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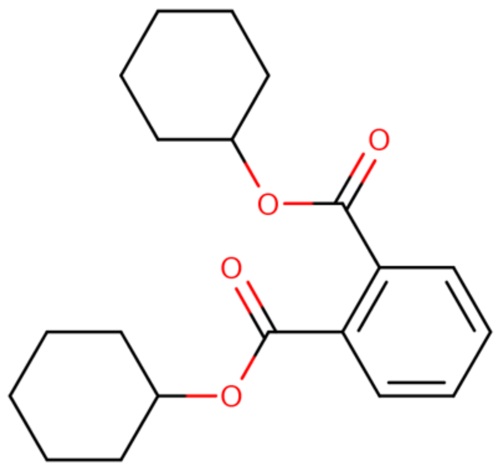
Environmental Release and Occupational Exposure Assessment for Dicyclohexyl Phthalate (DCHP)

Technical Support Document for the Risk Evaluation

CASRN 84-61-7



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KEY ABBREVIATIONS AND ACRONYMS

ADD	Average daily dose
APDR	Acute potential dermal dose rate
APF	Assigned protection factor
BLS	Bureau of Labor Statistics (U.S.)
CASRN	Chemical Abstracts Service Registry Number
CDR	Chemical Data Reporting
CEB	Chemical Engineering Branch
CEHD	Chemical Exposure Health Database
CFR	Code of Federal Regulations
COU	Conditions of use
CPS	Current Population Survey
CPSC	Consumer Product Safety Commission (U.S.)
CT	Central tendency
DD	Dermal daily dose
DCHP	Dicyclohexyl phthalate
DMR	Discharge monitoring report
ELG	Effluent limitation guidelines
EPA	Environmental Protection Agency (U.S.)
ESD	Emission scenario document
ETIMEOFF	Months When Not Working (CPS data)
GS	Generic scenario
HAP	Hazardous air pollutant
HE	High-end
HVLP	High volume low pressure
IADC	Intermediate average daily concentration
LADC	Lifetime average daily concentrations
LADD	Lifetime average daily dose
LOD	Limit of detection
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 (U.S.)
OECD	Organisation for Economic Co-Operation and Development
OEL	Occupational exposure limit
OES	Occupational exposure scenario
OIS	Occupational Safety and Health Information System (U.S.)
ONU	Occupational non-user
OPPT	Office of Pollution Prevention and Toxics (EPA)
OSHA	Occupational Safety and Health Administration (U.S.)
PBZ	Personal breathing zone
PEL	Permissible exposure limit
PESS	Potentially exposed or susceptible subpopulations
PF	Protection factor
PNOR	Particulates not otherwise regulated (also PNOR Model)

POTW	Publicly owned treatment works
PPE	Personal protective equipment
PV	Production volume
REL	Recommended exposure limits
RQ	Reportable quantity
SDS	Safety data sheet
SIC	Standard Industrial Classification
SIPP	Survey of Income and Program Participation
SpERC	Specific Emission Release Category
SUSB	Statistics of US Businesses
TDS	Technical data sheets
TLV	Threshold limit value
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
TWA	Time-weighted average
U.S.	United States
VP	DCHP vapor pressure
WEEL	Workplace Environmental Exposure Level
WWT	Wastewater treatment
WY	Working years per lifetime

SUMMARY

This technical support document accompanies the Toxic Substances Control Act (TSCA) *Risk Evaluation for Dicyclohexyl Phthalate (DCHP)* (U.S. EPA, 2025b). Although DCHP is not a Toxics Release Inventory (TRI)-reportable substance, it is included on the TRI and reported under the Chemical Data Reporting (CDR) rule. This TSD describes the use of reasonably available information to estimate environmental releases of DCHP and to evaluate occupational exposures. See Appendix C of the risk evaluation for a complete list of all TSDs and supplemental files for DCHP.

Focus of the Environmental Release and Occupational Exposure Assessment

During scoping, the U.S. Environmental Protection Agency (EPA or the Agency) considered all known TSCA uses for DCHP. The 2016 CDR indicated 500,000 to 1 million pounds (lb) of DCHP (CASRN 84-61-7) were manufactured or imported in the United States in 2015 (U.S. EPA, 2019a). The 2020 CDR report indicates the same range for the manufacture or import volume in 2019. Review of preliminary 2024 CDR data shows that that total production volume for the years 2020 to 2023 are similar to the previously reported range from 2020 CDR. The largest number of reported uses of DCHP was as a plasticizer in plastics. Secondary uses are as a plasticizer/additive in adhesives, sealants, paints, coatings, rubbers, and other applications.

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

Approach for Environmental Releases and Occupational Exposures Assessment

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 DCHP to air, water, and land from the OESs associated with the COUs assessed in the risk evaluation. The Agency did not identify release data from available literature sources and used modeling approaches to assess release estimates.

EPA evaluated acute, intermediate, and chronic exposures to workers and ONUs in association with DCHP OESs. The Agency did not find DCHP-specific dermal absorption or inhalation monitoring data from literature sources and assessed exposures using exposure models, which include surrogate monitoring data, for all OESs.

Results for Environmental Releases and Occupational Exposures

EPA evaluated environmental releases of DCHP to air, water, and/or land for 13 out of the 15 OESs assessed in the risk evaluation. The Agency did not quantitatively assess environmental releases for the other two OESs (Fabrication or use of final products or articles; Waste handling, treatment, and disposal) due to the lack of readily available process- and DCHP-specific data. The highest central tendency daily release was estimated from the Manufacturing OES, followed by the Application of paints and coatings OES. The highest high-end release was estimated from the Application of paints and coatings OES followed by the PVC plastics compounding OES.

EPA also evaluated inhalation and dermal exposures to worker populations, including ONUs and females of reproductive age, for each OES. DCHP often exists in a solid powder form and there is potential for powdered materials to become airborne during handling. Also, liquid paint and coating products containing DCHP may be sprayed, generating a mist that may lead to inhalation and dermal exposures. Although dermal exposures to DCHP in occupational settings are not expected to be significant based on modeled estimates of dermal absorption, the potential occupational exposure levels through inhalation are significant for all uses, with the exception of liquid laboratory chemicals and paste-like adhesive products. Detailed exposure results for each OES and exposure route can be found in Section 3.

Uncertainties of the Results for Environmental Releases and Occupational Exposures

Uncertainties exist with the monitoring and modeling approaches used to assess DCHP environmental releases and occupational exposures. For example, the lack of DCHP facility production volume data and use of estimates based on CDR reporting thresholds may not be representative of the actual production volume of DCHP used in the United States. The Agency also used generic EPA models and default input parameter values when site-specific data were not available. In addition, site-specific differences in use practices and engineering controls exist—but are largely unknown—which represents another source of variability that EPA could not quantify in the assessment. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day by one entire hand (front and back of hand for central tendency estimate) as well as by both hands (front and back of both hands for high-end estimate). Because DCHP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA assumed that absorption of DCHP from occupational dermal contact with materials containing DCHP may extend up to 8 hours per day (CEB, 1991). However, if a worker uses proper personal protective equipment (PPE) or washes their hands after contact with DCHP or DCHP-containing materials, dermal exposure may be reduced.

Use of the Results for Environmental Releases and Occupational Exposures – 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 DCHP COUs. The environmental release estimates developed by the Agency are used to estimate the presence of DCHP 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 DCHP) and ONUs for each OES. The Agency assumed that workers and ONUs would be individuals of both sexes (ages ≥16 years, including pregnant workers) based on occupational work permits. An objective of the assessment was to provide separate exposure level estimates for workers and ONUs. Dermal exposures were considered for all workers but only considered for ONUs with potential exposure to dust or mist deposited on surfaces.

1 INTRODUCTION

1.1 Overview

This TSD supported the TSCA *Risk Evaluation for Dicyclohexyl Phthalate (DCHP)* (U.S. EPA, 2025b), which is also referred to as the "risk evaluation." EPA conducted the risk evaluation for DCHP under the Frank R. Lautenberg Chemical Safety for the 21st Century Act, which amended TSCA on June 22, 2016. The new law includes statutory requirements and deadlines for actions related to conducting risk evaluations of existing chemicals.

Under TSCA section 6(b), EPA must designate chemical substances as high-priority substances for risk evaluation or low-priority substances for which risk evaluations are not warranted at the time, and upon designating a chemical substance as a high-priority substance, initiate a risk evaluation on the substance. TSCA section 6(b)(4) directs EPA to conduct risk evaluations for existing chemicals, to "determine whether a chemical substance presents an unreasonable risk of injury to health or the environment, without consideration of costs or other non-risk factors, including an unreasonable risk to a potentially exposed or susceptible subpopulation identified as relevant to the risk evaluation by the Administrator under the conditions of use."

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

DCHP is a common chemical name for a chemical substance that includes the following names: 1,2-benzenedicarboxylic acid, dicyclohexyl ester; phthalic acid, dicyclohexyl ester; and dicyclohexyl 1,2-benzenedicarboxylate. DCHP is a granular solid or crystalline powder that is used primarily as a plasticizer in PVC, though it is also used in adhesives, sealants, paints, coatings, rubbers, non-PVC materials and other applications. All uses are subject to federal and state regulations and reporting requirements. DCHP is not a TRI-reportable substance; however, it is on the TSCA Inventory and reported under the CDR rule.

1.2 Scope

EPA assessed environmental releases and occupational exposures for COUs as described in Table 2-2 of the *Final Scope of the Risk Evaluation for Dicyclohexyl Phthalate (DCHP); CASRN 84-61-7* (also called "final scope") (U.S. EPA, 2020c). To estimate environmental releases and occupational exposures, EPA first developed OESs related to the COUs of DCHP. An OES is based on a set of facts, assumptions, and inferences that describe how releases and exposures take place within an occupational COU. The occurrence of releases/exposures may be similar across multiple COUs, or there may be several ways in which releases/exposures take place for a given COU. Table 1-1 of this document shows mapping between the COUs in Table 2-2 of the *Risk Evaluation for Dicyclohexyl Phthalate (DCHP)* (U.S. EPA, 2025b) to the OES assessed in this assessment/TSD.

In general, EPA mapped OESs to COUs using professional judgment based on available data and information. Several of the COU categories and subcategories were grouped and assessed together in a single OES due to similarities in the processes or lack of data to differentiate between them. This grouping minimized repetitive assessments. In other cases, COU subcategories were further delineated into multiple OESs based on expected differences in process equipment and associated release/exposure potentials between facilities. EPA assessed environmental releases and occupational exposures as described in Table 1-1.

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

COU			OES[d]
Life Cycle Stage[a]	**Category[b]**	**Subcategory[c]**	
Manufacturing	Domestic manufacturing	Domestic manufacturing	Manufacturing
	Importing	Importing	Import and repackaging
Processing	Repackaging	Repackaging (*e.g.*, laboratory chemicals)	Import and repackaging
	Processing – incorporation into formulation, mixture, or reaction product	Adhesive and sealant chemicals in: - Adhesive manufacturing	Incorporation into adhesives and sealants
		Plasticizer in: - Adhesive manufacturing - Paint and coating manufacturing - Plastics product manufacturing - Printing ink manufacturing - Rubber product manufacturing - Plastic material and resin manufacturing	Incorporation into adhesives and sealants; Incorporation into paints and coatings; PVC plastics compounding; Non-PVC material compounding
		Stabilizing agent in: - Plastics product manufacturing - Paint and coating manufacturing - Asphalt paving, roofing, and coating materials manufacturing - Adhesive manufacturing	Incorporation into adhesives and sealants; Incorporation into paints and coatings; Incorporation into other formulations, mixtures, or reaction products; PVC plastics compounding; Non-PVC material compounding
	Processing – incorporation into article	Plasticizer in: - Plastics product manufacturing - Rubber product manufacturing	PVC plastics converting; Non-PVC material converting
	Recycling	Recycling	Recycling
Distribution	Distribution in commerce	Distribution in commerce	Distribution in commerce

COU			OES[d]
Life Cycle Stage[a]	Category[b]	Subcategory[c]	
Industrial Use	Adhesives and sealants	Adhesives and sealants in: - Transportation equipment manufacturing - Computer and electronic product manufacturing	Application of adhesives and sealants
	Finishing agent	Cellulose film production	Application of paints and coatings
	Inks, toner, and colorant products	Inks, toner, and colorant products (*e.g.*, screen printing ink)	Application of paints and coatings
	Paints and coatings	Paints and coatings	Application of paints and coatings
	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard) (*e.g.*, transportation equipment manufacturing)	Fabrication or use of final products or articles
Commercial Use	Adhesives and sealants	Adhesives and sealants	Application of adhesives and sealants
	Building/construction materials not covered elsewhere	Building/construction materials not covered elsewhere	Fabrication or use of final products or articles
	Inks, toner, and colorant products	Inks, toner, and colorant products (*e.g.*, screen printing ink)	Application of paints and coatings
	Laboratory chemicals	Laboratory chemicals	Use of laboratory chemicals
	Paints and coatings	Paints and coatings	Application of paints and coatings
	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Fabrication or use of final products or articles
Disposal	Disposal	Disposal	Waste handling, treatment, and disposal

[a] Life Cycle Stage Use Definitions (40 CFR 711.3)

- "Industrial Use" means use at a site at which one or more chemicals or mixtures are manufactured (including imported) or processed.
- "Commercial Use" means the use of a chemical or a mixture containing a chemical (including as part of an article) in a commercial enterprise providing saleable goods or services.
- "Consumer Use" means the use of a chemical or a mixture containing a chemical (including as part of an article, such as furniture or clothing) when sold to or made available to consumers for their use.
- Although EPA has identified both industrial and commercial uses here for purposes of distinguishing scenarios in this document, the Agency interprets the authority over "any manner or method of commercial use" under TSCA section 6(a)(5) to reach both.

[b] These categories of COU appear in the life cycle diagram, reflect CDR codes, and broadly represent COUs of DCHP in industrial and/or commercial settings.

COU			OES[d]
Life Cycle Stage[a]	Category[b]	Subcategory[c]	
[c] These subcategories represent more specific activities within the life cycle stage and category of the COU of DCHP. [d] An OES is based on a set of facts, assumptions, and inferences that describe how releases and exposures take place within an occupational COU. The occurrence of releases/exposures may be similar across multiple COUs (multiple COUs mapped to single OES), or there may be several ways in which releases/exposures take place for a given COU (single COU mapped to multiple OESs).			

The assessment of releases includes quantifying annual and daily releases of DCHP 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 TSD, 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). 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 DCHP into landfills, land treatment, surface impoundments, or other land applications. The purpose is to quantify releases; therefore, this TSD does not discuss downstream environmental fate and transport factors used to estimate exposures to the general population and ecological species. The *Risk Evaluation for Dicyclohexyl Phthalate (DCHP)* (U.S. EPA, 2025b) describes how these factors were considered when determining risk.

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

2 TYPICAL COMPONENTS OF EPA'S RELEASE AND OCCUPATIONAL EXPOSURE ASSESSMENT

EPA describes the assessed COUs for DCHP in Section 1.1.2 of the *Risk Evaluation for Dicyclohexyl Phthalate (DCHP)* (U.S. EPA, 2025b); however, some COUs differ in terms of specific DCHP processes and associated exposure/release scenarios. Therefore, Table 1-1 provides a crosswalk that maps the DCHP 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 DCHP 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 DCHP 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 ONUs:** 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 and ONUs.
  - **Aggregate Exposure Results:** Aggregated central tendency and high-end estimates from the combination of dermal and inhalation exposures.

2.1 Approach and Methodology for Process Descriptions

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

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

Where DCHP-specific process descriptions were unclear or not available, EPA referenced generic process descriptions from literature, including relevant emission scenario documents (ESDs) or generic scenarios (GSs). Sections 3.1 through 3.16 provide process descriptions for each OES.

2.2 Approach and Methodology for Estimating Number of Facilities

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

1. Identify or "map" each facility that reported DCHP 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 of the facilities within the OES. If so, the total number of facilities in the OES were assumed equal to the count of facilities mapped to the OES from each data set. If not, EPA proceeded to Step 3.
3. Supplement the available reporting data with U.S. economic and market data using the following steps:
    a. Identify the NAICS codes for the industry sectors associated with the OES.
    b. Estimate total number of facilities using the U.S. Census' Statistics of US Businesses (SUSB) data on total sites by 6-digit NAICS code.
    c. Use market penetration data to estimate the percentage of sites likely to be using DCHP 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 DCHP in each 6-digit NAICS code and sum across all applicable NAICS codes to arrive at an estimate of the total number of facilities within the OES. Typically, it was assumed that this estimate encompassed the facilities identified in Step 1; therefore, the total number of facilities for the OES were assessed as the total generated from the analysis.
4. If market penetration data required for Step 3.c. are not available, EPA relied on generic industry data from GSs, ESDs, and other literature sources on typical throughputs/use rates, operating schedules, and the DCHP production volume used within the OES to estimate the number of facilities. In cases where EPA identified a range of operating data in the literature for an OES, stochastic modeling was used to provide a range of estimates for the number of facilities within the OES. The approaches, equations, and input parameters used in stochastic modeling are described in the relevant OES sections throughout this report.

2.3 Environmental Releases Approach and Methodology

Releases to the environment were assessed using data obtained through direct measurement via monitoring, calculations based on empirical data, and/or assumptions and models. For each OES, EPA 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:** A combination of point estimates of each input parameter (*e.g.*, high-end and low-end values) were used to estimate central tendency and high-end release results. EPA documented the method and rationale for selecting parametric combinations representative of central tendency and high-end releases in the relevant OES subsections in Section 3.

- **Probabilistic (stochastic) calculations:** EPA ran Monte Carlo simulations using the statistical distribution for each input parameter to calculate a full distribution of the final release results. The Agency 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, the Agency used Monte Carlo modeling to estimate annual throughputs and emission factors but only had point estimates of release frequency and production volume. In this case, EPA documented the approach and rationale for combining point estimates with statistical distributions to estimate central tendency and high-end results in the relevant OES subsections in Sections 3.1 through 3.16.

2.3.1 Identifying Release Sources

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

2.3.2 Estimating Number of Release Days

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

1. **Facility-specific data:** EPA used facility-specific operating days per year data, if available. Otherwise, the Agency 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.

2. **Industry-specific data:** EPA used industry-specific data from GSs, ESDs, trade publications, or other relevant literature.
3. **Manufacture of large-production volume (PV) commodity chemicals:** For the manufacture of the large-PV commodity chemicals, EPA used a value of 350 days per year. This assumes the plant runs seven days per week and 50 weeks per year (with 2 weeks down for turnaround) and always produces the chemical.
4. **Manufacture of lower-PV specialty chemicals:** For the manufacture of lower-PV specialty chemicals, it is unlikely that the plant continuously manufactures the chemical throughout the year. Therefore, EPA used a value of 250 days per year. This assumes the plant manufactures the chemical five days per week and 50 weeks per year (with two weeks down for turnaround).
5. **Other chemical plant OESs:** For these OESs, EPA assumed that the facility does not always use the chemical of interest, even if the facility operates 24/7. Therefore, EPA used a value of 300 days/year, based on the assumption that the facility operates 6 days/week and 50 weeks/year (with 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).
6. **POTWs:** Although EPA expects POTWs to operate continuously 365 days per year, the discharge frequency of the chemical of interest from a POTW will depend on the discharge patterns of the chemical from upstream facilities discharging to the POTW. However, there can be multiple upstream facilities (possibly with different OESs) discharging to the same POTW and information on when the discharges from each facility occur (*e.g.*, on the same day or separate days) is typically unavailable. Since EPA could not determine the exact number of days per year that the POTW discharges the chemical of interest, a value of 365 days per year was assumed.
7. **All other OESs:** Regardless of the facility operating schedule, other OESs are unlikely to use the chemical of interest every day. Therefore, EPA used a value of 250 days per year for these OESs.

2.3.3 Estimating Releases from Models

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

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

For release models that utilized stochastic calculations, EPA performed a Monte Carlo simulation using the Palisade @Risk version 8.0 software with 100,000 iterations and the Latin Hypercube sampling method (Palisade, 2022). Section 0 and Appendix 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.

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

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 are available, the Agency may use that data to estimate releases for that facility. If facility-specific data are 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 are 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 3.16 provide a detailed description of how the Agency 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 DCHP and ONUs who do not directly handle DCHP but may be exposed to vapors, particulates, or mists that enter their breathing zone while working in locations near DCHP 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, the Agency 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, the Agency may assume that the mean, mode, or midpoint of the distribution represents the central tendency depending on the statistics available for the distribution.

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, 1992). For risk evaluation, EPA provided high-end results at the 95th percentile. If the 95th percentile is not reasonably available, the Agency used a different percentile greater than or equal to the 90th percentile but less than or equal to the 99.9th percentile, depending on the statistics available for the distribution. If the full distribution is not known and the preferred statistics are not reasonably available, EPA estimated a maximum or bounding estimate in lieu of the high-end.

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

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

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

Appendix 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-hour TWA) inhalation exposure concentrations as well as high-end and central tendency acute potential dermal dose rates (APDR). EPA applied the following hierarchy in selecting data and approaches for assessing occupational exposures:

- Monitoring data:
  a. Personal and directly applicable to the OES
  b. Area and directly applicable to the OES
  c. Personal and potentially applicable or similar to the OES
  d. Area and potentially applicable or similar to the OES
- Modeling approaches:
  a. Surrogate monitoring data
  b. Fundamental modeling approaches
  c. Statistical regression modeling approaches
- Occupational exposure limits:
  a. Company-specific occupational exposure limits (OELs) (for site-specific exposure assessments; for example, there is only one manufacturer who provides their internal OEL to EPA, but the manufacturer does not provide monitoring data)
  b. Occupational Safety and Health Administration (OSHA) permissible exposure limits (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 and 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 ONUs

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

1. Identify the NAICS codes for the industry sectors associated with these uses.
2. Estimate total employment by industry/occupation combination using the Bureau of Labor Statistics' Occupational Employment Statistics data (BLS Data).
3. Refine the Occupational Employment Statistics estimates where they are not sufficiently granular by using the 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 DCHP 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 DCHP in each industry/occupation combination and sum these to arrive at a total estimate of the number of employees with potential exposure within the OES.

2.4.3 Estimating Inhalation Exposures

2.4.3.1 Inhalation Monitoring Data

EPA reviewed workplace inhalation monitoring data collected by government agencies such as OSHA and NIOSH, monitoring data found in published literature (*i.e.*, personal exposure monitoring data and area monitoring data), and monitoring data submitted via public comments; however, the Agency did not identify any monitoring data (dust or vapor) for worker or ONU exposures to DCHP.

2.4.3.2 Inhalation Exposure Modeling

Where inhalation exposures are expected for an OES but monitoring data were unavailable, EPA utilized 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. The Agency used the following steps to estimate exposures for each OES:

1. Identify worker activities and potential sources of exposures from each process.
2. Identify or develop model equations for estimating exposures from each source.
3. Identify model input parameter values from relevant literature sources, including activity durations associated with sources of exposures.
4. If a range of input values is available for an input parameter, determine the associated distribution of input values.
5. Calculate exposure concentrations associated with each activity.

6. Calculate full-shift TWAs based on the exposure concentration and activity duration associated with each exposure source.
7. Calculate exposure metrics (AD, IADD, ADD) from full-shift TWAs.

For exposure models that utilize stochastic calculations, EPA performed a Monte Carlo simulation using the Palisade @Risk version 8.0 software with 100,000 iterations and the Latin Hypercube sampling method (Palisade, 2022). 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

EPA did not identify any studies related to the dermal absorption of DCHP through the systematic review process. Therefore, EPA relied on dermal absorption modeling to estimate occupational dermal exposures. DCHP exists in solid form at room temperature, and therefore workers are most likely to experience dermal contact with DCHP in solid form, paste form, or a low concentration liquid (see Appendix F for detailed list of products). As a conservative assumption, EPA assumes that DCHP will first migrate from the DCHP-containing material to a thin layer of moisture on the skin surface. It is important to note that there are mass transfer limitations from powders and solid matrices to the aqueous phase. However, it is conservatively assumed that the migration rate from the solid material will be sufficient to saturate the aqueous layer on the skin surface. Therefore, the upper bound of dermal absorption of DCHP is estimated using an aqueous absorption model as described below.

2.4.4.1 Dermal Absorption Modeling

The first step in modeling dermal absorption through aqueous media is to estimate the steady-state permeability coefficient, K_p (cm/h). EPA utilized the Consumer Exposure Model (CEM) (U.S. EPA, 2023a) to estimate the steady-state aqueous permeability coefficient of DCHP as 0.012 cm/h. Next, the Agency 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 for aqueous organic compounds. Specifically, Equation 3.2 from U.S. EPA (2004b), also shown in Equation 2-1 below, was used to estimate the dermally absorbed dose (DA_{event}, mg/cm^2) for an absorption event occurring over a defined duration (t_{abs}).

Equation 2-1.Dermal Absorption Dose During Absorption Event

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

Where:

DA_{event}	=	Dermally absorbed dose during absorption event t_{abs} (mg/cm^2)
FA	=	Effect of stratum corneum desquamation on quantity absorbed = 0.9 (see Exhibit A-5 of U.S. EPA (2004b))
K_p	=	Permeability coefficient = 0.012 cm/h (calculated using CEM (U.S. EPA, 2023a))
S_w	=	Water solubility = 1.48 mg/L (see Table Apx B-1 from the *Risk Evaluation for Dicyclohexyl Phthalate (DCHP)* (U.S. EPA, 2025b))
t_{lag}	=	$0.105*10^{0.0056MW} = 0.105*10^{0.0056*330.43}$ = 7.44 hours (calculated from A.4 of U.S. EPA (2004b))
t_{abs}	=	Duration of absorption event (hours)

The term "FA" is used to estimate the effect of desquamation of the stratum corneum during the absorption period. For DCHP, FA equals 0.9, which means that 10 percent of the chemical in the skin may be lost to desquamation during absorption. 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.

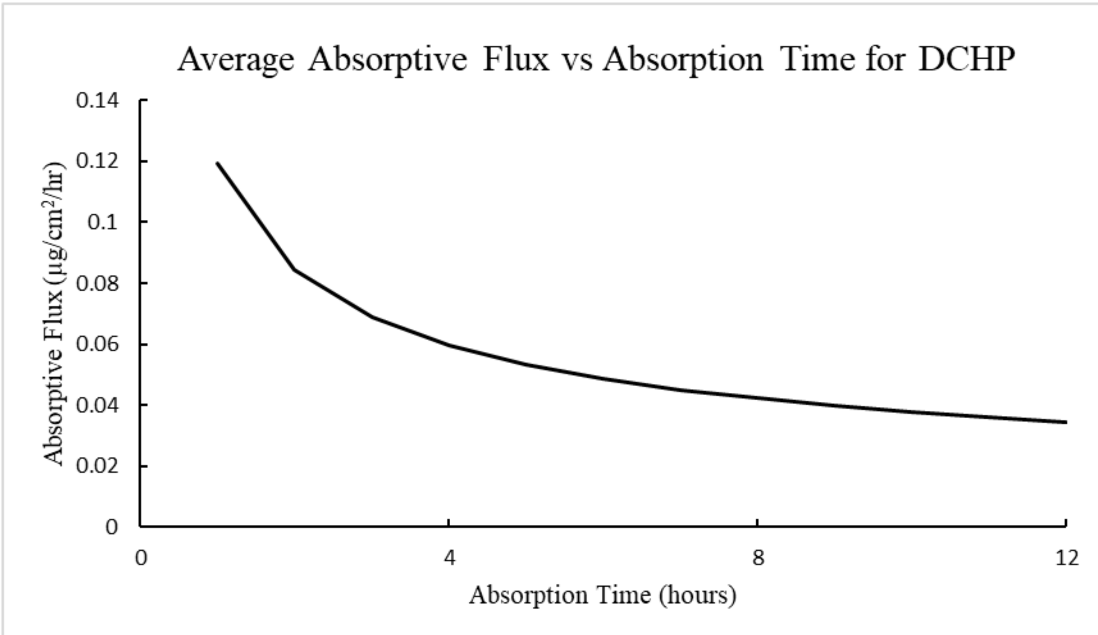

Figure 2-1. Average Absorptive Flux (DA_{event}/t_{abs}) as Function of Absorption Time (t_{abs})

Figure 2-1 shows that the average absorptive flux for aqueous DCHP is expected to vary between 3.44×10^{-5} and 1.19×10^{-4} mg/cm^2/h for durations between 1 and 12 hours, and the average absorptive flux for an 8-hour exposure is 4.22×10^{-5} mg/cm^2/h. The estimation of average flux of aqueous material is dependent on the duration of absorption and must be determined based on the scenario under assessment.

2.4.4.2 Flux-Limited Dermal Absorption

When estimating dermal absorption of finite doses (*i.e.*, typically 1–5 mg/cm^2 for solids), 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 2-2.

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

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

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 absorptive flux should be utilized for estimating dermal absorption of flux-limited scenarios.

To estimate N_{derm} for occupational exposure to DCHP, EPA assumed a typical dermal loading estimate of 1 mg/cm^2, an 8-hour exposure duration, and an average absorptive flux from an 8-hour exposure of 4.22×10^{-5} mg/cm^2/h (see Appendix D) as shown below.

Equation 2-3.

$$N_{derm} = \frac{1\ mg/cm^2}{4.22E-05\frac{mg}{cm^2 \cdot hr} \times\ 8hr} = 3.0E03$$

Because $N_{derm} >> 1$ for a typical occupational dermal exposure scenario, the absorption of DCHP is expected to be flux-limited even at finite doses, and percent absorption should not be considered transferrable across exposure conditions. Rather, the average absorptive flux of 4.22×10^{-5} mg/cm^2/h for an 8-hour absorption period, based on modeling from U.S. EPA (2004b), is expected to be representative of occupational dermal exposures to DCHP. The flux-based approach to estimating occupational dermal exposures to DCHP is further characterized in Appendix D.

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

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

For the final exposure 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 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

Occupational Safety and Health Administration (OSHA) and National Institute for Occupational Safety and Health (NIOSH) recommend employers utilize the hierarchy of controls[1] to address hazardous exposures in the workplace. The hierarchy of controls strategy outlines, in descending order of priority, 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,

[1] https://www.osha.gov/sites/default/files/Hierarchy_of_Controls_02.01.23_form_508_2.pdf (accessed December 16, 2025)

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 CFR 1910.134(d) and require that appropriate respirators be selected based on the respiratory hazard(s) to which the worker will be exposed, in addition to workplace and user factors that affect respirator performance and reliability. Assigned protection factors (APFs) are provided in Table 1 under CFR 1910.134(d)(3)(i)(A) (see below in Table 2-1) and refer to the level of respiratory protection that a respirator or class of respirators is expected to provide to employees when the employer implements a respiratory protection program according to the requirements of OSHA's Respiratory Protection Standard.

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

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

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

2.6 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 of systematic review. The Agency 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, the Agency may use lower ranked data over higher ranked data after carefully examining and comparing specific aspects of the data. For example, EPA may use a lower ranked data set that precisely matches the OES of interest over a higher ranked study that does not match the OES of interest as closely.
2. **Data Hierarchy:** EPA used both measured and modeled data to obtain accurate and representative estimates (*e.g.,* central tendency, high-end) of the environmental releases and occupational exposures resulting directly from a specific source, medium, or product. If available, measured release and exposure data are given preference over modeled data, with the highest preference given to data that are both chemical-specific and directly representative of the OES/exposure source.

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

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

3 ENVIRONMENTAL RELEASE AND OCCUPATIONAL EXPOSURE ASSESSMENTS BY OES

3.1 Manufacturing

3.1.1 Process Description

At a typical manufacturing site, DCHP is formed through the reaction of phthalic anhydride with cyclohexane ring alcohols (cyclohexanol). Similar to other phthalate manufacturing processes, the unreacted alcohols are recovered and reused, and the DCHP mixture is purified by vacuum distillation or activated charcoal. Current manufacturing processes can achieve a DCHP purity of 99 percent or greater, with some impurities of water and phthalic acid (CPSC, 2011).

In absence of information on DCHP manufacturing, it has been assumed that DCHP manufacturing process is similar to DIDP/DINP. Therefore, activities may include filtrations and quality control sampling of the DCHP product. Additionally, manufacturing operations include equipment cleaning/reconditioning and product transport to other areas of the manufacturing facility or offsite shipment for downstream processing or use. No changes to chemical composition are expected to occur during transportation (ExxonMobil, 2022a).

Figure 3-1 provides an illustration of the proposed manufacturing process for DCHP.

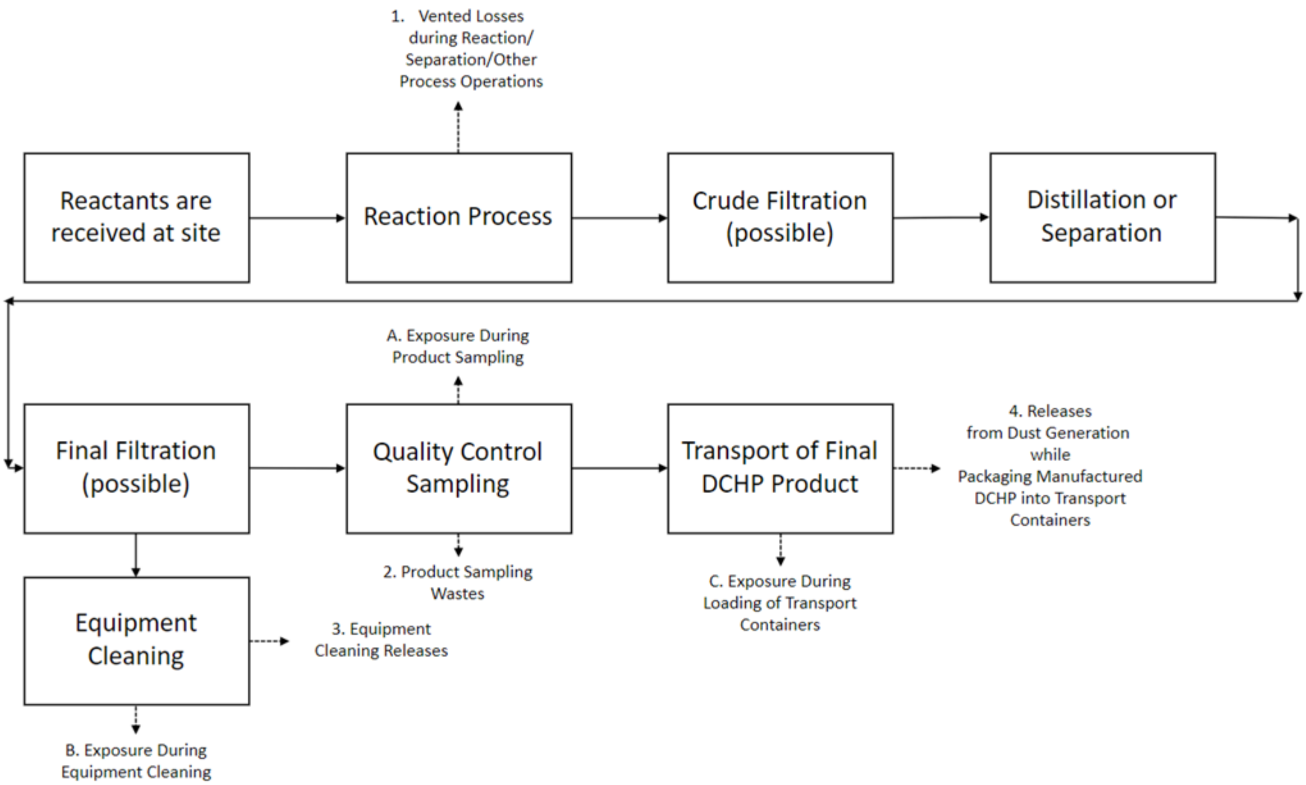

Figure 3-1. Proposed Manufacturing Flow Diagram (ExxonMobil, 2022b; CPSC, 2011)

3.1.2 Facility Estimates

In the 2020 CDR, two sites reported domestic manufacturing of DCHP (CASRN 84-61-7). LANXESS Corporation in Pittsburgh, Pennsylvania, reported a production volume of 17,291 lb for the 2019 CDR reporting year. They had previously reported between 55,124 lb and 440,953 lb DCHP manufactured between 2016 and 2018. Vertellus LLC reported their production volume as confidential business information (CBI) (U.S. EPA, 2020a). EPA did not identify additional data on current manufacturing sites or volumes from systematic review.

EPA calculated the production volume for the site that claimed this information as CBI using the reported exported PV and the reported industrial use percent. Vertellus LLC reported an export volume of 410,849 lb for 2019 and reported that 10 percent of their PV was used as a plasticizer in adhesive manufacturing. EPA assumed that this site had no uses of DCHP that fall under the reporting threshold and that 410,849 lb represented 90 percent of their total PV. Therefore, the Agency calculated the total manufactured PV from the site (410,849 ÷ 0.9 = 456,499 lb [207,064 kg]). This method was used to estimate the production volume so that the national aggregate production volume range from CDR would not have to be used which may potentially overestimate the production volume.

EPA did not identify information from systematic review for general site throughputs; site throughput information was estimated by dividing the site PV by the number of operating days. Based on the DCHP national aggregate PV reported in the 2020 CDR (500,000 to <1,000,000 lb), the Agency assumed the number of operating days was 250 days/year with 5 day/week operations and two full weeks of downtime each operating year. CDR reports indicated that DCHP is manufactured primarily in solid form at a concentration of 90 to 100 percent (U.S. EPA, 2020a). EPA modeled the solid container size using a triangular distribution with a lower bound and mode of 25 kg and upper bound of 500 kg based on the 2021 Use of Additives in Plastics Converting Draft Generic Scenario (U.S. EPA, 2021d), which states that compounded plastics in pellet form are routinely shipped in containers ranging from 25 kg bags to 500 kg gaylords. The Agency assumed that manufacturers ship DCHP in powder form in similarly sized containers. EPA converted the mass of the containers to volumes assuming a density of 1 kg/L. The resulting volumetric distribution for containers includes a lower bound and mode of 7 gallons and an upper bound of 132 gallons.

3.1.3 Release Assessment

3.1.3.1 Environmental Release Points

Two known sites manufacturing DCHP were identified in 2020 CDR Data: LANXESS Corporation and Vertellus LLC. EPA assigned a default model to quantify potential release from each release point and suspected fugitive air release point. The Agency expects stack air releases from vented losses during process operations. EPA expects water, incineration, or landfill releases from sampling, filtration, and equipment cleaning. The Agency evaluated fugitive and stack air releases along with releases to water, incineration, or landfill from dust generated while packaging manufactured DCHP into transport containers.

3.1.3.2 Environmental Release Assessment Results

Table 3-1 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES.

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

Modeled Scenario	Environmental Media	Annual Release (kg/site-year) [b]		Number of Release Days		Daily Release (kg/site-day) [b]	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
7,843 kg/year production volume	Stack air	24	1.1E02	250		9.4E−02	0.42
	Fugitive air, water, incineration, or landfill[a]	30	1.4E02			0.12	0.55
	Water, incineration, or landfill[a]	2.4E02	2.4E02			0.94	0.94
	Incineration or landfill[a]	38	1.4E02			0.15	0.57
207,064 kg/year production volume	Stack air	6.2E02	2.8E03	250		2.5	11
	Fugitive air, water, incineration, or landfill[a]	8.0E02	3.7E03			3.2	15
	Water, incineration, or landfill[a]	2.9E03	2.9E03			12	12
	Incineration or landfill[a]	1.0E03	3.7E03			4.0	15

[a] When multiple environmental media are addressed together, releases may go all to 1 media or be split between media depending on site-specific practices. Not enough data were available to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DCHP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

3.1.4 Occupational Exposure Assessment

3.1.4.1 Workers Activities

During manufacturing, worker exposures to DCHP may occur via inhalation of dust or dermal contact with dust during product sampling, equipment cleaning, container cleaning, and packaging and loading of DCHP into transport containers for shipment. EPA did not identify information on engineering controls or worker PPE used at DCHP manufacturing facilities.

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

3.1.4.2 Numbers of Workers and ONUs

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 DCHP during the manufacturing of DCHP. 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. The Agency assigned the NAICS code 325199 for this OES, based on the Emission Scenario Document on the Chemical Industry and CDR reported NAICS codes for DCHP 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 facilities in the United States that manufacture DCHP.

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

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
325199 – All Other Basic Organic Chemical Manufacturing	2	39	77	18	36

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

3.1.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data (dust or vapor) to assess exposures to DCHP during the manufacturing process. DCHP is manufactured as a solid powder and the Agency assessed worker inhalation exposures to DCHP dust during the loading process. Therefore, EPA estimated worker inhalation exposures during manufacturing using the Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR) (PNOR Model) (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix E.11.

EPA used a subset of the model data that came from facilities with NAICS codes starting with 325 (Chemical Manufacturing) to estimate DCHP particulate concentrations in the air. For this OES, the Agency selected 100 percent by mass as the highest expected DCHP concentration based on manufactured purity reported in the 2019 CDR to estimate the concentration of DCHP present in particulates. EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model (U.S. EPA, 2021b) estimates an 8-hour TWA for particulate concentrations by assuming exposures outside the sample duration are zero. The model does not determine exposures during individual worker activities. The Agency 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. 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. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure.

Table 3-3 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DCHP during manufacture. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DCHP in the form of particulates and does not account for other potential inhalation exposure routes, such as from the inhalation of vapors.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	4.8E-01	5.0
	Acute Dose (AD) (mg/kg-day)	6.0E−02	6.3E-01
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.4E−02	4.6E-01
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.1E−02	4.3E-01
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	4.8E-01	5.0
	Acute Dose (AD) (mg/kg-day)	6.6E−02	6.9E-01
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.9E−02	5.1E-01
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.5E−02	4.7E-01
ONU	8-hour TWA Exposure Concentration (mg/m^3)	4.8E-01	4.8E-01
	Acute Dose (AD) (mg/kg-day)	6.0E−02	6.0E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.4E−02	4.4E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.1E−02	4.1E−02

[a] EPA estimated worker inhalation exposures to dust using the PNOR Model (U.S. EPA, 2021c). For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES.

3.1.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various "Exposure Concentration Types" from Table 3-4 are explained in Appendix B. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Table 3-4 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	Dose Rate (APDR, mg/day)	1.8E−03	3.6E−01
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.5E−03	3.1E−03
Female of Reproductive Age	Dose Rate (APDR, mg/day)	1.5E−01	3.0E−01
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−03	2.8E−03
ONU	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute (AD, mg/kg-day)	1.1E−03	1.1E−03
	Intermediate (IADD, mg/kg-day)	8.3E−04	8.3E−04
	Chronic, Non-Cancer (ADD, mg/kg-day)	7.7E−04	7.7E−04

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).			

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 the table below.

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

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	6.2E−02	6.3E−01
	Intermediate (IADD, mg/kg-day)	4.6E−02	4.6E−01
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.3E−02	4.3E−01
Female of Reproductive Age	Acute (AD, mg/kg-day)	6.8E−02	6.9E−01
	Intermediate (IADD, mg/kg-day)	5.0E−02	5.1E−01
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.7E−02	4.8E−01
ONU	Acute (AD, mg/kg-day)	6.1E−02	6.1E−02
	Intermediate (IADD, mg/kg-day)	4.5E−02	4.5E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.2E−02	4.2E−02
Note: A worker or ONU could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.2 Import and Repackaging

3.2.1 Process Description

DCHP may be imported into the United States in bulk via water, air, land, and intermodal shipments (Tomer and Kane, 2015). Import and repackaging sites unload the import containers and transfer DCHP into smaller containers (bags or supersacks) for downstream processing, use within the facility, or offsite use. Operations may include quality control sampling of DCHP product and equipment cleaning. No changes to chemical composition occur during transportation (U.S. EPA, 2022). Figure 3-2 provides an illustration of the import and repackaging process.

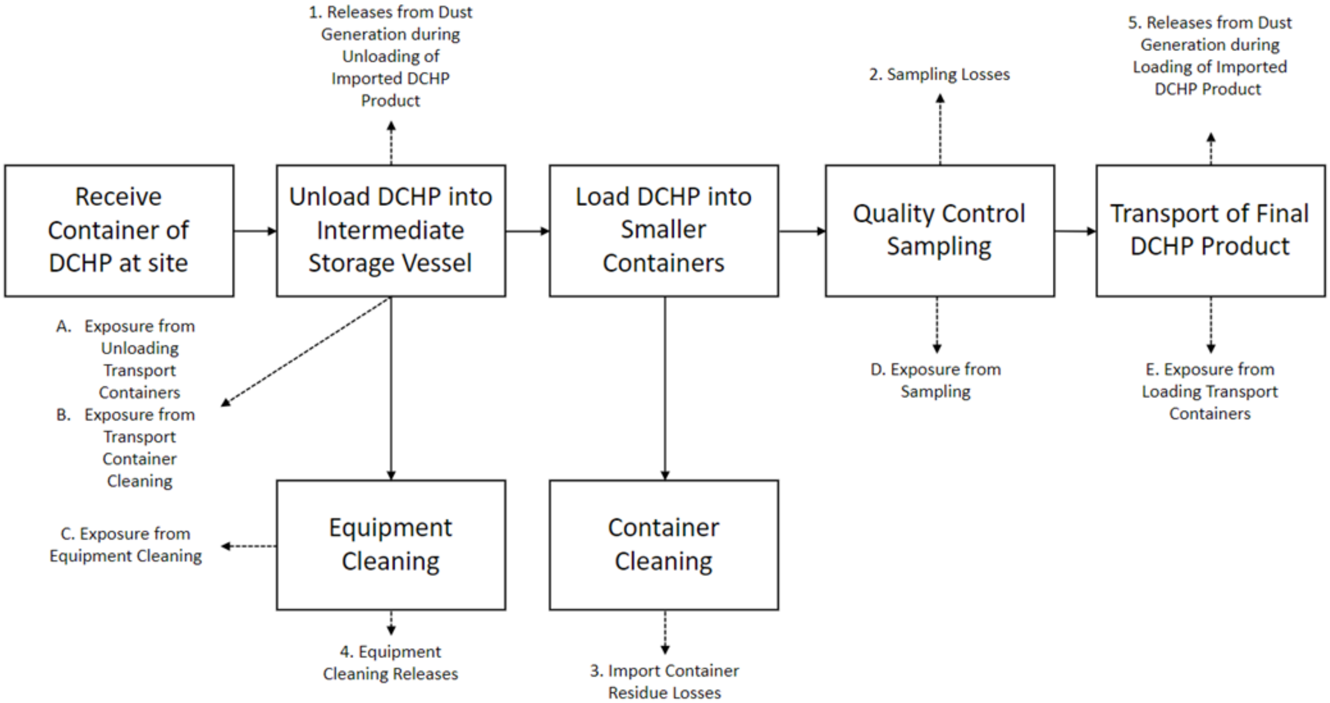

Figure 3-2. Import and Repackaging Flow Diagram (U.S. EPA, 2022)

3.2.2 Facility Estimates

In the 2020 CDR, two sites reported import and repackaging of DCHP CASRN 84-61-7. Both sites reported their production volumes as CBI (U.S. EPA, 2020a). Table 3-6 provides the location and reported production volume for DCHP import sites.

Table 3-6. Production Volume of DCHP Import and Repackaging Sites, 2020 CDR

DCHP Import Site, Site Location	2019 Reported Production Volume of DCHP CASRN 84-61-7 (kg/site-year)
United Initiators, Inc., Elyria, Ohio	CBI (Estimated as 5,945–119,343)
Nouryon Chemicals LLC, Chicago, Illinois	CBI (Estimated as 5,945–119,343)

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 DCHP production volume reported to the 2020 CDR. The 2020 CDR reported a range of national production volume for DCHP of 500,000 to less than 1,000,000 lb. EPA considered production volumes for both import and manufacturing sites because the annual DCHP production volumes in the CDR include both domestic manufacture and importation.[2] The Agency split the remaining production volume range evenly across both sites that reported this information as CBI. The calculated production volume for both sites ranged from 11,889 to 238,685 kg/year, or 5,945 to 119,343 kg/site-year. Review of preliminary 2024 CDR data shows that that total production volume for the years 2020 to 2023 are similar to the previously reported range from 2020 CDR.

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

EPA did not identify information from systematic review for import site operating days; therefore, the Agency assessed the total number of operating days for DCHP import as 174 to 260 days per year based on the length of worker shifts described in the 2022 GS on Chemical Repackaging (U.S. EPA, 2022). Import and repackaging facilities typically 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, DCHP is imported as a liquid, wet solid, or dry powder with concentrations ranging from 30 to 60 percent DCHP (U.S. EPA, 2020a). Based on reported manufactured forms of DCHP, EPA assumes most DCHP is manufactured and imported in solid form. The Agency did not identify chemical- or site-specific information on site throughputs; site throughput information was estimated by dividing the site PV by the number of operating days.

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, 2022) and used default models to quantify releases from each identified release point. Release points include releases to water, incineration, or landfill from sampling, container residue, and equipment cleaning. EPA expects fugitive or stack air releases as well as water, incineration, or landfill releases from packing and unpacking of imported DCHP into and out of transport containers.

3.2.3.2 Environmental Release Assessment Results

Table 3-7 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES.

Table 3-7. Summary of Modeled Environmental Releases for Import and Repackaging of DCHP

<table>
<tr><th rowspan="2">Modeled Scenario</th><th rowspan="2">Environmental Media</th><th colspan="2">Annual Release (kg/site-year) [b]</th><th colspan="2">Number of Release Days</th><th colspan="2">Daily Release (kg/site-day) [b]</th></tr>
<tr><th>Central Tendency</th><th>High-End</th><th>Central Tendency</th><th>High-End</th><th>Central Tendency</th><th>High-End</th></tr>
<tr><td rowspan="4">5,945–119,343 kg/year production volume</td><td>Stack air</td><td>311</td><td>1,922</td><td rowspan="4">208</td><td rowspan="4">260</td><td>1.5</td><td>9.3</td></tr>
<tr><td>Fugitive air, water, incineration, or landfill[a]</td><td>394</td><td>2,563</td><td>1.9</td><td>12</td></tr>
<tr><td>Water, incineration, or landfill[a]</td><td>860</td><td>1,589</td><td>4.0</td><td>8.2</td></tr>
<tr><td>Incineration or landfill[a]</td><td>498</td><td>2,667</td><td>2.4</td><td>13</td></tr>
<tr><td colspan="8">[a] When multiple environmental media are addressed together, releases may go all to 1 media or be split between media depending on site-specific practices. Not enough data were available to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DCHP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.</td></tr>
</table>

3.2.4 Occupational Exposure Assessment

3.2.4.1 Workers Activities

During import and repackaging, worker exposures to DCHP occur when transferring DCHP from the import vessels into smaller containers. Worker exposures also occur via inhalation of dust or dermal contact with dust when cleaning import vessels, loading and unloading DCHP, 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 DCHP from import vessels into smaller containers.

ONUs include employees who work at the import site where repackaging occurs but do not directly handle DCHP. Therefore, the Agency expects ONUs to have lower inhalation exposures and dermal exposures than workers. Nevertheless, potential exposures to ONUs through inhalation of dust and dermal contact with dust deposited on surfaces are assessed under the Import and Repackaging OES.

3.2.4.2 Number of Workers and ONUs

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 DCHP during DCHP 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. The Agency assigned the NAICS codes 325199 and 424690 for this OES, based on the Chemical Repackaging Generic Scenario and CDR reported NAICS codes for DCHP importers (U.S. EPA, 2022, 2020a). Table 3-8 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 DCHP.

Table 3-8. Estimated Number of Workers Potentially Exposed to DCHP During Import and Repackaging

NAICS Code	Number of Sites[a]	Exposed Workers per Site[b]	Total Number of Exposed Workers	Exposed ONUs per Site[b]	Total Number of Exposed ONUs
325199 – All Other Basic Organic Chemical Manufacturing	2	39	77	18	36
424690 – Other Chemical and Allied Products Merchant Wholesalers	0	1	0	0.4	0
Total/Average	2	20	40	9	18

[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 nonetheless included here because the reporting thresholds for CDR do not provide for a 100% capture of the industry.
[b] Number of workers and ONUs per site are calculated by dividing the total number of exposed workers or ONUs by the total number of establishments for a given NAICS code. The number of workers and ONUs are rounded to the nearest integer. Values that 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. DCHP is imported as a solid powder, per CDR, and the Agency assessed worker inhalation exposures to DCHP dust during the unloading and loading processes. Therefore, EPA estimated worker inhalation exposures during import and repackaging using the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix E.

EPA used a subset of the model data that came from facilities with NAICS codes starting with 42 through 45 (Wholesale and Retail Trade) to estimate DCHP particulate concentrations in the air. For this

OES, EPA selected 60 percent by mass as the highest expected DCHP concentration based on imported purity reported in the 2020 CDR to estimate the concentration of DCHP present in particulates. EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model 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, which is the expected maximum number of working days. The high-end exposures use 250 days per year as the conservative estimate of exposure frequency, and central tendency exposures use 208 working days per year. In the absence of data specific to ONU exposures, EPA assumed that worker central tendency exposures to dust containing DCHP are representative of ONU exposures and were used to generate conservative, screening level estimates for ONUs.

Table 3-9 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DCHP during import and repackaging. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DCHP in the form of particulates and does not account for other potential inhalation exposure routes, such as from the inhalation of vapors.

Table 3-9. Summary of Estimated Worker Inhalation Exposures for Import and Repackaging of DCHP

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	1.3E−01	3.0
	Acute Dose (AD) (mg/kg-day)	1.6E−02	0.38
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	1.2E−02	0.28
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	9.3E−03	2.6E−01
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	1.3	3.0
	Acute Dose (AD) (mg/kg-day)	1.8E−02	0.41
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	1.3E−02	0.30
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.0E−02	0.28
ONU	8-hour TWA Exposure Concentration (mg/m^3)	0.13	0.13
	Acute Dose (AD) (mg/kg-day)	1.6E−02	1.6E−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)	9.3E−03	1.1E−02

[a] EPA estimated worker inhalation exposures to dust using the PNOR Model (U.S. EPA, 2021c). For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES.

3.2.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various "Exposure Concentration Types" from Table 3-10 are explained in Appendix B. Because there might be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Table 3-10 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers, and ONUs.

Table 3-10. Summary of Estimated Worker Dermal Exposures for Import and Repackaging of DCHP

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	Dose Rate (APDR, mg/day)	0.18	0.36
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.3E−03	3.1E−03
Female of Reproductive Age	Dose Rate (APDR, mg/day)	0.15	0.30
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.2E−03	2.8E−03
ONU	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute Dose (AD) (mg/kg-day)	1.1E−03	1.1E−03
	Intermediate Average Daily Dose, Non-Cancer Exposures (IADD) (mg/m^3)	8.3E−04	8.3E−04
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	6.4E−04	7.7E−04

[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).

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 the table below.

Table 3-11. Summary of Estimated Worker Aggregate Exposures for Import and Repackaging of DCHP

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.9E−02	0.38
	Intermediate (IADD, mg/kg-day)	1.4E−02	0.28
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.1E−02	0.26

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Female of Reproductive Age	Acute (AD, mg/kg-day)	2.0E−02	0.42
	Intermediate (IADD, mg/kg-day)	1.5E−02	0.31
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.1E−02	0.29
ONU	Acute (AD, mg/kg-day)	1.7E−02	1.7E−02
	Intermediate (IADD, mg/kg-day)	1.3E−02	1.3E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	9.9E−03	1.2E−02
Note: A worker or ONU could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.3 Incorporation into Adhesives and Sealants

3.3.1 Process Description

The 2020 CDR and industry comments state that DCHP is used as a plasticizer and adhesive and sealant chemical for processing, incorporation into formulation, mixture, or reaction product in adhesive manufacturing (U.S. EPA, 2020a; AIA, 2019)

The identified industrial and commercial adhesive and sealant products for this OES include polymer sealants and industrial and commercial adhesives (see Appendix F for all EPA identified DCHP-containing products for this OES). Based on the 2009 ESD on the Manufacture of Adhesives, a typical adhesive incorporation site receives and unloads DCHP 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.*, DCHP) during the mixing process (OECD, 2009a). Blending or mixing operations can take up to 8 hours a day. Process operations may also include quality control sampling. Incorporation sites may dispose of off-specification product when the adhesive product does not meet quality or desired standards. EPA expects that sites will load DCHP-containing adhesive and sealant products into bottles, small containers, or drums depending on the product type. (OECD, 2009a). Figure 3-3 provides an illustration of the adhesive and sealant manufacturing process.

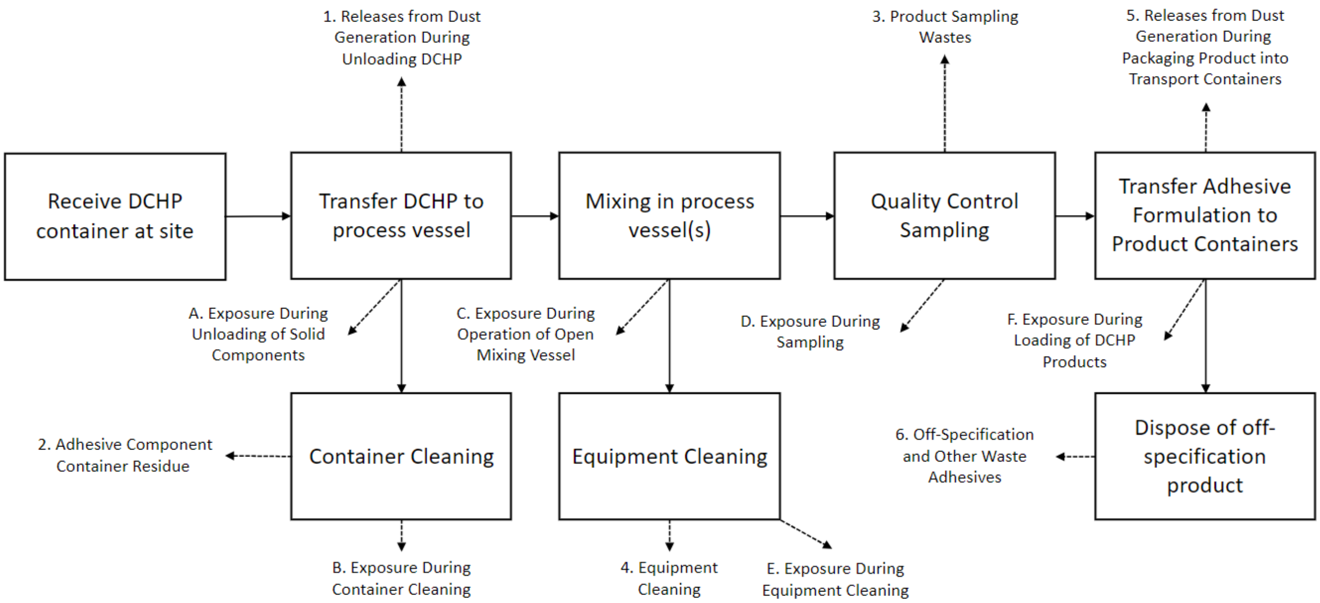

Figure 3-3. Incorporation into Adhesives and Sealants Flow Diagram (OECD, 2009a)

3.3.2 Facility Estimates

In the 2020 CDR, one site reported adhesive and sealant manufacturing for DCHP and reported their production volume as CBI (U.S. EPA, 2020a). EPA did not identify additional data on sites that use DCHP in adhesives and sealants or production volumes from systematic review. Therefore, the Agency used CDR reporting data to develop a representative production volume for DCHP processed into adhesive and sealant products.

The reporting site, Vertellus LLC, reported an overall PV as CBI but indicated an exported volume of 410,849 lb of DCHP for 2019. Vertellus LLC also reported domestic use of DCHP in adhesives manufacturing that amounted to 10 percent of their overall PV, with no other reported industrial or commercial uses. EPA therefore assumed that Vertellus LLC exports 90 percent of their manufactured PV and the remaining 10 percent is used in adhesives manufacturing. The Agency calculated that the overall PV for Vertellus LLC is equal to 410,849 lb ÷ 0.9 = 456,499 lb. The overall use volume in adhesives manufacture based on this PV would then be equal to 456,499 lb × 0.1 = 45,650 lb/year (20,706 kg/year).

EPA estimated the total number of sites that manufacture DCHP-containing adhesives and sealants using a uniform distribution based on CDR reporting data. Vertellus LLC indicated between 1 to 9 sites for adhesive manufacturing; this site range was used as the bounds for the uniform distribution in the assessment. The Agency did not identify operating information for this OES (*i.e.*, batch size or number of batches per year); EPA assumed the number of operating days was equivalent to the number of batches per year or 250 days/year operations for the given site throughput scenario (U.S. EPA, 2015). The annual throughput per facility was estimated by multiplying the daily throughput by the number of operating days, with the number of batches per day estimated by dividing the daily throughput by the ESD default batch size of 4,000 kg adhesive/batch and assuming a minimum of one batch/site-day (OECD, 2009a).

Based on CDR data for importers and manufacturers, EPA assumes that DCHP arrives at the sites and is added to the formulation as a solid. Incorporation sites are assumed to receive DCHP in containers with volumes between 7 to 132 gallons with DCHP concentrations of 90 to 100 percent based on CDR data and estimated container sizes from the manufacturing and import operations (see Section 3.1.2 and Section 3.2.2) (U.S. EPA, 2020a).

Most of the adhesive products formulated with DCHP identified by EPA are produced in solid form, with the purpose of being mixed by the user into a liquid or paste immediately before application. The Agency assumes that one of the solid products, Protectosil Degadeck CSS BPO, is representative and provides a conservative assessment of solid products with a reported DCHP concentration of 40 to 55 percent (Evonik Corporation, 2012)(see Appendix F for EPA identified DCHP-containing products for this OES).

EPA considered product container size data from default container size ranges identified in the *ChemSTEER User Guide* (U.S. EPA, 2015) as well as technical data sheets for solid DCHP-containing additive products, including those for adhesives/sealants, paints, and coatings. The Agency modeled product container size using a triangular distribution with a lower bound of 0.1 gallons, an upper bound of 20 gallons, and a mode of 1 gallon (see Section E.4.9).

3.3.3 Release Assessment

3.3.3.1 Environmental Release Points

EPA identified release points based on the 2009 ESD on the Manufacture of Adhesives (OECD, 2009a). The ESD identified default models to quantify releases from each release point and suspected fugitive air release point. The Agency expects stack air releases from unloading and packaging into transport containers. Water, incineration, or landfill releases are expected from sampling, container residue, equipment cleaning, and off-specification wastes. EPA expects fugitive air, water, incineration, or landfill releases from dust generated during transfer operations.

3.3.3.2 Environmental Release Assessment Results

Table 3-12 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES.

Table 3-12. Summary of Modeled Environmental Releases for Incorporation into Adhesives and Sealants

Modeled Scenario	Environmental Media	Annual Release (kg/site-year) [b]		Number of Release Days		Daily Release (kg/site-day) [b]	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
20,706 kg/year production volume	Stack air	27	176	250		0.11	0.70
	Fugitive air, water, incineration, or landfill[a]	35	233			0.14	0.93
	Water, incineration, or landfill[a]	222	665			2.6	4.9
	Incineration or landfill[a]	44	249			0.18	0.99

[a] When multiple environmental media are addressed together, releases may go all to 1 media or be split between media depending on site-specific practices. Not enough data were available to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DCHP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

3.3.4 Occupational Exposure Assessment

3.3.4.1 Workers Activities

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

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

3.3.4.2 Number of Workers and ONUs

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 DCHP during the incorporation of DCHP 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. The Agency 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 3-13 summarizes the per site estimates for this OES. EPA did not identify site-specific data for the number of facilities in the United States that incorporate DCHP into adhesives and sealants and estimated the number of facilities using reporting data from the 2020 CDR (U.S. EPA, 2020a).

Table 3-13. Estimated Number of Workers Potentially Exposed to DCHP 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	5–9	18	90–162	7	35–126

[a] The result is expressed as a range between the central tendency and high-end results.
[b] Number of workers and ONUs per site are calculated by dividing the total number of exposed workers or ONUs by the total number of establishments for a given NAICS code. The number of workers and ONUs are rounded to the nearest integer. Values that 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 adhesives and sealants from systematic review. DCHP is incorporated into adhesives and sealants as a solid powder and EPA assessed worker inhalation exposures to DCHP dust during all work activities. To estimate worker and ONU inhalation exposure, EPA used the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix E.

EPA used a subset of the model data that came from facilities with the NAICS code starting with 325 – Chemical Manufacturing to estimate DCHP particulate concentrations in the air. For this OES, EPA identified 100 percent by mass as the highest expected DCHP concentration based on manufactured purity reported in the 2020 CDR. EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model 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, which is 250 days/year, for this OES to estimate exposure frequency. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure.

Table 3-14 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DCHP during the incorporation into adhesives and sealants. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DCHP in the form of particulates and does not account for other potential inhalation exposure routes, such as from the inhalation of vapors, which EPA expects to be *de minimis* due to the low vapor pressure and solid physical form of DCHP.

Table 3-14. Summary of Estimated Worker Inhalation Exposures for Incorporation into Adhesives and Sealants

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	0.48	5.0
	Acute Dose (AD) (mg/kg-day)	6.0E−02	0.63
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.4E−02	0.46
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.1E−02	0.43
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	0.48	5.0
	Acute Dose (AD) (mg/kg-day)	6.6E−02	0.69
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.9E−02	0.51
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.5E−02	0.47
ONU	8-hour TWA Exposure Concentration (mg/m^3)	0.48	0.48
	Acute Dose (AD) (mg/kg-day)	6.0E−02	6.0E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.4E−02	4.4E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.1E−02	4.1E−02

[a] EPA estimated worker inhalation exposures to dust using the PNOR Model (U.S. EPA, 2021c). For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES.

3.3.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various "Exposure Concentration Types" from Table 3-15 are explained in Appendix B. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed.

Table 3-15 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	Dose Rate (APDR, mg/day)	0.18	0.36
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.5E−03	3.1E−03
Female of Reproductive Age	Dose Rate (APDR, mg/day)	0.15	0.30
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−03	2.8E−03
ONU	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute Dose (AD) (mg/kg-day)	1.1E−03	1.1E−03
	Intermediate Average Daily Dose, Non-Cancer Exposures (IADD) (mg/m^3)	8.3E−04	8.3E−04
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	7.7E−04	7.7E−04

[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).

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 the table below.

Table 3-16. 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)	6.2E−02	0.63
	Intermediate (IADD, mg/kg-day)	4.6E−02	0.46
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.3E−02	0.43
Female of Reproductive Age	Acute (AD, mg/kg-day)	6.8E−02	0.69
	Intermediate (IADD, mg/kg-day)	5.0E−02	0.51
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.7E−02	0.48
ONU	Acute (AD, mg/kg-day)	6.1E−02	6.1E−02
	Intermediate (IADD, mg/kg-day)	4.5E−02	4.5E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.2E−02	4.2E−02
Note: A worker or ONU could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.4 Incorporation into Paints and Coatings

3.4.1 Process Description

The 2020 CDR and industry comments state that DCHP is used as an additive and process regulator for paint and coating manufacturing (U.S. EPA, 2020a, d, 2019d). See Appendix F for EPA identified DCHP-containing industrial and commercial products for this OES.

A typical incorporation site receives and unloads DCHP into industrial mixing vessels as a batch blending or mixing process, with no reactions or chemical changes occurring to the additive (*i.e.*, DCHP) during the mixing process (U.S. EPA, 2014a). Blending or mixing operations can take up to 8 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. Sites may dispose of off-specification product when the product does not meet quality or desired standards. Following formulation, incorporation sites will load DCHP-containing products into bottles, small containers, or drums depending on the product type (U.S. EPA, 2014a). Figure 3-4 provides an illustration of the paint and coating manufacturing process.

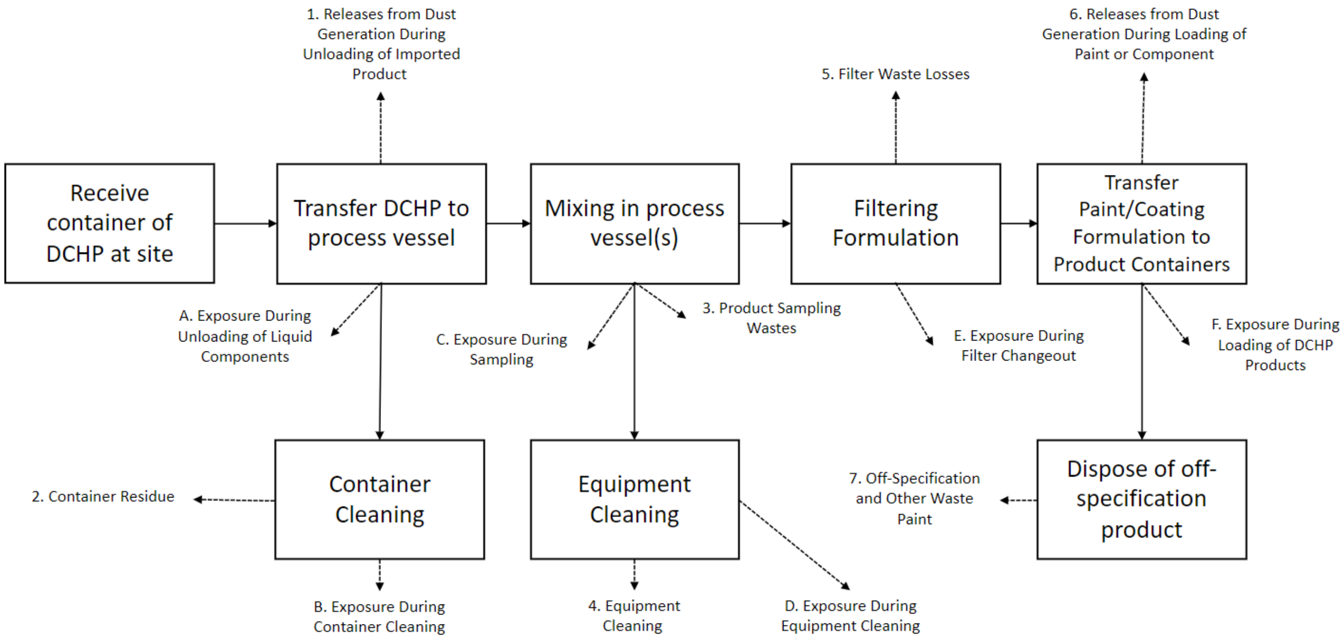

Figure 3-4. Incorporation into Paints and Coatings Flow Diagram (U.S. EPA, 2014a)

3.4.2 Facility Estimates

In the 2020 CDR, one importation site estimated that 18 percent of their total annual PV is used for Paint and Coating Manufacturing; however, they did not disclose their total annual PV value. EPA estimated a production volume range of 13,106 to 263,105 lb/import site[3]. Multiplying this range by the use percentage for paint and coating products results in: (13,106–263,105 lb × 0.18 = 2,359–47,359 lb/year, or 1,070–21,482 kg/year). The Agency used this range as the upper and lower bounds of a uniform distribution to estimate the volume of DCHP used in paint and coating products for the release model.

EPA used the 2020 CDR to estimate the number of paint and coating processing sites that use DCHP. The one submitting site provided four separate entries under CDR industrial use that were related to "Processing as a reactant" or "Incorporation into formulation, mixture, or reaction product" and tagged under use for paints and coatings. Each report specified less than 10 industrial use sites. EPA used this information to develop a range of sites with a minimum of 4 sites (1 for each report) and a maximum of 36 sites (assuming 9 sites per report), for a range of use sites between 4 to 36 sites.

Because EPA did not identify paint and coating site operating data (*i.e.*, batch size or number of batches per year), the Agency assumed 5,030 kg of paint or coating is produced per batch and 250 batches per year based on the 2014 GS on the Formulation of Waterborne Coatings (U.S. EPA, 2014a). The Agency assumed that the number of operating days was equivalent to the number of batches manufactured per year or 250 days/year for the given site throughput scenario. The annual throughput per facility was estimated by multiplying the daily throughput by the number of operating days.

Based on CDR data for importers and manufacturers, EPA assumes that DCHP arrives at incorporation sites and is added to the formulation as a solid. Incorporation sites are assumed to receive DCHP in containers with volumes between 7 gallons to 132 gallons with DCHP concentrations of 90 to 100

[3] For calculation of import production volumes using CDR, see the Import and Repackaging Facility Estimates (see Section 3.2.2).

percent based on CDR data and estimated container sizes from the manufacturing and import operations (see Sections 3.1.2 and 3.2.2) (U.S. EPA, 2020a). Most of the paint and coating products formulated with DCHP identified by EPA are produced in solid form, with the purpose of being mixed by the user into a liquid immediately before application. EPA evaluated the SDSs for these paint and coating products and modeled the final product concentration using a triangular distribution with a lower bound of 1 percent, an upper bound of 100 percent, and mode of 40 percent (see Appendix F for EPA identified DCHP-containing products for this OES). The value of 100 percent was used as an upper bound and there was no attempt to refine the upper limit since the MOEs for occupational exposures were above the benchmark for this OES. The Agency considered container size data from technical data sheets for solid DCHP-containing additive products, including those for adhesives/sealants and paints and coatings, as well as default container size ranges identified in the *ChemSTEER User Guide* (U.S. EPA, 2015). EPA modeled container size using a triangular distribution with a lower bound of 0.1 gallons, an upper bound of 20 gallons, and a mode of 1 gallon (see Section E.5.9).

3.4.3 Release Assessment

3.4.3.1 Environmental Release Points

EPA identified release points based on the 2014 Generic Scenario on the Formulation of Waterborne Coatings (U.S. EPA, 2014a). The GS identified a default model to quantify releases from each identified release point and fugitive air release point. The Agency expects stack air releases from vented losses during mixing, dust generation during transfer, and vented losses during process operations. Releases to water, incineration, or landfill are expected from container residue, sampling wastes, equipment cleaning, and off-specification wastes. Filter waste losses to incineration or landfill were also evaluated. EPA expects fugitive air releases as well as water, incineration, or landfill releases from dust generated during transfer operations.

3.4.3.2 Environmental Release Assessment Results

Table 3-17 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES.

Table 3-17. Summary of Modeled Environmental Releases for Incorporation into Paints and Coatings

Modeled Scenario	Environmental Media	Annual Release (kg/site-year) [b]		Number of Release Days		Daily Release (kg/site-day) [b]	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
1,070–21,482 kg/year production volume	Stack air	3.1	26	250		1.2E−02	0.10
	Fugitive air, water, incineration, or landfill[a]	3.9	34			1.6E−02	0.14
	Water, incineration, or landfill[a]	30	121			1.1	3.0
	Incineration or landfill[a]	5.0	37			2.0E−02	0.15

[a] When multiple environmental media are addressed together, releases may go all to 1 media or be split between media depending on site-specific practices. Not enough data were available to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DCHP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

3.4.4 Occupational Exposure Assessment

3.4.4.1 Worker Activities

During the formulation of paints and coatings that contain DCHP, workers may be potentially exposed to DCHP via inhalation of dust or dermal contact with dust when unloading DCHP, 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 DCHP-containing paint and coating formulation sites.

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

3.4.4.2 Number of Workers and ONUs

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 DCHP during the incorporation of DCHP 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 code 325510 – Paint and Coating Manufacturing – Paint and Coating Manufacturing for this OES based on the 2014 GS on the Formulation of Waterborne Coatings and CDR reported NAICS codes for incorporation into paints and coatings (U.S. EPA, 2020a, 2014a). Table 3-18 summarizes the per site estimates for this OES. EPA did not identify site-specific data on the number of facilities in the United States that incorporate DCHP into paints and coatings but estimated the number of facilities using reporting data from the 2020 CDR (U.S. EPA, 2020a).

Table 3-18. Estimated Number of Workers Potentially Exposed to DCHP During Incorporation into 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]
325510 – Paint and Coating Manufacturing	20–34	14	280–476	5	70–170

[a] The result is expressed as a range between the central tendency and high-end results.
[b] Number of workers and ONUs per site are calculated by dividing the total number of exposed workers or ONUs by the total number of establishments for a given NAICS code. The number of workers and ONUs are rounded to the nearest integer.

3.4.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for the incorporation of DCHP into paints and coatings during systematic review. DCHP is incorporated into paints and coatings as a solid powder and EPA assessed worker inhalation exposures to DCHP dust during all work activities. To estimate worker and ONU inhalation exposure, EPA used the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix E.

EPA used a subset of the model data that came from facilities with the NAICS code starting with 325 – Chemical Manufacturing to estimate DCHP particulate concentrations in the air. For this OES, EPA identified 100 percent by mass as the highest expected DCHP concentration based on manufactured purity reported in the 2020 CDR. EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model 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, which is 250 days/year, for this OES to estimate exposure frequency. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure.

Table 3-19 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DCHP during the incorporation into paints and coatings. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DCHP in the form of particulates and does not account for other potential inhalation exposure routes, such as from the inhalation of vapors, which EPA expects to be *de minimis* due to the low vapor pressure and solid physical form of DCHP.

Table 3-19. Summary of Estimated Worker Inhalation Exposures for Incorporation into Paints and Coatings

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	0.48	5.0
	Acute Dose (AD) (mg/kg-day)	6.0E−02	0.63
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.4E−02	0.46
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.1E−02	0.43
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	0.48	5.0
	Acute Dose (AD) (mg/kg-day)	6.6E−02	0.69
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.9E−02	0.51
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.5E−02	0.47
ONU	8-hour TWA Exposure Concentration (mg/m^3)	0.48	0.48
	Acute Dose (AD) (mg/kg-day)	6.0E−02	6.0E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.4E−02	4.4E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.1E−02	4.1E−02

[a] EPA estimated worker inhalation exposures to dust using the PNOR Model (U.S. EPA, 2021c). For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES.

3.4.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various "Exposure Concentration Types" from

Table 3-20 are explained in Appendix B. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed.

Table 3-20 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	Dose Rate (APDR, mg/day)	0.18	0.36
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.5E−03	3.1E−03
Female of Reproductive Age	Dose Rate (APDR, mg/day)	0.15	0.30
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−03	2.8E−03
ONU	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute Dose (AD) (mg/kg-day)	1.1E−03	1.1E−03
	Intermediate Average Daily Dose, Non-Cancer Exposures (IADD) (mg/m^3)	8.3E−04	8.3E−04
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	7.7E−04	7.7E−04

[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).

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 the table below.

Table 3-21. 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)	6.2E−02	0.63
	Intermediate (IADD, mg/kg-day)	4.6E−02	0.46
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.3E−02	0.43
Female of Reproductive Age	Acute (AD, mg/kg-day)	6.8E−02	0.69
	Intermediate (IADD, mg/kg-day)	5.0E−02	0.51
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.7E−02	0.48
ONU	Acute (AD, mg/kg-day)	6.1E−02	6.1E−02
	Intermediate (IADD, mg/kg-day)	4.5E−02	4.5E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.2E−02	4.2E−02
Note: A worker or ONU could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.5 Incorporation into Other Formulations, Mixtures, or Reaction Products

3.5.1 Process Description

"Incorporation into other formulations, mixtures, or reaction products" refers to the process of mixing or blending of several raw materials to obtain a single product or preparation. Exact process operations involved in the incorporation of DCHP into a chemical formulation, mixture, or reaction product are dependent on the specific manufacturing process or processes involved. EPA expects that each individual formulation process is small; therefore, EPA assessed releases and exposures for the incorporation of DCHP into a chemical formulation, mixture, or reaction product as a group rather than individually. While EPA identified limited information on the formulation of these types of products, the Agency expects that formulation follows the same general 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 DCHP 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 DCHP during the mixing process (U.S. EPA, 2014a). Blending or mixing operations can take up to 8 hours a day. Process operations may include quality control sampling and incorporation sites may transfer the blended formulation through an in-line filter. Sites may dispose of off-specification product when the product does not meet quality or desired standards. Following formulation, sites will load DCHP-containing products into bottles, small containers, or drums depending on the product type (U.S. EPA, 2014a). Figure 3-5 provides an illustration of the other formulations manufacturing process.

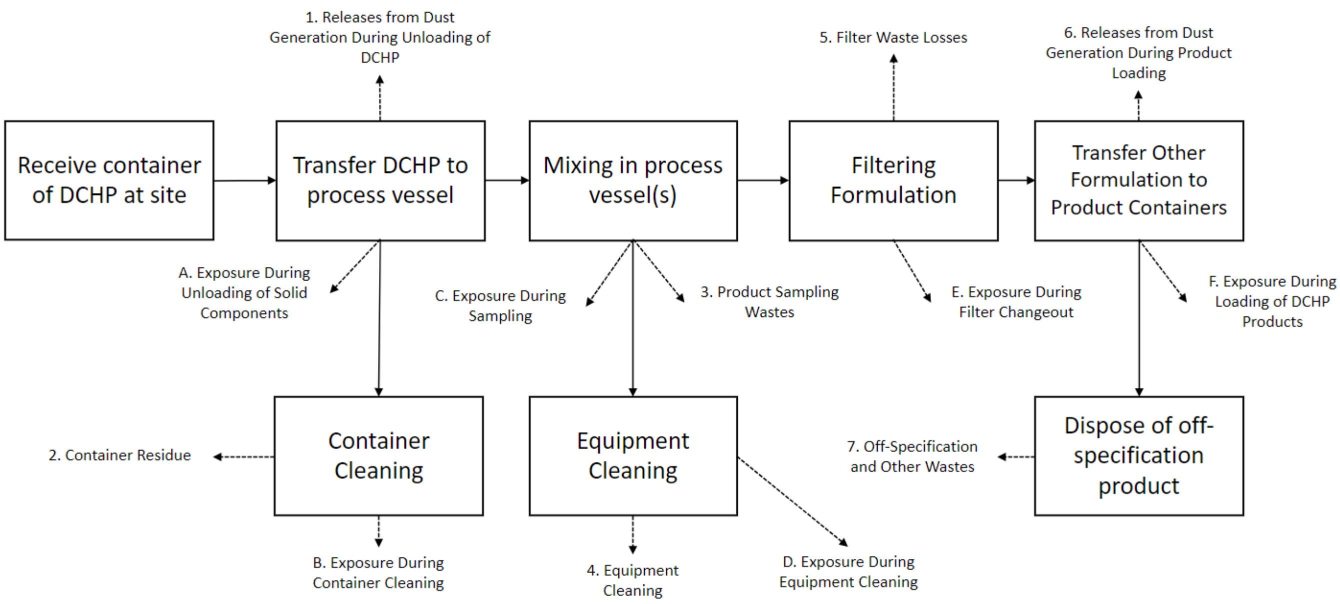

Figure 3-5. Incorporation into Other Formulations, Mixtures, or Reaction Products Flow Diagram (U.S. EPA, 2014a)

3.5.2 Facility Estimates

EPA did not identify any production volume information specific to this OES. The Agency assumed that a portion of the DCHP production volume from each CDR reporting site may be used for other formulations. Specifically, EPA estimated the total production volume of DCHP used in other formulations using the CDR reporting threshold limits of either 25,000 lb (11,340 kg) or 5 percent of a site's reported production volume—whichever value was smaller. EPA considered every site that reported using DCHP to CDR, regardless of assigned OES. The Agency assumed that sites that claimed their production volume as CBI produced 25,000 lb of DCHP-containing formulations annually. Table 3-22 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 estimated as 75,865 lb/year or 34,412 kg/year.

Table 3-22. CDR Reported Site Information for Use in Calculation of Other Formulations, Mixtures, and Reaction Products Production Volume

Site Name	Reported Production Volume (lb/year)	Threshold Limit Used	Production Volume Added to Total (lb/year)
United Initiators, Inc.	CBI	25,000 lb	25,000
Lanxess Corporation Greensboro	17,290	5%	865
Vertellus Greensboro LLC	CBI	25,000 lb	25,000
Nouryon Functional Chemicals LLC	CBI	25,000 lb	25,000

EPA modeled the total number of sites that manufacture other formulations using throughput data from the 2014 ESD on the Formulation of Waterborne Coatings (see Appendix E.6 for details) (U.S. EPA, 2014a). The overall range (minimum to maximum) was estimated to be 1 to 22 sites. EPA did not identify operating information (*i.e.*, batch size or number of batches per year) for this OES; EPA assessed 5,030 kg/batch of produced product and 250 batches/year based on the 2014 GS on the Formulation of Waterborne Coatings (U.S. EPA, 2014a). Additionally, EPA assumed that the number of operating days is equivalent to the number of batches per year, or 250 days/year for the given site throughput scenario. The annual throughput per facility was estimated by multiplying the daily throughput by the number of operating days.

EPA assumed container sizes were similar to those used for adhesives and sealants and paint and coating products. Specifically, incorporation sites are assumed to receive DCHP in containers with volumes between 7 gallons to 132 gallons with DCHP concentrations of 90 to 100 percent based on CDR data and estimated container sizes from the manufacturing and import operations (see Section 3.1.2 and Section 3.2.2) (U.S. EPA, 2020a). Most of the products formulated with DCHP identified by EPA are produced in solid form. EPA evaluated the SDSs for solid products and modeled the final product concentration using a using a triangular distribution with a lower bound of 0.1 percent, an upper bound of 100 percent, and a mode of 30 percent (see Appendix F for EPA identified DCHP-containing products for this OES). The value of 100 percent was used as an upper bound and there was no attempt to refine the upper limit since the MOEs for occupational exposures were above the benchmark for this OES. The Agency modeled product container size using a triangular distribution with a lower bound of 0.1 gallons, an upper bound of 20 gallons, and a mode of 1 gallon.

3.5.3 Release Assessment

3.5.3.1 Environmental Release Points

EPA identified release points based on the 2014 GS on the Formulation of Waterborne Coatings (U.S. EPA, 2014a). The GS identified default models to quantify potential releases from each release point. The Agency expects stack air releases from vented losses during mixing, dust generation during transfer, and vented losses during process operations. Releases to water, incineration, or landfill are expected from container residue, sampling wastes, equipment cleaning, and off-specification wastes. Filter waste losses to incineration or landfill were also evaluated. EPA expects fugitive air releases as well as water, incineration, or landfill releases from dust generated during transfer operations.

3.5.3.2 Environmental Release Assessment Results

Table 3-23 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES.

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

Modeled Scenario	Environmental Media	Annual Release (kg/site-year) [b]		Number of Release Days		Daily Release (kg/site-day) [b]	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
34,412 kg/year production volume	Stack air	21	194	250		8.3E−02	0.78
	Fugitive air, water, incineration, or landfill[a]	27	257			0.11	1.0
	Water, incineration, or landfill[a]	33	286			0.13	1.2
	Incineration or landfill[a]	33	286			0.13	1.2

[a] When multiple environmental media are addressed together, releases may go all to 1 media or be split between media depending on site-specific practices. Not enough data were available to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DCHP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

3.5.4 Occupational Exposure Assessment

3.5.4.1 Worker Activities

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

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

3.5.4.2 Number of Workers and ONUs

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 DCHP during the incorporation of DCHP into other formulations, mixtures, or reaction products. 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. The Agency assigned the NAICS codes 325110 – Petrochemical Manufacturing and 325199 – All Other Basic Organic Chemical Manufacturing for this OES based on the 2014 GS on the Formulation of Waterborne Coatings and CDR reported NAICS codes for incorporation into other formulations, mixtures, or reaction products (U.S. EPA, 2020a, 2014a). Table 3-24 summarizes the per site estimates for this OES. EPA did not identify site-specific data for the number of facilities in the United States that incorporate DCHP into other formulations, mixtures, or reaction products.

Table 3-24. Estimated Number of Workers Potentially Exposed to DCHP During Incorporation into Other Formulations, Mixtures, or Reaction Products

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]
325110 – Petrochemical Manufacturing	N/A	64	N/A	30	N/A
325199 – All Other Basic Organic Chemical Manufacturing		39		18	
Total/Average	11–21	51	561–1,122	24	264–528

[a] The result is expressed as a range between the central tendency and high-end number of expected sites. Results were not assessed by NAICS code for this scenario.
[b] Number of workers and ONUs per site are calculated by dividing the total number of exposed workers or ONUs by the total number of establishments for a given NAICS code. The number of workers and ONUs are rounded to the nearest integer. Values that would otherwise be displayed as "0" are left unrounded.

3.5.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for the incorporation of DCHP into other formulations, mixtures, and reaction products from systematic review. DCHP is expected to be incorporated into other formulations, mixtures, and reaction products as a solid powder based on the available manufactured and imported form reported to CDR (U.S. EPA, 2020a). EPA assessed worker inhalation exposures to DCHP dust during all work activities. To estimate worker and ONU inhalation exposure, the Agency used the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are detailed in Appendix E.

EPA used a subset of the model data that came from facilities with the NAICS code starting with 325 – Chemical Manufacturing to estimate DCHP particulate concentrations in the air. For this OES, EPA identified 100 percent by mass as the highest expected DCHP concentration based on manufactured purity reported in the 2020 CDR. EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model 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, which is 250 day/year, for this OES to estimate exposure frequency. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure.

Table 3-25 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DCHP during the incorporation into other formulations, mixtures, or reaction products. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DCHP in the form of particulates and does not account for other potential inhalation exposure routes, such as from the inhalation of vapors, which EPA expects to be *de minimis* due to the low vapor pressure and solid physical form of DCHP.

Table 3-25. Summary of Estimated Worker Inhalation Exposures for Incorporation into Other Formulations, Mixtures, or Reaction Products

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	0.48	5.0
	Acute Dose (AD) (mg/kg-day)	6.0E−02	0.63
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.4E−02	0.46
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.1E−02	0.43
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	0.48	5.0
	Acute Dose (AD) (mg/kg-day)	6.6E−02	0.69
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.9E−02	0.51
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.5E−02	0.47
ONU	8-hour TWA Exposure Concentration (mg/m^3)	0.48	0.48
	Acute Dose (AD) (mg/kg-day)	6.0E−02	6.0E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.4E−02	4.4E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.1E−02	4.1E−02

[a] EPA estimated worker inhalation exposures to dust using the PNOR Model (U.S. EPA, 2021c). For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES.

3.5.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various "Exposure Concentration Types" from Table 3-26 are explained in Appendix B. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Table 3-26 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs.

Table 3-26. Summary of Estimated Worker Dermal Exposures for Incorporation into Other Formulations, Mixtures, or Reaction Products

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	Dose Rate (APDR, mg/day)	0.18	0.36
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.5E−03	3.1E−03
Female of Reproductive Age	Dose Rate (APDR, mg/day)	0.15	0.30
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−03	2.8E−03

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
ONU	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute Dose (AD) (mg/kg-day)	1.1E−03	1.1E−03
	Intermediate Average Daily Dose, Non-Cancer Exposures (IADD) (mg/m^3)	8.3E−04	8.3E−04
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	7.7E−04	7.7E−04

[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).

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 the table below.

Table 3-27. Summary of Estimated Worker Aggregate Exposures for Incorporation into Other Formulations, Mixtures, or Reaction Products

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	6.2E−02	0.63
	Intermediate (IADD, mg/kg-day)	4.6E−02	0.46
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.3E−02	0.43
Female of Reproductive Age	Acute (AD, mg/kg-day)	6.8E−02	0.69
	Intermediate (IADD, mg/kg-day)	5.0E−02	0.51
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.7E−02	0.48
ONU	Acute (AD, mg/kg-day)	6.1E−02	6.1E−02
	Intermediate (IADD, mg/kg-day)	4.5E−02	4.5E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.2E−02	4.2E−02

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

3.6 PVC Plastics Compounding

3.6.1 Process Description

PVC plastics compounding involves mixing the polymer with the plasticizer and other chemicals such as fillers and heat stabilizers (U.S. EPA, 2019e, f). The plasticizer needs to be absorbed into the particle to impart flexibility to the polymer. For PVC plastics compounding scenarios, compounding occurs through mixing ingredients to produce a powder (dry blending) or a liquid (plastisol blending). The most common process for dry blending involves heating the ingredients in a high intensity mixer and transferring to a cold mixer. The plastisol blending is done at ambient temperature using specific mixers that allow for the breakdown of the agglomerates and the absorption of the plasticizer into the resin particle. The 2020 CDR reports use of DCHP as a plasticizer, processing aid, hardener, and stabilizing agent in plastic material and resin manufacturing and plastic product manufacturing (ACC, 2020; U.S. EPA, 2020a, 2019a, f).

EPA expects that a typical compounding site receives DCHP as a pure solid in containers ranging in size from seven to 132 gallons (U.S. EPA, 2021c). The site unloads and transfers DCHP 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 plastic compounding process (U.S. EPA, 2021c).

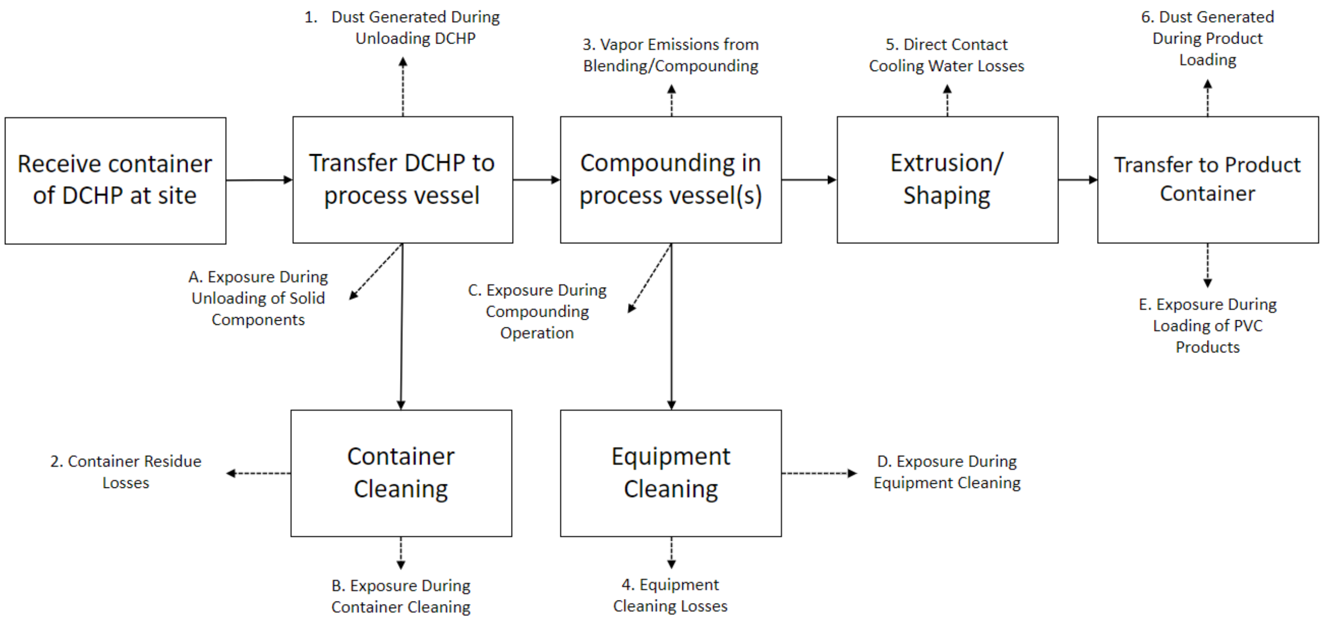

Figure 3-6. PVC Plastics Compounding Flow Diagram (U.S. EPA, 2021c)

3.6.2 Facility Estimates

In the 2020 CDR, three sites reported using DCHP as a plasticizer, processing aid, hardener, and stabilizing agent for two industrial sectors: plastic product manufacturing and plastic material and resin manufacturing. One site provided a non-CBI production volume, whereas two sites indicated that their production volume was CBI. EPA estimated these site production volumes using data from the 2020 CDR.[4] The following industrial use percentages from each site were attributed to industrial sectors within scope: Lanxess Corporation Greensboro in Greensboro, North Carolina (100%); United Initiators Inc. in Elyria, Ohio (100%); Vertellus Greensboro LLC in Greensboro, North Carolina (0%); and Nouryon Functional Chemicals LLC (80%). EPA's estimated use volumes for each site are summarized in Table 3-28.

[4] For calculation of import production volumes using CDR, see the Import and Repackaging Facility Estimates (see Section 3.2.2).

Table 3-28. Site CDR Volumes Used for the Production Volume Estimate in the Plastics Compounding and Converting OES

Site Name	Overall PV Estimate (kg)	Percent Industrial Use	Estimated PV Contribution to OES (kg)
UNITED INITIATORS, INC.	7,843	100	7,843
LANXESS CORPORATION GREENSBORO	5,945 – 119,342	100	5,945–119,342
NOURYON FUNCTIONAL CHEMICALS LLC	5,945 – 119,342	80	4,756–95,474

The total PV of DCHP across the three sites was therefore estimated to be 18,543 to 222,659 kg (40,881–490,879 lb). EPA estimated the number of sites for compounding based on DCHP CDR data identified with an industrial sector Plastics Material and Resin Manufacturing, which listed the number of sites as less than 10 (U.S. EPA, 2020a). The Agency assumed a uniform distribution of discrete integer values for the number of sites with a lower bound of one site and an upper bound of nine sites for the release model. EPA assessed the raw material DCHP concentration using a uniform distribution with a lower bound of 30 percent and an upper bound of 100 percent based on information reported in the 2020 CDR (U.S. EPA, 2020a).

EPA did not identify site- or chemical-specific operating data for plastics compounding (*i.e.*, facility production rate, number of batches, or operating days). The 2021 Draft Generic Scenario for the Use of Additives in Plastic Compounding provides a range of 30 percent to 40 percent for the typical weight fraction of plasticizers in rigid PVC (U.S. EPA, 2021c). The Agency assessed the total number of operating days of based on the GS range of 148 to 264 days/year for the given site throughput scenario (U.S. EPA, 2021c). Additionally, EPA assumed the number of batches per site per year was equivalent to the number of operating days, or one batch per day. The Agency estimated an annual facility DCHP throughput by dividing the annual production volume by the number of sites.

3.6.3 Release Assessment

3.6.3.1 Environmental Release Points

EPA identified release points based on the 2021 Draft Generic Scenario on Plastic Compounding (U.S. EPA, 2021c). The GS identified a default model to quantify releases at each release point. The Agency expects fugitive air, water, incineration, or landfill releases from loading plastic masterbatch and unloading plastic additives. EPA expects vapor emissions from blending/compounding to be emitted to fugitive or stack air. The Agency also expects releases to water from direct contact cooling. EPA expects releases to water, incineration, or landfill from container residues and equipment cleaning wastes.

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. The Agency 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 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES.

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

Modeled Scenario	Environmental Media	Annual Release (kg/site-year) [b]		Number of Release Days		Daily Release (kg/site-day) [b]	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
18,543–222,659 kg/year production volume	Fugitive or Stack air[a]	26	879	223	254	0.12	4.1
	Fugitive air, water, incineration, or landfill[a]	180	1,700			0.83	7.9
	Water, incineration, or landfill[a]	656	3,960			3.5	18
	Water	241	1,320			1.1	6.1
	Incineration or landfill[a]	303	2,370			1.4	11

[a] When multiple environmental media are addressed together, releases may go all to 1 media or be split between media depending on site-specific practices. Not enough data were available to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DCHP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

3.6.4 Occupational Exposure Assessment

3.6.4.1 Worker Activities

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

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

3.6.4.2 Number of Workers and ONUs

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 DCHP during 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. The Agency assigned the NAICS code 325211 – Plastics Material and Resin 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. EPA did not identify site-specific data for the number of facilities in the United States that compound PVC plastics but estimated a minimum of one site to a maximum of nine sites based on data from 2020 CDR (U.S. EPA, 2020a).

Table 3-30. Estimated Number of Workers Potentially Exposed to DCHP During Plastics 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]
325211 – Plastics Material and Resin Manufacturing	5–9	27	135–243	12	60–108

[a] The result is expressed as a range between the central tendency and high-end results.
[b] Number of workers and ONUs per site are calculated by dividing the total number of exposed workers or ONUs by the total number of establishments for a given NAICS code. The number of workers and ONUs are rounded to the nearest integer. Values that 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 DCHP from systematic review. The Agency expects worker inhalation exposures to DCHP via exposure to particulates of plastic materials during the compounding process in addition to DCHP unloading and loading tasks, container cleaning, and equipment cleaning. To estimate worker and ONU inhalation exposure, EPA used the PNOR Model (U.S. EPA, 2021b) approaches and parameters that are described in Appendix E.

EPA used a subset of the model data that came from facilities with the NAICS code starting with 326 – Plastics and Rubber Manufacturing to estimate plastic particulate concentrations in the air. For this OES, EPA identified 100 percent by mass as the highest expected DCHP concentration based on manufacture and importer stated use concentration reported in the 2020 CDR. EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model 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, which is the expected maximum number of working days. 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. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure.

Table 3-31 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker and ONU exposures to DCHP during the plastics compounding process. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DCHP in the form of particulates and does not account for other potential inhalation exposure routes, such as from the inhalation of vapors, which EPA expects to be *de minimis* due to the low vapor pressure and solid physical form of DCHP.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration to Dust (mg/m^3)	0.23	4.7
	Acute Dose (AD) (mg/kg-day)	2.9E−02	0.59
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	2.1E−02	0.43
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.8E−02	0.40
Female of Reproductive Age	8-hour TWA Exposure Concentration to Dust (mg/m^3)	0.23	4.7
	Acute Dose (AD) (mg/kg-day)	3.2E−02	0.65
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	2.3E−02	0.48
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.9E−02	0.44
ONU	8-hour TWA Exposure Concentration to Dust (mg/m^3)	0.23	0.23
	Acute Dose (AD) (mg/kg-day)	2.9E−02	2.9E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	2.1E−02	2.1E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.8E−02	2.0E−02

[a] EPA estimated worker inhalation exposures to dust using the PNOR Model (U.S. EPA, 2021c).. For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES.

3.6.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various "Exposure Concentration Types" from Table 3-32 are explained in Appendix B. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Table 3-32 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	Dose Rate (APDR, mg/day)	0.18	0.36
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−03	3.1E−03
Female of Reproductive Age	Dose Rate (APDR, mg/day)	0.15	0.30
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.3E−03	2.8E−03

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
ONU	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute (AD, mg/kg-day)	1.1E−03	1.1E−03
	Intermediate (IADD, mg/kg-day)	8.3E−04	8.3E−04
	Chronic, Non-Cancer (ADD, mg/kg-day)	6.9E−04	7.7E−04

[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).

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 the table below.

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

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	3.1E−02	0.59
	Intermediate (IADD, mg/kg-day)	2.3E−02	0.43
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.9E−02	0.41
Female of Reproductive Age	Acute (AD, mg/kg-day)	3.4E−02	0.65
	Intermediate (IADD, mg/kg-day)	2.5E−02	0.48
	Chronic, Non-Cancer (ADD, mg/kg-day)	2.1E−02	0.45
ONU	Acute (AD, mg/kg-day)	3.0E−02	3.0E−02
	Intermediate (IADD, mg/kg-day)	2.2E−02	2.2E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.8E−02	2.0E−02

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

3.7 PVC Plastics Converting

3.7.1 Process Description

DCHP is used as a plasticizer, processing aid, hardener, and stabilizing agent in plastics (see Appendix F for EPA-identified DCHP-containing products for this OES). The Agency expects that DCHP will arrive at a typical converting site as a solid in containers ranging in size from 5 to 1,000 gallons (U.S. EPA, 2004a). PVC plastic converting sites receive the DCHP masterbatch as a solid, which 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).

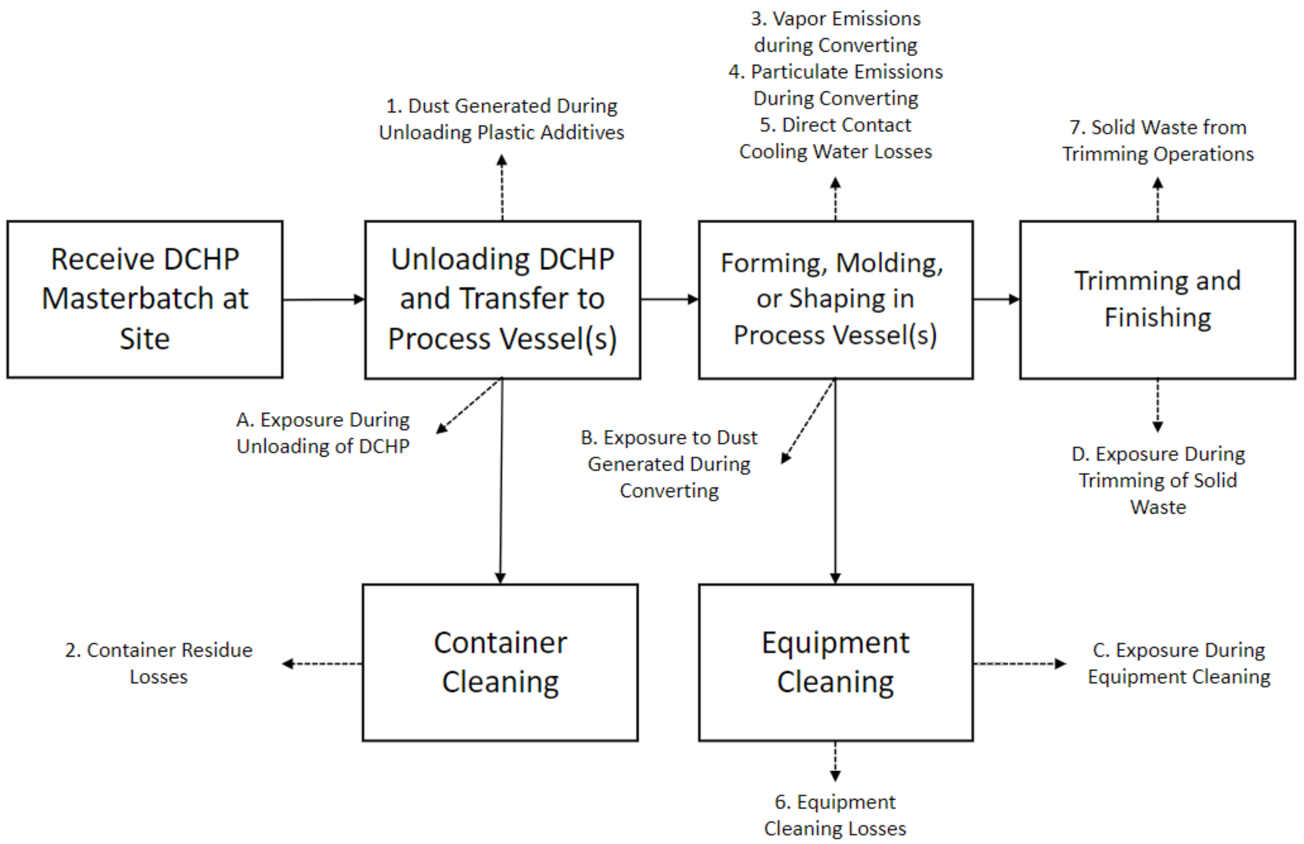

Figure 3-7. PVC Plastics Converting Flow Diagram (U.S. EPA, 2021d)

3.7.2 Facility Estimates

Since converting occurs immediately downstream of compounding, EPA expects the production volume for plastic converting to be identical to the production volume for the plastics compounding OES. The production volume of DCHP for use in plastics compounding was 18,543 to 222,659 kg/year. EPA estimated the number of sites for converting based on DCHP CDR data identified with the industrial sector, "Plastic Product Manufacturing", which included six reports. Five of these reports identified 1 to 9 sites, and 1 report identified 10 to 24 sites. Based on this, EPA assumed an overall range (minimum to maximum) of 15 to 69 converting sites (U.S. EPA, 2020a).

EPA did not identify plastic converting site operating data (*i.e.*, facility production rate, number of batches, or operating days). The Agency assessed the total number of operating days as 137 to 254 days/year for the given site throughput scenario using information from the 2014 Use of Additives in the Thermoplastic Converting Industry Draft GS and the 2021 Use of Additives in Plastics Converting Draft Generic Scenario (U.S. EPA, 2021d, 2014d). 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. The Agency estimated an annual facility DCHP throughput by dividing the annual production volume by the number of sites.

3.7.3 Release Assessment

3.7.3.1 Environmental Release Points

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

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

3.7.3.2 Environmental Release Assessment Results

Table 3-34 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES.

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

Modeled Scenario	Environmental Media	Annual Release (kg/site-year) [b]		Number of Release Days		Daily Release (kg/site-day) [b]	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
18,543–222,659 kg/year production volume	Fugitive or stack air[a]	1.5	40	219	251	7.2E−03	0.19
	Fugitive air, water, incineration, or landfill[a]	10	73			4.7E−02	0.35
	Water, incineration, or landfill[a]	86	258			0.96	1.9
	Water	29	86			0.13	0.41
	Incineration or landfill[a]	93	292			0.43	1.4

[a] When multiple environmental media are addressed together, releases may go all to 1 media or be split between media depending on site-specific practices. Not enough data were available to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DCHP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

3.7.4 Occupational Exposure Assessment

3.7.4.1 Worker Activities

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

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

3.7.4.2 Number of Workers and ONUs

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 DCHP during plastics converting. 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. The Agency assigned the NAICS code 326100 – Plastics Product Manufacturing for this OES based on the CDR reported NAICS codes for plastics converting (U.S. EPA, 2020a). Table 3-35 summarizes the per site estimates for this OES. EPA did not identify site-specific data for the number of facilities in the United States that convert plastics.

Table 3-35. Estimated Number of Workers Potentially Exposed to DCHP During PVC Plastics Converting

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]
326100 – Plastics Product Manufacturing	42–67	18	756–1,206	5	210–335

[a] The result is expressed as a range between the central tendency and high-end number of expected sites.
[b] Number of workers and ONUs per site are calculated by dividing the total number of exposed workers or ONUs by the total number of establishments for a given NAICS code. The number of workers and ONUs is rounded to the nearest integer.

3.7.4.3 Occupational Inhalation Exposure Results

EPA did not identify chemical-specific or OES-specific inhalation monitoring data for DCHP from systematic review of literature sources. DCHP is present in plastic materials (U.S. EPA, 2020c), so EPA expects worker inhalation exposures to DCHP via exposure to particulates of plastic materials during converting and unloading activities. To estimate worker and ONU inhalation exposures, EPA used the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix E.4.

EPA used a subset of the model data that came from facilities with NAICS codes starting with 326 – Plastics and Rubber Manufacturing to estimate plastic particulate concentrations in the air. The Agency used the highest expected concentration of DCHP in plastic products to estimate the concentration of DCHP in particulates. For this OES, EPA selected 45 percent by mass as the maximum expected DCHP concentration, based on the estimated plasticizer concentrations given by the Use of Additives in Plastic Compounding Generic Scenario (U.S. EPA, 2021c). EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model uses 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, which is the expected maximum number of working days. 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. 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 inhalation of dust containing DCHP were assumed to be representative of ONU inhalation exposures.

Table 3-36 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DCHP during PVC plastics converting. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DCHP in the form of particulates and does not account for other potential inhalation exposure routes.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration to Dust (mg/m^3)	0.10	2.12
	Acute Dose (AD) (mg/kg-day)	1.3E−02	0.26
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	9.5E−03	0.19
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	7.8E−03	0.18
Female of Reproductive Age	8-hour TWA Exposure Concentration to Dust (mg/m^3)	0.10	2.12
	Acute Dose (AD) (mg/kg-day)	1.4E−02	0.29
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	1.0E−02	0.21
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	8.6E−03	0.20
ONU	8-hour 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

[a] EPA estimated worker inhalation exposures to dust using the PNOR Model ((U.S. EPA, 2021c).. For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES.

3.7.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various "Exposure Concentration Types" from Table 3-37 are explained in Appendix B. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Table 3-37 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	Dose Rate (APDR, mg/day)	0.18	0.36
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−03	3.1E−03

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Female of Reproductive Age	Dose Rate (APDR, mg/day)	0.15	0.30
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.2E−03	2.8E−03
ONU	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute (AD, mg/kg-day)	1.1E−03	1.1E−03
	Intermediate (IADD, mg/kg-day)	8.3E−04	8.3E−04
	Chronic, Non-Cancer (ADD, mg/kg-day)	6.8E−04	7.7E−04

[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).

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 the table below.

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)	1.5E−02	0.27
	Intermediate (IADD, mg/kg-day)	1.1E−02	0.20
	Chronic, Non-Cancer (ADD, mg/kg-day)	9.1E−03	0.18
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.6E−02	0.30
	Intermediate (IADD, mg/kg-day)	1.2E−02	0.22
	Chronic, Non-Cancer (ADD, mg/kg-day)	9.8E−03	0.20
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)	8.4E−03	9.6E−03

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

3.8 Non-PVC Material Compounding

3.8.1 Process Description

The 2020 final scope (U.S. EPA, 2020c) and CDR reports for plastic material and resin manufacturing indicate DCHP use in non-PVC polymers, such as rubber and cellulose film (see Appendix F for EPA-identified DCHP-containing products for this OES) (U.S. EPA, 2020a, c). However, EPA did not identify specific non-PVC polymer products that contain DCHP from the data sources that underwent systematic review.

EPA expects that a typical non-PVC material compounding site operates similar to a plastic compounding site. Based on information from CDR and the 2021 Generic Scenario on Plastic Compounding, typical compounding sites receive DCHP as a pure solid in containers ranging in size from 7 to 132 gallons. Typical compounding sites receive and unload DCHP and transfer it into mixing vessels to produce a compounded resin masterbatch. Following completion of the masterbatch, sites transfer the solid resin to extruders that shape and size the plastic and package the final product for shipment to downstream conversion sites after cooling (U.S. EPA, 2021c). Figure 3-8 provides an illustration of the plastic compounding process (U.S. EPA, 2021c).

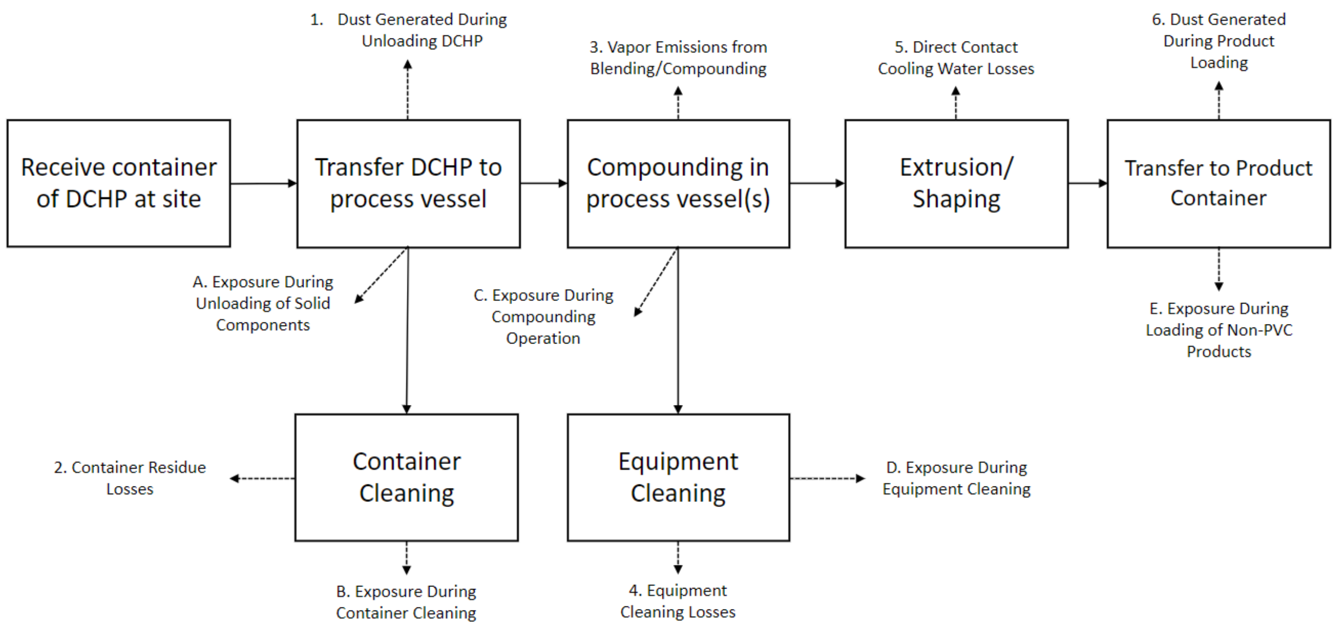

Figure 3-8. Non-PVC Material Compounding Flow Diagram (U.S. EPA, 2021c)

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

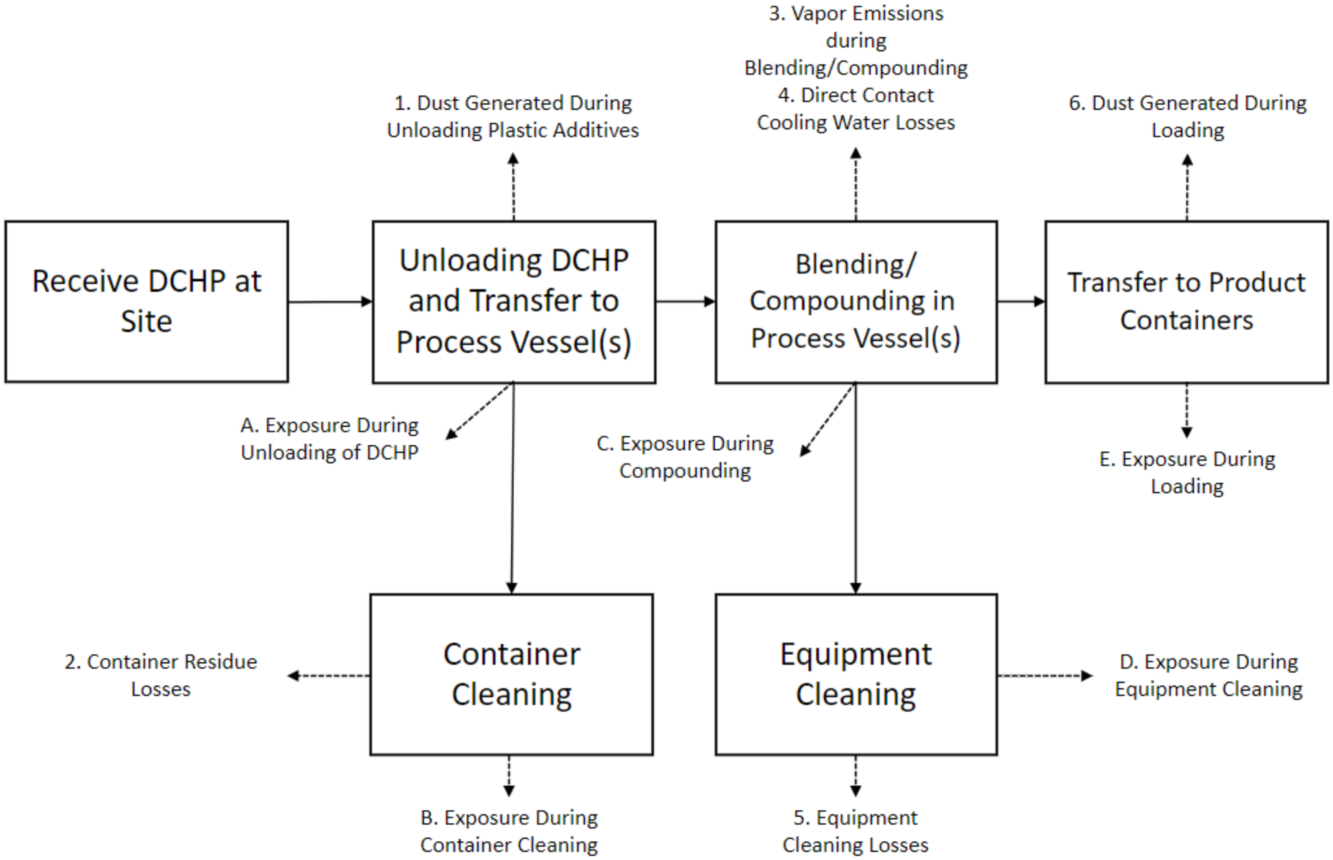

Figure 3-9. Consolidated Compounding and Converting Flow Diagram (ESIG, 2020; OECD, 2004a)

3.8.2 Facility Estimates

EPA did not identify any production volume information specific to this OES. The Agency estimated the total DCHP production volume for non-PVC materials using a uniform distribution with a lower bound of 11,340 kg/year and an upper bound of 22,680 kg/year. This range is based on DCHP CDR data and reporting thresholds for CDR reporters. CDR data for DCHP provides a national aggregate production volume of 500,000 to 1,000,000 lb/year(U.S. EPA, 2020a). CDR requires a site to report processing and use for a chemical if the usage exceeds 5 percent of its reported PV or if the use exceeds 25,000 lb per year (whichever is smaller). No sites reporting to CDR listed the manufacture of rubber as a downstream use for DCHP; therefore, EPA assumed that all unique sites reporting to CDR manufactured or imported DCHP for rubber end-uses up to the reporting threshold limit. Using these volume estimates, EPA calculated the total DCHP production volume for non-PVC plastic at 25,000 to 50,000 lb/year (11,340–22,680 kg/year).

Table 3-39. Site CDR Volumes Used for the Production Volume Estimate in the Non-PVC Materials Compounding and Converting OES

Reporting Year	Site Name	Estimated PV Contribution to this OES (lb)
2020	United Initiators, Inc.	655.3–13,155.3
2020	Lanxess Corporation Greensboro	864.5
2020	Vertellus Greensboro LLC	22,825
2020	Nouryon Functional Chemicals LLC	655.3–13,155.3

EPA did not identify site- or DCHP-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 plastics compounding operating data, as the operations are expected to be similar. The Agency estimated the number of sites for non-PVC material compounding as a uniform distribution of 1 to 4 sites based on the total number of reporters to CDR for DCHP (U.S. EPA, 2020a).

EPA based the estimated number of operating days on the 2021 Generic Scenario on Plastic Compounding product throughput of plastic additives. The Agency 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 estimated the total number of operating days as 148-300 days/year 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, 2021c). EPA estimated an annual facility DCHP throughput by dividing the annual production volume by the number of sites.

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, 2021c). The GS identified default models to quantify releases from each release point and suspected fugitive air release point. EPA expects blending and compounding operations to release vapor emissions to fugitive or stack air. The Agency expects releases to water, incineration, or landfill from container residues and equipment cleaning wastes. EPA expects releases to water from direct contact cooling. Releases to fugitive air, water, incineration, or landfill are expected during transfer operations and while loading plastic additives.

Sites may utilize air capture technology. If a site uses air capture technology, EPA expects dust releases from product loading to be controlled and released to disposal facilities for incineration or landfill. The Agency 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 3-40 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES.

Table 3-40. Summary of Modeled Environmental Releases for Non-PVC Materials Compounding

Modeled Scenario	Environmental Media	Annual Release (kg/site-year) [b]		Number of Release Days		Daily Release (kg/site-day) [b]	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
11,340 – 22,680 kg/year production volume	Fugitive or Stack air[a]	7.1	198	234	280	3.1E−02	0.88
	Fugitive air, water, incineration, or landfill[a]	56	359			0.25	1.6
	Water, incineration, or landfill[a]	182	539			1.5	2.9
	Water	68	204			0.30	0.90
	Incineration or landfill[a]	94	475			0.41	2.1

[a] When multiple environmental media are addressed together, releases may go all to 1 media or be split between media depending on site-specific practices. Not enough data were available to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DCHP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

3.8.4 Occupational Exposure Assessment

3.8.4.1 Worker Activities

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

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

3.8.4.2 Number of Workers and ONUs

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 DCHP 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 – Synthetic Rubber Manufacturing, 326200 – Rubber Product Manufacturing, and 424690 – Other Chemical and Allied Products Merchant Wholesalers 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, 2021c, 2020a). Table 3-41 summarizes the per site estimates for this OES. EPA did not identify site-specific data for the number of facilities in the United States that compound non-PVC material.

Table 3-41. Estimated Number of Workers Potentially Exposed to DCHP 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	2–4	23	46–92	6	12–24

[a] The result is expressed as a range between the central tendency and high-end number of expected sites. Results were not assessed by NAICS code for this scenario.
[b] Number of workers and ONUs per site are calculated by dividing the total number of exposed workers or ONUs by the total number of establishments for a given NAICS code. The number of workers and ONUs are rounded to the nearest integer. Values that 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 DCHP from systematic review of literature sources. DCHP is present in non-PVC materials such as rubbers per CDR reporting and industry comments (U.S. EPA, 2020a; AIA, 2019), so EPA expects worker inhalation exposures to DCHP via exposure to particulates of non-PVC materials during the compounding process in addition to DCHP unloading and loading tasks, container cleaning, and equipment cleaning. To estimate worker and ONU inhalation exposure, EPA used the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix E.

EPA used a subset of the model data that came from facilities with NAICS codes starting with 326 – Plastics and Rubber Manufacturing to estimate DCHP-containing, non-PVC material particulate concentrations in the air. For this OES, EPA selected 60 percent by mass as the highest expected DCHP concentration based on the importer-stated use concentration reported in the 2020 CDR (U.S. EPA, 2020a) to estimate the concentration of DCHP present in particulate that arrives at the compounding site. EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model 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, which is the expected maximum number of working days. The high-end exposures assume 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 227 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure. Therefore, worker central tendency exposure values for inhalation of dust containing DCHP were assumed to be representative of ONU inhalation exposure.

Table 3-42 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DCHP during non-PVC material compounding. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DCHP in the form of particulates and does not account for other potential inhalation exposure routes.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration to Dust (mg/m^3)	0.14	2.82
	Acute Dose (AD) (mg/kg-day)	1.7E−02	0.35
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	1.3E−02	0.26
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.1E−02	0.24
Female of Reproductive Age	8-hour TWA Exposure Concentration to Dust (mg/m^3)	0.14	2.82
	Acute Dose (AD) (mg/kg-day)	1.9E−02	0.39
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	1.4E−02	0.29
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.2E−02	0.27
ONU	8-hour TWA Exposure Concentration to Dust (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)	1.3E−02	1.3E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.1E−02	1.2E−02

[a] EPA estimated worker inhalation exposures to dust using the PNOR Model (U.S. EPA, 2021c). For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES.

3.8.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various "Exposure Concentration Types" from Table 3-43 are explained in Appendix B. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Table 3-43 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	Dose Rate (APDR, mg/day)	0.18	0.36
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−03	3.1E−03

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Female of Reproductive Age	Dose Rate (APDR, mg/day)	0.15	0.30
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.3E−03	2.8E−03
ONU	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute (AD, mg/kg-day)	1.1E−03	1.1E−03
	Intermediate (IADD, mg/kg-day)	8.3E−04	8.3E−04
	Chronic, Non-Cancer (ADD, mg/kg-day)	7.2E−04	7.7E−04
[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).			

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 the table below.

Table 3-44. 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)	2.0E−02	0.36
	Intermediate (IADD, mg/kg-day)	1.4E−02	0.26
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.2E−02	0.24
Female of Reproductive Age	Acute (AD, mg/kg-day)	2.1E−02	0.39
	Intermediate (IADD, mg/kg-day)	1.5E−02	0.29
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.3E−02	0.27
ONU	Acute (AD, mg/kg-day)	1.8E−02	1.8E−02
	Intermediate (IADD, mg/kg-day)	1.3E−02	1.3E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.2E−02	1.3E−02
Note: A worker or ONU could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.9 Non-PVC Material Converting

3.9.1 Process Description

The 2020 final scope (U.S. EPA, 2020c) and CDR reports indicate DCHP use in non-PVC materials such as rubber and cellulose film (see Appendix F for EPA-identified DCHP-containing products for this OES) (U.S. EPA, 2020a, c). In 2020 CDR, concentration ranges of 30 to 60 percent or 90 percent or greater is listed by reporters (U.S. EPA, 2020a). The concentration range of 30 to 60 percent was used for DCHP since this reported concentration range aligned with a six of the seven CDR entries with plastics-related industrial sectors in CDR. Therefore, the assumption was that the concentration range (30–60%) reported in CDR represents all the products for this OES.

EPA expects that a typical non-PVC material converting site operates similar to a plastic converting site. A typical converting site receives and unloads DCHP 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, 2021c).

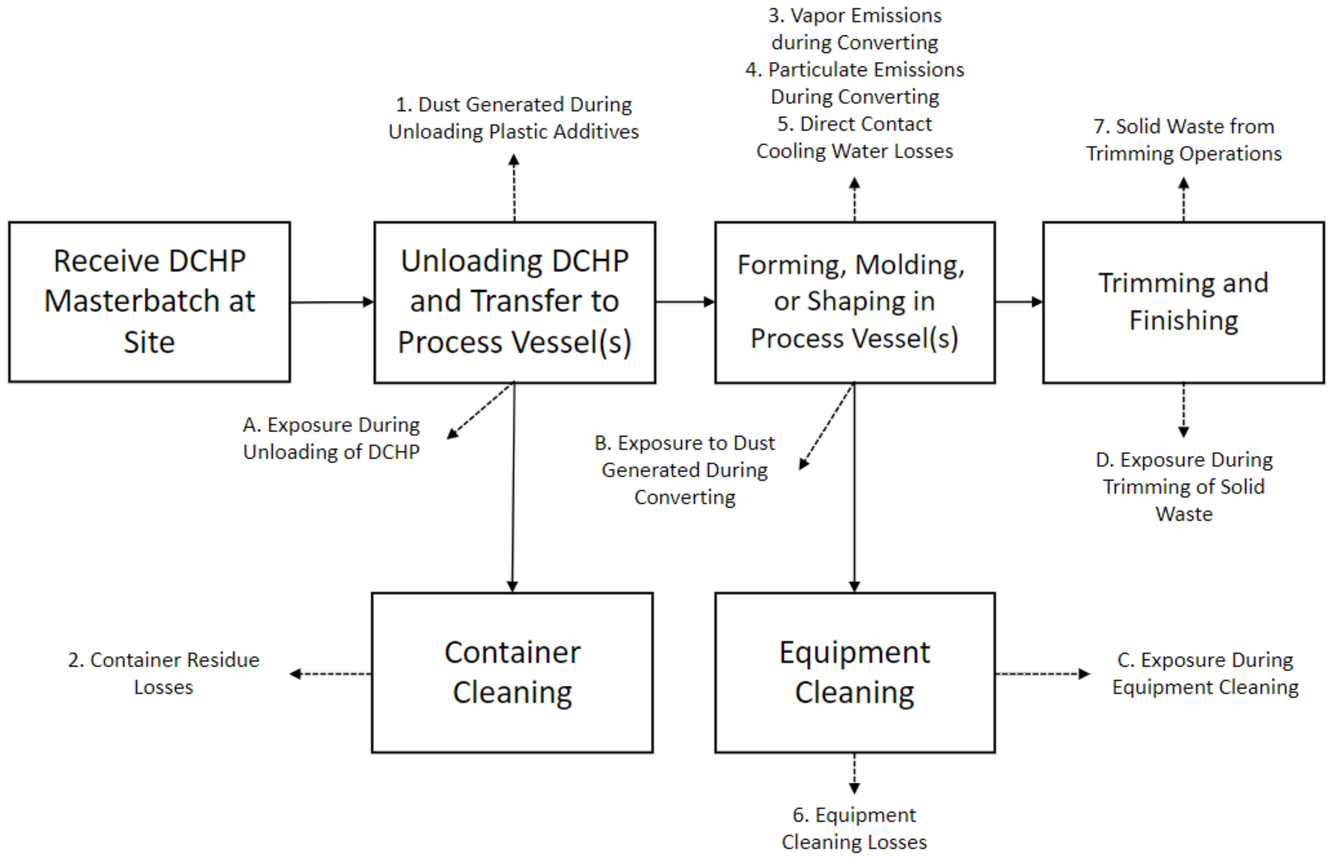

Figure 3-10. Non-PVC Material Converting Flow Diagram (U.S. EPA, 2021c)

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 DCHP for use in non-PVC material converting was estimated as 11,340 to 22,680 kg/year. The Agency estimated the number of non-PVC material converting sites as a uniform distribution of 1 to 4 sites based on the total number of reporters to CDR for DCHP (U.S. EPA, 2020a).

EPA did not identify site- or chemical-specific plastic converting operating data (*i.e.*, facility production rate, number of batches, or operating days). The 2021 Revised Generic Scenario on Plastic Converting estimated the total number of operating days as 137 to 254 days/year for the given site throughput scenario. The Agency assumed that the number of batches per site year was equivalent to the number of operating days, or one batch per day (U.S. EPA, 2021c). EPA estimated an annual facility DCHP throughput by dividing the annual production volume by the number of sites.

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, 2021c). The revised GS identified default models to quantify releases from each release point and suspected fugitive air release point. EPA expects blending and converting operations to release vapor emissions to fugitive or stack air and particulate emissions to fugitive air, water, incineration, or landfill. The Agency expects releases to water, incineration, or landfill from container residues and equipment cleaning wastes. EPA expects releases to water from direct contact cooling. Releases to fugitive air, water, incineration, or landfill are expected while unloading plastic additives. The Agency expects solid waste from trimming operations released to landfill or incineration.

3.9.3.2 Environmental Release Assessment Results

Table 3-45 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES.

Table 3-45. Summary of Modeled Environmental Releases for Non-PVC Material Converting

Modeled Scenario	Environmental Media	Annual Release (kg/site-year) [b]		Number of Release Days		Daily Release (kg/site-day) [b]	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
11,340–22,680 kg/year production volume	Fugitive or Stack air[a]	4.3	99	219	251	2.0E−02	0.47
	Fugitive air, water, incineration, or landfill[a]	29	181			0.13	0.86
	Water, incineration, or landfill[a]	204	611			1.1	2.9
	Water	68	204			0.32	0.96
	Incineration or landfill[a]	226	686			1.1	3.3

[a] When multiple environmental media are addressed together, releases may go all to 1 media or be split between media depending on site-specific practices. Not enough data were available to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DCHP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

3.9.4 Occupational Exposure Assessment

3.9.4.1 Worker Activities

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

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

3.9.4.2 Number of Workers and ONUs

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 DCHP 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 – Synthetic Rubber Manufacturing, 326200 – Rubber Product Manufacturing, and 424690 – Other Chemical and Allied Products Merchant Wholesalers 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 3-46 summarizes the per site estimates for this OES. EPA did not identify site-specific data for the number of facilities in the United States that convert non-PVC material.

Table 3-46. Estimated Number of Workers Potentially Exposed to DCHP 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[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	2–4	23	46–92	6	12–24

[a] The result is expressed as a range between the central tendency and high-end number of expected sites. Results were not assessed by NAICS code for this scenario.
[b] Number of workers and ONUs per site are calculated by dividing the total number of exposed workers or ONUs by the total number of establishments for a given NAICS code. The number of workers and ONUs are rounded to the nearest integer. Values that would otherwise be displayed as "0" are left unrounded.

3.9.4.3 Occupational Inhalation Exposure Results

EPA did not identify chemical-specific or OES-specific inhalation monitoring data for DCHP from systematic review of literature sources. DCHP is present in non-PVC materials (U.S. EPA, 2020a; AIA, 2019), so EPA expects worker inhalation exposures to DCHP via exposure to particulates of non-PVC materials during the non-PVC material converting. To estimate worker and ONU inhalation exposures, EPA used the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix E.

EPA used a subset of the model data that came from facilities with NAICS codes starting with 326 – Plastics and Rubber Manufacturing to estimate DCHP-containing, non-PVC material particulate concentrations in the air. The Agency used the highest expected concentration of DCHP in non-PVC material products to estimate the concentration of DCHP in particulates. For this OES, EPA selected 20 percent by mass as the maximum expected DCHP concentration, based on the estimated plasticizer concentrations in plastics given by the Use of Additives in Plastic Compounding Generic Scenario (U.S. EPA, 2021c). EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model uses 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, which is the expected maximum number of working days. 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. 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 inhalation of dust containing DCHP were assumed to be representative of ONU inhalation exposure.

Table 3-47 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DCHP during non-PVC plastics converting. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DCHP in the form of particulates and does not account for other potential inhalation exposure routes.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration to Dust (mg/m^3)	4.6E−02	0.94
	Acute Dose (AD) (mg/kg-day)	5.8E−03	0.12
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.2E−03	8.6E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	3.5E−03	8.0E−02
Female of Reproductive Age	8-hour TWA Exposure Concentration to Dust (mg/m^3)	4.6E−02	0.94
	Acute Dose (AD) (mg/kg-day)	6.4E−03	0.13
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.7E−03	9.5E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	3.8E−03	8.9E−02
ONU	8-hour 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	4.2E−03
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	3.5E−03	3.9E−03

[a] EPA estimated worker inhalation exposures to dust using the PNOR Model (U.S. EPA, 2021c). For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES.

3.9.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various "Exposure Concentration Types" from Table 3-48 are explained in Appendix B. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Table 3-48 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	Dose Rate (APDR, mg/day)	0.18	0.36
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−03	3.1E−03
Female of Reproductive Age	Dose Rate (APDR, mg/day)	0.15	0.30
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.2E−03	2.8E−03
ONU	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute (AD, mg/kg-day)	1.1E−03	1.1E−03
	Intermediate (IADD, mg/kg-day)	8.3E−04	8.3E−04
	Chronic, Non-Cancer (ADD, mg/kg-day)	6.8E−04	7.7E−04

[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).

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 the table below.

Table 3-49. 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)	8.0E−03	0.12
	Intermediate (IADD, mg/kg-day)	5.9E−03	8.9E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.8E−03	8.4E−02
Female of Reproductive Age	Acute (AD, mg/kg-day)	8.4E−03	0.13
	Intermediate (IADD, mg/kg-day)	6.2E−03	9.8E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	5.1E−03	9.2E−02
ONU	Acute (AD, mg/kg-day)	6.9E−03	6.9E−03
	Intermediate (IADD, mg/kg-day)	5.0E−03	5.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.1E−03	4.7E−03

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

3.10 Application of Adhesives and Sealants

3.10.1 Process Description

DCHP is an additive in adhesive and sealant products for industrial and commercial use, including polymer sealants, chemical anchors, and industrial adhesives and may arrive at end use sites in the solid or liquid/paste form. For solid formulations containing DCHP, the application site uses the solid as a component of a multi-part adhesive/sealant product. The solid formulation arrives at the site in containers ranging in size from 0.1 to 20 gallons and at concentrations of 40 to 55 percent DCHP (see Appendix F for EPA-identified DCHP-containing products for this OES). The application site transfers the solid formulation from the shipping container and mixes it with a liquid component to form the adhesive/sealant. The application site then uses application equipment, such as a caulk gun or syringe, to apply the final adhesive/sealant to the substrate (OECD, 2015a). For liquid/paste formulations containing DCHP, the application site receives the final formulation as a single-component adhesive/sealant product. The liquid/paste product arrives at the site in containers ranging in size from 1-20 gallons and at concentrations of 0.01 to 5 percent DCHP (see Appendix F for EPA identified-DCHP-containing products for this OES). The application site directly transfers the liquid/paste product to the application equipment to apply it as the final adhesive/sealant to the substrate (OECD, 2015a).

Application methods for the final adhesive/sealant include bead, roll, and syringe application. Application may occur over the course of an 8-hour workday at a given site, accounting for drying or curing times and additional coats where necessary. The site may trim excess adhesive/sealant from the applied substrate area. Figure 3-11 provides an illustration of the process of applying adhesives and sealants (OECD, 2015a).

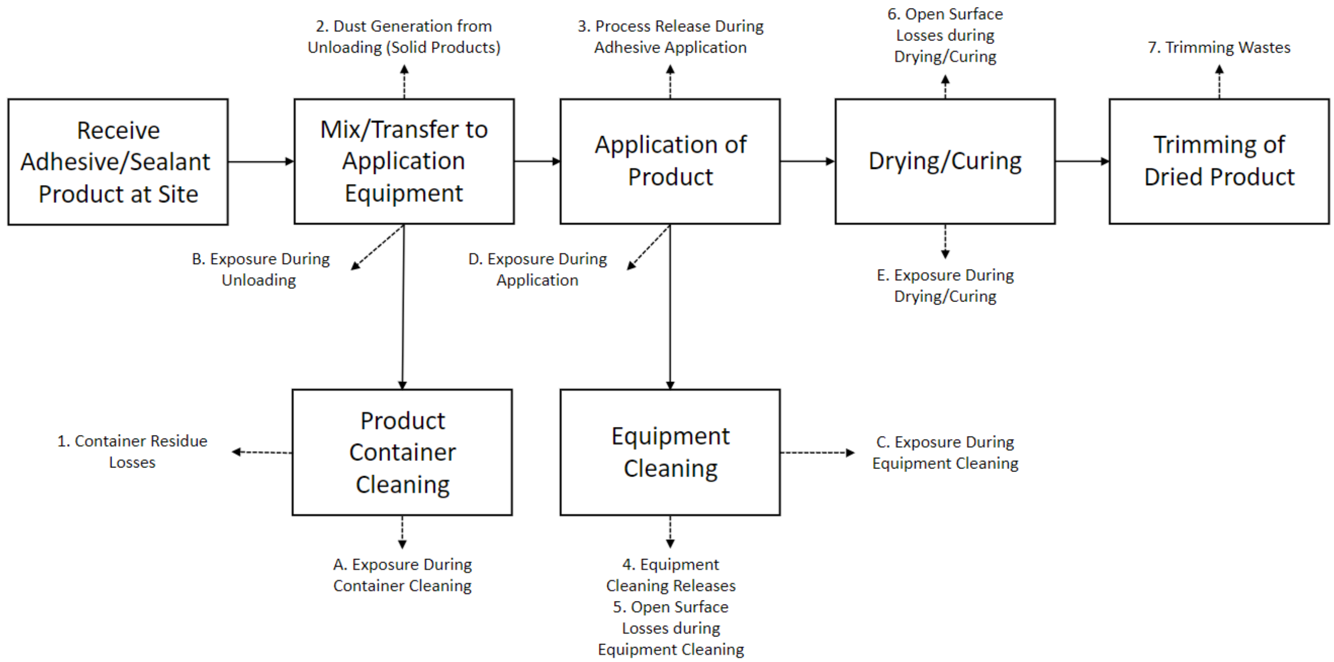

Figure 3-11. Application of Adhesives and Sealants Flow Diagram (OECD, 2015a)

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 DCHP 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 DCHP are applied using a syringe or caulk gun or spread on the surface using a trowel. The final scope for DCHP states that DCHP is used as a plasticizer in the manufacture of industrial and commercial adhesives and sealant end products (U.S. EPA, 2020c).

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 OESs. The production volume for adhesives and sealants use was estimated as 20,706 kg/year.

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 13,500 to 587,000 kg/site-year. Based on DCHP concentration in the liquid adhesive product of 0.01 to 5 percent, EPA estimated a DCHP use rate of 13.5 to 29,350 kg/site-year. Additionally, the ESD estimated the number of operating days as 50 to 365 days/year (OECD, 2015a). EPA did not identify estimates on the number of sites that may apply adhesive and sealant products containing DCHP. Therefore, EPA estimated the total number of application sites that use DCHP-containing adhesives and sealants using a Monte Carlo model (see Appendix E.10 for details). The 50th to 95th percentile range of the number of sites was 6 to 80 based on the production volume and site throughput estimates.

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). The ESD identified default models to quantify releases from each release point and suspected fugitive air release point. EPA expects fugitive air releases from unloading of solid adhesive products, container cleaning, equipment cleaning, and drying or curing processes. The Agency expects releases to water, incineration, or landfill from equipment cleaning waste and releases to incineration or landfill from container residue from small container disposal and trimming wastes. EPA expects releases to fugitive air, water, incineration, or landfill from process releases during adhesive application.

3.10.3.2 Environmental Release Assessment Results

Table 3-50 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES.

Table 3-50. Summary of Modeled Environmental Releases for Application of Adhesives and Sealants

Modeled Scenario	Environmental Media	Annual Release (kg/site-year) [b]		Number of Release Days		Daily Release (kg/site-day) [b]	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
20,706 kg/year production volume	Fugitive air	1.2E−07	3.7E−07	232	325	5.7E−10	1.5E−09
	Stack air	8.9	92			4.2E−02	0.46
	Fugitive air, water, incineration, or landfill[a]	11	121			5.3E−02	0.61
	Water, incineration, or landfill[a]	71	312			0.33	1.6
	Incineration or landfill[a]	146	700			0.67	3.6

[a] When multiple environmental media are addressed together, releases may go all to 1 media or be split between media depending on site-specific practices. Not enough data were available to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DCHP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

3.10.4 Occupational Exposure Assessment

3.10.4.1 Worker Activities

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

ONUs include supervisors, managers, and other employees who work in the application area but do not directly contact adhesives or sealants or handle or apply products. ONUs are potentially exposed via dust inhalation while present in the adhesives or sealant mixing area. ONUs may also experience dermal exposures from contact with surfaces where dust has been deposited.

3.10.4.2 Number of Workers and ONUs

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 DCHP 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 – Paper Bag and Coated and Treated Paper Manufacturing, 334100 – Computer and Peripheral Equipment Manufacturing, 334200 – Communications Equipment Manufacturing, 334300 – Audio and Video Equipment Manufacturing, 334400 – Semiconductor and Other Electronic Component Manufacturing, 334500 – Navigational, Measuring, Electromedical, and Control Instruments, 334600 – Manufacturing and Reproducing Magnetic and Optical Media, 335100 – Electric Lighting Equipment Manufacturing, 335200 – Household Appliance Manufacturing, 335300 – Electrical Equipment Manufacturing, 335900 – Other Electrical Equipment and Component Manufacturing, 336100 – Motor Vehicle Manufacturing, 336200 – Motor Vehicle Body and Trailer Manufacturing, 336300 – Motor Vehicle Parts Manufacturing, 336400 – Aerospace Product and Parts Manufacturing, 336500 – Railroad Rolling Stock Manufacturing, 336600 – Ship and Boat Building, and 336900 – Other Transportation Equipment Manufacturing 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 3-51 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 3-51. Estimated Number of Workers Potentially Exposed to DCHP During Application of 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]
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	
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	
Total/Average	**6–80**	**56**	**336–4,480**	**18**	**108–1,440**

[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 ONUs per site are calculated by dividing the total number of exposed workers or ONUs by the total number of establishments for a given NAICS code. The number of workers and ONUs are rounded to the nearest integer. Values that 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 during systematic review of literature sources. DCHP-containing products may be present at the use site in solid form, such as in a catalyst for a two-part system, or as pre-mixed liquids or pastes, based on adhesive and sealant product data. The Agency assessed worker inhalation exposures to dust from solid components. However, the literature and product data do not indicate the potential for spray coating and therefore EPA did not assess mist exposures. Also, inhalation exposures from the use of liquid/paste adhesive and sealant chemicals containing DCHP are expected to be *de minimis* since there are no mists generated during use and the vapor pressure of DCHP is similarly low as other phthalates. Consequently, EPA assumed negligible inhalation exposure from the use of liquid/paste adhesive and sealant chemicals and only assessed dermal exposures for liquid/paste adhesive and sealant use.

To estimate worker and ONU inhalation exposures to solid adhesives and sealants, EPA used the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are detailed in Appendix E.

The application of adhesives and sealants does not fall under a specific NAICS code; therefore, EPA used the entire PNOR Model data set to estimate DCHP particulate concentrations in the air during the use of solid DCHP-containing adhesive and sealant products. For this OES, EPA selected 55 percent by mass as the highest expected DCHP concentration, based on the high-end of adhesive/sealant products containing the chemical. EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model (U.S. EPA, 2021b) estimates 8-hour TWA 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. The high-end exposures use 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days. The central tendency exposures use 232 days per year as the exposure frequency, based on the 50th percentile of operating days from the release assessment. In absence of ONU exposure data, EPA assumed that worker central tendency exposures are representative of ONU exposures.

Table 3-52 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DCHP during the use of adhesives and sealants. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DCHP in the form of particulates and does not account for other potential inhalation exposure routes, such as from the inhalation of vapors, which EPA expects to be *de minimis*.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker – Solids	8-hour TWA Exposure Concentration (mg/m^3)	0.15	2.7
	Acute Dose (AD) (mg/kg-day)	1.9E−02	0.34
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	1.4E−02	0.25
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.2E−02	0.23
Female of Reproductive Age – Solids	8-hour TWA Exposure Concentration (mg/m^3)	0.15	2.7
	Acute Dose (AD) (mg/kg-day)	2.1E−02	0.37
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	1.5E−02	0.27
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.3E−02	0.26
ONU – Solids	8-hour TWA Exposure Concentration (mg/m^3)	0.15	0.15
	Acute Dose (AD) (mg/kg-day)	1.9E−02	1.9E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	1.4E−02	1.4E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.2E−02	1.3E−02
Average Adult Workers, Females of Reproductive Age, and ONUs – Pastes	All inhalation exposure types (*i.e.*, AD, IADD, ADD)	N/A	N/A

[a] EPA estimated worker inhalation exposures to dust using the PNOR Model (U.S. EPA, 2021c). For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES.

3.10.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various “Exposure Concentration Types” from
Table 3-53 are explained in Appendix B. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust or mist on surfaces were assessed.
Table 3-53 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker – Solids or Pastes	Dose Rate (APDR, mg/day)	0.18	0.36
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−03	3.1E−03

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Female of Reproductive Age – Solids or Pastes	Dose Rate (APDR, mg/day)	0.15	0.30
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.3E−03	2.8E−03
ONU – Solids	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute (AD, mg/kg-day)	1.1E−03	1.1E−03
	Intermediate (IADD, mg/kg-day)	8.3E−04	8.3E−04
	Chronic, Non-Cancer (ADD, mg/kg-day)	7.2E−04	7.7E−04

[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).

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 the table below.

Table 3-54. 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 – Solids	Acute (AD, mg/kg-day)	2.1E−02	0.34
	Intermediate (IADD, mg/kg-day)	1.5E−02	0.25
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.3E−02	0.23
Female of Reproductive Age – Solids	Acute (AD, mg/kg-day)	2.3E−02	0.38
	Intermediate (IADD, mg/kg-day)	1.7E−02	0.28
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−02	0.26
ONU – Solids	Acute (AD, mg/kg-day)	2.0E−02	2.0E−02
	Intermediate (IADD, mg/kg-day)	1.5E−02	1.5E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.3E−02	1.4E−02
Average Adult Worker – Pastes	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−03	3.1E−03
Female of Reproductive Age – Pastes	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.3E−03	2.8E−03

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

3.11 Application of Paints and Coatings

3.11.1 Process Description

DCHP is a plasticizer in paint and coating products for industrial and commercial use, including paints and colorant products. Solid paint and coating products containing DCHP may arrive at end use sites in containers ranging from 0.1 to 20 gallons in size with DCHP concentrations of 0.01-100 percent (see Appendix F for identified product information). The value of 100 percent was used as an upper bound and there was no attempt to refine the upper limit since the MOEs were above the benchmark when this concentration was used to estimate occupational exposures for application of paints and coatings (solid). Application sites transfer the solid product from the shipping container and mix it with other components to form a liquid paint/coating. Workers transfer the liquid mixture to the application equipment and apply the coating to the substrate (U.S. EPA, 2014b; OECD, 2009c; U.S. EPA, 2004d). End use sites may also receive liquid paint and coating formulations containing DCHP. For these products, the application site receives the final formulation as a single-component paint/coating product. The liquid product arrives at the site in containers ranging in size from 1 to 20 gallons and at concentrations of 2.5 to 10 percent DCHP (see Appendix F for EPA identified DCHP-containing products for this OES). The application site directly transfers the liquid product to the application equipment to apply the coating to the substrate (OECD, 2015a).

Application methods for DCHP-containing paints and coatings may include spray (*i.e.*, Thermaline 4900 Aluminum), brush, and/or 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). Brush and trowel application involve manual application by workers using a handheld tool (*i.e.*, brush, roller, trowel, etc.). DCHP will remain in the dried/cured coating as an additive following application to the substrate. EPA assumes that use sites perform coating activities using spray application methods, as this is expected to generate the highest release and exposure estimates. Applications may occur over the course of a worker's 8-hour workday at a given site and may include multiple coats and time for drying or curing (OECD, 2011b). Figure 3-12 provides an illustration of the spray application of paints and coatings (U.S. EPA, 2014b; OECD, 2011b, 2009c; U.S. EPA, 2004d).

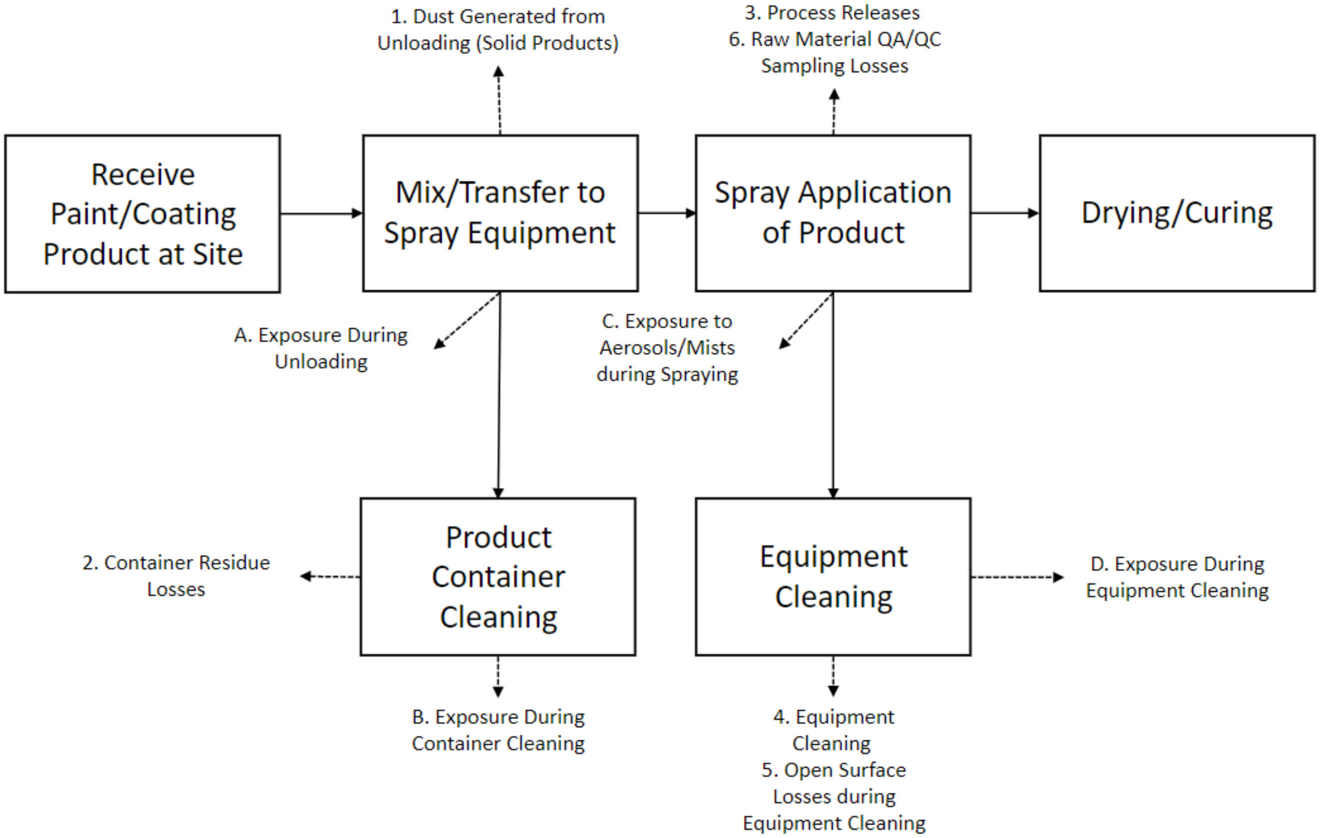

Figure 3-12. Application of Paints and Coatings Flow Diagram (U.S. EPA, 2014b; OECD, 2011b, 2009c; U.S. EPA, 2004d)

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 was estimated as 1,070 to 21,482 kg/year.

EPA did not identify site- or chemical-specific paint and coating use operating data (*e.g.*, facility use rates, operating days). The Agency based the facility use rate on the 2011 ESD on Radiation Curable Coatings, Inks and Adhesives, the 2011 ESD on Coating Application via Spray-Painting in the Automotive Finishing Industry, the 2004 GS on Spray Coatings in the Furniture Industry, and the European Council of the Paint, Printing Ink, and Artist's Colours Industry (CEPE) *SpERC Factsheet for Industrial Application of Coatings and Inks by Spraying.* The ESDs, GS, and SpERC estimated coating use rates of 946 to 446,600 kg/site-year. Based on a DCHP concentration in liquid paints and coatings of 2.5 to 10 percent, EPA estimated a DCHP use rate of 23.7 to 44,660 kg/site-year. Additionally, the ESDs, GS, and SpERC estimated the number of operating days as 225 to 300 days/year with 8 hour/day operations (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 DCHP. Therefore, EPA estimated the total number of application sites that use DCHP-containing paints and coatings using a Monte Carlo model (see Appendix E.9 for details). The 50th to 95th percentile range of the number of sites was 1 to 14.

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). The ESD identified default models to quantify releases from each release point. EPA expects stack air releases from additives during unloading and fugitive air releases from equipment cleaning and drying or curing. The Agency expects water, incineration, or landfill releases from container residue losses and sampling. Releases to incineration or landfill are expected from equipment cleaning in addition to fugitive air, water, incineration, or landfill releases from dust generated from transfer operations of solid additives. EPA modeled two scenarios, one where application sites use overspray control technologies and one where no controls are used. Sites may utilize overspray control technology to prevent additional air releases during spray application. If a site uses overspray control technology, EPA expects stack air releases of approximately 10 percent of process related operational losses. The Agency expects the site to release the remaining 90 percent of operational losses to water, landfill, or incineration (OECD, 2011b). If the site does not use control technology, EPA expects the site to release all process related operational losses to fugitive air, water, incineration, or landfill in unknown percentages.

3.11.3.2 Environmental Release Assessment Results

Table 3-55 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES.

Table 3-55. Summary of Modeled Environmental Releases for Application of Paints and Coatings

Modeled Scenario	Environmental Media	Annual Release (kg/site-year) [b]		Number of Release Days		Daily Release (kg/site-day) [b]	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
1,070–21,482 kg/year production volume Control Technology	Fugitive air	1.5E−06	3.3E−06	257	287	5.8E−09	1.3E−08
	Stack air	351	1300			1.4	5.1
	Fugitive air, water, incineration, or landfill[a]	24	211			9.4E−02	0.82
	Water, incineration, or landfill[a]	327	838			1.3	3.3
	Incineration or landfill[a]	2910	1.1E04			11	42
1,070–21,482 kg/year production volume No Control Technology	Fugitive air	1.5E−06	3.3E−06	257	287	5.8E−09	1.3E−08
	Stack air	19	161			7.4E−02	0.63
	Fugitive air, water, incineration, or landfill[a]	3.2E03	1.2E04			E−013	47
	Water, incineration, or landfill[a]	328	842			1.3	3.3
	Incineration or landfill[a]	31	227			0.12	0.88

[a] When multiple environmental media are addressed together, releases may go all to 1 media or be split between media depending on site-specific practices. Not enough data were available to estimate the partitioning between media.

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

3.11.4 Occupational Exposure Assessment

3.11.4.1 Worker Activities

During the use of DCHP-containing paints and coatings, workers may experience dermal or inhalation exposure to DCHP dust when unloading or mixing a multi-component product that includes DCHP in a solid form. Workers are potentially exposed to DCHP from overspray inhalation during spray coating. Workers may be exposed via dermal contact to liquids containing DCHP 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 DCHP-containing paints and coatings.

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

3.11.4.2 Number of Workers and ONUs

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 DCHP 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. The Agency assigned the NAICS codes 332431 – Metal Can Manufacturing, 335931 – Current-Carrying Wiring Device Manufacturing, 337124 – Metal Household Furniture Manufacturing, 337214 – Office Furniture (except wood) Manufacturing, 337127 – Institutional Furniture Manufacturing, 337215 – Showcase, Partition, Shelving, and Locker Manufacturing, 337122 – Nonupholstered Wood Household Furniture Manufacturing, 337211 – Wood Office Furniture Manufacturing, 337110 – Wood Kitchen Cabinet and Countertop Manufacturing, and 811120 – Automotive Body, Paint, Interior, and Glass Repair for this OES based on the 2009 ESD for the Coating Industry and the 2011 ESD on Coating Application via Spray-Painting in Automotive Refinishing (OECD, 2011a, 2009c). Table 3-56 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 DCHP-containing paints and coatings.

Table 3-56. Estimated Number of Workers Potentially Exposed to DCHP During Application of 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	
337110 – Wood Kitchen Cabinet and Countertop Manufacturing		3		2	
811120 – Automotive Body, Paint, Interior, and Glass Repair		3		0.3	
Total/Average	**1–14**	**12**	**12–168**	**5**	**5–70**

[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 ONUs per site are calculated by dividing the total number of exposed workers or ONUs by the total number of establishments for a given NAICS code. The number of workers and ONUs are rounded to the nearest integer. Values that 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. DCHP is expected to be used at the use site as a solid, such as in a catalyst for a multi-part system, or a pre-mixed liquid based on paint and coating product data. The Agency assessed potential for worker inhalation of dust from solid products and inhalation of mist from spray application of liquid mixtures. To estimate worker and ONU inhalation exposure to dust, EPA used the PNOR Model (U.S. EPA, 2021b). To estimate worker and ONU inhalation exposure to mist, EPA used the Automotive Refinishing Spray Coating Mist Inhalation Model from the 2011 ESD on Coating Application via Spray-Painting in the Automotive Refinishing Industry (OECD, 2011a). Model approaches and parameters are detailed in Appendix E.

The application of paints and coatings does not fall under a specific NAICS code profile, therefore EPA used the entire PNOR Model data set to estimate DCHP particulate concentrations in the air from the use of solid DCHP-containing components. For this OES, EPA identified 100 percent by mass as the highest expected DCHP concentration based on the solid paint and coating components containing DCHP. EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates at this fixed concentration throughout the working shift. The model 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.

Although paints and coatings can be applied in a variety of ways, EPA assessed exposures using spray application to encompass higher level exposures from this OES. For instance, EPA identified a commercial/industrial coating product containing DCHP (*i.e.*, Thermaline 4900 Aluminum) that is intended for conventional spray gun application. 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 DCHP in the paint from identified products (max of 10%) to estimate the central tendency and high-end inhalation exposures, respectively.

Table 3-57 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DCHP from unloading and mixing the solid DCHP-containing component of a paint and coating and the spray application of liquid 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 3-57. Summary of Estimated Worker Inhalation Exposures for Application of Paints and Coatings

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker – Solids	8-hour TWA Exposure Concentration (mg/m^3)	2.8E−01	4.90
	Acute Dose (AD) (mg/kg-day)	3.5E−02	0.61
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	2.6E−02	0.45
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	2.4E−02	0.42
Female of Reproductive Age – Solids	8-hour TWA Exposure Concentration (mg/m^3)	0.28	4.90
	Acute Dose (AD) (mg/kg-day)	3.9E−02	0.68
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	2.8E−02	0.50
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	2.6E−02	0.46
ONU – Solids	8-hour TWA Exposure Concentration (mg/m^3)	0.28	0.28
	Acute Dose (AD) (mg/kg-day)	3.5E−02	3.5E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	2.6E−02	2.6E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	2.4E−02	2.4E−02

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker – Dilute Liquids	8-hour TWA Exposure Concentration (mg/m^3)	0.42	8.8
	Acute Dose (AD) (mg/kg-day)	5.3E−02	1.1
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	3.9E−02	0.81
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	3.6E−02	0.76
Female of Reproductive Age – Dilute Liquids	8-hour TWA Exposure Concentration (mg/m^3)	0.42	8.8
	Acute Dose (AD) (mg/kg-day)	5.8E−02	1.2
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.3E−02	0.90
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.0E−02	0.84
ONU – Dilute Liquids	8-hour TWA Exposure Concentration (mg/m^3)	0.42	0.42
	Acute Dose (AD) (mg/kg-day)	5.3E−02	5.3E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	3.9E−02	3.9E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	3.6E−02	3.6E−02

[a] EPA estimated worker inhalation exposures to dust using the PNOR Model (U.S. EPA, 2021c). For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES. EPA estimated worker inhalation exposures to mist from spray application of liquid mixtures using the Automotive Refinishing Spray Coating Mist Inhalation Model which estimates worker inhalation exposures 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). EPA used the 50th and 95th percentile mist concentration along with the concentration of DCHP in the paint from identified products (max of 10%) to estimate the central tendency and high-end inhalation exposures, respectively.

3.11.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various "Exposure Concentration Types" from Table 3-58 are explained in Appendix B. Since there may be mist or dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with mist or dust on surfaces were assessed. Table 3-58 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker – Solids or Dilute Liquids	Dose Rate (APDR, mg/day)	0.18	0.36
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.5E−03	3.1E−03
Female of Reproductive Age – Solids or Dilute Liquids	Dose Rate (APDR, mg/day)	0.15	0.30
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−03	2.8E−03
ONU – Solids or Dilute Liquids	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute (AD, mg/kg-day)	1.1E−03	1.1E−03
	Intermediate (IADD, mg/kg-day)	8.3E−04	8.3E−04
	Chronic, Non-Cancer (ADD, mg/kg-day)	7.7E−04	7.7E−04

[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).

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 the table below.

Table 3-59. 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 – Solids	Acute (AD, mg/kg-day)	3.7E−02	0.62
	Intermediate (IADD, mg/kg-day)	2.7E−02	0.45
	Chronic, Non-Cancer (ADD, mg/kg-day)	2.6E−02	0.42
Female of Reproductive Age – Solids	Acute (AD, mg/kg-day)	4.1E−02	0.68
	Intermediate (IADD, mg/kg-day)	3.0E−02	0.50
	Chronic, Non-Cancer (ADD, mg/kg-day)	2.8E−02	0.47
ONU – Solids	Acute (AD, mg/kg-day)	3.6E−02	3.6E−02
	Intermediate (IADD, mg/kg-day)	2.6E−02	2.6E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	2.5E−02	2.5E−02
Average Adult Worker – Dilute Liquids	Acute (AD, mg/kg-day)	5.5E−02	1.1
	Intermediate (IADD, mg/kg-day)	4.0E−02	0.81
	Chronic, Non-Cancer (ADD, mg/kg-day)	3.8E−02	0.76

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Female of Reproductive Age – Dilute Liquids	Acute (AD, mg/kg-day)	6.0E−02	1.2
	Intermediate (IADD, mg/kg-day)	4.4E−02	0.90
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.1E−02	0.84
ONU – Dilute Liquids	Acute (AD, mg/kg-day)	5.4E−02	5.4E−02
	Intermediate (IADD, mg/kg-day)	4.0E−02	4.0E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	3.7E−02	3.7E−02
Note: A worker or ONU could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.12 Use of Laboratory Chemicals

3.12.1 Process Description

DCHP is a laboratory chemical used at commercial laboratory sites (U.S. EPA, 2020e). EPA identified relevant SDS that indicate laboratory chemicals containing DCHP in a concentration of 0.1 percent for liquid products or concentrations from 0.01 to 100 percent for solids. Laboratory chemicals containing DCHP arrive at end use sites in containers ranging in size from 0.5 to 1 gallons for liquid chemicals or 0.5 to 1 kg for solids (see Appendix F for EPA identified DCHP-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 DCHP-containing laboratory chemicals. Figure 3-13 provides an illustration of the use of laboratory chemicals (U.S. EPA, 2023c).

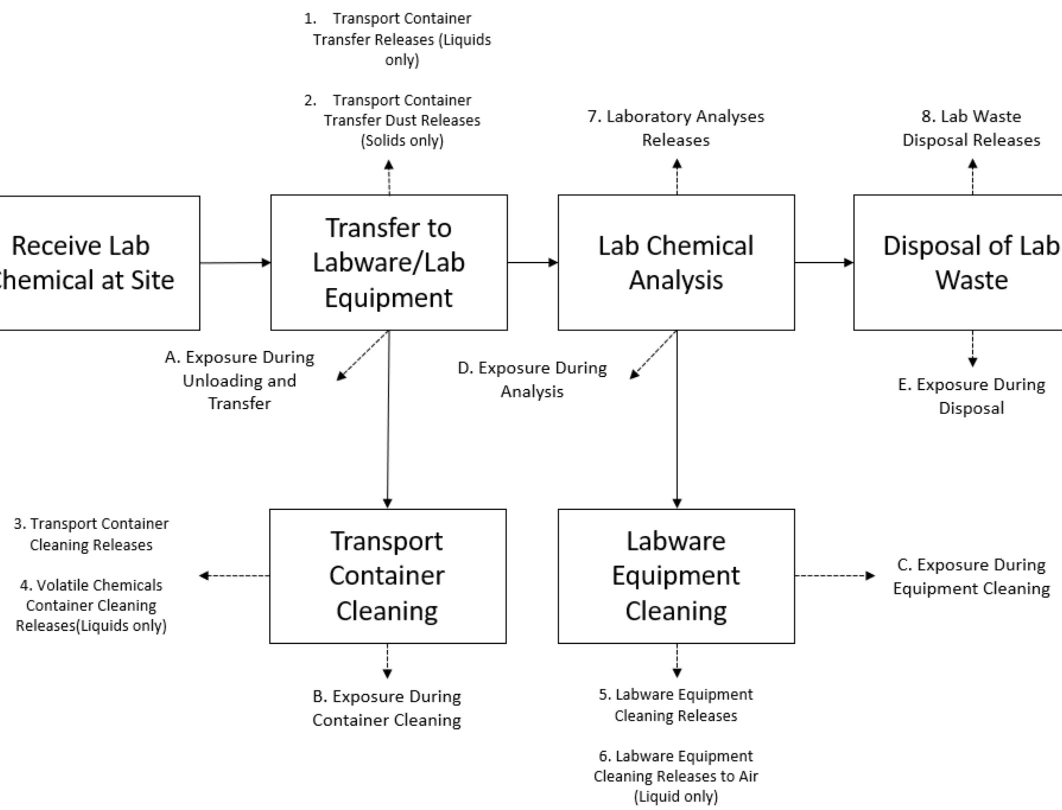

Figure 3-13. Use of Laboratory Chemicals Flow Diagram (U.S. EPA, 2023c)

3.12.2 Facility Estimates

No sites reported the use of DCHP-containing laboratory chemicals in the 2020 CDR. Instead, EPA assumed that a portion of the DCHP production volume from each CDR reporting site may be used in laboratory chemicals. Specifically, EPA estimated the total production volume of DCHP in laboratory chemicals using the CDR reporting threshold limits of either 25,000 lb (11,340 kg) or 5 percent of a site's reported production volume, whichever value was smaller. The Agency considered every site that reported using DCHP to CDR, regardless of assigned OES. EPA assumed that sites that claimed their production volume as CBI used 25,000 lb of DCHP-containing laboratory chemicals annually. Table 3-60 lists the sites and associated production volumes that the Agency considered in calculating the total production volume for this OES (U.S. EPA, 2020a). The total production volume for this OES was 75,865 lb/year, or 34,412 kg/year.

Table 3-60. CDR Reported Site Information for Use in Calculation of Laboratory Chemicals Production Volume

Site Name	Reported Production Volume (lb/year)	Threshold Limit Used	Production Volume Added to Total (lb/year)
United Initiators, Inc.	CBI	25,000 lb	25,000
Lanxess Corporation Greensboro	17,290	5%	865
Vertellus Greensboro LLC	CBI	25,000 lb	25,000
Nouryon Functional Chemicals LLC	CBI	25,000 lb	25,000

EPA did not identify site- or chemical-specific operating data for laboratory use of DCHP (*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 (U.S. EPA, 2023c). Based on the concentration of DCHP in the laboratory chemical of 0.01 to 100 percent, EPA estimated a daily facility use rate using Monte Carlo modeling, resulting in a 50th-95th percentile range of 0.07 to 0.27 kg/site-day. For liquid products, the 2023 GS provided an estimated throughput of 0.5 to 4,000 mL/site-day for liquid laboratory chemicals (U.S. EPA, 2023c). Based on the concentration of DCHP in liquid laboratory chemicals of 0.1 percent, (see Appendix F for EPA identified DCHP-containing products for this OES) and the DCHP density of 1.38 kg/L, EPA estimated a daily facility use rate of laboratory chemicals using Monte Carlo modeling, resulting in a 50th to 95th percentile range of 0.004 to 0.005 kg/site-day. Additionally, the GS estimated the number of operating days as 174 to 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 DCHP. Therefore, EPA estimated the total number of sites that use DCHP-containing laboratory chemicals using a Monte Carlo model (see Appendix E for details). Both the 50th and 95th percentile values for the number of sites resulted in a bounding estimate of 36,873 for the liquid use case. For the solid use case, the 50th to 95th percentile range of the number of sites was 1,978 to 25,643.

3.12.3 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). The GS identified default models to quantify releases from each release point. Laboratory sites may use a combination of solid and liquid laboratory chemicals, but for release modeling, EPA assumed each site used either the liquid or solid form (not both) of the DCHP-containing laboratory chemical. In the liquid laboratory chemical use case, EPA expects fugitive or stack air releases from transferring DCHP from transport containers, cleaning containers, labware cleaning, and laboratory analysis. In the solid laboratory chemical use case, EPA expects sites to release dust emissions from transferring powders containing DCHP to stack or fugitive air, water, incineration, or landfill. In both use cases, EPA expects water, incineration, or landfill releases from container cleaning wastes, labware equipment cleaning wastes, and laboratory waste disposal.

3.12.3.2 Environmental Release Assessment Results

Table 3-61 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES.

Table 3-61. Summary of Modeled Environmental Releases for Use of Laboratory Chemicals

Modeled Scenario	Environmental Media	Annual Release (kg/site-year) [b]		Number of Release Days		Daily Release (kg/site-day) [b]	
		Central Tendency	High-End	Central Tendency		Central Tendency	High-End
34,412 kg/year production volume – Liquid Laboratory Chemicals	Fugitive or stack air[a]	3.5E−10	6.0E−10	235	258	1.5E−12	2.6E−12
	Water, incineration, or landfill[a]	0.93	1.2			4.0E−03	5.0E−03
34,412 kg/year production volume – Solid Laboratory Chemicals	Stack air	3.0E−02	0.33	235	258	1.2E−04	1.0E−03
	Unknown media (air, water, incineration, or landfill) [a]	5.0E−02	0.51			2.3E−04	2.0E−03
	Water, incineration, or landfill[a]	15	62			6.6E−02	0.27
	Incineration or landfill[a]	7.0E−02	0.60			3.1E−04	3.0E−03

[a] When multiple environmental media are addressed together, releases may go all to 1 media or be split between media depending on site-specific practices. Not enough data were available to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DCHP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

3.12.4 Occupational Exposure Assessment

3.12.4.1 Worker Activities

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

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

3.12.4.2 Number of Workers and ONUs

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 DCHP 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. The Agency assigned the NAICS codes 541380 – Testing Laboratories, 541713 – Research and Development in Nanotechnology, 541714 – Research and Development in Biotechnology (except Nanobiotechnology), 541715 – Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology), and 621511– Medical Laboratories for this OES based on the GS on the Use of Laboratory Chemicals (U.S. EPA, 2023c). Table 3-62 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 DCHP-containing laboratory chemicals and instead modeled the number of sites for each use case with a bounding estimate of 36,873 laboratory chemical use sites based on data from the U.S. Census Bureau (U.S. BLS, 2016).

Table 3-62. Estimated Number of Workers Potentially Exposed to DCHP During Use of Laboratory Chemicals

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]
541380 – Testing Laboratories	N/A	1	N/A	9	N/A
621511 – Medical Laboratories		0.1		0.2	
Total/Average (Liquid)	36,873	1	36,873	4	147,492
Total/Average (Solid)	1,978–25,643	1	1,978– 25,643	4	7,912–102,572

[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 ONUs per site are calculated by dividing the total number of exposed workers or ONUs by the total number of establishments for a given NAICS code. The number of workers and ONUs are rounded to the nearest integer. Values that 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. DCHP is present in solid and liquid laboratory chemicals. The Agency assessed potential for worker and ONU inhalation to dust from solid laboratory chemicals. However, inhalation exposures from the use of liquid laboratory chemicals containing DCHP are expected to be *de minimis* since there are no mists generated during laboratory use and the vapor pressure of DCHP is similarly low as other phthalates. Consequently, EPA assumed negligible inhalation exposure from the use of liquid laboratory chemicals and only assessed dermal exposures to liquid laboratory chemicals.

To estimate worker and ONU inhalation exposure to dust for the use of solid laboratory chemicals, EPA used the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are detailed in Appendix E. EPA used a subset of the model data that came from facilities with the NAICS code starting with 54 – Professional, Scientific, and Technical Services – to estimate DCHP-containing particulate concentrations in the air. EPA used the highest expected concentration of DCHP to estimate the concentration of DCHP in particulates. For this OES this is 100 percent by mass based on identified lab-grade chemicals. EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model 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, which is the expected maximum number of working days. The high-end exposures use 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days. The central tendency exposures use 232 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. In the absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure.

Table 3-63 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DCHP during the use of solid laboratory chemicals. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DCHP in the form of particulates and does not account for other potential inhalation exposure routes, such as from the inhalation of vapors, which EPA expects to be *de minimis*.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker – Solids	8-hour TWA Exposure Concentration to Dust (mg/m^3)	1.9E−01	2.70
	Acute Dose (AD) (mg/kg-day)	2.4E−02	0.34
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	1.7E−02	0.25
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.5E−02	0.23
Female of Reproductive Age – Solids	8-hour TWA Exposure Concentration to Dust (mg/m^3)	0.19	2.70
	Acute Dose (AD) (mg/kg-day)	2.6E−02	0.37
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	1.9E−02	0.27
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.7E−02	0.26
ONU – Solids	8-hour TWA Exposure Concentration to Dust (mg/m^3)	0.19	0.19
	Acute Dose (AD) (mg/kg-day)	2.4E−02	2.4E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	1.7E−02	1.7E−02

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.5E−02	1.6E−02
Average Adult Workers, Females of Reproductive Age, and ONUs – Pastes and Dilute Liquids	All inhalation exposure types (*i.e.*, AD, IADD, ADD)	N/A	N/A
[a] EPA estimated worker inhalation exposures to dust using the PNOR Model (U.S. EPA, 2021c) For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES.			

3.12.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various "Exposure Concentration Types" from Table 3-64 are explained in Appendix B. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Table 3-64 summarizes the APDR, the AD, the IADD, and the ADD for average adult workers, female workers of reproductive age, and ONUs.

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

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker – Solids, Pastes, or Dilute Liquids	Dose Rate (APDR, mg/day)	0.18	0.36
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.5E−03	3.1E−03
Female of Reproductive Age – Solids, Pastes, or Dilute Liquids	Dose Rate (APDR, mg/day)	0.15	0.30
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.3E−03	2.8E−03
ONU – Solids	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute (AD, mg/kg-day)	1.1E−03	1.1E−03
	Intermediate (IADD, mg/kg-day)	8.3E−04	8.3E−04
	Chronic, Non-Cancer (ADD, mg/kg-day)	7.3E−04	7.7E−04
[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).			

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 the table below.

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

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker – Solids	Acute (AD, mg/kg-day)	2.6E−02	0.34
	Intermediate (IADD, mg/kg-day)	1.9E−02	0.25
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.7E−02	0.23
Female of Reproductive Age – Solids	Acute (AD, mg/kg-day)	2.8E−02	0.38
	Intermediate (IADD, mg/kg-day)	2.1E−02	0.28
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.8E−02	0.26
ONU – Solids	Acute (AD, mg/kg-day)	2.5E−02	2.5E−02
	Intermediate (IADD, mg/kg-day)	1.8E−02	1.8E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.6E−02	1.7E−02
Average Adult Worker – Pastes or Dilute Liquids	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.5E−03	3.1E−03
Female of Reproductive Age – Pastes or Dilute Liquids	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.3E−03	2.8E−03
Note: A worker or ONU could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.13 Fabrication or Use of Final Products or Articles

3.13.1 Process Description

EPA anticipates that DCHP may be present in a wide array of different final articles that are used both commercially and industrially. The 2020 final scope states that DCHP is industrially used in plastic and rubber products in transportation equipment manufacturing and commercially used in "building/construction materials not covered elsewhere" and "other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)." Based on uses for similar phthalate chemicals, this may include use of products such as vinyl tiles, resilient flooring, PVC-backed carpeting, scraper mats, and wall coverings (U.S. EPA, 2020c, 2019c). Use cases may include melting articles containing DCHP; drilling, cutting, grinding, or otherwise shaping articles containing DCHP. EPA did not identify any specific product data to support these uses; the only source that indicated these potential uses was the 2020 CDR report, which provides minimal information on the specific uses (U.S. EPA, 2020a). EPA was unable to identify specific DCHP-containing plastic or rubber materials for the fabrication or use of final products or articles OES. In absence of concentration information for products for this OES, it has been assumed that these products contain the same amount as plastic products and used the estimated concentration from the plastic compounding/converting OESs to represent this scenario, with DCHP at a concentration ranging from 30 to 45 percent (U.S. EPA, 2021c). This concentration range may be an overestimate for some products included in this OES.

3.13.2 Facility Estimates

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

3.13.3 Release Assessment

3.13.3.1 Environmental Release Points

EPA did not quantitatively assess environmental releases for this OES due to the lack of readily available process-specific and DCHP-specific data; however, the Agency expects releases from this OES to be small and disperse in comparison to other upstream OES, as EPA expects DCHP to be present in smaller amounts and predominantly remain in the final article, limiting the potential for release. Table 3-66 describes the expected fabrication and use activities that may potentially generate releases. All releases are non-quantifiable due to a lack of identified process- and product- specific data.

Table 3-66. Release Activities for Fabrication/Use of Final Articles Containing DCHP

Release Point	Release Behavior	Release Media
Cutting, grinding, shaping, drilling, abrading, and similar activities	Dust generation	Fugitive or stack air, water, incineration, or landfill
Heating/plastic welding activities	Vapor generation	Fugitive or stack air

3.13.4 Occupational Exposure Assessment

3.13.4.1 Worker Activities

During fabrication or use of final products or articles, worker exposures to DCHP may occur via dermal contact while handling and shaping articles containing DCHP 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. EPA did not identify chemical-specific information on engineering controls and worker PPE used at final product or article formulation or use sites.

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

3.13.4.2 Number of Workers and ONUs

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 DCHP during the fabrication or use of final 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 estimate the number of workers and ONUs per site. EPA assigned the NAICS codes 236100 – Residential Building Construction, 236200 – Nonresidential Building Construction, 237100 – Utility System Construction, 237200 – Land Subdivision, 237300 – Highway, Street, and Bridge Construction, 237900 – Other Heavy and Civil Engineering Construction, 337100 – Household and Institutional Furniture Manufacturing, and 337200 – Office Furniture (including Fixtures) Manufacturing for this OES based on NAICS codes that matched the relevant COUs for this scenario. Table 3-67 summarizes the per site estimates for this OES. As discussed in Section 3.13.2, 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 DCHP.

Table 3-67. Estimated Number of Workers Potentially Exposed to DCHP During the Fabrication or Use of Final 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 ONUs per site are calculated by dividing the total number of exposed workers or ONUs by the total number of establishments for a given NAICS code. The number of workers and ONUs are rounded to the nearest integer. Values that would otherwise be displayed as "0" are left unrounded.

3.13.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data to assess exposures to DCHP during fabrication or use of final products or articles containing DCHP. Based on the presence of DCHP as an additive in articles (CPSC, 2011), EPA assessed worker inhalation exposures to DCHP as an exposure to particulates of final products. Therefore, EPA estimated worker inhalation exposures during fabrication or use of final products or articles using the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix E.11.

In the model, EPA used a subset of the PNOR Model 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 occur during trimming, cutting, and/or abrasive actions on the DCHP-containing product. EPA used the highest expected concentration of DCHP in final products to estimate the concentration of DCHP in the particulates. For this OES, EPA identified 45 percent by mass as the highest expected DCHP concentration based on the estimated plasticizer concentrations in relevant products given by the Use of Additives in Plastic Compounding Generic Scenario (U.S. EPA, 2021c). EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates at this fixed concentration throughout the working shift.

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

Table 3-68 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposure to DCHP during fabrication or use of final products or articles. The high-end and central tendency exposures both use 250 days per year as the exposure frequency based on the assumption of facilities operating for 5 days/week with two full weeks of downtime. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DCHP in the form of product particulates and does not account for other potential inhalation exposure routes, such as from vapors, which EPA expects to be *de minimis*.

Table 3-68. Summary of Estimated Worker Inhalation Exposures for Fabrication or Use of Final Products or Articles

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration 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-hour TWA Exposure Concentration to Dust (mg/m^3)	0.09	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-hour TWA Exposure Concentration to Dust (mg/m^3)	0.09	0.09
	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

[a] EPA estimated worker inhalation exposures to dust using the PNOR Model (U.S. EPA, 2021c). For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES.

3.13.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various "Exposure Concentration Types" from Table 3-69 are explained in Appendix B. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Table 3-69 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs.

Table 3-69. Summary of Estimated Worker Dermal Exposures for Fabrication or Use of Final Products or Articles

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	Dose Rate (APDR, mg/day)	0.18	0.36
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.5E−03	3.1E−03
Female of Reproductive Age	Dose Rate (APDR, mg/day)	0.15	0.30
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−03	2.8E−03

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
ONU	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute (AD, mg/kg-day)	1.1E−03	1.1E−03
	Intermediate (IADD, mg/kg-day)	8.3E−04	8.3E−04
	Chronic, Non-Cancer (ADD, mg/kg-day)	7.7E−04	7.7E−04
[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).			

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 the table below.

Table 3-70. Summary of Estimated Worker Aggregate Exposures for Fabrication or Use of Final Products or Articles

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.4E−02	0.11
	Intermediate (IADD, mg/kg-day)	9.9E−03	7.8E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	9.3E−03	7.2E−02
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.5E−02	0.12
	Intermediate (IADD, mg/kg-day)	1.1E−02	8.5E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	9.9E−03	7.9E−02
ONU	Acute (AD, mg/kg-day)	1.2E−02	1.2E−02
	Intermediate (IADD, mg/kg-day)	9.1E−03	9.1E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	8.5E−03	8.5E−03
Note: A worker or ONU could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.14 Recycling

3.14.1 Process Description

EPA identified minimal information regarding the recycling of products containing DCHP but assumed that DCHP is primarily recycled industrially in the form of DCHP-containing PVC/plastic waste streams. Based on this report by Sika Corporation, plastic roofing membrane recycling is completed using mechanical recycling technology, in the form of scrap regrinding and recycling (Irwin, 2022). The Agency did not identify additional information on PVC/plastic recycling from systematic review. Although chemical/feedstock recycling is possible, EPA did not identify any market share data indicating chemical/feedstock recycling processes for DCHP-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 to 453 kg (APR, 2023). The bales are unloaded into process vessels, where the DCHP is ground and separated from non-PVC fractions using electrostatic separation, washing/floatation, or air/jet separation. Following cooling of ground PVC, 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 3-14 provides an illustration of the PVC recycling process (U.S. EPA, 2021c).

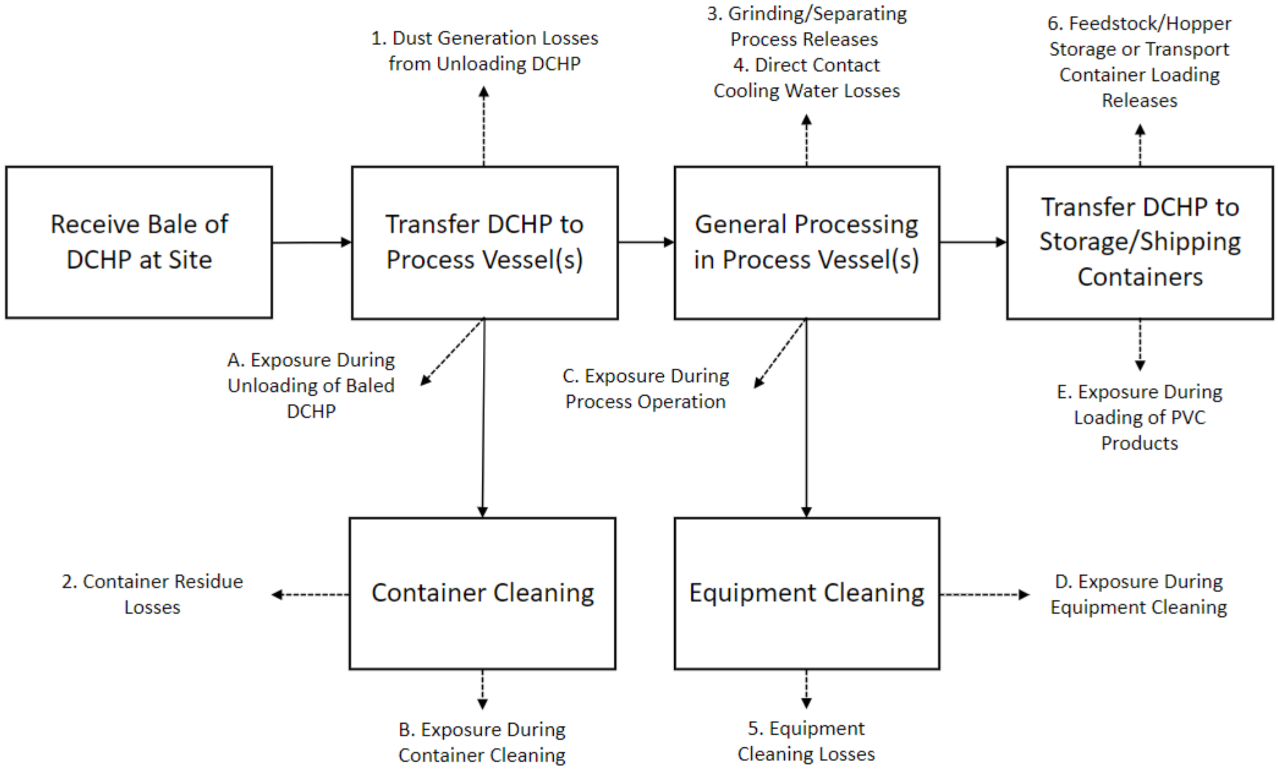

Figure 3-14. DCHP-containing PVC Recycling Flow Diagram (Irwin, 2022; U.S. EPA, 2021c)

3.14.2 Facility Estimates

ENF Recycling (ENF, 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 at the same site. Such sites would be identified primarily by the manufactured product; however, EPA used compounding site parameters and release estimates based on generic values specified in the 2021 Generic Scenario on Plastics Compounding, which would incorporate all PVC material streams whether from recycled or virgin production (U.S. EPA, 2021c).

EPA was unable to identify a quantifiable recyclable volume of DCHP-containing PVC. The Agency based volume estimates on data found for PVC waste that contained the phthalates Diisononyl Phthalate (DINP) and Diisodecyl Phthalate (DIDP), and scaled these estimates based on overall production volumes for the use of these chemicals in plastic products. The *Quantification and Evaluation of Plastic Waste in the United States* estimated that of the 699 kilotons of PVC waste managed in 2019, 3 percent, or 20,970,000 kg, of PVC was recycled (Milbrandt et al., 2022). The 2010 technical report on the *Evaluation of New Scientific Evidence Concerning DINP and DIDP* estimated the fraction of DIDP-containing and DINP-containing PVC used in the overall PVC market as 9.78 percent and 18.3 percent, respectively (ECHA, 2010). As a result, EPA calculated the use rate of recycled PVC plastics containing DIDP as 9.78 percent of the yearly recycled production volume of PVC, or 2,050,866 kg/year. For DINP the use rate was calculated as 18.3 percent of the yearly recycled production volume of PVC or

3,846,801 kg/year. The Agency related the DINP and DIDP information to the production volume of DCHP used in plastic products to develop scaling factors for recyclable PVC volumes (see Table 3-71).

Table 3-71. Production Volumes Used to Develop Recycling Estimates

Chemical	Production Volume of Plastic Products (kg/year)	Source
DCHP	18,543–222,659	See Section 3.8.2
DINP	64,568,873–473,505,075	(U.S. EPA, 2025c)
DIDP	43,859,857–434,749,009	(U.S. EPA, 2024)

EPA divided the end points of the PV range for DCHP by the endpoints for the ranges of the other two phthalates to develop scaling factors:

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

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

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

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

3.14.3 Release Assessment

3.14.3.1 Environmental Release Points

EPA assigned release points based on the 2021 Generic Scenario on Plastic Compounding (U.S. EPA, 2021c). The GS identified default models to quantify releases from each release point. The Agency expects fugitive air, water, incineration, or landfill releases from storage or loading of recycled plastic and general recycling processing. Releases to water, incineration, or landfill are expected from container residue losses and equipment cleaning. EPA expects wastewater releases from direct contact cooling water. The Agency expects stack air releases from loading recycled plastics into storage or transport containers. Due to lack of process information at recycling sites, EPA assumes that these sites do not utilize air pollution capture and control technologies.

3.14.3.2 Environmental Release Assessment Results

Table 3-72 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES.

Table 3-72. Summary of Modeled Environmental Releases for Recycling

Modeled Scenario	Environmental Media	Annual Release (kg/site-year) [b]		Number of Release Days		Daily Release (kg/site-day) [b]	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	Central Tendency
5,857 kg production volume	Stack air	0.16	0.93	223	254	7.4E−04	4.3E−03
	Fugitive air, water, incineration, or landfill[a]	0.61	2.0			2.8E−03	9.2E−03
	Wastewater	0.42	0.83			1.9E−03	3.9E−03
	Water, incineration, or landfill[a]	1.4	2.9			1.3	1.8

[a] When multiple environmental media are addressed together, releases may go all to 1 media or be split between media depending on site-specific practices. Not enough data were available to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DCHP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

3.14.4 Occupational Exposure Assessment

3.14.4.1 Worker Activities

At PVC recycling sites, worker exposures from dermal contact with solids and inhalation of dust may occur during the unloading of bailed PVC, or loading of 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 who work in the processing area but do not directly handle DCHP-containing PVC to be recycled 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.

3.14.4.2 Number of Workers and ONUs

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 DCHP during recycling. 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. The Agency assigned the NAICS codes 562212 – Solid Waste Landfill, 562213 – Solid Waste Combustors and Incinerators, and 562219 – Other Nonhazardous Waste Treatment and Disposal for this OES based on the NAICS codes that related to the process description in Section 3.13.1.
Table 3-73 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 recycle and dispose of DCHP-containing materials and estimated the total number of potential recycling sites to be 58 sites based on the number of PVC recyclers from ENF Recycling (ENF, 2024).

Table 3-73. Estimated Number of Workers Potentially Exposed to DCHP During Recycling and Disposal

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]
562212 – Solid Waste Landfill	N/A	3	N/A	2	N/A
562213 – Solid Waste Combustors and Incinerators		13		8	
562219 – Other Nonhazardous Waste Treatment and Disposal		3		2	
Total/Average	**58**	**6**	**348**	**4**	**232**

[a] Results not assessed by NAICS code for this scenario.
[b] Number of workers and ONUs per site are calculated by dividing the total number of exposed workers or ONUs by the total number of establishments for a given NAICS code. The number of workers and ONUs are rounded to the nearest integer. Values that would otherwise be displayed as "0" are left unrounded.

3.14.4.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data (dust or vapor) to assess exposures to DCHP during recycling processes. Based on the presence of DCHP as an additive in plastics (CPSC, 2011), EPA assessed worker inhalation exposures to DCHP as an exposure to particulates of recycled plastic materials. Therefore, EPA estimated worker inhalation exposures during recycling using the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix E.11.

In the model, EPA used a subset of the PNOR Model 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. The Agency used the highest expected concentration of DCHP in recyclable plastic products to estimate the concentration of DCHP present in particulates. For this OES, EPA identified 45 percent by mass as the highest expected DCHP concentration based on the estimated plasticizer concentrations in flexible PVC given by the 2021 Generic Scenario on Plastic Compounding (U.S. EPA, 2021c). EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates of the plastic at this fixed concentration throughout the working shift.

The PNOR Model (U.S. EPA, 2021b) estimates an 8-hour TWA for particulate concentrations by assuming exposures outside the sample duration are zero. The model does not determine exposures during individual worker activities. EPA used the number of operating days estimated in the release assessment for this OES to estimate exposure frequency. 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. In absence of data specific to ONU exposure, EPA assumes that worker central tendency exposure is representative of ONU exposure.

Table 3-74 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DCHP during recycling. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DCHP in the form of plastic particulates and does not account for other potential inhalation exposure routes, such as from the inhalation of vapors, which EPA expects to be *de minimis*.

Table 3-74. Summary of Estimated Worker Inhalation Exposures for Recycling

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration 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-hour 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-hour 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

[a] EPA estimated worker inhalation exposures to dust using the PNOR Model (U.S. EPA, 2021c),. For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES.

3.14.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-75 are explained in Appendix B. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Table 3-75 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs.

Table 3-75. Summary of Estimated Worker Dermal Exposures for Recycling

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	Dose Rate (APDR, mg/day)	0.18	0.36
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−03	3.1E−03
Female of Reproductive Age	Dose Rate (APDR, mg/day)	0.15	0.30
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.3E−03	2.8E−03
ONU	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute (AD, mg/kg-day)	1.1E−03	1.1E−03
	Intermediate (IADD, mg/kg-day)	8.3E−04	8.3E−04
	Chronic, Non-Cancer (ADD, mg/kg-day)	6.9E−04	7.7E−04

[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).

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 the table below.

Table 3-76. Summary of Estimated Worker Aggregate Exposures for Recycling

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.6E−02	0.20
	Intermediate (IADD, mg/kg-day)	1.2E−02	0.15
	Chronic, Non-Cancer (ADD, mg/kg-day)	9.6E−03	0.14
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.7E−02	0.22
	Intermediate (IADD, mg/kg-day)	1.2E−02	0.16
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.0E−02	0.15
ONU	Acute (AD, mg/kg-day)	1.5E−02	1.5E−02
	Intermediate (IADD, mg/kg-day)	1.1E−02	1.1E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	8.9E−03	1.0E−02

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

3.15 Waste Handling, Treatment, and Disposal

3.15.1 Process Description

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

Wastewater

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

Solid Wastes

Solid wastes are defined under RCRA as any material that is discarded by being: abandoned; inherently waste-like; a discarded military munition; or recycled in certain ways (certain instances of the generation and legitimate reclamation of secondary materials are exempted as solid wastes under RCRA). Solid wastes may subsequently meet RCRA's definition of hazardous waste by either being listed as a waste at 40 CFR 261.30 to 261.35 or by meeting waste-like characteristics 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. DCHP 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 DCHP 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 DCHP is included in each of the COU assessments in Sections 3.1 through 3.14.

Off-site transfers of DCHP and DCHP-containing wastes to land disposal, wastewater treatment, incineration, and recycling facilities are expected based on industry supplied data, and published EPA and OECD emission documentation such as Generic Scenarios and Emission Scenario Documents. Off-site transfers are incinerated, sent to land disposal, sent to wastewater treatment, are recycled off-site, and/or are sent to other or unknown off-site disposal/treatment (see Figure 3-15).

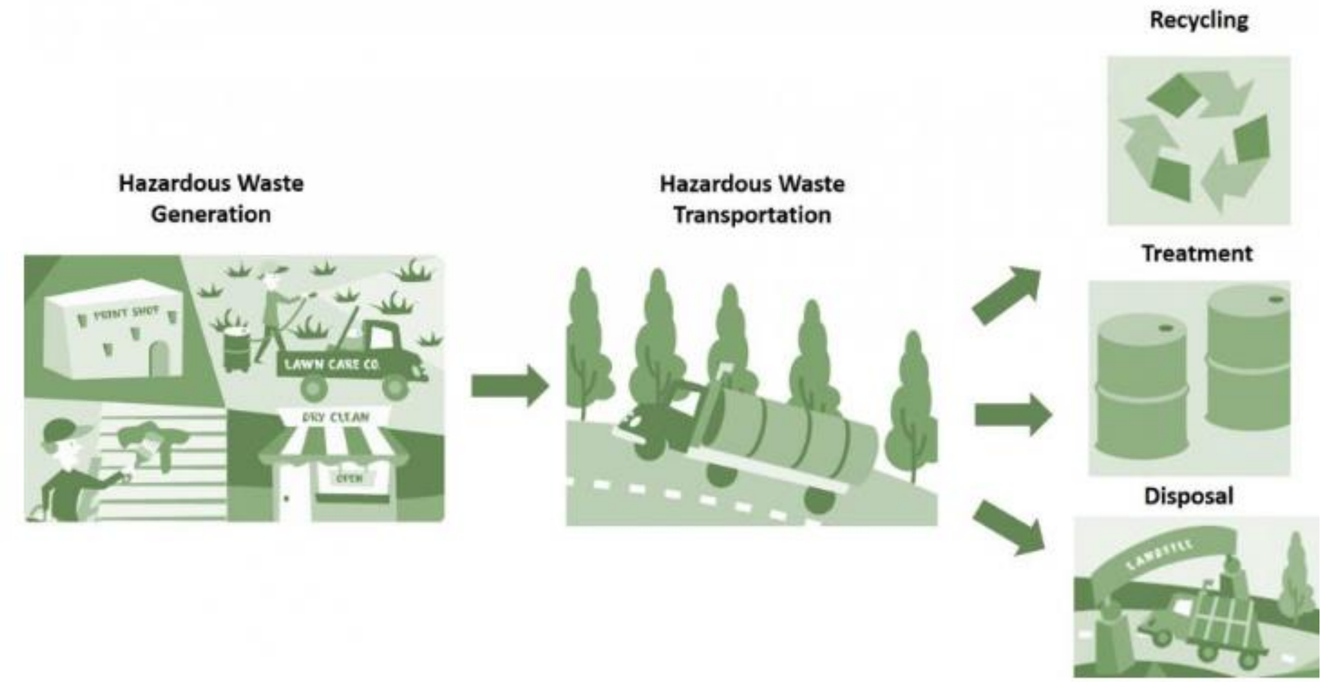

Figure 3-15. Typical Waste Disposal Process
Source: (U.S. EPA, 2019b) (https://www.epa.gov/hw/learn-basics-hazardous-waste; accessed December 16, 2025)

Municipal Waste Incineration
Municipal waste combustors (MWCs) that recover energy are generally located at large facilities and comprised of an enclosed tipping floor and a deep waste storage pit. Typical large MWCs range in capacity from 250 to over 1,000 tons per day. At facilities of this scale, waste materials are not generally handled directly by workers. Trucks may dump the waste directly into the pit, or waste may be tipped to the floor and later pushed into the pit by a worker operating a front-end loader. A large grapple from an overhead crane is used to grab waste from the pit and drop it into a hopper, where hydraulic rams feed the material continuously into the combustion unit at a controlled rate. The crane operator also uses the grapple to mix the waste within the pit, in order to provide 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, is continuously drawn into the combustion unit via one or more forced air fans to serve as the primary combustion air and minimize odors. Dust and lint present in the air is typically captured in filters or other cleaning devices to prevent the clogging of steam coils, which are used to heat the combustion air and help dry higher-moisture inputs (Kitto and Stultz, 1992).

Municipal Waste Landfill
Municipal solid waste landfills are discrete areas of land or excavated sites that receive household wastes and other types of non-hazardous wastes (*e.g.*, industrial and commercial solid wastes). Standards and requirements for municipal waste landfills include location restrictions, composite liner requirements, leachate collection and removal systems, operating practices, groundwater monitoring

requirements, corrective action provisions, and closure-and post-closure care requirements that include financial assurance. Non-hazardous solid wastes are regulated under RCRA Subtitle D, but states may impose more stringent requirements.

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

Hazardous Waste Landfill

Hazardous waste landfills are excavated or engineered sites specifically designed for the final disposal of non-liquid hazardous wastes. Design standards for these landfills require double liner, double leachate collection and removal systems, leak detection systems, runoff and wind dispersal controls, and construction quality assurance program.[5] 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 40 CFR 264/265, subpart N.

3.15.2 Facility Estimates

The concentration of DCHP in waste materials varies depending on the type of product and the 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 DCHP-containing wastes occur at all levels of the DCHP life cycle. The Agency 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. 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 DCHP-specific data; however, EPA expects releases to the environment from disposal sites to be small and disperse in comparison to other upstream OES, as EPA expects DCHP 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.

3.15.4 Occupational Exposure Assessment

3.15.4.1 Worker Activities

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

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[5] https://www.epa.gov/hwpermitting/hazardous-waste-management-facilities-and-units (accessed December 16, 2025).

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 to 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 and dust 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.

3.15.4.2 Number of Workers and ONUs

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 DCHP during 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. The Agency assigned the NAICS codes 562212 – Solid Waste Landfill, 562213 – Solid Waste Combustors and Incinerators, and 562219 – Other Nonhazardous Waste Treatment and Disposal for this OES based on the NAICS codes that related to the process description in Section 3.15.1. Table 3-77 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 DCHP-containing materials.

Table 3-77. Estimated Number of Workers Potentially Exposed to DCHP During Waste Handling, Treatment, and Disposal

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
562212 – Solid Waste Landfill	N/A	3	N/A	2	N/A
562213 – Solid Waste Combustors and Incinerators		13		8	
562219 – Other Nonhazardous Waste Treatment and Disposal		3		2	

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
Total/Average	58	6	348	4	232
[a] Number of workers and ONUs per site are calculated by dividing the total number of exposed workers or ONUs by the total number of establishments for a given NAICS code. The number of workers and ONUs are rounded to the nearest integer. Values that 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 DCHP during disposal processes. Based on the presence of DCHP as an additive in plastics (CPSC, 2011), EPA assessed worker inhalation exposures to DCHP as an exposure to particulates of discarded plastic materials. Therefore, EPA estimated worker inhalation exposures during disposal using the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix E.11.

In the model, EPA used a subset of the PNOR Model 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. The Agency used the highest expected concentration of DCHP in plastic products to estimate the concentration of DCHP present in particulates. For this OES, EPA identified 45 percent by mass as the highest expected DCHP concentration based on the estimated plasticizer concentrations in flexible PVC given by the 2021 Generic Scenario on Plastic Compounding (U.S. EPA, 2021c). EPA assumed that the concentration of DCHP in the dust in the air is the same the material. The estimated exposures assume that DCHP is present in particulates of the plastic at this fixed concentration throughout the working shift.

The PNOR Model (U.S. EPA, 2021b) estimates an 8-hour TWA for particulate concentrations by assuming exposures outside the sample duration are zero. The model does not determine exposures during individual worker activities. Due to expected process similarities, EPA used the number of operating days estimated in the release assessment for the recycling OES to estimate exposure frequency. The high-end 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.

Table 3-78 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DCHP during disposal. Appendix B describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DCHP in the form of plastic particulates and does not account for other potential inhalation exposure routes, such as from the inhalation of vapors, which EPA expects to be *de minimis*.

Table 3-78. Summary of Estimated Worker Inhalation Exposures for Disposal

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration to Dust (mg/m³)	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-hour TWA Exposure Concentration to Dust (mg/m³)	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-hour TWA Exposure Concentration to Dust (mg/m³)	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

[a] EPA estimated worker inhalation exposures to dust using the PNOR Model (U.S. EPA, 2021c),. For the PNOR Model, EPA multiplied the concentration of DCHP with the CT and HE estimates of the relevant NAICS code from the PNOR Model to calculate the CT and HE estimates for this OES.

3.15.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal absorption modeling approach outlined in Appendix D. The various “Exposure Concentration Types” from Table 3-79 are explained in Appendix B. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. Table 3-79 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs.

Table 3-79. Summary of Estimated Worker Dermal Exposures for Disposal

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	Dose Rate (APDR, mg/day)	0.18	0.36
	Acute (AD, mg/kg-day)	2.3E−03	4.5E−03
	Intermediate (IADD, mg/kg-day)	1.7E−03	3.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−03	3.1E−03
Female of Reproductive Age	Dose Rate (APDR, mg/day)	0.15	0.30
	Acute (AD, mg/kg-day)	2.1E−03	4.1E−03
	Intermediate (IADD, mg/kg-day)	1.5E−03	3.0E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.3E−03	2.8E−03
ONU	Dose Rate (APDR, mg/day)	9.0 E−02	9.0 E−02
	Acute (AD, mg/kg-day)	1.1E−03	1.1E−03
	Intermediate (IADD, mg/kg-day)	8.3E−04	8.3E−04
	Chronic, Non-Cancer (ADD, mg/kg-day)	6.9E−04	7.7E−04

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
[a] For high-end estimates of workers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates of workers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers). For dermal exposure estimates of ONUs, EPA assumed the exposure surface area was equivalent to the mean value for 1 palm of an adult male (*i.e.*, 268 cm^2). An absorption duration of 8 hours was used for estimating all occupational dermal exposures. 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).			

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 the table below.

Table 3-80. Summary of Estimated Worker Aggregate Exposures for Disposal

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.6E−02	0.20
	Intermediate (IADD, mg/kg-day)	1.2E−02	0.15
	Chronic, Non-Cancer (ADD, mg/kg-day)	9.6E−03	0.14
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.7E−02	0.22
	Intermediate (IADD, mg/kg-day)	1.2E−02	0.16
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.0E−02	0.15
ONU	Acute (AD, mg/kg-day)	1.5E−02	1.5E−02
	Intermediate (IADD, mg/kg-day)	1.1E−02	1.1E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	8.9E−03	1.0E−02
Note: A worker or ONU could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.16 Distribution in Commerce

3.16.1 Process Description

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

4 WEIGHT OF SCIENTIFIC EVIDENCE CONCLUSIONS

4.1 Environmental Releases

For each OES, EPA considered the assessment approach; the quality of the data and models; and the strengths, limitations, assumptions, and key sources of uncertainties in the assessment results to determine a weight of scientific evidence rating. The Agency 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). The Agency 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 environmental release 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 surrogates DINP and DIDP industry-supplied data). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, with media of release assessed using assumptions from EPA/OPPT models and industry supplied data. EPA believes a strength of the Monte Carlo modeling approach is that variation in model input values allows for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Additionally, Monte Carlo modeling uses a large number of data points (simulation runs) and considers the full distributions of input parameters. EPA used facility-specific DCHP manufacturing volumes for all facilities that reported this information to CDR and non-DCHP-specific operating parameters derived using data from a current U.S. manufacturing site for DIDP and DINP that is assumed to operate using similar operating parameters as DCHP manufacturing. This information was used to provide more accurate estimates than the generic values provided by the EPA/OPPT models. These strengths increase the weight of evidence. The primary limitation of EPA's approach is the uncertainty in the representativeness of release estimates toward the true distribution of the potential releases. In addition, one DCHP manufacturing site claimed their DCHP production volume as CBI for the purpose of CDR reporting; therefore, DCHP throughput estimates for this site are based on the site's reported export volume and their reported PV percentage for industrial use. Additional limitations include uncertainties in the representativeness of the surrogate industry-provided operating parameters from DIDP and DINP and the generic EPA/OPPT models for DCHP manufacturing sites. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several limitations discussed above, such as using surrogate parameters, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is slight to moderate, 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 Generic Scenario (U.S. EPA, 2022), which the systematic review process rated high for data quality. EPA also referenced the *2023 Methodology for Estimating Environmental Releases from Sampling Wastes* (U.S. EPA, 2023b). EPA 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 GS and EPA/OPPT models. EPA believes a strength of the Monte Carlo modeling approach is that variation in model input values allows for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Additionally, Monte Carlo modeling uses a large number of data points (simulation runs) and the full distributions of input parameters. These strengths increase the weight of evidence. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of the potential releases at all sites in this OES. Specifically, because the default values in the GS 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 DCHP. In addition, EPA lacks DCHP facility import volume data for all CDR-reporting import and repackaging sites

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	due to claims of CBI; therefore, throughput estimates for these sites are based on the CDR reporting threshold of 25,000 lb and an annual DCHP national aggregate production volume range from CDR. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several limitations discussed above, such as using default generic parameters, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is slight to moderate, considering the strengths and limitations of the reasonably available data.
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 (OECD, 2009a), which has a high data quality rating based on the systematic review process. 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 a strength of the Monte Carlo modeling approach is that variation in model input values allows for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DCHP-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. The safety and product data sheets that EPA obtained these values from have high and medium data quality ratings based on the systematic review process. These strengths increase the weight of evidence. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of the 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 DCHP into adhesives and sealants. In addition, EPA lacks data on DCHP-specific facility production volume and number of formulation sites, which are needed to estimate site throughput of DCHP. EPA based throughput on the CDR reporting threshold of 25,000 lb, an annual DCHP national aggregate production volume range, and ranges of downstream sites. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several limitations discussed above, such as using default generic parameters, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is slight to moderate, 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 (U.S. EPA, 2014a), which has a medium data quality rating based on systematic review. 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 a strength of the Monte Carlo modeling approach is that variation in model input values allows for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DCHP-specific data on concentrations in paint and coating products to provide more accurate estimates of DCHP concentrations than the generic values provided by the GS. The safety and

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	product data sheets that EPA obtained these values from have medium to high data quality ratings based on the systematic review process. These strengths increase the weight of evidence. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of the 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 DCHP into paints and coatings, particularly for sites formulating other coating types (*e.g.*, solvent-borne coatings). In addition, EPA lacks data on DCHP-specific facility production volume and number of formulation sites; therefore, EPA based throughput and production volume estimates on CDR which has a reporting threshold of 25,000 lb, an annual DCHP production national aggregate production volume range, and ranges of downstream sites. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several limitations discussed above, such as using default generic parameters, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is slight to moderate, considering the strengths and limitations of the reasonably available data.
Incorporation into other formulations, mixtures, or reaction products	EPA found limited chemical specific data for the incorporation into other formulations, mixtures, or reaction products OES and assessed releases to the environment using the Draft GS for the Formulation of Waterborne Coatings (U.S. EPA, 2014a), which has a medium data quality rating based on systematic review process. 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 a strength of the Monte Carlo modeling approach is that variation in model input values allows for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DCHP-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 and medium data quality ratings based on the systematic review process. These strengths increase the weight of evidence. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of the potential releases at all sites in this OES. Specifically, the generic default values in the GS are based on the formulation of paints and coatings and may not represent releases from real-world sites that incorporate DCHP into other formulations, mixtures, or reaction products. In addition, because no entries in CDR indicated a use relevant to this formulation OES, and there were no other sources to estimate the volume of DCHP used in this OES, EPA developed a high-end bounding estimate for production volume based on the CDR reporting threshold of 25,000 lb or 5% of total product volume for a given use, which by definition is expected to over-estimate the average release case. For DCHP facility throughputs, EPA used a range of generic default values in the GS. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several limitations discussed above, such as using default generic parameters, reduced the

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is slight to moderate, considering the strengths and limitations of the reasonably available data.
PVC plastics compounding	EPA found limited chemical specific data for the plastics compounding OES and assessed releases to the environment using the Revised Draft GS for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c), which has a medium data quality rating based on systematic review. 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 a strength of the Monte Carlo modeling approach is that variation in model input values allows for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. These strengths increase the weight of evidence. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of the potential releases at all sites in this OES. The generic default concentration values in the GS consider all types of plastic compounding and may not represent releases from real-world sites that compound DCHP into specific types of plastic raw material. In addition, EPA lacks data on DCHP-specific facility production volume and number of compounding sites; therefore, EPA estimated throughput and production volume based on CDR which has a reporting threshold of 25,000 lb and an annual DCHP production national aggregate production volume range. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several limitations discussed above, such as using default generic parameters, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is slight to moderate, considering the strengths and limitations of the reasonably available data.
PVC plastics converting	EPA found limited chemical specific data for the 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, 2021d). 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 a strength of the Monte Carlo modeling approach is that variation in model input values allows for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Monte Carlo also considers a large number of data points (simulation runs) and the full distributions of input parameters. These strengths increase the weight of evidence. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of the 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 DCHP-containing raw material into plastic articles using a variety of methods, such as extrusion or calendering. In addition, EPA lacks data on DCHP-specific facility production volume and number of converting sites; therefore, EPA estimated throughput based on CDR which has a reporting threshold of 25,000 lb, an annual DCHP national aggregate production volume range, and ranges of downstream sites. These limitations decrease the weight of evidence.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several limitations discussed above, such as using default generic parameters, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is slight to moderate, 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 (U.S. EPA, 2021c; OECD, 2004a). Both sources have a medium data quality rating based on the systematic review process. 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 a strength of the Monte Carlo modeling approach is that variation in model input values allows for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. These strengths increase the weight of evidence. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of the potential releases at all sites in this OES. Specifically, there was a lack of concentration data for specific products that contained DCHP; EPA relied on the GS and ESD to generate concentration estimates. These values may not be representative of actual values from real-world sites that compound DCHP into non-PVC material. In addition, because no entries in CDR indicated a use relevant to compounding or converting non-PVC material, and there were no other sources to estimate the volume of DCHP used in this OES, EPA developed a high-end bounding estimate based on the CDR reporting threshold of 25,000 lb or 5% of total product volume for a given use, which by definition is expected to over-estimate the average release case. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several limitations discussed above, such as using generic concentration values, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is slight to moderate, 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 (U.S. EPA, 2021d; OECD, 2004a). Both documents have a medium data quality rating based on systematic review. 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 a strength of the Monte Carlo modeling approach is that variation in model input values allows for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. These strengths increase the weight of evidence. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of the potential releases at all sites in this OES. Specifically, there was a lack of concentration data for specific products that

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	contained DCHP; EPA relied on the GS and ESD to generate concentration estimates. These values may not be representative of actual values from real-world sites that convert DCHP into non-PVC articles. In addition, because no entries in CDR indicated a use relevant to compounding or converting non-PVC material, and there were no other sources to estimate the volume of DCHP or number of sites used in this OES, EPA developed a range of high-end bounding estimates based on the CDR reporting thresholds, or 25,000 lb of 5% of total product volume for a given use, which by definition is expected to over-estimate the average release case. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several limitations discussed above, such as using generic concentration values, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is slight to moderate, 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* (OECD, 2015a), which has a medium data quality rating based on systematic review. 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 a strength of the Monte Carlo modeling approach is that variation in model input values allows for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DCHP-specific data on concentration and application methods for different DCHP-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 and medium data quality ratings from the systematic review process. These strengths increase the weight of evidence. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of the 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 DCHP into adhesives and sealants. The overall production volume of DCHP for this OES was based on CDR data using the same assumptions as the Incorporation into adhesives and sealants OES. EPA lacks data on DCHP-specific facility use volume and number of use sites; therefore, EPA based facility throughput estimates and number of sites on industry-specific default facility throughputs from the ESD, DCHP product concentrations, and the overall production volume range from CDR data which has a reporting threshold of 25,000 lb. EPA also had minimal data for solid additives in adhesives, and had to base the DCHP concentration range for solid additives on the SDS for one product. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several limitations discussed above, such as using generic default values, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is slight to moderate, considering the strengths and limitations of the reasonably available data.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
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 and the GS on Coating Application via Spray Painting in the Automotive Refinishing Industry (U.S. EPA, 2014b; OECD, 2011b). These documents have a medium data quality rating based on the systematic review process. 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 a strength of the Monte Carlo modeling approach is that variation in model input values allows for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DCHP-specific data on concentration for different DCHP-containing paints and coatings 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 and medium data quality ratings based on the systematic review process. These strengths increase the weight of evidence. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of the potential releases at all sites in this OES. Specifically, the generic default values in the GS and ESD may not represent releases from real-world sites that incorporate DCHP 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 DCHP-specific facility use volume and number of use sites; therefore, EPA based throughput estimates on values from ESD, GS, and CDR data which has a reporting threshold of 25,000 lb and an annual DCHP production volume range. EPA also lacked data for ready-to-apply coatings and consequently assumed a concentration range for liquid coatings based on the SDS for one product. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several limitations discussed above, such as using generic default values, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is slight to moderate, considering the strengths and limitations of the 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 (U.S. EPA, 2023c), which has a high data quality rating based on systematic review. 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 DCHP materials. EPA believes a strength of the Monte Carlo modeling approach is that variation in model input values allows for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. EPA used SDSs from identified laboratory DCHP products to inform product concentration and material states. These strengths increase the weight of evidence. EPA believes the primary limitation to be the uncertainty in the representativeness of values toward the true distribution of the potential releases. In addition, EPA lacks data on DCHP-specific laboratory chemical throughput and number of laboratories; therefore, EPA

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	based the number of laboratories and throughput estimates on stock solution throughputs from the GS on the Use of Laboratory Chemicals (U.S. EPA, 2023c) and on CDR reporting thresholds. Additionally, because no entries in CDR indicate a laboratory use and there were no other sources to estimate the volume of DCHP used in this OES, EPA developed a high-end bounding estimate based on the CDR reporting threshold of 25,000 lb or 5% of total product volume for a given use, which, by definition, is expected to over-estimate the average release case. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several limitations discussed above, such as using generic default values, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is slight to moderate, considering the strengths and limitations of the reasonably available data.
Fabrication or use of final 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.
Recycling	EPA found limited chemical specific data for the recycling OES. EPA assessed releases to the environment from recycling activities using the Revised Draft GS for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c) as surrogate for the recycling process. The GS has a medium data quality rating based on systematic review. EPA/OPPT models were combined with Monte Carlo modeling to estimate releases to the environment. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values is more likely to capture actual releases than discrete values. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. EPA referenced the *Quantification and Evaluation of Plastic Waste in the United States*, which has a medium quality rating based on systematic review (Milbrandt et al., 2022), to estimate the rate of PVC recycling in the United States. EPA estimated the DCHP PVC market share (based on the surrogate market shares from DINP and DIDP) to define an approximate recycling volume of PVC containing DCHP. These strengths increase the weight of evidence. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of the potential releases at all sites in this OES. Specifically, the generic default values and release points in the GS represent all types of plastic compounding sites and may not represent sites that recycle PVC products containing DCHP. In addition, EPA lacks DCHP-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 DCHP, and may not accurately reflect current U.S. recycling volume. DCHP may also be present in non-PVC plastics that are recycled; however, EPA was unable to identify information on these recycling practices. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several limitations discussed above, such as using generic default values, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is slight to moderate, considering the strengths and limitations of the reasonably available data.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
Waste handling, treatment, and disposal	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.
Distribution in commerce	These releases are assessed as part of individual OESs where the relevant activities occur.

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. The Agency considered factors that increase or decrease the strength of the evidence supporting the occupational exposure estimate—including quality of the data/information, applicability of the exposure data to the OES (including considerations of temporal relevance, locational relevance) and the representativeness of the estimate for the whole industry. The best professional judgment is summarized using the descriptors of robust, moderate, slight, or indeterminant, according to EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances, Version 1.0: A Generic TSCA Systematic Review Protocol with Chemical-Specific Methodologies* (also called the "2021 Systematic Review Protocol") (U.S. EPA, 2021a). For example, a conclusion of moderate is appropriate where exposure data are generated from a generic model with high data quality and some chemical-specific or industry-specific inputs such that the exposure estimate is a reasonable representation of potential 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 the 2021 Systematic Review Protocol 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 OES.

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 8-hour TWA inhalation exposure estimates for the manufacturing OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA CEHD data (OSHA, 2020). EPA used a subset of the respirable particulate data from the generic model identified with the Chemical Manufacturing NAICS code (NAICS code 325) to assess this OES, which EPA expects to be the most representative subset of the particulate data in the absence of chemical-specific data. EPA estimated the highest expected concentration of DCHP in particulates during manufacturing using DCHP concentration information from CDR reporters, which was also rated high for data quality in the systematic review process (U.S. EPA, 2020a). These strengths increase the weight of scientific evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DCHP is uncertain. Further, the model is not chemical specific and lacks metadata on worker activities. EPA also assumed 8 exposure hours per day and 250 exposure days per year based on continuous DCHP exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. EPA did not account for vapor inhalation exposures, but vapor exposures are not expected to significantly contribute to overall inhalation exposure when compared to particulate exposures. This is based on DCHP's vapor pressure, and the solid physical form assessed for this OES. These limitations decrease the weight of evidence. The use of the PNOR Model which contains industry monitoring data from OSHA CEHD data set increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific and not containing worker activities reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation exposures.
Import and repackaging	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates for the import and repackaging OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA CEHD data (OSHA, 2020). EPA used a subset of the respirable particulate data from the generic model identified with the Wholesale and Retail Trade NAICS codes (NAICS codes 42 through 45) to assess this OES, which EPA expects to be the most representative subset of the particulate data in the absence of chemical-specific data. EPA estimated the highest expected concentration of DCHP in particulates during import and repackaging using DCHP concentration information from CDR reporters, which was also rated high for data quality in the systematic review process (U.S. EPA, 2020a). These strengths increase the weight of evidence.

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DCHP is uncertain. Further, the model is not chemical specific and lacks metadata on worker activities. EPA also assumed 8 exposure hours per day and 208 to 250 exposure days per year based on continuous DCHP exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. EPA did not account for vapor inhalation exposures, but vapor exposures are not expected to significantly contribute to overall inhalation exposure compared to particulate exposures based on DCHP's vapor pressure and the solid physical form assessed for this OES. These limitations decrease the weight of evidence. The use of the PNOR Model which contains industry monitoring data from OSHA CEHD data set increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific and not containing worker activities reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation exposures.
Incorporation into 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-hour TWA inhalation exposure estimates for the incorporation into adhesives and sealants OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA CEHD data (OSHA, 2020). EPA used a subset of the respirable particulate data from the generic model identified with the Chemical Manufacturing NAICS code (NAICS code 325) to assess this OES, which EPA expects to be the most representative subset of the particulate data for chemical product manufacturing in the absence of DCHP-specific data. EPA estimated the highest expected concentration of DCHP in particulates during adhesive and sealant manufacturing using DCHP concentration information from CDR reporters, which was also rated high for data quality in the systematic review process (U.S. EPA, 2020a). These strengths increase the weight of evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DCHP is uncertain. Further, the model is not chemical specific and lacks metadata on worker activities. EPA also assumed 8 exposure hours per day and 250 exposure days per year based on continuous DCHP particulate exposure while unpacking DCHP received on site each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. EPA did not account for vapor inhalation exposures, but vapor exposures are not expected to significantly contribute to overall inhalation exposure compared to particulate exposures based on DCHP's vapor pressure and the solid physical form assessed for this OES. These limitations decrease the weight of evidence. The use of the PNOR Model which contains industry monitoring data from OSHA CEHD data set increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific and not containing worker activities

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation exposures.
Incorporation into 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-hour TWA inhalation exposure estimates for the incorporation into paints and coatings OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA CEHD data (OSHA, 2020). EPA used a subset of the respirable particulate data from the generic model identified with the Chemical Manufacturing NAICS code (NAICS code 325) to assess this OES, which EPA expects to be the most representative subset of the particulate data for chemical product manufacturing in the absence of DCHP-specific data. EPA estimated the highest expected concentration of DCHP in particulates during paint and coating manufacturing using DCHP concentration information from CDR reporters, which was also rated high for data quality in the systematic review process (U.S. EPA, 2020a). These strengths increase the weight of evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DCHP is uncertain. Further, the model is not chemical specific and lacks metadata on worker activities. EPA also assumed 8 exposure hours per day and 250 exposure days per year based on continuous DCHP particulate exposure while unpacking DCHP received on site each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. EPA did not account for vapor inhalation exposures, but vapor exposures are not expected to significantly contribute to overall inhalation exposure compared to particulate exposures based on DCHP's vapor pressure and the solid physical form assessed for this OES. These limitations decrease the weight of evidence. The use of the PNOR Model which contains industry monitoring data from OSHA CEHD data set increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific and not containing worker activities reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation exposures.
Incorporation into other formulations, mixtures, or reaction products	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates for the incorporation into other formulations, mixtures, or reaction products OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA CEHD data (OSHA, 2020). EPA used a subset of the respirable particulate data from the generic model identified with the Chemical Manufacturing NAICS code (NAICS code 325) to assess this OES, which EPA expects to be the most representative subset of the particulate data for chemical product manufacturing in the absence of DCHP-specific data. EPA estimated the highest expected concentration of DCHP in particulates during formulation, mixture or other

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	chemical product manufacturing using DCHP concentration information from CDR reporters, which was also rated high for data quality in the systematic review process (U.S. EPA, 2020a). These strengths increase the weight of evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DCHP is uncertain. Further, the model is not chemical specific and lacks metadata on worker activities. EPA also assumed 8 exposure hours per day and 250 exposure days per year based on continuous DCHP particulate exposure while unpacking DCHP received on site each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. EPA did not account for vapor inhalation exposures, but vapor exposures are not expected to significantly contribute to overall inhalation exposure compared to particulate exposures based on DCHP's vapor pressure and the solid physical form assessed for this OES. These limitations decrease the weight of evidence. The use of the PNOR Model which contains industry monitoring data from OSHA CEHD data set increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific and not containing worker activities reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation 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-hour TWA inhalation exposure estimates for PVC plastics compounding OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA CEHD data (OSHA, 2020). EPA used a subset of the respirable particulate data from the generic model identified with the Plastics and Rubber Manufacturing NAICS code (NAICS code 326) to assess this OES, which EPA expects to be the most representative subset of the particulate data for PVC plastic manufacturing in the absence of DCHP-specific data. EPA estimated the highest expected concentration of DCHP in particulates during PVC plastic compounding using DCHP concentration information from CDR reporters, which was also rated high for data quality in the systematic review process (U.S. EPA, 2020a). These strengths increase the weight of evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DCHP is uncertain. Further, the model is not chemical specific and lacks metadata on worker activities. EPA also assumed 8 exposure hours per day based on continuous DCHP particulate exposure while unpacking DCHP received on site each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. EPA set the number of exposure days based on Monte Carlo modeling of the operating days from the release assessment, with a maximum number of working days capped at 250 days per year based on EPA default assumptions. 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

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	assessment exceeded 250 days per year. 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. EPA did not account for vapor inhalation exposures, but vapor exposures are not expected to significantly contribute to overall inhalation exposure compared to particulate exposures based on DCHP's vapor pressure and the solid physical form assessed for this OES. These limitations decrease the weight of evidence. The use of the PNOR Model which contains industry monitoring data from OSHA CEHD data set increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific and not containing worker activities reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation exposures.
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 8-hour TWA inhalation exposure estimates for PVC plastics converting OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA CEHD data (OSHA, 2020). EPA used a subset of the respirable particulate data from the generic model identified with the Plastics and Rubber Manufacturing NAICS code (NAICS code 326) to assess this OES, which EPA expects to be the most representative subset of the particulate data for PVC plastics product manufacturing in the absence of DCHP-specific data. EPA estimated the highest expected concentration of DCHP in particulates during PVC plastic converting using plasticizer additive concentration information from the Use of Additives in Plastic Converting Generic Scenario that was rated medium for data quality in the systematic review process (U.S. EPA, 2004a). These strengths increase the weight of evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DCHP is uncertain. Further, the model is not chemical specific and lacks metadata on worker activities. EPA also assumed 8 exposure hours per day based on continuous DCHP particulate exposure while handling DCHP-containing plastics on site each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. EPA set the number of exposure days based on Monte Carlo modeling of the operating days from the release assessment, with a maximum number of working days capped at 250 days per year based on EPA default assumptions. 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. 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. EPA did not account for vapor inhalation exposures, but vapor exposures are not expected to significantly contribute to overall inhalation exposure compared to particulate exposures based on DCHP's vapor pressure and the solid physical form assessed for this OES. These limitations decrease the weight of evidence. The use of the PNOR Model which contains industry monitoring data from OSHA CEHD data set increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific and not containing worker activities

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation 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-hour TWA inhalation exposure estimates for non-PVC material compounding OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA CEHD data (OSHA, 2020). EPA used a subset of the respirable particulate data from the generic model identified with the Plastics and Rubber Manufacturing NAICS code (NAICS code 326) to assess this OES, which EPA expects to be the most representative subset of the particulate data for non-PVC plastic or rubber manufacturing in the absence of DCHP-specific data. EPA estimated the highest expected concentration of DCHP in particulates during non-PVC material compounding using DCHP concentration information from CDR reporters, which was also rated high for data quality in the systematic review process (U.S. EPA, 2020a). These strengths increase the weight of evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DCHP is uncertain. Further, the model is not chemical specific and lacks metadata on worker activities. EPA also assumed 8 exposure hours per day based on continuous DCHP particulate exposure while unpacking DCHP received on site each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. EPA set the number of exposure days based on Monte Carlo modeling of the operating days from the release assessment, with a maximum number of working days capped at 250 days per year based on EPA default assumptions. 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. The central tendency exposures use 227 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. EPA did not account for vapor inhalation exposures, but vapor exposures are not expected to significantly contribute to overall inhalation exposure compared to particulate exposures based on DCHP's vapor pressure and the solid physical form assessed for this OES. These limitations decrease the weight of evidence. The use of the PNOR Model which contains industry monitoring data from OSHA CEHD data set increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific and not containing worker activities reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation 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-hour TWA inhalation exposure estimates for non-PVC material converting OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA CEHD data (OSHA, 2020). EPA used a subset of the respirable particulate data from the generic model identified with the Plastics and Rubber Manufacturing NAICS code (NAICS code 326) to assess this OES, which EPA expects to be the most representative subset of the particulate data for non-PVC plastic and rubber product manufacturing in the absence of DCHP-specific data. EPA estimated the highest expected concentration of DCHP in particulates during non-PVC material converting using rubber plasticizer concentration information from the Emission Scenario Document on Additives in Rubber Industry which has a medium rating for data quality in the systematic review process (OECD, 2004a). These strengths increase the weight of evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DCHP is uncertain. Further, the model is not chemical specific and lacks metadata on worker activities. EPA also assumed 8 exposure hours per day based on continuous DCHP particulate exposure while handling DCHP-containing plastics or rubbers on site each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. EPA set the number of exposure days based on Monte Carlo modeling of the operating days from the release assessment, with a maximum number of working days capped at 250 days per year based on EPA default assumptions. 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. 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. EPA did not account for vapor inhalation exposures, but vapor exposures are not expected to significantly contribute to overall inhalation exposure compared to particulate exposures based on DCHP vapor pressure and the solid physical form assessed for this OES. These limitations decrease the weight of evidence. The use of the PNOR Model which contains industry monitoring data from OSHA CEHD data set increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific and not containing worker activities reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation 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-hour TWA inhalation exposure estimates for the application of adhesives and sealants OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA CEHD data (OSHA, 2020). EPA used the entire respirable particulate data set from the generic model to assess this OES, since adhesives and sealants containing DCHP may be used in a variety of end-use industries. EPA estimated the highest expected concentration of DCHP in particulates during application of adhesives and sealants using SDSs and product data sheets from identified DCHP-containing adhesives and sealant products in solid form. These strengths increase the weight of evidence.

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DCHP is uncertain. Further, the model is not chemical specific and lacks metadata on worker activities. EPA also assumed 8 exposure hours per day based on continuous DCHP particulate exposure while handling DCHP-containing products on site each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. EPA set the number of exposure days based on Monte Carlo modeling of the operating days from the release assessment, with a maximum number of working days capped at 250 days per year based on EPA default assumptions. 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. 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. EPA did not account for vapor inhalation exposures, but vapor exposures are not expected to significantly contribute to overall inhalation exposure compared to particulate exposures based on DCHP's vapor pressure and the solid physical form assessed for this OES. These limitations decrease the weight of evidence. The use of the PNOR Model which contains industry monitoring data from OSHA CEHD data set increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific and not containing worker activities reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation 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-hour 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 to DCHP in the liquid form (OECD, 2011a). EPA also used the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate, since DCHP may be received on site in solid form. The respirable particulate concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA CEHD data (OSHA, 2020). EPA used the entire respirable particulate data set from the generic model to assess this OES, since paints and coatings containing DCHP may be used in a variety of end-use industries. EPA used SDSs and product data sheets from identified DCHP-containing products to identify product concentrations for the liquid spray and the solid particulate assessments. A strength of this approach is that both models (for solid particulate and for mist exposure) resulted in exposure estimates within an order of magnitude of each other. These strengths increase the weight of evidence. The primary limitation is the lack of DCHP-specific monitoring data. Specifically, the ESD serves 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, and the generic model data represents particulate concentrations in air for solids handling exposures. 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 DCHP-

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	containing coatings. EPA only assessed mist or solid exposures to DCHP over a full 8-hour work shift to estimate the level of exposure, though other activities may result in exposures other than mist or solid particulate and application duration may be variable 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 DCHP-containing coatings at much lower or variable frequencies. These limitations decrease the weight of evidence. The use of the PNOR Model and Automotive Refinishing Spray Coating Mist Inhalation Model which contains industry monitoring data increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation exposures.
Use of laboratory chemicals	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates for use of laboratory chemicals OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA CEHD data (OSHA, 2020). EPA used a subset of the respirable particulate data from the generic model identified with the Professional, Scientific, and Technical Services NAICS code (NAICS code 54) to assess this OES, which EPA expects to be the most representative subset of the particulate data for use of laboratory chemicals in the absence of DCHP-specific data. EPA estimated the highest expected concentration of DCHP in particulates during laboratory use using SDSs and product data sheets from identified lab-grade chemicals. These strengths increase the weight of evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DCHP is uncertain. Further, the model is not chemical specific and lacks metadata on worker activities. EPA also assumed 8 exposure hours per day based on continuous DCHP particulate exposure while handling DCHP-containing products on site each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. EPA set the number of exposure days based on Monte Carlo modeling of the operating days from the release assessment, with a maximum number of working days capped at 250 days per year based on EPA default assumptions. 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. 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. EPA did not account for vapor inhalation exposures, but vapor exposures are not expected to significantly contribute to overall inhalation exposure compared to particulate exposures based on DCHP's vapor pressure and the solid physical form assessed for this OES. These limitations decrease the weight of evidence. The use of the PNOR Model which contains industry monitoring data from OSHA CEHD data set increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific and not containing worker activities reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation exposures.
Fabrication or use of final 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-hour TWA inhalation exposure estimates for the fabrication or use of final products or articles OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA CEHD data (OSHA, 2020). EPA used a subset of the respirable particulate data from the generic model identified with the Furniture and Related Product Manufacturing NAICS code (NAICS code 337) to assess this OES, which EPA expects to be the most representative subset of the particulate data for this OES. EPA estimated the highest expected concentration of DCHP in particulates during product fabrication using plasticizer additive concentration information from the Use of Additives in Plastic Converting Generic Scenario that has a medium rating for data quality from the systematic review process (U.S. EPA, 2004a). These strengths increase the weight of evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DCHP is uncertain. Further, the model is not chemical specific and lacks metadata on worker activities. EPA also assumed 8 exposure hours per day based on continuous DCHP particulate exposure while handling DCHP-containing products on site each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. EPA set the number of exposure days based on Monte Carlo modeling of the operating days from the release assessment, with a maximum number of working days capped at 250 days per year based on EPA default assumptions. 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. 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. EPA did not account for vapor inhalation exposures, but vapor exposures are not expected to significantly contribute to overall inhalation exposure compared to particulate exposures based on DCHP vapor pressure and the solid physical form assessed for this OES. These limitations decrease the weight of evidence. The use of the PNOR Model which contains industry monitoring data from OSHA CEHD data set increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific and not containing worker activities reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation exposures.
Recycling	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates for the recycling OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	CEHD data (OSHA, 2020). EPA used a subset of the respirable particulate data from the generic model identified with the Administrative and Support and Waste Management and Remediation Services NAICS code (NAICS code 56) to assess this OES, which EPA expects to be the most representative subset of the particulate data for this OES. EPA estimated the highest expected concentration of DCHP in plastic using plasticizer additive concentration information from the Use of Additives in Plastic Converting Generic Scenario that has a medium rating for data quality from the systematic review process (U.S. EPA, 2004a). These strengths increase the weight of evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DCHP is uncertain. Further, the model is not chemical specific and lacks metadata on worker activities. 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. These limitations decrease the weight of evidence. The use of the PNOR Model which contains industry monitoring data from OSHA CEHD data set increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific and not containing worker activities reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation exposures.
Waste handling, treatment, and disposal	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates for the waste handling, treatment, and disposal OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model were rated high for data quality from the systematic review process, and the model was built using OSHA CEHD data (OSHA, 2020). EPA used a subset of the respirable particulate data from the generic model identified with the Administrative and Support and Waste Management and Remediation Services NAICS code (NAICS code 56) to assess this OES, which EPA expects to be the most representative subset of the particulate data for this OES. EPA estimated the highest expected concentration of DCHP in plastic using plasticizer additive concentration information from the Use of Additives in Plastic Converting Generic Scenario that has a medium rating for data quality from the systematic review process (U.S. EPA, 2004a). These strengths increase the weight of evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DCHP is uncertain. Further, the model is not chemical specific and lacks metadata on worker activities. The high-end exposures use 250 days per year as the exposure frequency since the 95th percentile of operating days

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	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. These limitations decrease the weight of evidence. The use of the PNOR Model, which contains industry monitoring data from OSHA CEHD data set, increases the confidence of the assessment, but limitations of the model discussed above like data not being chemical specific and not containing worker activities reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence in the assessed inhalation exposures for average adult workers and females of reproductive age is moderate. EPA has slight to moderate confidence in the assessed inhalation exposures for ONUs since worker central tendency exposure values were assumed to be representative of ONU inhalation exposures.
Distribution in commerce	These exposures are assessed as part of individual OESs where the relevant activities occur.
Dermal	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 dermal exposure estimates. EPA used dermal modeling of aqueous materials (U.S. EPA, 2023a, 2004b) to estimate occupational dermal exposures of DCHP to workers and ONUs. The modeling approach for determining the aqueous permeability coefficient was within the range of applicability given the physical and chemical parameters of DCHP, and the modeling approach received a medium rating through EPA's systematic review process. Additionally, the neat form of DCHP is a solid, the concentrated formulations are paste-like, and any liquid containing DCHP has very low concentrations; therefore, it is reasonable to assume that flux-limited absorption of aqueous DCHP serves as a reasonable upper bound for the dermal absorption of DCHP from occupational scenarios. Additionally, EPA assumed a standard 8-hour workday and that the chemical is contacted at least once per day. Because DCHP 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 DCHP from occupational dermal contact with materials containing DCHP may extend up to 8 hours per day (U.S. EPA, 1991). For average adult workers, the surface area of contact was assumed equal to the area of one hand (or two palms) (*i.e.*, 535 cm^2) for central tendency, or two hands (*i.e.*, 1,070 cm^2) for high-end exposures (U.S. EPA, 2011). Regarding surface area of dermal exposure to ONUs experiencing incidental contact to mist or dust deposited on surfaces, EPA assumed a representative exposure surface area equivalent to the mean value for 1 palm (*i.e.*, 268 cm^2) of adult males (U.S. EPA, 2011). The standard sources for exposure duration and area of contact received high ratings through EPA's systematic review process. These strengths increase the weight of evidence. EPA acknowledges that variations in chemical concentration and co-formulant components affect the rate of dermal absorption, and that these variations were not considered in the occupational dermal exposure assessment in favor of an upper bound dermal absorption estimate from flux-limited absorption of aqueous DCHP. Additionally, worker activity metadata used in the model, such as surface area of skin contact and exposure duration, are not facility or industry-specific and are meant to address generic dermal exposures in all OESs assessed. These limitations decrease the weight of evidence.

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	The occupational dermal exposure assessment for contact with materials containing DCHP was based on dermal absorption modeling of aqueous DCHP, 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 for average adult workers and female workers of reproductive age. However, due to the uncertainties in exposure frequency and extent of dermal exposures to ONUs, there is slight to moderate confidence in the dermal exposure estimates for ONUs.

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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 DCHP in each of its COUs. 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 COU.
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 DCHP instead of other chemicals (*i.e.*, the market penetration of DCHP in the COU).
6. Estimate the number of sites and number of potentially exposed employees per site.
7. Estimate the number of potentially exposed employees within the COU.

Step 1: Identifying Affected NAICS Codes

As a first step, EPA identified NAICS industry codes associated with each COU. The Agency generally identified NAICS industry codes for a COU by:

- Querying the U.S. Census Bureau's *NAICS Search* tool using keywords associated with each COU to identify NAICS codes with descriptions that match the COU.
- Referencing EPA GSs and Organisation for Economic Co-operation and Development (OECD) ESDs for a COU 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 COU section in the main body of this report identifies the NAICS codes EPA identified for the respective COU.

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 DCHP. Table_Apx A-1 shows the SOC codes EPA classified as occupations potentially exposed to DCHP. These occupations are classified as workers (W) and ONUs (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 the fact that different workers may be expected to rotate among activities with higher exposure potential (*e.g.*, unloading the dry-cleaning machine, pressing/finishing a dry-cleaned load), EPA made different SOC code worker and ONU assignments for this COU. Table_Apx A-2 summarizes the SOC codes with worker and ONU designations used for dry cleaning facilities.

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

SOC	Occupation	Designation
41-2000	Retail Sales Workers	O
49-9040	Industrial Machinery Installation, Repair, and Maintenance Workers	W
49-9070	Maintenance and Repair Workers, General	W
49-9090	Miscellaneous Installation, Maintenance, and Repair Workers	W
51-6010	Laundry and Dry-Cleaning Workers	W
51-6020	Pressers, Textile, Garment, and Related Materials	W
51-6030	Sewing Machine Operators	O
51-6040	Shoe and Leather Workers	O
51-6050	Tailors, Dressmakers, and Sewers	O
51-6090	Miscellaneous Textile, Apparel, and Furnishings Workers	O
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 results 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 DCHP 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 DCHP 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 DCHP may be only one of multiple chemicals used for the applications of interest. EPA did not identify market penetration data for any COUs. In the absence of market penetration data for a given COU, EPA assumed DCHP 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 COU in the main body of this report.

Step 5: Estimating the Number of Workers per Site

EPA calculated the number of workers and ONUs 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 ONUs 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 ONUs per site.

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

EPA estimated the number of workers and ONUs potentially exposed to DCHP and the number of sites that use DCHP in a given COU through the following steps. Obtaining the total number of establishments by the following:

1. 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 COU and summing these values; or
2. Obtaining the number of establishments from the TRI, DMR, NEI, or literature for the COU.
3. Estimating the number of establishments that use DCHP by taking the total number of establishments and multiplying it by the market penetration factor from Step 4.
4. Estimating the number of workers and ONUs potentially exposed to DCHP by taking the number of establishments calculated in Step 1 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 DCHP inhalation exposures to workers in occupational settings, presented as an 8-hour 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 DCHP dermal exposures to workers in occupational settings, presented as a dermal acute potential dose rate (APDR). The APDRs are then used to calculate the AD, IADD, and ADD. This section 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 <1 day) from workplace inhalation exposures per Equation_Apx B-1.

Equation_Apx 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 (hours/day)
BR = Breathing rate (m^3/h)
BW = Body weight (kg)

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

Equation_Apx 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 (days)
ID = Intermediate duration (days)

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

Equation_Apx 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 (days/year)
WY = Working years per lifetime (years) – 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_Apx B-4.

Equation_Apx 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_Apx B-5.

Equation_Apx 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 (days)
ID = Intermediate duration (days)

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

Equation_Apx 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 (days/year)
WY = Working years per lifetime (years)

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_Apx 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 dose (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	h/day
Breathing Rate	BR	1.25	m^3/h
Exposure Frequency	EF	208–250[a]	days/year
Exposure Frequency, Intermediate	EF_{int}	22	days
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 8 hours per day for averaging full-shift exposures.

B.4.2 Breathing Rate (BR)

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

B.4.3 Exposure Frequency (EF)

EPA generally used a maximum exposure frequency of 250 days per year based on the assumptions of daily exposure during each working day, 5 workdays per week, and 2 weeks of vacation per year. However, for some OES where a range of exposure frequencies 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_Apx B-8.

$$EF = AWD \times f$$

Where:

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

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

EPA identified approximately 140 NAICS codes applicable to the multiple COUs 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). The Agency converted the working hours per employee to working days per year per employee assuming employees work an average of 8 hours per day. The average number of working days per year, or AWD, ranges from 169 to 282 days per year, with a 50th percentile value of 250 days per year. EPA repeated this analysis for all NAICS codes at the 4-digit level. The average AWD for all 4-digit NAICS codes ranges from 111 to 282 days per year, with a 50th percentile value of 228 days per year. 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 DCHP-specific data, EPA assumed the parameter, f, is equal to one for all OES.

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

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

The U.S. Census Bureau (2016) Survey of Income and Program Participation (SIPP) provides information on *lifetime tenure with all employers*. SIPP is a household survey that collects data on income, labor force participation, social program participation and eligibility, and general demographic characteristics through a continuous series of national panel surveys of between 14,000 and 52,000 households (U.S. BLS, 2016). EPA analyzed the 2008 SIPP Panel Wave 1, a panel that began in 2008 and covers the interview months of September 2008 through December 2008 (U.S. BLS, 2016). For this panel, lifetime tenure data are available by Census Industry Codes, which can be cross walked with NAICS codes.

SIPP data include fields that describe, for each surveyed worker, the industry in which they work (TJBIND1); their age (TAGE); and years of work experience *with all employers* over the surveyed individual's lifetime.[6] Census household surveys use different industry codes than the NAICS codes, so EPA converted these industry codes to NAICS using a published crosswalk (U.S. Census Bureau, 2012). EPA calculated the average tenure for the following age groups: (1) workers aged 50 and older; (2) workers aged 60 and older; and (3) workers of all ages employed at time of survey. The Agency used tenure data for age group "50 and older" to determine the high-end lifetime working years, because the sample size in this age group is often substantially higher than the sample size for age group "60 and older." For some industries, the number of workers surveyed, or the *sample size*, was too small to provide a reliable representation of the worker tenure in that industry. Therefore, EPA excluded data where the sample size is less than five from the 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.

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

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: (U.S. BLS, 2016) Note: Industries where sample size is <5 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 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	4.1	4.4	4.6	4.6
16–17 years	0.7	0.7	0.7	0.7
18–19 years	0.8	1.0	0.8	0.8
20–24 years	1.3	1.5	1.3	1.3
25+ years	5.1	5.2	5.4	5.5
25–34 years	2.7	3.1	3.2	3.0
35–44 years	4.9	5.1	5.3	5.2
45–54 years	7.6	7.8	7.8	7.9
55–64 years	9.9	10.0	10.3	10.4
65+ years	10.2	9.9	10.3	10.3
Source: (U.S. BLS, 2014)				

B.4.7 Body Weight (BW)

EPA assumes a BW of 80 kg for average adult workers. The Agency 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 COU, 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}:

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

$$AD_{HE} = \frac{4.7\ \frac{mg}{m^3} \times 8\frac{hr}{day} \times 1.25\frac{m^3}{hr}}{80\ kg} = \ 0.59\ \frac{\frac{mg}{kg}}{day}$$

Calculating $IADD_{HE}$:

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

$$IADD_{HE} = \frac{4.7\ \frac{mg}{m^3} \times 8\frac{hr}{day} \times 1.25\frac{m^3}{hr} \times 22\frac{days}{year}}{80\ kg \times 30\frac{days}{year}} = 0.43\ \frac{\frac{mg}{kg}}{day}$$

Calculating ADD_{HE}:

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

$$ADD_{HE} = \frac{4.7\ \frac{mg}{m^3} \times 8\frac{hr}{day} \times 1.25\frac{m^3}{hr} \times 250\frac{days}{year} \times 40\ years}{80\ kg \times 365\frac{days}{year} \times 40\ years} = 0.40\frac{\frac{mg}{kg}}{day}$$

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

Calculating AD_{CT}:

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

$$AD_{CT} = \frac{0.23\ \frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr}}{80\ kg} = 2.9\ \times 10^{-2}\ \frac{\frac{mg}{kg}}{day}$$

Calculating $IADD_{CT}$:

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

$$IADD_{CT} = \frac{0.23\ \frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr} \times 22\,\frac{days}{year}}{80\ kg \times 30\,\frac{days}{year}} = 2.1 \times 10^{-2}\ \frac{\frac{mg}{kg}}{day}$$

Calculating ADD_{CT}:

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

$$ADD_{CT} = \frac{0.23\ \frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr} \times 223\,\frac{days}{year} \times 31\ years}{80\ kg \times 365\,\frac{days}{year} \times 31\ years} = 1.8 \times 10^{-2}\,\frac{\frac{mg}{kg}}{day}$$

C.2 Dermal Exposures

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

Calculating AD_{HE}:

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

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

Calculate $IADD_{HE}$:

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

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

Calculate ADD_{HE} (non-cancer):

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

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

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

Calculating AD_{CT}:

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

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

Calculating $IADD_{CT}$:

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

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

Calculate ADD_{CT} (non-cancer):

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

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

Appendix D DERMAL EXPOSURE ASSESSMENT METHOD

D.1 Dermal Dose Equation

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

Equation_Apx D-1.

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

Where:

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

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

D.2 Parameters of the Dermal Dose Equation

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

Table_Apx D-1. Summary of Dermal Dose Equation Values

Input Parameter	Symbol	Value	Unit	Rationale
Absorptive Flux	J	Dermal Contact with DCHP 4.22E−05	$mg/cm^2/h$	See Appendix D.2.1
Surface Area	S	Workers: 535 (central tendency) 1,070 (high-end) Females of reproductive age: 445 (central tendency) 890 (high-end) ONUs: 268 (central tendency)	cm^2	See Appendix D.2.2
Absorption Time	t_{abs}	8	h	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

As described in Section 2.4.4.1, the average absorptive flux of DCHP is expected to vary between 3.44×10^{-5} and 1.19×10^{-4} $mg/cm^2/h$ for durations between 1 and 12 hours based on aqueous absorption modeling from U.S. EPA (2004b), and the average absorptive flux of DCHP over an 8-hour exposure period was calculated as 4.22×10^{-5} $mg/cm^2/h$. Because it was conservatively assumed that DCHP must first migrate into a thin film of moisture on the surface of the skin, and that solubility of DCHP by the moisture layer limits absorption, the 8-hour time weighted average (TWA) aqueous flux value of 4.22×10^{-5} $mg/cm^2/h$ was chosen as a representative value for occupational dermal exposures to DCHP.

The neat form of DCHP is a solid, the concentrated formulations are paste-like, and any liquid containing DCHP has very low concentrations; therefore, it is reasonable to assume that flux-limited absorption of aqueous DCHP serves as a reasonable upper bound for the dermal absorption of DCHP across occupational scenarios.

Using the work of Kissel (2011) to interpret the dermal modeling results for aqueous DCHP, it was determined that dermal absorption of DCHP may be flux-limited, even for finite doses (*i.e.*, typically 1 to 5 mg/cm^2 for solids (OECD, 2004b)). Therefore, the 8-hour TWA flux (*i.e.*, 4.22×10^{-5} mg/cm^2/h) of aqueous DCHP was assumed for the duration of chemical retention on the skin, which is expected to last up to 8 hours in occupational settings.

Because it was assumed that dermal absorption of DCHP may extend up to 8 hours in occupational settings, it was also important to consider the magnitude of dermal loading relative to the rate of dermal absorption. For contact with solids or powders in occupational settings, EPA generally assumes a range of dermal loading of 900 to 3,100 mg/day (50–95th percentile from Lansink *et al.* (1996)) as shown in the ChemSTEER manual (U.S. EPA, 2015). For contact with materials such as solder/pastes in occupational settings, EPA assumes a range of dermal loading of 450 to 1,100 mg/day (50–95th percentile from Lansink *et al.* (1996)) as shown in the ChemSTEER Manual (U.S. EPA, 2015). The average absorptive flux of DCHP for an 8-hour absorption period, as determined through modeling efforts (U.S. EPA and ICF Consulting, 2022; U.S. EPA, 2004b), would result in maximum absorption of less than 1 mg per workday for the average adult worker. With such a low rate of dermal absorption, a typical occupational dermal load would not be depleted through absorption and evaporation during an 8-hour period and material could remain on the skin for the extent of a work shift.

D.2.2 Surface Area

Regarding surface area of occupational dermal exposure, EPA assumed a high-end value of 1,070 cm^2 for male workers and 890 cm^2 for female workers. These high-end occupational dermal exposure surface area values are based on the mean two-hand surface area for adults of age 21 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 1 side of 2 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). Regarding surface area of dermal exposure to ONUs experiencing incidental contact to mist or dust deposited on surfaces, EPA assumed a representative exposure surface area equivalent to the mean value for one palm (*i.e.*, 268 cm^2) of adult males (U.S. EPA, 2011).

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 DCHP does not rapidly absorb or evaporate, and the worker may contact the material multiple times throughout the workday, EPA assumes that absorption of DCHP in occupational settings may occur throughout the entirety of an 8-hour work shift (U.S. EPA, 1991).

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 vs. 50% effectiveness).

Gloves only offer barrier protection until the chemical breaks through the glove material. Using a conceptual model, Cherrie *et al.* (2004) proposed a glove workplace protection factor—the ratio of estimated uptake through the hands without gloves to the estimated uptake though the hands while wearing gloves; this protection factor is driven by flux, and 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). Where, similar to the APR for respiratory protection, the inverse of the protection factor is the fraction of the chemical that penetrates the glove.

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

Table_Apx 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)
E.9.1 Any glove / gauntlet without permeation data and without employee training	Both industrial and professional users	0	1
E.9.2 Gloves with available permeation data indicating that the material of construction offers good protection for the substance		80	5
E.9.3 Chemically resistant gloves (*i.e.*, as b above) with "basic" employee training		90	10
E.9.4 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 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. The Agency assigned statistical distributions based on reasonably available literature data. A Monte Carlo simulation (a type of stochastic simulation) was conducted to capture variability in the model input parameters. The simulation was conducted using the Latin hypercube sampling method in @Risk Industrial Edition, Version 8.0 (Palisade, 2022). The Latin hypercube sampling method generates a sample of possible values from a multi-dimensional distribution and is considered a stratified method, meaning the generated samples are representative of the probability density function (variability) defined in the model. EPA performed the model at 100,000 iterations to capture a broad range of possible input values, including values with low probability of occurrence.

EPA used the 95th and 50th percentile Monte Carlo simulation model result values for assessment. The 95th percentile value represents the high-end release amount or exposure level, whereas the 50th percentile value represents the 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* (CEB, 1991), *Evaporation of Pure Liquids From OPEN SURFACES* (Arnold and Engel, 2001), *Evaluation of the Mass Balance Model Used by the References Environmental Protection Agency for Estimating Inhalation Exposure to New Chemical Substances* (Fehrenbacher and Hummel, 1996), and *Releases During Cleaning of Equipment* (PEI Associates, 1988). The models include loss fraction models as well as models for estimating chemical vapor generation rates used in subsequent model equations to estimate the volatile releases to air 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 DCHP.

The **EPA/OPPT Penetration Model** (U.S. EPA, 2015) 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_Apx E-1.

$$G_{activity} = \frac{(8.24 \times 10^{-8}) * (MW_{DCHP}^{0.835}) * F_{correction\_factor} * VP * \sqrt{Rate_{air\_speed}} * (0.25\pi D_{opening}^2)\sqrt[4]{\frac{1}{29} + \frac{1}{MW_{DCHP}}}}{T^{0.05} * \sqrt{D_{opening}} * \sqrt{P}}$$

Where:

$G_{activity}$	=	Vapor generation rate for activity (g/s)
MW_{DCHP}	=	DCHP molecular weight (g/mol)
$F_{correction\_factor}$	=	Vapor pressure correction factor (unitless)
VP	=	DCHP vapor pressure (torr)
$Rate_{air\_speed}$	=	Air speed (cm/s)
$D_{opening}$	=	Diameter of opening (cm)
T	=	Temperature (K)
P	=	Pressure (torr)

The EPA/OPPT Mass Transfer Coefficient Model estimates releases to air from the evaporation of a chemical from an open, exposed liquid surface (U.S. EPA, 2015). This model is appropriate for determining this type of volatile release from activities that are performed outdoors or when air velocities are expected to be greater than 100 feet per minute. The EPA/OPPT Mass Transfer Coefficient Model calculates the average vapor generation rate of the chemical from the exposed liquid surface using the following equation:

Equation_Apx E-2.

$$G_{activity} = \frac{(1.93 \times 10^{-7}) * \left(MW_{DCHP}{}^{0.78}\right) * F_{correction\_factor} * VP * Rate_{air\_speed}^{0.78} * (0.25\pi D_{opening}^{2})^{3}\sqrt{\frac{1}{29} + \frac{1}{MW_{DCHP}}}}{T^{0.4} D_{opening}^{0.11} (\sqrt{T} - 5.87)^{2/3}}$$

Where:

$G_{activity}$	=	Vapor generation rate for activity (g/s)
MW_{DCHP}	=	DCHP molecular weight (g/mol)
$F_{correction\_factor}$	=	Vapor pressure correction factor (unitless)
VP	=	DCHP vapor pressure (torr)
$Rate_{air\_speed}$	=	Air speed (cm/s)
$D_{opening}$	=	Diameter of opening (cm)
T	=	Temperature (K)

The EPA's Office of Air Quality Planning and Standards (OAQPS) AP-42 Loading Model estimates releases to air from the displacement of air containing chemical vapor as a container/vessel is filled with a liquid (U.S. EPA, 2015). This model assumes that the rate of evaporation is negligible compared to the vapor loss from the displacement and is used as the default for estimating volatile air releases during both loading activities and unloading activities. This model is used for unloading activities because it is assumed while one vessel is being unloaded another is assumed to be loaded. The EPA/OAQPS AP-42 Loading Model calculates the average vapor generation rate from loading or unloading using the following equation:

Equation_Apx E-3.

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

Where:

$G_{activity}$	=	Vapor generation rate for activity (g/s)
$F_{saturation\_factor}$	=	Saturation factor (unitless)
MW_{DCHP}	=	DCHP molecular weight (g/mol)
$V_{container}$	=	Volume of container (gal/container)

$F_{correction\_factor}$	=	Vapor pressure correction factor (unitless)
VP	=	DCHP vapor pressure (torr)
$RATE_{fill}$	=	Fill rate of container (containers/h)
R	=	Universal gas constant (L*torr/mol-K)
T	=	Temperature (K)

For each of the vapor generation rate models, the vapor pressure correction factor ($F_{correction\_factor}$) can be estimated using Raoult's Law and the mole fraction of DCHP 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 DCHP in the liquid of interest. Using the mass fraction of DCHP 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 DCHP, 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 DCHP, the mass fraction of DCHP will be an overestimate of the mole fraction. If other components in the liquid of interest have much higher molecular weights than DCHP, the mass fraction of DCHP will underestimate the mole fraction.

If calculating an environmental release, the vapor generation rate calculated from one of the above models (Equation_Apx E-1, Equation_Apx E-2, and Equation_Apx E-3) is then used along with an operating time to calculate the release amount:

Equation_Apx E-4.

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

Where:

$Release\_Year_{activity}$	=	DCHP released for activity per site-year (kg/site-year)
$Time_{activity}$	=	Operating time for activity (h/site-year)
$G_{activity}$	=	Vapor generation rate for activity (g/s)

The EPA/OPPT Small Volume Solids Handling Inhalation Model estimates the amount of chemical inhaled by a worker during handling of "small volumes" (<54 kg/worker-shift) of solid/powdered materials containing the chemical (U.S. EPA, 2015). The handling of these small volumes is assumed to be scooping, weighing, and pouring of the solid materials. The EPA/OPPT Small Volume Solids Handling Inhalation Model calculates the inhalation potential dose rate using the following equation:

Equation_Apx E-5.

$$I = EF * AH * Y_s * S_d$$

Where:

I	=	Inhalation potential dose rate (mg/day)
EF	=	Exposure factor (mg/kg)
AH	=	The amount of solids/powder (containing the chemical) handled ($0 \leq AH \leq 54$) (kg/worker-shift)
Y_S	=	Weight fraction of chemical in particulate (unitless)
S_d	=	Number of shifts worked by each worker during a workday (unitless)

In addition to the dust and 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 Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders
- EPA/OPPT Multiple Process Vessel Residual Model
- EPA/OPPT Single Process Vessel Residual Model
- EPA/OPPT Solid Residuals in Transport Containers Model
- March 2023 Methodology for Estimating Environmental Releases from Sampling Waste

The loss fraction models apply a given loss fraction to the overall throughput of DCHP for the given process. More information for each model can be found in the ChemSTEER User Guide (U.S. EPA, 2015). The loss fraction value or distribution of values differs for each model; however, each model follows the same general equation based on the approaches described for each OES:

Equation_Apx E-6.

$$Release\_Year_{activity} = PV * F_{activity\_loss}$$

Where:

$Release\_Year_{activity}$	=	DCHP released for activity per site-year (kg/site-year)
PV	=	Production volume throughput of DCHP (kg/site-year)
$F_{activity\_loss}$	=	Loss fraction for activity (unitless)

The EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders (Dust Release Model) 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 Dust Release Model calculates the amount of dust not captured, captured but not controlled, and both captured and controlled, using the following equations (U.S. EPA, 2021b):

Equation_Apx E-7.

$$\mathrm{Elocal}_{\mathrm{dust\_not\_captured}} = \mathrm{Elocal}_{\mathrm{dust\_generation}} * \left(1 - \mathrm{F}_{\mathrm{dust\_capture}}\right)$$

Where:

$Elocal_{dust\_not\_captured}$	=	Daily amount emitted from transfers/unloading that is not captured (kg not captured/site-day)
$Elocal_{dust\_generation}$	=	Daily release of dust from transfers/unloading (kg generated/site-day)
$F_{dust\_capture}$	=	Capture technology efficiency (kg captured/kg generated)

Equation_Apx E-8.

$$Elocal_{dust\_cap\_uncontrol} = Elocal_{dust\_generation} * F_{dust\_capture} * \left(1 - F_{dust\_control}\right)$$

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_Apx E-9.

$$Elocal_{dust\_cap\_control} = Elocal_{dust\_generation} * F_{dust\_capture} * F_{dust\_control}$$

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_Apx E-1, Equation_Apx E-2, and Equation_Apx 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 DCHP using the following equation:

Equation_Apx E-10.

$$Cv_{activity} = Minimum: \begin{cases} \left[\dfrac{170{,}000 * T * G_{activity}}{MW_{DCHP} * Q * k}\right] \\ \left[\dfrac{1{,}000{,}000 ppm * F_{correction\_factor} * VP}{P}\right] \end{cases}$$

Where:

$Cv_{activity}$	=	Exposure activity volumetric concentration (ppm)
$G_{activity}$	=	Exposure activity vapor generation rate (g/s)
MW_{DCHP}	=	DCHP 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	=	DCHP vapor pressure (torr)
P	=	Pressure (torr)

Mass concentration can be estimated by multiplying the volumetric concentration by the molecular weight of DCHP and dividing by molar volume at standard temperature and pressure.

EPA uses the above equations in the DCHP 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 section presents the modeling approach and equations used to estimate environmental releases and occupational exposures for DCHP during the manufacturing OES. This approach utilizes CDR data (U.S. EPA, 2020a) combined with Monte Carlo simulation (a type of stochastic simulation).

Based on DCHP's physical properties and a virtual tour of the manufacturing processes for other phthalates (DIDP and DINP) (ExxonMobil, 2022b), EPA identified the following potential release sources from manufacturing operations:

- Release source 1: Vented Losses to Air During Reaction/Separations/Other Process Operations.
- Release source 2: Product Sampling Wastes.
- Release source 3: Equipment Cleaning Wastes.
- Release source 4: Transfer Operation Losses to Air from Packaging Manufactured DCHP into Transport Containers.

Environmental releases for DCHP during manufacturing are a function of DCHP's physical properties, container size, mass fractions, and other model parameters. Although physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: DCHP concentration, air speed, diameter of openings, efficiencies for dust capture and control methods, saturation factor, container size, and loss fractions. The Agency used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts and exposure concentrations for this OES.

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 DCHP 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_Apx E-11	Q_{DCHP_day}; F_{DCHP_SPERC}
Release source 2: Product Sampling Wastes.	March 2023 Methodology for Estimating Environmental Releases	Q_{DCHP_day}; $LF_{sampling}$

Release Source	Model(s) Applied	Variables Used
	from Sampling Waste (Appendix E.1)	
Release source 3: Equipment Cleaning Wastes.	EPA/OPPT Single Process Vessel Residual Model (Appendix E.1)	Q_{DCHP_day}; LF_{equip_clean}
Release source 4: Transfer Operation Losses to Air from Packaging Manufactured DCHP into Transport Containers.	EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders (Appendix E.1)	Q_{DCHP_day}; $F_{dust\_generation}$; $F_{dust\_capture}$; $F_{dust\_control}$

Release source 1 daily release (Vented Losses to Air During Reaction/Separations/Other Process Operations) is calculated using the following equation:

Equation_Apx E-11.

$$Release\_perDay_{RP1} = Q_{DCHP\_day} * F_{DCHP\_SPERC}$$

Where:

$Release\_perDay_{RP1}$ = DCHP released for release source 1 (kg/site-day)
Q_{DCHP_day} = Facility throughput of DCHP (kg/site-day)
F_{DCHP_SPERC} = Loss fraction for unit operations (unitless)

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 this table.

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	
Number of Sites	Ns	sites	2	–	–	–	–	See Appx. E.2.3
Facility Production Rate – Known Site 1	PV	kg/site-year	7,843	–	–	–	–	See Appx. E.2.4
Facility Production Rate – Known Site 2	PV	kg/site-year	2.1E05	–	–	–	–	See Appx. E.2.4
Manufactured DCHP Concentration	F_{DCHP}	kg/kg	1.0	0.90	1.0	—	Uniform	See Appx. E.2.7
Solid Container Size	V_{cont}	gal	7.0	7.0	132	7.0	Triangular	See Appx. E.2.8
Fraction of Chemical Lost During Transfer of Solid Powders	$F_{dust\_generation}$	kg/kg	5.0E−03	6.0E−06	4.5E−02	5.0E−03	Triangular	See Appx. E.2.9
Capture Efficiency for Dust Capture Methods	$F_{dust\_capture}$	kg/kg	0.96	0.93	1.0	0.96	Triangular	See Appx. E.2.9
Control Efficiency for Dust Capture Methods	$F_{dust\_control}$	kg/kg	0.79	0	1.0	0.79	Triangular	See Appx. E.2.9
Fraction of DCHP Lost During Sampling – 1 (Q_{DCHP_day} < 50 kg/site-day)	$F_{sampling\_1}$	kg/kg	2.0E−02	2.0E−03	2.0E−02	2.0E−02	Triangular	See Appx. E.2.10
Fraction of DCHP Lost During Sampling – 2 (Q_{DCHP_day} 50–200 kg/site-day)	$F_{sampling\_2}$	kg/kg	5.0E−03	6.0E−04	5.0E−03	5.0E−03	Triangular	See Appx. E.2.10
Fraction of DCHP Lost During Sampling – 3 (Q_{DCHP_day} 200–5,000 kg/site-day)	$F_{sampling\_3}$	kg/kg	4.0E−03	5.0E−04	4.0E−03	4.0E−03	Triangular	See Appx. E.2.10
Fraction of DCHP Lost During Sampling – 4 (Q_{DCHP_day} > 5,000 kg/site-day)	$F_{sampling\_4}$	kg/kg	4.0E−04	8.0E−05	4.0E−04	4.0E−04	Triangular	See Appx. E.2.10
Operating Days	OD	days/year	250	–	–	–	–	See Appx. E.2.11
Vapor Pressure at 25 °C	VP	mmHg	4.9E−07	–	–	–	–	Physical property
Vapor Pressure at 140 °F	VP_{140}	mmHg	5.2E−05	–	–	–	–	Physical property

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Vapor Pressure at 250 °F	VP_{250}	mmHg	6.2E−03	–	–	–	–	Physical property
Vapor Pressure at 375 °F	VP_{375}	mmHg	0.28	–	–	–	–	Physical property
Molecular Weight	MW	g/mol	330	–	–	–	–	Physical property
Gas Constant	R	atm-cm^3/gmol-L	82	–	–	–	–	Universal constant
Process Operation Emission Factor	F_{DCHP_SPERC}	kg/kg	1.0E−05	–	–	–	–	See Appx. E.2.12
Temperature	T	K	298	–	–	–	–	Process parameter
Pressure	P	atm	1.0	–	–	–	–	Process parameter
Equipment cleaning loss fraction	LF_{equip_clean}	kg/kg	1.0E−02	–	–	–	–	See Appx. E.2.13
Drum Fill Rate	$RATE_{fill\_drum}$	drums/h	20	–	–	–	–	See Appx. E.2.14
Tote Fill Rate	$RATE_{fill\_tote}$	totes/h	20	–	–	–	–	See Appx. E.2.14
Truck Fill Rate	$RATE_{fill\_truck}$	trucks/h	2.0	–	–	–	–	See Appx. E.2.14
Rail Car Fill Rate	$RATE_{fill\_rail}$	rails/h	1.0	–	–	–	–	See Appx. E.2.14
Density of DCHP	RHO	kg/L	1.4	–	–	–	–	Physical property

E.2.3 Number of Sites

EPA used 2020 CDR data (U.S. EPA, 2020a) to identify the number of sites that manufacture DCHP. In CDR, two sites reported domestic manufacturing of DCHP. Table_Apx E-3 presents the names and locations of these sites.

Table_Apx E-3. Sites Reporting to CDR for Domestic Manufacture of DCHP

Facility Name	Facility Location
LANXESS Corporation	Pittsburgh, PA
Vertellus LLC	Indianapolis, IN

E.2.4 Throughput Parameters

EPA ran the Monte Carlo model twice to estimate releases from both sites. The Agency used 2020 CDR data (U.S. EPA, 2020a) to identify annual facility PV for each site. One site provided a production volume. LANXESS Corporation reported 17,290 lb (7,843 kg) of DCHP manufactured.

For the other site, EPA used the reported export volume and reported use percentage to estimate the production volume. Vertellus LLC reported an export volume of 410,849 lb and reported that 10 percent of their PV is used as a plasticizer in adhesive manufacturing. The Agency assumed that this site had no uses of DCHP that fall under the reporting threshold and that 410,849 lb represented 90 percent of their total PV. Therefore, EPA calculated the total manufactured PV from the site as 410,849/0.9 = 456,499 lb (207,064 kg).

The daily throughput of DCHP is calculated using Equation_Apx E-12 by dividing the annual production volume by the number of operating days. The number of operating days is determined according to Appendix E.2.11.

Equation_Apx E-12.

$$Q_{DCHP\_day} = \frac{PV}{OD}$$

Where:

Q_{DCHP_day}	=	Facility throughput of DCHP (kg/site-day)
PV	=	Annual production volume (kg/site-year)
OD	=	Operating days (see Appendix E.2.11) (days/year)

E.2.5 Number of Containers Per Year

The number of manufactured DCHP product containers filled by a site per year is calculated using the following equation:

Equation_Apx E-13.

$$N_{cont\_load\_yr} = \frac{PV}{V_{drum/cont}}$$

Where:

$N_{cont\_load\_yr}$	=	Annual number of product containers (container/site-year)
$V_{drum/cont}$	=	Product container volume (see Appendix E.2.8) (gal/container)
PV	=	Facility production rate (see Appendix E.2.4) (kg/site-year)

E.2.6 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 equipment cleaning and loading into transport containers.

The operating hours for loading of DCHP into transport containers (release point 4) is calculated based on the number of product containers filled at the site and the fill rate using the following equation:

Equation_Apx E-14.

$$Time_{RP4} = \frac{N_{cont\_load\_yr}}{RATE_{fill\_drum/cont} * OD}$$

Where:

$Time_{RP4}$	=	Operating time for release point 4 (h/site-day)
$RATE_{fill\_drum/cont}$	=	Fill rate of container, dependent on volume (see Appendix E.2.14) (containers/h)
$N_{cont\_load\_yr}$	=	Annual number of product containers (see Appendix E.2.5) (containers/site-year)
OD	=	Operating days (see Appendix E.2.11) (days/site-year)

E.2.7 Manufactured DCHP Concentration

EPA used the manufactured concentration range reported in CDR for both sites (U.S. EPA, 2020a) to make a uniform distribution of 90 to 100 percent DCHP.

E.2.8 Container Size

Both manufacturing sites reporting to CDR identified that DCHP was manufactured as a solid. For packaging of DCHP in solid form, 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, 2021d), which states that compounded plastics in pellet form are routinely shipped in containers ranging from 25 kg bags to 500 kg gaylords. EPA assumes that manufacturers ship DCHP in powder/pellet form in similarly sized containers. The Agency converted the mass of the container to volume assuming a density of 1 kg/L. The volumetric distribution used a lower bound and mode of 7 gallons and an upper bound of 132 gallons.

E.2.9 Dust Generation Loss Fraction, Dust Capture Efficiency, and Dust Control Efficiency

The 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 distributions require the fewest assumptions and are 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 6.0×10^{-6} to 0.045 with a mode of 0.005 by mass. The Agency assigned the mode based on the recommended default value for the parameter in the Dust Release Model. The range of initial loss fraction values comes from the range of values compiled from various sources and considered in the development of the Dust Release Model (U.S. EPA, 2021b). For the fraction captured, EPA assigned a range of 0 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.

For the fraction removed/controlled, EPA assigned a range of 0 to 1.0 with a mode of 0.79 by mass. The Agency assigned the range for the fraction controlled based on the minimum and maximum estimated control efficiencies listed in the data compiled for the Dust Release Model. EPA assigned the mode for the fraction controlled based on the average of all lower bound estimated control efficiency values for all control technologies presented in the model.

E.2.10 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 Initial Review Engineering Report (IRERs) completed in the years 2021 and 2022 for sampling release data, including a similar proportion of both Pre-Manufacture Notices (PMNs) and Low Volume Exemptions (LVEs). Of the searched IRERs, 60 data points for sampling release loss fractions, primarily for sampling releases from submitter-controlled sites (≈75% of IRERs), were obtained. The data points were analyzed as a function of the chemical daily throughput and industry type. This analysis showed that the sampling loss fraction generally decreased as the chemical daily throughput increased. Therefore, the methodology provides guidance for selecting a loss fraction based on chemical daily throughput. Table_Apx 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 Appendix E.2.4.

E.2.11 Operating Days

EPA was unable to identify specific information for operating days for the manufacturing of DCHP. Therefore, EPA assumes a constant value of 250 days/year, which assumes the production sites operate five days per week and 50 weeks per year, with 2 weeks down for turnaround.

E.2.12 Process Operations Emission Factor

In order to estimate releases from reactions, separations, and other process operations, EPA used an emission factor from the European Solvents Industry Group (ESIG). According to the ESD on Plastic Additives, the processing temperature during manufacture of plasticizers is 375 °F (OECD, 2009b). However, the rate of release is expected to be limited by the ambient temperature of the manufacturing facility. At room temperature, the vapor pressure of DCHP is less than 1 Pa. The ESIG Specific Environmental Release Category for Industrial Substance Manufacturing (Solvent-Borne) states that a chemical with a vapor pressure of less than 1 Pa will have an emission factor of 0.00001 (ESIG, 2012). Therefore, EPA used this emission factor as a constant value for process operation releases.

E.2.13 Equipment Cleaning Loss Fraction

EPA used the EPA/OPPT Single Process Residual Model to estimate the releases from equipment cleaning. That model, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015), provides an overall loss fraction of 1 percent from equipment cleaning.

E.2.14 Container Fill Rates

The *ChemSTEER User Guide* (U.S. EPA, 2015) provides a typical fill rate of 20 containers per hour for containers with 20 to 1,000 gallons of material, a rate of two containers per hour for containers with 1,000 to 10,000 gallons of material, and a typical fill rate of one container per hour for containers with over 10,000 gallons of liquid.

E.3 Repackaging into Large and Small Containers Model Approaches and Parameters

This section presents the modeling approach and equations used to estimate environmental releases for DCHP during the import and repackaging OES. This approach utilizes the Generic Scenario for Chemical Repackaging (U.S. EPA, 2022) 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, Water, Incineration, or Landfill from Unpacking Imported DCHP from Transport Containers.
- Release source 2: Sampling Wastes Disposed to Water, Incineration, or Landfill.
- Release source 3: Import Container Residue Released to Water, Incineration, or Landfill.
- Release source 4: Equipment Cleaning Releases to Water, Incineration, or Landfill.
- Release source 5: Transfer Operation Losses to Air, Water, Incineration, or Landfill from Packing Imported DCHP into Transport Containers.

Environmental releases for DCHP during import and repackaging are a function of DCHP'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, DCHP concentration, container size, and loss fractions. The Agency used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

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 DCHP 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 Repackaging OES

Release Source	Model(s) Applied	Variables Used
Release source 1: Transfer Operation Losses to Air, Water, Incineration, or Landfill from Unpacking Imported DCHP from Transport Containers	EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders (Appendix E.1)	$Q_{DCHP_{day}}$; $F_{dust_{generation}}$; $F_{dust_{capture}}$; $F_{dust_{control}}$
Release source 2: Sampling Wastes Disposed to Water, Incineration, or Landfill	March 2023 Methodology for Estimating Environmental Releases from Sampling Waste (Appendix E.1)	Q_{DCHP_day}; $LF_{sampling}$
Release source 3: Import Container Residue Released to Water, Incineration, or Landfill	EPA/OPPT Bulk Transport Residual Model (Appendix E.1)	Q_{DCHP_day}; LF_{bulk}
Release source 4: Equipment Cleaning Releases to Water, Incineration, or Landfill	EPA/OPPT Single Process Vessel Residual Model (Appendix E.1)	Q_{DCHP_day}; LF_{equip_clean}
Release source 5: Transfer Operation Losses to Air, Water, Incineration, or Landfill from Packing Imported DCHP into Transport Containers	EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders (Appendix E.1)	$Q_{DCHP_{day}}$; $F_{dust_{generation}}$; $F_{dust_{capture}}$; $F_{dust_{control}}$

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 this table.

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	
Number of Sites	Ns	sites	2	–	–	–	–	See Appx. E.3.3
Facility Production Rate	PV	kg/site-year	1.2E05	5,945	1.2E05	–	Uniform	See Appx. E.3.4
Operating Hours for Equipment Cleaning	OH_{equip_clean}	h/day	4	–	–	–	–	See Appx. E.3.6
Operating Days	OD	days/year	208	174	260	–	Discrete	See Appx. E.3.7
Imported DCHP Concentration	F_{DCHP}	kg/kg	0.6	0.3	0.6	–	Uniform	See Appx. E.3.8
Bulk Solid Container Size	V_{bulk}	kg	227	–	–	–	–	See Appx. E.3.9
Solid Container Size	V_{cont}	kg	25	25	499	25	Triangular	See Appx. E.3.9
Bulk Container Loss Fraction	LF_{bulk}	kg/kg	7.0E−04	2.0E−04	2.0E−03	7.0E−04	Triangular	See Appx. E.3.10
Fraction of DCHP Lost During Sampling – 1 (Q_{DCHP_day} < 50 kg/site-day)	$F_{sampling\_1}$	kg/kg	2.0E−02	2.0E−03	2.0E−02	2.0E−02	Triangular	See Appx. E.3.11
Fraction of DCHP Lost During Sampling – 2 (Q_{DCHP_day} 50–200 kg/site-day)	$F_{sampling\_2}$	kg/kg	5.0E−03	6.0E−04	5.0E−03	5.0E−03	Triangular	See Appx. E.3.11
Fraction of DCHP Lost During Sampling – 3 (Q_{DCHP_day} 200–5,000 kg/site-day)	$F_{sampling\_3}$	kg/kg	4.0E−03	5.0E−04	4.0E−03	4.0E−03	Triangular	See Appx. E.3.11
Fraction of DCHP Lost During Sampling – 4 (Q_{DCHP_day} > 5,000 kg/site-day)	$F_{sampling\_4}$	kg/kg	4.0E−04	8.0E−05	4.0E−04	4.0E−04	Triangular	See Appx. E.3.11
Fraction of Chemical Lost During Transfer of Solid Powders	$F_{dust\_generation}$	kg/kg	5.0E−03	6.0E−06	4.5E−02	5.0E−03	Triangular	See Appx. E.3.14
Capture Efficiency for Dust Capture Methods	$F_{dust\_capture}$	kg/kg	0.96	0.93	1.0	0.96	Triangular	See Appx. E.3.14
Control Efficiency for Dust Capture Methods	$F_{dust\_control}$	kg/kg	0.79	0	1.0	0.79	Triangular	See Appx. E.3.14
Equipment Cleaning Loss Fraction	LF_{equip_clean}	kg/kg	1.0E−02	–	–	–	–	See Appx. E.3.12
Small Container Fill Rate	$RATE_{fill\_cont}$	cont/h	60	–	–	–	–	See Appx. E.3.13
Bulk Container Fill Rate	$RATE_{fill\_bulk}$	drums/h	20	–	–	–	–	See Appx. E.3.13
Density of DCHP	RHO	kg/L	1.4	–	–	–	–	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 DCHP. In CDR, two sites reported importing DCHP. Table_Apx E-7 presents the names and locations of these sites.

Table_Apx E-7. Sites Reporting to CDR for Import of DCHP

Facility Name	Facility Location
United Initiators, Inc.	Elyria, OH
Nouryon Chemicals LLC	Chicago, IL

E.3.4 Throughput Parameters

Both sites that reported importing DCHP in CDR reported their production volume as CBI. For the two import sites, EPA estimated the PV with a uniform distribution with bounds calculated by subtracting the known manufacturing production volumes from the estimated national aggregate DCHP PV from CDR.

CDR estimated a total national aggregate DCHP PV between 500,000 to less than 1,000,000 lb. EPA subtracted the combined known PV from manufacturers (473,789 lb) from each of these endpoints, resulting in a remaining import PV range of 26,211 to 526,211 lb. This PV was then averaged over the two import sites.

The daily throughput of DCHP is calculated using Equation_Apx E-15 by dividing the annual facility production volume by the number of operating days. The number of operating days is determined according to Appendix E.3.7.

Equation_Apx E-15.

$$Q_{DCHP\_day} = \frac{PV}{OD}$$

Where:

Q_{DCHP_day}	=	Facility throughput of DCHP (kg/site-day)
PV	=	Annual overall production volume (kg/site-year)
OD	=	Operating days (see Appendix E.3.7) (days/year)

E.3.5 Number of Containers per Year

The number of imported DCHP containers unloaded by a site per year is calculated using the following equation:

Equation_Apx E-16.

$$N_{cont\_unload\_yr} = \frac{PV}{V_{bulk}}$$

Where:

V_{bulk}	=	Bulk solid container size (see Appendix E.3.9) (kg)
PV	=	Annual overall production volume (kg/site-year)
$N_{cont\_unload\_yr}$	=	Annual number of containers unloaded (containers/site-year)

The number of DCHP containers loaded by a site per year is calculated using the following equation:

Equation_Apx E-17.

$$N_{cont\_load\_yr} = \frac{PV}{V_{cont}}$$

Where:

V_{cont}	=	Solid container size (see Appendix E.3.9) (kg)
PV	=	Annual overall production volume (kg/site-year)
$N_{cont\_load\_yr}$	=	Annual number of containers loaded (containers/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 and loading transport containers.

For unloading (release point 1), the operating hours are calculated based on the number of imported bulk containers unloaded at the site and the unloading rate using the following equation:

Equation_Apx E-18.

$$OH_{unload\_cont} = \frac{N_{cont\_unload\_year}}{RATE_{fill\_bulk} * OD}$$

Where:

OH_{unload_cont}	=	Daily operating hours for unloading containers (h/site-day)
$RATE_{fill\_bulk}$	=	Fill rate of bulk container, dependent on volume (see Appendix E.3.13) (containers/h)
$N_{cont\_unload\_year}$	=	Number of containers used per year (see Appendix E.3.5) (containers/site-year)
OD	=	Operating days (see Appendix E.3.7) (days/site-year)

For loading into transport containers (release point 5), 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_Apx E-19.

$$OH_{load} = \frac{N_{cont\_load\_yr}}{RATE_{fill} * OD}$$

Where:

OH_{load_year}	=	Operating time for release point 5 (h/site-day)
$RATE_{fill}$	=	Fill rate of container, dependent on volume (see Appendix E.3.13) (containers/h)
$N_{cont\_load\_yr}$	=	Annual number of containers (see Appendix E.3.5) (containers/site-year)
OD	=	Operating days (see Appendix 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 to 12 hours/day yields a number of operating days between 174 to 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-, 10-, 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 Imported DCHP Concentration

EPA used the imported concentration range reported in CDR for both sites (U.S. EPA, 2020a) to make a uniform distribution of 30 to 60 percent DCHP.

E.3.9 Container Size

Both CDR reports indicate that DCHP is imported as a solid (U.S. EPA, 2020a). In addition, it has been shown that DCHP in higher purities exists primarily in solid form. Therefore, EPA assumes that DCHP is primarily imported as a solid. For repackaging of DCHP in solid form, the Agency 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, 2021d), which states that compounded plastics in pellet form are routinely shipped in containers ranging from 25 kg bags to 500 kg gaylords. EPA assumes that shipping manufactured DCHP in powder/pellet form may occur in similarly sized containers. The Agency converted the mass of the container to volume assuming a 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.3.10 Bulk Container Residue Loss Fraction

EPA paired the data from the PEI Associates Inc. study (PEI 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 (PEI 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. The Agency assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the EPA/OPPT 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 (PEI Associates, 1988).

E.3.11 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 that methodology, EPA completed a search of over 300 IRERs completed in the years 2021 and 2022 for sampling release data, including a similar proportion of both PMNs and LVEs. Of the searched IRERs, 60 data points for sampling release loss fractions, primarily for sampling releases from submitter-controlled sites (≈75% of

IRERs), were obtained. The data points were analyzed as a function of the chemical daily throughput and industry type. This analysis showed that the sampling loss fraction generally decreased as the chemical daily throughput increased. Therefore, the methodology provides guidance for selecting a loss fraction based on chemical daily throughput. Table_Apx E-8 presents a summary of the chemical daily throughputs and corresponding loss fractions.

Table_Apx E-8. Sampling Loss Fraction Data from the March 2023 Methodology for Estimating Environmental Releases from Sampling Waste

Chemical Daily Throughput (kg/site-day) ($Q_{chem\_site\_day}$)	Number of Data Points	Sampled Quantity (kg chemical/day)		Sampling Loss Fraction ($LF_{sampling}$)	
		50th Percentile	95th Percentile	50th Percentile	95th Percentile
<50	13	0.03	0.20	0.002	0.02
50 to <200	10	0.10	0.64	0.0006	0.005
200 to <5,000	25	0.37	3.80	0.0005	0.004
≥5,000	10	1.36	6.00	0.00008	0.0004
All	58	0.20	5.15	0.0005	0.008

For each range of daily throughputs, EPA estimated sampling loss fractions using a triangular distribution of the 50th percentile value as the lower bound, and the 95th percentile value as the upper bound and mode. The sampling loss fraction distribution was chosen based on the calculation of daily throughput, as shown in Appendix E.3.4

E.3.12 Equipment Cleaning Loss Fraction

EPA used the EPA/OPPT Single Process Residual Model to estimate the releases from equipment cleaning. That model, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015), provides an overall loss fraction of 1 percent from equipment cleaning.

E.3.13 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 1,000 gallons of material, a rate of 2 containers per hour for containers with 1,000 to 10,000 gallons of material, and a typical fill rate of 1 container per hour for containers with over 10,000 gallons of liquid.

E.3.14 Dust Generation Loss Fraction, Dust Capture Efficiency, and Dust Control Efficiency

The 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 6.0×10^{-6} to 0.045 with a mode of 0.005 by mass. The Agency assigned the mode based on the recommended default value for the parameter in the Dust Release Model. The range of initial loss fraction values comes from the range of values compiled from various sources and considered in the development of the Dust Release Model (U.S. EPA, 2021b).

For the fraction captured, EPA assigned a range of 0 to 1.0 with a mode of 0.963 by mass. The Agency 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.

For the fraction removed/controlled, EPA assigned a range of 0 to 1.0 with a mode of 0.79 by mass. The Agency assigned the range for the fraction controlled based on the minimum and maximum estimated control efficiencies listed in the data compiled for the Dust Release Model. EPA assigned the mode for the fraction controlled based on the average of all lower bound estimated control efficiency values for all control technologies presented in the model.

E.4 Incorporation into Adhesives and Sealants Model Approaches and Parameters

This appendix section presents the modeling approach and equations used to estimate environmental releases for DCHP 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: Dust Generation from Transfer Operations.
- Release source 2: Container Cleaning Wastes.
- Release source 3: Product Sampling Wastes.
- Release source 4: Equipment Cleaning Wastes.
- Release source 5: Dust Generation from Transfer Operations.
- Release source 6: Off-Spec and Other Waste Adhesive.

Environmental releases for DCHP during incorporation into adhesives and sealants are a function of DCHP'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, DCHP concentrations, air speed, saturation factor, container size, loss fractions, diameters of openings, and operating durations. The Agency used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.4.1 Model Equations

Table_Apx E-9 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 DCHP 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-9. 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: Dust Generation from Transfer Operations	EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/ Unloading/Loading Operations of Solid Powders (Appendix E.1)	Q_{DCHP_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_{DCHP_year}; LF_{cont}; V_{cont}; F_{DCHP_import}
Release source 3: Product Sampling Wastes	March 2023 Methodology for Estimating Environmental Releases from Sampling Waste (Appendix E.1)	Q_{DCHP_day}; $LF_{sampling}$
Release source 4: Equipment Cleaning Wastes	EPA/OPPT Multiple Process Vessel Residual Model (Appendix E.1)	Q_{DCHP_day}; LF_{equip_clean}
Release source 5: Dust Generation from Transfer Operations	EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/ Unloading/Loading Operations of Solid Powders (Appendix E.1)	Q_{DCHP_day}; $F_{dust\_generation}$; $F_{dust\_capture}$; $F_{dust\_control}$
Release source 6: Off-Specification and Other Waste Adhesive	See Equation_Apx E-20	Q_{DCHP_day}; $LF_{offspec}$

Release source 6 daily release (Off-Spec and Other Waste Adhesive) is calculated using the following equation:

Equation_Apx E-20.

$$Release\_perDay_{RP6} = Q_{DCHP\_day} * LF_{offspec}$$

Where:

$Release\_perDay_{RP6}$ = DCHP released for release source 11 (kg/site-day)
Q_{DCHP_day} = Facility throughput of DCHP (kg/site-day)
$LF_{offspec}$ = Loss fraction for off-spec and waste adhesive (unitless)

E.4.2 Model Input Parameters

Table_Apx E-10 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 this table.

Table_Apx E-10. 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 DCHP at All Sites	PV_{total}	kg/year	2.1E04	–	–	–	–	See Appx. E.4.4
Initial DCHP Concentration	F_{DCHP_import}	kg/kg	1.0	0.9	1.0	–	Uniform	See Appx. E.4.7
Final DCHP Concentration	F_{DCHP_final}	kg/kg	0.55	0.40	0.55	–	Uniform	See Appx. E.4.8
Import Container Size	V_{cont}	kg	25	25	499	25	Triangular	See Appx. E.4.9
Packaged Container Size	$V_{cont\_packaged}$	gal	1.0	0.10	20	1.0	Triangular	See Appx. E.4.9
Fraction of Chemical Lost During Transfer of Solid Powders	$F_{dust\_generation}$	kg/kg	5.0E−03	6.0E−06	4.5E−02	5.0E−03	Triangular	See Appx. E.4.10
Capture Efficiency for Dust Capture Methods	$F_{dust\_capture}$	kg/kg	0.96	0.93	1.0	0.96	Triangular	See Appx. E.4.10
Control Efficiency for Dust Capture Methods	$F_{dust\_control}$	kg/kg	0.79	0	1.0	0.79	Triangular	See Appx. E.4.10
Container Residue Loss Fraction	LF_{cont}	kg/kg	0.10	–	–	–	–	See Appx. E.4.11
Fraction of DCHP Lost During Sampling – 1 (Q_{DCHP_day} < 50 kg/site-day)	$F_{sampling\_1}$	kg/kg	2.0E−02	2.0E−03	2.0E−02	2.0E−02	Triangular	See Appx. E.4.12
Fraction of DCHP Lost During Sampling – 2 (Q_{DCHP_day} 50–200 kg/site-day)	$F_{sampling\_2}$	kg/kg	5.0E−03	6.0E−04	5.0E−03	5.0E−03	Triangular	See Appx. E.4.12
Fraction of DCHP Lost During Sampling – 3 (Q_{DCHP_day} 200–5,000 kg/site-day)	$F_{sampling\_3}$	kg/kg	4.0E−03	5.0E−04	4.0E−03	4.0E−03	Triangular	See Appx. E.4.12
Fraction of DCHP Lost During Sampling – 4 (Q_{DCHP_day} > 5,000 kg/site-day)	$F_{sampling\_4}$	kg/kg	4.0E−04	8.0E−05	4.0E−04	4.0E−04	Triangular	See Appx. E.4.12
Molecular Weight	MW	g/mol	330	–	–	–	–	Physical property
Density of DCHP	RHO	kg/L	1.4	–	–	–	–	Physical property
Operating Days	OD	days/year	250	–	–	–	–	See Appx. E.4.13
Batch Size	Q_{batch}	kg/batch	4000	–	–	–	–	See Appx. E.4.14
Drum and Tote Fill Rate	$RATE_{fill\_drum\_tote}$	containers/h	20	–	–	–	–	See Appx. E.4.15

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/h	60	–	–	–	–	See Appx. E.4.15
Equipment Cleaning Loss Fraction	LF_{equip_clean}	kg/kg	0.02	–	–	–	–	See Appx. E.4.16
Off-Spec and Waste Loss Fraction	$LF_{offspec}$	kg/kg	0.01	–	–	–	–	See Appx. E.4.17

E.4.3 Number of Sites

EPA used 2020 CDR data (U.S. EPA, 2020a) to identify the number of sites that may incorporate DCHP into adhesive and sealant products. In CDR under industrial use, there was one reporter that identified DCHP use in adhesives manufacturing: Vertellus LLC. This report specified less than 10 industrial use sites. EPA used this information to assume a range of 1 to 9 processing sites.

E.4.4 Throughput Parameters

EPA estimated the total production volume for all sites using 2020 CDR data (U.S. EPA, 2020a). One reporting manufacturing site, Vertellus LLC, reported an overall PV that was CBI but indicated an exporting volume of 410,849 lb of DCHP for 2019. Vertellus LLC also reported use of DCHP in adhesives manufacturing that amounted to 10 percent of their overall PV. The Agency assumed that the site exports 90 percent of their manufactured PV and the remaining 10 percent is used in adhesives manufacturing (see Appendix E.2.4). EPA calculated that the overall PV for this site is equal to 410,849 lb ÷ 0.9 = 456,499 lb. The overall use volume in adhesives manufacture based on this PV would then be equal to 456,499 lb × 0.1 = 45,650 lb/year (20,706 kg/year).

The daily throughput of DCHP is calculated using Equation_Apx E-21 by dividing the annual overall production volume by the number of sites multiplied by the operating days. The number of operating days is determined according to Appendix E.4.13.

Equation_Apx E-21.

$$Q_{DCHP\_day} = \frac{PV}{N_s * OD}$$

Where:

Q_{DCHP_day}	=	Facility throughput of DCHP (kg/site-day)
PV	=	Overall PV for DCHP in adhesive/sealant formulation (20,706 kg/-year)
N_s	=	Number of sites (see Appendix E.4.3)
OD	=	Operating days (see Appendix E.4.13) (days/year)

The annual throughput of DCHP is calculated using Equation_Apx E-22 by multiplying the daily facility throughput by the number of operating days. Operating days is determined according to Appendix E.4.13. EPA assumes the number of batches is equal to the number of operating days.

Equation_Apx E-22,

$$Q_{DCHP\_year} = Q_{DCHP\_day} * OD$$

Where:

Q_{DCHP_year}	=	Facility annual throughput of DCHP (kg/site-year)
Q_{DCHP_day}	=	Facility daily throughput of DCHP (kg/site-day)
OD	=	Operating days (see Appendix E.4.13) (days/year)

E.4.5 Number of Containers per Year

The number of DCHP raw material containers received and unloaded by a site per year is calculated using the following equation:

Equation_Apx E-23.

$$N_{cont\_unload\_yr} = \frac{Q_{DCHP\_year}}{V_{cont}}$$

Where:

V_{cont}	=	Import container volume (see Appendix E.4.9) (kg/container)
Q_{DCHP_year}	=	Facility annual throughput of DCHP (see Appendix E.4.4) (kg/site-year)
$N_{cont\_unload\_yr}$	=	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_Apx E-24.

$$N_{cont\_load\_yr} = \frac{Q_{DCHP\_year}}{RHO * \left(3.79\ \frac{L}{gal}\right) * F_{DCHP\_final} * V_{cont\_packaged}}$$

Where:

$V_{cont\_packaged}$	=	Product container volume (see Appendix E.4.9) (gal/container)
Q_{DCHP_year}	=	Facility annual throughput of DCHP (see Appendix E.4.4) (kg/site-year)
RHO	=	DCHP density (kg/L)
F_{DCHP_final}	=	Final DCHP concentration (see Appendix 4.2E.4.4) (kg/kg)
$N_{cont\_load\_yr}$	=	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 (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_Apx E-25.

$$OH_{RP1} = \frac{N_{cont\_unload\_yr}}{RATE_{fill\_cont} * OD}$$

Where:

OH_{RP1}	=	Operating time for release point 1 (h/site-day)
$RATE_{fill\_cont}$	=	Fill rate of solid containers (see Appendix E.4.15) (containers/h)
$N_{cont\_unload\_yr}$	=	Annual number of containers unloaded (see Appendix E.4.5) (container/site-year)
OD	=	Operating days (see Appendix E.4.13) (days/site-year)

For loading into transport containers (release point 5), 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_Apx E-26.

$$OH_{RP5} = \begin{cases} \frac{N_{cont\_load\_yr}}{RATE_{fill\_cont} * OD}, \frac{N_{cont\_load\_yr}}{RATE_{fill\_cont} * OD} \leq [24 - OH_{RP1}] \\ 24 - OH_{RP1}, \frac{N_{cont\_load\_yr}}{RATE_{fill\_cont} * OD} > [24 - OH_{RP1}] \end{cases}$$

Where:

OH_{RP5}	=	Operating time for release point 5 (h/site-day)
$RATE_{fill\_cont}$	=	Fill rate of containers (see Appendix E.4.15) (containers/h)
$N_{cont\_load\_yr}$	=	Annual number of containers loaded (see Appendix E.4.5) (container/site-year)
OD	=	Operating days (see Appendix E.4.13) (days/site-year)
OH_{RP1}	=	Operating time for release point 1 (h/site-day)

E.4.7 Initial DCHP Concentration

EPA modeled the initial DCHP concentration using a uniform distribution with a lower bound of 90 percent and upper bound of 100 percent based on information reported in the 2020 CDR by sites indicating DCHP use in adhesives and sealants (U.S. EPA, 2020a).

E.4.8 Final DCHP Concentration

EPA modeled final DCHP concentration in adhesives and sealants using a uniform distribution with a lower bound of 40 percent and an upper bound of 55 percent. These bounds are based on the concentration range for one adhesive product, Protectosil Degadeck CSS BPO, a solid product that is mixed into the final adhesive formulation by the user before application. This product was chosen as it can be used to generate conservative release and worker exposure estimates for this formulation process, where there is minimal DCHP-specific process information (see Appendix F for EPA identified DCHP-containing products for this OES).

E.4.9 Container Size

EPA assumed that DCHP would arrive at formulation sites in solid form. For DCHP in solid form, 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, 2021d), which states that compounded plastics in pellet form are routinely shipped in containers ranging from 25 kg bags to 500 kg gaylords. The Agency assumes that manufacturers ship DCHP in powder/pellet in similarly sized containers. EPA converted the mass of the container to volume assuming a density of 1 kg/L. The Agency used a volumetric distribution with a lower bound and mode of 7 gallons and an upper bound of 132 gallons.

EPA considered container sizes for solid DCHP-containing additive products, including those for adhesives/sealants as well as paints and coatings. Container sizes for the solids containing DCHP had capacities ranging from less than 0.1 gallons up to approximately 10 gallons based on available technical data sheets reviewed by EPA (see Appendix F for EPA identified DCHP-containing products for this OES). Additionally, EPA considered default container size ranges identified in the *ChemSTEER User Guide*. According to that Guide, bottles are defined as containing between 1 and 5 gallons of material with a default bottle size of 1 gallon, and small containers are defined as containing between 5 and 20 gallons of material with a default size of 5 gallons (U.S. EPA, 2015). EPA modeled container size using a triangular distribution accounting for the identified product container sizes and the *ChemSTEER User Guide* size ranges. The Agency used a lower bound of 0.1 gallons based on an order-of-magnitude estimate for identified product container sizes, an upper bound of 20 gallons based on the upper bound for small containers defined by the Guide, and a mode of 1 gallon based on typical identified container sizes and the default bottle size defined by the *ChemSTEER User Guide*.

E.4.10 Dust Generation Loss Fraction, Dust Capture Efficiency, and Dust Control Efficiency

The 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 distributions require the fewest assumptions and are completely defined by the 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 6.0×10^{-6} to 0.045 with a mode of 0.005 by mass. The Agency assigned the mode based on the recommended default value for the parameter in the Dust Release Model. The range of initial loss fraction values comes from the range of values compiled from various sources and considered in the development of the Dust Release Model (U.S. EPA, 2021b).

For the fraction captured, EPA assigned a range of 0 to 1.0 with a mode of 0.963 by mass. The Agency 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.

For the fraction removed/controlled, EPA assigned a range of 0 to 1.0 with a mode of 0.79 by mass. The Agency assigned the range for the fraction controlled based on the minimum and maximum estimated control efficiencies listed in the data compiled for the Dust Release Model. EPA assigned the mode for the fraction controlled based on the average of all lower bound estimated control efficiency values for all control technologies presented in the model.

E.4.11 Container Residue Loss Fraction

For solid containers, EPA used the EPA/OPPT Solid Residuals in Transport Containers Model to estimate residual releases from solid container cleaning. The EPA/OPPT Solid Residuals in Transport Containers Model, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015), provides an overall loss fraction of 1 percent from container cleaning.

E.4.12 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-11 presents a summary of the chemical daily throughputs and corresponding loss fractions.

Table_Apx E-11. Sampling Loss Fraction Data from the March 2023 Methodology for Estimating Environmental Releases from Sampling Waste

Chemical Daily Throughput (kg/site-day) ($Q_{chem\_site\_day}$)	Number of Data Points	Sampled Quantity (kg chemical/day)		Sampling Loss Fraction ($LF_{sampling}$)	
		50th Percentile	95th Percentile	50th Percentile	95th Percentile
<50	13	0.03	0.20	0.002	0.02
50 to <200	10	0.10	0.64	0.0006	0.005
200 to <5,000	25	0.37	3.80	0.0005	0.004
≥5,000	10	1.36	6.00	0.00008	0.0004
All	58	0.20	5.15	0.0005	0.008

For each range of daily throughputs, EPA estimated sampling loss fractions using a triangular distribution of the 50th percentile value as the lower bound, and the 95th percentile value as the upper bound and mode. The sampling loss fraction distribution was chosen based on the calculation of daily throughput, as shown in Appendix E.4.4.

E.4.13 Operating Days

EPA was unable to identify DCHP-specific information for operating days in the production of adhesives and sealants. Therefore, EPA assumes a constant value of 250 days/year, which assumes the production sites operate 5 days per week and 50 weeks per year, with 2 weeks down for turnaround.

E.4.14 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.4.15 Container Fill Rates

The *ChemSTEER User Guide* (U.S. EPA, 2015) provides a typical fill rate of 20 containers per hour for containers with 20 to 1,000 gallons of material, a rate of 2 containers per hour for containers with 1,000 to 10,000 gallons of material, and a typical fill rate of 1 container per hour for containers with over 10,000 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 5).

Equation_Apx E-27,

$$if\ 24 < (OH_{RP1} + OH_{RP5}),\ RATE_{fill\_adjusted} = \frac{N_{cont\_load\_yr}}{(24 - OH_{RP1}) * OD}$$

Where:

$RATE_{fill\_adjusted}$	=	Corrected fill rate for product containers (containers/h)
$N_{cont\_load\_yr}$	=	Annual number of product containers (containers/site-year)
OH_n	=	Operating time for release point "n" (h/site-day)
OD	=	Operating days see Appendix E.4.13) (days/site-year)

E.4.16 Equipment Cleaning Loss Fraction

EPA used the EPA/OPPT Multiple Process Residual Model to estimate the releases from equipment cleaning. That model, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015) provides an overall loss fraction of 2 percent from equipment cleaning.

E.4.17 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 1 percent of throughput disposed from off-specification material during manufacturing. The 1 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 DCHP 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: Dust Generation from Transfer Operations.
- Release source 2: Container Cleaning Wastes.
- Release source 3: Product Sampling Wastes.
- Release source 4: Equipment Cleaning Wastes.
- Release source 5: Filter Waste Losses.
- Release source 6: Dust Generation from Transfer Operations.
- Release source 7: Off-Spec and Other Waste Paint/Coatings.

Environmental releases for DCHP during incorporation into paints and coatings are a function of DCHP'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, DCHP concentrations, air speed, container size, loss fractions, and operating durations. The Agency used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.5.1 Model Equations

Table_Apx E-12 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 DCHP 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-12. Models and Variables Applied for Release Sources in the Incorporation into Paints and Coatings OES

Release Source	Model(s) Applied	Variables Used
Release source 1: Dust Generation from Transfer Operations.	EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders (Appendix E.1)	Q_{DCHP_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)	LF_{cont}; $OD\ V_{cont}$; Q_{DCHP_year}; F_{DCHP_import}
Release source 3: Product Sampling Wastes.	March 2023 Methodology for Estimating Environmental Releases from Sampling Waste (Appendix E.1)	Q_{DCHP_day}; $LF_{sampling}$
Release source 4: Equipment Cleaning Wastes.	EPA/OPPT Multiple Process Vessel Residual Model (Appendix E.1)	Q_{DCHP_day}; LF_{equip_clean}
Release source 5: Filter Waste Losses.	No available data or models for estimation. Estimate on a case-by-case basis.	N/A
Release source 6: Dust Generation from Packaging Paint/Coating into Transport Containers.	EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders (Appendix E.1)	Q_{DCHP_day}; $F_{dust\_generation}$; $F_{dust\_capture}$; $F_{dust\_control}$
Release source 7: Off-Specification and Other Waste Paint/Coating.	See Equation_Apx E-28	Q_{DCHP_day}; $LF_{offspec}$

Release source 7 daily release (Off-Spec and Other Waste Coating) is calculated using the following equation:

Equation_Apx E-28.

$$Release\_perDay_{RP7} = Q_{DCHP\_day} * LF_{offspec}$$

Where:

$Release\_perDay_{RP7}$ = DCHP released for release source 7 (kg/site-day)
Q_{DCHP_day} = Facility throughput of DCHP (see Appendix E.5.4) (kg/site-day)
$LF_{offspec}$ = Loss fraction for off-spec and waste adhesive (see Appendix E.5.17) (unitless)

E.5.2 Model Input Parameters

Table_Apx E-13 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 this table.

Table_Apx E-13. 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	
Number of Sites	N_{sites}	Dimension-less	36	4	36	–	Uniform	See Appx. E.5.3
Total PV of DCHP at All Sites	PV_{total}	kg/year	2.1E04	1,070	2.1E04	–	Uniform	See Appx. E.5.4
Initial DCHP Concentration	F_{DCHP_import}	kg/kg	1.0	0.30	1.0	–	Uniform	See Appx. E.5.7
Final DCHP Concentration	F_{DCHP_final}	kg/kg	0.40	0.01	1.0	0.40	Triangular	See Appx. E.5.8
Import Container Size	V_{cont}	kg	25	25	499	25	Triangular	See Appx. E.5.9
Packaged Container Size	$V_{cont\_packaged}$	gal	1.0	0.10	20	1.0	Triangular	See Appx. E.5.9
Fraction of Chemical Lost During Transfer of Solid Powders	$F_{dust\_generation}$	kg/kg	5.0E−03	6.0E−06	4.5E−02	5.0E−03	Triangular	See Appx. E.5.10
Capture Efficiency for Dust Capture Methods	$F_{dust\_capture}$	kg/kg	0.96	0.93	1.0	0.96	Triangular	See Appx. E.5.10
Control Efficiency for Dust Capture Methods	$F_{dust\_control}$	kg/kg	0.79	0	1.0	0.79	Triangular	See Appx. E.5.10
Container Residue Loss Fraction	LF_{cont}	kg/kg	0.01	–	–	–	–	See Appx. E.5.11
Fraction of DCHP Lost During Sampling – 1 (Q_{DCHP_day} < 50 kg/site-day)	$F_{sampling\_1}$	kg/kg	2.0E−02	2.0E−03	2.0E−02	2.0E−02	Triangular	See Appx. E.5.12
Fraction of DCHP Lost During Sampling – 2 (Q_{DCHP_day} 50–200 kg/site-day)	$F_{sampling\_2}$	kg/kg	5.0E−03	6.0E−04	5.0E−03	5.0E−03	Triangular	See Appx. E.5.12
Fraction of DCHP Lost During Sampling – 3 (Q_{DCHP_day} 200–5,000 kg/site-day)	$F_{sampling\_3}$	kg/kg	4.0E−03	5.0E−04	4.0E−03	4.0E−03	Triangular	See Appx. E.5.12
Fraction of DCHP Lost During Sampling – 4 (Q_{DCHP_day} > 5,000 kg/site-day)	$F_{sampling\_4}$	kg/kg	4.0E−04	8.0E−05	4.0E−04	4.0E−04	Triangular	See Appx. E.5.12
Vapor Pressure at 25 °C	VP	mmHg	4.9E−07	–	–	–	–	Physical property
Molecular Weight	MW	g/mol	330	–	–	–	–	Physical property
Density of DCHP	RHO	kg/L	1.4	–	–	–	–	Physical property

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Temperature	T	K	298	–	–	–	–	Process parameter
Pressure	P	atm	1	–	–	–	–	Process parameter
Operating Days	OD	days/year	250	–	–	–	–	See Appx. E.5.13
Batch Size	Q_{batch}	kg/batch	5,030	–	–	–	–	See Appx. E.5.14
Drum and Tote Fill Rate	$RATE_{fill\_drum\_tote}$	containers/h	20	–	–	–	–	See Appx. E.5.15
Small Container Fill Rate	$RATE_{fill\_cont}$	containers/h	60	–	–	–	–	See Appx. E.5.15
Equipment Cleaning Loss Fraction	LF_{equip_clean}	kg/kg	0.02	–	–	–	–	See Appx. E.5.16
Off-Spec and Waste Loss Fraction	$LF_{offspec}$	kg/kg	0.012	–	–	–	–	See Appx. E.5.17

E.5.3 Number of Sites

EPA used 2020 CDR data (U.S. EPA, 2020a) to identify the number of sites that may incorporate DCHP into paint and coating products. In CDR under industrial use, there were four entries related to "Processing as a reactant" or "Incorporation into formulation, mixture, or reaction product" and tagged under use for paints and coatings. Each report specified less than 10 industrial use sites. EPA used this information to develop a range of sites with a minimum of 4 sites (one for each report) and a maximum of 36 sites (assuming 9 sites per report).

E.5.4 Throughput Parameters

EPA estimated the total production volume for all sites using a uniform distribution with a lower bound of 1,070 kg/year and an upper bound of 21,482 kg/year.

The upper and lower bounds are based on CDR data (U.S. EPA, 2020a). One reporter in CDR estimated that a total of 18 percent of their annual PV is used for Paint and Coating Manufacturing; however, they did not disclose their annual total PV. They also reported as an importer in the 2020 CDR but did not disclose their import volume. The national aggregate PV for DCHP according to CDR is 500,000 to less than 1,000,000 lb. Subtracting the known PVs for the two manufacturing sites results in a remaining range of 26,211 to 526,211 lb.

Dividing this range by 2 results in the PV range per import site based on the national aggregate PV: (26,211–526,211 lb) ÷ 2 = 13,106 to 263,105 lb/import site.

Multiplying this range by the use percentage for paint and coating products results in: (13,106–263,105 lb) * 0.18 = 2,359 to 47,359 lb/year, or 1,070 to 21,482 kg/year.

The annual throughput of DCHP per facility is calculated using Equation_Apx E-29 by dividing the overall PV for all sites by the number of use sites. The number of sites is determined according to Appendix E.5.3.

Equation_Apx E-29.

$$Q_{DCHP\_year} = \frac{PV}{N_{sites}}$$

Where:

Q_{DCHP_year}	=	Facility annual throughput of DCHP (see Appendix E.5.4) (kg/site-year)
PV	=	Overall annual production volume for DCHP in paints/coating products for all sites (kg/year)
N_{sites}	=	Number of paint/coating production sites (see Appendix E.5.3)

The daily throughput of DCHP is calculated using Equation_Apx E-30 by dividing the annual production volume by the number of operating days. The number of operating days is determined according to Appendix E.5.13.

Equation_Apx E-30.

$$Q_{DCHP\_day} = \frac{Q_{DCHP\_year}}{OD}$$

Where:

Q_{DCHP_day}	=	Facility throughput of DCHP (kg/site-day)
Q_{DCHP_year}	=	Facility annual throughput of DCHP (see Appendix E.5.4) (kg/site-year)
OD	=	Operating days (see Appendix E.5.13) (days/year)

E.5.5 Number of Containers per Year

The number of DCHP raw material containers received and unloaded by a site per year is calculated using the following equation:

Equation_Apx E-31.

$$N_{cont\_unload\_yr} = \frac{Q_{DCHP\_year}}{V_{cont}}$$

Where:

V_{cont}	=	Import container volume (see Appendix E.5.9) (kg/container)
Q_{DCHP_year}	=	Facility annual throughput of DCHP (see Appendix E.5.4) (kg/site-year)
$N_{cont\_unload\_yr}$	=	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_Apx E-32.

$$N_{cont\_load\_yr} = \frac{Q_{DCHP\_year}}{RHO * \left(3.79\ \frac{L}{gal}\right) * V_{cont\_packaged}}$$

Where:

$V_{cont\_packaged}$	=	Product container volume (see Appendix E.5.9) (gal/container)
Q_{DCHP_year}	=	Facility annual throughput of DCHP (see Appendix E.5.4) (kg/site-year)
RHO	=	DCHP 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 (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_Apx E-33.

$$OH_{RP1} = \frac{N_{cont\_unload\_yr}}{RATE_{fill\_drum\_tote} * OD}$$

Where:

OH_{RP1}	=	Operating time for release point 1 (h/site-day)
$RATE_{fill\_drum\_tote}$	=	Fill rate of drums and totes (see Appendix E.5.15) (containers/h)
$N_{cont\_unload\_yr}$	=	Annual number of containers unloaded (see Appendix E.5.5) (container/site-year)
OD	=	Operating days (see Appendix E.5.13) (days/site-year)

For loading into transport containers (release point 6), 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_Apx E-34.

$$OH_{RP6} = \begin{cases} \frac{N_{cont\_load\_yr}}{RATE_{fill\_cont} * OD}, & \frac{N_{cont\_load\_yr}}{RATE_{fill\_cont} * OD} \leq [24 - OH_{RP1}] \\ 24 - OH_{RP1}, & \frac{N_{cont\_load\_yr}}{RATE_{fill\_cont} * OD} > [24 - OH_{RP1}] \end{cases}$$

Where:

OH_n	=	Operating time for release point "n" (h/site-day)
$RATE_{fill\_cont}$	=	Fill rate of containers, dependent on volume (see Appendix E.5.15) (containers/h)
$N_{cont\_load\_yr}$	=	Annual number of containers loaded (see Appendix E.5.5) (container/site-year)
OD	=	Operating days (see Appendix E.5.13) (days/site-year)

E.5.7 Initial DCHP Concentration

Based on information reported in the 2020 CDR by sites indicating DCHP use in paints and coatings, DCHP is contained in coating products in concentrations of 30 to 60 percent (U.S. EPA, 2020a). However, several product SDSs listed DCHP concentrations that exceeded the 60 percent maximum that was reported in CDR, with some products reporting a maximum DCHP concentration of 100 percent (see Appendix F for EPA identified DCHP-containing products for this OES). Because of this, EPA increased the maximum concentration for paint/coating products to 100 percent, for a final DCHP initial concentration range of 30 to 100 percent modeled using a uniform distribution.

E.5.8 Final DCHP Concentration

EPA modeled the final DCHP concentration in paints and coatings using a triangular distribution with a lower bound of 0.01 percent, upper bound of 100 percent, and mode of 40 percent. This is based on compiled SDS information for paint and coating products containing DCHP. 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 DCHP-containing products for this OES).

To avoid cases where the DCHP concentration in the initial material exceeded the concentration in the finished product while modeling, EPA adjusted the concentration of the finished product to bind it to a maximum concentration equal to the concentration of the initial material.

E.5.9 Container Size

EPA assumed that DCHP arrives at formulation sites in solid form. For DCHP in solid form, EPA modeled solid containers using a triangular distribution with a lower bound and mode of 25 kg and an upper bound of 500 kg. This is based on the 2021 Use of Additives in Plastics Converting Draft Generic Scenario (U.S. EPA, 2021d), which states that compounded plastics in pellet form are routinely shipped in containers ranging from 25 kg bags to 500 kg gaylords. The Agency assumes that manufacturers ship DCHP in powder/pellet form in similarly sized containers. EPA converted the mass of the container to volume assuming a density of 1 kg/L. The Agency used a volumetric distribution with a lower bound and mode of 7 gallons and an upper bound of 132 gallons.

EPA considered container sizes for solid DCHP-containing additive products, including those for adhesives/sealants as well as paints and coatings. Container sizes for the solids containing DCHP had capacities ranging from less than 0.1 gallons up to approximately 10 gallons based on available technical data sheets reviewed by EPA (see Appendix F for EPA identified DCHP-containing products for this OES). Additionally, EPA considered default container size ranges identified in the *ChemSTEER User Guide*. According to the guide, bottles are defined as containing between 1 and 5 gallons of material with a default bottle size of 1 gallon, and small containers are defined as containing between 5 and 20 gallons of material with a default size of 5 gallons (U.S. EPA, 2015). The Agency modeled container size using a triangular distribution accounting for the identified product container sizes and the *ChemSTEER User Guide* size ranges. EPA used a lower bound of 0.1 gallons based on an order-of-magnitude estimate for identified product container sizes, an upper bound of 20 gallons based on the upper bound for small containers defined by the *ChemSTEER User Guide*, and a mode of 1 gallon based on typical identified container sizes and the default bottle size defined by the guide.

E.5.10 Dust Generation Loss Fraction, Dust Capture Efficiency, and Dust Control Efficiency

The 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 distributions require the fewest assumptions and are completely defined by the 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 6.0×10^{-6} to 0.045 with a mode of 0.005 by mass. The Agency assigned the mode based on the recommended default value for the parameter in the Dust Release Model. The range of initial loss fraction values comes from the range of values compiled from various sources and considered in the development of the Dust Release Model (U.S. EPA, 2021b).

For the fraction captured, EPA assigned a range of 0 to 1.0 with a mode of 0.963 by mass. The Agency 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.

For the fraction removed/controlled, EPA assigned a range of 0 to 1.0 with a mode of 0.79 by mass. The Agency assigned the range for the fraction controlled based on the minimum and maximum estimated control efficiencies listed in the data compiled for the Dust Release Model. EPA assigned the mode for the fraction controlled based on the average of all lower bound estimated control efficiency values for all control technologies presented in the model.

E.5.11 Container Residue Loss Fraction

For solid containers, EPA used the *EPA/OPPT Solid Residuals in Transport Containers Model* to estimate residual releases from solid container cleaning. The EPA/OPPT Solid Residuals in Transport Containers Model, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015) provides an overall loss fraction of 1 percent from container cleaning.

E.5.12 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 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-14 presents a summary of the chemical daily throughputs and corresponding loss fractions.

Table_Apx E-14. Sampling Loss Fraction Data from the March 2023 Methodology for Estimating Environmental Releases from Sampling Waste

Chemical Daily Throughput (kg/site-day) ($Q_{chem\_site\_day}$)	Number of Data Points	Sampled Quantity (kg chemical/day)		Sampling Loss Fraction ($LF_{sampling}$)	
		50th Percentile	95th Percentile	50th Percentile	95th Percentile
<50	13	0.03	0.20	0.002	0.02
50 to <200	10	0.10	0.64	0.0006	0.005
200 to <5,000	25	0.37	3.80	0.0005	0.004
≥5,000	10	1.36	6.00	0.00008	0.0004
All	58	0.20	5.15	0.0005	0.008

For each range of daily throughputs, EPA estimated sampling loss fractions using a triangular distribution of the 50th percentile value as the lower bound, and the 95th percentile value as the upper bound and mode. The sampling loss fraction distribution was chosen based on the calculation of daily throughput, as shown in Appendix E.4.3

E.5.13 Operating Days

EPA was unable to identify DCHP-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/year, which assumes the production sites operate 5 days per week and 50 weeks per year, with 2 weeks down for turnaround.

E.5.14 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.5.15 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 6).

Equation_Apx E-35

$$if\ 24 < (OH_{RP1}),\ RATE_{fill\_adjusted} = \frac{N_{cont\_load\_yr}}{(24 - OH_{RP1}) * OD}$$

Where:

$RATE_{fill\_adjusted}$	=	Corrected fill rate for product containers (containers/h)
$N_{cont\_load\_yr}$	=	Annual number of product containers (containers/site-year)
OH_n	=	Operating time for release point "n" (h/site-day)
OD	=	Operating days (days/site-year)

E.5.16 Equipment Cleaning Loss Fraction

EPA used the EPA/OPPT Multiple Process Residual Model to estimate the releases from equipment cleaning. That model as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015) provides an overall loss fraction of 2 percent from equipment cleaning.

E.5.17 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, or Reaction Products Model Approaches and Parameters

This appendix section presents the modeling approach and equations used to estimate environmental releases for DCHP during the incorporation into other formulations, mixtures, or reaction products 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 the number of formulation sites and the final product DCHP concentrations, will be presented in this section for brevity.

E.6.1 Throughput Parameters

No sites reported to CDR for use of DCHP in the formulation of these products. EPA estimated the total production volume for all sites assuming a static value of 75,865 lb/year (34,412 kg/year) that was estimated based on the reporting requirements for CDR. The threshold for CDR reporters requires a site to report processing and use for a chemical if the usage exceeds 5 percent of its reported PV or if the use exceeds 25,000 lb per year (whichever is smaller). The CDR sites and their PV contributions to this OES are show in Table_Apx E-15.

Table_Apx E-15. Site CDR Volume's Used for the Production Volume Estimate in the Incorporation into Other Formulations OES

Reporting Year	Site Name	PV CBI?	PV Contribution to this OES (lb)
2020	United Initiators, Inc.	Yes	25,000
2020	Lanxess Corporation Greensboro	No	864.5
2020	Vertellus Greensboro LLC	Yes	25,000
2020	Nouryon Functional Chemicals LLC	No	25,000

E.6.2 Number of Sites

The number of sites is calculated using the following equation.:

Equation_Apx E-36.

$$N_s = \frac{PV}{Q_{formulation\ site\_year\_GS} \times F_{DCHP}}$$

Where:

N_s	=	Number of sites (sites)
PV	=	Production volume (see Appendix 4.2E.6.1) (kg/year)
$Q_{formulation_{site-yr,GS}}$	=	Facility annual throughput of formulated product estimate per the GS (1.6–16 million kg/site-year)
F_{DCHP}	=	Weight fraction of DCHP in the formulation (see Appendix E.6.3)

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-year. For special purpose coatings, the GS estimates 1.6 million kg of coatings/site-year. EPA estimated the number of sites using this PV range, multiplying the production rates by the concentration range of DCHP in the final products (see Appendix E.6.3) and capping the production rate at the total annual PV across all sites (see Appendix E.6.1). To calculate the overall range, EPA multiplied the minimum formulation throughput by the minimum DCHP concentration and the maximum formulation throughput by the maximum DCHP concentration. Because the maximum calculation resulted in a DCHP throughput greater than the PV assessed for this OES, EPA assessed at a max of 34,412 kg/site-year.

Using this range of DCHP site throughputs and Equation_Apx E-33, the number of sites was estimated to be between 1 to 22 sites.

E.6.3 Final DCHP Concentration

EPA modeled final DCHP concentration in other articles using a triangular distribution with a lower bound of 0.1 percent, upper bound of 100 percent, and mode of 30 percent. The lower bound and mode is based on compiled SDS information for formulation products containing DCHP. From the compiled data, the minimum concentration was 0.1 percent, and the mode was 30 percent. The mode represents the mode of all solid product high-end values of the concentration ranges found in SDSs.

E.6.4 Non-PVC Materials Model Approaches and Parameters

This appendix section presents the modeling approach and equations used to estimate environmental releases for DCHP during the Non-PVC Materials Compounding and Non-PVC Materials Converting OESs. This approach utilizes the Generic Scenario for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c), the 2021 Use of Additives in Plastics Converting Draft Generic Scenario (U.S. EPA, 2021d), 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 materials compounding:

- Release source 1: Dust Generation from Transfer Operations Released to Air, or Collected and Released to Water, Incineration, or Landfill.
- Release source 2: Container Residue Losses to Water, Incineration, or Landfill.
- Release source 3: Vapor Emissions from Blending/Compounding/Converting to Fugitive or Stack Air.
- Release source 4: Equipment Cleaning Losses to Water, Landfill, or Incineration.
- Release source 5: Direct Contact Cooling Water Losses to Water.
- Release source 6: Release of Additives during Loading.

Based on the GS, EPA identified the following release sources from non-PVC materials converting:

- Release source 1: Transfer Operations Losses to Air, Water, Incineration, or Landfill from Unloading Plastics additives.
- Release source 2: Container Residue Losses to Water, Incineration, or Landfill.
- Release source 3: Vapor Emissions During Converting to Fugitive or Stack Air.
- Release source 4: Particulate Emissions During Converting to Air, Water, Incineration, or Landfill.
- Release source 5: Equipment Cleaning Losses to Water, Landfill, or Incineration.
- Release source 6: Direct Contact Cooling Water Losses to Water.
- Release source 7: Solid Wastes from Trimming Operation to Landfill or Incineration.

Environmental releases for DCHP during non-PVC materials production are a function of DCHP'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, DCHP concentrations, operating days, number of sites, container size, loss fractions, and dust control/capture efficiencies. The Agency used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.6.5 Model Equations

Table_Apx E-16 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the non-PVC 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.6.6. The Monte Carlo simulation calculated the total DCHP 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-16. Models and Variables Applied for Release Sources in the Non-PVC Materials OES

Release Source	Model(s) Applied	Variables Used
Compounding		
Release source 1: Dust Generation from Transfer Operations Released to Air, or Collected and Released to Water, Incineration, or Landfill	EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders (Appendix E.1)	Q_{DCHP_day}; $F_{dust\_generation}$; $F_{dust\_capture}$ $F_{dust\_control\_filter}$; $F_{dust\_control\_scrubber}$; OD_{comp}
Release source 2: Container Residue Losses to Water, Incineration, or Landfill	EPA/OPPT Drum Residual Model or EPA/OPPT Bulk Transport Residual Model, based on container size (Appendix E.1)	Q_{DCHP_year}; LF_{cont}; V_{cont}; F_{DCHP_import}; OD_{comp};
Release source 3: Vapor Emissions from Blending / Compounding/ Converting to Fugitive or Stack Air	See Equation_Apx E-37	Q_{DCHP_day}; $F_{vapor\_emissions}$
Release source 4: Equipment Cleaning Losses to Water, Landfill, or Incineration	EPA/OPPT Multiple Process Vessel Residual Model (Appendix E.1)	Q_{DCHP_day}; LF_{equip_clean}
Release source 5: Direct Contact Cooling Water Losses to Water	See Equation_Apx E-39	Q_{DCHP_day}; $F_{cooling\_water}$
Release source 6: Release of Additives during Loading	EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders (Appendix E.1)	Q_{DCHP_day}; $F_{dust\_generation}$; $F_{dust\_capture}$; $F_{dust\_control\_filter}$; $F_{dust\_control\_scrubber}$; OD_{comp}
Converting		
Release source 1: Transfer Operations Losses to Air, Water, Incineration, or Landfill from Unloading Plastics additives	EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders (Appendix E.1)	Q_{DCHP_day}; $F_{dust\_generation}$; $F_{dust\_capture}$; $F_{dust\_control\_filter}$; $F_{dust\_control\_scrubber}$; OD_{conv}
Release source 2: Container Residue Losses to Water, Incineration, or Landfill	EPA/OPPT Solid Residuals in Transport Containers Model (Appendix E.1)	Q_{DCHP_year}; LF_{cont}; V_{cont}; $F_{chemresin}$; $N_{cont\_unload\_day}$; OD_{conv}
Release source 3: Vapor Emissions During Converting to Fugitive or Stack Air	See Equation_Apx E-37	Q_{DCHP_day}; $F_{vapor\_emissions}$
Release source 4: Particulate Emissions During Converting to Air, Water, Incineration, or Landfill	See Equation_Apx E-38	Q_{DCHP_day}; $F_{particulate\_emissions}$
Release source 5: Equipment Cleaning Losses to Water, Landfill, or Incineration.	EPA/OPPT Multiple Process Vessel Residual Model (Appendix E.1)	Q_{DCHP_day}; LF_{equip_clean}

Release Source	Model(s) Applied	Variables Used
Release source 6: Direct Contact Cooling Water Losses to Water	See Equation_Apx E-39	Q_{DCHP_day}; $F_{cooling\_water}$
Release source 7: Solid Wastes from Trimming Operation to Landfill or Incineration	See Equation_Apx E-40	Q_{DCHP_day}; $F_{trimming}$

Compounding and converting release source 3 daily release (Vapor Emissions During Compounding/Converting) is calculated using the following equation:

Equation_Apx E-37.

$$Release\_perDay_{RP3} = Q_{DCHP\_day} * F_{vapor\_emissions}$$

Where:

$Release\_perDay_{RP3}$	=	DCHP released for release source 3 (kg/site-day)
Q_{DCHP_day}	=	Facility throughput of DCHP (see Appendix E.6.8) (kg/site-day)
$F_{vapor\_emissions}$	=	Fraction of DCHP lost from volatilization during compounding/converting operations (see Appendix E.6.21) (kg/kg)

Converting release source 4 daily release (Particulate Emissions from Converting) is calculated using the following equation:

Equation_Apx E-38.

$$Release\_perDay_{RP4} = Q_{DCHP\_day} * F_{particulate\_emissions}$$

Where:

$Release\_perDay_{RP4}$	=	DCHP released for release source 4 (kg/site-day)
Q_{DCHP_day}	=	Facility throughput of DCHP (see Appendix E.6.8) (kg/site-day)
$F_{particulate\_emissions}$	=	Fraction of DCHP lost as particulates during converting operations (see Appendix E.6.17) (kg/kg)

Compounding release source 5 and converting release source 6 daily releases (Direct Contact Cooling Water Losses) are calculated using the following equation:

Equation_Apx E-39.

$$Release\_perDay_{RP5,6} = Q_{DCHP\_day} * F_{cooling\_water}$$

Where:

$Release\_perDay_{RP5,6}$	=	DCHP released for compounding release source 5 and converting release source 6 (kg/site-day)
Q_{DCHP_day}	=	Facility throughput of DCHP (see Appendix E.6.8) (kg/site-day)
$F_{cooling\_water}$	=	Cooling water loss fraction (see Appendix E.6.20) (kg/kg)

Converting release source 7 daily release (Solid Wastes from Trimming Operations) is calculated using the following equation:

Equation_Apx E-40

$$Release\_perDay_{RP7} = Q_{DCHP\_day} * F_{trimming}$$

Where:

$Release\_perDay_{RP7}$	=	DCHP released for release source 7 (kg/site-day)
Q_{DCHP_day}	=	Facility throughput of DCHP (see Appendix E.6.7) (kg/site-day)
$F_{trimming}$	=	Trimming loss fraction (see Appendix E.6.22) (kg/kg)

E.6.6 Model Input Parameters

Table_Apx E-17 and summarizes the model parameters and their values for the Non-PVC Materials Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after this table.

Table_Apx E-17. Summary of Parameter Values and Distributions Used in the Non-PVC 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 DCHP at all Sites	PV_{total}	kg/year	2.3E04	1.1E04	2.3E04	–	Uniform	See Appx. E.6.7
Number of Sites	N_{sites}	sites	4	1	4	–	Uniform	See Appx. E.6.7
Initial DCHP Concentration	F_{DCHP_import}	kg/kg	0.60	0.30	0.60	–	Uniform	See Appx. E.6.11
Non-PVC Materials DCHP Concentration	F_{chem_rubber} / F_{chem_resin}	kg/kg	0.20	0.10	0.20	–	Uniform	See Appx. E.6.12
Operating Days – Compounding	OD_{comp}	days/year	246	147	301	246	Triangular	See Appx. E.6.13
Operating Days – Converting	OD_{conv}	days/year	253	136	255	253	Triangular	See Appx. E.6.13
Solid Container Size	V_{cont}	kg	25	25	499	25	Triangular	See Appx. E.6.14
Fraction of Chemical Lost During Transfer of Solid Powders	$F_{dust\_generation}$	kg/kg	5.0E−03	6.0E−06	4.5E−02	5.0E−03	Triangular	See Appx. E.6.16
Capture Efficiency for Dust Capture Methods	$F_{dust\_capture}$	kg/kg	0.96	0	1.0	0.96	Triangular	See Appx. E.6.16
Control Efficiency for Dust Filters	$F_{dust\_control\_filter}$	kg/kg	0.99	0.97	1.0	0.99	Triangular	See Appx. E.6.16
Control Efficiency for Wet Scrubbers	$F_{dust\_control\_scrubber}$	kg/kg	0.55	0.20	1.0	0.55	Triangular	See Appx. E.6.16
Fraction of DCHP Lost as Particulates During Converting Processes	$F_{particulate\_emissions}$	kg/kg	6.0E−05	2.0E−05	1.0E−04	6.0E−05	Triangular	See Appx. E.6.17
Drum and Tote Fill Rate	$RATE_{fill\_drum\_tote}$	containers/h	20	–	–	–	–	See Appx. E.6.18
Small Container Fill Rate	$RATE_{fill\_cont}$	containers/h	60	–	–	–	–	See Appx. E.6.18
Tank Truck Fill Rate	$RATE_{fill\_truck}$	containers/h	2.0	–	–	–	–	See Appx. E.6.18
Rail Car Fill Rate	$RATE_{fill\_rail}$	containers/h	1.0	–	–	–	–	See Appx. E.6.18
Equipment Cleaning Loss Fraction	LF_{equip_clean}	kg/kg	2.0E−02	–	–	–	–	See Appx. E.6.19
Cooling Water Loss Fraction	$F_{cooling\_water}$	kg/kg	1.0E−02	–	–	–	–	See Appx. E.6.20

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Fraction of the Chemical of Interest Lost from Volatilization During Forming and Molding Processes (Open Process)	$F_{vapor\_emissions\_open}$	kg/kg	1.0E−04	–	–	–	–	See Appx. E.6.21
Fraction of the Chemical of Interest Lost from Volatilization During Forming and Molding Processes (Open Process)	$F_{vapor\_emissions\_closed}$	kg/kg	2.0E−05	–	–	–	–	See Appx. E.6.21
Solid Container Loss Fraction	LF_{cont}	kg/kg	1.0E−02	–	–	–	–	See Appx. E.6.15
Trimming Loss Fraction	$F_{trimming}$	kg/kg	2.5E−02	–	–	–	–	See Appx. E.6.22

E.6.7 Production Volume and Number of Sites

EPA estimated the total DCHP production volume for non-PVC materials using a uniform distribution with a lower bound of 11,340 kg/year and an upper bound of 22,680 kg/year. This range is based on DCHP CDR data and reporting thresholds for CDR reporters. CDR data for DCHP provides a national aggregate production volume of 500,000 to 1,000,000 lb/YEAR (U.S. EPA, 2020a). CDR reports require a site to report processing and use for a chemical if the usage exceeds 5 percent of its reported PV or if the use exceeds 25,000 lb per year (whichever is smaller). No sites reporting to CDR listed the manufacture of rubber as a downstream use for DCHP; therefore, EPA assumed that all unique sites reporting to CDR manufactured or imported DCHP for rubber end-uses up to the reporting threshold limit. Using these volume estimates, EPA calculated the total DCHP production volume for non-PVC materials at 25,000 to 50,000 lb/year (11,340–22,680 kg/year).

Table_Apx E-18. Site CDR Volumes Used for the Production Volume Estimate in the Non-PVC Materials Compounding and Converting OES

Reporting Year	Site Name	Estimated PV Contribution to this OES (lb)
2020	United Initiators, Inc.	655.3–13,155.3
2020	Lanxess Corporation Greensboro	864.5
2020	Vertellus Greensboro LLC	22,825
2020	Nouryon Functional Chemicals LLC	655.3–13,155.3

The Emission Scenario Document on Additives in Rubber Industry (OECD, 2004a) suggests a default generic point source throughput estimate of 22,000 kg/site-day for rubber products. However, calculating an annual per-site DCHP throughput using this default generic point source throughput (multiply by DCHP concentration in the product and number of operating days) would result in a per-site DCHP throughput greater than the total DCHP production volume for non-PVC materials. Because the calculation would result in an unreasonable value, EPA estimated the number of sites for non-PVC material compounding and converting as a uniform distribution of 1 to 4 sites based on the total number of reporters to CDR for DCHP (U.S. EPA, 2020a), and EPA calculated the per-site throughput based on this assumption as shown in Appendix E.6.8.

E.6.8 Throughput Parameters

For compounding and converting, the annual throughput of DCHP per site is calculated by dividing the production volume of DCHP for these OESs by the number of sites as shown in Equation_Apx E-41. The production volume and number of sites are determined according to Appendix E.6.7.

Equation_Apx E-41.

$$Q_{DCHP\_year} = \frac{PV}{N_{sites}}$$

Where:

Q_{DCHP_year}	=	Facility annual throughput of DCHP (kg/site-year)
N_s	=	Number of sites (see Appendix E.6.7) (sites)
PV	=	Production volume (see Appendix E.6.7) (kg/year)

For both OESs, the daily throughput of DCHP is calculated using Equation_Apx E-42 by dividing the annual production volume by the number of operating days. The number of operating days is determined according to Appendix E.6.13.

Equation_Apx E-42,

$$Q_{DCHP\_day} = \frac{Q_{DCHP\_year}}{OD_{comp/conv}}$$

Where:

Q_{DCHP_day}	=	Facility throughput of DCHP (kg/site-day)
Q_{DCHP_year}	=	Facility annual throughput of DCHP (kg/site-year)
$OD_{comp/conv}$	=	Operating days for either compounding or converting (based on the specific OES assessed) (see Appendix E.6.13) (days/year)

E.6.9 Number of Containers per Year

The number of DCHP raw material containers received and unloaded by a site per year is calculated using the following equation:

Equation_Apx E-43.

$$N_{cont\_unload\_yr} = \frac{Q_{DCHP\_year}}{V_{cont}}$$

Where:

V_{cont} (kg/container)	=	Container mass for raw DCHP (see Appendix E.6.14)
Q_{DCHP_year}	=	Facility annual throughput of DCHP (see Appendix E.6.8) (kg/site-year)
$N_{cont\_unload\_yr}$	=	Annual number of containers unloaded (container/site-year)

The number of compounded plastic product containers loaded (for compounding) or unloaded (for converting) by a site per year is calculated using the following equation:

Equation_Apx E-44.

$$N_{cont\_load\_yr} = \frac{Q_{DCHP\_year}}{V_{cont} * F_{chemrubber/resin}}$$

Where:

V_{cont}	=	Product container mass (see Appendix E.6.14) (kg/container)
Q_{DCHP_year}	=	Facility annual throughput of DCHP (see Appendix E.6.8) (kg/site-year)
$N_{cont\_unload\_yr}$	=	Annual number of containers unloaded (container/site-year)
$F_{chemrubber/resin}$	=	Mass fraction of DCHP in compounded resin (kg/kg)

E.6.10 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, 2021c), 2021 Use of Additives in Plastics Converting Draft Generic Scenario (U.S. EPA, 2021d), *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 (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_Apx E-45.

$$OH_{RP1} = \frac{N_{cont\_unload\_yr}}{RATE_{fill\_cont} * OD_{comp}}$$

Where:

OH_{RP1}	=	Operating time for compounding release point 1 (h/site-day)
$RATE_{fill\_cont}$	=	Fill rate of containers (see Appendix E.6.18) (containers/h)
$N_{cont\_unload\_yr}$	=	Annual number of containers unloaded (see Appendix E.6.9) (container/site-year)
OD_{comp}	=	Operating days for compounding or converting (see Appendix E.6.13) (days/year)

For loading during compounding (release point 6) and unloading during converting (release point 1), the operating hours are calculated based on the number of containers loaded/unloaded at the site, the loading rate, and the number of operating days using the following equation:

Equation_Apx E-46.

$$OH_{RP6/1} = \frac{N_{cont\_load\_yr}}{RATE_{fill\_cont} * OD_{comp/conv}}$$

Where:

$OH_{RP6/1}$	=	Operating time for compounding release point 6 and converting release point 1 (h/site-day)
$RATE_{fill\_cont}$	=	Fill rate of containers (see Appendix E.6.18) (containers/h)
$N_{cont\_unload\_yr}$	=	Annual number of containers unloaded (see Appendix E.6.9) (container/site-year)
$OD_{comp/conv}$	=	Operating days for compounding or converting (see Appendix E.6.13) (days/year)

For compounding and converting operations (release point 3 for compounding, 3 and 4 for converting), EPA assumes compounding and converting occurs for the entirety of a work-shift and assigns a duration of 8 hours/day. EPA did not have data on operating times for other release points.

E.6.11 Initial DCHP Concentration

EPA modeled the initial DCHP concentration using a uniform distribution with a lower bound of 30 percent and an upper bound of 60 percent based on information reported in the 2020 CDR, with concentration ranges of 30 to 60 percent or 90 percent or greater listed by reporters (U.S. EPA, 2020a). The concentration range of 30 to 60 percent was used for DCHP used in this OES since this reported concentration range aligned with a six of the seven CDR entries with plastics-related industrial sectors in CDR.

E.6.12 Fraction of DCHP in Compounded Non-PVC Materials

EPA modeled final DCHP concentration in non-PVC materials using a uniform distribution with a lower bound of 10 percent and upper bound of 20 percent. This is based on the Emission Scenario Document on Additives in Rubber Industry (OECD, 2004a). The ESD states that plasticizers for rubber additives are expected to be present at 10 to 20 percent for rubber products.

E.6.13 Operating Days

For compounding, EPA modeled the operating days per year using a triangular distribution with a lower bound of 148 days/year, an upper bound of 300 days/year, and a mode of 246 days/Year. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 148 to 300 days/year. 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 to 264 days/year 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/year for rubber manufacturing. The mode is based on the 2021 Generic Scenario for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c), which states that 246 days/year 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/year, an upper bound of 254 days/year, and a mode of 253 days/year. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 137 to 254 days/year. 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 to 254 days/year should be assumed. The mode is based on the 2021 Use of Additives in Plastics Converting Draft Generic Scenario (U.S. EPA, 2021d), which states that an average value of 2year days/year should be used as a default.

E.6.14 Container Size

EPA assumed that non-PVC material manufacturing sites would receive solid DCHP raw material and package compounded plastics in containers with capacities ranging in size from 24.95 kg to 498.95 kg. These container sizes are based on the 2021 Use of Additives in Plastics Converting Draft Generic Scenario (U.S. EPA, 2021d), which states that compounded plastics in pellet form are routinely shipped in containers ranging from 55 lb bags to 1,100 lb gaylord boxes. EPA developed a triangular distribution for DCHP raw material and compounded plastic container sizes using these values, with the lower bound and mode set equal to 24.95 kg and an upper bound of 498.95 kg.

E.6.15 Container Residue Loss Fractions

The *EPA/OPPT Solid Residuals in Transport Containers Model* from the *ChemSTEER User Guide* (U.S. EPA, 2015) provides a fixed container residue loss fraction of 1 percent for any container of solid material. EPA used this loss fraction for the containers of raw material DCHP additive and the compounded plastic received at converting sites.

E.6.16 Dust Generation Loss Fraction, Dust Capture Efficiency, and Dust Control Efficiency

The 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 6.0×10^{-6} to 0.045 with a mode of 0.005 by mass. The Agency assigned the mode based on the recommended default value for the parameter in the Dust Release Model. The range of initial loss fraction values comes from the range of values compiled from various sources and considered in the development of the Dust Release Model (U.S. EPA, 2021b).

For the fraction captured, EPA assigned a range of 0 to 1.0 with a mode of 0.963 by mass. The Agency assigned the upper bound for the fraction captured based on the maximum estimated capture efficiency 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, since potential capture technologies are unknown. The Agency assigned 0 for the lower bound because there is potential for some sites to have no capture technology in operation (U.S. EPA, 2021b).

For the fraction removed/controlled, the 2021 Generic Scenario for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c) and 2021 Use of Additives in Plastics Converting Draft Generic Scenario (U.S. EPA, 2021d) 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, 2021b).

E.6.17 Fraction of DCHP Lost as Particulates During Converting Processes

EPA modeled the loss fraction of particulate DCHP during converting using a triangular distribution with a lower bound of 2.0×10^{-5} kg/kg, upper bound of 1.0×10^{-4} kg/kg, and mode of 6.0×10^{-5} kg/kg. This is based on the 2021 Use of Additives in Plastics Converting Draft Generic Scenario (U.S. EPA, 2021d). The GS presents loss fractions for "Other or unknown unreacted additive types" for three types of converting: open process (1.0×10^{-4} kg/kg), partially open process (6.0×10^{-5} kg/kg), or closed process (2.0×10^{-5} 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 set as the mode of the triangular distribution. The distribution does not reflect prevalence of each type of process in the industry.

E.6.18 Container Fill Rates

The *ChemSTEER User Guide* (U.S. EPA, 2015) provides typical fill rates of 1 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. EPA assumed a conversion of 1 kg/L, or 3.79 kg/gal, for applying the container fill rates to containers holding solids.

E.6.19 Equipment Cleaning Loss Fraction

EPA used the EPA/OPPT Multiple Process Residual Model to estimate the releases from equipment cleaning. That model, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015), provides an overall loss fraction of 2 percent from equipment cleaning.

E.6.20 Cooling Water Loss Fraction

The 2021 Generic Scenario for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c) and 2021 Use of Additives in Plastics Converting Draft Generic Scenario (U.S. EPA, 2021d) state that if direct contact cooling water is used for compounding/converting, that the EPA/OPPT Single Vessel Residual Model should be used to estimate releases. That model, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015), provides an overall loss fraction of 1 percent residual in equipment. This model is intended for equipment; however, in the context of losses to contact cooling water, using this model assumes 1 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.6.21 Vapor Emissions Loss Fraction

For compounding, EPA used the applicable vapor emission loss fraction presented in the 2021 Generic Scenario for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c), with DCHP assessed as a plasticizer additive with a low volatility (<0.2 Torr at 200 °C). The GS assigned a loss fraction of 0.002 percent to plasticizers with low volatility during blending/compounding activities.

For converting, EPA used the applicable vapor emission loss fractions presented in the 2021 Use of Additives in Plastics Converting Draft Generic Scenario (U.S. EPA, 2021d), with DCHP assessed as a plasticizer additive with a low volatility (<0.2 Torr at 200 °C). The GS assigned loss fractions of 0.002 percent for closed converting processes and 0.01 percent for open converting processes with low volatility plasticizers. Each converting process type (open or closed) has an equal probability of being selected during each iteration of the simulation. EPA assessed both vapor emissions and particulate emissions during converting due to the melting point of DCHP being above room temperature and below 200 °C.

E.6.22 Trimming Loss Fraction

The 2021 Use of Additives in Plastics Converting Draft Generic Scenario (U.S. EPA, 2021d) recommends a default trimming loss fraction of 0.025 kg/kg.

E.7 Plastics Model Approaches and Parameters

This appendix section presents the modeling approach and equations used to estimate environmental releases for DCHP during the PVC Plastics Compounding and PVC Plastics Converting OESs. This approach utilizes the same equations and assumptions presented for non-PVC materials in Appendix E.6.4. Therefore, only the parameters that differ between approaches, including production volume, number of sites, operating days, and DCHP concentrations, will be presented in this section for brevity.

E.7.1 Production Volume and Number of Sites

EPA estimated the total DCHP production volume for plastics using a uniform distribution with a lower bound of 18,543 kg/year and an upper bound of 222,659 kg/year. This range is based on DCHP CDR data of site production volumes, national aggregate production volumes, and percentages of the production volumes going to various industrial sectors.

CDR data for DCHP provides a national aggregate production volume of 500,000 to 1,000,000 lb/year, and only one site, Lanxess Corporation Greensboro in Greensboro, North Carolina, reported a non-CBI value in 2019 with a production volume of 17,290 lb/year (U.S. EPA, 2020a). Possible production volumes for sites reporting the values as CBI were calculated in Appendix E.2.4 and Appendix E.3.4 for manufacturing and import sites, respectively.

EPA considered industrial sectors "Plastics Material and Resin Manufacturing" and "Plastics Product Manufacturing," to be within the scope of the Plastics OES. Of the reported production volumes, the following percentages from each site were attributed to industrial sectors within scope: Lanxess Corporation Greensboro in Greensboro, North Carolina (100%); United Initiators Inc in Elyria, Ohio (100%); Vertellus Greensboro LLC in Greensboro, North Carolina (0%); and Nouryon Functional Chemicals LLC (80%). EPA's estimated use volumes for each site were the following:

Table_Apx E-19. Site CDR Volumes Used for the Production Volume Estimate in the Plastics Compounding and Converting OES

Site Name	Overall PV Estimate (lb)	Percent Industrial Use	Estimated PV Contribution to this OES (lb)
United Initiators, Inc.	17,290	100	17,290
Lanxess Corporation Greensboro	13,106–263,105	100	13,106–263,105
Nouryon Functional Chemicals LLC	13,106–263,105	80	10,485–210,484

The total PV of DCHP across the three sites was therefore estimated to be 40,881 to 490,879 lb (18,543–222,659 kg).

EPA estimated the number of sites for compounding based on DCHP CDR data identified with an industrial sector "Plastics Material and Resin Manufacturing," which listed the number of sites as less than 10 (U.S. EPA, 2020a). For the model, EPA used a uniform distribution of discrete integer values for the number of sites with a lower bound of one site and an upper bound of nine sites.

EPA estimated the number of sites for converting based on DCHP CDR data identified with an industrial sector as "Plastics Product Manufacturing." There were 5 CDR entries showing less than 10 sites each within the industrial sector (1–9 sites each), and 1 entry showing 10 to 24 sites within the industrial sector (U.S. EPA, 2020a). For the model, EPA used a uniform distribution of discrete integer values for the number of sites with a lower bound of 15 sites and an upper bound of 69 sites.

E.7.2 Operating Days

For compounding, EPA modeled the operating days per year using a triangular distribution with a lower bound of 148 days/year, an upper bound of 264 days/year, and a mode of 246 days/Year. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 148 to 264 days/year. The lower bound and upper bound are based on the 2014 Plastics Compounding Draft Generic Scenario (U.S. EPA, 2014c). The report states that a typical range of 148-264 days/year are assumed. The mode is based on the 2021 Generic Scenario for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c), which states that 246 days/year should be used as a default.

For converting, EPA used the same nested triangular distribution for operating days as described in Appendix E.6.4.

E.7.3 Initial DCHP Concentration

EPA modeled the initial DCHP concentration using a uniform distribution with a lower bound of 30 percent and an upper bound of 100 percent based on information reported in the 2020 CDR, with concentration ranges of 30 to 60 percent or 90+ percent listed by reporters (U.S. EPA, 2020a). Because CDR entries with industrial sectors "Plastics Material and Resin Manufacturing" or "Plastics Product

Manufacturing" showed both concentration ranges of 30 to 60 percent and 90-plus percent, EPA used a single uniform distribution covering the full range of possible concentrations.

E.7.4 Fraction of DCHP in Compounded Plastic Resin

EPA modeled the mass fraction of DCHP 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, 2021c). The GS provides a range of 0.3 to 0.45 for the typical weight fraction of plasticizers in rigid PVC.

E.8 Application of Adhesives and Sealants Model Approaches and Parameters

This appendix section presents the modeling approach and equations used to estimate environmental releases for DCHP 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). EPA assessed this OES with DCHP arriving on site as an additive in the solid component of a multi-component adhesive or sealant, which is then mixed and applied as a liquid.

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: Transfer Operation Losses from Unloading.
- Release source 3: Open Surface Losses to Air During Adhesive Application.
- Release source 4: Equipment Cleaning Wastes.
- Release source 5: Open Surface Losses to Air During Equipment Cleaning.
- Release source 6: Open Surface Losses to Air During Curing/Drying.
- Release source 7: Trimming Wastes.

Environmental releases for DCHP during use of adhesives and sealants are a function of DCHP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: product throughput, DCHP concentrations, air speed, container size, loss fractions, control technology efficiencies, and operating days. The Agency used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.8.1 Model Equations

Table_Apx E-20 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.8.2. The Monte Carlo simulation calculated the total DCHP 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-20. 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_{DCHP_day}; $F_{residue}$
Release source 2: Transfer Operation Losses from Unloading	EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders (Appendix E.1)	Q_{DCHP_day}; $F_{dust\_generation}$; $F_{dust\_capture}$ $F_{dust\_control}$
Release source 3: Open Surface Losses to Air During Adhesive Application	Unable to estimate due to lack of substrate surface area data.	N/A
Release source 4: Equipment Cleaning Wastes	EPA/OPPT Multiple Process Vessel Residual Model (Appendix E.1)	Q_{DCHP_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_{DCHP}; MW; VP; $RATE_{air\_speed}$; D_{equip_clean}; T; P Operating Time: OH_{equip_clean}
Release source 6: Open Surface Losses to Air During Curing/Drying	Unable to estimate due to a lack of the required data for DCHP pertaining to curing times and conditions.	N/A
Release source 7: Trimming Wastes	See Equation_Apx E-47	Q_{DCHP_day}; $F_{trimming}$

Release source 7 daily release (Trimming Wastes) is calculated using the following equation:

Equation_Apx E-47.

$$Release\_perDay_{RP7} = Q_{DCHP\_day} * F_{trimming}$$

Where:

$Release\_perDay_{RP7}$ = DCHP released for release source 7 (kg/site-day)

Q_{DCHP_day} = Facility throughput of DCHP (see Appendix E.8.4) (kg/site-day)

$F_{trimming}$ = Fraction of DCHP released as trimming waste (see Appendix E.8.12) (kg/kg)

E.8.2 Model Input Parameters

Table_Apx E-21 summarizes the model parameters and their values for the Application of Adhesives and Sealants Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after this table.

Table_Apx E-21. 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	
DCHP Production Volume for Adhesives/ Sealants	PV_{total}	kg/year	2.1E04	–	–	–	–	See Appx. E.8.3
Annual Facility Throughput of Adhesive/ Sealant	$Q_{product\_year}$	kg/year	1.4E04	1.4E04	5.9E05	1.4E04	Triangular	See Appx. E.8.4
Operating Hours for Equipment Cleaning	OH_{equip_clean}	h/day	1.0	–	–	–	–	See Appx. E.8.6
Solid Coating Product DCHP Concentration	F_{DCHP_unload}	kg/kg	0.55	0.40	0.55	–	Uniform	See Appx. E.8.7
Adhesive/Sealant DCHP Concentration	F_{DCHP}	kg/kg	5.0E−02	1.0E−04	5.0E−02	–	Uniform	See Appx. E.8.7
Operating Days	OD	days/year	250	49	366	260	Triangular	See Appx. E.8.8
Air Speed	$RATE_{air\_speed}$	ft/min	20	2..6	398	—	Lognormal	See Appx. E.8.9
Small Container Volume	V_{cont}	gal	1.0	0.10	20	1.0	Triangular	See Appx. E.8.10
Small Container Residual Loss Fraction	$F_{residue}$	kg/kg	0.01	–	–	–	–	See Appx. E.8.11
Fraction of DCHP Released as Trimming Waste	$F_{trimming}$	kg/kg	0.04	0	0.04	0.04	Triangular	See Appx. E.8.12
Vapor Pressure at 25 °C	VP	mmHg	4.93E−07	–	–	–	–	Physical property
Molecular Weight	MW	g/mol	330	–	–	–	–	Physical property
Gas Constant	R	atm-cm^3/gmol-L	82	–	–	–	–	Universal constant
Density of DCHP	RHO	kg/L	1.4	–	–	–	–	Physical property
Temperature	T	K	298	–	–	–	–	Process parameter
Pressure	P	atm	1	–	–	–	–	Process parameter
Small Container Fill Rate	$RATE_{fill\_cont}$	containers/h	60	–	–	–	–	See Appx. E.8.13
Diameter of Opening – Equipment Cleaning	D_{equip_clean}	cm	92	–	–	–	–	See Appx. E.8.14
Equipment Cleaning Loss Fraction	$F_{equipment\_cleaning}$	kg/kg	2.0E−02	–	–	–	–	See Appx. E.8.15

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Fraction Lost During Transfer of Solid Powders	$F_{dust\_generation}$	kg/kg	5.0E−03	6.0E−06	4.5E−02	5.0E−03	Triangular	See Appx. E.8.16
Capture Efficiency for Dust Capture Methods	$F_{dust\_capture}$	kg/kg	0.96	0.93	1.0	0.96	Triangular	See Appx. E.8.16
Control Efficiency for Dust Filter	$F_{dust\_control}$	kg/kg	0.79	0	1.0	0.79	Triangular	See Appx. E.8.16

E.8.3 Production Volume and Number of Sites

EPA assessed this OES using a DCHP production volume of 20,706 kg/year for adhesive and sealant products, which is based on CDR data (U.S. EPA, 2020a). 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 a per-site throughput and total production volume with the following equation:

Equation_Apx E-48.

$$N_s = \frac{PV_{total}}{Q_{DCHP_{year}}}$$

Where:

N_s	=	Number of sites (sites)
PV_{total}	=	DCHP production volume for adhesives/sealants (kg/year)
Q_{DCHP_year}	=	Facility annual throughput of DCHP (see Appendix E.8.4) (kg/site-year)

E.8.4 Throughput Parameters

The annual throughput of adhesive and sealant product is modeled using a triangular distribution with a lower bound of 13,500 kg/year, an upper bound of 587,800 kg/year, and mode of 13,500 kg/year. 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 containing DCHP, which included general assembly, construction, labels and tapes, vehicle assembly, and wood and related products. The lower and upper bound adhesive use rates for these categories was 13,500 to 587,800 kg/year. The mode is based on the ESD default for unknown end-use markets.

The annual throughput of DCHP in adhesives/sealants is calculated using Equation_Apx E-49 by multiplying the annual throughput of all adhesives and sealants by the concentration of DCHP in the adhesives/sealants.

Equation_Apx E-49.

$$Q_{DCHP\_year} = Q_{product\_yr} * F_{DCHP}$$

Where:

Q_{DCHP_year}	=	Facility annual throughput of DCHP (kg/site-year)
$Q_{product\_yr}$	=	Facility annual throughput of all adhesives/sealants (kg/batch)
F_{DCHP}	=	Concentration of DCHP in adhesives/sealants (see Appendix E.8.7) (kg/kg)

The daily throughput of DCHP is calculated using Equation_Apx E-50 by dividing the annual production volume by the number of operating days. The number of operating days is determined according to Appendix E.8.8.

Equation_Apx E-50.

$$Q_{DCHP\_day} = \frac{Q_{DCHP\_year}}{OD}$$

Where:

Q_{DCHP_day} = Facility daily throughput of DCHP (kg/site-day)
Q_{DCHP_year} = Facility annual throughput of DCHP (kg/site-year)
OD = Operating days (see Appendix E.8.8) (days/year)

E.8.5 Number of Containers per Year

The number of DCHP raw material containers received and unloaded by a site per year is calculated using the following equation:

Equation_Apx E-51.

$$N_{cont\_unload\_yr} = \frac{Q_{DCHP\_year}}{RHO * \left(3.79\ \frac{L}{gal}\right) * F_{DCHP\_unload} * V_{cont}}$$

Where:

$N_{cont\_unload\_yr}$ = Annual number of containers unloaded (container/site-year)
Q_{DCHP_year} = Facility annual throughput of DCHP (see Appendix E.8.4) (kg/site-year)
F_{DCHP_unload} = Concentration of DCHP in solid products received on site (see Appendix E.8.7) (kg/kg)
RHO = DCHP density (kg/L)
V_{cont} = Container volume (see Appendix E.8.10) (gal/container)

E.8.6 Operating Hours

EPA estimated operating hours or hours of release 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.

For container unloading (release point 2), the operating hours are calculated based on the number of containers unloaded at the site and the unloading rate using the following equation:

Equation_Apx E-52.

$$OH_{RP2} = \frac{N_{cont\_unload\_yr}}{RATE_{fill\_cont} * OD}$$

Where:

OH_{RP2} = Operating time for release point 2 (h/site-day)
$N_{cont\_unload\_yr}$ = Annual number of containers unloaded (see Appendix E.8.5) (container/site-year)
$RATE_{fill\_cont}$ = Container fill rate (see Appendix E.8.13) (containers/h)
OD = Operating days (see Appendix E.8.8) (days/site-year)

For equipment cleaning (release point 5), the Emission Scenario Document on Use of Adhesives (OECD, 2015b) 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 1 hour/day.

E.8.7 Adhesive/ Sealant DCHP Concentration

EPA determined DCHP concentrations in both the incoming solid adhesive/sealant additives (F_{DCHP_unload}) and the final adhesive/sealant products (F_{DCHP}) using compiled SDS information. EPA did not have information on the prevalence or market share of different adhesive/ sealant products in commerce; therefore, EPA assumed a uniform distribution of concentrations in each case (see Appendix F for EPA identified DCHP-containing products for this OES). For the solid adhesive/sealant additives received on site, EPA developed the uniform distribution of DCHP concentration using a lower bound of 40 percent and an upper bound of 55 percent based on SDS composition information from a single sealant product identified as containing DCHP. For the final liquid adhesive/sealant products, EPA developed the uniform distribution of DCHP concentration using a lower bound of 0.01 percent and an upper bound of 5 percent based on the minimum and maximum concentrations compiled from SDS for multiple adhesives and sealant products containing DCHP.

E.8.8 Operating Days

EPA modeled the operating days per year using a triangular distribution with a lower bound of 50 days/year, an upper bound of 365 days/year, and a mode of 260 days/year. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 50 to 365 days/year. This is based on the Emission Scenario Document on Use of Adhesive*s* (OECD, 2015b). The ESD provides operating days for several end-use categories, as listed in Appendix E.8.3. The range of operating days for the end-use categories is 50 to 365 days/year. The mode of the distribution is based on the ESD's default of 260 days/year for unknown or general use cases.

E.8.9 Air Speed

Baldwin and Maynard measured indoor air speeds across a variety of occupational settings in the United Kingdom (Baldwin and Maynard, 1998). Fifty-five work areas were surveyed across a variety of workplaces. EPA analyzed the air speed data from Baldwin and Maynard and categorized the air speed surveys into settings representative of industrial facilities and representative of commercial facilities. The Agency fit separate distributions for these industrial and commercial settings and used the industrial distribution for this OES.

EPA fit a lognormal distribution for the data set as consistent with the authors' observations that the air speed measurements within a surveyed location were lognormally distributed and the population of the mean air speeds among all surveys were lognormally distributed (Baldwin and Maynard, 1998). Because lognormal distributions are bound by zero and positive infinity, EPA truncated the distribution at the largest observed value among all of the surveyed 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.8.10 Container Size

EPA considered container sizes for solid DCHP-containing additive products, including those for adhesives/sealants as well as paints and coatings. Container sizes for the solid additive products containing DCHP had capacities ranging from less than 0.1 gallons up to approximately 10 gallons based on available technical data sheets reviewed by EPA (see Appendix F for EPA identified DCHP-containing products for this OES). Additionally, EPA considered default container size ranges for bottles and small containers identified in the *ChemSTEER User Guide*. According to that guide, bottles are defined as containing between 1 and 5 gallons of material with a default bottle size of 1 gallon, and small containers are defined as containing between 5 and 20 gallons of material with a default size of 5 gallons (U.S. EPA, 2015). EPA modeled container size using a triangular distribution accounting for the identified product container sizes and the *ChemSTEER User Guide* size ranges. Specifically, EPA used a lower bound of 0.1 gallons based on for the minimum identified product container size, an upper bound of 20 gallons based on the upper bound for small containers defined by the *ChemSTEER User Guide*, and a mode of 1 gallon based on typical identified container sizes and the default bottle size defined by the *ChemSTEER User Guide*.

E.8.11 Container Residue Loss Fraction

The EPA/OPPT Solid Residuals in Transport Containers Model from the *ChemSTEER User Guide* (U.S. EPA, 2015) provides a fixed container residue loss fraction of 1 percent for any container of solid material. EPA used this loss fraction for the containers of solid adhesive/sealant additive containing DCHP received on site.

E.8.12 Fraction of DCHP Released as Trimming Waste

EPA modeled the fraction of DCHP released as trimming waste using a triangular distribution with a lower bound of 0, an upper bound of 0.04, and a mode of 0.04. This is based on the Emission Scenario Document on Use of Adhesives (OECD, 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 and mode are based on the ESD's default waste fraction of 0.04 kg chemical in trimmings/kg chemical applied.

E.8.13 Container Unloading Rate

The *ChemSTEER User Guide* (U.S. EPA, 2015) provides a typical fill rate of 60 containers per hour for containers with less than 20 gallons of liquid.

E.8.14 Diameter 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 guide indicates a single default value of 92 cm (U.S. EPA, 2015).

E.8.15 Equipment Cleaning Loss Fraction

EPA used the EPA/OPPT Multiple Process Residual Model to estimate the releases from equipment cleaning. That model, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015), provides an overall loss fraction of 2 percent from equipment cleaning.

E.8.16 Dust Generation Loss Fraction, Dust Capture Efficiency, and Dust Control Efficiency

The Dust Release Model compiled data for loss fractions of solids from various sources in addition to the capture and removal efficiencies for control technologies in order to estimate releases of dust to the environment during transfer operations. Dust releases estimated from the model are based on three different parameters: the initial loss fraction, the fraction captured by the capture technology, and the fraction removed/controlled by the control technology. The underlying distribution 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 6.0×10^{-6} to 0.045 with a mode of 0.005 by mass. The Agency assigned the mode based on the recommended default value for the parameter in the Dust Release Model. The range of initial loss fraction values comes from the range of values compiled from various sources and considered in the development of the Dust Release Model (U.S. EPA, 2021b).

For the fraction of dust captured, EPA assigned a range of 0 to 1.0 with a mode of 0.963 by mass. The Agency assigned the upper bound for the fraction captured based on the maximum estimated capture efficiency 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, since potential capture technologies are unknown. The Agency assigned 0 for the lower bound because there is potential for some sites to have no capture technology in operation (U.S. EPA, 2021b).

For the fraction of capture dust that is removed/controlled, EPA assigned a range of 0 to 1.0 with a mode of 0.79 by mass. The Agency assigned the upper bound for the fraction controlled based on the 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, since potential control technologies are unknown. The Agency assigned 0 for the lower bound because there is potential for some sites to have no control technology in operation (U.S. EPA, 2021b).

E.9 Application of Paints and Coatings Model Approaches and Parameters

This section presents the modeling approach and equations used to estimate environmental releases for DCHP 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). EPA assessed this OES with DCHP arriving on site as an additive in the solid component of a multi-component coatings, which is then mixed and spray-applied as a liquid. The Agency modeled spray application as opposed to other application methods because it provides a more protective estimate of releases and exposures, with the prevalence of each application method unknown for DCHP-containing coatings. Based on the ESDs, EPA identified the following release sources from the application of paints and coatings:

- Release source 1: Transfer Operation Losses from Unloading.
- Release source 2: Container Cleaning Wastes.
- Release source 3: Process Releases During Application Operations.
- Release source 4: Equipment Cleaning Wastes.
- Release source 5: Open Surface Losses to Air During Equipment Cleaning.

- Release source 6: Raw Material Sampling Wastes.

Environmental releases for DCHP during the application of paints and coatings are a function of DCHP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: production volume, paint and coating throughput, DCHP concentrations, air speed, container size, loss fractions, control technology efficiencies, transfer efficiency, and operating days. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.9.1 Model Equations

Table_Apx E-22 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.9.2. The Monte Carlo simulation calculated the total DCHP 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-22. Models and Variables Applied for Release Sources in the Application of Paints and Coatings OES

Release Source	Model(s) Applied	Variables Used
Release source 1: Transfer Operation Losses from Unloading	EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/ Unloading/Loading Operations of Solid Powders (Appendix E.1)	Q_{DCHP_day}; $F_{dust\_generation}$; $F_{dust\_capture}$ $F_{dust\_control}$
Release source 2: Container Cleaning Wastes	EPA/OAQPS AP-42 Small Container Residual Model (Appendix E.1)	Q_{DCHP_day}; $F_{residue}$
Release source 3: Process Releases During Operations	See Equation_Apx E-53 through Equation_Apx E-57	Q_{DCHP_day}; $F_{transfer\_eff}$; $F_{capture\_eff}$; $F_{solidrem\_eff}$
Release source 4: Equipment Cleaning Wastes	EPA/OPPT Multiple Process Vessel Residual Model (Appendix E.1)	Q_{DCHP_day}; LF_{equip_clean}
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_{DCHP}; MW; VP; $RATE_{air\_speed}$; D_{equip_clean}; T; P Operating Time: OH_{equip_clean}
Release source 6: Raw Material Sampling Wastes	March 2023 Methodology for Estimating Environmental Releases from Sampling Waste (Appendix E.1)	Q_{DCHP_day}; $LF_{sampling}$

Release source 3 (Process Releases During Operations) is partitioned out by release media depending upon the paint and coating overspray control technology employed. EPA modeled two scenarios: one scenario in the absence of control technology with a total release from release source 3 to unknown media (*i.e.*, a release to fugitive air, water, incineration, or landfill); and one scenario with control technology and releases partitioned to land, stack air, or water for release source 3 based on capture and removal efficiencies. In order to calculate the total release from release source 3, the following equation was used:

Equation_Apx E-53.

$$Release\_perDay_{RP3\_total} = Q_{DCHP\_day} * \left(1 - F_{transfer\_eff}\right)$$

Where:

$Release\_perDay_{RP3\_total}$	=	DCHP released for release source 3 to all release media (kg/site-day)
Q_{DCHP_day}	=	Facility throughput of DCHP (see Appendix E.9.4) (kg/site-day)
$F_{transfer\_eff}$	=	Paint/coating transfer efficiency fraction (see Appendix E.9.13) (unitless)

Transfer efficiency is determined according to Appendix E.9.13. For the scenario in which control technologies are accounted for, the percent of the total release that is released to water is calculated using the following equation:

Equation_Apx E-54.

$$\%_{water} = F_{capture\_eff} * \left(1 - F_{solidrem\_eff}\right)$$

Where:

$\%_{water}$	=	Percent of release 3 that is released to water (unitless)
$F_{capture\_eff}$	=	Booth capture efficiency for spray-applied paints/ coatings (see Appendix E.9.18) (kg/kg)
$F_{solidrem\_eff}$	=	Fraction of solid removed in the spray mist of sprayed paints/ coatings (see Appendix E.9.19) (kg/kg)

Booth capture efficiency is determined according to Appendix E.9.18, and solid removal efficiency is determined according to Appendix E.9.19. The percent of the total release that is released to air is calculated using the following equation:

Equation_Apx E-55.

$$\%_{air} = \left(1 - F_{capture\_eff}\right)$$

Where:

$\%_{air}$	=	Percent of release 3 that is released to air (unitless)
$F_{capture\_eff}$	=	Booth capture efficiency for spray-applied paints/ coatings (see Appendix E.9.18) (kg/kg)

The percent of the total release that is released to land is calculated using the following equation:

Equation_Apx E-56.

$$\%_{land} = F_{capture\_eff} * F_{solidrem\_eff}$$

Where:

$\%_{land}$	=	Percent of release 3 that is released to land (unitless)
$F_{capture\_eff}$	=	Booth capture efficiency for spray-applied paints/ coatings (see

Appendix E.9.18) (kg/kg)

$F_{solidrem\_eff}$ = Fraction of solid removed in the spray mist of sprayed Paints/ Coatings (see Appendix E.9.19) (kg/kg)

If control technologies are used, the release amounts to each media are calculated using the following equation:

Equation_Apx E-57.

$$Release\_perDay_{RP3\_media} = Release\_perDay_{RP3\_total} * \%_{media}$$

Where:

$Release\_perDay_{RP3\_media}$ = Amount of release 3 that is released to water, air, or land (kg/site-day)

$Release\_perDay_{RP3\_total}$ = DCHP released for release source 3 to all release media (kg/site-day)

$\%_{media}$ = Percent of release 3 that is released to water, air, or land (unitless)

E.9.2 Model Input Parameters

Table_Apx E-23 summarizes the model parameters and their values for the Application of Paints and Coatings Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after this table.

Table_Apx E-23. Summary of Parameter Values and Distributions Used in the Application of Paints and Coatings Model

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Production Volume of DCHP	PV	kg/year	2.1E04	1.1E03	2.1E04	–	Uniform	See Appx. E.9.3
Annual Facility Throughput of Paint/Coating	Q_{coat_year}	kg/site-year	5,704	946	4.5E05	5,704	Triangular	See Appx. E.9.4
Solid Coating Product DCHP Concentration	F_{DCHP_unload}	kg/kg	0.3	1.0E−03	1.0	0.30	Triangular	See Appx. E.9.7
Paint/Coating DCHP Concentration	F_{DCHP}	kg/kg	0.10	2.5E−02	0.10	–	Uniform	See Appx. E.9.7
Operating Days	OD	days/year	250	224	301	250	Triangular	See Appx. E.9.8
Air Speed	$RATE_{air\_speed}$	ft/min	20	2.6	398	–	Lognormal	See Appx. E.9.9
Container Size	V_{cont}	gal	1.0	0.10	20	1.0	Triangular	See Appx. E.9.10
Container Residue Loss Fraction	$F_{residue}$	kg/kg	1.0E−02	–	–	–	–	See Appx. E.9.11
Fraction of DCHP Lost During Sampling – 1 (Q_{DCHP_day} < 50 kg/site-day)	$F_{sampling\_1}$	kg/kg	2.0E−03	2.0E−03	2.0E−02	2.0E−02	Triangular	See Appx. E.9.12
Fraction of DCHP Lost During Sampling – 2 (Q_{DCHP_day} 50–200 kg/site-day)	$F_{sampling\_2}$	kg/kg	6.0E−04	6.0E−04	5.0E−03	5.0E−03	Triangular	See Appx. E.9.12
Fraction of DCHP Lost During Sampling – 3 (Q_{DCHP_day} 200–5,000 kg/site-day)	$F_{sampling\_3}$	kg/kg	5.0E−04	5.0E−04	4.0E−03	4.0E−03	Triangular	See Appx. E.9.12
Fraction of DCHP Lost During Sampling – 4 (Q_{DCHP_day} > 5,000 kg/site-day)	$F_{sampling\_4}$	kg/kg	8.0E−05	8.0E−05	4.0E−04	4.0E−04	Triangular	See Appx. E.9.12
Transfer Efficiency Fraction	$F_{transfer\_eff}$	unitless	0.65	0.20	0.80	0.65	Triangular	See Appx. E.9.13
Fraction Lost during Transfer of Solid Powders	$F_{dust\_generation}$	kg/kg	5.0E−03	6.0E−06	4.5E−02	5.0E−03	Triangular	See Appx. E.9.14
Capture Efficiency for Dust Capture Methods	$F_{dust\_capture}$	kg/kg	0.96	0.93	1.0	0.96	Triangular	See Appx. E.9.14
Control Efficiency for Dust Filter	$F_{dust\_control}$	kg/kg	0.79	0	1.0	0.79	Triangular	See Appx. E.9.14

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Vapor Pressure at 25 °C	VP	mmHg	4.93E−07	–	–	–	–	Physical property
Molecular Weight	MW	g/mol	330	–	–	–	–	Physical property
Gas Constant	R	atm-cm^3/gmol-L	82	–	–	–	–	Universal constant
Density of DCHP	RHO	kg/L	1.4	–	–	–	–	Physical property
Temperature	T	K	298	–	–	–	–	Process parameter
Pressure	P	atm	1.0	–	–	–	–	Process parameter
Equipment Cleaning Duration	OH_{equip_clean}	h/day	4.0	–	–	–	–	See Appx. E.9.6
Diameter of Opening – Equipment Cleaning	D_{equip_clean}	cm	92	–	–	–	–	See Appx. E.9.15
Small Container Fill Rate	$RATE_{fill\_cont}$	containers/h	60	–	–	–	–	See Appx. E.9.16
Equipment Cleaning Loss Fraction	LF_{equip_clean}	kg/kg	2.0E−02	–	–	–	–	See Appx. E.9.17
Capture Efficiency for Spray Booth	$F_{capture\_eff}$	kg/kg	0.90	–	–	–	–	See Appx. E.9.18
Fraction of Solid Removed in Spray Mist	$F_{solidrem\_eff}$	kg/kg	1.0	–	–	–	–	See Appx. E.9.19

E.9.3 Production Volume and Number of Sites

EPA assessed this OES using a uniform distribution of potential DCHP production volumes, with a lower bound of 1,070 kg/year and upper bound of 21,482 kg/year based on CDR data for paint and coating products (U.S. EPA, 2020a). 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 a per-site throughput and DCHP production volume with the following equation:

Equation_Apx E-58.

$$N_s = \frac{PV}{Q_{DCHP\_year}}$$

Where:

N_s	=	Number of sites (sites)
PV	=	Production volume of DCHP (kg/year)
Q_{DCHP_year}	=	Facility annual throughput of DCHP (see Appendix E.9.4) (kg/site-year)

E.9.4 Throughput Parameters

The annual site throughput of paint and coating product is modeled using a triangular distribution with a lower bound of 946 kg/site-year, an upper bound of 446,600 kg/site-year, and mode of 5,704 kg/site-Year. The upper bound is based on the Generic Scenario for Spray Coatings in the Furniture Industry (U.S. EPA, 2004d), which provides a range of 5,000 to 446,600 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 mode is based on the default use rate for coating products from the Emission Scenario Document on Coating Application via Spray-Painting in the Automotive Refinishing Industry (OECD, 2011a). The ESD provides a default site use rate for a coating product as 1,505 gal/site-year, which is converted to 5,704 kg/site-year using an assumption of 1 kg/L for product density. The lower bound is based on possible site use rates from a summary table of available use rates in the Emission Scenario Document on Coating Application via Spray-Painting in the Automotive Refinishing Industry (OECD, 2011a). EPA selected a lower bound from this table of 1 gallon of coating product used per site for 250 days/year (*e.g.,* 250 gallons/site-year or 946 L/site-year) and an assumption of 1 kg/L for product density.

The annual throughput of DCHP in the Paints and Coatings OES is calculated using Equation_Apx E-59 by multiplying the annual throughput of all paints and coatings by the concentration of DCHP found in the paints and coatings.

Equation_Apx E-59.

$$Q_{DCHP\_year} = Q_{coat\_yr} * F_{DCHP}$$

Where:

Q_{DCHP_year}	=	Facility annual throughput of DCHP (kg/site-year)
Q_{coat_yr}	=	Facility annual throughput of all paints/ coatings (kg/site-year)
F_{DCHP}	=	Concentration of DCHP in paints/ coatings (see Appendix E.9.7) (kg/kg)

The daily throughput of DCHP is calculated using Equation_Apx E-60 by dividing the annual throughput by the number of operating days. The number of operating days is determined according to Appendix E.9.8.

Equation_Apx E-60.

$$Q_{DCHP\_day} = \frac{Q_{DCHP\_year}}{OD}$$

Where:

Q_{DCHP_day}	=	Facility daily throughput of DCHP (kg/site-day)
Q_{DCHP_year}	=	Facility annual throughput of DCHP (kg/site-year)
OD	=	Operating days (see Appendix E.9.8) (days/year)

E.9.5 Number of Containers per Year

The number of solid DCHP-containing coating additive containers received and unloaded by a site per year is calculated using the following equation:

Equation_Apx E-61.

$$N_{cont\_unload\_yr} = \frac{Q_{DCHP\_year}}{RHO * F_{DCHP\_unload} * \left(3.79\ \frac{L}{gal}\right) * V_{cont}}$$

Where:

$N_{cont\_unload\_yr}$	=	Annual number of containers unloaded (container/site-year)
Q_{DCHP_year}	=	Facility annual throughput of DCHP (see Appendix E.9.4) (kg/site-year)
RHO	=	DCHP density (kg/L)
F_{DCHP_unload}	=	Coating additive DCHP concentration received on site (kg/kg)

E.9.6 Operating Hours

EPA estimated operating hours or hours of release duration using data provided from the *ChemSTEER User Guide* (U.S. EPA, 2015) and/or through calculation from other parameters. 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_Apx E-62.

$$OH_{RP1} = \frac{N_{cont\_unload\_yr}}{RATE_{fill\_cont} * OD}$$

Where:

OH_{RP1}	=	Operating time for release point 1 (h/site-day)
$N_{cont\_unload\_yr}$	=	Annual number of containers unloaded (see Appendix E.9.5) (container/site-year)
$RATE_{fill\_cont}$	=	Container fill rate (see Appendix E.9.14) (containers/h)
OD	=	Operating days (see Appendix E.9.8) (days/site-year)

For equipment cleaning (release point 5), the *ChemSTEER User Guide* provides an estimate of 4 hours per day for cleaning multiple vessels (U.S. EPA, 2015).

E.9.7 Paint/Coating DCHP Concentration

EPA modeled DCHP concentrations in both the incoming solid paint and coating additives (F_{DCHP_unload}) and the final paint and coating products (F_{DCHP}) using compiled SDS information. The Agency did not have information on the prevalence or market share of different paint and coating products in commerce; therefore, EPA assumed a uniform or triangular distribution of concentrations (see Appendix F for EPA identified DCHP-containing products for this OES). For the solid coating additives received on site, EPA developed the triangular distribution of DCHP concentrations using a lower bound of 0.1 percent, a mode of 30 percent, and an upper bound of 100 percent based on compiled SDS composition information from coating products containing DCHP. The lower bound is based on an order-of-magnitude estimate since the minimum concentration listed on available SDSs reviewed was 0 percent. The mode uses the mode of low-end DCHP concentrations from available SDSs reviewed, and the upper bound uses the maximum DCHP concentration listed on available SDSs.

For the final liquid coatings products, EPA developed the uniform distribution of DCHP concentration using a lower bound of 2.5 percent and an upper bound of 10 percent based on the DCHP concentration range listed in a single coating product SDS.

E.9.8 Operating Days

EPA modeled the operating days per year using a triangular distribution with a lower bound of 225 days/year, an upper bound of 300 days/year, and a mode of 250 days/year. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 225 to 300 days/year. The lower bound is based on ESIG's Specific Environmental Release Category Factsheet for Industrial Application of Coatings by Spraying (CEPE, 2020), which estimates 225 days/year as the number of emission days. The upper bound is based on the European Risk Report for DCHP (ECJRC, 2003), which provided a default of 300 days/year. The mode is based on the Generic Scenario for Automobile Spray Coating (SAIC, 1996), which estimates 250 days/year, based on five days/week operation that takes place 50 weeks/year.

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. The Agency fit separate distributions for these industrial and commercial settings and used the industrial distribution for this OES.

EPA fit a lognormal distribution for the data set as consistent with the authors' observations that the air speed measurements within a surveyed location were lognormally distributed and the population of the mean air speeds among all surveys were lognormally distributed (Baldwin and Maynard, 1998). 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 Container Size

EPA considered container sizes for solid DCHP-containing additive products, including those for adhesives/sealants as well as paints and coatings. Container sizes for the solid additive products containing DCHP had capacities ranging from less than 0.1 gallons up to approximately 10 gallons based on available technical data sheets reviewed by EPA (see Appendix F for EPA identified DCHP-containing products for this OES). Additionally, EPA considered default container size ranges for bottles and small containers identified in the *ChemSTEER User Guide*. According to the *ChemSTEER User Guide*, bottles are defined as containing between 1 and 5 gallons of material with a default bottle size of 1 gallon, and small containers are defined as containing between 5 and 20 gallons of material with a default size of 5 gallons (U.S. EPA, 2015). EPA modeled container size using a triangular distribution accounting for the identified product container sizes and the *ChemSTEER User Guide* size ranges. The Agency used a lower bound of 0.1 gallons based on the minimum identified product container size, an upper bound of 20 gallons based on the upper bound for small containers defined by the guide, and a mode of 1 gallon based on typical identified container sizes and the default bottle size defined by the *ChemSTEER User Guide*.

E.9.11 Container Residue Loss Fraction

The EPA/OPPT Solid Residuals in Transport Containers Model from the *ChemSTEER User Guide* (U.S. EPA, 2015) provides a fixed container residue loss fraction of 1 percent for any container of solid material. EPA used this loss fraction for the containers of solid coating additive containing DCHP received on site.

E.9.12 Sampling Loss Fraction

Sampling loss fractions were estimated using the *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-24 presents a summary of the chemical daily throughputs and corresponding loss fractions.

Table_Apx E-24. Sampling Loss Fraction Data from the March 2023 Methodology for Estimating Environmental Releases from Sampling Waste

Chemical Daily Throughput (kg/site-day) ($Q_{chem\_site\_day}$)	Number of Data Points	Sampled Quantity (kg chemical/day)		Sampling Loss Fraction ($LF_{sampling}$)	
		50th Percentile	95th Percentile	50th Percentile	95th Percentile
<50	13	0.03	0.20	0.002	0.02
50 to <200	10	0.10	0.64	0.0006	0.005
200 to <5,000	25	0.37	3.80	0.0005	0.004
≥5,000	10	1.36	6.00	0.00008	0.0004
All	58	0.20	5.15	0.0005	0.008

For each range of daily throughputs, EPA estimated sampling loss fractions using a triangular distribution of the 50th percentile value as the lower bound, and the 95th percentile value as the upper bound and mode. The sampling loss fraction distribution was chosen based on the calculation of daily throughput, as shown in Appendix E.9.3.

E.9.13 Transfer Efficiency Fraction

EPA modeled paint and coating spray application transfer efficiency fraction using a triangular distribution with a lower bound of 0.2, an upper bound of 0.8, and a mode of 0.65. The lower bound and mode are based on the EPA/OPPT Automobile OEM Overspray Loss Model. Per the model, the transfer efficiency varies based on the type of spray gun used. For high volume, low pressure (HVLP) spray guns, the default transfer efficiency is 0.65. For conventional spray guns, the default transfer efficiency is 0.2 by mass. Across all spray technologies, the ESD on Coating Industry (OECD, 2009c) estimates a transfer efficiency of 30 to 80 percent. Therefore, EPA used 0.8 as the upper bound.

E.9.14 Dust Generation Loss Fraction, Dust Capture Efficiency, and Dust Control Efficiency

The Dust Release Model compiled data for loss fractions of solids from various sources in addition to the capture and removal efficiencies for control technologies in order to estimate releases of dust to the environment during transfer operations. Dust releases estimated from the model are based on three different parameters: the initial loss fraction, the fraction captured by the capture technology, and the fraction removed/controlled by the control technology. The underlying distributions for each of these parameters is not known; therefore, EPA assigned triangular distributions, 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 6.0×10^{-6} to 0.045 with a mode of 0.005 by mass. The Agency assigned the mode based on the recommended default value for the parameter in the Dust Release Model. The range of initial loss fraction values comes from the range of values compiled from various sources and considered in the development of the Dust Release Model (U.S. EPA, 2021b).

For the fraction of dust captured, EPA assigned a range of 0 to 1.0 with a mode of 0.963 by mass. The Agency assigned the upper bound for the fraction captured based on the maximum estimated capture efficiency 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, since potential capture technologies are unknown. The Agency assigned 0 for the lower bound because there is potential for some sites to have no capture technology in operation (U.S. EPA, 2021b).

For the fraction of captured dust that is removed/controlled, EPA assigned a range of 0 to 1.0 with a mode of 0.79 by mass. The Agency assigned the upper bound for the fraction controlled based on the 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, since potential control technologies are unknown. The Agency assigned 0 for the lower bound because there is potential for some sites to have no control technology in operation (U.S. EPA, 2021b).

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).

E.9.16 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 a capacity of less than 20 gallons.

E.9.17 Equipment Cleaning Loss Fraction

EPA used the EPA/OPPT Multiple Process Residual Model to estimate the releases from equipment cleaning. That model, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015), provides an overall loss fraction of 2 percent from equipment cleaning.

E.9.18 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 percent.

E.9.19 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. The model assumes both a capture efficiency and a solid removal efficiency for spray booths. The solid removal efficiency refers to the fraction of overspray material that is disposed to incineration or landfill after being captured. This model assumes a solid removal efficiency of 100 percent.

E.10 Use of Laboratory Chemicals Model Approaches and Parameters

This section presents the modeling approach and equations used to estimate environmental releases for DCHP 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: Release from Transferring DCHP from Transport Containers (Liquids Only)

- Release source 2: Dust Emissions from Transferring Powders Containing DCHP (Solids Only)
- Release source 3: Releases from Transport Container Cleaning
- Release source 4: Release from Cleaning Containers Used for Volatile Chemicals (Liquids Only)
- Release source 5: Labware Equipment Cleaning
- Release source 6: Releases during Labware Cleaning (Liquids Only)
- Release source 7: Releases During Laboratory Analysis (Liquids Only)
- Release source 8: Releases from Laboratory Waste Disposal

Environmental releases for DCHP during the use of laboratory chemicals are a function of DCHP'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, DCHP concentrations, air speed, saturation factor, container size, loss fractions, and diameters of equipment openings. The Agency used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

E.10.1 Model Equations

Table_Apx E-25 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.10.2. The Monte Carlo simulation calculated the total DCHP 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-25. Models and Variables Applied for Release Sources in the Use of Laboratory Chemicals OES

Release Source	Model(s) Applied	Variables Used
Release source 1: Release from Transferring DCHP from Transport Containers (Liquids Only)	EPA/OAQPS AP-42 Loading Model (Appendix E.1)	Vapor Generation Rate: F_{DCHP-L}; VP; f_{sat}; MW; R; T; V_{cont}; $RATE_{fill}$ Operating Time: Q_{DCHP_day}; F_{DCHP-L}; V_{cont}; RHO
Release source 2: Dust Emissions from Transferring Powders Containing DCHP (Solids Only)	EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders (Appendix E.1)	$Q_{DCHP_{day}}$; $F_{dust_{generation}}$; $F_{dust\_capture}$; $F_{dust\_control}$
Release source 3: Releases from Transport Container Cleaning	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_{DCHP_day}; $F_{container_{residue}-L}$; $F_{container_{residue}-S}$; V_{cont}; RHO; F_{DCHP-S}; F_{DCHP-L}; Q_{cont_solid}; Q_{cont_liquid}

Release Source	Model(s) Applied	Variables Used
Release source 4: Release from Cleaning Containers Used for Volatile Chemicals (Liquids Only)	EPA/OPPT Penetration Model or EPA/OPPT Mass Transfer Coefficient Model, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DCHP-L}; MW; VP; $RATE_{air\_speed}$; $D_{cleaning}$; T; P Operating Time: Q_{DCHP_day}; F_{DCHP-L}; V_{cont}; RHO
Release source 5: Labware Equipment Cleaning	EPA/OPPT Multiple Process Vessel Residual Model or EPA/OPPT Solids Residuals in Transport Container Model, based on physical form (Appendix E.1)	Q_{DCHP_day}; $F_{lab\_residue\_L}$; $F_{lab\_residue\_S}$; RHO
Release source 6: Releases during Labware Cleaning (Liquids Only)	EPA/OPPT Penetration Model or EPA/OPPT Mass Transfer Coefficient Model, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DCHP-L}; MW; VP; $RATE_{air\_speed}$; $D_{cleaning}$; T; P Operating Time: $OH_{cleaning}$
Release source 7: Releases During Laboratory Analysis (Liquids Only)	EPA/OPPT Penetration Model or EPA/OPPT Mass Transfer Coefficient Model, based on air speed (Appendix E.1)	Vapor Generation Rate: F_{DCHP-L}; MW; VP; $RATE_{air\_speed}$; $D_{testing}$; T; P Operating Time: $OH_{testing}$
Release source 8: Releases from Laboratory Waste Disposal	See Equation_Apx E-63 and Equation_Apx E-64	$Q_{DCHP_{day}}$; $F_{container_{residue}-S}$; $F_{container_{residue}-L}$; $F_{lab_{residue_S}}$; $F_{lab_{residue_L}}$; $F_{dust_{generation}}$; Release Points 1, 3, 6, and 7

For liquid DCHP, release source 8 (Laboratory Waste Disposal) is calculated via a mass-balance, using the following equation:

Equation_Apx E-63.

$$Release\_perDay_{RP8-L} = \left(Q_{DCHP\_day} - Release_{perDay_{RP1}} - Release_{perDay_{RP3}} - Release_{perDay_{RP6}} - Release\_perDay_{RP7}\right) * \left(1 - F_{container_{residue}-L} - F_{lab\_residue\_L}\right)$$

Where:

$Release\_perDay_{RP8-L}$	=	Liquid DCHP released for release source 8 (kg/site-day)
Q_{DCHP_day}	=	Facility throughput of DCHP (see Appendix E.10.3) (kg/site-day)
$Release\_perDay_{RP1}$	=	Liquid DCHP released for release source 1 (kg/site-day)
$Release\_perDay_{RP3}$	=	Liquid DCHP released for release source 3 (kg/site-day)
$Release\_perDay_{RP6}$	=	Liquid DCHP released for release source 6 (kg/site-day)
$Release\_perDay_{RP7}$	=	Liquid DCHP released for release source 7 (kg/site-day)
$F_{container_{residue}-L}$	=	Fraction of DCHP remaining in container as Residue (see Appendix E.10.12) (kg/kg)
$F_{lab\_residue\_L}$	=	Fraction of DCHP remaining in lab equipment (see Appendix E.10.16) (kg/kg)

For solids containing DCHP, release source 8 (Laboratory Waste Disposal) is calculated via a mass-balance, via the following equation:

Equation_Apx E-64

$$Release\_perDay_{RP8-S} = Q_{DCHP\_day} * \left(1 - F_{dust\_generation} - LF_{cont} - F_{lab\_residue\_S}\right)$$

Where:

$Release\_perDay_{RP8-S}$	=	Solid DCHP released for release source 8 (kg/site-day)
Q_{DCHP_day}	=	Facility throughput of DCHP (see Appendix E.10.3) (kg/site-day)
$F_{dust\_generation}$	=	Fraction of DCHP lost during unloading of solid powder (see Appendix E.10.13) (kg/kg)
LF_{cont}	=	Fraction of DCHP remaining in transport containers (see Appendix E.10.12) (kg/kg)
$F_{lab\_residue\_S}$	=	Fraction of solid DCHP remaining in lab equipment (see Appendix E.10.16) (kg/kg)

E.10.2 Model Input Parameters

Table_Apx E-26 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 this table.

Table_Apx E-26. Summary of Parameter Values and Distributions Used in the Use of Laboratory Chemicals Model

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Production Volume	PV	kg/year	3.4E04	–	–	–	–	See Appx. E.10.3
Facility Throughput of Solid DCHP	$Q_{stock\_site\_day\_S}$	g/site-day	255	3.0E−03	510	–	Uniform	See Appx. E.10.3
Facility Throughput of Liquid DCHP	$Q_{stock\_site\_day\_L}$	mL/site-day	2,000	0.50	4,000	–	Uniform	See Appx. E.10.3
Number of Sites (Max)	N_s	sites	3.7E04	–	–	–	–	See Appx. E.10.4
Lab Testing Duration	$OH_{testing}$	h/day	1.0	–	–	–	–	See Appx. E.10.6
Equipment Cleaning Duration	$OH_{cleaning}$	h/day	4.0	–	–	–	–	See Appx. E.10.6
DCHP Solid Lab Chemical Concentration	F_{DCHP_solid}	kg/kg	0.10	1.0E−03	1.0	0.10	Triangular	See Appx. E.10.8
DCHP Liquid Lab Chemical Concentration	F_{DCHP_liquid}	kg/kg	1.0E−03	–	–	–	–	See Appx. E.10.8
Operating Days	OD	days/year	260	174	260	–	Discrete	See Appx. E.10.9
Air Speed	$RATE_{air\_speed}$	ft/min	20	2.6	398	–	Lognormal	See Appx. E.10.10
Saturation Factor	f_{sat}	dimension-less	0.50	0.50	1.5	0.50	Triangular	See Appx. E.10.11
Liquid Container Size	V_{cont}	gal	1.0	0.50	1.0	1.0	Triangular	See Appx. E.10.12
Solid Container Mass	Q_{cont_solid}	kg	1.0	0.5	1.0	1.0	Triangular	See Appx. E.10.12
Fraction of DCHP Remaining in Container as Residue – Solid	$F_{container\_residue-solid}$	kg/kg	1.0E−02	–	–	–	–	See Appx. E.10.12
Fraction of DCHP Remaining in Container as Residue – Liquid	$F_{container\_residue-liquid}$	kg/kg	3.0E−03	3.0E−04	6.0E−03	3.0E−03	Triangular	See Appx. E.10.12
Fraction of chemical lost during transfer of solid powders	$F_{dust\_generation}$	kg/kg	5.0E−03	6.0E−06	4.5E−02	5.0E−03	Triangular	See Appx. E.10.13
Dust Capture Technology Efficiency	$F_{dust\_capture}$	kg/kg	0.95	0	1.0	0.95	Triangular	See Appx. E.10.13

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Dust Control Technology Removal Efficiency	$F_{dust\_control}$	kg/kg	0.99	0	1.0	0.99	Triangular	See Appx. E.10.13
Vapor Pressure at 25 °C	VP	mmHg	4.9E−07	–	–	–	–	Physical property
Molecular Weight	MW	g/mol	330	–	–	–	–	Physical property
Gas Constant	R	atm-cm^3/gmol-L	82	–	–	–	–	Universal constant
Density of DCHP	RHO	kg/L	1.4	–	–	–	–	Physical property
Temperature	T	K	298	–	–	–	–	Process parameter
Pressure	P	atm	1	–	–	–	–	Process parameter
Small Container Fill Rate	$RATE_{fill}$	containers/h	60	–	–	–	–	See Appx. E.10.14
Diameter of Opening, Lab Analyses	$D_{testing}$	cm	2.5	2.5	10	2.5	Triangular	See Appx. E.10.15
Diameter of Opening – Container Cleaning	$D_{cleaning}$	cm	5.1	–	–	–	–	See Appx. E.10.15
Fraction of DCHP Remaining in Container as Residue Lab Equipment – Liquid	$F_{lab\_residue\_L}$	kg/kg	2.0E−02	–	–	–	–	See Appx. E.10.16
Fraction of DCHP Remaining in Container as Residue Lab Equipment – Solid	$F_{lab\_residue\_S}$	kg/kg	1.0E−02	–	–	–	–	See Appx. E.10.16

E.10.3 Production Volume and Throughput Parameters

No sites reported to CDR for use of DCHP in laboratory chemicals. EPA estimated the total production volume (PV) for all sites assuming a static value of 75,865 lb/year (34,412 kg/year) that was estimated based on the reporting requirements for CDR. The threshold for CDR reporters requires a site to report processing and use for a chemical if the usage exceeds 5 percent of its reported PV or if the use exceeds 25,000 lb per year. For the four sites that reported to CDR for the manufacture or import of DCHP, EPA assumed that each site used DCHP for laboratory chemicals in volumes up to the reporting threshold limit of 5 percent of their reported PV. If 5 percent of each site's reported PV exceeds the 25,000 lb reporting limit, EPA assumed the site used only 25,000 lb annually. If the site reported a PV that was CBI, EPA assumed the maximum PV contribution of 25,000 lb. The CDR sites and their PV contributions to this OES are show in Table_Apx E-15.

The Use of Laboratory Chemicals – Generic Scenario for Estimating Occupational Exposures and Environmental Releases (U.S. EPA, 2023c) provides daily throughput of DCHP 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 per the GS. The Agency assigned a uniform distribution for the daily throughput of laboratory stock solutions with upper and lower bounds corresponding to the high and low use rates, respectively.

The daily throughput of DCHP in liquid laboratory chemicals is calculated using Equation_Apx E-65 by multiplying the daily throughput of all laboratory solutions by the concentration of DCHP in the solutions and converting volume to mass.

Equation_Apx E-65.

$$Q_{DCHP\_day\_S} = Q_{stock\_site\_day\_L} * F_{DCHP-L} * RHO * \frac{0.001L}{mL}$$

Where:

$Q_{DCHP\_day\_L}$	=	Facility daily throughput of liquid DCHP (kg/site-day)
$Q_{stock\_site\_day\_L}$	=	Facility annual throughput of liquid laboratory chemicals (mL/site-day)
F_{DCHP-L}	=	Concentration of DCHP in liquid laboratory chemicals (see Appendix E.10.7) (kg/kg)
RHO	=	Density of DCHP (kg/L)

The daily throughput of DCHP in solid laboratory chemicals is calculated using Equation_Apx E-66 by multiplying the daily throughput of all laboratory solids by the concentration of DCHP in the solids.

Equation_Apx E-66.

$$Q_{DCHP\_day\_S} = Q_{stock\_site\_day\_S} * F_{DCHP-S} * \frac{0.001kg}{g}$$

Where:

$Q_{DCHP\_day\_S}$	=	Facility daily throughput of solid DCHP (kg/site-day)

$Q_{stock\_site\_day\_S}$ = Facility annual throughput of solid laboratory chemicals (g/site-day)
F_{DCHP-S} = Concentration of DCHP in solid laboratory chemicals (see Appendix E.10.7) (kg/kg)

To avoid cases where the number of sites is greater than the bounding estimate of 36,873 sites (see Appendix E.10.4), EPA calculated an adjusted value for the daily throughput of DCHP. If the number of sites is less than the bounding estimate, then the adjusted facility throughput of DCHP will be the same as the facility throughput calculated in Equation_Apx E-66. Otherwise, the adjusted facility throughput is calculated using Equation_Apx E-67 by dividing the facility production rate by the maximum number of sites and operating days. The number of operating days is determined according to Appendix E.10.8.

Equation_Apx E-67.

$$Q_{DCHP\_day\_adj} = \frac{PV}{N_s * OD}$$

$Q_{DCHP\_day\_adj}$ = Adjusted daily facility throughput of DCHP (kg/site-day)
N_s = Maximum number of sites (see Appendix E.10.4) (sites)
PV = Facility production rate of DCHP in laboratory chemicals (see Appendix E.10.7) (kg/kg)
OD = Operating days (see Appendix E.10.8) (days/site-year)

E.10.4 Number of Sites

Per 2020 U.S. Census Bureau data for the NAICS codes identified in the Use of Laboratory Chemicals – Generic Scenario for Estimating Occupational Exposures and Environmental Releases (U.S. EPA, 2023c), there are 36,873 laboratory chemical 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 a per-site throughput and DCHP production volume with the following equation:

Equation_Apx E-68.

$$N_s = \frac{PV}{Q_{DCHP_{day}} * OD}$$

Where:

N_s = Number of sites (sites)
PV = Production volume of DCHP (kg/year)
Q_{DCHP_day} = Facility daily throughput of DCHP (kg/site-day)
OD = Operating days (see Appendix E.10.8) (days/site-year)

E.10.5 Number of Containers per Year

The number of liquid DCHP laboratory containers unloaded by a site per year is calculated using the following equation:

Equation_Apx E-69.

$$N_{cont\_unload\_yr} = \frac{Q_{DCHP_{day}} * OD}{F_{DCHP-L} * RHO * \left(3.79\ \frac{L}{gal}\right) * V_{cont}}$$

Where:

$N_{cont\_unload\_yr}$ = Annual number of containers unloaded (container/site-year)

Q_{DCHP_day}	=	Facility daily throughput of DCHP (kg/site-day)
OD	=	Operating days (see Appendix E.10.8) (days/site-year)
V_{cont}	=	Container volume (see Appendix E.10.11) (gal/container)
RHO	=	DCHP density (kg/L)
F_{DCHP-L}	=	Mass fraction of DCHP in liquid (see Appendix E.10.7) (kg/kg)

The number of laboratory containers containing solids with DCHP unloaded by a site per year is calculated using the following equation:

Equation_Apx E-70.

$$N_{cont\_unload\_yr} = \frac{Q_{DCHP_{day}} * OD}{F_{DCHP-S} * Q_{cont\_solid}}$$

Where:

$N_{cont\_unload\_yr}$	=	Annual number of containers unloaded (container/site-year)
Q_{DCHP_day}	=	Facility daily throughput of DCHP (kg/site-day)
OD	=	Operating days (see Appendix E.10.8) (days/site-year)
F_{DCHP-S}	=	Mass fraction of DCHP in solid (see Appendix E.10.7) (kg/kg)
Q_{cont_solid}	=	Mass in container of solids (see Appendix E.10.11) (kg/container)

E.10.6 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.

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_Apx E-71.

$$OH_{RP1/RP4} = \frac{N_{cont\_unload\_yr}}{RATE_{fill} * OD}$$

Where:

$OH_{RP1/RP4}$	=	Operating time for release points 1 and 4 (h/site-day)
$N_{cont\_unload\_yr}$	=	Annual number of containers unloaded (container/site-year)
$RATE_{fill}$	=	Container fill rate (see Appendix E.10.14) (containers/h]
OD	=	Operating days (see Appendix E.10.8) (days/site-year)

For equipment cleaning (release point 6), the *ChemSTEER User Guide* provides an estimate of 4 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.10.7 DCHP Concentration in Laboratory Chemicals

EPA modeled DCHP concentration in liquid laboratory chemicals using SDS concentrations for two liquid lab products, both containing DCHP at a concentration of 0.1 percent. For solid laboratory chemicals, EPA modeled concentrations using a triangular distribution with a lower bound of 0.01

percent, upper bound of 100 percent, and mode of 10 percent, based on the concentration ranges reported in eight SDSs found for solid laboratory chemicals. The lower and upper bounds represent the minimum and maximum reported concentrations in the SDSs. The mode represents the median of all high-end range endpoints reported in the SDSs (see Appendix F for EPA identified DCHP-containing products for this OES).

E.10.8 Operating Days

EPA modeled the operating days per year using a discrete distribution with a low-end of 174 days/year and a high-end of 260 days/year. 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 8 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.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. The Agency fit separate distributions for these industrial and commercial settings and used the industrial distribution for this OES.

EPA fit a lognormal distribution for the data set as consistent with the authors' observations that the air speed measurements within a surveyed location were lognormally distributed and the population of the mean air speeds among all surveys were lognormally distributed (Baldwin and Maynard, 1998). 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 (CEB, 1991). The CEB Manual indicates that saturation concentration for bottom filling was expected to be about 0.5 (CEB, 1991). The underlying distribution of this parameter is not known; therefore, EPA assigned a triangular distribution based on the lower bound, upper bound, and mode of the parameter. Because a mode was not provided for this parameter, EPA assigned a mode value of 0.5 for bottom filling as bottom filling minimizes volatilization (CEB, 1991). This value also corresponds to the typical value provided in the *ChemSTEER User Guide* for the EPA/OAQPS AP-42 Loading Model (U.S. EPA, 2015).

E.10.11 Container Size

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 DCHP showed container sizes less than 1 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, the Agency built a triangular distribution for liquid volumes with a lower bound of 0.5 gallons, and an upper bound and mode of 1 gallon. EPA similarly built a triangular distribution for solid quantities with a lower bound of 0.5 kg, and an upper bound and mode of one kg.

E.10.12 Container Loss Fractions

The *EPA/OPPT Small Container Residual Model* from the *ChemSTEER User Guide* (U.S. EPA, 2015) recommends a default central tendency loss fraction of 0.3 percent and a high-end loss fraction of 0.6 percent.

The underlying distribution of the loss fraction parameter for small containers is not known; therefore, EPA assigned a triangular distribution, since triangular distributions 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). The Agency assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study (PEI Associates, 1988).

For solid containers, EPA used the EPA/OPPT Solid Residuals in Transport Containers Model to estimate residual releases from solid container cleaning. That model, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015) provides an overall loss fraction of 1 percent from container cleaning.

E.10.13 Dust Generation Loss Fraction, Dust Capture Efficiency, and Dust Control Efficiency

The Dust Release Mode) compiled data for loss fractions of solids from various sources in addition to the capture and removal efficiencies for control technologies in order to estimate releases of dust to the environment during transfer operations. Dust releases estimated from the model are based on three different parameters: the initial loss fraction, the fraction captured by the capture technology, and the fraction removed/controlled by the control technology. The underlying distributions for each of these parameters is not known; therefore, EPA assigned triangular distributions, 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 6.0×10^{-6} to 0.045 with a mode of 0.005 by mass. The Agency assigned the mode based on the recommended default value for the parameter in the Dust Release Model. The range of initial loss fraction values comes from the range of values compiled from various sources and considered in the development of the Dust Release Model (U.S. EPA, 2021b).

For the fraction of dust captured, EPA assigned a range of 0 to 1.0 with a mode of 0.95 by mass. The Agency assigned the range for the fraction captured based on the minimum and maximum estimated capture efficiencies listed in the data compiled for the Dust Release Model. EPA assigned the mode for the fraction captured based on the capture efficiency for laboratory fume hoods, since EPA expects that capture technology will likely be used.

For the fraction of captured dust that is removed/controlled, EPA assigned a range of 0 to 1.0 with a mode of 0.99 by mass. The Agency assigned the range for the fraction controlled based on the minimum and maximum estimated control efficiencies listed in the data compiled for the Dust Release Model. EPA assigned the mode for the fraction controlled based on control efficiency for filtering systems.

E.10.14 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.10.15 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*)*. For sampling and equipment cleaning releases, the Use of Laboratory Chemicals – Generic Scenario for Estimating Occupational Exposures and Environmental Releases (U.S. EPA, 2023c) estimates using a triangular distribution between a 1-inch (2.5 cm) diameter bottle opening for typical releases, and a 4-inch (10-centimeter) diameter beaker opening for worst-case estimates.

E.10.16 Equipment Cleaning Loss Fraction

For liquids, EPA used the EPA/OPPT Multiple Process Residual Model to estimate the releases from equipment cleaning. That model, as detailed in the ChemSTEER User Guide (U.S. EPA, 2015) provides an overall loss fraction of 2 percent from equipment cleaning.

For solids, used the EPA/OPPT Solid Residuals in Transport Containers Model to estimate the releases from equipment cleaning. Theat model, as detailed in the *ChemSTEER User Guide* (U.S. EPA, 2015) provides an overall loss fraction of 1 percent from equipment cleaning.

E.11 Inhalation Exposure to Respirable Particulates Model Approach and Parameters

The PNOR Model (U.S. EPA, 2021b) estimates worker inhalation exposure to respirable solid particulates using personal breathing zone PNOR Model monitoring data from OSHA's CEHD data set. The CEHD data provides PNOR Model 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 Model values for applicable NAICS codes as the central tendency and high-end exposure estimates, respectively.

Due to lack of data on the concentration of DCHP in the particulates, EPA assumed DCHP 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, the Agency calculates the 8-hour TWA exposure to DCHP present in dust and particulates using the following equation:

Equation_Apx E-72.

$$C_{DCHP,8hr-TWA} = C_{PNOR,8hr-TWA} \times F_{DIDP}$$

Where:

$C_{DCHP,8hr-TWA}$ = 8-hour TWA exposure to DCHP (mg/m^3)
$C_{PNOR,8hr-TWA}$ = 8-hour TWA exposure to PNOR (mg/m^3)
F_{DCHP} = Mass fraction of DCHP in PNOR (mg/mg)

Table_Apx E-27 provides a summary of the OESs assessed using the PNOR Model (U.S. EPA, 2021b) along with the associated NAICS code, PNOR 8-hour TWA exposures, DCHP mass fraction, and DCHP 8-hour TWA exposures assessed for each OES.

Table_Apx E-27. Summary of DCHP Exposure Estimates for OESs Using the Generic Model for Exposure to PNOR

OES	NAICS Code Assessed	Respirable PNOR 8-Hour TWA from Model (mg/m^3)		DCHP Mass Fraction Assessed	DCHP 8-Hour TWA (mg/m^3)	
		Central Tendency	High-End		Central Tendency	High-End
Manufacturing	325 – Chemical Manufacturing	0.48	5.0	1.0	0.48	5.0
Import – repackaging	42 – Wholesale and Retail Trade	0.22	5.0	0.60	0.13	3.0
Incorporation into formulation, mixture, or reaction product – paints and coatings	325 – Chemical Manufacturing	0.48	5.0	1.0	0.48	5.0
Incorporation into formulation, mixture, or reaction product – adhesives and sealants	325 – Chemical Manufacturing	0.48	5.0	1.0	0.48	5.0
Incorporation into formulation, mixture, or reaction product – other formulations	325 – Chemical Manufacturing	0.48	5.0	1.0	0.48	5.0
Non-PVC materials compounding	326 – Plastics and Rubber Manufacturing	0.23	4.7	0.60	0.14	2.8
Non-PVC materials converting	326 – Plastics and Rubber Manufacturing	0.23	4.7	0.20	4.6E−02	0.94
Plastics compounding	326 – Plastics and Rubber Manufacturing	0.23	4.7	1.0	0.23	4.7
Plastics converting	326 – Plastics and Rubber Manufacturing	0.23	4.7	0.45	0.10	2.1

OES	NAICS Code Assessed	Respirable PNOR 8-Hour TWA from Model (mg/m^3)		DCHP Mass Fraction Assessed	DCHP 8-Hour TWA (mg/m^3)	
		Central Tendency	High-End		Central Tendency	High-End
Application of paints and coatings (solid)	PNOR Model Defaults	0.28	4.9	1.0	0.28	4.9
Application of adhesives and sealants (solid)	PNOR Model Defaults	0.28	4.9	0.55	0.15	2.7
Use of laboratory chemicals (solid)	54 – Professional, Scientific, and Technical Services	0.19	2.7	1.0	0.19	2.7
Recycling	56 – Administrative and Support and Waste Management and Remediation Services	0.24	3.5	0.45	0.11	1.6
Fabrication or use of final product / articles containing DCHP	337 – Furniture and Related Product Manufacturing	0.20	1.8	0.45	9.0E−02	0.81
Waste handling, treatment, and disposal	56 – Administrative and Support and Waste Management and Remediation Services	0.24	3.5	0.45	0.11	1.6

E.12 Spray Exposure Model Approach and Parameters

This section presents the modeling approach and equations used to estimate occupational exposures for DCHP during the application of paints and coatings OES. 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 DCHP in the paint to estimate the central tendency and high-end inhalation exposures, respectively.

E.12.1 Model Design Equations

The Automotive Refinishing Spray Coating Mist Inhalation Model calculates the 8-hour TWA exposure to DCHP present in mist and particulates using the following equation:

Equation_Apx E-73.

$$C_{DCHP,8hr-TWA} = \frac{C_{mist} \times F_{DCHP\_solids} \times ED}{8\ hrs}$$

Where:

$C_{DCHP,8hr-TWA}$	=	8-hour TWA inhalation exposure to DCHP (mg/m^3)
C_{mist}	=	Over sprayed product mist concentration in the air within worker's breathing zone (mg/m^3)
F_{DCHP_solids}	=	Mass fraction of DCHP in the non-volatile portion of the spray (mg$_{DCHP}$/mg$_{nonvolatile\ components}$)
ED	=	Exposure Duration (h)

E.12.2 Model Parameters

Table_Apx E-28 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 this table.

Table_Apx E-28. 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 Appendix E.12.2.2
DCHP Concentration in Product	F_{DCHP_prod}	kg/kg	Use of paints and coatings	0.0625	0.10	See Appendix E.12.2.2
Concentration of Nonvolatile Solids in the Spray Product	F_{solids_prod}	kg/kg	Use of paints and coatings	0.25	0.5	See Appendix E.12.2.3
DCHP Concentration of Nonvolatile Components	F_{DCHP_solids}	mg/mg	Use of paints and coatings	0.13	0.40	See Appendix E.12.2.4
Exposure Duration	ED	hour	Use of paints and coatings	8		See Appendix E.12.2.5

E.12.2.1 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 are divided into various combinations of spray booth types (*e.g.*, downdraft and crossdraft) and spray gun types (*e.g.*, conventional, high-volume low-pressure). The Agency 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.12.2.2 DCHP Product Concentration

EPA developed the concentration inputs based on the single finished liquid coating product SDS available, which listed DCHP concentration with a range of 2.5 to less than 10 percent by weight (see Appendix F for EPA identified DCHP-containing products for this OES). From this range, EPA used the average of the minimum and maximum concentrations as the central tendency and the maximum concentration as the high-end DCHP concentration. The central tendency value was 0.0625, and the high-end value was 0.10.

E.12.2.3 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 to 0.50 mg/mg (OECD, 2011a; Bryant, 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.12.2.4 DCHP Concentration in Nonvolatile Components

The mass fraction of DCHP in the nonvolatile portion of the sprayed product is calculated using the following equation:

Equation_Apx E-74.

$$F_{DCHP\_solids} = \frac{F_{DCHP\_prod}}{F_{solids\_prod}}$$

Where:

F_{DCHP_solids}	=	Mass fraction of DCHP in the nonvolatile portion of the sprayed product ($mg_{DCHP}/mg_{nonvolatile\ components}$)
F_{DCHP_prod}	=	Mass fraction of DCHP in the paint or coating product, spray-applied ($mg_{DCHP}/mg_{sprayed\ product}$)
F_{solids_prod}	=	Mass fraction of nonvolatile components within the sprayed product ($mg_{nonvolatile\ components}/mg_{sprayed\ product}$)

If this equation results in F_{DCHP_solids} exceeding 1, then the value of F_{DCHP_solids} is assessed at a value of 1. EPA divided the high-end F_{DCHP_prod} by the central tendency F_{solids_prod} in order to calculate the highest concentration of F_{DCHP_solids} given the available central tendency and high-end parameters. The Agency also divided the central tendency F_{DCHP_prod} by the high-end F_{solids_prod} in order to calculate the lowest F_{DCHP_solids} given the available central tendency and high-end parameters. EPA used these calculated F_{DCHP_solids} values as the central tendency and high-end parameters for the variable, 0.13 and 0.40, respectively.

E.12.2.5 Exposure Duration

EPA did not identify DCHP-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 8-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 8-hour duration for spraying is used and assumed to be protective of any contribution to exposures from vapors.

Appendix F PRODUCTS CONTAINING DCHP

This section includes a sample of products containing DCHP. This is not a comprehensive list of products containing DCHP. In addition, some manufacturers may appear over-represented in this table. 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 DCHP

OES	Product	Manufacturer	DCHP Concentration	Source	HERO ID
Adhesives and sealants	Fusor 108B, 109B Metal Bonding ADH PT B	LORD Corporation	1–5%, unspecified	LORD Corporation (2017)	6303150
Adhesives and sealants	Metal Bonding Adhesive	Ford Motor Company	3 to <5%, unspecified	Ford Motor Company (2015)	6303132
Adhesives and sealants	HVU M8 - M39	Hilti (Canada) Corp.	1–2.5%, unspecified	Hilti (Canada) Corp. (2015)	6303171
Adhesives and sealants	HVU-TZ M10-M20	Hilti Deutschland AG	1–2.5%, unspecified	Hilti Deutschland AG (2017)	11437783
Adhesives and sealants	HVU2 M8 - M30	Hilti Deutschland AG	1–3%, unspecified	Hilti Deutschland AG (2019)	6303159
Adhesives and sealants	V-P M8, V-P M10, V-P M12, V-P M14, V-P M16, V-P M20, V-P M22, V-P M24, V-P M30	MKT Metall-Kunststoff-Technik GmbH & Co. KG	DCHP is not in this product	MKT Metall-Kunststoff-Technik GmbH & Co. KG (2018)	6303154
Adhesives and sealants	SC-PRO -M8, M10, M12, M16, M20, M24, M30	DeWALT	0–1.5%, unspecified	DeWALT (2017)	6303124
Adhesives and sealants	R-CAS-V	Rawlplug S.A.	<1.8%, by weight	Rawlplug S.A. (2015)	
Adhesives and sealants	Protectosil Degadeck CSS BPO	Evonik Corporation USA	40–55%, by weight	Evonik Corporation USA (2012)	6303145
Adhesives and sealants	Polyethylene protection sheet No. 9430	Teraoka Seisakusho Co., Ltd.	Unknown	Teraoka Seisakusho Co. Ltd. (2013)	6303176
Adhesives and sealants	Chem-Stud Adhesive Anchor capsules	Power Fasteners, Inc.	Unknown	Power Fasteners Inc. (2011a)	6303152
Adhesives and sealants	Hammer-Capsule^{TM} Adhesive Anchor Capsule	Power Fasteners, Inc.	Unknown	Power Fasteners Inc. (2011b)	6303156

OES	Product	Manufacturer	DCHP Concentration	Source	HERO ID
Laboratory chemical/other formulations	JB-4® Plus Catalyst: Component of 18040JB-4® Plus	Ted Pella, Inc.	51–60%, unspecified	Ted Pella Inc. (2017)	6303173
Laboratory chemical/other formulations	33227 / EPA Method 8061A Phthalate Esters Mixture	Restek Corporation	0.1%, unspecified	Restek Corporation (2019)	6302566
Laboratory chemical/other formulations	Dicyclohexyl Phthalate	SPEX CertiPrep, LLC	0.1%, unspecified	SPEX CertiPrep LLC (2017)	6303183
Laboratory chemical/other formulations	JB-4 CATALYST	Electron Microscopy Sciences	25-50%, unspecified	Electron Microscopy Sciences (2016)	6303131
Laboratory chemical/other formulations	MATFIX RESIN	Electron Microscopy Sciences	≤2.5%, unspecified	Electron Microscopy Sciences (2018)	6303149
Laboratory chemical/other formulations	TECHNOVIT 3040 POWDER	Electron Microscopy Sciences	>2.5 to ≤10%, unspecified	Electron Microscopy Sciences (2019)	6303134
Laboratory chemical/other formulations	VariDur 200 Powder	Buehler	0–1%, by weight	Buehler (2017)	6303137
Laboratory chemical/other formulations	VariDur 3003 Powder	Buehler	0–2.5%, by weight	Buehler (2018)	6303142
Laboratory chemical/other formulations	Technovit 7100 Hardener 1	Kulzer GmbH	25–50%, unspecified	Kulzer GmbH (2017b)	6303146
Laboratory chemical/other formulations	Technovit 4000 powder	Kulzer GmbH	0–5%, unspecified	Kulzer GmbH (2017a)	6303139
Other formulations	Duco Cement (bottle and tube)^{1}	ITW Consumer - Devcon/Versachem	<3%, by weight	ITW Permatex (2012); ITW Consumer - Devcon/Versachem (2008)	6303170
Paints and coatings	Cowslips Powder	Shoof International Ltd.	<3%, unspecified	Shoof International Ltd. (2019)	6303186
Paints and coatings	RK-1300 - RK-1500 Activator	WEICON GmbH & Co. KG	10–20%, by weight	WEICON GmbH & Co. KG (2018)	6303195
Paints and coatings	X60 - A	Hottinger Baldwin Messtechnik GmbH	0.5–1.5%, unspecified	Hottinger Baldwin Messtechnik GmbH (2015)	6303160

OES	Product	Manufacturer	DCHP Concentration	Source	HERO ID
Paints and coatings	KEMPEROL® CP Catalyst Powder	Kemper System America, Inc.	DCHP is not in this product	Kemper System America Inc. (2023)	6303169
Paints and coatings	PUMADEQ Catalyst	Henry Company	30–60%, by weight	Henry Company (2018)	6303167
Paints and coatings	TREMCO CP510	Tremco Illbruck Ltd.	30 to <50%, unspecified	Tremco Illbruck Ltd. (2018)	6303178
Paints and coatings	Gard-Deck ® Hardener 500	Hydro-Gard, LLC	40–55%, unspecified	Hydro-Gard LLC (2017)	6303165
Paints and coatings	THERMALINE 4900 ALUMINUM	Carboline Company	1.0 to <2.5%, unspecified	Carboline Company (2019)	6311506
Paints and coatings	DURAL MMA - INITIATOR - 5#-1 GAL PAIL	Euclid Chemical Company	DCHP is not in this product	Euclid Chemical Company (2018)	6303140
Paints and coatings	Sikafloor® Pronto Hardener	Sika Limited	≥40 to <60%, unspecified	Sika Limited (2017)	6303185
Paints and coatings	Duro-Last® Liquid-Applied Flashing Catalyst	Duro-Last®, Inc.	49–51%, unspecified	Duro-Last Inc. (2019)	6303128
Paints and coatings	PERKADOX CH-50	Akzo Nobel	48–55%, unspecified	Akzo Nobel (2017)	6303143
Paints and coatings	Pro Catalyst	Siplast, Inc.	40–55%, by weight	Siplast Inc. (2015)	6303190
Paints and coatings	MMA CATALYST	Hitex Traffic Safety Ltd	47.5–51%, by weight	Hitex Traffic Safety Ltd (2023)	6303168
Paints and coatings	BP-30-FT1	United Initiators GmbH	≥30 to <35%, by weight	United Initiators GmbH (2018)	6303197
Paints and coatings	JM PMMA Catalyst, SeamFree™ Catalyst	Johns Manville	≥30 to ≤60%, unspecified	Johns Manville (2018)	6303164
Paints and coatings	BENOX C-50	United Initiators, Inc.	≥50 to <55%, by weight	United Initiators Inc. (2018)	6303189
Paints and coatings	Echostar 30 BCP Tecno	Beads Belgium	0.56 to 0.77%, unspecified	Beads Belgium (2016)	6303138
Paints and coatings	MH-1 Hardener	Dudick, Inc.	40 to 60%, by weight	Dudick Inc. (2015)	6303125
Paints and coatings	ALT Catalyst Powder	ALT Global, LLC	25 to 50%, unspecified	ALT Global LLC (2015)	6303141
Paints and coatings	HydroSeal® Catalyst	American Hydrotech, Inc.	25 to 50%, unspecified	American Hydrotech Inc. (2016)	6303148
Paints and coatings	400 Vinyl Ester Mortar (Silica Filled), Powder	Sauereisen	<0.005%, by weight	Sauereisen (2015)	6303188

OES	Product	Manufacturer	DCHP Concentration	Source	HERO ID
Paints and coatings	Cadox BFF-50/	Akzo Nobel Chemicals Inc., Chemical div/Akzo Nv	50%, unspecified	Akzo Nobel (2019)	6303147
Paints and coatings	EMACO 2020 PART C	ChemRex®	45–60%, unspecified	ChemRex (2003)	6303123
Paints and coatings	Härterpulver 50	BEIL	40–50%, unspecified	BEIL (2015)	6303144
Paints and coatings	PEROXAN BP-Pulver 30 W	PERGAN GmbH	25–30%, unspecified	PERGAN GmbH (2018)	6303151
Paints and coatings	MONOTEK® Hardener Powder	D.P.J. Coating Systems Pty Ltd.	30–60%, unspecified	DPJ Coating Systems Pty Ltd (2019)	6303129
Paints and Coatings	Cryl-A-Tex Liquid	Dur-A-Flex, Inc.	DCHP is not in this product	Dur-A-Flex Inc. (2014)	6303127
Paints and coatings/other formulations	Sikagard® CRV-20 Part B	Sika Corporation	≥50 to 100%, unspecified	Sika Corporation (2017)	6303191
Plastic compounding	HistoResin M.M.Pulver	Leica Biosystems Nussloch GmbH	0–5%, unspecified	Leica Biosystems Nussloch GmbH (2015)	6303153
Plastic compounding	MORFLEX* 150	Vertellus LLC	≈100%, by weight	Vertellus LLC (2018)	6303193
Printing ink (assessed under paints and coatings)	X102452, X102822, X102839, X102840, L-3049	Gans Ink and Supply Co, Inc.	30–60%, by weight	Gans Ink and Supply (2018)	6303157