apx E-24 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the use of laboratory chemicals OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix E.11.2. The Monte Carlo simulation calculated the total

DIDP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th percentile and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx E-24. Models and Variables Applied for Release Sources in the Use of Laboratory Chemicals OES

Release source	Model(s) Applied	Variables Used
Release source 1: Transfer Operation Losses to Air from Unloading Laboratory Chemicals.	*EPA/OAQPS AP-42 Loading Model* (Appendix E.1)	Vapor Generation Rate: F_{DIDP-L}; VP; f_{sat}; MW; R; T; V_{cont}; $RATE_{fill}$ Operating Time: Q_{DIDP_day}; V_{cont}; $RATE_{fill}$; RHO; OD; F_{DIDP-L}
Release source 2: Dust Emissions from Transferring Powders.	*EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders* (Appendix E.1)	Q_{DIDP_day}; $F_{dust\_generation}$
Release source 3: Container Cleaning Wastes.	*EPA/OAQPS AP-42 Small Container Residual Model* or *EPA/OPPT Solid Residuals in Transport Containers Model*, based on physical form (Appendix E.1)	Q_{DIDP_day}; $F_{residue}$; V_{cont}; RHO; F_{DIDP-S}; F_{DIDP-L}; LF_{cont}; OD; Q_{cont_solid}
Release source 4: Open Surface Losses to Air During Container Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP-L}; MW; VP; $RATE_{air\_speed}$; $D_{cleaning}$; T; P Operating Time: Q_{DIDP_day}; V_{cont}; $RATE_{fill}$; RHO; OD; F_{DIDP-L}
Release source 5: Equipment Cleaning Wastes.	*EPA/OPPT Multiple Process Vessel Residual Model* or *EPA/OPPT Solids Residuals in Transport Container Model*, based on physical form (Appendix E.1)	Q_{DIDP_day}; $F_{lab\_residue\_L}$; $F_{lab\_residue\_S}$
Release source 6: Open Surface Losses to Air During Equipment Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP-L}; MW; VP; $RATE_{air\_speed}$; $D_{cleaning}$; T; P Operating Time: $OH_{cleaning}$
Release source 7: Releases During Laboratory Analysis.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP-L}; MW; VP; $RATE_{air\_speed}$; $D_{testing}$; T; P Operating Time: $OH_{testing}$
Release source 8: Laboratory Waste Disposal.	See Equation E-72 and Equation E-73	Q_{DIDP_day}; $F_{residue}$; LF_{cont}; $F_{lab\_residue\_L}$; $F_{lab\_residue\_S}$;

Release source	Model(s) Applied	Variables Used
		$F_{dust\_generation}$; Release Points 1,3,6,and 7

For liquid DIDP, release source 8 (Laboratory Waste Disposal) is calculated via a mass-balance, via the following equation:

Equation E-72.

$$Release\_perDay_{RP8-L} = \left(Q_{DIDP\_day} - Release_{perDay}{}_{RP1} - Release_{perDay}{}_{RP3} - Release_{perDay}{}_{RP6} - Release\_perDay_{RP7}\right) * \left(1 - F_{residue} - F_{lab\_residue\_L}\right)$$

Where:

$Release\_perDay_{RP8-L}$ = Liquid DIDP released for release source 8 [kg/site-day]
Q_{DIDP_day} = Facility throughput of DIDP (see Section E.11.3) [kg/site-day]
$Release\_perDay_{RP1}$ = Liquid DIDP released for release source 1 [kg/site-day]
$Release\_perDay_{RP3}$ = Liquid DIDP released for release source 3 [kg/site-day]
$Release\_perDay_{RP6}$ = Liquid DIDP released for release source 6 [kg/site-day]
$Release\_perDay_{RP7}$ = Liquid DIDP released for release source 7 [kg/site-day]
$F_{residue}$ = Fraction of DIDP remaining in transport containers (see Section E.11.11) [kg/kg]
$F_{lab\_residue\_L}$ = Fraction of DIDP remaining in lab equipment (see Section E.11.15) [kg/kg]

For solids containing DIDP, release source 8 (Laboratory Waste Disposal) is calculated via a mass-balance, via the following equation:

Equation E-73.

$$Release\_perDay_{RP8-S} = Q_{DIDP\_day} * \left(1 - F_{dust\_generation} - LF_{cont} - F_{lab\_residue\_S}\right)$$

Where:

$Release\_perDay_{RP8-S}$ = Solid DIDP released for release source 8 [kg/site-day]
Q_{DIDP_day} = Facility throughput of DIDP (see Section E.11.3) [kg/site-day]
$F_{dust\_generation}$ = Fraction of DIDP lost during unloading of solid powder (see Section E.11.12) [kg/kg]
LF_{cont} = Fraction of DIDP remaining in transport containers (see Section E.11.11) [kg/kg]
$F_{lab\_residue\_S}$ = Fraction of DIDP remaining in lab equipment (see Section E.11.15) [kg/kg]

E.11.2 Model Input Parameters

Table_Apx E-25 summarizes the model parameters and their values for the Use of Laboratory Chemicals Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after Table_Apx E-25.

7786 **Table_Apx E-25. Summary of Parameter Values and Distributions Used in the Use of Laboratory Chemicals Model**

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Facility Throughput of Solid DIDP	$Q_{stock\_site\_day\_S}$	g/site-day	330	–	–	–	–	See Section E.11.3
Facility Throughput of Liquid DIDP	$Q_{stock\_site\_day\_L}$	mL/site-day	4,000	17.05	4000	–	Uniform	See Section E.11.3
Liquid DIDP Concentration	$F_{DIDP\text{-}L}$	kg/kg	0.95	0.9	1	0.95	Triangular	See Section E.11.6
Solid DIDP Concentration	$F_{DIDP\text{-}S}$	kg/kg	0.03	–	–	–	–	See Section E.11.6
Operating Days	OD	days/yr	260	174	260	260	Triangular	See Section E.11.7
Air Speed	$RATE_{air\_speed}$	ft/min	19.7	2.56	398	–	Lognormal	See Section E.11.8
Saturation Factor	f_{sat}	dimensionless	0.5	0.5	1.45	0.5	Triangular	See Section E.11.9
Liquid Container Size	V_{cont}	gal	1	0.5	1	1	Triangular	See Section E.11.10
Solid Container Mass	Q_{cont_solid}	kg	1	0.5	1	1	Triangular	See Section E.11.10
Small Container Loss Fraction	$F_{residue}$	kg/kg	0.003	0.003	0.006	0.003	Triangular	See Section E.11.11
Solid Container Loss Fraction	LF_{cont}	kg/kg	0.01	–	–	–	–	See Section E.11.11
Fraction of chemical lost during transfer of solid powders	$F_{dust\_generation}$	kg/kg	0.005	–	–	–	–	See Section E.11.12
Vapor Pressure at 25C	VP	mmHg	5.28E−07	–	–	–	–	Physical property

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Molecular Weight	MW	g/mol	446.68	–	–	–	–	Physical property
Gas Constant	R	atm-cm3/gmol-L	82.05	–	–	–	–	Universal constant
Density of DIDP	RHO	kg/L	0.9634	–	–	–	–	Physical property
Temperature	T	K	298	–	–	–	–	Process parameter
Pressure	P	atm	1	–	–	–	–	Process parameter
Small Container Fill Rate	$RATE_{fill}$	containers/hr	60	–	–	–	–	See Section E.11.13
Diameter of Opening – Container Cleaning	$D_{cleaning}$	cm	5.08	–	–	–	–	See Section E.11.14
Lab Testing Duration	$OH_{testing}$	hr/day	1	–	–	–	–	See Section E.11.5
Equipment Cleaning Duration	$OH_{cleaning}$	hr/day	4	–	–	–	–	See Section E.11.5
Equipment Cleaning Loss Fraction–-Liquid	$F_{lab\_residue\_L}$	kg/kg	0.02	–	–	–	–	See Section E.11.15
Equipment Cleaning Loss Fraction–-Solid	$F_{lab\_residue\_S}$	kg/kg	0.01	–	–	–	–	See Section E.11.15

E.11.3 Throughput Parameters

The *Use of Laboratory Chemicals – Generic Scenario for Estimating Occupational Exposures and Environmental Releases* (U.S. EPA, 2023c) provides daily throughput of DIDP required for laboratory stock solutions. According to the GS, laboratory liquid use rates range from 0.5 mL up to four liters per day, and laboratory solid use rates range from 0.003 grams to 510 grams per day. Laboratory stock solutions are used for multiple analyses and eventually need to be replaced. The expiration or replacement times range from daily to six months (U.S. EPA, 2023c). For this scenario, EPA assumes stock solutions are prepared daily. EPA initially assigned a uniform distribution for the daily throughput of laboratory stock solutions with upper and lower bounds corresponding to the high and low use rates, respectively.

However, the proposed distributions resulted in an unreasonably high result for the calculated number of sites. Therefore, for liquid stock solutions, EPA modified the lower bound to 17.05 mL. This lower bound was calculated using the minimum operating days of 174 days/yr and the lowest known weight fraction of liquid laboratory chemicals (0.9 kg/kg). For solids, EPA used a deterministic value of 330 g/site-day. This deterministic value was calculated using the maximum operating days of 260 days/yr and the highest known weight fraction of solid laboratory chemicals (0.03 kg/kg).

The daily throughput of DIDP in liquid laboratory chemicals is calculated using Equation E-74 by multiplying the daily throughput of all laboratory solutions by the concentration of DIDP in the solutions and converting volume to mass.

Equation E-74.

$$Q_{DIDP\_day} = Q_{stock\_site\_day\_L} * F_{DIDP-L} * RHO * \frac{0.001L}{mL}$$

Where:

Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
$Q_{stock\_site\_day\_L}$ = Facility annual throughput of liquid laboratory chemicals [mL/site-day]
F_{DIDP-L} = Concentration of DIDP in liquid laboratory chemicals (see Section E.11.6) [kg/kg]
RHO = Density of DIDP [kg/L]

The daily throughput of DIDP in solid laboratory chemicals is calculated using Equation E-75 by multiplying the daily throughput of all laboratory solids by the concentration of DIDP in the solids.

Equation E-75.

$$Q_{DIDP\_day} = Q_{stock\_site\_day\_S} * F_{DIDP-S} * \frac{0.001kg}{g}$$

Where:

Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
$Q_{stock\_site\_day\_S}$ = Facility annual throughput of solid laboratory chemicals [g/site-day]
F_{DIDP-S} = Concentration of DIDP in solid laboratory chemicals (see Section E.11.6) [kg/kg]

The annual throughput of DIDP is calculated using Equation E-76 by multiplying the daily throughput by the number of operating days. The number of operating days is determined according to Section E.11.7.

Equation E-76.

$$Q_{DIDP\_year} = Q_{DIDP\_day} * OD$$

Where:

Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
Q_{DIDP_day} = Facility throughput of DIDP (see Section E.11.3) [kg/site-day]
OD = Operating days (see Section E.11.7) [days/yr]

E.11.4 Number of Containers per Year

The number of liquid DIDP laboratory containers unloaded by a site per year is calculated using the following equation:

Equation E-77.

$$N_{cont\_unload\_yr} = \frac{Q_{DIDP\_year}}{F_{DIDP-L} * RHO * \left(3.79\ \frac{L}{gal}\right) * V_{cont}}$$

Where:

V_{cont} = Container volume (see Section E.11.10) [gal/container]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.11.3) [kg/site-yr]
RHO = DIDP density [kg/L]
F_{DIDP-L} = Mass fraction of DIDP in liquid (see Section E.11.6) [kg/kg]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded [container/site-year]

The number of laboratory containers containing solids with DIDP unloaded by a site per year is calculated using the following equation:

Equation E-78.

$$N_{cont\_unload\_yr} = \frac{Q_{DIDP\_year}}{F_{DIDP-S} * Q_{cont\_solid}}$$

Where:

Q_{cont_solid} = Mass in container of solids (see Section E.11.10) [kg/container]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.11.3) [kg/site-yr]
F_{DIDP-S} = Mass fraction of DIDP in solid (see Section E.11.6) [kg/kg]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded [container/site-year]

E.11.5 Operating Hours

EPA estimated operating hours or hours of duration using data provided from the *Use of Laboratory Chemicals – Generic Scenario for Estimating Occupational Exposures and Environmental Releases*

(U.S. EPA, 2023c), *ChemSTEER User Guide* (U.S. EPA, 2015), and/or through calculation from other parameters. Release points with operating hours provided from these sources include unloading, container cleaning, equipment cleaning, and product sampling.

For unloading and container cleaning (release points 1 and 4), the operating hours are calculated based on the number of containers unloaded at the site and the unloading rate using the following equation:

Equation E-79.

$$OH_{RP1/RP4} = \frac{N_{cont\_unload\_yr}}{RATE_{fill} * OD}$$

Where:

$OH_{RP1/RP4}$ = Operating time for release points 1 and 4 [hrs/site-day]
$RATE_{fill}$ = Container fill rate (see Section E.11.13) [containers/hr]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded (see Section E.11.4) [container/site-year]
OD = Operating days (see Section E.11.7) [days/site-year]

For equipment cleaning (release point 6), the *ChemSTEER User Guide* provides an estimate of four hours per day for cleaning multiple vessels (U.S. EPA, 2015).

For product sampling (release point 7), the *ChemSTEER User Guide* (U.S. EPA, 2015) indicates a single value of one hour/day.

E.11.6 DIDP Concentration in Laboratory Chemicals

EPA modeled DIDP concentration in liquid laboratory chemicals using a triangular distribution with a lower bound of 90%, upper bound of 100%, and mode of 95%. The *Use of Laboratory Chemicals – Generic Scenario for Estimating Occupational Exposures and Environmental Releases* (U.S. EPA, 2023c) states that most laboratory chemicals are sold as reagent grade equal to or higher than 95% purity. EPA built the triangular distribution by using this value as the mode and including concentrations 5% lower and higher than the mode to be the lower and upper bounds. For solid laboratory chemicals, EPA used the maximum weight fraction out of four identified SDSs (3% DIDP by mass) as a deterministic value (see Appendix F for EPA identified DIDP-containing products for this OES).

E.11.7 Operating Days

EPA modeled the operating days per year using a discrete distribution with a low end of 174 days/yr and a high end of 260 days/yr. These values were based on U.S. BLS Occupational Employment Statistics (U.S. BLS, 2016). Per the U.S. BLS website, operating duration for each NAICS code is assumed as a ‘year-round, full-time’ hours figure of 2,080 hours (U.S. BLS, 2016). Therefore, dividing this time by an assumed working duration of eight or 12 hours/day yields 174 or 260 days/year. EPA assumed an equal probability that the number of operating days would be either 174 or 260 days/year.

E.11.8 Air Speed

Baldwin and Maynard measured indoor air speeds across a variety of occupational settings in the United Kingdom (Baldwin and Maynard, 1998). Fifty-five work areas were surveyed across a variety of workplaces. EPA analyzed the air speed data from Baldwin and Maynard and categorized the air speed surveys into settings representative of industrial facilities and representative of commercial facilities.

EPA fit separate distributions for these industrial and commercial settings and used the industrial distribution for this OES.

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

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

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

E.11.9 Saturation Factor

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

E.11.10 Container Size

EPA identified laboratory chemicals packaged in small containers no larger than one gallon in size (liquids) or one kg in quantity (solids). The *Use of Laboratory Chemicals – Generic Scenario for Estimating Occupational Exposures and Environmental Releases* (U.S. EPA, 2023c) states that, in the absence of site-specific information, a default liquid volume of one gal and a default solid quantity of one kg may be used. Laboratory products containing DIDP showed container sizes less than one gallon or one kg. Based on model assumptions of site daily throughput, EPA decided to allow for a lower bound of 0.5 gallons or 0.5 kg to account for smaller container sizes while maintaining the daily number of containers unloaded per site at a reasonable value. Therefore, EPA built a triangular distribution for liquid volumes with a lower bound of 0.5 gallons, and an upper bound and mode of one gallon. EPA similarly built a triangular distribution for solid quantities with a lower bound of 0.5 kg, and an upper bound and mode of one kg.

E.11.11 Container Loss Fractions

For small liquid containers, EPA paired the data from the PEI Associates Inc. study (Associates, 1988) such that the residuals data for emptying drums by pouring was aligned with the default central tendency and high-end values from the *EPA/OPPT Small Container Residual Model*. For unloading drums by pouring in the PEI Associates Inc. study (Associates, 1988), EPA found that the average percent residual from the pilot-scale experiments showed a range of 0.03 percent to 0.79 percent and an average of 0.32 percent. The *EPA/OPPT Small Container Residual Model* from the *ChemSTEER User Guide* (U.S. EPA, 2015) recommends a default central tendency loss fraction of 0.3 percent and a high-end loss fraction of 0.6 percent.

The underlying distribution of the loss fraction parameter for small containers is not known; therefore, EPA assigned a triangular distribution, since triangular distributions require least assumptions and are completely defined by range and mode of a parameter. EPA assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the *EPA/OPPT Small Container Residual Model* in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study (Associates, 1988) for emptying drums by pouring.

For solid containers, EPA used the *EPA/OPPT Solid Residuals in Transport Containers Model* to estimate residual releases from solid container cleaning. The *EPA/OPPT Solid Residuals in Transport Containers Model*, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015) provides an overall loss fraction of one percent from container cleaning.

E.11.12 Dust Generation Loss Fraction, Dust Capture Efficiency, and Dust Control Efficiency

The *EPA/OPPT Solids Transfer Dust Loss Model* from the *ChemSTEER User Guide* (U.S. EPA, 2015) recommends a default loss fraction of 0.5 percent. This model may estimate releases to different media based on the presence of control technologies and removal efficiencies. EPA does not expect control technologies for solids transfer during laboratory uses; therefore, EPA did not apply any additional parameters besides the overall loss fraction from the *EPA/OPPT Solids Transfer Dust Loss Model*.

E.11.13 Small Container Fill Rate

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

E.11.14 Diameters of Opening

For container cleaning activities, the *ChemSTEER User Guide* indicates a single default value of 5.08 cm for containers less than 5,000 gallons (U.S. EPA, 2015).

E.11.15 Equipment Cleaning Loss Fraction

For liquids, EPA used the *EPA/OPPT Multiple Process Residual Model* to estimate the releases from equipment cleaning. The *EPA/OPPT Multiple Process Residual Model*, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015) provides an overall loss fraction of two percent from equipment cleaning.

For solids, used the *EPA/OPPT Solid Residuals in Transport Containers Model* to estimate the releases from equipment cleaning. The *EPA/OPPT Solid Residuals in Transport Containers Model*, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015) provides an overall loss fraction of one percent from equipment cleaning.

E.12 Use of Lubricants and Functional Fluids Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DIDP during the use of lubricants and functional fluids OES. This approach utilizes the *Emission Scenario Document on Lubricants and Lubricant Additives* (OECD, 2004b) combined with Monte Carlo simulation (a type of stochastic simulation).

Based on the ESD, EPA identified the following release sources from the use of lubricants and functional fluids:

- Release source 1: Release During the Use of Equipment.
- Release source 2: Release During Changeout.

Environmental releases for DIDP during the use of lubricants and fluids are a function of DIDP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: production volume, DIDP concentrations, product density, container size, loss fractions, and operating days. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.12.1 Model Equations

Table_Apx E-26 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the use of lubricants and fluids OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix E.12.2. The Monte Carlo simulation calculated the total DIDP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th percentile and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx E-26. Models and Variables Applied for Release Sources in the Use of Lubricants and Functional Fluids OES

Release Source	Model(s) Applied	Variables Used
Release source 1: Release During the Use of Equipment.	See Equation E-80 through Equation E-84	Q_{DIDP_day}; LF_{land_use}; LF_{water_use}
Release source 2: Release During Changeout.		Q_{DIDP_day}; $LF_{land\_disposal}$; $LF_{water\_disposal}$

Release source 1 (Release During the Use of Equipment) and 2 (Release During Changeout) are partitioned out by release media. Loss fractions are described in the model parameter sections below. For both water and land media, release 1 is then calculated using the following equation:

Equation E-80.

$$Release\_perDay_{RP1\_land/water} = Q_{DIDP\_day} * \left(LF_{land\_use} + LF_{water\_use}\right)$$

Where:

$Release\_perDay_{RP1\_land/water}$ = DIDP loss to land/water for release source 1 [kg/site-day]

Q_{DIDP_day} = Facility throughput of DIDP (see Section E.12.3) [kg/site-day]

LF_{land_use} = Loss fraction to land during the use of equipment (see Section E.12.7) [unitless]

LF_{water_use} = Loss fraction to water during the use of equipment (see Section E.12.7) [unitless]

A similar equation is used to calculate release 2 to water and land:

Equation E-81.

$$Release\_perDay_{RP2\_land/water} = Q_{DIDP\_day} * \left(LF_{land\_disposal} + LF_{water\_disposal}\right)$$

Where:

$Release\_perDay_{RP2\_land/water}$ = DIDP loss to land/water for release source 2 [kg/site-day]

Q_{DIDP_day} = Facility throughput of DIDP (see Section E.12.3) [kg/site-day]

$LF_{land\_disposal}$ = Loss fraction to land during lubricant disposal (see Section E.12.7) [unitless]

$LF_{water\_disposal}$ = Loss fraction to water during lubricant disposal (see Section E.12.7) [unitless]

If the sum of LF_{land_use}, LF_{water_use}, $LF_{land\_disposal}$, and $LF_{water\_disposal}$ is over 100%, EPA creates adjusted loss fractions based on weighted contributions to equal exactly 100% release. The releases per day are then re-calculated using the adjusted loss fractions. For example, the adjusted land use loss fraction would be calculated using the following equation:

Equation E-82.

$$LF_{land\_use\_adjusted} = \frac{LF_{land\_use}}{\left(LF_{land\_use} + LF_{water\_use} + LF_{land\_disposal} + LF_{water\_disposal}\right)}$$

Where:

$LF_{land\_use\_adjusted}$ = Adjusted loss fraction to land during the use of equipment [unitless]

LF_{land_use} = Loss fraction to land during the use of equipment (see Section E.12.7) [unitless]

LF_{water_use} = Loss fraction to water during the use of equipment (see Section E.12.7) [unitless]

$LF_{land\_disposal}$ = Loss fraction to land during lubricant disposal (see Section E.12.7) [unitless]

$LF_{water\_disposal}$ = Loss fraction to water during lubricant disposal (see Section E.12.7) [unitless]

Finally, EPA will assess any DIDP not released to the environment after accounting for release sources 1 and 2 as going to recycling and fuel blending (incineration). If all DIDP is released during release sources 1 and 2, then the release to recycling and fuel blending won't be calculated. The following equations are used to calculate the amount of remaining DIDP sent for recycling and fuel blending:

Equation E-83.

$$Release\_perDay_{RP2\_recycle} = \left(Q_{DIDP\_day} - Release_{perDay}{}_{RP1\_land} - Release_{perDay}{}_{RP1\_water-}Release_{perDay}{}_{RP2\_land} - Release\_perDay_{RP2\_water}\right) * F_{waste\_recycle}$$

Equation E-84.

$$Release\_perDay_{RP2\_fuel\_blend} = \left(Q_{DIDP\_day} - Release_{perDay}{}_{RP1\_land} - Release_{perDay}{}_{RP1\_water-}Release_{perDay}{}_{RP2\_land} - Release\_perDay_{RP2\_water}\right) * F_{waste\_incineration}$$

Where:

$Release\_perDay_{RP2\_recycle}$ = DIDP recycled [kg/site-day]
$Release\_perDay_{RP2\_fuel\_blend}$ = DIDP sent for fuel blending [kg/site-day]
Q_{DIDP_day} = Facility throughput of DIDP (see Section E.12.3) [kg/site-day]
$Release\_perDay_{RP1\_land}$ = DIDP released for release source 1 to land [kg/site-day]
$Release\_perDay_{RP1\_water}$ = DIDP released for release source 1 to water [kg/site-day]
$Release\_perDay_{RP2\_land}$ = DIDP released for release source 2 to land [kg/site-day]
$Release\_perDay_{RP2\_water}$ = DIDP released for release source 2 to water [kg/site-day]
$F_{waste\_recycle}$ = Fraction of DIDP that goes to recycling (see Section E.12.8) [kg/kg]
$F_{waste\_incineration}$ = Fraction of DIDP that goes to fuel blending (see Section E.12.9) [kg/kg]

E.12.2 Model Input Parameters

Table_Apx E-27 summarizes the model parameters and their values for the Use of Lubricants and Fluids Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after Table_Apx E-27.

Table_Apx E-27. Summary of Parameter Values and Distributions Used in the Use of Lubricants and Functional Fluids Model

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Total Production Volume of DIDP at All Sites	PV_{total}	kg/yr	1,679,970	169,485	1,679,970	—	Uniform	See Section E.12.3
Mass Fraction of DIDP in Product	F_{DIDP}	kg/kg	0.2	0.01	0.99	0.2	Triangular	See Section E.12.4
Density of DIDP-based Products	$RHO_{product}$	kg/m3	900	840	1000	900	Triangular	See Section E.12.4
Operating Days	OD	days/yr	4	1	4	—	Uniform	See Section E.12.5
Container Size	V_{cont}	gal	55	20	330	55	Triangular	See Section E.12.6
Loss Fraction to Land During Use	LF_{land_use}	kg/kg	0.16	0.014	0.16	—	Uniform	See Section E.12.7
Loss Fraction to Water During Use	LF_{water_use}	kg/kg	0.45	0.003	0.45	—	Uniform	See Section E.12.7
Loss Fraction to Land During Disposal	$LF_{land\_disposal}$	kg/kg	0.30	0.010	0.3	—	Uniform	See Section E.12.7
Loss Fraction to Water During Disposal	$LF_{water\_disposal}$	kg/kg	0.37	0.230	0.37	—	Uniform	See Section E.12.7
Percentage of Waste to Recycling	$F_{waste\_recycle}$	kg/kg	0.043	—	—	—	—	See Section E.12.8
Percentage of Waste to Fuel Blending	$F_{waste\_incineration}$	kg/kg	0.957	—	—	—	—	See Section E.12.9

E.12.3 Throughput Parameters

EPA estimated the total production volume for all sites using a uniform distribution with a lower bound of 169,485 kg/yr and an upper bound of 1,679,970 kg/yr. This is based on CDR data (U.S. EPA, 2020a) and the 2003 European Union Risk Assessment on DIDP (ECJRC, 2003b). The EU Risk Assessment found that only 1.1% of the DIDP produced goes to non-PVC, non-polymer end use categories. As this Risk Evaluation includes three OESs that fall under this category, EPA assumes that each category contributes 0.37% of the DIDP produced. CDR states that the total U.S. national production volume of DIDP is a range of 100,986,354 lbs/yr to 1.001 billion lbs/yr. Multiplying these figures by 0.37% results in 373,650 lb./yr (169,485 kg/yr) to 3,703,700 lbs/yr (1,679,970 kg/yr).

Product throughput is calculated by converting container volume to mass using the product density and multiplying by operating days. This equation assumes that each site uses one container of product each day. Container size is determined according to Section E.12.6. Product density is determined according to Section E.12.4. Operating days are determined according to Section E.12.5.

Equation E-85.

$$Q_{product\_year} = V_{cont} * 0.00379\frac{m3}{gal} * RHO_{product} * OD$$

Where:

$Q_{product\_year}$ = Facility annual throughput of lubricant/fluid [kg/site-yr]
V_{cont} = Container size (see Section E.12.6) [gal]
$RHO_{product}$ = Product density (see Section E.12.4) [kg/m3]
OD = Operating days (see Section E.12.5) [days/yr]

The annual throughput of DIDP is calculated using Equation E-86 by multiplying product annual throughput by the concentration of DIDP in the product. Concentration of DIDP in the product is determined according to Section E.12.4.

Equation E-86.

$$Q_{DIDP\_year} = Q_{product\_year} * F_{DIDP}$$

Where:

Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
$Q_{product\_year}$ = Facility annual throughput of lubricant/fluid [kg/site-yr]
F_{DIDP} = Concentration of DIDP in lubricant/fluid (see Section E.12.4) [kg/kg]

The daily throughput of DIDP is calculated using Equation E-87 by dividing the annual production volume by the number of operating days. The number of operating days is determined according to Section E.12.5.

Equation E-87.

$$Q_{DIDP\_day} = \frac{Q_{DIDP\_year}}{OD}$$

Where:

Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
OD = Operating days (see Section E.12.5) [days/yr]

E.12.4 Mass Fraction of DIDP in Lubricant/Fluid and Product Density

EPA modeled DIDP concentration in lubricants and fluids using a triangular distribution with a lower bound of 1%, upper bound of 99%, and mode of 20%. EPA modeled product density using a triangular distribution with a lower bound of 840 kg/m^3, an upper bound of 1,000 kg/m^3, and a mode of 900 kg/m^3. This is based on compiled SDS information for lubricants and fluids containing DIDP (see Appendix F for EPA identified DIDP-containing products for this OES).

E.12.5 Operating Days

EPA modeled operating days per year using a uniform distribution with a lower bound of one day/yr and an upper bound of four days/yr. To ensure that only integer values of this parameter were selected, EPA nested the uniform distribution probability formula within a discrete distribution that listed each integer between (and including) one to four days/yr. Both bounds are based on the *Emission Scenario Document on Lubricants and Lubricant Additives* (OECD, 2004b). The ESD states that changeout rates for hydraulic fluids range from three to 60 months. This corresponds to one to four changeouts per year, which EPA assumes is equal to operating days. Where changeout frequency occurs over 12 months, EPA used a value one container per 12 months as a representative value.

E.12.6 Container Size

EPA modeled container size using a triangular distribution with a lower bound of 20 gallons, an upper bound of 330 gallons, and a mode of 55 gallons. This was based on SDS and technical data sheets for DIDP-containing lubricants. In this data, EPA identified lubricants in containers from less than one gallon to 330 gallons. The mode of the reported container sizes was 55 gallons. However, when running the model, smaller use rates produced an unreasonable number of use sites. Therefore, EPA assumed this to be an indication that it is unlikely that sites only have one small piece of equipment. Based on this and the remaining technical data, EPA selected 20 gallons as the lower bound.

E.12.7 Loss Fractions

The loss fractions to each release media for the use and disposal of lubricants are based on the *Emission Scenario Document on Lubricants and Lubricant Additives* (OECD, 2004b). The ESD provides multiple values for loss fractions to land and water. EPA used these values to build the uniform distributions for each loss fraction. For the use of lubricants, the ESD provided a range of 0.014 to 0.16 for loss fractions to land, and 0.003 to 0.45 for loss fractions to water. For the disposal of lubricants, the ESD provided a range of 0.01 to 0.3 for loss fractions to land, and 0.23 to 0.37 for loss fractions to water.

E.12.8 Percentage of Waste to Recycling

The *Emission Scenario Document on Lubricants and Lubricant Additives* (OECD, 2004b) estimates that 4.3% of all hydraulic fluids are recycled.

E.12.9 Percentage of Waste to Fuel Blending

The *Emission Scenario Document on Lubricants and Lubricant Additives* (OECD, 2004b) estimates that 95.7% of all hydraulic fluids are reused for fuel oil or other general incineration releases.

E.13 Use of Penetrants and Inspection Fluids Release Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DIDP during the use of penetrants and inspection fluids OES. This approach utilizes the *Emission Scenario Document on the Use of Metalworking Fluids* (OECD, 2011d) combined with Monte Carlo simulation (a type of stochastic simulation). EPA assessed the environmental releases for this OES separately for non-aerosol penetrants and for aerosol-applied penetrants.

Based on the ESD, EPA identified the following release sources from the use of non-aerosol penetrants:

- Release source 1: Transfer Operation Losses to Air from Unloading Penetrant.
- Release source 2: Container Cleaning Wastes.
- Release source 3: Open Surface Losses to Air During Container Cleaning.
- Release source 4: Equipment Cleaning Wastes.
- Release source 5: Open Surface Losses to Air During Equipment Cleaning.
- Release source 7: Disposal of Used Penetrant.

Based on the ESD, EPA identified the following release sources from the use of aerosol-applied penetrants:

- Release source 2: Container Cleaning Wastes.
- Release source 6: Aerosol Application of Penetrant.

Environmental releases for DIDP during the use of penetrants are a function of DIDP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: DIDP concentrations, air speed, saturation factor, container size, loss fractions, and operating days. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.13.1 Model Equations

Table_Apx E-28 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the use of penetrants OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix E.13.2. The Monte Carlo simulation calculated the total DIDP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th percentile and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx E-28. Models and Variables Applied for Release Sources in the Use of Penetrants and Inspection Fluids OES

Release source	Model(s) Applied	Variables Used
Release source 1: Transfer Operation Losses to Air from Unloading Penetrant.	*EPA/OAQPS AP-42 Loading Model* (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; VP; f_{sat}; MW; R; T; V_{cont}; $RATE_{fill\_cont}$; $RATE_{fill\_drum}$ Operating Time: Q_{DIDP_year} ; V_{cont}; OD; $RATE_{fill\_cont}$; $RATE_{fill\_drum}$; RHO; F_{DIDP}
Release source 2: Container Cleaning Wastes.	*EPA/OPPT Drum Residual Model* or *EPA/OPPT Bulk Transport Residual Model*, based on container size (Appendix E.1)	Q_{DIDP_day}; LF_{drum}; LF_{cont}; V_{cont}; RHO; OD; F_{DIDP}
Release source 3: Open Surface Losses to Air During Container Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; MW; VP; $RATE_{air\_speed}$; D_{cont_clean}; T; P Operating Time: Q_{DIDP_year} ; V_{cont}; OD; $RATE_{fill\_cont}$; $RATE_{fill\_drum}$; RHO; F_{DIDP}
Release source 4: Equipment Cleaning Wastes.	*EPA/OPPT Multiple Process Vessel Residual Model* (Appendix E.1)	Q_{DIDP_day}; LF_{equip}
Release source 5: Open Surface Losses to Air During Equipment Cleaning.	*EPA/OPPT Penetration Model* or *EPA/OPPT Mass Transfer Coefficient Model*, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DIDP}; MW; VP; $RATE_{air\_speed}$; D_{equip_clean}; T; P Operating Time: OH_{equip_clean}
Release source 6: Aerosol Application of Penetrant.	See Equation E-88 and Equation E-89	Q_{DIDP_day}; $\%_{air}$; $\%_{uncertain}$; Release Point 2
Release source 7: Disposal of Used Penetrant.	See Equation E-90	Q_{DIDP_day}; Release Points 1 through 5

Release source 6 (Aerosol Application of Penetrant) is partitioned out by release media. In order to calculate the releases to each media, the total release is calculated first using the following equation:

Equation E-88.

$$Release\_perDay_{RP6} = Q_{DIDP\_day} - Release\_perDay_{RP2}$$

Where:

$Release\_perDay_{RP6}$ = DIDP released for release source 6 to all release media [kg/site-day]
Q_{DIDP_day} = Facility throughput of DIDP (see Section E.13.3) [kg/site-day]
$Release\_perDay_{RP2}$ = DIDP released for release source 2 [kg/site-day]

Then, the release amounts to each media are calculated using the following equation:

Equation E-89.

$$Release\_perDay_{RP6\_media} = Release\_perDay_{RP6} * \%_{media}$$

Where:

$Release\_perDay_{RP6\_media}$ = Amount of release 6 that is released to selected media [kg/site-day]

$Release\_perDay_{RP6}$ = DIDP released for release source 6 to all release media [kg/site-day]

$\%_{media}$ = Percent of release 6 that is released to selected media [unitless]

Release source 7 (Disposal of Used Penetrant) is calculated via a mass-balance, via the following equation:

Equation E-90.

$$Release\_perDay_{RP7} = Q_{DIDP\_day} - \sum_{i=1}^{5} Release\_perDay_{RPi}$$

Where:

$Release\_perDay_{RP7}$ = DIDP released for release source 7 [kg/site-day]

Q_{DIDP_day} = Facility throughput of DIDP (see Section E.13.3) [kg/site-day]

$\sum_{i=1}^{5} Release\_perDay_{RPi}$ = The sum of release points 1-5 emissions [kg/site-day]

E.13.2 Model Input Parameters

Table_Apx E-29 summarizes the model parameters and their values for the Use of Penetrants Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after Table_Apx E-29.

Table_Apx E-29. Summary of Parameter Values and Distributions Used in the Release Estimation of Penetrants and Inspection Fluids

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Penetrant DIDP Concentration	F_{DIDP}	kg/kg	0.2	0.1	0.2	—	Uniform	See Section E.13.6
Operating Days	OD	days/yr	247	246	249	247	Triangular	See Section E.13.7
Air Speed	$RATE_{air\_speed}$	ft/min	19.7	2.56	398	—	Lognormal	See Section E.13.8
Saturation Factor	f_{sat}	dimensionless	0.5	0.5	1.45	0.5	Triangular	See Section E.13.9
Container Size	V_{cont}	gal	0.082	0.082	55	0.082	Triangular	See Section E.13.10
Small Container Loss Fraction	LF_{cont}	kg/kg	0.003	0.003	0.006	0.003	Triangular	See Section E.13.11
Drum Residual Loss Fraction	LF_{drum}	kg/kg	0.025	0.017	0.03	0.025	Triangular	See Section E.13.11
Equipment Cleaning Loss Fraction	LF_{equip}	kg/kg	0.002	0.0007	0.01	0.002	Triangular	See Section E.13.12
Vapor Pressure at 25C	VP	mmHg	5.28E−07	—	—	—	—	Physical property
Molecular Weight	MW	g/mol	446.68	—	—	—	—	Physical property
Gas Constant	R	atm-cm3/gmol-L	82.05	—	—	—	—	Universal constant
Density of DIDP	RHO	kg/L	0.9634	—	—	—	—	Physical property
Temperature	T	K	298	—	—	—	—	Process parameter
Pressure	P	atm	1	—	—	—	—	Process parameter

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Small Container Fill Rate	$RATE_{fill\_cont}$	containers/hr	60	—	—	—	—	See Section E.13.13
Drum Fill Rate	$RATE_{fill\_drum}$	containers/hr	20	—	—	—	—	See Section E.13.13
Diameter of Opening – Container Cleaning	D_{cont_clean}	cm	5.08	—	—	—	—	See Section E.13.14
Diameter of Opening – Equipment Cleaning	D_{equip_clean}	cm	92	—	—	—	—	See Section E.13.14
Equipment Cleaning Duration	OH_{equip_clean}	hr/day	0.5	—	—	—	—	See Section E.13.5
Penetrant User per Job	$Q_{penetrant\_job}$	oz/job	10.5	—	—	—	—	See Section E.13.15
Application Jobs per Day	N_{jobs_day}	jobs/day	8	—	—	—	—	See Section E.13.16
Percentage of Aerosol Released to Fugitive Air	$\%_{air}$	unitless	0.15	—	—	—	—	See Section E.13.17
Percentage of Aerosol Released to Uncertain Media	$\%_{uncertain}$	unitless	0.85	—	—	—	—	See Section E.13.17

E.13.3 Throughput Parameters

The daily throughput of DIDP in penetrants is calculated using Equation E-91 by multiplying the amount of penetrant per job by the number of jobs per day, density, and concentration of DIDP. The amount of penetrant used per job is determined according to Section E.13.15. The number of jobs per day is determined according to Section E.13.16.

Equation E-91.

$$Q_{DIDP\_day} = Q_{penetrant\_job} * N_{jobs\_day} * \frac{0.00781 gal}{oz} * 0.264 \frac{L}{gal} * RHO * F_{DIDP}$$

Where:

Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
$Q_{penetrant\_job}$ = Amount of penetrant used per job (see Section E.13.15) [oz/job]
N_{jobs_day} = Application jobs of penetrant per day (see Section E.13.16) [jobs/day]
RHO = Density of DIDP [kg/m3]
F_{DIDP} = Concentration of DIDP in penetrants (see Section E.13.6) [kg/kg]

The annual throughput of DIDP is calculated using Equation E-92 by multiplying the daily production volume by the number of operating days. The number of operating days is determined according to Section E.13.7.

Equation E-92.

$$Q_{DIDP\_year} = Q_{DIDP\_day} * OD$$

Where:

Q_{DIDP_year} = Facility annual throughput of DIDP [kg/site-yr]
Q_{DIDP_day} = Facility throughput of DIDP [kg/site-day]
OD = Operating days (see Section E.13.7) [days/yr]

E.13.4 Number of Containers per Year

The number of containers unloaded by a site per year is calculated using the following equation:

Equation E-93.

$$N_{cont\_unload\_yr} = \frac{Q_{DIDP\_year}}{F_{DIDP} * RHO * \left(3.79 \frac{L}{gal}\right) * V_{cont}}$$

Where:

V_{cont} = Container volume (see Section E.13.10) [gal/container]
Q_{DIDP_year} = Facility annual throughput of DIDP (see Section E.13.3) [kg/site-yr]
RHO = DIDP density [kg/L]
F_{DIDP} = Mass fraction of DIDP in product (see Section E.13.6) [kg/kg]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded [container/site-year]

E.13.5 Operating Hours

EPA estimated operating hours or hours of duration using data provided from *the Emission Scenario Document on the Use of Metalworking Fluids* (OECD, 2011d), *ChemSTEER User Guide* (U.S. EPA, 2015), and/or through calculation from other parameters. Release points with operating hours provided from these sources include unloading, container cleaning, equipment cleaning, filter media replacement, and aerosol application.

For unloading and container cleaning (release points 1 and 3), the operating hours are calculated based on the number of containers unloaded at the site and the unloading rate using the following equation:

Equation E-94.

$$OH_{RP1/RP3} = \frac{N_{cont\_unload\_yr}}{RATE_{fill\_drum/cont} * OD}$$

Where:

$OH_{RP1/RP3}$ = Operating time for release points 1 and 3 [hrs/site-day]
$RATE_{fill\_drum/cont}$ = Container fill rate, depending on container size (see Section E.13.13) [containers/hr]
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded (see Section E.13.4) [container/site-year]
OD = Operating days (see Section E.13.7) [days/site-year]

For equipment cleaning (release point 5), the *ChemSTEER User Guide* (U.S. EPA, 2015) provides a typical equipment cleaning duration of 0.5 hours/day for cleaning a single, small vessel.

For aerosol application (release point 6), EPA treats this activity as container unloading. Therefore, EPA calculates the operating duration for this release using Equation E-94.

E.13.6 Penetrant DIDP Concentration

EPA modeled DIDP concentration in paints and coatings using a uniform distribution with a lower bound of 10% and upper bound of 20%. This is based on compiled SDS information for penetrants containing DIDP. EPA identified one product in the DINP Use Report which is being used as a surrogate for DIDP concentration, since no penetrants containing DIDP were readily found (see Appendix F for EPA identified DIDP-containing products for this OES).

E.13.7 Operating Days

EPA modeled the operating days per year using a triangular distribution with a lower bound of 246 days/yr, an upper bound of 249 days/yr, and a mode of 247 days/yr. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 246-249 days/yr. This is based on the *Emission Scenario Document on the Use of Metalworking Fluids* (OECD, 2011d). The ESD cites a general average for metal shaping operations to be 246-249 days/yr, and it recommends a default value of 247 days/yr.

E.13.8 Air Speed

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

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

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

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

E.13.9 Saturation Factor

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

E.13.10 Container Size

EPA modeled container size using a triangular distribution with a lower bound of 0.082 gallons, an upper bound of 55 gallons, and a mode of 0.082 gallons. EPA identified penetrants in 10.5 oz (0.082 gallon) aerosol cans, and one gallon, five gallon, and 55-gallon containers. EPA used 10.5 oz cans as the mode because most products indicated using 10.5 oz cans.

E.13.11 Container Loss Fractions

For small containers, EPA paired the data from the PEI Associates Inc. study (Associates, 1988) such that the residuals data for emptying drums by pouring was aligned with the default central tendency and high-end values from the *EPA/OPPT Small Container Residual Model*. For unloading drums by pouring in the PEI Associates Inc. study (Associates, 1988), EPA found that the average percent residual from the pilot-scale experiments showed a range of 0.03 percent to 0.79 percent and an average of 0.32 percent. The *EPA/OPPT Small Container Residual Model* from the *ChemSTEER User Guide* (U.S. EPA, 2015) recommends a default central tendency loss fraction of 0.3 percent and a high-end loss fraction of 0.6 percent.

The underlying distribution of the loss fraction parameter for small containers is not known; therefore, EPA assigned a triangular distribution, since triangular distributions require least assumptions and are completely defined by range and mode of a parameter. EPA assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the *EPA/OPPT Small Container Residual Model* in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study (Associates, 1988) for emptying drums by pouring.

For drums, EPA paired the data from the PEI Associates Inc. study (Associates, 1988) such that the residuals data for emptying drums by pumping was aligned with the default central tendency and high-end values from the *EPA/OPPT Drum Residual Model*. For unloading drums by pumping in the PEI Associates Inc. study, EPA found that the average percent residual from the pilot-scale experiments showed a range of 1.7 percent to 4.7 percent and an average of 2.6 percent. The *EPA/OPPT Drum Residual Model* from the *ChemSTEER User Guide* recommends a default central tendency loss fraction of 2.5 percent and a high-end loss fraction of 3.0 percent (U.S. EPA, 2015).

The underlying distribution of the loss fraction parameter for drums is not known; therefore, EPA assigned a triangular distribution, since triangular distributions require least assumptions and are completely defined by range and mode of a parameter. EPA assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the *EPA/OPPT Drum Residual Model* in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study (Associates, 1988) for emptying drums by pumping.

E.13.12 Equipment Cleaning Loss Fraction

EPA used the *EPA/OPPT Single Vessel Residual Model* to estimate the releases from equipment cleaning. The *EPA/OPPT Single Vessel Residual Model*, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015) provides a default loss fraction of 0.002 for equipment cleaning. In addition, the model provides non-default loss fractions of 0.01 and 0.0007. Therefore, developed a triangular distribution for equipment cleaning, with a lower bound of 0.0007, an upper bound of 0.01, and a mode of 0.002, based on the *ChemSTEER User Guide* (U.S. EPA, 2015).

E.13.13 Container Fill Rates

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

E.13.14 Diameters of Opening

The *ChemSTEER User Guide* indicates diameters for the openings for various vessels that may hold liquids in order to calculate vapor generation rates during different activities (U.S. EPA, 2015). For equipment cleaning operations, the *ChemSTEER User Guide* indicates a single default value of 92 cm (U.S. EPA, 2015).

For container cleaning activities, the *ChemSTEER User Guide* indicates a single default value of 5.08 cm for containers less than 5,000 gallons (U.S. EPA, 2015).

E.13.15 Penetrant Used per Job

EPA identified 10.5 oz as a standard size for aerosol cans. EPA assumed that one container is used per job, so the amount of penetrant used per job is 10.5 oz.

E.13.16 Jobs per Day

EPA assumes eight penetrant jobs occur per day. As there was no available usage data, EPA assumed a duration of one hour per job, and eight jobs/day due to a typical shift being eight hours long. Therefore, EPA could not develop a distribution of values for this parameter and used the single value of eight jobs/day.

E.13.17 Percentage of Aerosol Released to Fugitive Air and Uncertain Media

According to the *Generic Scenario on Chemicals Used in Furnishing Cleaning Products* (U.S. EPA, 2022b), 15% of spray application releases are to fugitive air, and 85% are to water, incineration, or landfill.

E.14 Spray Exposure Model Approach and Parameters

This section presents the modeling approach and equations used to estimate occupational exposures for DIDP during the use in paints and coatings and use in adhesives and sealants OESs. This approach utilizes the *Automotive Refinishing Spray Coating Mist Inhalation Model* from the *ESD on Coating Application via Spray-Painting in the Automotive Refinishing Industry* (OECD, 2011a). The model estimates worker inhalation exposure based on the concentration of the chemical of interest in the nonvolatile portion of the sprayed product and the concentration of over sprayed mist/particles. The model is based on PBZ monitoring data for mists during automotive refinishing. EPA used the 50th and 95th percentile mist concentration along with the concentration of DIDP in the paint to estimate the central tendency and high-end inhalation exposures, respectively.

E.14.1 Model Design Equations

The *Automotive Refinishing Spray Coating Mist Inhalation Model* calculates the 8-hour TWA exposure to DIDP present in mist and particulates using the following equation:

Equation E-95.

$$C_{DIDP,8hr-TWA} = \frac{C_{mist} \times F_{DIDP\_solids} \times ED}{8\ hrs}$$

Where:

$C_{DIDP,8hr-TWA}$ = 8-hr TWA inhalation exposure to DIDP (mg/m^3)
C_{mist} = Over sprayed product mist concentration in the air within worker's breathing zone (mg/m^3)
F_{DIDP_solids} = Mass fraction of DIDP in the non-volatile portion of the spray (mg$_{\text{DIDP}}$/mg$_{\text{nonvolatile components}}$)
ED = Exposure Duration (hr)

E.14.2 Model Parameters

Table_Apx E-30 summarizes the input model parameters and their values for the *Automotive Refinishing Spray Coating Mist Inhalation Model*. Additional explanations of EPA's selection of the values for each parameter are provided after Table_Apx E-30.

Table_Apx E-30. Summary of Parameter Values Used in the Spray Inhalation Model

Input Parameter	Symbol	Unit	OES	Parameter Value		Rationale/ Basis
				Central Tendency	High End	
Concentration of Mist	C_{mist}	mg/m^3	Use of Paints and Coatings	3.38	22.1	See Section E.14.2.1
			Use of Adhesives and Sealants			
DIDP Concentration in Product	F_{DIDP_prod}	kg/kg	Use of Paints and Coatings	0.01	0.05	See Section E.14.2.2
			Use of Adhesives and Sealants	0.01	0.78	
Concentration of Nonvolatile Solids in the Spray Product	F_{solids_prod}	kg/kg	Use of Paints and Coatings	0.25	0.5	See Section E.14.2.3
			Use of Adhesives and Sealants			
DIDP Concentration of Nonvolatile Components	F_{DIDP_solids}	mg/mg	Use of Paints and Coatings	0.04	0.10	See Section E.14.2.4
			Use of Adhesives and Sealants	0.04	1.00	
Exposure Duration	ED	hr	Use of Paints and Coatings	8		See Section E.14.2.5
			Use of Adhesives and Sealants			

E.14.2.1 Concentration of Mist

EPA utilized coating mist concentrations within spray booths obtained through a search of available OSHA In-Depth Surveys of the Automotive Refinishing Shop Industry and other relevant studies, as published in the *ESD on Coating Application via Spray-Painting in the Automotive Refinishing Industry* (OECD, 2011a). The data is divided into various combinations of spray booth types (*e.g.*, downdraft and cross draft) and spray gun types (*e.g.*, conventional, high-volume low-pressure). EPA expects there to be a variety of facility types and substrates being coated such that a variety of spray booth and spray gun combinations may be used to apply the products. Due to this, EPA used mist concentrations from all scenarios for this parameter. Central tendency and high-end scenario parameters represent the 50th and 95th percentile mist concentrations, respectively. The central tendency mist concentration was 3.38 mg/m^3 and the high-end concentration was 22.1 mg/m^3.

E.14.2.2 DIDP Product Concentration

EPA compiled DIDP concentration information from various paint, coating, adhesive, and sealant products containing DIDP (see Appendix F). EPA used material safety data sheets and technical data sheets to develop DIDP concentration distributions in each of these product categories. These distributions were implemented in the modeled Monte Carlo release assessments for each scenario outlined in Sections E.9.7 and E.10.7. For the exposure assessment, EPA used the 50th and 95th percentile results as the central tendency and high-end product concentration input parameters, respectively. For paints and coatings, the central tendency value was 0.01, and the high-end value was 0.05. For adhesives and sealants, the central tendency value was 0.01, and the high-end value was 0.78.

E.14.2.3 Concentration of Nonvolatile Solids in the Spray Product

The *ESD on Coating Application via Spray-Painting in the Automotive Refinishing Industry* cites data from Volume 6 of the *Kirk-Othmer Encyclopedia of Chemical Technology* stating that nonvolatile solids in a spray paint or coating product can range from 0.15-0.50 mg/mg (OECD, 2011a; Kirk-Othmer, 1993). 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 (OECD, 2011a).

E.14.2.4 DIDP Concentration in Nonvolatile Components

The mass fraction of DIDP in the nonvolatile portion of the sprayed product is calculated using the following equation:

Equation E-96.

$$F_{DIDP\_solids} = \frac{F_{DIDP\_prod}}{F_{solids\_prod}}$$

Where:

F_{DIDP_solids} = Mass fraction of DIDP in the nonvolatile portion of the sprayed product ($mg_{DIDP}/mg_{nonvolatile\ components}$)

F_{DIDP_prod} = Mass fraction of DIDP in the paint, coating, adhesive, or sealant product, spray-applied ($mg_{DIDP}/mg_{s\ prayed\ product}$)

F_{solids_prod} = Mass fraction of nonvolatile components within the sprayed product ($mg_{nonvolatile\ components}/mg_{sprayed\ product}$)

If this equation results in $F_{DIDP\_solids} > 1$, then the value of F_{DIDP_solids} is assessed at a value of 1. The results of this equation were a central tendency DIDP concentration of 0.04 for both scenarios, a high-end concentration of 0.10 for paints and coatings, and a high-end concentration of 1.00 for adhesives and sealants.

E.14.2.5 Exposure Duration

EPA did not identify DIDP-specific data on spray application duration. Due to this, and the expected variety in substrates and facility types for these scenarios, the exposure duration was assessed at a full eight-hour shift. The full-shift assumption may overestimate the application duration as workers likely have other activities (*e.g.*, container unloading and cleaning) during their shift; however, those activities may also result in exposures to vapors that volatilize during those activities. Since EPA is not factoring in those vapor exposures, an eight-hour duration for spraying is used and assumed to be protective of any contribution to exposures from vapors.

E.15 Inhalation Exposure Modeling for Penetrants and Inspection Fluids

This appendix presents the modeling approach and model equations used in the near-field/far-field exposure modeling of the use of penetrants and inspection fluids. EPA developed the model through review of the literature and consideration of existing EPA/OPPT exposure models. This model is based on a near-field/far-field approach (AIHA, 2009), where an aerosol application located inside the near-field generates a mist of droplets, and indoor air movements lead to the convection of the droplets between the near-field and far-field. The model assumes workers are exposed to DIDP droplets in the near-field, while occupational non-users are exposed in the far-field.

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

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

An individual model parameter could be either a discrete value or a distribution of values. EPA assigned statistical distributions based on available literature data. EPA used a Monte Carlo simulation (a type of stochastic simulation) to capture variability in the model parameters. EPA conducted the simulation using the Latin hypercube sampling method in @Risk Industrial Edition, Version 8.0.0. The Latin hypercube sampling method generates parameter values from a multi-dimensional distribution and is a stratified method, where the generated samples are representative of the probability density function (variability) defined in the model. EPA selected 100,000 model iterations to capture a broad range of possible input values, including values with low probability of occurrence.

Model results from the Monte Carlo simulation are presented as 95th and 50th percentile values in Section 3.14.4.3. The statistics were calculated directly in @Risk. EPA selected the 95th percentile value to represent high-end exposure level and the 50th percentile value to represent the central tendency exposure level. The following subsections detail the model design equations and parameters for the near-field/far-field model.

E.15.1 Model Design Equations

Penetrant/inspection fluid application generates a mist of droplets in the near-field, resulting in worker exposures at a DIDP concentration C_{NF}. This concentration is directly proportional to the amount of penetrant applied by the worker standing in the near-field-zone (*i.e.*, the working zone). The near-field-zone volume is denoted as V_{NF}. The ventilation rate for the near-field-zone (Q_{NF}) determines the rate of DIDP dissipation into the far-field (*i.e.*, the facility space surrounding the near-field), resulting in occupational bystander exposures to DIDP at a concentration C_{FF}. V_{FF} denotes the volume of the far-field space into which the DIDP dissipates from the near-field. The ventilation rate of the surroundings, denoted as Q_{FF}, determines the rate of DIDP dissipation from the surrounding space into the outside air.

EPA denoted the top of each five-minute period for each hour of the day (*e.g.*, 8:00 am, 8:05 am, 8:10 am, etc.) as $t_{m,n}$. Here, m has the values of 0, 1, 2, 3, 4, 5, 6, and 7 to indicate the top of each hour of the day (*e.g.*, 8 am, 9 am, etc.) and n has the values of 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 to indicate the top of each five-minute period within the hour. The worker begins the first penetrant application job during the first hour, $t_{0,0}$ to $t_{1,0}$ (*e.g.*, 8 am to 9 am). The worker applies the penetrant at the top of the second 5-minute period $t_{m,1}$ (*e.g.*, 8:05 am, 9:05 am, etc.).

The model design equations are presented below in Equation E-97 through Equation E-117.

<u>Near-Field Mass Balance:</u>

Equation E-97.

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

Far-Field Mass Balance

Equation E-98.

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

Where:

V_{NF} = near-field volume [m^3]
V_{FF} = far-field volume [m^3]
Q_{NF} = near-field ventilation rate [m^3/hr]
Q_{FF} = far-field ventilation rate [m^3/hr]
C_{NF} = average near-field concentration [mg/m^3]
C_{FF} = average far-field concentration [mg/m^3]
t = elapsed time [hr]

Solving Equation E-97 and Equation E-98 in terms of the time-varying concentrations in the near-field and far-field yields Equation E-99 and Equation E-100. EPA assessed Equation E-99 and Equation E-100 for all values of $t_{m,n}$. For each five-minute increment, EPA calculated the initial near-field concentration at the top of each period ($t_{m,n}$), accounting for the burst of DIDP from the penetrant application (if the five-minute increment is during an application) and the residual near-field concentration remaining after the previous five-minute increment ($t_{m,n-1}$; except during the first hour and $t_{m,0}$ of the first penetrant application job, in which case there would be no residual DIDP from a previous application). The initial far-field concentration is equal to the residual far-field concentration remaining after the previous five-minute increment. EPA then calculated the decayed concentration in the near-field and far-field at the end of the five-minute period, just before the penetrant application at the top of the next period ($t_{m,n+1}$). EPA then calculated 5-minute TWA exposures for the near-field and far-field, representative of the worker's and ONU's exposures to the airborne concentrations during each five-minute increment using Equation E-109 and Equation E-110. *k* coefficients (Equation E-101 through Equation E-104) are a function of initial near-field and far-field concentrations and are re-calculated at the top of each five-minute period.

In the equations below, if n−1 is less than zero, the value at "m-1, 11" is used instead. Additionally, if n+1 is greater than 11, the value at "m+1, 0" is used instead.

Equation E-99.

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

Equation E-100.

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

Equation E-101.

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

Equation E-102.

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

Equation E-103.

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

Equation E-104.

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

Equation E-105.

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

Equation E-106.

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

Equation E-107.

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

Equation E-108.

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

Equation E-109.

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

Equation E-110.

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

After calculating all near-field/far-field 5-minute TWA exposures (*i.e.*, $C_{NF,5-\min TWA,t_{m,n}}$ and $C_{FF,5-\min TWA,t_{m,n}}$), EPA calculated the near-field/far-field 1-hour and 8-hour TWA concentrations according to the following equations:

Equation E-111.

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

Equation E-112.

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

Equation E-113.

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

Equation E-114.

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

EPA calculated rolling 1-hour TWAs throughout the workday, while the model reported the maximum calculated 1-hour TWA.

To calculate the mass transfer to and from the near field, the free surface area (FSA) is defined as the surface area through which mass transfer can occur. The FSA is not equal to the surface area of the entire near field. EPA defined the near-field zone to be a hemisphere with its major axis oriented vertically, against the application surface. The top half of the circular cross-section rests against, and is blocked by, the surface and is not available for mass transfer. The FSA is calculated as the entire surface area of the hemisphere's curved surface and half of the hemisphere's circular surface per Equation E-115:

Equation E-115.

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

Where: R_{NF} is the radius of the near-field [m]

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

Equation E-116.

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

The far-field volume, V_{FF}, and the air exchange rate (AER) are used to calculate the far-field ventilation rate, Q_{FF}:

Equation E-117.

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

Using the model inputs described in Section E.15.2, EPA estimated DIDP worker inhalation exposures in the near-field and ONU inhalation exposures in the far-field. EPA then conducted Monte Carlo simulations using @Risk Version 8.0.0 to calculate exposure results shown in Section 3.14.4.3. The simulations applied the Latin Hypercube sampling method using 100,000 iterations.

E.15.2 Model Parameters

Table_Apx E-31 summarizes the model parameters for the near-field/far-field modeling of the use penetrants and inspection fluids. Each parameter is discussed in further detail in the following subsections.

Table_Apx E-31. Summary of Parameter Values Used in the Near-Field/Far-Field Inhalation Exposure Modeling of Penetrants and Inspection Fluids

Input Parameter	Symbol	Unit	Constant Value[11]	Variable Model Parameter Values				Rationale
				Lower Bound	Upper Bound	Mode	Distribution Type	
Far-field Volume	V_{FF}	m^3	—	206	70,679	3,769	Triangular	See Section E.15.2.1
Air Exchange Rate	AER	m^3/hr	—	1	20	3.5	Triangular	See Section E.15.2.2
Near-field Indoor Air Speed	v_{NF}	cm/s	—	1.3	202.2	—	Lognormal	See Section E.15.2.3
		ft/min	—	2.56	398.05	—	Lognormal	
Near-field Radius	R_{NF}	m^3	1.5	—	—	—	—	See Section E.15.2.4
Application Time	t_2	hr	0.0833	—	—	—	—	See Section E.15.2.5
Averaging Time	t_{avg}	hr	8	—	—	—	—	See Section E.15.2.6
DIDP Product Concentration	F_{DIDP}	kg/kg	—	0.1	0.2	—	Uniform	See Section E.15.2.7
Volume of Penetrant Used per Job	$Q_{penetrant\_job}$	oz/job	—	1.05	2.63	—	Uniform	See Section E.15.2.8
Number of Applications per Job	N_{app_job}	applications/job	1	—	—	—	—	See Section E.15.2.9
Number of Jobs per Work Shift	N_{jobs_day}	jobs/day	8	—	—	—	—	See Section E.15.2.11

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[11] Each parameter is represented either by a constant value or a distribution.

E.15.2.1 Far-Field Volume

Since EPA was not able to identify any penetrant- or DIDP-specific use or exposure data, EPA utilized a near-field/far-field approach (AIHA, 2009). The far-field volume is based on site visits of 137 automotive maintenance and repair shops in California (CARB, 2000). The California Air Resources Board indicated that shop volumes ranged from 200 to 70,679 m^3 with an average shop volume of 3,769 m^3. EPA assumed that the range of facility volumes in this data set would also be representative of other facility types which use DIDP-based penetrants and inspection fluids Based on this data EPA assumed a triangular distribution bound from 200 m^3 to 70,679 m^3 with a mode of 3,769 m^3 (the average of the data from CARB).

CARB measured the physical dimensions of the brake service work area within each automotive maintenance and repair shop. CARB did not consider other areas of the facility, such as customer waiting areas and adjacent storage rooms if they were separated by a normally closed door. If the door was normally open, CARB considered these areas as part of the area in which brake servicing emissions could occur (CARB, 2000). CARB's methodology for measuring the physical dimensions of the visited facilities provides the appropriate physical dimensions needed to represent the far-field volume in EPA's model. Therefore, CARB's reported facility volume data are appropriate for EPA's modeling purposes.

E.15.2.2 Air Exchange Rate

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

E.15.2.3 Near-Field Indoor Air Speed

Baldwin and Maynard measured indoor air speeds within 55 occupational settings in the United Kingdom (Baldwin and Maynard, 1998). EPA analyzed the air speed data from Baldwin and Maynard and categorized the air speed surveys into data representative of industrial facilities and data representative of commercial facilities. EPA fit separate distributions for these industrial and commercial settings and used the industrial distribution for this model.

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

EPA resulting lognormal distribution had a mean of 22.414 ± 19.958 cm/s, a minimum allowed value of 1.3 cm/s, and a maximum allowed value of 202.2 cm/s (largest surveyed mean air speed observed in

Baldwin and Maynard) to prevent the model from sampling values that approach infinity or are otherwise unrealistically small or large (Baldwin and Maynard, 1998).

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

E.15.2.4 Near-Field Volume

EPA defined the near-field zone as a hemisphere with its major axis oriented vertically against the application surface. EPA also defined a near-field radius (R_{NF}) of 1.5 meters, approximately 4.9 feet, as an estimate of the working height of the application surface, as measured from the floor to the center of the surface.

Equation E-118.

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

E.15.2.5 Application Time

EPA modeled the application time at 5-minute intervals, as it is expected that the penetrant will be sprayed onto the surface, allowed to sit on the surface, and finally wiped away after the surface has been examined for defects. For this process, it is expected that the application step will only take 5 minutes.

E.15.2.6 Averaging Time

EPA uses 8-hr TWAs for its risk calculations; therefore, EPA used a constant averaging time of eight hours.

E.15.2.7 DIDP Product Concentration

EPA was not able to identify DIDP-specific penetrant product information; however, EPA assessed the DIDP penetrant concentration using surrogate DINP concentration information from a penetrant and inspection fluid product, Spotcheck ® SKL-SP2. EPA used the safety data sheet to develop a range of concentrations for the product (ITW Inc, 2018). EPA assessed the DIDP product concentration using a uniform distribution ranging from 0.1 to 0.2.

E.15.2.8 Volume of Penetrant Used per Job

EPA utilized a penetrant and inspection fluid containing DINP as surrogate and assessed the product information using the safety data sheet (ITW Inc, 2018). Based on this information, EPA estimated that the amount of penetrant per aerosol container was 10.5 oz. EPA then assumed the quantity of penetrant used per job as a uniform distribution ranging from 10-25% of can per job or 1.05 to 2.63 oz.

This throughput range differs from the throughput used to assess the releases for this OES as outlined in Section E.13.3. The discrepancy reflects the expected discrepancy in number of workers applying the product and working the job at a given site. EPA expects that these tasks will be performed by multiple workers per day, and that no one worker would regularly apply these products for a full shift. Thus, the 10-25% range results in less penetrant per job and is expected be more representative of aerosol exposures for a single worker.

E.15.2.9 Number of Applications per Job

EPA modeled the penetrant scenario with one application per job, as it is expected that the penetrant will be sprayed onto the surface, allowed to sit on the surface, and finally wiped away after the surface has been examined for defects.

E.15.2.10 Amount of DIDP Used per Application

EPA calculated the amount of DIDP used per application using Equation E-119. The calculated mass of DIDP per application ranges from 2.09×10^{-3} to 4.17×10^{-3} grams.

Equation E-119.

$$Amt = \frac{Q_{penetrant\_job} \times F_{DIDP} \times 28.3495 \frac{g}{oz}}{N_{app\_job}}$$

Where:

Amt = Amount of DIDP used per application [g/application]
$Q_{penetrant\_job}$ = Amount of penetrant used per job [oz/job]
F_{DIDP} = Product concentration [kg/kg]
N_{app_job} = Number of applications per job [applications/job]

E.15.2.11 Number of Jobs per Work Shift

EPA did not identify DIDP-specific data on penetrant and inspection fluid application frequency. Therefore, EPA assessed exposures assuming 8 jobs per work shift, which is equivalent to one job per hour for a full 8-hour shift. The full-shift assumption may overestimate the application duration, as workers likely have other activities during their shift; however, those activities may also result in exposures to vapors that volatilize during those activities. Since EPA is not factoring in those vapor exposures, a full-shift exposure assessment is assumed to be protective of any contribution to exposures from vapors.

E.16 Inhalation Exposure to Respirable Particulates Model Approach and Parameters

The *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d) estimates worker inhalation exposure to respirable solid particulates using personal breathing zone Particulate, Not Otherwise Regulated (PNOR) monitoring data from OSHA's Chemical Exposure Health Data (CEHD) data set. The CEHD data provides PNOR exposures as 8-hour TWAs by assuming exposures outside the sampling time are zero, and the data also include facility NAICS code information for each data point. To estimate particulate exposures for relevant OESs, EPA used the 50th and 95th percentiles of respirable PNOR values for applicable NAICS codes as the central tendency and high-end exposure estimates, respectively.

EPA assumed DIDP is present in particulates at the same mass fraction as in the bulk solid material, whether that is a plastic product or another solid article. Therefore, EPA calculates the 8-hour TWA exposure to DIDP present in dust and particulates using the following equation:

Equation E-120.

$$C_{DIDP,8hr-TWA} = C_{PNOR,8hr-TWA} \times F_{DIDP}$$

Where:

$C_{DIDP,8hr-TWA}$ = 8-hour TWA exposure to DIDP [mg/m^3]
$C_{PNOR,8hr-TWA}$ = 8-hour TWA exposure to PNOR [mg/m^3]
F_{DIDP} = Mass fraction of DIDP in PNOR [mg/mg]

Table_Apx E-32 provides a summary of the OESs assessed using the *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)* (U.S. EPA, 2021d) along with the associated NAICS code, PNOR 8-hour TWA exposures, DIDP mass fraction, and DIDP 8-hour TWA exposures assessed for each OES.

Table_Apx E-32. Summary of DIDP Exposure Estimates for OESs Using the Generic Model for Exposure to PNOR

Occupational Exposure Scenario	NAICS Code Assessed	Respirable PNOR 8-hr TWA from Model (mg/m^3)		DIDP Mass Fraction Assessed	DIDP 8-hr TWA (mg/m^3)	
		Central Tendency	High-End		Central Tendency	High-End
Non-PVC Materials Compounding	326 – Plastics and Rubber Manufacturing	0.23	4.7	0.20	4.6E−02	0.94
PVC Plastics Compounding	326 – Plastics and Rubber Manufacturing	0.23	4.7	0.20	4.6E−02	0.94
Non-PVC Materials Converting	326 – Plastics and Rubber Manufacturing	0.23	4.7	0.45	0.10	2.1
PVC Plastics Converting	326 – Plastics and Rubber Manufacturing	0.23	4.7	0.45	0.10	2.1
Recycling and Disposal	56 – Administrative and Support and Waste Management and Remediation Services	0.24	3.5	0.45	0.11	1.6
Fabrication and Final Use of Products or Articles	337 – Furniture and Related Product Manufacturing	0.20	1.8	0.45	9.0E−02	0.81

Appendix F Products Containing DIDP

This section includes a sample of products containing DIDP. This is not a comprehensive list of products containing DIDP. In addition, some manufacturers may appear over-represented in Table_Apx F-1. This may mean that they are more likely to disclose product ingredients online than other manufacturers but does not imply anything about use of the chemical compared to other manufacturers in this sector.

Table_Apx F-1. Products Containing DIDP

OES	Product	Manufacturer	DIDP Concentration	Source	HERO ID
Adhesive/ Sealant	M-3180 Part A	BJB Enterprises, Inc.	5 – 10%, by weight	BJB Enterprises Inc. (2013)	6984628
Adhesive/ Sealant	WC-766 Part B	BJB Enterprises, Inc.	1 – 5%, by weight	BJB Enterprises Inc. (2017e)	6984634
Adhesive/ Sealant	BR-90 Brushable Part B	BJB Enterprises, Inc.	10 – 30%, by weight	BJB Enterprises Inc. (2018)	6984636
Adhesive/ Sealant	TC-808 Part A	BJB Enterprises, Inc.	10 – 30%, by weight	BJB Enterprises Inc. (2017b)	6984631
Adhesive/ Sealant	TC-885 FR Rev 1 Part A	BJB Enterprises, Inc.	15 – 40%, by weight	BJB Enterprises Inc. (2017c; 2017d)	6984632
Adhesive/ Sealant	TC-886 FR Rev 1 Part A	BJB Enterprises, Inc.	15 – 40%, by weight	BJB Enterprises Inc. (2017c; 2017d)	6984633
Adhesive/ Sealant	Carboseal Flex Joint Part B	Carboline Company	50 – <75%, unspecified	Carboline Company (2019)	6984645
Adhesive/ Sealant	Fast Cast™	Environmental Technology, Inc.,	10 – 40%, unspecified	Environmental Technology Inc. (2016)	6984665
Adhesive/ Sealant	Quikjoint UVR Standard Gray 1:1 Part B	Euclid Chemical Company	0.01 – <1%, unspecified	Euclid Chemical Company (2017)	6984667
Adhesive/ Sealant	Euco Qwikjoint 200 Part B - 50 Gallon	Euclid Chemical Company	50 – <100%, unspecified	Euclid Chemical Company (2019)	6984669
Adhesive/ Sealant	Part #3475 Urethane Casting Resin, 75 Shore D, Part B	Fibre Glast Developments Corp.	<30%, unspecified	Fibre Glast Developments Corp. (2019)	6984678
Adhesive/ Sealant	Floor 2-Glk Epoxy Floor Patching Comp Part B	Rust-Oleum Corporation	0.1%, by weight	Rust-Oleum Corporation (2018a)	6984580
Adhesive/ Sealant	InstaPatch Part B Tile Red	Rust-Oleum Corporation	24%, by weight	Rust-Oleum Corporation (2018b, 2017)	6984579
Adhesive/ Sealant	InstaPatch Part B Gray	Rust-Oleum Corporation			6984581

OES	Product	Manufacturer	DIDP Concentration	Source	HERO ID
Adhesive/ Sealant	Heavy Duty Construction Adhesive	Gorilla Glue Company	Unknown	Home Depot (2019a)	6984539
Adhesive/ Sealant	3M(TM) Marine Adhesive Sealant Fast Cure 4000 UV, White	3M	10 – 20%, by weight	3M Company (2019)	6984622
Adhesive/ Sealant	3.0 Gutter & Flashing Sealant Crystal Clear	DAP Products Inc.	Unknown	DAP Products Inc. (2015)	6984655
Adhesive/ Sealant	3.0 Window, Door, Trim & Siding Sealant -Crystal Clear	DAP Products Inc.	Unknown	DAP Products Inc. (2019)	6836835
Adhesive/ Sealant	Genova Products Vinyl Adhesive/Filler - Clear	Genova Products	<30%, by weight	Genova Products (2013)	6984680
Adhesive/ Sealant	Marldon MXA 200 600ml	Havwoods Accessories	1 – <5%, unspecified	Havwoods Accessories (2017)	6984536
Adhesive/ Sealant	Red Devil King Kaul All In One Adhesive, Caulk, Sealant	Red Devil, Inc.	1%, unspecified	Walmart (2019)	6984555
Adhesive/ Sealant	King Kaulk Adhesive & Sealant-White & colors	Red Devil, Inc.		Red Devil (2016)	6984577
Adhesive/ Sealant	Soudaseal SL	Soudal	Unknown	Soudal (2019a; 2019b)	6984584
Adhesive/ Sealant	Soudaseal MB	Soudal	Unknown	Soudal (2019a; 2019b)	6984583
Adhesive/ Sealant	Bird Barrier Bond	SOUDAL Accumetric	1%, unspecified	SOUDAL Accumetric (2015a)	6984586
Adhesive/ Sealant	Soudaseal AP	SOUDAL Accumetric	20 – 30%, unspecified	SOUDAL Accumetric (2015b)	6984588
Adhesive/ Sealant	Soudaseal FC	SOUDAL Accumetric	1%, unspecified	SOUDAL Accumetric (2015c)	6984589
Adhesive/ Sealant	3M™ MSP Seam Sealer – White, PN 08369	3M	1 – 5%, by weight	3M Company (2018)	5353143
Adhesive/ Sealant	Childers CP-70	H.B. Fuller Construction Products Inc.	1 – 5%, unspecified	H.B. Fuller Construction Products Inc. (2017)	6984517

OES	Product	Manufacturer	DIDP Concentration	Source	HERO ID
Adhesive/ Sealant	Protecto Sealant 25XL	Protecto Wrap Company	3 – 7%, by weight	Protecto Wrap Company (2008)	6302503
Adhesive/ Sealant	Joint and Termination Sealant	R.M. Lucas Company	10 – 20%, by weight	R.M. Lucas Company (2015a)	6984563
Adhesive/ Sealant	Semi-Selfleveling Sealer	R.M. Lucas Company	10 – 20%, by weight	R.M. Lucas Company (2015b)	6984576
Adhesive/ Sealant	Watertite 10.1-Oz 12 Pk Polyurethan SLR	Rust-Oleum Corporation	0.1 – <1%, by weight	Rust-Oleum Corporation (2015)	6984578
Adhesive/ Sealant	Zinsser 10 oz. Watertite Waterproofing Poly Seal Tube	Rust-Oleum Corporation	0.1 – 1%, by weight	Home Depot (2019b)_ENREF_78	6984543
Adhesive/ Sealant	Sakrete Polyurethane Self Leveling Sealant	Sakrete of North America	20 – 40%, by weight	Sakrete of North America (2018)	6984582
Adhesive/ Sealant	TremGrip Gray Adh. 12 X 300 ML CTG	Tremco Canadian Sealants	1 – <5%, unspecified	Tremco Canadian Sealants (2018)	6984637
Adhesive/ Sealant	Dymonic 100 White - 30 CTG	Tremco Canadian Sealants	0.1 – 1%, unspecified	Tremco Canadian Sealants (2019a)	6984640
Adhesive/ Sealant	Vulkem 116 Limestone	Tremco Incorporated	15 – 40%, by weight	Tremco Incorporated (2010)	6984648
Adhesive/ Sealant	Vulkem 116 Gray	Tremco Incorporated		Tremco Incorporated (2010)	6984646
Adhesive/ Sealant	Vulkem 116 LV Buff 30 CTG/CS	Tremco Incorporated		Tremco Incorporated (2010)	6984650
Adhesive/ Sealant	Vulkem 116 White	Tremco Incorporated		Tremco Incorporated (2010)	6984654
Adhesive/ Sealant	TremSeal Pro Limestone- 30 CTG CS	Tremco U.S. Roofing	0.1 – 1%, unspecified	Tremco U.S. Roofing (2019)	6984522
Adhesive/ Sealant	Spectrem® 4	Tremco U.S. Sealants	1 – <5%, unspecified	Tremco U.S. Sealants (2018)	6302529
Adhesive/ Sealant	Dymonic 100 Redwood Tan - 30 CG CS	Tremco U.S. Sealants	0.1 – <1%, unspecified	Tremco U.S. Sealants (2017a)	6984532
Adhesive/ Sealant	Vulkem 116 LV Off White 30 CTG/CS	Tremco U.S. Sealants	10 – <25%, unspecified	Tremco U.S. Sealants (2017b)	6984533
Functional Fluid	Duratherm G-LV	Duratherm	10 – 30%, unspecified	Duratherm (2019)	6984663

OES	Product	Manufacturer	DIDP Concentration	Source	HERO ID
Functional Fluid	Duratherm G	Duratherm	10 – 30%, unspecified	Duratherm (2019)	6984662
Functional Fluid	U-Clean	Duratherm	10 – 20%, unspecified	Duratherm (2018c)	6984660
Functional Fluid	Duraclean Ultra	Duratherm	20 – 75%, unspecified	Duratherm (2019)	6984661
Functional Fluid	Duraclean	Duratherm	20 – 75%, unspecified	Duratherm (2019)	6984658
Functional Fluid	Duraclean LSC	Duratherm	20 – 75%, unspecified	Duratherm (2019)	6984659
Functional Fluid	DELF Clean Ultra	Mokon	20 – 75%, unspecified	Mokon (2018b)	6984550
Functional Fluid	DELF Clean	Mokon	10 – 20%, unspecified	Mokon (2018a)	6836818
Functional Fluid	BG ATC Plus	BG Products Inc.	3 – 7%, unspecified	BG Products Inc. (2016)	6984626
Functional Fluid	ANDEROL 497	Chemtura Corporation	≥10 – <20%, unspecified	Chemtura Corporation (2015)	6984647
Functional Fluid	ANDEROL 3046	Chemtura Corporation	≥10 – <20%, unspecified	Chemtura Corporation (2015)	6984649
Functional Fluid	XL 700	Ingersoll Rand Industrial Technologies	10 – 40%, by weight	Ingersoll Rand (2015)	6984520
Functional Fluid	PS-200	Klüber Lubrication NA LP	5 – 10%, by weight	Klüber Lubrication NA LP (2018b)	6984525
Functional Fluid	DSL- 125	Klüber Lubrication NA LP	10 – 30%, by weight	Klüber Lubrication NA LP (2018)	6984523
Functional Fluid	ULTIMA- 68	Klüber Lubrication NA LP	10 – 30%, by weight	Klüber Lubrication NA LP (2018)	6984527
Functional Fluid	QuinSyn Flush Fluid	Quincy Compressor	99%, unspecified	Quincy Compressor (2012)	6836826
Functional Fluid	DACNIS SB 68	TOTAL Specialties USA Inc.	1 – 10%, by weight	TOTAL Specialties USA Inc. (2015a)	6984599
Functional Fluid	SYNOLAN DE 100	TOTAL Specialties USA Inc.	10 – 40%, by weight	TOTAL Specialties USA Inc. (2015b)	6984635
Lab Use	Phthalates in Poly(vinyl chloride)	SPEX CertiPrep, LLC	3%, unspecified	SPEX CertiPrep LLC (2017a)	6301562
Lab Use	Phthalates in Polyethylene Standard	SPEX CertiPrep, LLC	3%, unspecified	SPEX CertiPrep LLC (2017c)	6301560
Lab Use	Diisodecyl phthalate in PE	SPEX CertiPrep, LLC	0.1%, unspecified	SPEX CertiPrep LLC (2017b)	6984594

OES	Product	Manufacturer	DIDP Concentration	Source	HERO ID
Lab Use	Phthalates in Polyethylene Standard w/BPA	SPEX CertiPrep, LLC	3%, unspecified	SPEX CertiPrep LLC (2017d)	6301542
Lab Use	Diisodecyl Phthalate	Toronto Research Chemicals	Unknown	Toronto Research Chemicals (2017)	6984598
Paints/ Coatings	Super Diamond Clear 350 - 5 Gal Pail	Euclid Admixture Canada Inc.	1 – <5%, unspecified	Euclid Admixture Canada Inc. (2017)	6984666
Paints/ Coatings	Crystal Shine	SpecChem	<2%, by weight	SpecChem (2018)	6984591
Paints/ Coatings	AlphaGuard® MTS	Tremco U.S. Roofing	0.01 – <1%, unspecified	Tremco U.S. Roofing (2018)	6984521
Paints/ Coatings	6823 Orange	BJB Enterprises, Inc.	60 – 100%, by weight	BJB Enterprises Inc. (2019a)	6984639
Paints/ Coatings	6827 Burnt Sienna	BJB Enterprises, Inc.	30 – 60%, by weight	BJB Enterprises Inc. (2019b)	6984641
Paints/ Coatings	6800 Pigment Thinner	BJB Enterprises, Inc.	60 – 100%, by weight	BJB Enterprises Inc. (2017a)	6984630
Paints/ Coatings	Universal C/P Amarillo White	Tremco Canadian Sealants	25 – <50%, unspecified	Tremco Canadian Sealants (2019b)	6984643
Paints/ Coatings	Universal C/P Dark Gray	Tremco Canadian Sealants	50 – <100%, unspecified	Tremco Canadian Sealants (2019c)	6984644
Paints/ Coatings	Universal C/P Baptist Brick	Tremco U.S. Sealants	25 – <50%, unspecified	Tremco U.S. Sealants (2019 or 2016)	11373489
Paints/ Coatings	Universal C/P Toast Tan	Tremco U.S. Sealants	25 – <50%, unspecified	Tremco U.S. Sealants (2019)	6984540
Paints/ Coatings	Universal C/P Sunset Yellow	Tremco U.S. Sealants	25 – <50%, unspecified	Tremco U.S. Sealants (2016)	6302292
Paints/ Coatings	Universal C/P River Rouge Red	Tremco U.S. Sealants	25 – <50%, unspecified	Tremco U.S. Sealants (2016)	6984530
Paints/ Coatings	Universal C/P Navy Blue	Tremco U.S. Sealants	25 – <50%, unspecified	Tremco U.S. Sealants (2016)	6984529
Paints/ Coatings	Universal C/P Limestone	Tremco U.S. Sealants	25 – <50%, unspecified	Tremco U.S. Sealants (2019)	6984535
Paints/ Coatings	Universal C/P Kelly Pink	Tremco U.S. Sealants	25 – <50%, unspecified	Tremco U.S. Sealants (2016)	6984528
Paints/ Coatings	Universal C/P Hartford Green	Tremco U.S. Sealants	25 – <50%, unspecified	Tremco U.S. Sealants (2016)	6984526
Paints/ Coatings	Universal C/P Dover Sky	Tremco U.S. Sealants	25 – <50%, unspecified	Tremco U.S. Sealants (2019)	6984534
Paints/ Coatings	Universal C/P Antique Pink	Tremco U.S. Sealants	25 – <50%, unspecified	Tremco U.S. Sealants (2016)	6984524

OES	Product	Manufacturer	DIDP Concentration	Source	HERO ID
Formulation Other	Tracer Tech P-133D	Evident Crime Scene Products	Unknown	Evident Crime Scene Products (n.d.)	6984674
Plastic Compounding	SC-22	BJB Enterprises, Inc.	60 – 100%, by weight	BJB Enterprises Inc. (2014)	6984629
Plastic Compounding	SKINFLEX III Part C Castable	BJB Enterprises, Inc.	90 – 100%, by weight	BJB Enterprises Inc. (2012)	6984627
Plastic Compounding	DIDP DLD	HB Chemical	65 – 73%, unspecified	HB Chemical (2014c)	6984519
Plastic Compounding	DIDP	HB Chemical	99%, by weight	HB Chemical (2014a)	6836813
Plastic Compounding	DIDP-E	HB Chemical	99%, by weight	HB Chemical (2014b)	6984518
Plastic Compounding	Diisodecyl Phthalate	Megaloid Laboratories	100%	Megaloid Laboratories (2013)	6984546
Plastic Compounding	Plasthall® DIDP	The HallStar Company	100%	The HallStar Company (2015)	6984597
Plastics Converting	Vinyl Barrier	Acoustical Surfaces, Inc.	0.23%, unspecified	Acoustical Surfaces Inc. (2014)	6984624
Other Formulation	Spotcheck ® SKL-SP2	ITW Ltd.		ITW Ltd. (2018)	6984562