Economic Analysis for the Final Regulation of Decabromodiphenyl ether (DecaBDE) and Phenol, isopropylated phosphate (3:1) (PIP (3:1)) Under TSCA Section 6(h)

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Notice

This is not an official guidance document and should not be relied upon to determine applicable regulatory requirements. This document was prepared to provide economic information for the rulemaking process and to meet various administrative and legislative requirements. Due to the nature of the information available to EPA, the document contains various assumptions that may not reflect the regulatory determinations that an individual firm would make were it to apply the rule's requirements to its specific circumstances. Persons seeking information on regulatory requirements as they apply to specific facilities should consult 40 CFR part 751, the preamble for the regulatory action, and EPA guidance documents.

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Acronyms

AIA	Aerospace Industry Association
APF	Assigned Protection Factor
APR	Air Purifying Respirator
ATSDR	Agency for Toxic Substances and Disease Registry
BLS	Bureau of Labor Statistics
CBI	Confidential business information
CDR	Chemical Data Reporting
CFR	Code of Federal Regulations
CHCCs	Chemicals of high concern to children
DecaBDE	Decabromodiphenyl ether
ECEC	Employer Costs for Employee Compensation
EJ	Environmental Justice
EPA	Environmental Protection Agency
EU	European Union
FAA	Federal Aviation Administration
FAST Act	Fixing America's Surface Transportation Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FR	Final Rule
FRN	Final Rule Notice
GDP	Gross Domestic Product
HIPS	High-impact polystyrene
ICR	Information collection request
IEEE 383	Institute of Electrical and Electronics Engineers 383
IMDS	International Material Data System
IUR	Inventory Update Rule
JMTBA	Japan Machine Tool Builders' Association
LOAEL	Lowest-observed-adverse-effect level
LOEC	Lowest observed effect concentration
MRL	Minimum Risk Level
NAICS	North American Industry Classification System
NEMA	National Electronic Manufacturer's Association
NIOSH	National Institute for Occupational Safety & Health
nonaBDEs	Congeners with 9 bromine atoms
NR	Not reported
NRC	Nuclear Regulatory Commission
NTP	National Toxicology Program
OES	Occupational Employment Statistics
OEWS	Occupational Employment and Wage Statistics
OSHA	Occupational Safety and Health Administration
PBDEs	Polybrominated diphenyl ethers
PBT	Persistent, bioaccumulative, and toxic
PDV	Present discounted value
PFOA	Perfluorooctanoic acid
PIC	Prior Informed Consent
PIP (3:1)	Phenol, isopropylated phosphate (3:1)
PND	Postnatal day
POP	Persistent organic pollutant
POPs	Persistent Organic Pollutants

PPE	Personal protective equipment
PVC	Polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RFA	Regulatory Flexibility Act
RY	Reporting Year
SAR	Supplied Air Respirator
SBA	Small Business Administration
SBREFA	Small Business Regulatory Enforcement Fairness Act
SDS	Safety data sheet
SKU	Stock keeping unit
SOC	Standard Occupational Classification
SUSB	Statistics of U.S. Businesses
TDCPP	Tris (1,3-dichloroisopropyl) phosphate
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
TTDs	Target Organ Toxicity Doses
UMRA	Unfunded Mandates Reform Act
VECAP	Voluntary Emissions Control Action Programme
VOC	Volatile Organic Compounds

Executive Summary

Introduction

The U.S. Environmental Protection Agency (EPA) is finalizing revisions to the regulations for decabromodiphenyl ether (decaBDE) and phenol, isopropylated phosphate (3:1) (PIP (3:1)), two of the five persistent, bioaccumulative, and toxic (PBT) chemicals addressed in final rules issued under section 6(h) of the Toxic Substances Control Act (TSCA) in January 2021. After receiving additional comments following the issuance of the 2021 PBT final rules, the Agency has determined that revisions to the decaBDE and PIP (3:1) regulations were necessary to address implementation issues and to reduce further exposures. As required under TSCA section 6(h), these finalized requirements will reduce the potential for exposures to humans and the environment to decaBDE and PIP (3:1) to the extent practicable. The Agency is not revising the existing regulations for the other three PBT chemicals (2,4,6-TTBP, HCBD, and PCTP).

EPA requested and received comments on the January 2021 PBT rules following the issuance of Executive Order 13990 (Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis) and other administration priorities. In a March 16, 2021 public notice, EPA asked for comment on additional actions that could be taken to reduce PBT chemical exposures. Information submitted by regulated entities regarding the final rules for decaBDE and PIP (3:1) and EPA's own review of the regulations has led the Agency to determine that amendments to both rules are necessary to further reduce the potential for exposure to the extent practicable.

The Agency published a Notice of Proposed Rulemaking (NPRM) in 2023 and received public comment submissions on the proposed rule from a variety of stakeholders, including industry and trade associations, product manufacturers, chemical users, non-governmental organizations (NGOs), labor advocacy organizations, and Tribal governments (U.S. Environmental Protection Agency (EPA) 2023c). Subsequently, this action finalizes regulatory requirements that will reduce exposures and risks through prohibiting or limiting the processing and distribution of PIP (3:1) and decaBDE and products or articles containing the chemicals and requiring the use of PPE to protect workers. The final rule also prohibits releasing decaBDE to water during manufacturing, processing, and distribution in commerce of decaBDE and decaBDE-containing products. The final options for each chemical use (along with alternative options) for decaBDE and PIP (3:1) are summarized in Table ES- 1 and Table ES-2, respectively. As indicated by TSCA section 6(c)(2)(A)(iv)(II) and (III), EPA must consider and publish a statement based on reasonably available information with respect to the reasonably ascertainable economic consequences of the rule, including consideration of the costs and benefits and the cost effectiveness of the Final Regulatory Action and one or more Primary Alternative regulatory actions considered by the Agency. Therefore, Table ES-1 and Table ES-2 denote both final and primary alternative options.

Table ES-1: Summary of DecaBDE Risk Management Options		
Chemical Use	**Final Option[1]**	**Primary Alternative Option**
Distribution in commerce of decaBDE-containing plastic shipping pallets manufactured before March 8, 2021; and, Processing and distribution in commerce for recycling of decaBDE-containing plastic from products or articles and decaBDE-containing products or articles made from such recycled plastic, where no new decaBDE is added during the recycling process	Require signage providing notice to workers that PPE is required to be worn during the recycling, of plastic shipping pallets, which will reduce potential exposures to decaBDE. Require inhalation and dermal PPE (N95 mask and chemical-resistant gloves) during the recycling process of shipping pallets known to contain decaBDE.	Require a label on all recycled plastic articles containing decaBDE. Require inhalation and dermal PPE (e.g., N95 mask, chemical-resistant gloves) during all recycling processes of plastics.
Manufacture and processing of decaBDE for use in replacement parts and the manufacture of such parts, specifically use in parts installed in and distributed as part of new aerospace vehicles, and the manufacturing and processing of parts to which decaBDE has been added for such vehicles.	Require inhalation and dermal PPE (N95 mask and chemical-resistant gloves), except for the processing of parts to which decaBDE has been added.	No changes from 2021 Final Rule
Manufacture and processing of decaBDE for use in replacement parts and the manufacture of such parts, specifically decaBDE and decaBDE-containing products for use in replacement parts for motor vehicles, and the manufacturing and processing of replacement parts to which decaBDE has been added for such vehicles.	Require inhalation and dermal PPE (N95 mask and chemical-resistant gloves), except for the processing of parts to which decaBDE has been added	No changes from 2021 Final Rule
Releases of decaBDE to water	Prohibit the releases to water during manufacturing, processing, distribution in commerce of decaBDE, decaBDE-containing products, and all persons are required to follow all applicable regulations for preventing the release of decaBDE.	No changes from 2021 Final Rule
Processing and distribution in commerce of decaBDE for use in wire and cable insulation in nuclear power generation facilities	After the end of the wire and cables' service life, all persons are prohibited from all processing and distribution in commerce of decaBDE-containing wire and cable insulation for use in wire and cable insulation in nuclear power generation facilities (including research and test reactors). Require export notification for all persons intending to export decaBDE-containing wire and cable insulation for nuclear power generation facilities.	No changes from 2021 Final Rule

[1] In response to public comments on the NPRM, the final rule also establishes a regulatory threshold level of 0.1%. This amendment in § 751.405 (a) prohibits all manufacturing and processing of decaBDE or decaBDE-containing products or articles after March 8, 2021, and prohibits all distribution in commerce of decaBDE or decaBDE-containing products or articles after January 6, 2022, unless decaBDE concentrations are at or below 0.1% by weight, not including any amount present due to excluded uses, including recycling or phased-out

Table ES-1: Summary of DecaBDE Risk Management Options		
Chemical Use	**Final Option[1]**	**Primary Alternative Option**
uses. As noted in § 751.405 (a)(2), this exclusion does not apply to the processing and distribution in commerce of decaBDE-containing wire and cable insulation for nuclear power generation facilities (including research and test reactors).		

Table ES- 2: Summary of PIP (3:1) Risk Management Options		
Chemical Use	**Final Option[1,2]**	**Primary Alternative Option**
Processing and distribution in commerce for use in lubricants and greases, PIP (3:1) containing products for use in lubricants and greases, and PIP (3:1)-containing lubricants and greases	Modify exclusion for processing and distribution in commerce of PIP (3:1) for use in lubricants and greases and require PPE. • Limit this exclusion to only aerospace use and turbine applications. • Add a 15-year time limit to the exclusion for manufacturing, processing and distribution in commerce of any other lubricants and greases that contain PIP (3:1 and PIP (3:1)-containing products for use in); thus, non-turbine and non-aerospace uses will be prohibited after 15 years. • Require a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator, and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during the manufacturing and processing of PIP (3:1) and PIP (3:1)-containing products for use in lubricants and greases.	Same as the Final Option, except using a 5-year time limit, rather than 15-years, to the exclusion for manufacturing, processing and distribution in commerce of PIP (3:1) and PIP (3:1)-containing products for use in any other lubricants and greases that contain PIP (3:1) and PIP (3:1)-containing products for use in); thus, non-turbine and non-aerospace uses would be prohibited after 5 years.
Processing and distribution in commerce of new and replacement parts for motor vehicles	Modify compliance dates for processing and distribution in commerce of PIP (3:1) for use in new and replacement parts for motor vehicles and PPE during manufacturing and processing. • Prohibit with 15-year phase-in the processing and distribution in commerce of PIP (3:1) and manufacturing, processing, and distribution in commerce of PIP (3:1)-containing products for use in parts for new motor vehicles (i.e., newly produced vehicles), and manufacturing and processing of PIP (3:1)-containing parts for such new vehicles. • Prohibit with 30-year phase-in the processing and distribution in commerce of PIP (3:1) and manufacturing, processing, and distribution in commerce of PIP (3:1)-containing products for use in replacement parts for motor vehicles, and manufacturing and processing of PIP (3:1)-containing replacement parts for such vehicles. • Require a respirator at least as protective as a NIOSH-approved N95 respirator (APF 10) and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of PIP (3:1) and PIP (3:1)-containing products for use in new and replacement parts for motor vehicles. Processing of PIP (3:1)-containing parts to which PIP (3:1) has been added are excluded from this requirement.	No changes from 2021 Final Rule

Table ES- 2: Summary of PIP (3:1) Risk Management Options		
Chemical Use	**Final Option[1,2]**	**Primary Alternative Option**
Processing and distribution in commerce of new and replacement parts for aerospace vehicles	Prohibition phase-in dates for PIP (3:1)-containing new and replacement parts for aerospace vehicles. • Prohibit the manufacturing, processing and distribution in commerce of PIP (3:1) and PIP (3:1)-containing products for use in new and replacement parts for aerospace vehicles after 30 years; • After the end of the aerospace vehicles service lives, prohibit the importing, processing and distribution of aerospace vehicles manufactured before the 30-year prohibition is in effect. • Prohibit manufacturing, processing and distribution in commerce of PIP (3:1), PIP (3:1)-containing products, and PIP (3:1)-containing replacement parts after the end of the vehicle service life. (Allow replacement parts that contain PIP (3:1) through the life cycle of the vehicle.) • Require a respirator at least as protective as a NIOSH-approved N95 respirator (APF 10) and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of PIP (3:1) and PIP (3:1)-containing products for use in new and replacement parts for aerospace vehicles. Processing of PIP (3:1)-containing parts to which PIP (3:1) has been added are excluded from this requirement.	No changes from 2021 Final Rule
Processing and distribution in commerce for use in wire harnesses and electric circuit boards	Exclusion for the processing and distribution of PIP (3:1), PIP (3:1)-containing products for use in circuit boards and wire harnesses, including but not limited to terminal and fuse covers, cable sleeves, casings, connectors and tapes, and PIP (3:1)-containing circuit boards and wire harnesses including but not limited to terminal and fuse covers, cable sleeves, casings, connectors and tapes. Require a respirator at least as protective as NIOSH-approved APF 10 air-purifying half mask respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of PIP (3:1) for use in wire harnesses or electric circuit boards.	Prohibit manufacturing (including import), processing, and distribution and commerce of PIP (3:1) for use in circuit boards and wire harnesses, including but not limited to terminal and fuse covers, cable sleeves, casings, connectors and tapes, and PIP (3:1)-containing circuit boards and wire harnesses including but not limited to terminal and fuse covers, cable sleeves, casings, connectors and tapes, after 20 years.
Manufacturing (import) and distribution in commerce of PIP (3:1) that is intended for formulation into a FIFRA-registered marine antifouling coating	Provide an exclusion of 5 years for the processing and distribution in commerce of PIP (3:1) for use in FIFRA-registered marine anti-fouling coatings only for products that meet Department of Defense specification requirements. Require a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of PIP (3:1)-for use in FIFRA-registered marine antifouling coating.	

Table ES- 2: Summary of PIP (3:1) Risk Management Options		
Chemical Use	**Final Option[1,2]**	**Primary Alternative Option**
Processing and distribution in commerce for use in semiconductor manufacturing, and electronic, HVACR and water heating, and power generating equipment manufacturing.	Prohibition phase-in dates for PIP (3:1)-containing new and replacement parts for products and articles for use installed in equipment in a variety of industries: manufacturing, semiconductor manufacturing, electronic, HVACR and water heating, and power generating. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing products and articles for use in new parts installed in equipment in a variety of industries: manufacturing, semiconductor manufacturing, electronic, HVACR and water heating, and power generating after 10 years. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in manufacturing equipment, including semiconductor manufacturing after the end of the products service life. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in electronic equipment after 7 years for personal use, 25 years for commercial use, and after the products service life for laboratory use. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in HVACR and water heating equipment after 25 years. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in power generating equipment after 25 years. Require a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask-respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing for use in PIP (3:1)-containing manufacturing equipment or semiconductors. Processing of PIP (3:1)-containing parts to which PIP (3:1) has been added are excluded from this requirement.	Same as the Final Option, except using a 20-year time limit, rather than 10 years, to the exclusion for manufacturing, processing and distribution in commerce of PIP (3:1) and PIP (3:1)-containing products for use in semiconductor manufacturing, and electronic, HVACR and water heating, and power generating equipment manufacturing.
Processing and distribution in specialized engine filters for locomotive and marine applications	Require half or full respirators, and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible for workers using PIP (3:1) in the manufacturing of specialized engine filters for locomotive and marine applications. Processing of PIP (3:1)-containing parts are excluded from this requirement.	No changes from 2021 Final Rule
Processing and distribution in intermediate in a closed system to produce cyanoacrylate adhesives	Require respiratory protection that must be at least as protective as a NIOSH-approved APF 50 respirator, except when the PIP (3:1) or PIP (3:1)-containing product is contained in a closed-system. Codify requirements for engineering controls of closed loop, as well as local exhaust ventilation and general ventilation.	No changes from 2021 Final Rule

Table ES- 2: Summary of PIP (3:1) Risk Management Options		
Chemical Use	**Final Option[1,2]**	**Primary Alternative Option**
Processing and distribution in aviation hydraulic fluids	Require a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of any PIP (3:1)-containing aviation hydraulic fluid.	No changes from 2021 Final Rule

[1] In response to public comments on the NPRM, the final rule also establishes a regulatory threshold level of 0.1%. This exclusion prohibits manufacturing, processing, and distribution in commerce of PIP (3:1)-containing products and articles, unless PIP (3:1) concentrations are at or below 0.1% by weight, not including any amount present due to excluded uses, including recycling, or uses that have not yet been phased out.

[2] EPA is also amending the downstream notification statement that must accompany shipments of PIP (3:1) or PIP (3:1) containing products to conform to the terms of the prohibitions in the final rule. EPA is providing a 3-month transition period to update SDS sheets and an 18-month transition period for updating labels. products. During the 3-month transition period, downstream notification under 40 CFR 751.407(e)(1) and (2) is still required; entities may use the new information provided in new 40 CFR 751.407(e)(3) or existing notification consistent with the restrictions described in this subpart. During the 15-month period between the SDS revision date and the label revision date, manufacturers, processors or distributors are required to provide the updated SDS with the "new" information when distributing products with the "old" label.

Estimated Number of Affected Entities and Individuals

The number of entities affected by the final rule is estimated based on: 1) identifying specific companies, where possible, or 2) U.S. Census data reporting the number of entities in North American Industry Classification System (NAICS) industries affected by the rule (U.S. Census Bureau 2020). When relying on NAICS-level estimates of the affected industry, the number of entities may be overstated since only some of the entities in each NAICS may be engaged in using or making products or articles containing the regulated chemical. In total, EPA estimates that this rulemaking may affect approximately 26,800 entities under the final option (Table ES-3).

Table ES- 3: Estimated Number of Entities Affected by Final Rule (Final Option)		
Chemical and Use	**Basis**	**Number of Entities**
DecaBDE		
Plastic Shipping Pallets	Identified Companies	1
Replacement Parts for Aerospace Vehicles (makers)	NAICS	0
Replacement Parts for Motor Vehicles (makers)	NAICS	0
Wire and Cable Insulation	Identified Companies	1
All DecaBDE Uses		**2**
PIP (3:1)		
Lubricants and Greases (except Aerospace and Turbine) (makers)	Identified Companies	5
Lubricants & Greases (Aerospace) (makers)	Identified Companies	11
New and Replacement Parts for Motor Vehicles (consumers)	NAICS	4,562
New and Replacement Parts for Motor Vehicles (makers)	NAICS	8,091
New and Replacement Parts for Aerospace Vehicles (consumers)	NAICS	324
New and Replacement Parts for Aerospace Vehicles (makers)	NAICS	1,787
Wire Harnesses and Electric circuit Boards (makers)	NAICS	1,780
Marine Antifouling Coatings	Identified Companies	1
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	NAICS	1,165
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	NAICS	9,071
Engine Filters for Locomotive and Marine Applications	Identified Companies	1

Table ES- 3: Estimated Number of Entities Affected by Final Rule (Final Option)		
Chemical and Use	**Basis**	**Number of Entities**
Cyanoacrylate Adhesives	Identified Companies	0
Aviation Hydraulic Fluid (makers)	Identified Companies	5
All PIP (3:1) Uses		**26,803**
Total		**26,805**

Estimated Costs

Total industry costs for the final rule are estimated to be approximately $400 million (at a 3% discount rate, annualized over 30 years), and $430 million (at a 7% discount rate). Of the rule costs, those associated with decaBDE alone were approximately $86 at a 3% discount rate and $128 at a 7% discount rate. Costs associated with PIP (3:1) were $400 million and $430 million (at 3 and 7% discount rates, respectively.) The total industry costs associated with the alternative option were approximately $829 million and $821 million (at 3% and 7% discount rates, respectively). Of the alternative option costs, those associated with decaBDE were $655 and $656 million (at 3% and 7%) while those for PIP (3:1) were $173 million and $165 million (at 3% and 7% discount rates, respectively). Total costs are summarized in Table ES-4.

Table ES-4: Summary of Total Industry Costs (2022$)				
Cost Type	**Final Option (3%)**	**Final Option (7%)**	**Alternative Option (3%)**	**Alternative Option (7%)**
DecaBDE				
Rule Familiarization	$16	$25	$107,684	$165,436
Prohibition Costs	$0	$0	$0	$0
Worker Protection	$13	$20	$654,844,921	$654,895,281
Singage	$10	$11	$400,288	$614,967
Export Notification	$47	$72	$0	$0
Total:	**$86**	**$128**	**$655,352,894**	**$655,675,684**
PIP (3:1)				
Rule Familiarization	$211,859	$325,480	$85,370	$131,155
Prohibition Costs	$27,054,456	$20,187,608	-$7,643,116	-$19,912,918
Worker Protection	$372,646,017	$409,516,445	$180,762,214	$184,765,958
Singage	$0	$0	$0	$0
Export Notification	$0	$0	$0	$0
Total:	**$399,912,332**	**$430,029,534**	**$173,204,467**	**$164,984,194**
TOTAL				
Rule Familiarization	$211,875	$325,505	$193,054	$296,591
Prohibition Costs	$27,054,456	$20,187,608	-$7,643,116	-$19,912,918
Worker Protection	$372,646,030	$409,516,465	$835,607,135	$839,661,239
Singage	$10	$11	$400,288	$614,967
Export Notification	$47	$72	$0	$0
Total:	**$399,912,418**	**$430,029,661**	**$828,557,361**	**$820,659,879**

For this cost analysis, the actions required by manufacturers and processors to comply with the final rule are organized into seven cost categories, summarized below.

1. **Rule Familiarization.** Rule familiarization includes costs incurred by all regulated entities to understand the requirements of the final rule and how the rule applies to their operation. EPA assumes that each manufacturer (including importers) and processor of products subject to the rule who will have PPE requirements will spend 3 hours of professional/technical labor in the first year to become familiar with the requirements of the rule and to develop an understanding of what actions are necessary to comply. EPA assumes firms not subject to PPE requirements will spend 1 hour in the first year on rule familiarization. The total annualized industry cost for rule familiarization, under the final option, using 3% and 7% discount rates, respectively, are approximately $212,000 and $326,000. PIP (3:1) accounts for 99 percent of total rule familiarization cost. Under the primary alternative option, the total annualized industry cost for rule familiarization is approximately $193,000 (3%) and $297,000 (7%). In this case decaBDE accounts for the majority of costs, about 59 percent. Rule familiarization costs are higher for the alternative option since it requires labelling for all recycled decaBDE-containing articles, whereas the final option only requires posting warning signs where decaBDE-containing plastic pallets are being recycled.

2. **Prohibition.** Prohibition-related costs may result from the need to determine whether components of products may contain the regulated chemical (consumers), and/or to reformulate products or components so that they do not contain the prohibited substance (makers).

   Prohibition costs were estimated for companies that manufacture an article containing PIP (3:1) (makers, reformulation costs) and for those who use those articles (consumers, supply chain analysis). Each of these types of costs depend on the number of products/articles affected. For lubricants and greases, EPA identified 18 affected non-aerospace/turbine formulated products. These products are currently available for sale in the United States and EPA expects that the manufacturers will incur costs to reformulate and stop selling them within the prohibition timeframe.

   For new and replacement parts for motor vehicles and aerospace vehicles, the number of affected parts is unknown[1]. EPA notes that the rule exempts replacement parts from prohibition until the end of the equipment's service life. EPA uses the number of firms in each affected NAICS code as a proxy for the number of parts. EPA understands that it likely for companies who manufacture affected parts to make more than one, but it is unlikely that every company in the NAICS does make parts using PIP (3:1), so an average of 1 part per company may be reasonable (See Table ES-3, above, for the estimated numbers of affected firms/parts).

   Processing and distribution in commerce of PIP (3:1) for use in articles and PIP (3:1)-containing articles, including in articles used in manufacturing equipment and in the semiconductor industry, was prohibited, except for certain exclusions, under the 2021 final rule and the compliance date was extended to October 31, 2024 (40 CFR § 751.401(a)(2)(iii)). For example, this rule prohibits the processing and distribution in commerce of PIP (3:1) for use in articles and PIP (3:1)-containing articles for use in new manufacturing equipment and production and other new equipment used in the semiconductor industry after 10 years. The rule extends the time before a prohibition on these PIP

[1] As described in Section 3.3.2, the regulated community provided, in comments, lists of potentially affected parts but was not able to determine an exact number, as supply chain analysis is still ongoing. The Aerospace Industries Association (AIA), for example, noted that aerospace products consist of thousands of parts, so EPA believes that the order of magnitude estimated here is accurate.

(3:1) uses goes into effect, therefore it represents a cost savings for these companies, who can postpone their transition costs and have more time to potentially develop more cost-effective alternatives. Due to the compliance delay, reformulation costs will be incurred in a later year than they would be incurred in the baseline and are thus discounted further. The cost savings are the differential between the reformulation costs incurred in the rule scenario and the reformulation costs that would be incurred in the baseline scenario. Similarly, the rule extends the time before a prohibition on the use of PIP (3:1) in marine anti-fouling coatings products. These cost savings are accounted for as negative values in the total cost estimates. There may be additional cost savings if having additional time allows for the development of more cost-effective alternatives. However, these potential savings are not known, and therefore are not quantified.

For the final option, prohibition costs for PIP (3:1) annualized at a 3% discount rate are approximately $27.0 million and $20.2 million annualized at a 7% discount rate. For the primary alternative option, prohibitions costs for PIP (3:1) annualized at a 3% discount rate are -$7.6 million and -$19.9 million annualized at a 7% discount rate. The negative values represent the cost savings discussed in the preceding paragraph.

3. **Worker Protection.** Worker protection costs include providing workers with the required personal protective equipment (PPE), such as respirators and gloves. The total worker protection costs under the final regulatory option annualized at a 3% discount rate is approximately $372.6 million and $409.5 million at a 7% discount rate with PIP (3:1) accounting for all costs. For the primary alternative option, PPE costs to industry are $835.6 million at a 3% discount rate with decaBDE accounting for $654.8 million and PIP (3:1) accounting for $180.8 million. PPE costs to industry total at $839.6 million at a 7% discount rate for the alternative option with decaBDE accounting for $654.9 million and PIP (3:1) accounting for $184.8 million.

4. **Signage in Regulated Areas.** There is only one firm (iGPS) known to recycle pallets and EPA assumes they will post two signs. EPA also assumes each of the signs will be replaced every five years during the period of the analysis, leading to a total of 12 total signs over the 30-year period of the analysis.

   For the final option, the total signage costs to industry are about $10 and $11 at 3% and 7% discount rates, respectively.

5. **Release Prevention.** This includes costs associated with instituting engineering controls aimed at reducing or eliminating environmental releases of the regulated chemical. Under the final option, EPA prohibits the release of decaBDE to water during manufacture, processing, distribution in commerce. Under this requirement, all persons are required to follow all known regulations to prevent the release of decaBDE and decaBDE-containing product to water during use. EPA contends there are no known releases to water based on the reasonably available information. Therefore, this analysis assumes costs to industry associated with releases to water to be zero.

6. **Export Notification.** This includes costs for required export notifications under TSCA section 12(b) and the provisions of subpart D in 40 CFR part 707 for decaBDE, or products and articles that are known to contain decaBDE. EPA requires that all persons intending to export decaBDE-containing wire and cable for nuclear power generation facilities are required to notify EPA under TSCA section 12(b) and the provisions of subpart D in 40 CFR part 707. The 2020 TSCA Section 12(b) ICR (U.S. Environmental Protection Agency (EPA) 2020d), estimated the annual export notification cost for an exporter under the one-time export notification requirement. These costs include the cost to the exporter of compiling a list of their products that are subject to TSCA Section 12(b) requirements,

writing or revising an export notification letter to EPA, checking the outgoing shipments, and sending the notification letters with the associated shipping costs. Export notification costs to industry total at $47 annualized at a 3% discount rate and $72 at a 7% discount rate.

7. **Engineering Control Costs.** EPA is requiring engineering controls for the use of PIP (3:1) in the manufacturing of cyanoacrylate adhesives. According to stakeholders, the production process using PIP (3:1) is carried out in an automated batch distillation plant and in a well ventilated closed system (Henkel Corporation 2019). EPA is requiring engineering controls for the use of PIP (3:1) as an intermediate in the production of cyanoacrylate adhesives such that the processing of PIP (3:1) must take place in a closed loop system and general and local area ventilation must be provided. In codifying these measures, EPA does not intend to supplant OSHA's requirements at 29 CFR 1910.134a (1) which require engineering controls to prevent atmospheric contamination. Given the OSHA requirements that already exist, and the controls already in place by the affected company, EPA believes that this requirement will incur no incremental costs.

8. **Downstream Notification Costs.** EPA is also amending the downstream notification statement that must accompany shipments of PIP (3:1) or PIP (3:1) containing products to conform to the terms of the prohibitions in the final rule. EPA is providing a 3-month transition period to update SDS sheets and an 18-month transition period for updating labels. During the 3-month transition period, downstream notification under 40 CFR 751.407(e)(1) and (2) is still required; entities may use the new information provided in new 40 CFR 751.407(e)(3) or existing notification consistent with the restrictions described in this subpart. During the 15-month period between the SDS revision date and the label revision date, manufacturers, processors or distributors are required to provide the updated SDS with the "new" information when distributing products with the "old" label. Since downstream notification was required in the 2021 PIP (3:1) PBT rule, EPA generally assumes that firms have updated their product's Safety Data Sheets (SDS) in the baseline. EPA acknowledges, however, that some firms may have to update the SDSs to reflect changes associated with requirements of this final rule. EPA believes that the costs of making any minor adjustments to the SDS text needed as a result of this final rule would be minimal, but since the exact number of firms modifying their SDS is unknown, incremental downstream notification costs are not quantified.

EPA notes that while these direct costs associated with rule compliance are incurred by the companies that make the products or articles containing a regulated chemical, a portion – or all – of the cost may be passed through to consumers via price increases. These and other uncertainties are discussed in Section 4.9. Many of the products affected by this regulation are relatively price inelastic with respect to demand due to the nature of their specific industrial use (e.g., aviation hydraulic fluid). Therefore, increases in price are more likely to be passed on to the end-users than to be borne by the manufacturer or processor as a loss in revenue or a shift in market volume. However, given the wide range of products, number of end-users and variability in consumer behavior, EPA was not able to estimate the indirect costs to end-users.

With respect to Agency burden, for the economic analyses for the 2021 final rules, EPA estimated that the Agency needs one full-time equivalent (FTE) employee for implementation (e.g., compliance assistance and enforcement) activities under both the decaBDE and PIP (3:1) rules (two FTEs total). This final rule modifies the existing rules, and EPA does not expect that it will require any additional (incremental) Agency staff time to implement the final rule.[2]

[2] Note that TSCA Implementation cannot be delegated to states.

Estimated Benefits

The benefits of reducing potential exposure to decaBDE and PIP (3:1) are qualitatively described in this analysis because information required to quantify benefits was not available in the chemical Risk Evaluations. This includes describing specific human and environmental health effects associated with these chemicals as this is crucial to understanding the benefits of reducing exposure potential. Due to data limitations, it is not possible to link exposures to specific uses of decaBDE or PIP (3:1). General exposure considerations and potential health effects (cancer, non-cancer and environmental) are described for each chemical. Most of the information on general exposure considerations and potential health effects is gathered from the U.S. EPA (U.S. Environmental Protection Agency (EPA) 2020b) Use and Exposure Assessment of Five PBT Chemicals, and the Environmental and Human Health Hazards of Five Persistent, Bioaccumulative and Toxic Chemicals (U.S. Environmental Protection Agency (EPA) 2018b).

DecaBDE

Under the final action, workers that may come into contact with decaBDE associated with several uses are required to use worker protection methods (wearing N95 masks and chemical-resistant gloves). Evidence suggests that decaBDE is carcinogenic and the EPA Summary Information on the Integrated Risk Information System (IRIS) (U.S. Environmental Protection Agency (EPA) 2008c) states that "the weight of experimental evidence is on the strong end of the spectrum for the descriptor suggestive evidence of carcinogenic potential, since there is some evidence that decaBDE is carcinogenic in more than one species, sex, and site." Therefore, this evidence from animal studies suggests that reductions in exposure to decaBDE may lead to decreases in the incidence of liver cancer. Reductions in the exposures to decaBDE may also lead to reductions in developmental neurotoxicity, as well as hepatic, renal, immune and reproductive toxicity. Decreases of decaBDE in the environment may be beneficial for growth and other endpoints in fish, aquatic invertebrates, and terrestrial invertebrates, as evidence indicates both acute and chronic toxicity in these species.

Under EPA's final regulatory action, inhalation and dermal PPE is required during the recycling process of pallets, as well as use in replacement parts and the manufacture of such parts, containing decaBDE. Additionally, release of decaBDE to water is prohibited during the manufacture, processing, or distribution in commerce. Individuals who may be occupationally exposed in the sectors that use decaBDE under these regulated conditions may experience reduced exposures as a result of the final action.

The primary alternative option would further reduce potential exposure to decaBDE by including the requirement for inhalation and dermal PPE during all recycling processes of plastics and requiring a label on all recycled plastic articles containing decaBDE. Individuals who may be occupationally exposed in the sectors that use decaBDE under these additional regulated conditions would experience further reduced exposures as a result of the alternative option. Individuals who may be occupationally exposed in the sectors that use decaBDE under these regulated conditions will experience a lesser reduction in exposures as a result of the alternative option.

PIP (3:1)

Under the final action, certain uses of PIP (3:1) will be phased out over the next 30 years and worker personal protective equipment (masks, respirators, and gloves) will be required during the manufacturing and processing of PIP (3:1) in certain uses that are not prohibited. For the processing of PIP (3:1) in the manufacturing of cyanoacrylate adhesives, other industry best practices for engineering controls and exhaust ventilation will also be required. Due to exposure to PIP (3:1), data indicate the potential for reproductive and developmental effects, neurological effects and effects on systemic organs. These

regulatory actions would reduce exposure of PIP (3:1) to workers and other potentially susceptible subpopulations as well as the environment.

Under the final regulatory action, prohibitions on the processing and distribution for various uses of PIP (3:1) above a regulatory threshold level of 0.1% by weight are phased in: non-turbine/non-aerospace uses of lubricants and greases (15-year phase-in), new motor vehicle parts (15-year phase-in) and replacement parts (30-year phase-in), aerospace (30-year phase-in), articles in manufacturing equipment and semiconductors (10-year phase in), FIFRA approved marine antifouling coatings products (5-year phase-in). Replacement parts are exempted from the prohibition until after the end of the vehicle's service life for replacement aerospace parts, and equipment's service life for laboratory uses. Replacement parts are exemptions for other uses include 7 years (personal use electronic equipment), 25 years (commercial use electronic equipment, HVACR and water heating equipment, and power generating equipment). Additionally, worker personal protective equipment (masks, respirators, and/or gloves) are required during the manufacturing and processing of PIP (3:1) in certain uses that are not prohibited. Individuals who may be occupationally exposed in the sectors that use PIP (3:1) under these regulated conditions will experience reduced exposures as a result of the final action.

Under the primary alternative option, EPA would have prohibited PIP (3:1) in all lubricants and greases (30-year phase-in) and in articles in manufacturing equipment and semiconductors (20-year phase-in). To the extent that prohibition is delayed under the primary alternative option, benefits would be reduced. However, potential exposure would be mitigated to the extent that personal protective equipment is required until the use is prohibited.

The final action is expected to reduce the exposures to decaBDE and PIP (3:1) and thus have benefits for human health and the environment. Careful selection and avoidance of harmful substitutes for the chemical will help ensure that these benefits are realized. Further research would help characterize the full set of health hazards and environmental concerns associated with decaBDE and PIP (3:1).

Estimated Small Business Impacts

The Regulatory Flexibility Act (RFA) requires an assessment of whether a rule results in "significant (economic) impact on a substantial number of small entities" (SISNOSE) but does not mandate the method to be used for calculating economic impacts nor define the terms "significant" nor "substantial." The EPA guidance document (U.S. Environmental Protection Agency (EPA) 2006b) does not provide a single preferred method for assessing whether the economic impacts are *significant* or whether the number of entities affected is *substantial*, but generally recommends examining rule compliance costs in relation to resources available to determine the significance of the impacts, and a number and/or percentage measure to determine the extent of the impacts across small entities. The small entity analysis found that of the 24,865 small entities assessed at 3% and 7% discount rates, 860 (3.46%) are expected to incur negative impacts of 1% or greater, under the final action, all of which were for PIP (3:1) and none for decaBDE. The cost per small firm impacted above the 1% or greater threshold ranged from $21,129 – $956,719 at a 3% discount rate and ranged from $21,131 – $956,726 at a 7% discount rate. No entities for either chemical are expected to incur negative impacts at 3% or greater. Among all small entities, the costs ranged from -$42 to $1,146,853 at a 3% discount rate and -$128 to $1,272,107 at a 7% discount rate. Negative costs indicate cost savings relative to the 2021 PBT Final Rules.

In accordance with RFA requirements and SBA guidance (SBA, 2017), EPA has prepared a screening analysis to assess small entity impacts. This analysis involved three main steps:

- Identifying the subset of small entities potentially affected by the action based on SBA criteria for each NAICS industry.
- Assessing the potential impact of the rule on those small entities using the cost-to-revenue threshold test. The Agency compared the annualized cost per small entity to annual revenues and identified entities where costs exceed one or three percent of annual revenues[3]; and,
- Based on the results of the threshold test, assessing (1) magnitude of economic impact that may be experienced by regulated small entities; (2) total number of regulated small entities that may experience the economic impact; and (3) percentage of regulated small entities that may experience the economic impact, in order to make a SISNOSE determination

For the firms included in this screening assessment, the extent to which companies would be affected by this rule will depend on whether the chemicals are actually being used, and how they are used. Furthermore, recent uses of PIP (3:1) are likely being phased out. Therefore, many companies or perhaps entire NAICS categories included may not use the chemicals at all. Therefore, EPA believes that number of firms actually impacted at this level is lower.

[3] As indicated in (U.S. Small Business Administration (SBA) 2017) and (U.S. Environmental Protection Agency (EPA) 2006a), for small businesses it is appropriate to compare the annualized costs as a percentage of sales ("sales test") to examine significant economic effect. EPA (2006a) also notes that annualizing the compliance costs is appropriate when a stream of cash flows or a large capital expenditure is involved with compliance, and that revenue or receipts can serve as a reasonable proxy for sales when sales data are unavailable, as is the case in this analysis.

Table ES- 5: SISNOSE Determination Summary							
Annualization Discount Rate	Affected Businesses	Affected Small Businesses	Range of Costs to Impacted Small Businesses	1% Threshold		3% Threshold	
				Number	Percent	Number	Percent
PIP (3:1)							
3% discount rate	26,803	24,865	-$42 – $1,146,853	860	3.46%	0	0%
7% discount rate	26,803	24,865	-$128 – $1,272,107	860	3.46%	0	0%
DecaBDE							
3% discount rate	2	0	$0	0	0%	0	0%
7% discount rate	2	0	$0	0	0%	0	0%

1. Introduction

The U.S. Environmental Protection Agency (EPA) is finalizing revisions to the regulations for decabromodiphenyl ether (DecaBDE) and phenol, isopropylated phosphate (3:1) (PIP (3:1)), two of the five persistent, bioaccumulative, and toxic (PBT) chemicals addressed in final rules issued under section 6(h) of the Toxic Substances Control Act (TSCA) in January 2021. After receiving additional comments following the issuance of the 2021 PBT final rules, the Agency has determined that revisions to the decaBDE and PIP (3:1) regulations were necessary to address implementation issues and to reduce further exposures. As required under TSCA section 6(h), these finalized requirements will reduce the potential for exposures to humans and the environment to decaBDE and PIP (3:1) to the extent practicable. The Agency is not revising the existing regulations for the other three PBT chemicals (2,4,6-TTBP, HCBD, and PCTP).

1.1 Background

Persistent, bioaccumulative, and toxic (PBT) chemicals are of particular concern with regard to human and environmental health. These chemicals are not easily degraded, so they remain in the environment for long periods of time. Additionally, they will result in biomagnification as they can accumulate up the food chain as they are consumed through each trophic level and have toxic attributes in small quantities. Subsequently, they can cause adverse health and ecological consequences for a substantial amount of time (years to decades or more).

A risk evaluation was not required or contemplated to be conducted for either decaBDE or PIP (3:1). Pursuant to TSCA section 6(h)(2), for chemical substances that meet the criteria of TSCA section 6(h)(1), a risk evaluation is not required for EPA to meet its obligations to address PBT chemicals under TSCA section 6(h)(4). See Unit II.B.3. in the 2021 final rules for decaBDE or PIP (3:1) for more information. This economic analysis addresses EPA's final rule amending requirements for decaBDE and PIP (3:1).

The EPA finalized regulations for five PBT chemicals including decaBDE (86 FR 880, January 6, 2021) and PIP (3:1) (86 FR 894, January 6, 2021) in January 2021. Compliance date extensions were provided for PIP (3:1) on September 17, 2021 (86 FR 51823) and March 8, 2022 (87 FR 12875), with deadlines ultimately extended to October 31, 2024. EPA reasoned that this further extension would avoid significant disruption in the supply chains for certain articles and would provide the public with regulatory certainty, while EPA determined whether any further compliance date extensions were necessary.

EPA requested and received comments on the January 2021 PBT rules following the issuance of Executive Order 13990 (Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis) and other administration priorities. In a March 16, 2021 public notice, EPA asked for comment on additional actions that could be taken to reduce PBT chemical exposures. Information submitted by regulated entities regarding the final rules for decaBDE and PIP (3:1) and EPA's own review of the regulations has led the Agency to determine that amendments to both rules are necessary to further reduce potential exposure to these chemical substances and protect human health and the environment to the extent practicable.

The Agency published a Notice of Proposed Rulemaking (NPRM) in 2023 and received public comment submissions on the proposed rule (88 FR 82287; November 24, 2023). Subsequently, this action finalizes regulatory requirements that will reduce exposures risks through prohibiting or limiting the processing and distribution of PIP (3:1) and decaBDE and products or articles containing these chemicals above a regulatory threshold level of 0.1% by weight and requiring the use of PPE to protect workers. The final

rule also has engineering control requirements for PIP (3:1) and prohibits releasing decaBDE to water during manufacturing, processing, and distribution in commerce, and during commercial use of decaBDE and decaBDE-containing products.

1.2 Options Analyzed

Under Section 6(a) of TSCA, the law authorizes EPA to issue regulations requiring one or more of the following actions to the extent necessary so that the chemical substance no longer presents an unreasonable risk:

- Prohibit or otherwise restrict manufacture, processing, or distribution in commerce (§6(a)(1));
- Prohibit or otherwise restrict for a particular use or above a set concentration (§6(a)(2));
- Require minimum warnings and instructions with respect to use, distribution in commerce, or disposal (§6(a)(3));
- Require recordkeeping or testing (§6(a)(4));
- Prohibit or regulate any manner or method of commercial use (§6(a)(5));
- Prohibit or regulate any manner or method of disposal (§6(a)(6)); and/or
- Direct manufacturers or processors to give notice of the unreasonable risk to distributors and replace or repurchase products if required (§6(a)(7)).

According to the 2014 update of the *TSCA Work Plan for Chemical Assessments*, decaBDE and PIP (3:1) have high persistence and high potential for bioaccumulation (U.S. Environmental Protection Agency (EPA) 2014c). The general population, commercial and consumer end-users, other vulnerable subpopulations (workers, children, Tribes) and the environment may be exposed and, if so, negatively affected. EPA is finalizing measures that reduce the amount of decaBDE and PIP (3:1) in the market or limit exposure to these chemicals. For decaBDE, this rule requires use of PPE during manufacturing or processing of products containing decaBDE. For PIP (3:1), this rule prohibits manufacture (including import) after specified periods of time for certain uses and require PPE use for the manufacturing and processing of products and articles that contain PIP (3:1).

The final regulatory action reduces the negative externalities for workers associated with both chemicals. As processing and distribution is generally prohibited unless otherwise excluded, the regulation also eliminates the negative externalities associated with the exposure generally, including by consumers.

As indicated by TSCA section 6(c)(2)(A)(iv)(II) and (III), EPA must consider and publish a statement based on reasonably available information with respect to the reasonably ascertainable economic consequences of the rule, including consideration of the costs and benefits and the cost effectiveness of the Final Regulatory Action and one or more Primary Alternative regulatory actions considered by the Agency.

Table 1-1 and Table 1-2 summarize the risk management options that EPA has chosen for current uses of decaBDE and PIP (3:1) for the Final Regulatory Action and one or more Primary Alternative regulatory actions considered by the Agency.

Table 1-1: Summary of DecaBDE Risk Management Options		
Chemical Use	**Final Option[1]**	**Primary Alternative Option**
Distribution in commerce of decaBDE-containing plastic shipping pallets manufactured before March 8, 2021; and, Processing and distribution in commerce for recycling of decaBDE-containing plastic from products or articles and decaBDE-containing products or articles made from such recycled plastic, where no new decaBDE is added during the recycling process	Require signage providing notice to workers that PPE is required to be worn during the recycling, of plastic shipping pallets, which will reduce potential exposures to decaBDE. Require inhalation and dermal PPE (N95 mask and chemical-resistant gloves) during the recycling process of shipping pallets known to contain decaBDE.	Require a label on all recycled plastic articles containing decaBDE. Require inhalation and dermal PPE (e.g., N95 mask, chemical-resistant gloves) during all recycling processes of plastics.
Manufacture and processing of decaBDE for use in replacement parts and the manufacture of such parts, specifically use in parts installed in and distributed as part of new aerospace vehicles, and the manufacturing and processing of parts to which decaBDE has been added for such vehicles.	Require inhalation and dermal PPE (N95 mask and chemical-resistant gloves), except for the processing of parts to which decaBDE has been added.	No changes from 2021 Final Rule
Manufacture and processing of decaBDE for use in replacement parts and the manufacture of such parts, specifically decaBDE and decaBDE-containing products for use in replacement parts for motor vehicles, and the manufacturing and processing of replacement parts to which decaBDE has been added for such vehicles.	Require inhalation and dermal PPE (N95 mask and chemical-resistant gloves), except for the processing of parts to which decaBDE has been added	No changes from 2021 Final Rule
Releases of decaBDE to water	Prohibit the releases to water during manufacturing, processing, distribution in commerce of decaBDE, decaBDE-containing products, and all persons are required to follow all applicable regulations for preventing the release of decaBDE.	No changes from 2021 Final Rule
Processing and distribution in commerce of decaBDE for use in wire and cable insulation in nuclear power generation facilities	After the end of the wire and cables' service life, all persons are prohibited from all processing and distribution in commerce of decaBDE-containing wire and cable insulation for use in wire and cable insulation in nuclear power generation facilities (including research and test reactors). Require export notification for all persons intending to export decaBDE-containing wire and cable insulation for nuclear power generation facilities.	No changes from 2021 Final Rule

[1] In response to public comments on the NPRM, the final rule also establishes a regulatory threshold level of 0.1%. This amendment in § 751.405 (a) prohibits all manufacturing and processing of decaBDE or decaBDE-containing products or articles after March 8, 2021, and prohibits all distribution in commerce of decaBDE or decaBDE-containing products or articles after January 6, 2022, unless decaBDE concentrations are at or below 0.1% by weight, not including any amount present due to excluded uses, including recycling or phased-out uses.

Table 1-2: Summary of Final PIP (3:1) Risk Management Options		
Chemical Use	**Final Option[1,2]**	**Primary Alternative Regulatory Option**
Processing and distribution in commerce for use in lubricants and greases, PIP (3:1) containing products for use in lubricants and greases, and PIP (3:1)-containing lubricants and greases	Modify exclusion for processing and distribution in commerce of PIP (3:1) for use in lubricants and greases and require PPE. • Limit this exclusion to only aerospace use and turbine applications. • Add a 15-year time limit to the exclusion for manufacturing, processing and distribution in commerce of any other lubricants and greases that contain PIP (3:1 and PIP (3:1)-containing products for use in); thus, non-turbine and non-aerospace uses will be prohibited after 15 years. • Require a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator, and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible that provide an impervious barrier to prevent dermal exposure during expected durations of use and normal conditions of exposure within the workplace during the manufacturing and processing of PIP (3:1) and PIP (3:1)-containing products for use in lubricants and greases.	Same as the Final Option, except using a 5-year time limit, rather than 15-years, to the exclusion for manufacturing, processing and distribution in commerce of PIP (3:1) and PIP (3:1)-containing products for use in any other lubricants and greases that contain PIP (3:1) and PIP (3:1)-containing products for use in); thus, non-turbine and non-aerospace uses would be prohibited after 5 years.
Processing and distribution in commerce of new and replacement parts for motor vehicles	Modify compliance dates for processing and distribution in commerce of PIP (3:1) for use in new and replacement parts for motor vehicles and PPE during manufacturing and processing. • Prohibit with 15-year phase-in the processing and distribution in commerce of PIP (3:1) and manufacturing, processing, and distribution in commerce of PIP (3:1)-containing products for use in parts for new motor vehicles (i.e., newly produced vehicles), and manufacturing and processing of PIP (3:1)-containing parts for such new vehicles. • Prohibit with 30-year phase-in the processing and distribution in commerce of PIP (3:1) and manufacturing, processing, and distribution in commerce of PIP (3:1)-containing products for use in replacement parts for motor vehicles, and manufacturing and processing of PIP (3:1)-containing replacement parts for such vehicles. • Require a respirator at least as protective as a NIOSH-approved N95 respirator (APF 10) and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of PIP (3:1) and PIP (3:1)-containing products for use in new and replacement parts for motor vehicles. Processing of PIP (3:1)-containing parts to which PIP (3:1) has been added are excluded from this requirement.	No changes from 2021 Final Rule

Processing and distribution in commerce of new and replacement parts for aerospace vehicles	Prohibition phase-in dates for PIP (3:1)-containing new and replacement parts for aerospace vehicles. • Prohibit the manufacturing, processing and distribution in commerce of PIP (3:1) and PIP (3:1)-containing products for use in new and replacement parts for aerospace vehicles after 30 years; • After the end of the aerospace vehicles service lives, prohibit the importing, processing and distribution of aerospace vehicles manufactured before the 30-year prohibition is in effect. • Prohibit manufacturing, processing and distribution in commerce of PIP (3:1), PIP (3:1)-containing products, and PIP (3:1)-containing replacement parts after the end of the vehicle service life. (Allow replacement parts that contain PIP (3:1) through the life cycle of the vehicle.) • Require a respirator at least as protective as a NIOSH-approved N95 respirator (APF 10) and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of PIP (3:1) and PIP (3:1)-containing products for use in new and replacement parts for aerospace vehicles. Processing of PIP (3:1)-containing parts to which PIP (3:1) has been added are excluded from this requirement.	No changes from 2021 Final Rule
Processing and distribution in commerce for use in wire harnesses and electric circuit boards	Exclusion for the processing and distribution of PIP (3:1), PIP (3:1)-containing products for use in circuit boards and wire harnesses, including but not limited to terminal and fuse covers, cable sleeves, casings, connectors and tapes, and PIP (3:1)-containing circuit boards and wire harnesses including but not limited to terminal and fuse covers, cable sleeves, casings, connectors and tapes. • Require a respirator at least as protective as NIOSH-approved APF 10 air-purifying half mask respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of PIP (3:1) for use in wire harnesses or electric circuit boards.	Prohibit manufacturing (including import), processing, and distribution and commerce of PIP (3:1) for use in circuit boards and wire harnesses, including but not limited to terminal and fuse covers, cable sleeves, casings, connectors and tapes, and PIP (3:1)-containing circuit boards and wire harnesses including but not limited to terminal and fuse covers, cable sleeves, casings, connectors and tapes, after 20 years.
Manufacturing (import) and distribution in commerce of PIP (3:1) that is intended for formulation into a FIFRA-registered marine antifouling coating	Provide an exclusion of 5 years for the processing and distribution in commerce of PIP (3:1) for use in FIFRA-registered marine anti-fouling coatings only for products that meet Department of Defense specification requirements. • Require a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of PIP (3:1)-for use in FIFRA-registered marine antifouling coating.	No changes from 2021 final rule

Processing and distribution in commerce for use in semiconductor manufacturing, and electronic, HVACR and water heating, and power generating equipment manufacturing.	Prohibition phase-in dates for PIP (3:1)-containing new and replacement parts for products and articles for use installed in equipment in a variety of industries: manufacturing, semiconductor manufacturing, electronic, HVACR and water heating, and power generating. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing products and articles for use in new parts installed in equipment in a variety of industries: manufacturing, semiconductor manufacturing, electronic, HVACR and water heating, and power generating after 10 years. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in manufacturing equipment, including semiconductor manufacturing after the end of the products service life. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in electronic equipment after 7 years for personal use, 25 years for commercial use, and after the products service life for laboratory use. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in HVACR and water heating equipment after 25 years. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in power generating equipment after 25 years. • Require a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask-respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing for use in PIP (3:1)-containing manufacturing equipment or semiconductors. Processing of PIP (3:1)-containing parts to which PIP (3:1) has been added are excluded from this requirement.	Same as the Final Option, except using a 20-year time limit, rather than 10 years, to the exclusion for manufacturing, processing and distribution in commerce of PIP (3:1) and PIP (3:1)-containing products for use in semiconductor manufacturing, and electronic, HVACR and water heating, and power generating equipment manufacturing.
Processing and distribution in specialized engine filters for locomotive and marine applications	Require half or full respirators, and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible for workers using PIP (3:1) in the manufacturing of specialized engine filters for locomotive and marine applications. Processing of PIP (3:1)-containing parts are excluded from this requirement.	No changes from 2021 Final Rule
Processing and distribution in intermediate in a closed system to produce cyanoacrylate adhesives	Require respiratory protection that must be at least as protective as a NIOSH-approved APF 50 respirator, except when the PIP (3:1) or PIP (3:1)-containing product is contained in a closed-system. Codify requirements for engineering controls of closed loop, as well as local exhaust ventilation and general ventilation. - Processing of PIP (3:1)-containing parts to which PIP (3:1) has been added are excluded from this requirement.	No changes from 2021 Final Rule

Processing and distribution in aviation hydraulic fluids	Require a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of any PIP (3:1)-containing aviation hydraulic fluid.	No changes from 2021 Final Rule

[1] In response to public comments on the NPRM, the final rule also establishes a regulatory threshold level of 0.1%. This exclusion prohibits manufacturing, processing, and distribution in commerce of PIP (3:1)-containing products and articles, unless PIP (3:1) concentrations are at or below 0.1% by weight, not including any amount present due to excluded uses, including recycling, or uses that have not yet been phased out.

[2] EPA is also amending the downstream notification statement that must accompany shipments of PIP (3:1) or PIP (3:1) containing products to conform to the terms of the prohibitions in the final rule. EPA is providing a 3-month transition period to update SDS sheets and an 18-month transition period for updating labels. During the 3-month transition period, downstream notification under 40 CFR 751.407(e)(1) and (2) is still required; entities may use the new information provided in new 40 CFR 751.407(e)(3) or existing notification consistent with the restrictions described in this subpart. During the 15-month period between the SDS revision date and the label revision date, manufacturers, processors or distributors are required to provide the updated SDS with the "new" information when distributing products with the "old" label.

1.3 Organization of this Document

Chapter 2 presents a discussion of the problems with decaBDE and PIP (3:1) that are addressed by the rule. Chapter 3 presents general industry statistics for the sectors expected to be affected under the options. The estimated costs and benefits of the options are presented in Chapter 4 and Chapter 5, respectively. Chapter 6 includes EPA's analysis of potential small entity impacts, Chapter 7 presents other impact analyses required by statute and Executive Order (E.O.) and Chapter 8 addresses key uncertainties and sensitivities in the analysis. Finally, the references are listed in Chapter 9.

2. Problem Definition / Market Failure

Persistent, bioaccumulative, and toxic (PBT) chemicals are of particular concern with regard to human and environmental health. These chemicals are not easily degraded, so they remain in the environment for long periods of time. Additionally, they will result in biomagnification as they can accumulate up the food chain as they are consumed through each trophic level and have toxic attributes in small quantities. Subsequently, they can cause adverse health and ecological consequences for a substantial amount of time (years to decades or more).

15 USC §2605(h)

CHEMICALS THAT ARE PERSISTENT, BIOACCUMULATIVE, AND TOXIC.— (1) EXPEDITED ACTION.—Not later than 3 years after the date of enactment of the Frank R. Lautenberg Chemical Safety for the 21st Century Act, the Administrator shall propose rules under subsection (a) with respect to chemical substances identified in the 2014 update of the TSCA Work Plan for Chemical Assessments— (A) that the Administrator has a reasonable basis to conclude are toxic and that with respect to persistence and bioaccumulation score high for 1 and either high or moderate for the other, pursuant to the TSCA Work Plan Chemicals Methods Document published by the Administrator in February 2012 (or a successor scoring system), and are not a metal or metal compound, and for which the Administrator has not completed a Work Plan Problem Formulation, initiated a review under section 5, or entered into a consent agreement under section 4, prior to the date of enactment of the Frank R. Lautenberg Chemical Safety for the 21st Century Act; and (B) exposure to which under the conditions of use is likely to the general population or to a potentially exposed or susceptible subpopulation identified by the Administrator, or the environment, on the basis of an exposure and use assessment conducted by the Administrator.

Section 6(h) of TSCA, as amended by the Frank R. Lautenberg Chemical Safety for the 21st Century Act, requires that EPA take expedited regulatory action to address certain PBT chemicals. To meet this statutory requirement, EPA finalized regulations in January 2021 for five PBT chemicals including decabromodiphenyl ether (DecaBDE) (86 FR 880, January 6, 2021) and Phenol, isopropylated, phosphate (3:1) (PIP (3:1)) (86 FR 894, January 6, 2021). Several stakeholders (e.g., electronics and electrical manufacturing sector and their customers) raised significant concerns about their ability to meet the March 8, 2021, compliance date for the processing and distribution of PIP (3:1) and PIP (3:1)-containing articles, despite extensive EPA outreach. To address the hardships inadvertently created by the January 2021 final rule on PIP (3:1) due to uses and supply chain challenges that were not communicated to EPA until after the rule was published, compliance date extensions were provided for PIP (3:1) on September 17, 2021 (86 FR 51823) and March 8, 2022 (87 FR 12875) for certain articles until October 30, 2024.

Executive Order 13990 (Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis) established a policy of limiting exposure to dangerous chemicals and pesticides and instructed EPA to prioritize environmental justice when delivering on that goal. Additionally, it directed EPA to review all existing agency actions promulgated, issued, or adopted between January 20, 2017, and January 20, 2021, that were or may have been inconsistent with, or presented obstacles to, the policy of limiting chemical exposure, and as appropriate and consistent with applicable law, to consider suspending, revising, or rescinding the agency actions. In a notice published on March 16, 2021, EPA EPA requested and received comment on the January 2021 PBT rules[4] and additional actions that could be taken to reduce exposures to these PBT chemicals to the extent practicable, including for potentially exposed or susceptible populations and the environment.

[4] See announcement at https://www.epa.gov/newsreleases/epa-seeks-public-comment-protecting-human-health-and-environment-pbt-chemicals.

The Agency published a Notice of Proposed Rulemaking (NPRM) in 2023 and received public comment submissions on the proposed rule from a variety of stakeholders, including industry and trade associations, product manufacturers, chemical users, non-governmental organizations (NGOs), labor advocacy organizations, and Tribal governments (U.S. Environmental Protection Agency (EPA) 2023c). This action finalizes regulatory requirements that will reduce exposures/risk.

2.1 Overview of the Affected Chemical Substances

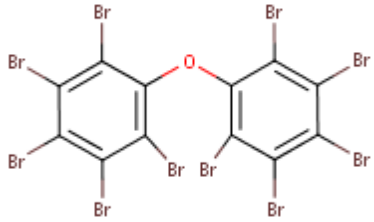
This economic analysis addresses EPA's final rule amending requirements for decaBDE and PIP (3:1).

Pursuant to TSCA section 6(h)(2), for chemical substances that meet the criteria of TSCA section 6(h)(1), a risk evaluation is not required for EPA to meet its obligations to address PBT chemicals under TSCA section 6(h)(4). Thus, a risk evaluation was not required to be conducted for either decaBDE or PIP (3:1). See Unit II.B.3. in the 2021 final rules for decaBDE or PIP (3:1) for more information.

2.1.1 Decabromodiphenyl ether (DecaBDE; CAS RN 1163-19-5)

The commercial decaBDE product is composed almost entirely of the single fully brominated congener, known as BDE-209, which has the maximum 10 bromine atoms. DecaBDE products also contains small quantities of nonaBDEs (congeners with nine bromine atoms) (U.S. Environmental Protection Agency (EPA) 2006c). DecaBDE is a PBT chemical that has been used as a brominated flame retardant in a variety of industrial, commercial, and consumer roles including textiles, plastics, adhesives, and polyurethane foam. Primary hazard concerns include carcinogenicity, developmental toxicity, liver effects, and aquatic toxicity. Exposure to individuals in the general population may occur via air and airborne dust, direct skin contact with contaminated dust or by ingestion of contaminated food or drinking water (U.S. Environmental Protection Agency (EPA) 2018c, 2023b). Key identification details of decaBDE are listed in Table 2-1.

Table 2-1: Chemical Name, Synonyms, and CAS RN for DecaBDE

Chemical Name	Decabromodiphenyl ether
CAS RN	1163-19-5
Synonyms	1,1'-Oxybis-[2,3,4,5,6-pentabromobenzene]; Bis(pentabromophenyl) ether; Bis(pentabromophenyl) ether; DBDPO; deca-BDE; DecaBDE; Decabromobiphenyl oxide; Decabromobiphenyl ether; decabromodiphenyl oxide; decabromophenyl ether; Pentabromophenyl ether
Molecular Formula	$C_{12}Br_{10}O$
Structure	
Trade Names	BDE-209; Berkflam B 10E; FR 300; FRP 53; BR 55N; Bromkal 82-0DE; Bromkal 83-10DE

Source: Hazardous Substances Data Bank (HSDB) 2017

DecaBDE's assessment scores from the 2014 update of the *TSCA Work Plan for Chemical Assessments* (U.S. Environmental Protection Agency (EPA) 2014c) are summarized in Table 2-2. Possible scores

ranged from 1 to 3, with 3 representing the most adverse score. As can be seen in the table, persistence and bioaccumulation are a concern for the chemical. While each chemical on the TSCA Work Plan for Chemical Assessments was given an exposure score, TSCA section 6(h)(1)(B) directs EPA to determine whether exposure to the PBT chemicals is likely based on an exposure and use assessment. EPA has determined that, based on the Exposure and Use Assessment of Five Persistent, Bioaccumulative and Toxic Chemicals (U.S. Environmental Protection Agency (EPA) 2020b) and other reasonably available information, exposure to the five PBT chemicals under the conditions of use is likely to the general population, to a potentially exposed or susceptible subpopulation, or the environment. EPA's final determination is based on the opportunities for exposure throughout the lifecycle of each of the five PBT chemicals, including decaBDE.

Table 2-2: Hazard, Exposure, and Persistence & Bioaccumulation Scores for DecaBDE

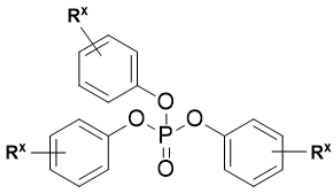
Chemical Name	CAS RN	Hazard Score	Exposure Score	Persistence & Bioaccumulation Score
Decabromodiphenyl ether (DecaBDE)	1163-19-5	3	3	3

Note:
3 = High, 2 = Moderate, 1 = Low.
Source: (U.S. Environmental Protection Agency (EPA) 2014c)

2.1.2 Phenol, isopropylated, phosphate (3:1) (PIP (3:1); CAS RN 68937-41-7)

PIP (3:1) is a non-halogenated aromatic phosphate compound, containing not a single chemical but a mixture of as many as fifty unspecified isomers. Different commercial products contain varying amounts of different isomers ranging from isopropyl phenyl diphenyl phosphate to tris(isopropylphenyl phosphate) (Biomonitoring California 2012). PIP (3:1) is used by industry as a flame retardant, plasticizer, anti-compressibility additive, anti-wear additive, or in some combination of these roles (U.S. Environmental Protection Agency (EPA) 2020b.

Depending on its composition, PIP (3:1) is associated with aquatic toxicity, and data suggests associations with neurotoxicity, reproductive and developmental toxicity, and systemic toxicity (U.S. Environmental Protection Agency (EPA) 2020b). Through the manufacturing, processing, and use of PIP (3:1), there may be releases of the chemical to air, land, and water. Table 2-3 presents the chemical structure and key characteristics of PIP (3:1).

Table 2-3: Chemical Name, Synonyms, and CAS RN for PIP (3:1)	
Chemical Name	Phenol, isopropylated, phosphate (3:1)
CAS RN	68937-41-7
Synonyms	PIP (3:1); PIP 3:1; iPPP; iPTPP; iPTPP; Tris (4-isopropylphenyl) phosphate; Isopropylated phenol phosphate (3:1); Isopropylated phenol phosphate; Isopropylphenyl phosphate; Isopropylated triphenyl phosphate; ITP; Phenol isopropylated phosphate; TIPPP
Molecular Formula[1]	Unspecified (UVCB substance)[2]
Representative Structure	 Where R^x = H or $CH(CH_3)_2$ and all three rings have at least one -$CH(CH_3)_2$ group.
Note(s): [1]U.S. EPA 's description of phenol, isopropylated, phosphate (3:1) lists C27H33O4P as the chemical formula for tri-propyl substitution although other sources including the National Medical Library have listed it as an UVCB (U.S. Environmental Protection Agency (EPA) 2015; U.S. National Library of Medicine (NLM) n.d.) [2]Unknown of Variable Composition, Complex Reaction Products and Biological Materials. **Sources:** European Chemicals Agency (ECHA) 2016c; National Toxicology Program (NTP) 2016; U.S. Environmental Protection Agency (EPA) 2017e; U.S. Environmental Protection Agency (EPA) 2024; U.S. National Library of Medicine (NLM) n.d.	

PIP (3:1)'s assessment scores from the 2014 update of the *TSCA Work Plan for Chemical Assessments* (U.S. Environmental Protection Agency (EPA) 2014c) are summarized in Table 2-4. Possible scores range from 1 to 3, with 3 representing the most adverse score. While each chemical on the TSCA Work Plan for Chemical Assessments was given an exposure score, TSCA section 6(h)(1)(B) directs EPA to determine whether exposure to the PBT chemicals is likely under the conditions of use based on an exposure and use assessment. EPA has determined that, based on their *Exposure and Use Assessment of Five Persistent, Bioaccumulative and Toxic Chemicals* (U.S. Environmental Protection Agency (EPA) 2020b) and other reasonably available information, exposure to PIP (3:1) under the conditions of use is likely to the general population as well as in occupational contexts, to a potentially exposed or susceptible subpopulation, or the environment. EPA's determination is based on the opportunities for exposure throughout the lifecycle of PIP (3:1).

Table 2-4: Assessment Scores for PIP (3:1)				
Chemical Name	**CAS RN**	**Hazard Score**	**Exposure Score**	**Persistence & Bioaccumulation Score**
Phenol, isopropylated, phosphate (3:1) (PIP (3:1))	68937-41-7	3	3	3
Note: 3 = High, 2 = Moderate, 1 = Low. **Source:** U.S. Environmental Protection Agency (EPA) 2014c				

2.2 Regulatory Background

DecaBDE and PIP (3:1) are subject to various U.S. federal, state, and international regulations. This section summarizes existing regulation of the two chemicals.

2.2.1 Decabromodiphenyl ether (DecaBDE)

EPA published a rule on January 6, 2021 that affects decaBDE. Under Section 6(h) of TSCA, EPA's rule at 40 CFR 751.405 prohibits the manufacture and processing of decaBDE and decaBDE-containing products and articles[5] after March 8, 2021, and distribution in commerce of products and articles to which decaBDE has been added after January 6, 2022. Compliance dates or exclusions that are different include:

- By July 6, 2022 for any manufacture, processing and distribution in commerce of decaBDE for use in curtains in the hospitality industry, and of the curtains to which decaBDE has been added.
- By January 6, 2023 for any processing and distribution in commerce of decaBDE for use in decaBDE-containing wire and cable insulation, and the decaBDE-containing wire and cable insulation, in nuclear power generation facilities.
- By January 8, 2024 for manufacture, processing and distribution in commerce of decaBDE for use in parts installed in and sold as part of new aerospace vehicles, and of the parts to which decaBDE has been added for such vehicles. After the end of their service lives, import, processing, and distribution in commerce of aerospace vehicles that contain decaBDE in any part that are manufactured by January 8, 2024. After the end of their service lives manufacture, processing, and distribution in commerce of decaBDE for use in replacement parts for aerospace vehicles, and the replacement parts to which decaBDE has been added for such vehicles
- After the end of their service lives, or 2036, whichever is earlier, manufacture, processing and distribution in commerce of decaBDE for use in replacement parts for motor vehicles, and the replacement parts to which decaBDE has been added for such vehicles.
- After the end of their service lives, processing and distribution in commerce for plastic shipping pallets manufactured prior to March 8, 2021 that contain decaBDE.

Excluded from the prohibition is:

- Processing and distribution in commerce for recycling of decaBDE-containing plastic products and articles (i.e., the plastic to be recycled is from product and articles that were originally made with decaBDE), and for decaBDE-containing products or articles made from such recycled plastic, where no new decaBDE is added during the recycling or production process.

[5] Article means a manufactured item (1) which is formed to a specific shape or design during manufacture, (2) which has end use function(s) dependent in whole or in part upon its shape or design during end use, and (3) which has either no change of chemical composition during its end use or only those changes of composition which have no commercial purpose separate from that of the article, and that result from a chemical reaction that occurs upon end use of other chemical substances, mixtures, or articles; except that fluids and particles are not considered articles regardless of shape or design.

Furthermore, manufacturers, processors, and distributors of decaBDE and articles to which decaBDE has been added are required to maintain ordinary business records, such as invoices and bills-of-lading, related to compliance with the prohibitions, restrictions, and other provisions of this rule. These records need to be maintained for a period of five years. These records must include a statement that the decaBDE-containing products or articles are in compliance with 40 CFR § 751.405(a). These records must be made available to EPA upon request. This recordkeeping requirement does not apply to the processing and distribution in commerce for recycling of plastic that contains decaBDE, and processing and distribution of those products and articles containing decaBDE from recycled plastic, and plastic shipping pallets, which are excluded from the rule.

In addition to these requirements, decaBDE is subject to various other U.S. federal, state, and international regulations. Other U.S. federal actions regarding the chemical are shown in Table 2-5.

Table 2-5: Other Federal Policies Regarding DecaBDE

Agency or Statute	Policy Name and Description
Toxic Substances Control Act (EPA)	One of the chemical substances required to be tested for dioxin/furan contamination (40 CFR part 766). Reportable under the TSCA 8(a) Chemical Data Reporting rule and health and safety data reporting required under TSCA 8(d) as outlined in 40 CFR part 716.
Emergency Planning and Community Right-to- Know Act (EPA)	DecaBDE has been on the Toxics Release Inventory (TRI) list of reportable chemicals since 1988 (53 FR 4500, February 16, 1988).
Agency for Toxic Substances and Disease Registry (ATSDR)	ATSDR established an acute-duration oral Minimum Risk Level (MRL) of 0.01 mg/kg/day for decaBDE and specific Target Organ Toxicity Doses (TTDs).

Many states have either enacted legislation of their own or adopted others' legislation. A list of the states with active legislation regarding brominated flame retardants can be found in Table 2-6.

Table 2-6: State Policies for Controlling Flame Retardants (including DecaBDE and PIP (3:1))

State	Policy Name and Description
Alaska	HB27: Bans the manufacture and sale of children's products containing chemical flame retardants, creates a system for identifying chemicals of high concern, and establishes participation in the Interstate Chemicals Clearinghouse.
	HB53: Bans the manufacture and sale of children's products and residential upholstered furniture containing chemical flame retardants.
California	AB 127: Requires the state fire marshal review flammability standards and chemical flame retardants, and propose updated insulation flammability standards that maintain both overall building safety and occupant/firefighter protection. (Adopted in 2013)
	SB 1019: Requires products to indicate if they contain added flame retardants, and make information available online. (Adopted in 2014)
	AB2998: Bans certain flame retardants (specifically including halogenated flame retardants) in children's products, mattresses, and upholstered furniture. This ban covers flame retardants at concentrations above 1,000 parts per million (ppm). (Adopted in 2018)
	TB 117: Outlines the required testing methods to determine the flame retardancy of various articles.
Connecticut	SB 255: Requires disclosure of flame retardants in consumer products. Beginning January 1, 2023, prohibits the sale of children's products containing flame retardants. (Status in Senate Committee)
Delaware	HB 77: Prohibits the manufacture, sale, or distribution of children's products, upholstered furniture used in residences, and mattresses that contain harmful flame retardant chemicals. (Effective in 2023)
Hawaii	HCR 235 / SR 107: Supports the industry phase-out of the flame retardant decaBDE and encourages the EPA to continue its efforts to end importation of decaBDE into the United States. (Adopted in 2010)

Table 2-6: State Policies for Controlling Flame Retardants (including DecaBDE and PIP (3:1))	
State	**Policy Name and Description**
Illinois	HB 2572: Bans products containing more than one tenth of 1% of the flame retardants penta-BDE or octa-BDE. Directs the Illinois EPA to review the health impacts of and alternatives available to decaBDE and submit a report to the Governor. (Adopted in 2005)
Iowa	HF 457: Prohibits the manufacture and sale of bedding, carpeting, children's products, residential upholstered furniture, or window coverings containing toxic flame retardants.
Maine	LD182: Bans the sale of residential upholstered furniture containing chemical flame retardants in concentration greater than 0.1%. (Adopted in 2017)
	HB206: Prohibits the manufacture and sale of children's products and residential upholstered furniture containing chemical flame retardants.
	LD 1568: Prohibits the manufacture and sale of shipping pallets, or any product made from them, containing decaBDE. (Adopted in 2010)
	Executive Order: Creates a report assessing lead-free alternatives in consumer products, and one on alternatives to the flame retardant decaBDE. Establishes Governor's Task Force to Promote Safer Chemicals in Consumer Products. (Adopted in 2006)
	LD 1790: Bans products containing added brominated flame retardants. (Adopted in 2004)
	LD 1658: Clarifies earlier PBDE phase-out. (Adopted in 2007)
Maryland	SB 556: Bans mattresses, residential upholstered furniture, and electronic equipment containing decaBDE by 2010. (Adopted in 2010)
	HB 83: Bans products containing the flame retardants penta- and octa-brominated diphenyl ether. Requires the Department of the Environment to report decaBDE in products, and make recommendations regarding the use, sale, and disposal of products containing it. (Adopted in 2005)
Massachusetts	S539: Prohibits the manufacture and sale of bedding, carpeting, children's products, residential upholstered furniture, and window treatment containing chemical flame retardants, and establishes a system to evaluate new flame retardants for toxicity.
Michigan	SB 1458: Authorizes the department to establish a committee to determine the risk posed by the release of toxic flame retardants PBDEs, other than penta-BDE or octa-BDE, to human health and the environment. (Adopted in 2004)
Minnesota	HF1627 / SF1535: Bans the manufacture and sale of children's products and residential upholstered furniture containing toxic flame retardants.
	SF 2096: Bans products containing the toxic flame retardants pentaBDE or octaBDE. Requires review of the flame retardant decaBDE, looking at safer alternatives, fire safety, and any evidence regarding the potential harm to public health and the environment. (Adopted in 2007)
	HF 1100 / SF 1215: Bans specified toxic flame retardants from children's products, mattresses, and residential upholstered furniture, specifies that not be replaced with chemicals that are carcinogens, endocrine disruptors, or otherwise cause developmental toxicity. (Adopted in 2015)
Mississippi	SB2816: Prohibits the manufacture and sale of children's products and residential upholstered furniture containing chemical flame retardants.
New Hampshire	SB193: Prohibits the manufacture and sale of upholstered furniture containing flame retardants in concentration greater than 0.1%. (Adopted in 2019)
New Jersey	A3885: Prohibits manufacture and sale of children's products and residential upholstered furniture containing toxic chemical flame retardants.
New Mexico	HB450 / SB453: Prohibits the manufacture and sale of children's products and residential upholstered furniture containing toxic chemical flame retardants
New York	S2718: Bans the sale of residential upholstered furniture containing chemical flame retardants. (Status: In Committee)
	A3368: Prohibits the sale and use of chemical flame retardants on residential upholstered furniture.
	S4465: Requires labelling of seasonal decorative lighting using lead as an additive flame retardant.

Table 2-6: State Policies for Controlling Flame Retardants (including DecaBDE and PIP (3:1))	
State	**Policy Name and Description**
	S7621: Prohibits the use of flame retardants pentaBDE and octaBDE. Create a task force on flame retardant safety to review and report on relevant studies, risk assessments, findings, or rulings on decaBDE and its alternatives. (Adopted in 2004)
	S7737/A8723. Relates to the ban of the use of certain flame retardant chemicals in furniture and mattresses and in electronic casings (modifies the definition of "organohalogen flame retardant chemical" to specify that the chemical's functional use is to inhibit fire. (Effective in December 2024)
Oregon	SB 596: Phases the toxic flame retardant decaBDE from products bought and sold in the state. (Adopted in 2009)
	SB 962: Bans the toxic flame retardants pentaBDE and octaBDE, ands recommend banning decaBDE if safer alternatives are nationally available. (Adopted in 2005)
Rhode Island	H5082: Prohibits the manufacture and sale of children's products and residential upholstered bedding or furniture containing toxic flame retardants.
	HB 7917: Restricts the manufacturing or distribution of flame retardants containing pentaBDE or octaBDE, and requires study on decaBDE. (Adopted in 2006)
Tennessee	HB1029 / SB1049: Prohibits the manufacture and sale of children's products and residential upholstered furniture containing toxic flame retardants, sets limitations on their replacements, and requires disclosure of flame retardants used in all commercial upholstered furniture.
Vermont	H 444 / S 109: Bans the flame retardants octaBDE and pentaBDE from all products, and decaBDE from certain home products (mattresses and pads, residential furniture, televisions and computers). Prohibits a manufacturer from replacing decaBDE with a known or suspected carcinogen, or a chemical identified by the U.S. EPA as causing birth defects, hormone disruption, or harm to reproduction or development. (Adopted in 2009)
	S 81 / H 241: Bans the flame retardants octaBDE and pentaBDE from all products, bans the sale of mattresses and furniture with decaBDE. (Adopted in 2013)
Virginia	HB1861: Bans the manufacture and sale of children's products and residential upholstered furniture containing chemical flame retardants.
Washington	HB1596: Requires manufacturers of electronic products to disclose high priority chemicals used in said products.
	HB 1024: Bans the sale of certain products containing the flame retardants PBDEs and mattresses containing decaBDE and requires the state to study alternatives to them. Restricts the sale of televisions, computers, and residential upholstered furniture containing decaBDE as a result of the Departments' finding that safer and technically feasible alternatives that meet fire safety standards are available. (Adopted in 2007)
	Executive Order 04-01: Directs the Department of Ecology to move forward on phasing out the use of PBDEs. (Adopted in 2004)
Washington D.C.	B21-0143: Prohibits the manufacture, sale, or distribution of any children's product or residential upholstered furniture containing carcinogenic flame retardants or chemicals known to be carcinogenic to humans. (Adopted in 2016)
West Virginia	HB2121: Prohibits the manufacture and sale of children's products and residential upholstered furniture containing toxic chemical flame retardants and establishes rules for replacing those chemicals.
	HB2126: Prohibits the use of certain flame retardant chemicals (specifically including decaBDE) in children's products or upholstered residential furniture. (Status: House Introduced)
Sources:	

The U.S. EPA's Design for the Environment (DfE) program released a final Alternatives Assessment for decaBDE in 2014. The assessment "provides detailed hazard information on 29 substances and mixtures

that have been identified as potentially viable alternatives to decaBDE in a variety of polymers and applications" (U.S. Environmental Protection Agency (EPA) 2014a).[6]

The Voluntary Emissions Control Action Programme (VECAP) is a voluntary initiative of the European Brominated Flame Retardant Industry Panel to reduce uncontrolled decaBDE emissions from manufacturing processes. The program was initiated in 2004 by the UK Textile Finishers Association. In recent years it has expanded to include the European textiles and plastics industry and has been introduced in North America (2006), Mexico, China, Japan, Singapore, Thailand, Indonesia, South Korea and Taiwan. VECAP is characterized by a 6-step cycle to promote chemical management and environmental stewardship, which includes a commitment to the VECAP principles in work procedures and operations, a self-audit, a mass balance approach, a baseline emissions survey, an emissions improvement plan, and implementation and continuous improvement. There was an increase of VECAP participation of decaBDE users in North America by 40% from 2011 to 2012 (Voluntary Emissions Control Action Programme (VECAP) 2012).

In Canada, the Prohibition of Certain Toxic Substances Regulations were amended on October 23, 2016 to include all polybrominated diphenyl ethers (PBDEs), including decaBDE, among the prohibited toxic substances for Canada. This regulation prohibits the import, manufacture, use, sale, and offer for sale of PBDEs and products containing PBDEs unless present in a manufactured article, effective on December 23, 2016 (Environment and Climate Change Canada 2016).

In February 2017, the European Union published a restriction under their Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulation for decaBDE. The restrictions are as follows:

- DecaBDE will not be manufactured or placed on the market as a substance on its own after March 2, 2019
- DecaBDE in a concentration equal to or greater than 0.1% by weight will not be used on the production of, or placed on the market in another substance, as a constituent; a mixture; or an article, or any part thereof
- Exemptions include use in:
    - The production of aircraft before March 2, 2027
    - The production of spare parts for aircraft produced before March 2, 2027 or motor vehicles, agricultural and forestry vehicles, or machinery produced before March 2, 2019.
    - Articles placed on the market before March 2, 2019
    - Certain electrical or electrical equipment (European Chemicals Agency (ECHA) n.d.)

On November 29, 2017, Japan proposed restrictions on the import of products containing decaBDE. The prohibited decaBDE-containing products include: textiles, adhesives and sealing fillers, floor coverings, curtains, banner flags, and any chemicals for flame retardant treatment for textiles, resin and rubber (Chemical Safety Office et al. 2017). There does not appear to be any restriction on domestic manufacture of decaBDE in Japan, and no other restrictions or regulations for other Asian countries were found.

On June 20, 2019, decaBDE was listed in Annex I of Regulation (EU) 2019/1021 of the European Parliament and the Council of the European Union on Persistent Organic Pollutants (POP Regulation). Under this regulation, the manufacturing, placing on the market and use of decaBDE, whether on its own, in mixtures, or in articles, is prohibited (European Union (EU) 2019). On October 28, 2021, the European Commission proposed new concentration limits for PBDEs including decaBDE in waste as a revision to

[6] U.S. Environmental Protection Agency (EPA), 2014. An Alternatives Assessment for the Flame Retardant Decabromodiphenyl Ether (DecaBDE). https://www.epa.gov/sites/default/files/2014-05/documents/decabde_final.pdf.

Annexes IV and V to Regulation (EU) 2019/1021 on Persistent Organic Pollutants. The new limits aim to reduce concentrations in waste from 1000 mg/kg to 500 mg/kg. A draft report of these thresholds was published by the EP rapporteur on February 9, 2022. On November 23, 2022, Annexes IV and V were amended to reduce the sum of concentrations limits for decaBDE and other PBDEs. Concentration limits would be reduced from 500 mg/kg to 350 mg/kg beginning on December 30, 2025, and 200 mg/kg beginning December 30, 2027 (European Union (EU) 2019). The sum of concentration limits to be reduced includes Tetra-, Penta-, Hexa-, Hepta-, and DecaBDE. There is also a 10 mg/kg unintentional trace contaminant concentration for decaBDE, defined as equal to or below 10 mg/kg (0.001% by weight), set forth in ANNEX I.

In October 2019, the Chemical Review Committee (CRC-15) of the Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade recommended that decaBDE be made subject to the PIC procedure (Wagner 2019).

DecaBDE is also listed as a persistent organic pollutant (POP) under the Stockholm Convention, which requires parties to take measures to eliminate production and use of the chemical.

Table 2-7 summarizes these policies.

Table 2-7: International Policies regarding DecaBDE

Source	Policy Name and Description
Voluntary Emissions Control Action Programme (VECAP)	VECAP is characterized by a 6-step cycle to promote chemical management and environmental stewardship, which includes a commitment to the VECAP principles in work procedures and operations, a self-audit, a mass balance approach, a baseline emissions survey, an emissions improvement plan, and implementation and continuous improvement (Voluntary Emissions Control Action Programme (VECAP) 2016). There was an increase of VECAP participation of decaBDE users in North America by 40% from 2011 to 2012 (Voluntary Emissions Control Action Programme (VECAP) 2012).
Canada	Prohibition of Certain Toxic Substances Regulations were amended on October 23, 2016 to include all polybrominated diphenyl ethers (PBDEs), including decaBDE.
European Union	Under the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), published a regulation for decaBDE in In February 2017. The regulation included a prohibition and a concentration limit with numerous exemptions.
European Union	DecaBDE listed in Annex I of Regulation (EU) 2019/1021 of the European Parliament and the Council of the European Union on Persistent Organic Pollutants (POP Regulation).
Japan	Proposed restrictions on the import of products containing decaBDE, including: textiles, adhesives and sealing fillers, floor coverings, curtains, banner flags, and any chemicals for flame retardant treatment for textiles, resin and rubber.
Rotterdam Convention	The Chemical Review Committee (CRC-15) of the Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade recommended that decaBDE be made subject to the PIC procedure.
Stockholm Convention	HCR 235 / SR 107: Supports the industry phase-out of the flame retardant decaBDE and encourages the EPA to continue its efforts to end importation of decaBDE into the United States. (Adopted in 2010)

2.2.2 Phenol, isopropylated, phosphate (3:1) (PIP (3:1))

EPA published a rule on January 6, 2021 that affects PIP (3:1). Under Section 6(h) of TSCA (promulgated at 40 CFR 751.407), after March 8, 2021 the processing and distribution in commerce for use of PIP (3:1) or PIP (3:1)-containing products or articles is prohibited, with exceptions for the processing and distribution for use in commerce of PIP (3:1) and PIP (3:1)-containing products for use in:

- Adhesives or sealants, PIP (3:1)-containing products for use in adhesives and sealants and PIP (3:1)-containing adhesives and sealants, until January 6, 2025;
- PIP (3:1)-containing photographic printing articles, and PIP (3:1)-containing photographic printing articles, until January 1, 2022;
- Hydraulic fluids either for the aerospace industry or to meet military specifications for safety and performance where no alternative chemical is available that meets U.S. Department of Defense specification requirements, PIP (3:1)-containing products for use in such hydraulic fluids, and PIP (3:1)-containing hydraulic fluids either for the aerospace industry or to meet military specifications for safety and performance where no alternative chemical is available that meets U.S. Department of Defense specification requirements;
- Lubricants and greases, PIP (3:1) containing products for use in lubricants and greases; and PIP (3:1)-containing lubricants and greases;
- New and replacement parts for motor and aerospace vehicles, the new and replacement parts to which PIP (3:1) has been added for such vehicles, and the motor and aerospace vehicles that contain new and replacement parts to which PIP (3:1) has been added;
- Use as an intermediate in a closed system to produce cyanoacrylate adhesives;
- Specialized engine filters for locomotive and marine applications, PIP (3:1) containing products for use in specialized engine air filters for locomotive and marine applications, and PIP (3:1)-containing specialized engine air filters for locomotive and marine applications;
- Plastic for recycling from products or articles containing PIP (3:1), where no new PIP (3:1) is added during the recycling process;
- Finished products and articles made of plastic recycled from products or articles containing PIP (3:1), where no new PIP (3:1) was added during the production of the products or articles made of recycled plastic.

EPA also prohibited releases to water from the ongoing processing, distribution in commerce, and commercial use activities that are permitted to occur as outlined in the preceding bullets. All persons are required to follow all applicable regulations and best management practices for preventing the release of PIP (3:1) and PIP (3:1)-containing product to water during commercial use. Furthermore, processors and distributors of PIP (3:1) and products containing PIP (3:1) in commerce are required to notify their customers of these prohibitions on processing and distribution, and the prohibition on releases, via safety data sheet (SDS) or labeling. In addition, each person who continues to manufacture, process, or distribute in commerce PIP (3:1) or PIP (3:1)-containing products or articles must maintain ordinary business records—such as invoices and bills-of-lading—related to compliance with the prohibitions, restrictions, and other provisions of the rule. These records must be maintained for a period of three years from the date the record is generated. These records also must include a statement that the PIP (3:1), or the PIP (3:1)-containing products or articles, are in compliance with 40 CFR § 751.407(a). Upon request, these records must be made available to EPA. This recordkeeping requirement does not apply to the processing and distribution in commerce for recycling of plastic that contains PIP (3:1), and processing and distribution of those products and articles containing PIP (3:1) from recycled plastic, that are excluded from the rule.

In September 2021, EPA extended the compliance date applicable to the processing and distribution in commerce of certain PIP (3:1)-containing articles, and the PIP (3:1) used to make those articles from March 8, 2021, to March 8, 2022. In March 2022, EPA further extended the compliance date applicable to the prohibition on processing and distribution in commerce of certain PIP (3:1)-containing articles, and the PIP (3:1) used to make those articles, until October 31, 2024, along with the compliance date for the associated recordkeeping requirements for manufacturers, processors, and distributors of PIP (3:1)-containing articles.

Prior to the January 2021 final rule, no federal action was taken to restrict the use of PIP (3:1). Other federal actions related to PIP (3:1) are listed in Table 2-8.

Table 2-8: Other Federal Policies Regarding PIP (3:1)

Agency or Statute	Policy Name and Description
Toxic Substances Control Act (EPA)	Added to the Priority Testing List by the TSCA Interagency Testing Committee in May 2012 (77 FR 30855).
Resource Conservation and Recovery Act (EPA)	When discarded, aviation and industrial hydraulic fluid and lubricants and greases are subject to RCRA guidelines for managing used oil (40 CFR part 279).

PIP (3:1) functions as a phosphorus-based flame retardant. A number of states have rules regulating chemical flame retardants. A list of the states with active legislation regarding chemical flame retardants can be found in Table 2-6 in Section 2.2.1.

PIP (3:1) is a component in the flame-retardant product Firemaster® 550, developed by the firm Chemtura and introduced in 2004 as an alternate to pentaBDE, which was phased out by agreements between industry and EPA (Dodson et al. 2012). Following the phase-out of pentaBDE, Firemaster® 550 and Tris (1,3-dichloroisopropyl) phosphate (TDCPP) were used to comply with a 1975 California furniture flammability standard called Technical Bulletin 117 (TB117) (Blum et al. 2012). The replacement standard, TB-117-2013, took effect in January 2014 and no longer necessitates the use of chemical flame retardants to meet fire safety standards.

PIP (3:1) was added to Washington State Department of Ecology's list of chemicals of high concern to children (CHCCs) in 2017, but manufacturers were not obligated to report it until January 31, 2019 (Washington State Department of Ecology 2018).

No international regulations were identified that restrict the use of PIP (3:1). However, the chemical is under assessment as Persistent, Bioaccumulative and Toxic under REACH, as of 2020, (European Union (EU) 2022) and under risk evaluation under the Canadian Environmental Protection Act.

2.3 Justification for Risk Management Action for DecaBDE and PIP (3:1)

This section provides legal and economic justification of the rule to regulate decaBDE and PIP (3:1) in the United States at the federal level of government. Section 2.3.1 indicates the statutory authority for EPA to take risk management action, Section 2.3.2 identifies market failure in the industries where decaBDE and PIP (3:1) is used, Section 2.3.3 discusses regulatory remedies to address market failure from negative externalities, and Section 2.3.4 provides justification for regulation at the federal level specifically.

2.3.1 Statutory Authority

TSCA section 6(h), 15 U.S.C. 2601 *et seq.*, directs EPA to take expedited action to complete TSCA section 6(a) rules on certain PBT chemical substances. EPA must apply one or more of the requirements listed in TSCA section 6(a) to the extent necessary to meet the TSCA section 6(h)(4) statutory standard. More specifically, EPA must take action on those chemical substances identified in the 2014 Update to the TSCA Work Plan for Chemical Assessments (U.S. Environmental Protection Agency (EPA) 2014c) that, among other factors, EPA has a reasonable basis to conclude are toxic and that with respect to persistence and bioaccumulation score high for one and either high or moderate for the other, pursuant to the TSCA Work Plan Chemicals: Methods Document (U.S. Environmental Protection Agency (EPA) 2012).

In response to this directive, in January 2021, EPA promulgated five rules to regulate the following five PBT chemical substances: DecaBDE; PIP (3:1); 2,4,6-TTBP (CASRN 732-26-3); HCBD (CASRN 87-68-3); and PCTP (CASRN 133-49-3) (Refs. 3, 4, 5, 6, and 7). With the obligation to promulgate these rules, the Agency also has the authority to amend them (e.g., if circumstances change, including in relation to the receipt of new information). It is well settled that EPA has inherent authority to reconsider, revise, or repeal past decisions to the extent permitted by law so long as the Agency provides a reasoned explanation. See *F.C.C.* v. *Fox Television Stations, Inc.*, 556 U.S. 502, 515 (2009). Based on information submitted by regulated entities since the publication of the 2021 decaBDE and PIP (3:1) final rules, the Agency has determined that amendments to both rules are necessary to address implementation issues and to further reduce exposure to these chemical substances to the extent practicable.

2.3.2 Market Failure

The private market is a mechanism that can allocate resources efficiently. However, the market's allocation of resources will not always be desirable from the standpoint of society. The market will fail to achieve a socially efficient outcome when differences exist between private market values and social values.

Welfare economics states that a socially efficient outcome is achieved if no alternative allocation of society's resources can make at least one person better off without making another one worse off. This is referred to as a Pareto optimal outcome. If the private market fails to achieve this efficient outcome, too little or too much is produced, resulting in a loss in economic welfare. This is referred to as a market failure.

However, Pareto optimality is a strict condition and can allow for very unequal allocations. It does not address redistributive actions, in which one group is made worse off and another group is made better off. A less strict criteria for measuring economic improvement is Kaldor-Hicks efficiency. Under this criterion, economic efficiency is improved if those who benefit from an action gain more than those who lose from that action.[7] This is the fundamental efficiency criterion of benefit-cost analysis: society is

[7] The Kaldor-Hicks criterion is also referred to as the potential Pareto criterion or the potential compensation principle because it implies that economic efficiency is improved if those who benefit from an action could fully compensate those who lose from that action, and still be better off. In other words, it is theoretically possible to achieve a Pareto improvement – in which some are made better off, and no one is made worse off – if those who benefit from a regulation were to fully compensate those who pay the cost. The word "potential" is used because the compensation does not have to actually occur, it just has to be theoretically possible to do so for this to be a social improvement.

considered to be better off (in terms of economic efficiency) if the benefits of an action outweigh the cost of undertaking it.

Government regulation of a private market is justified when the market fails to deliver a socially efficient outcome. If a regulation can produce benefits that exceeds its cost, then economic efficiency has been improved. The economic literature has identified the following common causes of market failure and economic inefficiency:

- Existence of externalities (negative and positive);
- Under-provision of common property resources, and public goods;
- Market power (e.g., monopolies);
- Inadequate or asymmetric information

This section discusses how negative externalities are present in the market for the chemical regulated under this rule[8]. By understanding how the market is affected by this market failure, more effective regulations can be designed.

Externalities

A negative externality occurs when one party's action imposes an uncompensated negative effect on another party. For example, the manufacturer, processor, or consumer of a good may impose costs on another party if the good causes an adverse health impact that is not known or factored into the market transaction. Since these external costs are not internalized by the manufacturer, processor, or user, they are not considered in the production (or processing, use) and pricing decisions. As a result, the societal cost of these goods is under-valued and the level of output produced (or processed, used) is higher than the social optimal output level. In other words, a negative externality occurs when a firm makes decisions based on private costs instead of social costs, leading to an excess of product in the market.

EPA believes that the cause of market failure in the market for decaBDE and PIP (3:1) subject to this final rule stems from negative externalities. The releases and exposure to decaBDE and PIP (3:1) that may impose health and environmental costs on third parties are not internalized by those manufacturing, processing, distributing, or using the chemical. Negative externalities are exacerbated by the persistence and bioaccumulation of this chemical, which causes it to linger in the environment and exert toxic effects on human health and/or the environment over an extended period. By reducing the volume through prohibition or by reducing the exposure through use of PPE of decaBDE and PIP (3:1) in the market, the negative externalities caused by exposure to these chemicals are reduced, thereby resulting in an improvement in welfare.

Society will experience health benefits from regulatory measures that limit or eliminate the manufacture, processing and use or limit exposure due to PPE of decaBDE and PIP (3:1). However, society will experience *net benefits* from these regulatory measures only up to the point where the benefits of reducing these negative externalities are less than the costs of achieving them. If the costs of these regulatory measures on manufacturers and users of decaBDE and PIP (3:1) are greater than the external costs imposed by their use, the regulation is too strict and the new state is also suboptimal. Social welfare would be decreased by any regulatory measure that goes beyond the point where the volume of methylene

[8] This discussion focuses on negative externalities because this is the market failure addressed by this proposed regulation. Please refer to EPA Guidelines for Preparing Economic Analyses (EPA 2014b) for a discussion on additional sources of market failure identified in the literature.

chloride has been reduced to the same point as if the externalities were internalized. The economically efficient level of control is where the additional (marginal) cost of further control equals society's willingness to pay for the next increment of control. Adverse effects may still occur at this level, but additional regulatory costs to further reduce or eliminate these effects would not be Pareto optimal. Conversely, if post-rule, the cost to society from release and exposure to methylene chloride remains greater than costs to regulated firms, the rule would also not produce a Pareto optimal outcome.

2.3.3 Remedies to Reduce Negative Externalities

As discussed below in Section 2.4, the final rule regulatory option and alternative options detail various requirements that will reduce the negative human health costs associated with the negative externality. EPA contends that these measures are sufficient to reduce negative externalities associated with decaBDE and PIP (3:1).

2.3.4 Justification for Regulation at the Federal Level

The chemicals and products associated with this rulemaking are distributed in commerce across state lines, and thus they fall under the federal jurisdiction of regulation under TSCA. It is more efficient for companies manufacturing, processing, and distributing these products to comply with a single federal standard rather than a patchwork of different state regulations. While this rule will not preempt state standards, states would not need to promulgate regulations if there is a federal regulation in place.

2.4 Regulatory Options and Alternative Regulatory Approaches

Section 6 of TSCA, as amended by the Frank R. Lautenberg Chemical Safety for the 21st Century Act, provides EPA with the authority to prohibit or limit the manufacture, processing, distribution in commerce, use, or disposal of a chemical if EPA evaluates the risk and concludes that the chemical presents an unreasonable risk to human health or the environment.

Under Section 6(a), the law authorizes EPA to issue regulations requiring one or more of the following actions to the extent necessary so that the chemical substance no longer presents an unreasonable risk:

- Prohibit or otherwise restrict manufacture, processing, or distribution in commerce (§6(a)(1));
- Prohibit or otherwise restrict for a particular use or above a set concentration (§6(a)(2));
- Require minimum warnings and instructions with respect to use, distribution in commerce, or disposal (§6(a)(3));
- Require recordkeeping or testing (§6(a)(4));
- Prohibit or regulate any manner or method of commercial use (§6(a)(5));
- Prohibit or regulate any manner or method of disposal (§6(a)(6)); and/or
- Direct manufacturers or processors to give notice of the unreasonable risk to distributors and replace or repurchase products if required (§6(a)(7)).

The following subsections describe the risk management options that EPA has chosen for current uses of decaBDE and PIP (3:1).

2.4.1 Regulatory Remedies to Reduce Negative Externalities

According to the 2014 update of the *TSCA Work Plan for Chemical Assessments*, decaBDE and PIP (3:1) have high persistence and high potential for bioaccumulation (U.S. Environmental Protection Agency (EPA) 2014c). The general population, commercial and consumer end-users, other vulnerable subpopulations (workers, children, Tribes) and the environment may be exposed and, if so, negatively affected. EPA is finalizing measures that reduce the amount of decaBDE and PIP (3:1) in the market or limit exposure to these chemicals. For decaBDE, the final rule requires the use of PPE during manufacturing or processing of certain products containing decaBDE. For PIP (3:1), the rule prohibits the manufacture for certain uses (including import), after specified periods of time, and requires PPE use for the manufacturing and processing of products and articles that contain PIP (3:1).

The final regulatory action will reduce the negative externalities for workers associated with both chemicals. As processing and distribution is generally prohibited unless otherwise excluded, the regulation also eliminates the negative externalities associated with the exposure generally, including by consumers.

In the absence of a risk evaluation with quantified risk estimates, this analysis does not quantify the benefits of the regulatory options.[9]

2.4.2 Decabromodiphenyl ether (DecaBDE)

The regulatory amendments that for decaBDE under this rulemaking, as well as the primary alternative option, are summarized in Table 2-9, and described in the sections below.

[9] Marginal changes in risk are needed to estimate/quantify welfare changes.

Table 2-9: Summary of Final DecaBDE Risk Management Options		
Chemical Use	**Final Option[1]**	**Primary Alternative Option**
Distribution in commerce of decaBDE-containing plastic shipping pallets manufactured before March 8, 2021; and, Processing and distribution in commerce for recycling of decaBDE-containing plastic from products or articles and decaBDE-containing products or articles made from such recycled plastic, where no new decaBDE is added during the recycling process	Require signage providing notice to workers that PPE is required to be worn during the recycling, of plastic shipping pallets, which will reduce potential exposures to decaBDE. Require inhalation and dermal PPE (N95 mask and chemical-resistant gloves) during the recycling process of shipping pallets known to contain decaBDE.	Require a label on all recycled plastic articles containing decaBDE. Require inhalation and dermal PPE (e.g., N95 mask, chemical-resistant gloves) during all recycling processes of plastics.
Manufacture and processing of decaBDE for use in replacement parts and the manufacture of such parts, specifically use in parts installed in and distributed as part of new aerospace vehicles, and the manufacturing and processing of parts to which decaBDE has been added for such vehicles.	Require inhalation and dermal PPE (N95 mask and chemical-resistant gloves), except for the processing of parts to which decaBDE has been added.	No changes from 2021 Final Rule
Manufacture and processing of decaBDE for use in replacement parts and the manufacture of such parts, specifically decaBDE and decaBDE-containing products for use in replacement parts for motor vehicles, and the manufacturing and processing of replacement parts to which decaBDE has been added for such vehicles.	Require inhalation and dermal PPE (N95 mask and chemical-resistant gloves), except for the processing of parts to which decaBDE has been added	No changes from 2021 Final Rule
Releases of decaBDE to water	Prohibit the releases to water during manufacturing, processing, distribution in commerce of decaBDE, decaBDE-containing products, and all persons are required to follow all applicable regulations for preventing the release of decaBDE.	No changes from 2021 Final Rule
Processing and distribution in commerce of decaBDE for use in wire and cable insulation in nuclear power generation facilities	After the end of the wire and cables' service life, all persons are prohibited from all processing and distribution in commerce of decaBDE-containing wire and cable insulation for use in wire and cable insulation in nuclear power generation facilities (including research and test reactors). Require export notification for all persons intending to export decaBDE-containing wire and cable insulation for nuclear power generation facilities.	No changes from 2021 Final Rule

[1] In response to public comments on the NPRM, the final rule also establishes a regulatory threshold level. This amendment in § 751.405 (a) prohibits all manufacturing and processing of decaBDE or decaBDE-containing products or articles after March 8, 2021, and prohibits all distribution in commerce of decaBDE or decaBDE-containing products or articles after January 6, 2022, unless decaBDE concentrations are at or below 0.1% by weight, not including any amount present due to excluded uses, including recycling or phased-out uses.

Final Amendments – DecaBDE

This final rule addresses public comments received on the NPRM requesting that EPA establish a regulatory threshold level for quantities of PIP (3:1) and decaBDE in products and articles. The final rule

sets a threshold level of 0.1 percent for both decaBDE and PIP (3:1). Using this threshold concentration, the bans on manufacturing, processing, and distributing in commerce products and articles only apply to products and articles containing more than 0.1 percent decaBDE by weight or 0.1 percent PIP (3:1) by weight, not counting decaBDE or PIP (3:1) in products or articles that are excluded from the bans or for which the delayed bans have not reached their compliance date.

For all uses, except as noted below, the final rule establishes a regulatory threshold level such that: all persons are prohibited from all manufacturing and processing of decaBDE or decaBDE-containing products or articles after March 8, 2021, and all persons are prohibited from all distribution in commerce of decaBDE or decaBDE-containing products or articles after January 6, 2022, unless decaBDE concentrations are at or below 0.1 percent by weight.

Worker protection (PPE) requirements. To ensure minimal potential for exposure to workers during domestic manufacturing and processing, the owner or operator must demarcate regulated areas[10] from the rest of the workplace in a manner that adequately establishes and alerts persons to the boundaries of the regulated area and minimizes the number of authorized persons exposed to decaBDE within the regulated area in where activities involving decaBDE—specifically manufacture and processing of decaBDE for use in replacement parts and the manufacture of such parts and processing through recycling of pallets—occur. The final rule also requires certain PPE requirements to address potential respiratory and dermal exposure to occupational workers during permitted ongoing domestic manufacturing or processing activities involving decaBDE. EPA requires respiratory and dermal PPE for manufacturing and processing of decaBDE and decaBDE-containing products and articles with exclusions. This will affect the recycling process of decaBDE-containing plastic shipping pallets and the manufacturing and processing of decaBDE for aerospace and auto replacement parts. EPA is not requiring respiratory and dermal PPE during the recycling of any other products or articles that might contain decaBDE. EPA is not requiring PPE for processing of decaBDE-containing wire and cable for use in nuclear power generation facilities or decaBDE-containing parts where the decaBDE has already been added. EPA is not requiring PPE for distribution in commerce of decaBDE-containing articles, since the processing and distribution in commerce of these decaBDE containing articles would result in minimal potential for worker exposure (U.S. Environmental Protection Agency (EPA) 2020b).

For the activities subject to this final rule, EPA is requiring, at a minimum, a respirator at least as protective as a NIOSH-approved air-purifying filtering facepiece/dust mask respirator with an assigned protection factor (APF) of 10, commonly referred to as an N95 mask, and gloves that are chemically resistant to decaBDE with activity-specific training where dermal contact with decaBDE is possible. For respirators with an APF 10, EPA is requiring that the owner or operator must ensure that all respirators used in the workplace are NIOSH-approved as listed on the NIOSH Certified Equipment List (NIOSH 2023). In choosing appropriate gloves, EPA is requiring that owners and operators consider effectiveness of glove type when preventing exposures from decaBDE alone and in likely combination with other chemical substances used in the work area, degree of dexterity required to perform tasks, and temperature, as identified in the Hand Protection section of OSHA's Personal Protective Equipment guidance (Occupational Safety and Health Administration (OSHA) 2004). EPA is requiring owners and operators in these domestic manufacturing and processing activities to provide and require wearing of the specified PPE to persons potentially exposed to decaBDE.

EPA is finalizing the requirement for implementation of a PPE program in alignment with certain elements of OSHA's General Requirements for PPE at 29 CFR 1910.132 and Respiratory Protection

[10] As defined in 40 CFR 751.403 d

requirements in 29 CFR 1910.134.[11] Owners and operators are required to provide PPE that is of safe design and construction for the work to be performed. EPA is requiring that owners and operators maintain PPE in a sanitary, reliable, and undamaged condition and ensure that each potentially exposed person who is required to wear PPE uses such PPE. EPA is requiring owners and operators ensure each potentially exposed person who is required to wear PPE to use and maintain PPE in a sanitary, reliable, and undamaged condition. Owners and operators are required to select and provide PPE that properly fits each potentially exposed person who is required to use PPE and communicate PPE selections to each affected person.

EPA is also finalizing its proposal to require each owner/operator to comply with OSHA's respiratory protection training requirements at 29 CFR 1910.134(k) and general PPE training requirements at 29 CFR 1910.132(f) when using respirators and gloves. EPA is requiring that owners and operators provide PPE training to each potentially exposed person who is required to wear PPE prior to or at the time of initial assignment to a job involving potential exposure to decaBDE.

EPA is also requiring implementation of a respiratory protection program in alignment with certain elements of 29 CFR 1910.134, which requires each owner or operator to select respiratory protection in accordance with the guidelines for proper respirator use, maintenance, fit-testing, medical evaluation, and training. EPA is also requiring that owners or operators who are required to administer a respiratory protection program must ensure that when a respirator utilized, it complies with 29 CFR 1910.134(d)(1)(iv). The employer must ensure that all potentially exposed persons within the regulated area are using the provided respirators whenever exposures to airborne concentrations of decaBDE can reasonably be expected and are not already controlled by one or a combination of elimination, substitution, engineering controls, or administrative controls to reduce exposure to the extent practicable.

EPA requires that owners and operators document respiratory protection used and PPE program implementation. EPA requires that owners and operators document in the PPE program the following information, as applicable, and are available to EPA upon request:

> (A) The name, workplace address, work shift, job classification, and work area of each person reasonably likely to directly handle decaBDE or handle equipment or materials on which decaBDE may be present and the type of PPE selected to be worn by each of these persons;
>
> (B) The basis for PPE selection (e.g., demonstration based on permeation testing or manufacturer specifications that each item of PPE selected provides an impervious barrier to prevent exposure

[11] As discussed in the FRN for this final rule, EPA also considered the National Institute for Occupational Safety and Health (NIOSH) hierarchy of controls. In order of precedence, this hierarchy of controls includes elimination of the hazard, substitution with a less hazardous substance, engineering controls, administrative controls (e.g., training or exclusion zones with warning signs), and, finally, use of PPE (Ref. 23 of FRN). Under the hierarchy of controls, the use of respirators should only be considered after all other measures have been taken to reduce exposures, and then under the context of the OSHA Respiratory Protection Standard at 29 CFR 1910.134. Under OSHA's standards, the various exposure controls are prioritized equally, followed by PPE requirements when necessary. When formulating the proposed worker protection requirements on the limited time allotted for the TSCA section 6(h) rulemakings, no risk evaluation or assessment was required or feasible and an already existing risk assessment was not available to support calculation of safe exposure levels for these two chemicals, which would be necessary for EPA to establish a workplace chemical protection program. Thus, EPA is finalizing specific engineering controls and PPE for one industry sector, specifically the use of PIP (3:1) as an intermediate in cyanoacrylate adhesives in which the Agency had additional information about existing practice.

during expected duration and conditions of exposure, including the likely combinations of chemical substances to which the PPE may be exposed in the work area); and

(C) Appropriately sized PPE and training on proper application, wear, and removal of PPE, and proper care/disposal of PPE.

EPA is requiring each owner or operator supply PPE to each potentially exposed person within 60 days after publication of the final rule.

Plastic shipping pallets. EPA's 2023 NPRM proposed a labeling requirement for decaBDE-containing plastic shipping pallets. The purpose of EPA's proposed label was to provide notice that PPE is required during the recycling of plastic shipping pallets. However, since exposure to decaBDE in plastic shipping pallets that are in use and moving throughout commerce is not expected (U.S. Environmental Protection Agency (EPA) 2020b), and after considering public comments received on the proposal, EPA is not finalizing the labeling requirement for plastic shipping pallets.

To reduce potential exposures to decaBDE during the recycling of decaBDE-containing plastic shipping pallets, EPA is finalizing a signage requirement in the regulated area, defined at 40 CFR 751.403 as "an area established by the regulated entity to demarcate areas where airborne concentrations of a specific chemical substance can reasonably be expected." This definition is intended to include those areas where plastic pallets are recycled. This sign will provide notice to workers that PPE is required to be worn during recycling of plastic shipping pallets manufactured before March 8, 2021, which will reduce potential exposures to decaBDE (see Unit III.C.2. for more information on specific PPE requirements). A sign must be posted at every entry point into the regulated area that clearly, prominently, in multiple languages as appropriate, and in an easily readable font size, contains the following text: "Decabromodiphenyl ether (decaBDE) (CASRN 1163-19-5), a chemical that has been identified as a persistent, bioaccumulative, and toxic (PBT) chemical by the U.S. Environmental Protection Agency, may be present in this regulated area. All persons in this regulated area who recycle plastic shipping pallets manufactured before March 8, 2021 are required to wear personal protective equipment, including respiratory protection that is at least as protective as a NIOSH-approved N95 respirator with an assigned protection factor (APF) of 10 and dermal protection of gloves that are chemically resistant to decaBDE, per regulations at 40 CFR 751.405(e). EPA is not requiring testing to determine if decaBDE is present in the plastic shipping pallets.

Releases of DecaBDE to water. EPA is prohibiting the releases to water during the manufacturing, processing, and distribution in commerce of decaBDE, decaBDE-containing products, and all persons are required to follow any applicable regulations that may apply or preventing the release of decaBDE to water.

Prohibiting releases to water highlights the importance of reducing environmental releases of chemicals regulated by TSCA section 6(h) and reduces exposures that could occur. Despite the decreasing reporting trends of decaBDE, prohibiting releases to water during manufacture, processing, and distribution in commerce of decaBDE will prevent any future releases of decaBDE to water from any excluded uses under both the 2021 final decaBDE rule and this rule, overall reducing the potential for exposures.

Taking into account the comments received and this approach to ensure future activities are prohibited, EPA is prohibiting releases to water for from the manufacture, processing, and distribution in commerce of decaBDE from uses that are permitted to occur. EPA is not extending this restriction to include a ban on the release to water for articles, including recycled materials, that may contain decaBDE.

Wire and cable in nuclear power generation facilities. EPA is extending the compliance date, limited to processing and distribution in commerce of decaBDE-containing wire and cables in nuclear power plants,

until after the end of the service life of the wire and cable and the components containing the wire and cable. Stakeholders have indicated that existing decaBDE-containing wire and cable may need to be distributed and processed for refurbishment, maintenance, and repair until the wire and cable is replaced. In addition, EPA's "Exposure and Use Assessment of Five Persistent, Bioaccumulative, and Toxic Chemicals" notes that releases of decaBDE could occur during the processing of decaBDE to make the wire and cable. However, once formulated, decaBDE is encased in the cured coating and the potential for worker exposure is minimal. Therefore, EPA believes allowing this is necessary and practicable while being protective of potential exposure of decaBDE.

EPA is not allowing resumption of processing and distribution in commerce of raw or compounded decaBDE for use in wire and cable insulation in nuclear power generation facilities.

DecaBDE is listed on Annex A of the Stockholm Convention on Persistent Organic Pollutants (the POPs Convention), which prohibits the production, use, import, and export of decaBDE and decaBDE-containing products and articles for Parties to the listing decision for decaBDE, unless otherwise subject to a specific exemption (United Nations 2019). Due to this listing, EPA is requiring that all persons intending to export decaBDE or decaBDE-containing wire and cable for nuclear power generation facilities be required to notify EPA under TSCA section 12(b) and the provisions of subpart D in 40 CFR part 707. EPA recognizes that articles are generally exempt under 40 CFR 707.60(b) for notices of export under TSCA section 12(b). However, persons who export decaBDE contained in articles are not be exempt from the requirement to submit a notice of export respecting such decaBDE.

Primary Alternative Option – DecaBDE

Plastic shipping pallets. EPA considered requiring a label on all recycled plastic articles known to contain decaBDE. This label suggestion came from a government-to-government consultation and comments received after this consultation (Yurok Tribe 2023). Domestic manufacture of decaBDE has ceased; however, decaBDE-containing articles may still be imported into the United States. Due to the complexity of supply chains, it is difficult to identify at which point decaBDE is added in an article, hence making it difficult to determine where a label would be attached.

EPA also considered requiring respiratory and dermal PPE during all recycling processes of decaBDE-containing plastic products and articles. EPA explained in the 2021 PBT final rules, EPA it did not intend to use its TSCA section 6(a) authorities to restrict recycling activities generally. EPA did not reevaluate the practicability of further exposure reductions relating to prohibiting, or further regulatory restrictions on, the general recycling of decaBDE-containing plastic in the United States. In order to determine if decaBDE is present in plastics at recycling facilities, a testing program would need to be established. As described in the 2021 final decaBDE rule EPA maintains its position this it would be overly burdensome and not practicable to establish a testing program to determine the presence of decaBDE in recycled materials. A testing program is not assessed in this analysis.

2.4.3 Phenol, isopropylated, phosphate (3:1) (PIP (3:1))

EPA is considering regulatory requirements specific to each existing use of PIP (3:1). These uses are described in Section 3.3.2. The regulatory amendments that EPA is requiring, as well as the primary alternative option, are summarized in Table 2-10 and described in the sections below.

Table 2-10: Summary of Final PIP (3:1) Risk Management Options		
Chemical Use	**Final Option[1,2]**	**Primary Alternative Regulatory Option**
Processing and distribution in commerce for use in lubricants and greases, PIP (3:1) containing products for use in lubricants and greases, and PIP (3:1)-containing lubricants and greases	Modify exclusion for processing and distribution in commerce of PIP (3:1) for use in lubricants and greases and require PPE. • Limit this exclusion to only aerospace use and turbine applications. • Add a 15-year time limit to the exclusion for manufacturing, processing and distribution in commerce of any other lubricants and greases that contain PIP (3:1 and PIP (3:1)-containing products for use in); thus, non-turbine and non-aerospace uses will be prohibited after 15 years. • Require a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator, and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible that provide an impervious barrier to prevent dermal exposure during expected durations of use and normal conditions of exposure within the workplace during the manufacturing and processing of PIP (3:1) and PIP (3:1)-containing products for use in lubricants and greases.	Same as the Final Option, except using a 5-year time limit, rather than 15-years, to the exclusion for manufacturing, processing and distribution in commerce of PIP (3:1) and PIP (3:1)-containing products for use in any other lubricants and greases that contain PIP (3:1) and PIP (3:1)-containing products for use in); thus, non-turbine and non-aerospace uses would be prohibited after 5 years.
Processing and distribution in commerce of new and replacement parts for motor vehicles	Modify compliance dates for processing and distribution in commerce of PIP (3:1) for use in new and replacement parts for motor vehicles and PPE during manufacturing and processing. • Prohibit with 15-year phase-in the processing and distribution in commerce of PIP (3:1) and manufacturing, processing, and distribution in commerce of PIP (3:1)-containing products for use in parts for new motor vehicles (i.e., newly produced vehicles), and manufacturing and processing of PIP (3:1)-containing parts for such new vehicles. • Prohibit with 30-year phase-in the processing and distribution in commerce of PIP (3:1) and manufacturing, processing, and distribution in commerce of PIP (3:1)-containing products for use in replacement parts for motor vehicles, and manufacturing and processing of PIP (3:1)-containing replacement parts for such vehicles. • Require a respirator at least as protective as a NIOSH-approved N95 respirator (APF 10) and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of PIP (3:1) and PIP (3:1)-containing products for use in new and replacement parts for motor vehicles. Processing of PIP (3:1)-containing parts to which PIP (3:1) has been added are excluded from this requirement.	No changes from 2021 Final Rule

Table 2-10: Summary of Final PIP (3:1) Risk Management Options		
Chemical Use	**Final Option[1,2]**	**Primary Alternative Regulatory Option**
Processing and distribution in commerce of new and replacement parts for aerospace vehicles	Prohibition phase-in dates for PIP (3:1)-containing new and replacement parts for aerospace vehicles. • Prohibit the manufacturing, processing and distribution in commerce of PIP (3:1) and PIP (3:1)-containing products for use in new and replacement parts for aerospace vehicles after 30 years; • After the end of the aerospace vehicles service lives, prohibit the importing, processing and distribution of aerospace vehicles manufactured before the 30-year prohibition is in effect. • Prohibit manufacturing, processing and distribution in commerce of PIP (3:1), PIP (3:1)-containing products, and PIP (3:1)-containing replacement parts after the end of the vehicle service life. (Allow replacement parts that contain PIP (3:1) through the life cycle of the vehicle.) • Require a respirator at least as protective as a NIOSH-approved N95 respirator (APF 10) and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of PIP (3:1) and PIP (3:1)-containing products for use in new and replacement parts for aerospace vehicles. Processing of PIP (3:1)-containing parts to which PIP (3:1) has been added are excluded from this requirement.	No changes from 2021 Final Rule
Processing and distribution in commerce for use in wire harnesses and electric circuit boards	Exclusion for the processing and distribution of PIP (3:1), PIP (3:1)-containing products for use in circuit boards and wire harnesses, including but not limited to terminal and fuse covers, cable sleeves, casings, connectors and tapes, and PIP (3:1)-containing circuit boards and wire harnesses including but not limited to terminal and fuse covers, cable sleeves, casings, connectors and tapes. • Require a respirator at least as protective as NIOSH-approved APF 10 air-purifying half mask respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of PIP (3:1) for use in wire harnesses or electric circuit boards.	Prohibit manufacturing (including import), processing, and distribution and commerce of PIP (3:1) for use in circuit boards and wire harnesses, including but not limited to terminal and fuse covers, cable sleeves, casings, connectors and tapes, and PIP (3:1)-containing circuit boards and wire harnesses including but not limited to terminal and fuse covers, cable sleeves, casings, connectors and tapes, after 20 years.

Table 2-10: Summary of Final PIP (3:1) Risk Management Options		
Chemical Use	**Final Option[1,2]**	**Primary Alternative Regulatory Option**
Manufacturing (import) and distribution in commerce of PIP (3:1) that is intended for formulation into a FIFRA-registered marine antifouling coating	Provide an exclusion of 5 years for the processing and distribution in commerce of PIP (3:1) for use in FIFRA-registered marine anti-fouling coatings only for products that meet Department of Defense specification requirements. • Require a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of PIP (3:1)-for use in FIFRA-registered marine antifouling coating.	No changes from 2021 Final Rule
Processing and distribution in commerce for use in semiconductor manufacturing, and electronic, HVACR and water heating, and power generating equipment manufacturing.	Prohibition phase-in dates for PIP (3:1)-containing new and replacement parts for products and articles for use installed in equipment in a variety of industries: manufacturing, semiconductor manufacturing, electronic, HVACR and water heating, and power generating. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing products and articles for use in new parts installed in equipment in a variety of industries: manufacturing, semiconductor manufacturing, electronic, HVACR and water heating, and power generating after 10 years. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in manufacturing equipment, including semiconductor manufacturing after the end of the products service life. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in electronic equipment after 7 years for personal use, 25 years for commercial use, and after the products service life for laboratory use. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in HVACR and water heating equipment after 25 years. • Prohibit the processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in power generating equipment after 25 years. • Require a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask-respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing for use in PIP (3:1)-containing manufacturing equipment or semiconductors. Processing of PIP (3:1)-containing parts to which PIP (3:1) has been added are excluded from this requirement.	Same as the Final Option, except using a 20-year time limit, rather than 10 years, to the exclusion for manufacturing, processing and distribution in commerce of PIP (3:1) and PIP (3:1)-containing products for use in semiconductor manufacturing, and electronic, HVACR and water heating, and power generating equipment manufacturing.

Table 2-10: Summary of Final PIP (3:1) Risk Management Options		
Chemical Use	**Final Option[1,2]**	**Primary Alternative Regulatory Option**
Processing and distribution in specialized engine filters for locomotive and marine applications	Require half or full respirators, and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible for workers using PIP (3:1) in the manufacturing of specialized engine filters for locomotive and marine applications. Processing of PIP (3:1)-containing parts are excluded from this requirement.	No changes from 2021 Final Rule
Processing and distribution in intermediate in a closed system to produce cyanoacrylate adhesives	Require respiratory protection that must be at least as protective as a NIOSH-approved APF 50 respirator, except when the PIP (3:1) or PIP (3:1)-containing product is contained in a closed-system. Codify requirements for engineering controls of closed loop, as well as local exhaust ventilation and general ventilation.	No changes from 2021 Final Rule
Processing and distribution in aviation hydraulic fluids	Require a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible during manufacturing and processing of any PIP (3:1)-containing aviation hydraulic fluid.	No changes from 2021 Final Rule

[1] In response to public comments on the NPRM, the final rule also establishes a regulatory threshold level. This exclusion prohibits manufacturing, processing, and distribution in commerce of PIP (3:1)-containing products and articles, unless PIP (3:1) concentrations are at or below 0.1% by weight, not including any amount present due to excluded uses, including recycling, or uses that have not yet been phased out.

[2] EPA is also amending the downstream notification statement that must accompany shipments of PIP (3:1) or PIP (3:1) containing products to conform to the terms of the prohibitions in the final rule. EPA is providing a 3-month transition period to update SDS sheets and an 18-month transition period for updating labels. During the 3-month transition period, downstream notification under 40 CFR 751.407(e)(1) and (2) is still required; entities may use the new information provided in new 40 CFR 751.407(e)(3) or existing notification consistent with the restrictions described in this subpart. During the 15-month period between the SDS revision date and the label revision date, manufacturers, processors or distributors are required to provide the updated SDS with the "new" information when distributing products with the "old" label.

Final Amendments – PIP (3:1)

As noted previously, this final rule addresses public comments received on the NPRM requesting that EPA establish a regulatory threshold for quantities of PIP (3:1) and decaBDE in products and articles. The final rule sets a threshold level of 0.1 percent for both decaBDE and PIP (3:1). Using this threshold concentration, the bans on manufacturing, processing, and distributing in commerce products and articles only apply to products and articles containing more than 0.1 percent decaBDE by weight or 0.1 percent PIP (3:1) by weight, not counting decaBDE or PIP (3:1) in products or articles that are excluded from the bans or for which the delayed bans have not reached their compliance date.

In addition, as detailed in the preamble to this final rule, EPA does not believe, unless otherwise specified, that products and articles containing PBT chemicals should continue to be distributed without end, and therefore is not adopting a generally applicable "manufactured by" provision. EPA acknowledges that retailers and distributors may keep some amount of stock on hand and may not have ways to track which inventory may be subject to a prohibition. EPA agrees with commenters that it would not be practicable to force retailers to dispose of stocks, disrupting supply chains and potentially be costly. Hence, for practicability reasons EPA is providing longer "sell through" dates for distribution of articles containing PIP (3:1) for those articles with a compliance date of October 31, 2024. Instead, EPA has finalized specific phase-in prohibitions or exclusions for certain PBT-containing articles and finalized an exclusion solely for the purpose of repair and maintenance of an existing article. However, to

discourage stockpiling, EPA is not providing for a sell-through provision for those articles covered by a phase-in prohibition, in particular for new and replacement parts.

EPA is also amending the downstream notification statement that must accompany shipments of PIP (3:1) or PIP (3:1) containing products to conform to the terms of the prohibitions in the final rule. EPA is providing a 3-month transition period to update SDS sheets and an 18-month transition period for updating labels. EPA believes that this transition period will allow time to clear product with old labels through channels of trade. During the 3-month transition period, downstream notification under 40 CFR 751.407(e)(1) and (2) is still required; entities may use the new information provided in new 40 CFR 751.407(e)(3) or existing notification consistent with the restrictions described in this subpart. During the 15-month period between the SDS revision date and the label revision date, manufacturers, processors or distributors are required to provide the updated SDS with the "new" information when distributing products with the "old" label.

Lubricants and greases. EPA applies an exclusion for manufacturing, processing, and distribution in commerce of PIP (3:1) for use in lubricants and greases, PIP (3:1)-containing products for use in lubricants and greases, and PIP (3:1)-containing lubricants and greases in 40 CFR part 751.407(b)(ii) to only lubricants and greases for aerospace and turbine engine applications. The Agency is also including a 15-year time limit to the exclusion for manufacturing, processing and distribution in commerce of any other lubricants and greases that contain PIP (3:1) and PIP (3:1)-containing products. The Agency's NPRM proposed a 5-year time limit, however several public commenters raised concerns that they will not have access to these critical products that meet their unique performance criteria, and that alternatives have not yet been identified for all PIP-containing lubricants and greases. Therefore, EPA is extending the phase-out of lubricants and greases from 5 to 15 years so that PIP (3:1) can be phased-out of these products while accounting for the time needed to find suitable alternatives that meet the performance criteria for these industries.

EPA has acknowledged and continues to acknowledge the degree to which PIP (3:1) is a crucial anti-wear component for aerospace lubricants and greases, which need to perform at a wide range of temperatures and pressures. EPA understands there are some non-aerospace uses of these lubricants and greases where PIP (3:1) is a crucial anti-wear component, such as turbines used in power generation or in marine settings (Akin Gump Strauss Hauer & Feld LLP (Akin Gump) 2017). However, uses in non-aircraft machinery and non-turbine equipment may not be subject to these same environmental stresses or safety and performance requirements from industry and government as uses in the aerospace sector. EPA believes a 15-year phase-in prohibition is practicable amount of time for users to research, formulate, and test alternative products for such non-aerospace, non-turbine uses. This timeframe also aligns with the 15-year phase-out for new parts for motor vehicles.

New and replacement parts for motor vehicles. EPA is modifying the exclusion for new and replacement auto parts in 40 CFR 751.407(b)(1)(iii). Specifically, EPA is changing the exclusion for use of PIP (3:1) in new and replacement parts for motor vehicles so that after 15 years, processing and distribution in commerce of PIP (3:1) and processing and distribution of PIP (3:1)-containing products for use in parts, not covered by an exclusion, installed in and distributed as part of new motor vehicles, including heavy motorized machinery, and the parts to which PIP (3:1) has been added for such motor vehicles, including heavy motorized machinery, will be prohibited. Similarly, after such time, the importing, processing, and distribution of motor vehicles, including heavy motorized machinery, that contain PIP (3:1) parts not covered by an exclusion will be prohibited.

EPA is also allowing processing and distribution in commerce for an additional 15 years (i.e., through 30 years after publication date of the final rule), for PIP (3:1) and PIP (3:1)-containing products for use in

replacement parts and PIP (3:1)-containing replacement parts for use in motor vehicles, including heavy motorized machinery. Allowing these parts to be distributed for an additional 15 years is consistent with industry practices, the National Transport and Safety Authority (NTSA) legal requirements and would allow the clearing of these replacement parts through the supply chain. This additional time for processing and distribution of replacement parts does not impose costs on industry and will not be assessed further in this analysis.

EPA generally interprets the term "motor vehicle" to mean a transport vehicle that is propelled or drawn by mechanical power, such as cars, trucks, motorcycles, boats, and construction, agricultural, and industrial machinery. EPA is including a reference to "heavy motorized machinery" in the exclusion to clarify this.

New and replacement parts for aerospace vehicles. EPA is amending the exclusion for new and replacement parts for aerospace vehicles described in 40 CFR 751.407(b)(1)(iii). This includes a prohibition on the processing and distribution in commerce of PIP (3:1) and for processing and distribution in commerce of PIP (3:1)-containing products, for use in new and replacement parts for aerospace vehicles, after 30 years. EPA is prohibiting the manufacture, processing, and distribution in commerce of PIP (3:1) for use in replacement parts for aerospace vehicles, and the replacement parts to which PIP (3:1) has been added for such vehicles that commences after the end of their service lives. The additional time for processing and distribution of replacement parts (until after the end of their service lives) does not impose costs on industry and will not be assessed further in this analysis.

Wire harnesses and circuit boards. EPA is amending 40 CFR 751.407 to include an exclusion for the processing and distribution of PIP (3:1), PIP (3:1)-containing products for use in wire harnesses and circuit boards, and for wire harnesses and circuit boards containing PIP (3:1). This exclusion for use in wire harnesses and circuit boards is based on industry comments provided in response to the March 2021 notification opening a comment period. EPA interprets wire harness to include a broad class of articles, including but not limited to terminal and fuse covers, cable sleeves, casings, connectors and tapes used in a variety of applications, from defense to aerospace and motor vehicle applications, to medical instrumentation and more. In these articles, PIP (3:1) is used as a plasticizer and flame retardant. Hence, EPA is also excluding the processing and manufacturing of PIP (3:1) and PIP (3:1)-containing products for use in adhesives and sealants in electronic component manufacturing.

In the January 2021 PIP (3:1) final rule, EPA finalized a prohibition on the use of PIP (3:1) in adhesives and sealants and PIP (3:1)-containing adhesives and sealants after January 6, 2025. In the March 2022 PIP (3:1), EPA extended the compliance deadline to October 31, 2024 for articles not otherwise addressed by an exclusion or phased-in prohibition. This exclusion for wire-harnesses and circuit boards applies to articles that would have been subject to either the 2024 compliance deadline and certain products subject to the 2025 compliance deadline. EPA is allowing for the exclusion of adhesive and sealants used in or on circuit boards and is thus adding this exclusion to 40 CFR 751.407 (b).

Marine anti-fouling coatings products. EPA is adding a time-limited exclusion for processing and distribution of PIP (3:1) for use in a FIFRA-registered marine anti-fouling coating products for products that meet Department of Defense specification requirements. The January 2021 prohibition on processing and distribution of PIP (3:1) has prohibited the U.S. Navy from procuring PIP (3:1) for use in a FIFRA-registered marine anti-fouling coating products. This time-limited exclusion will allow the Navy to continue to procure PIP (3:1) while it completes its development of an alternative PIP (3:1)-free formulation. EPA is putting in place a five-year compliance deadline for use of PIP (3:1) in a FIFRA-approved marine antifouling coating products.

Manufacturing equipment and semi-conductor manufacturing equipment, new and replacement parts. EPA is amending 40 CFR 751.407(a)(2) to add a compliance deadline of 10 years for processing and distribution in commerce of PIP (3:1)-containing articles for use in new parts installed in equipment in a variety of industries: manufacturing, semiconductor manufacturing, electronic, HVACR and water heating, and power generating. After the January 2021 PIP (3:1) final rule was published, a number of stakeholders from a variety of industrial sectors, including the electronics and electrical manufacturing, semiconductor manufacturing, and equipment and heavy equipment manufacturing equipment, requested an extension of the compliance date to clear the existing articles through the supply chain, find and certify an alternative chemical, and produce or import new articles or complex goods that do not contain PIP (3:1). These stakeholders informed EPA of the use of PIP (3:1) as a flame retardant and plasticizer in plastic components such as wire covers and casings. Other components that were identified, include, but are not limited to, PVC tubes, harnesses, cables, covers, sleeves, and casings, as well as internal components of high-tech robotics and manufacturing equipment, in components in scanning electron microscopes utilized in research, national laboratories, academia, in manufacturing and electronic components utilized for electronic design and assembly, and in electronics and semiconductor manufacturing equipment. EPA is amending the provision to allow the processing and distribution in commerce of PIP (3:1) for use in articles and of PIP (3:1)-containing articles for use in new parts installed in equipment in a variety of industries: manufacturing, semiconductor manufacturing, electronic, HVACR and water heating, and power generating for an additional 10 years. EPA is also amending the recordkeeping for these and other articles that have PIP (3:1) in them, up and until the date of prohibition, in an effort to increase transparency of PIP (3:1) in supply chains.

For associated replacement parts, 40 CFR 751.407(a)(2)(ix) add varying compliance deadlines for parts installed in equipment in a variety of industries: manufacturing, semiconductor manufacturing, electronic, HVACR and water heating, and power generating equipment. This includes prohibiting the processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in manufacturing equipment, including semiconductor manufacturing after the end of the products service life. The processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in electronic equipment is prohibited after 7 years for personal use, 20 years for commercial use, and after the products service life for laboratory use. The rule prohibits the processing and distribution of PIP (3:1) and PIP (3:1)-containing replacement parts in HVACR, water heating equipment, and power generating equipment after 25 years.

Worker protection (PPE) requirements (all Options). To ensure minimal potential for exposure to workers during domestic manufacturing and processing, the owner or operator must demarcate regulated areas from the rest of the workplace in a manner that adequately establishes and alerts persons to the boundaries of the regulated area and minimizes the number of authorized persons exposed to PIP (3:1) within the regulated area. The final rule also requires inhalation and dermal PPE during manufacturing and processing of PIP (3:1) and PIP (3:1)-containing products and articles, which will impact the excluded activities under the 2021 final PIP (3:1) rule and uses with compliance date extensions under this ruling. EPA is not requiring PPE for distribution in commerce, or processing of certain PIP (3:1)-containing articles (i.e., new and replacement parts for motor and aerospace vehicles to which PIP (3:1) has already been added, motor and aerospace vehicles that contain new and replacement parts containing PIP (3:1), PIP (3:1)-containing specialized air filters for locomotive and marine applications, plastic for recycling from products or articles containing PIP (3:1), and finished products or articles made of plastic recycled from PIP (3:1) containing-products or articles) since the handling and processing of these articles would result in minimal potential for worker exposure (U.S. Environmental Protection Agency (EPA) 2020b).

EPA is requiring implementation of a PPE program in alignment with OSHA's General Requirements for Personal Protective Equipment at 29 CFR 1910.132. Consistent with 29 CFR 1910.132 and 29 CFR 1910.134, owners and operators are required to provide PPE, including respiratory and dermal protection of safe design and construction appropriate for the work to be performed. EPA is requiring owners and operators to ensure that each potentially exposed person who is required to wear PPE to use and maintain PPE in a sanitary, reliable, and undamaged condition. Owners and operators are required to select and provide PPE that properly fits each potentially exposed person who is required to use PPE and communicate PPE selections to each affected person.

While EPA is implementing a PPE program in alignment with OSHA, EPA is also prescribing the level of PPE that must be worn based on the information EPA has regarding the adoption of those levels by industry. Where EPA is prescribing the use of PPE, EPA is not supplanting OSHA requirements, but clarifying the level of PPE that EPA believes is practicable under TSCA section 6(h). For the manufacturing and processing of PIP (3:1), and PIP (3:1) products for use in hydraulic fluid, wire harnesses and circuit boards, and articles used in manufacturing equipment and in the semiconductor industry (including in semiconductor manufacturing equipment), EPA is requiring, a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator and chemical resistant gloves that provide an impervious barrier to prevent dermal exposure during expected durations of use and normal conditions of exposure within the workplace. Processing of PIP (3:1)-containing parts to which PIP (3:1) has been added are excluded from this requirement. For the manufacturing of PIP (3:1) and PIP (3:1) products for use in new and replacement parts for motor, including heavy motorized machinery, and aerospace vehicles, EPA is requiring a respirator at least as protective as a NIOSH-approved APF 10, air-purifying filtering facepiece/dust mask respirator (commonly referred to as an N95 mask), and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible. For processing of PIP (3:1) and PIP (3:1)-containing products for use in the manufacturing of cyanoacrylate adhesives, EPA is requiring respiratory protection which must be at least as protective as a NIOSH-approved APF 50 respirator, except when the PIP (3:1) or PIP (3:1)-containing product is contained in a closed-system. For the use of PIP (3:1) in the manufacturing of specialized engine filters for locomotive and marine applications, EPA is requiring that workers be provided half or full respirators and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible. Based on stakeholder comments (Daikin Industries 2019) and OSHA required Safety Data Sheets, EPA believes these levels of protection are used as industry best practices, although EPA lacks sufficient information to determine the scale of adoption.

While EPA is requiring PPE in alignment with OSHA, EPA is also prescribing the level of PPE that must be worn where EPA has information regarding the adoption of those levels by industry. For industries in which EPA believes PPE is industry standard, EPA is codifying existing industry practice. For those in which EPA believes PPE is used by some workers, but not widely adopted, EPA is prescribing PPE. Where EPA is prescribing the use of PPE, EPA is not supplanting OSHA requirements, but clarifying the level of PPE that EPA believes is practicable under TSCA section 6(h). EPA's requirements are as follows:

- For the manufacturing and processing of PIP (3:1), and PIP (3:1)-containing products for use in hydraulic fluid, wire harnesses and circuit boards, and articles used in manufacturing equipment, including semiconductor manufacturing, electronic, HVACR and water heating, and power generating equipment, EPA is requiring, at a minimum, a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator and chemical resistant gloves that provide an impervious barrier to prevent dermal exposure during expected durations of use and normal conditions of exposure within the workplace.

- For the manufacturing of PIP (3:1) and PIP (3:1) products for use in new and replacement parts for motor, including heavy machinery, and aerospace vehicles, EPA is requiring a respirator at least as protective as a NIOSH-approved APF 10, air-purifying filtering facepiece/dust mask respirator (commonly referred to as an N95 mask), and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible.
- For the manufacturing and processing of PIP (3:1) and PIP (3:1) containing products for use in lubricants and greases and as an intermediate in the closed loop production of cyanoacrylate adhesives, EPA is requiring, at a minimum, a respirator at least as protective as a NIOSH-approved APF 50 and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible.
- For the use of PIP (3:1) in the manufacturing of specialized engine filters for locomotive and marine applications, EPA is requiring that workers be provided half or full respirators and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible.

For APF 10 respirators, EPA is requiring that the owner or operator must ensure that all respirators used in the workplace are NIOSH-approved as listed on the NIOSH Certified Equipment List. In choosing appropriate gloves, EPA is requiring that owners and operators consider effectiveness of glove type when preventing exposures from PIP (3:1) alone and in likely combination with other chemical substances used in the work area, degree of dexterity required to perform tasks, and temperature, as identified in the Hand Protection section of OSHA's Personal Protective Equipment guidance (Occupational Safety and Health Administration (OSHA) 2004). EPA is requiring owners and operators in these manufacturing and processing uses to provide and require wearing of the specified PPE to persons potentially exposed to PIP (3:1) or PIP (3:1)-containing products or articles.

EPA is requiring each owner or operator comply with OSHA's general PPE training requirements at 29 CFR 1910.132 and 29 CFR 1910.134 for selection, proper use, maintenance and training when using respirators and gloves. EPA is requiring that owners and operators provide PPE training to each potentially exposed person who is required to wear PPE prior to or at the time of initial assignment to a job involving potential exposure to PIP (3:1). Owners and operators also have to re-train each affected person at least once annually or whenever the owner or operator has reason to believe that a previously trained person does not have the required understanding and skill to properly use PPE, or when changes in the workplace or in the PPE to be used render the previous training obsolete.

EPA requires that owners and operators document in the PPE program the following information, as applicable:

(A) The name, workplace address, work shift, job classification, and work area of each person reasonably likely to directly handle PIP (3:1) or handle equipment or materials on which PIP (3:1) may present and the type of PPE selected to be worn by each of these persons;

(B) The basis for PPE selection (e.g., demonstration based on permeation testing or manufacturer specifications that each item of PPE selected provides an impervious barrier to prevent exposure during expected duration and conditions of exposure, including the likely combinations of chemical substances to which the PPE may be exposed in the work area); and

(C) Appropriately sized PPE and training on proper application, wear, and removal of PPE, and proper care/disposal of PPE.

EPA is requiring each owner or operator supply PPE, selected in accordance with this unit, to each potentially exposed person within 60 days after publication of the final rule.

Cyanoacrylate adhesives. EPA is requiring engineering controls for the use of PIP (3:1) in the manufacturing of cyanoacrylate adhesives. EPA is requiring engineering controls for the use of PIP (3:1) as an intermediate in the production of cyanoacrylate adhesives such that the processing of PIP (3:1) must take place in a closed loop and general and local area ventilation must be provided.

Primary Alternative Option – PIP (3:1)

EPA considered an alternative regulatory action that would modify the existing exclusions as follows.

Lubricants and greases. EPA considered a 5-year time limit on manufacturing (including import) and processing of PIP (3:1) for end use lubricants and greases, with a prohibition on manufacturing, processing, and industrial/commercial use occurring at 5 years.

Wire harnesses and circuit boards. EPA considered a 20-year time limit on manufacturing (including import) for PIP (3:1) used for wire harnesses and electric conduit boards. EPA also considered a 20-year time limit on manufacturing (including import), processing, and distribution and commerce for PIP (3:1) present in wire harnesses and electric conduit boards. Articles with an end use in new and replacement parts vehicles would be exempt from this time limit.

Manufacturing equipment and semi-conductor manufacturing equipment, new and replacement parts. EPA considered a 20-year time limit on manufacturing (including import) for PIP (3:1) used for manufacturing equipment, and in the semiconductor industry. EPA also considered a 20-year time limit on manufacturing (including import), processing, and distribution and commerce for PIP (3:1) present in in the semiconductor manufacturing industry and electronic, HVACR and water heating, and power generating equipment manufacturing.

3. Profile of Affected Industries and Entities (Baseline)

This chapter provides background information on the industry sectors and entities potentially affected by the final rule.

3.1 Key Data Sources

Data used in this chapter are primarily sourced from EPA's Chemical Data Reporting (CDR), from the proprietary Descartes Datamyne database, D&B Hoovers database, and Experian's TargetIQ database. These sources, and their limitations, are described below.

Other secondary sources and contacts with industry representatives were also used to provide data. These other data sources were used as described in each applicable section.

Chemical Data Reporting (CDR)

The CDR rule under TSCA requires manufacturers (including importers) to provide information to EPA every four years on the chemicals they manufacture or import into the United States. Table 3-1, below, presents the various conditions under which a facility subject to TSCA must report to CDR. Typically, a manufacturer is required to report any volume above 25,000 pounds, while small manufacturers[12] are only required to report any volume above 100,000 pounds. However, the chemicals regulated under this rulemaking are subject to a 2,500 lbs. reporting threshold, with no small manufacturer exemption, because they are already regulated under a TSCA section 6 rule. Data collected under CDR for each chemical include the company name, volume of each chemical manufactured/imported, the number of workers at each site, and information on whether the chemical is used in the industrial, commercial, and/or consumer sector. Exemptions apply to small manufacturers. CDR can be accessed at https://www.epa.gov/chemical-data-reporting.

Table 3-1: Conditions Under Which a Company Must Report to CDR

TSCA Action	Subject to 25,000 lbs. reporting threshold	Subject to 2,500 lbs. reporting threshold	Not eligible for certain full or partial exemptions from reporting	Not eligible for small manufacturer exemption
Not subject to TSCA action	✓			
TSCA section 4 rules (proposed or promulgated)	✓		✓	✓
Enforceable Consent Agreements (ECAs)	✓		✓	
TSCA section 5(a)(2) SNURs (proposed or promulgated)		✓	✓	
TSCA section 5(b)(4) rules (proposed or promulgated)		✓	✓	✓
TSCA section 5(e) orders		✓	✓	✓
TSCA section 5(f) orders		✓	✓	
TSCA section 5 civil actions		✓	✓	✓
TSCA section 6 rules (proposed or promulgated)		✓	✓	✓

Source: U.S. Environmental Protection Agency (EPA) 2017c)
Note: Shaded row is applicable to decaBDE and PIP (3:1)

[12] The definition of a small manufacturer varies depending on the sector in which it operates.

Descartes Datamyne Database

Datamyne collects import data on shipments into the United States and provides information on each shipment. Datamyne is a commercial searchable trade database that covers the import-export data and global commerce of more than 50 countries across five continents (approximately 85% of the world's import trade by value) and includes the cross-border commerce of the United States with over 230 trading partners (Descartes Datamyne 2023). The trade data are gathered from U.S. Customs Automated Manifest System. For this analysis, EPA queried the database for bills of lading related to each of the chemicals subject to the rule as described in the sections below. Due to the nature of Datamyne data, some shipments containing the chemical of concern may be excluded due to being categorized under other names that were not included in the search terms. There also may be typos in the data that prevent shipment records containing the chemical from being located. Datamyne does not include articles/products containing the chemical unless the chemical name is included in the description of the article/product.

D&B Hoovers

Business statistics (revenue and number of employees) for some companies were gathered using the proprietary Dun & Bradstreet (D&B) Hoovers database, a comprehensive information source containing entries on over 120 million companies. The data may be limited by how recently each company's information is updated; entries vary by company.

Experian

Business statistics (revenue and number of employees) for some companies were gathered using the Experian Business TargetIQ database, which provides comprehensive, third-party verified information on 99.9 percent of all U.S. companies and millions of companies worldwide. Experian receives public record information from government and vendor sources on a daily, weekly, monthly or quarterly schedule. Once Experian receives public record updates from the government or vendor sources, turnaround time for formatting, cleansing and loading data is generally 48 to 72 hours.

Census: Statistics of U.S. Businesses (SUSB)

The Statistics of U.S. Businesses (SUSB) is an annual series by the United States Census Bureau that provides national and subnational data on the distribution of economic data by enterprise size and industry. Data are presented by geographic area, industry detail, and enterprise size. Annual data consist of number of firms, number of establishments, employment during the week of March 12 for a given year, and annual payroll. In addition, receipts data are included for years ending in 2 or 7 (i.e., 2007, 2012, 2017, 2022 etc.). The series generally covers all U.S. business establishments with paid employees. The SUSB covers all NAICS industries except crop and animal production; rail transportation; postal service; pension, health, welfare, and vacation funds; trusts, estates, and agency accounts; office of notaries; private households; and public administration. The SUSB also excludes most government employees. Tabulations providing data by employment size of enterprise have been assembled as far back as 1989. These data were developed in cooperation with, and partially funded by, the Office of Advocacy of the U.S. Small Business Administration (SBA). SUSB can be accessed at: https://www.census.gov/programs-surveys/susb.html.

3.2 Decabromodiphenyl ether (DecaBDE)

3.2.1 Manufacture/Import

In December 2009, the largest producers and suppliers of decaBDE in the United States committed to end their production, imports, and sales for all uses of the chemical by the end of 2013 (U.S. Environmental Protection Agency (EPA) 2014a). Data from the 2016 CDR shows that production of decaBDE has dropped dramatically from 2006 to 2016, and continued at a low level through 2019, supporting this commitment. Table 3-2 presents the historical production volume of decaBDE from the Inventory Update Rule (IUR) and CDR from 1986 to 2019.

Table 3-2: 1986 to 2019 National Production Volume Data for DecaBDE

Year	Non-Confidential Production Volume in Pounds
1986 to 2002	10 to 100 M
2006	50 to 100 M
2011	18,110,827
2012	10 to 50 M
2013	1 to 10 M
2014	100 to 500 K
2015	<25 K
2016	<1 M
2017	<1 M
2018	<1 M
2019	<1 M

Note: M = million, K = thousand
Sources: (U.S. Environmental Protection Agency (EPA) 2010b; U.S. Environmental Protection Agency (EPA) 2017a; U.S. Environmental Protection Agency (EPA) 2020a)

According to the most recent CDR data collection (2020), decaBDE was manufactured or imported by three companies in the United States for Reporting Year (RY) 2019. Table 3-3 presents these manufacturers or importers of decaBDE. The information presented in this table does not represent all of the facilities potentially manufacturing, producing, and/or using decaBDE because only certain industries and types of facilities are required to report to CDR, though EPA does not expect for there to be any companies manufacturing decaBDE below the reporting thresholds.[13]

Based on the CDR data, domestic manufacture of decaBDE has ceased, but decaBDE may continue to be imported to the United States. The 2020 CDR data indicate that import volume increased from 2018 to 2019; however, EPA notes that the identified importers have likely since stopped using decaBDE. One of the importers, Rockland Industries, was expected to cease use of decaBDE by July 2022 as, all persons are prohibited from all manufacture, processing and distribution in commerce of decaBDE for use in curtains in the hospitality industry under the 2021 final rule (40 CFR § 751.405(a)(2)(i)). The other identified importer, Metals and Additives LLC is a private holding company for Polymer Additives Group the manufacturer of BroFlam DB-17, a flame retardant containing decaBDE (Polymer Additives Group 2018), but which is no longer sold in the United States or anywhere else (Ficarro 2022).

[13] Please refer to Section 3.1 for information on who is required to report to CDR.

Table 3-3: U.S. Manufacturers and Importers of DecaBDE (CAS RN 1163-19-5)								
Parent Company	**Site**	**Manufacture or Import**	**Manufactured Volume (2019) (lbs./yr)**	**Imported Volume (2019) (lbs./yr)**	**Past Production Volume (2018) (lbs./yr)**	**Type of Process or Use**	**Industrial Sector**	**Category of Use**
Rockland Industries, Inc.	Rockland Bamberg Industries 253 Calhoun Street Bamberg, SC 29003	Import	0	176,367	132,275	Processing-incorporation into article	Textiles, apparel, and leather manufacturing	Flame retardant
Metals and Additives LLC (dba Omni Oxide)	Omni Oxide Indiana Oxide 10665 N St Rd 59 Brazil, IN 47834	Import	0	22,046	4,409	Processing-incorporation into formulation, mixture, or reaction product	Plastics Material and Resin Manufacturing	Flame retardant
CBI	CBI	CBI	CBI	CBI	CBI	Processing-incorporation into formulation, mixture, or reaction product	Plastics Material and Resin Manufacturing	Flame retardant
Source: U.S. Environmental Protection Agency (EPA) 2020a								

For additional importer data, the Datamyne database was queried for records from 2021[14] to September 2022 using "decabromodiphenyl* ANDNOT ethane*" as a search term in order to limit false hits. Results are provided in Table 3-4. Due to the nature of Datamyne data, some shipments containing decaBDE may be excluded due to being categorized under different chemical names or synonyms. There also may be typos in the data that prevent shipment records containing decaBDE from being located. Import data do not include imported articles that contain decaBDE, which could constitute another potential portion of decaBDE entering the United States. There also may be typos in the data that prevent shipment records containing decaBDE from being located. Import data do not include imported articles that contain decaBDE, which could constitute another potential portion of decaBDE entering the United States. The total weight represents the shipment weight, not the weight of decaBDE specifically.

Table 3-4: U.S. Importers of DecaBDE, 2021 to 2022

Consignee Declared (Importer)	Use Category	Number of Shipments			
		March to December 2021	Total Weight (kg)	January to September 2022	Total Weight (kg)
MB TECHNOLOGY INC	Roofing systems	1	3,580	1	10,200
PACIFIC COAST ENTERPRISE, INC.	Distribution (textiles)	1	18,300	0	0
SANKO U.S.A., INC.	Chemical manufacturer (including flame retardants)	1	20,260	0	0
Grand Total		**3**	**42,140**	**1**	**10,200**

Based on Datamyne data, import of decaBDE into the United States decreased significantly in recent years and is believed to have now ceased. The only import of the chemical from January to September 2022 was for use in roofing systems. Use of decaBDE in building and construction materials (such as roofing systems) and in textiles was prohibited under the 2021 final rule.

3.2.2 Regulated Uses

DecaBDE is considered the most effective of the brominated flame retardants for certain uses. Flame retardants have been used in a variety of industries and applications to prevent a fire from occurring or slow down the spread of a fire. Because relatively small quantities of decaBDE are required for outstanding flame retardant properties, it has minimal influence on the physical and mechanical properties of the product in which it is used (IHS Specialty Chemicals Update Program (IHS SCUP) 2014).

EPA's economic analysis for the January 2021 final rule described the historical uses of decaBDE as well as the uses that were currently ongoing during the development of that rule. The 2021 final rule prohibited several of those ongoing uses. This economic analysis focuses on certain remaining ongoing uses that EPA is regulating in this rulemaking, as described in the following subsections.

Plastic Shipping Pallets

Recycled plastics containing decaBDE are used in the manufacturing of plastic shipping pallets by Intelligent Pooling Systems Company LLC ("iGPS"). iGPS provides a pallet rental service using plastic shipping pallets. In order to meet U.S. fire safety standards, the pallets that iGPS originally purchased used a polymeric composite matrix that contains small quantities of decaBDE; decaBDE was only added to this first generation of pallets. iGPS' business model focuses on the recycling of damaged pallets. Damaged pallets are removed from service and disassembled so that the plastic can be remolded into

[14] EPA used March 8, 2021 as a start date for the Datamyne query, consistent with the compliance date of the January 2021 rule. The September 19, 2022 end date reflects the most recent available information on the date of the query.

replacement pallets. No additional decaBDE is added during the recycling process; the decaBDE that is present in a recycled pallet is due only to the recycled content. In a public comment on the proposed rule, iGPS stated that the pallets from the Company's original pallet fleet containing decaBDE are visually indistinguishable from those that have been newly formed (or reformed) as part of the business' recycling operations. Thus, iGPS cannot distinguish which pallets in its fleet contain decaBDE without performing chemical testing on each pallet (iGPS 2024). iGPS would have to sample its pallets to determine which ones contain decaBDE, these figures would need to be used to calculate the costs of testing all pallets in a multi-million pallet fleet. The foregoing does not include the prohibitive expense of manually labeling and re-labelling shipping pallets. iGPS has previously estimated the pallet labelling requirements EPA has proposed would impose additional costs approaching $10 million to implement. The additional costs of testing, storage, and movement of pallets alone is greater than the asset value of the fleet of pallets many times over. With the added burden of labelling each pallet, these figures would further skyrocket (iGPS 2024).

Another public commenter, the Institute of Scrap Recycling Industries, Inc. (ISRI), noted that recyclers that receive plastic pallets for recycling are in no position to determine whether an unlabeled pallet contains decaBDE (Institute of Scrap Recycling Industries 2024). iGPS does not apply labels (or replace damaged labels) to its shipping pallets when they pass through a facility. iGPS originally distributed pallets with adhesive labels containing the pallets' serial numbers but moved away from this approach as they became illegible due to the rigorous conditions to which pallets are routinely subjected (iGPS 2024). Embedded radio frequency identification devises (RFID technology) enable the iGPS pallets to be traced and tracked (iGPS 2021).

iGPS relies on a third-party recycler to recycle its pallets in accordance with specific procedures[15], at one facility, located in the United States. To clean the ambient air of the facility, they use a dual-stage industrial air filtration system comprising a pre-filter which effectively removes particles of 3 microns and greater at up to 70% efficiency, and the main bag filter which captures submicron particles down to 0.3 microns at an efficiency of 95%. They use a closed-loop remanufacturing process to ensure that recycled content from pallets is used only in the production of more pallets, and not diverted for use in manufacturing of other goods (iGPS 2021). PPE for workers involved in the recycling process are safety glasses, gloves, N95 masks, and ear plugs (iGPS 2022).

An independent study provided to the Agency documented that there is no transfer of decaBDE from the pallets to the packaging of goods carried on these platform (Environ International Corporation 2009); this rule focuses only on the recycling activity (not on use of the pallets).

iGPS is the only specific company confirmed by the EPA to be associated with this use. Therefore, in estimating the number of entities affected by this rule, EPA assumes one company (the unidentified third-party recycler is assumed to operate under iGPS' auspices).

Table 3-5: Business Statistics for Company Associated with Plastic Shipping Pallets

Company	Parent Company	NAICS	Parent Number of Employees	Revenue (2022$, Millions USD)
iGPS Logistics LLC	iGPS Logistics LLC	532490 Other Commercial and Industrial Machinery and Equipment Rental and Leasing	60	$45

[15] See iGPS 2015, General iGPS Pallet Procedure Overview.

Source: (Dun & Bradstreet 2022)

Recycling of DecaBDE-containing Plastic

Historically, decaBDE was widely used in plastics as a general-purpose additive flame retardant. Many plastic products and articles that contain decaBDE are commonly recycled in the United States. High-impact polystyrene (HIPS), polyethylene, polypropylene, polybutylene terephthalate, and unsaturated polyesters were the most common plastics treated with decaBDE (Alaee et al., 2003; BSEF, 2006 as cited in EPA Exposure Assessment of PBDE, 2010, pg. 2-7 and 2-8). Polyethylene plastics are used in the insulation of wire and cables of electrical equipment. Polypropylene plastics are used in communication cables, capacitor films, building cables, pipes, stadium seats, lamp sockets and holders, and kitchen hoods. Polybutylene terephthalate plastics are used as connectors in electrical and electronic equipment. Unsaturated polyesters are used in building and construction materials as reinforced plastic panels.

Recycling includes any activity that attempts to reclaim either decaBDE or the components in which decaBDE is applied or bound. Given the prominence of decaBDE in past years, it is expected to be present in recycled materials. A 2018 study found that 92% of the e-waste samples tested contained decaBDE at concentrations ranging from 1 to 3,310 ppm (Strakova 2018). While these levels are well below the percent at which decaBDE is used intentionally as flame retardant (120,000 ppm for most applications), decaBDE can persist through recycling processes for some time (Weil and Levchik 2016).

The industries listed in Table 3-6 may be associated with recycling of decaBDE-containing plastic from products or articles and decaBDE-containing products or articles made from such recycled plastic, where no new decaBDE is added during the recycling process.

Table 3-6: Industry Sectors Associated with Recycling of DecaBDE-containing Plastic

NAICS Code	NAICS Description	Number of firms in NAICS
325991	Custom Compounding of Purchased Resins	340
3261	Plastics Product Manufacturing	7,550
562920	Materials Recovery Facilities	1,004
Total		**8,894**

Source: (U.S. Census Bureau 2020)

Replacement Parts for Use in Aerospace Vehicles

According to the Aerospace Industry Association (AIA), decaBDE is used as a fire proofing and protective coating on some fixed and/or rotary wing aircraft, and in aircraft interiors materials applications to protect against and suppress fire aboard the aircraft (Aerospace Industries Association (AIA) 2019). Some large aerospace companies, such as Boeing, have already phased decaBDE out of use (U.S. Environmental Protection Agency (EPA) 2017d). AIA stated that it believes that the phase-out of decaBDE from new products in the aerospace industry as a whole would be achieved by 2023 (Aerospace Industries Association (AIA) 2019); the 2021 final rule allows until January 8, 2024 to cease manufacture, processing and distribution in commerce of decaBDE for use in parts installed in and sold as part of new aerospace vehicles, and of the parts to which decaBDE has been added for such vehicles.

However, as EPA stated in the preamble to the 2021 final rule (86 FR 888, January 6, 2021), the decaBDE-containing parts produced for aerospace vehicles before January 2024 may require replacement parts to meet flame-retardancy standards through the end of the service lives of the vehicles. Any transition to alternatives for those replacement parts will require verification to meet these standards. Imposing immediate restrictions on replacement parts for those vehicles could have increased costs and safety concerns, but, without meaningful exposure reductions. Therefore, EPA adopted, in the 2021 final

rule, the compliance deadline of the end of the service lives for aerospace vehicles from the prohibition on the manufacture (including import), processing, and distribution in commerce of decaBDE for use in aerospace replacement parts, and the replacement parts that contain decaBDE.

For the purpose of this rule, replacement parts are those parts designed before January 6, 2021 to replace parts already made with decaBDE. Under the 2021 final rule, EPA does not allow replacement parts containing decaBDE to be manufactured, processed, or distributed in commerce to replace parts that were not previously designed to contain decaBDE.

The rule will affect U.S. workers during the manufacturing and processing of decaBDE-containing replacement parts for use in aerospace vehicles by requiring PPE. EPA is not requiring PPE for distribution in commerce of decaBDE-containing articles nor for processing of aerospace parts to which decaBDE has been added, since the processing and distribution in commerce of these decaBDE-containing articles will result in minimal potential for worker exposure. Given that there is no domestic manufacture of aerospace vehicle replacement parts containing decaBDE (that is, they are all imported), there are no companies and no industry sectors associated with this activity.

The industries listed in Table 3-7 may be associated with import/export of replacement parts for aerospace vehicles.

Table 3-7: Industry Sectors Associated with Replacement Parts for Aerospace Vehicles

NAICS Code	NAICS Description	Number of firms in NAICS
336412	Aircraft Engine and Engine Parts Manufacturing	321
336413	Other Aircraft Part and Auxiliary Equipment Manufacturing	738
336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	17
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	31
Total		**1,107**

Source: (U.S. Census Bureau 2020)

Replacement Parts for Motor Vehicles

The Alliance of Automobile Manufacturers (Auto Alliance) has provided evidence to suggest that decaBDE-containing articles are imported into the United States in the form of automobile replacement parts. A wide array of auto parts have historically contained decaBDE as a flame retardant to meet safety standards. While the Auto Alliance has claimed that no production parts contain decaBDE any longer except for wire and cable assemblies, automakers are required by law to maintain replacement parts for fifteen years after production has ceased. As such, there are likely ongoing imports to support automakers in abiding by these laws (Alliance of Automobile Manufacturers (Auto Alliance) 2018).

This rule affects U.S. workers during the manufacturing and processing of decaBDE-containing replacement parts for use in motor vehicles by requiring PPE. EPA is not requiring PPE for distribution in commerce of decaBDE-containing articles nor for processing of motor vehicle parts to which decaBDE has been added, since the processing and distribution in commerce of these decaBDE-containing articles will result in minimal potential for worker exposure. Given that there is no domestic manufacture of motor vehicle replacement parts containing decaBDE (that is, they are all imported), there are no companies and no industry sectors associated with this activity.

The industries listed in Table 3-8 may be associated with import/export of replacement parts for motor vehicles.

Table 3-8: Industry Sectors Associated with Replacement Parts for Motor Vehicles		
NAICS Code	**NAICS Description**	**Number of firms in NAICS**
336211	Motor Vehicle Body Manufacturing	609
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	656
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing	528
336390	Other Motor Vehicle Parts Manufacturing	1,090
336991	Motorcycle, Bicycle and Parts Manufacturing	378
336999	All Other Transportation Equipment Manufacturing	389
Total		**3,650**

Wire and Cable Insulation in Nuclear Power Generation Facilities

DecaBDE can be used as a flame retardant in the rubber casings of electrical wires and cables. DecaBDE has been used in Class 1E cables, which are qualified to meet industry standards and the Nuclear Regulatory Commission's (NRC) requirements in 10 CFR 50.49, "Environmental qualification of electric equipment important to safety for nuclear power plants," including the Institute of Electrical and Electronics Engineers 383 ("IEEE 383") standard for instrumentation and power cable insulation. Communications with the National Electronic Manufacturer's Association (NEMA) and RSCC Wire and Cable indicate that RSCC is the only remaining user of decaBDE for this application, and that the decaBDE-containing wire and cable is currently only used in wire and cable insulation in nuclear power generation facilities (U.S. Environmental Protection Agency (EPA) 2018d).

Under the 2021 final rule, for any processing and distribution in commerce of decaBDE for use in decaBDE-containing wire and cable insulation, and the decaBDE-containing wire and cable insulation, in nuclear power generation facilities was to be prohibited by January 6, 2023. However, the only known supplier, RSCC, has been permitted to resume these activities for a limited time under a settlement agreement (U.S. Environmental Protection Agency (EPA) 2023a). In addition, this company has already begun transitioning to a decaBDE-free alternative and only requested an extension until April 30, 2024 which EPA expects will be before this rulemaking is finalized (U.S. Environmental Protection Agency (EPA) 2023a). Another company, Prysmian Group, indicated that they have already taken steps to reformulate its products for the nuclear power generation industry to eliminate decaBDE, with some formulations decaBDE-free since 2014 (Prysmian Group North America 2024).

In a public comment on the proposed rule, the Nuclear Energy Institute (NEI) estimated that there may be approximately 450 miles of decaBDE-containing cable and approximately 2,000 decaBDE-containing components installed in each of the 92 units that were in operation at that time (Nuclear Energy Institute 2024). NEI outlined a number of specific reuse practices, including production of new components that incorporate decaBDE-containing wire and cable that has not reached the end of its service life and rewiring of existing components utilizing decaBDE-containing wire and cable that has not reached the end of its service life.

Table 3-9: Business Statistics for Company Associated with Wire and Cable Insulation in Nuclear Power Generation Facilities				
Company	**Parent Company**	**NAICS**	**Parent Number of Employees**	**Revenue (2022$, Millions USD)**
RSCC Wire and Cable	Berkshire Hathaway Inc	335921 Fiber Optic Cable Manufacturing	372,000	$276,094
Source: (Experian 2023)				

3.3 Phenol, isopropylated, phosphate (3:1) (PIP (3:1))

3.3.1 Manufacture/Import

Table 3-10 presents the historical U.S. production volume of PIP (3:1) as reported though the IUR and CDR from 1986 to 2020. Overall, national production of PIP (3:1) has trended downward, with a notable drop between 2011 and 2012. For the 2020 CDR submission period, production held steady at between 1 and 10 million pounds.

Table 3-10: 1986 to 2019 National Production Volume Data for PIP (3:1)

Year	Non-Confidential Production Volume in Pounds
1986 to 2002	>10M to 50M
2006	10 to > 50 M
2010	12,362,683
2011	14,932,040
2012	3,191,017
2013	2,968,861
2014	5,632,272
2015	5,951,318
2016	1 M to < 10 M
2017	1 M to < 10 M
2018	1 M to < 10 M
2019	1 M to < 10 M

Note: M = Million
Sources: (U.S. Environmental Protection Agency (EPA) 2010b; U.S. Environmental Protection Agency (EPA) 2017a; U.S. Environmental Protection Agency (EPA) 2020a)

According to the 2020 CDR data, PIP (3:1) was manufactured or imported by nine facilities in the United States from 2016 to 2019 . Table 3-11 presents the publicly available information on the PIP 3:1) from the 2020 CDR. The information presented in Table 3-11 may not represent all of the facilities potentially manufacturing or using PIP (3:1); only certain industries and types of facilities are required to report to CDR.[16]

[16] Please refer to Section 3.1 for information on who is required to report to CDR.

Table 3-11: U.S. Manufacturers and Importers of PIP (3:1)							
Parent Company	**Site**	**Manufacture or Import**	**Manufactured Volume (2019) (lbs./yr)**	**Imported Volume (2019) (lbs./yr)**	**Type of Process or Use**	**Industrial Sector**	**Category of Use**
ChemSpec, Ltd.	Chemspec, Ltd. 1559 Corporate Woods Pkwy, Suite 150 Uniontown, OH 44685	Import	0	34,392	Processing as a reactant	Plastics Material and Resin Manufacturing	Flame retardant
ICL Specialty Products North America Inc.	ICL-IP America Inc. 11636 Huntington Road Gallipolis Ferry, WV 25515	Manufacture	CBI	0	Processing-incorporation into formulation, mixture, or reaction product	Plastics Material and Resin Manufacturing	Flame retardant
						Transportation Equipment Manufacturing	Hydraulic fluids
Klüber Lubrication North America L.P.	Kluber Lübrication NA LP32 Industrial Drive Londonderry, NH 03053-2008	NR	0	0	NR	NR	NR
Lanxess Corporation	Lanxess Solutions---Shelton 2 Armstrong Rd Shelton, CT 06484	Import	CBI	CBI	Processing-incorporation into formulation, mixture, or reaction product	Petroleum Lubricating Oil and Grease Manufacturing	Lubricating agent
						Plastics Product Manufacturing	Flame retardant
					Processing-incorporation into article	Furniture and Related Product Manufacturing	Flame retardant
						Other (requires additional information)	Hydraulic fluids
Metals and Additives LLC Dba Omni Oxide	Omni Oxide Indiana Oxide 10665 N St Rd 59 Brazil, IN 47834	Import	0	28,043	Processing-incorporation into formulation, mixture, or reaction product	Plastics Material and Resin Manufacturing	Flame retardant
NYCO America LLC	NYCO America LLC 87 Amlajack Way Shenandoah Industrial Park Newnan, GA 30265	Import	CBI	CBI	Use-non-incorporative activities	Petroleum Lubricating Oil and Grease Manufacturing	Lubricants and lubricant additives

Table 3-11: U.S. Manufacturers and Importers of PIP (3:1)							
Parent Company	**Site**	**Manufacture or Import**	**Manufactured Volume (2019) (lbs./yr)**	**Imported Volume (2019) (lbs./yr)**	**Type of Process or Use**	**Industrial Sector**	**Category of Use**
Special Materials Company	Special Materials Company 70 West 40th Street New York, NY 10018	Import	CBI	CBI	Not Known or Reasonably Ascertainable	Not Known or Reasonably Ascertainable	Flame retardant
St. Louis Group	St. Louis Group HQ 8888 Keystone Xing Indianapolis, IN 46240	CBI	CBI	CBI	Processing-incorporation into formulation, mixture, or reaction product	Rubber Product Manufacturing	Flame retardant
						Wood Product Manufacturing	
						Asphalt Paving, Roofing, and Coating Materials Manufacturing	
						Plastics Material and Resin Manufacturing	
						Synthetic Rubber Manufacturing	
						Paint & Coating Manufacturing	
						Plastics Product Manufacturing	
						Construction	
						Transportation Equipment Manufacturing	
						Custom Compounding of Purchased Resins	
Univar Solutions	Chempoint 411 108th Ave NE Bellevue, WA 98004	NR	0	0	NR	NR	NR
Notes: CBI = Confidential Business Information; NR = Not reported							

For additional importer data, the Datamyne database was queried for records from 2021[17] to September 2022 using "phenol isopropylated phosphate" as a search term (see Table 3-12). Due to the nature of Datamyne data, some shipments containing PIP (3:1) may be excluded due to being categorized under different chemical names or synonyms. There also may be typos in the data that prevent shipment records containing PIP (3:1) from being located. By far, the most significant category of products reported as being imported is PIP (3:1) in vehicles (motor and marine vehicles, and motorcycles), associated with the Suzuki company.

Table 3-12: U.S. Importers of PIP (3:1), 2021 to 2022[1]

Consignee Declared (Importer)	Use Category	Number of Shipments	
		March to December 2021	January to September 2022
Interamericana Trading *[Freight Management Service]*	**New and Replacement Parts for Motor Vehicles** (Suzuki Motor Corporation)	0	20
Lanxess Solutions US Inc.	**Lubricants and Greases** (includes shipments of Reolube 140, Reofos 65)	0	4
Livingston International *[Customs broker]*	**Lubricants and Greases** (includes shipments of Reolube 140, Reofos 65, Reofos 1800)	14	21
Lubrizol Advance Materials	**Lubricants and Greases** (includes shipments of Reofos 65)	4	0
McCain International Inc.	**New and Replacement Parts for Motor Vehicles** (from Suzuki Motorcycles)	0	2
Montgomery Motors Ltd.	**New and Replacement Parts for Motor Vehicles** (from Suzuki Motor Corporation)	4	6
NYCO America	**Aviation Hydraulic Fluid** **Lubricants and Greases (AVIATION ONLY)** (includes Turbonycoil 160)	3	10
Quaker Chemical Corporation	**Lubricants and Greases**	0	2
Santo Domingo Motors Co. S.A.	**New and Replacement Parts for Motor Vehicles** (from Suzuki Motors)	1	4
Suttons International N.A. Inc. *[Freight Management Service]*	**Lubricants and Greases** (includes shipments of Reolube 140, Reofos 65, Reofos 1800)	4	10
Suzuki Marine USA, LLC	**New and Replacement Parts for Motor Vehicles**	225	764
Suzuki Motor USA, LLC	**New and Replacement Parts for Motor Vehicles**	69	197
Not Declared	**Unknown**	44	13
Total		**368**	**1,053**

Notes:
[1]March 8, 2021 to September 19, 2022
Datamyne original search results were cleaned to exclude imports of other chemicals besides PIP (3:1).
Source: (Descartes Datamyne 2023)

3.3.2 Regulated Uses (Processing and Distribution)

PIP (3:1) functions in industry as a flame retardant, plasticizer, anti-compressibility additive, anti-wear additive, or some combination of functions (U.S. Environmental Protection Agency (EPA) 2020b). PIP (3:1) is incorporated into articles, used as a chemical processing or manufacturing aid, and can be

[17] EPA used March 8, 2021 as a start date for the Datamyne query, consistent with the compliance date of the January 2021 rule. The September 19, 2022 end date reflects the most recent available information on the date of the query.

incorporated into formulations, mixtures or reaction products (U.S. Environmental Protection Agency (EPA) 2020b). PIP (3:1) is incorporated into various end-use products across industries and is also used as an additive that can be combined with other formulated products.

PIP (3:1) is marketed as a flame retardant/plasticizer additive by two of the manufacturers identified in Table 3-12, ICL-IP and Lanxess, as follows. The extent that any of these additive products is used in any of the specific uses described below is unknown.

- **Phosflex 31L:** flame retardant/plasticizer by ICl-IP. Used primarily in PVC formulations, may be applied in other resin systems as well (ICL-Industrial Products 2017a)
- **Phosflex 41 L:** flame retardant/plasticizer by ICL-IP. Used primarily in PVC formulations, may be applied in other resin systems as well (ICL-Industrial Products 2010)
- **Reofos 35:** a flame retardant by Lanxess used in plastisols and coated fabrics (LANXESS 2017f)
- **Reofos 65:** flame retardant/plasticizer by Lanxess used primarily in PVC and phenolic resins (Great Lakes Solutions 2010)
- **Reofos 95:** flame retardant by Lanxess for PVC, flexible polyurethanes, cellulosic resins, and synthetic rubber (LANXESS 2017g)
- **Reofos 1800:** flame retardant by Lanxess used in a wide range of polymers, particularly flexible PVC and phenolic resin (Lanxess 2021)

EPA's economic analysis for the January 2021 final rule described the historical uses of PIP (3:1) as well as the uses that were currently ongoing. The 2021 final rule prohibited or limited several of these uses. The current rule addresses the following uses which remain ongoing. Each of these are described in the following subsections.

Lubricants and Greases

PIP (3:1) functions as a lubricant and as a lubricant additive in the petroleum lubricating oil and grease manufacturing sector (U.S. Environmental Protection Agency (EPA) 2017a). The chemical is used for both its anti-wear and lubricant properties (U.S. Environmental Protection Agency (EPA) 2017b) and is included for fire resistance in lubricant and grease products (American Petroleum Institute (API) 2017). The types of products containing the chemical are hydraulic lubricating fluids, gear lubricating oils, and lubricating greases, which are primarily used in industrial machinery, along with servicing aircraft and automobiles (American Petroleum Institute (API) 2017). PIP (3:1) has typically been used in lubricants at a concentration of 0.1 to 3.0% (American Petroleum Institute (API) 2017).

Lubricants and Greases Used in Aerospace and Turbines

PIP (3:1)-containing products for use in lubricants and greases and PIP (3:1)-containing lubricants and greases were excluded from the 2021 final rule. This rule continues to exclude turbine engine and aerospace uses from regulation.

According to Boeing, fire-resistant properties of PIP (3:1) in oils and fluid limit fire degradation of aircraft systems, reducing the frequency at which aircraft parts need to be replaced (Boeing 2019). Aerospace products containing PIP (3:1) also have the challenge of conformance with external government specifications such as DOD military specifications, FAA or NASA standards. Boeing reiterated this in a comment on the proposed rule, contending that chemical substitutes cannot necessarily be implemented by the aerospace industry within an arbitrarily defined time period (Boeing 2024). Eastman also indicated the difficulty in reformulating lubricants and greases in the aerospace industry (Eastman Chemical Company 2024). They noted that after the identification of possible alternatives through extensive research and development activities, product testing must then be performed. Following

that, regulatory approvals as required by the Federal Aviation Association (FAA) and the varied Military Specifications must be met and certified. Finally, Original Equipment Manufacturers (OEM) approvals must be sought through further testing and research before circulation into use. Lanxess and NYCO both reported in the 2020 CDR that they import PIP (3:1) for use in the petroleum lubricating oil and grease manufacturing sector. Lanxess manufactures the PIP (3:1)-containing Durad line of anti-wear and extreme pressure additives (including Durad 110, Durad 150, Durad 220, Durad 300, Durad 310M); these are also marketed for aerospace and other turbine uses, including power-generating turbines such as those used for nuclear and wind energy (NYCO 2020b). These and other aerospace lubrication products are listed in Table 3-13. Nye Lubricant's Rheolube 374A has been discontinued (NYE Lubricants 2023).This rule affects workers involved in the manufacturing and processing of PIP (3:1) for use in lubricants and greases used in aerospace and gas turbines, not the consumers of these products. The companies associated with manufacturing and processing of PIP (3:1) for use in lubricants and greases used in aerospace and turbines are provided in Table 3-14.

Table 3-13: Aerospace or Turbine Lubricant and Grease Products Containing PIP (3:1)

Product Name	Product Function	Manufacturer	Reference Source
Castrol AN157	Helicopter Gear Oil	BP	(BP Lubricants USA Inc. 2010)
Durad 110	Fire retardant additive	LANXESS	(Lanxess 2017a)
Durad 150	Flame retardant additive	LANXESS	(Lanxess 2018)
Durad 220	Fire retardant / lubricant additive	LANXESS	(Lanxess 2017b)
Durad 300	Fire retardant / lubricant additive	LANXESS	(Lanxess 2017c)
Durad 310M	Fire retardant / lubricant additive	LANXESS	(Lanxess 2017d)
HALO 157	Engine lubricant in helicopter gearboxes	Eastman	(Eastman Chemical Company 2019)
Syn-O-Ad 9578	Phosphorus Lubricant Additive and Aviation Fluid Base Stock	ICL-IP America Inc.	(ICL-Industrial Products 2017b)
Turbonycoil 160	Lubricant for stationary aeroderivative jet turbine engines	NYCO	(NYCO 2021)
Turbonycoil 600	Lubricating oil for stationary industrial gas turbines	NYCO	(NYCO 2020b)

Table 3-14: Business Statistics for Company Associated with PIP (3:1) in Lubricants and Greases used in Aerospace and Turbines

Company	Parent Company	NAICS	Parent Number of Employees	Revenue (2022$, Millions USD)
BP Lubricants/Castrol	BP America Inc.	324110 Petroleum Refineries4	23,000	$7,617
Eastman Chemical Company	Eastman Chemical Company	325199 All Other Basic Organic Chemical Manufacturing	14,500	$10,480
ICL-IP America	ICL Specialty Products North America Inc.	325180 Other Basic Inorganic Chemical Manufacturing	13,000	$940
LANXESS	Lanxess Services US LLC	424690 Other Chemical and Allied Products Merchant Wholesalers	14,548	$8,550
NYCO	NYCO Products Co.	324191 Petroleum Lubricating Oil and Grease Manufacturing	80	$169

Source: (Dun & Bradstreet 2022; Experian 2023)

Lubricants and Greases Used in Other Industries

PIP (3:1)-containing lubricant products that EA was able to identify, other than those described in the previous section as being for aerospace use and turbine engines only, include those listed in Table 3-15.

This regulation affects workers involved in the manufacturing and processing of PIP (3:1) for use in lubricants and greases (excluding aerospace use and turbine engines), not the consumers of these products. Based on the information above, the companies associated with manufacturing and processing of PIP (3:1) for use in lubricants and greases (excluding aerospace use and turbine engines) are provided in Table 3-16.

Table 3-15: Non-Aerospace/Turbine Lubricant and Grease Products Containing PIP (3:1)

Product Name	Product Function	Manufacturer	Reference Source
AC Smartshot Cool Enhancer	Two catalysts and a lubricating agent to maximize efficiency of air conditioning and refrigeration systems	Cool Air Products	(Cool Air Products 2018)
Airpress 15	Oil for industrial installations and airless systems	Klüber Lubrication	(Klüber Lubrication 2015, 2022a)
Excelene 316	Grinding oil for machining metals	Houghton International, Inc.	(Flywheel Distribution LLC 2022)
Experimental Oil RM190422U	Not available	Nye Lubricants	(NYE Lubricants 2020)
Klüberlub BE 41-1501	Grease for highly-loaded rolling bearings operating at low speeds	Klüber Lubrication	(Klüber Lubrication 2017, 2022b))
Metco S2 Grease	Lubricating grease	Fuchs Lubricants Co.	(Fuchs Lubricants Co. 2021a)
Optigear 1100/100	Gear lubricant	BP Lubricants USA Inc.	(BP Lubricants USA Inc. 2022)
Petamo GHY 133 N	Long-term and high-temperature grease for rolling bearings	Klüber Lubrication	(Klüber Lubrication 2011)
Platinol B 804/3 COW-1	Metalworking lubricant	Walter Surface Technologies	(Walter Surface Technologies 2018)
Renoform 5547 RPX	Metalworking fluid	Fuchs Lubricants Co.	(Fuchs Lubricants Co. 2021b)
Reolube 140	Lubricant for industrial use	Lanxess	(Lanxess 2017e)
Shell Omala S4 WE 320	Gear lubricant (can be used in vehicle replacement parts)	Shell Oil Products US	(Shell Oil Products US 2021)
Stabylan CL 126	Lubricating fluid: high temperature chain oil developed for textile tenter chains	Fuchs Lubricants Co.	(Fuchs Lubricants Co. 2017)
Syn-O-Ad 9578	Anti-wear oil additive	ICL-IP	(ICL-Industrial Products 2017b, 2022)
Tribol CS 1555/32	Compressor lubricant	BP Lubricants USA Inc.	(BP Lubricants USA Inc. 2017)
V32 Vacuum Pump Oil	Synthetic vacuum pump oil	Tire Seal, Inc.	(Tire Seal Inc. 2014)
Variocut G 500	Metalworking fluid	BP Lubricants USA Inc.	(BP Lubricants USA Inc. 2021)
Verkomax SG-2	Lubricating rolling mill bearings (steel or paper industries)	Quaker Houghton	(Quaker Houghton 2020)

Table 3-16: Business Statistics for Parent Companies Associated with PIP (3:1) in Lubricants and Greases (excluding Aerospace and Turbine Use)				
Company	**Parent Company**	**NAICS**	**Parent Number of Employees**	**Revenue (2022$, Millions USD)**
BP Lubricants USA Inc.	BP America Inc.	324110 Petroleum Refineries4	23,000	$7,617
Cool Air Products	Cool Air Products LLC	333415 Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	10	$2
Fuchs Lubricants Co.	Fuchs Lubricants Corporation	324191 Petroleum Lubricating Oil and Grease Manufacturing	5,858	$3,400
Houghton International, Inc.	Quaker Chemical Corporation	324191 Petroleum Lubricating Oil and Grease Manufacturing	4,600	$1,944
ICL-IP	ICL Specialty Products North America Inc.	325180 Other Basic Inorganic Chemical Manufacturing	13,000	$940
Klüber Lubrication	Kluber Lubrication NA LP	324191 Petroleum Lubricating Oil and Grease Manufacturing	48,490	$10,480
Lanxess	Lanxess Services US LLC	424690 Other Chemical and Allied Products Merchant Wholesalers	14,548	$8,550
Nye Lubricants	Nye Lubricants, Inc.	324191 Petroleum Lubricating Oil and Grease Manufacturing	5,858	$3,400
Quaker Houghton	Quaker Chemical Corporation	324191 Petroleum Lubricating Oil and Grease Manufacturing	4,600	$1,944
Shell Oil Products US	Shell Oil Co.	324110 Petroleum Refineries	24,000	$126,100
Tire Seal, Inc.	BP America Inc.	324110 Petroleum Refineries	23,000	$7,617
Walter Surface Technologies	Cool Air Products LLC	333415 Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	10	$2
Source: (Dun & Bradstreet 2022; Experian 2023)				

New and Replacement Parts for Motor Vehicles

Automakers are obligated by law[18] and customer requirements to maintain a supply of replacement parts for 15 years or more after production of the automobile has ceased. The Motor & Equipment Manufacturers Association (MEMA) and the Alliance for Automotive Innovation (Auto Innovators) have stated that based on a recent vehicle manufacturer data collection, PIP (3:1) was identified in more than 800 motor vehicle components in International Material Data System (IMDS) record submissions[19] (Motor & Equipment Manufacturers Associates (MEMA) and Auto Innovators 2021). Another industry group, the Auto Alliance, previously found that PIP (3:1) is present in at least 32 production parts and 15 replacement parts (Alliance of Automobile Manufacturers (Auto Alliance) 2018). The Auto Alliance

[18] Fixing America's Surface Transportation (FAST) Act of 2015, Public Law 114-94, § 30120(g)(1), Dec. 4, 2015

[19] According to MEMA and the Auto Innovators, this number is not reflective of total parts in the motor vehicle universe that contain PIP (3:1). Vehicle manufacturers do not include part number information in the data collection query, and therefore, it is not a 1:1 ratio.

indicated that as of February 2018, the industry had no current plans to phase out of PIP (3:1) in the production of U.S. vehicles. Similarly, MEMA and Auto Innovators claim that there is currently no known technically feasible alternative to PIP (3:1) in the motor vehicle industry (Motor & Equipment Manufacturers Associates (MEMA) and Auto Innovators 2021).

Under the 2021 final rule, use of PIP (3:1) in both new and replacement parts for *motor vehicles* are excluded from prohibition. In the comment period following the 2021 rule's promulgation [docket identification number EPA-HQ-OPPT-2021-0202], stakeholders revealed that a number of parts and components in heavy machinery could also potentially contain PIP (3:1). These parts, listed in Table 3-17, are very similar (and in some cases identical, according to commenters), to the parts used in on-road motor vehicles. For the purposes of regulation under this rule, this use category now includes heavy machinery such as off-road vehicles (e.g., utility terrain vehicles, all-terrain vehicles, side by sides, snowmobiles, golf carts), motorcycles (including scooters, mopeds, and other two-wheel gas and electric vehicles), agricultural equipment (e.g., tractors, combines), construction equipment (e.g., excavators, bulldozers, cranes), lawn and garden equipment (e.g., riding mowers), forklifts, marine watercraft/boats, and rail and bus transportation vehicles (e.g., train engines, subway rail cars, buses).

During the 2021 comment period, stakeholders listed examples of components that could contain PIP (3:1), given the chemical's known uses; these are summarized in Table 3-17. Stakeholders described that the supply chains for the parts and components in the equipment they manufacture are often several layers deep and that it is difficult and time-consuming to discern the parts that can definitively be identified as containing PIP (3:1); therefore the list in Table 3-17 may be an overestimate of products and articles that actually contain PIP (3:1).

This was reiterated in 2023 comments on the proposed rule. The Alliance for Automotive Manufacturers noted that PIP (3:1) continues to serve many essential uses in thousands of parts and applications (Alliance for Automotive Innovation 2024). Across the parts listed in Table 3-17, PIP (3:1) serves many different functions, including as a flame retardant, elastomer, and lubricant, and as an essential component of some hydraulic fluids.

Table 3-17: Examples of Components in Motor Vehicles and Heavy Equipment that Potentially Contain PIP (3:1)	
• adhesives • air filters • alarm components (including audible alarm resistor) • automatic tire inflation equipment • body panels • circuit boards • compressors • elastomers • electronic components / electrical controllers • engine compartment • engine emission control systems • fabrics and upholstery (seating) • fire prevention systems • foam • gaskets • ground cables • headlamps / headliners • hydraulic fluids • hydraulic hoses • insulation	• lubricants and greases (including permanent magnet or electric motor lubricants) • motor gears • oils • paints & coating applications • pre-wired motors • PVC (including caps and covers) • resin in fiberglass components • resistors • sealants and coatings • sensors (e.g., to measure temperature, pressure, flow rate, etc.) • splitters • starters • switches • water pumps • windshield wipers • wiring • wire sleeving / jacketing • wiring harnesses
Sources: (Association of Equipment Manufacturers (AEM) 2021; Clark Equipment Company 2021; CNH Industrial America 2021; Industrial Truck Association 2021; Kubota North America Corporation 2021; Motor & Equipment Manufacturers Associates (MEMA) and Auto Innovators 2021 ; National Marine Manufacturers Association 2021; Outdoor Power Equipment Institute 2021; The Motor & Equipment Manufacturers Association 2021; Truck and Engine Manufacturers Association 2021)	

This regulation affects U.S. workers during the manufacturing and processing of PIP (3:1)-containing new and replacement parts for use in motor vehicles as well as companies who use these parts. These types of products and articles are listed in Table 3-17. These types of products and articles typically do not require an SDS (except for hydraulic fluids and lubricants and greases), so EPA is not able to develop a comprehensive list of associated firms. Based on the list of potentially impacted components, industries provided in Table 3-18 (listed by NAICS codes) may be considered makers or consumers of PIP (3:1) in new and replacement parts for motor vehicles and heavy machinery.

Table 3-18: Industry Sectors Associated with Replacement Parts for Use in Motor Vehicles

NAICS Code	NAICS Description	Number of firms in NAICS
Makers		
325211	Plastics Material and Resin Manufacturing	847
325991	Custom Compounding of Purchased Resins	340
326199	All Other Plastics Product Manufacturing	4,857
336211	Motor Vehicle Body Manufacturing	609
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	656
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing	528
336390	Other Motor Vehicle Parts Manufacturing	1,090
336991	Motorcycle, Bicycle and Parts Manufacturing	378
336999	All Other Transportation Equipment Manufacturing	389
Total		**9,694**
Consumers		

Table 3-18: Industry Sectors Associated with Replacement Parts for Use in Motor Vehicles		
NAICS Code	**NAICS Description**	**Number of firms in NAICS**
333111	Farm Machinery and Equipment Manufacturing	1,014
333112	Lawn and Garden Tractor and Home Lawn and Garden Equipment Manufacturing	147
333120	Construction Machinery Manufacturing	625
333131	Mining Machinery and Equipment Manufacturing	223
333924	Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing	323
333998	All Other Miscellaneous General Purpose Machinery Manufacturing	1,380
334290	Other Communications Equipment Manufacturing	317
336110	Automobile and Light Duty Motor Vehicle Manufacturing	198
336120	Heavy Duty Truck Manufacturing	76
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing	528
336612	Boat Building	837
336991	Motorcycle, Bicycle and Parts Manufacturing	378
336999	All Other Transportation Equipment Manufacturing	389
Total		**6,435**
Source: (U.S. Census Bureau 2020)		

New and Replacement Parts for Aerospace Vehicles

PIP (3:1) is also used in aerospace vehicles for its flame-retardant properties, anti-wear, and, in some formulations, for enhancement of load carrying capability of materials and resistance to compressibility (Boeing 2021). Under the current regulation, new and replacement parts for aerospace vehicles are excluded from prohibition.

The Aerospace Industries Association (AIA) members notified EPA that PIP (3:1) is found in articles such as electronics that are manufactured by the aerospace sector, and that it is also found in formulated products – including epoxy and polyester coatings, resins, masking agents, potting compounds and laminates – which conform to product specifications such as for moisture and flammability and are used by the aerospace and defense industry for the development, production, and servicing of industry products (Aerospace Industries Association (AIA) 2019). Products used in the aerospace industry have highly specified requirements for safety and performance standards. Specific components that may contain PIP (3:1), as identified by commenters, are listed in Table 3-19.

Table 3-19: Examples of Components in New and Replacement Parts for Aerospace Industry that Potentially Contain PIP (3:1)	
• cable sleeves • casings • circuit board materials and circuit card assemblies, including in housings and components in storage devices • clamps • commercial and industrial apparatus • condenser covers • connection cables • electronic equipment • engine oils (including oils for auxiliary power units) • fuse housings • ground cables • harnesses • HDMI cables • hydraulic fluids • insulation covers/sleeves used in conjunction with internal and external cables and wirings	• internal tapes, gaskets, and sheets that are used to shield/protect from electromagnetic waves and for other safety measures • landing gear fluids • manufactured articles to which PIP 3:1-containing adhesives and sealants have been applied during testing or assembly • manufacturing equipment • power supplies (and power supply cords) • PVC cables • specialty clamps and connections that have insulating and anti-vibration properties • switch cable • tapes and the products to which such adhesives and tapes have been applied • terminal covers • tubes • USB cables
Source: (Aerospace Industries Association (AIA) 2019; Boeing 2021)	

This regulation affects U.S. workers during the manufacturing and processing of PIP (3:1)-containing new and replacement parts for use in aerospace vehicles as well as companies who use these parts. The types of products and articles listed in Table 3-19 typically do not require an SDS, so EPA is not able to develop a comprehensive list of associated firms. Based on the list of potentially impacted components, industries provided in Table 3-20 (listed by NAICS codes) may be considered makers or consumers of PIP (3:1) in new and replacement parts for aerospace vehicles.

Table 3-20: Industry Sectors Associated with Replacement Parts for Use in Aerospace Vehicles

NAICS Code	NAICS Description	Number of firms in NAICS
Makers		
325211	Plastics Material and Resin Manufacturing	847
325613	Surface Active Agent Manufacturing	383
325991	Custom Compounding of Purchased Resins	340
336412	Aircraft Engine and Engine Parts Manufacturing	321
336413	Other Aircraft Part and Auxiliary Equipment Manufacturing7	738
336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	17
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	31
Total		**2,677**
Consumers		
336411	Aircraft Manufacturing	295
336414	Guided Missile and Space Vehicle Manufacturing	29
Total		**324**
Source: (U.S. Census Bureau 2020)		

Wire Harnesses and Electric Circuit Boards

Wire harnesses and electric circuit boards are articles that may contain PIP (3:1) as a flame retardant. A wire harness is a system of insulated conducting wires (a collection of individually sheathed wires) bound together with insulating materials to form a unit, used in the electrical system of a machine, such as a motor vehicle or washing machine that are bundled together to form a unit. This unit of wires provides electrical connectivity while keeping electrical components organized (Regole 2021). EPA interprets wire harness to include a broad class of articles, including but not limited to terminal and fuse covers; cable sleeves; casings; connectors; tapes; and gaskets. Wire harnesses are used in a variety of applications, from defense to aerospace and motor vehicle applications, to medical instrumentation and more. In these articles, PIP (3:1) is used as a plasticizer and flame retardant. EPA also understands that PIP (3:1) use in electronic component manufacturing includes the use of PIP (3:1) in circuit boards and printed circuit connectors as well as the use of PIP (3:1) products as adhesives for encapsulation of capacitors in electronics components and as resins in overmolding, dip molding, insert molding applications, or conformal coatings.

EPA is not aware of a replacement for PIP (3:1) for use in wire harnesses and circuit boards that combines properties as a plasticizer, a fire retardant, an anti-wear additive, and an insulator. Hence, replacing PIP (3:1) for these will not be a direct substitute but might require multiple chemicals. EPA acknowledges the process of replacing PIP (3:1) with separate chemicals for each function would require an un-estimable amount of time to certify new end-use products (Boeing 2019; Association of Equipment Manufacturers (AEM) 2021). EPA also acknowledges that it is unclear if a technically and economically feasible alternative for PIP (3:1) exist that would meet the voluntary and regulatory safety standards these articles meet. EPA and commenters are not aware of industry efforts to identify or qualify an alternative. For these reasons, EPA has determined that it is impracticable to prohibit the processing and distribution of PIP (3:1) for use in wire harnesses and circuit boards.

This rule affects U.S. workers during the manufacturing and processing of PIP (3:1)-containing wire harnessing and electric circuit boards. Industries provided in Table 3-21 (listed by NAICS codes) may be considered makers wire harnessing and electric circuit boards that may contain PIP (3:1).

Table 3-21: Industry Sectors Associated with Wire Harnesses and Electric Circuit Boards

NAICS Code	NAICS Description	Number of firms in NAICS
Makers		
325211	Plastics Material and Resin Manufacturing	847
325991	Custom Compounding of Purchased Resins	340
334412	Bare Printed Circuit Board Manufacturing	406
334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing	722
335931	Current-Carrying Wiring Device Manufacturing	355
Total		**2.670**

Source: (U.S. Census Bureau 2020)

Marine Antifouling Coatings

PIP (3:1) is used as a plasticizer in the formulation and is an inert ingredient under FIFRA. PIP (3:1) is used as a plasticizer in the paint and coating manufacturing sector (U.S. Environmental Protection Agency (EPA) 2017a) where the chemical is found in boat antifouling products. Antifouling paint is utilized to prevent biofouling—the accumulation of microorganisms, plants, algae, or animals on wetted surfaces—on the hull of boats.

According to the 2021 final rule at § 751.407(a)(1), this use of PIP (3:1) has been prohibited since March 8, 2021. PIP (3:1)'s use in this capacity was unknown to the EPA at the time the rule was promulgated. In discussion with the U.S. Navy, they indicated that this antifouling paint falls under the "mission critical" category because hull corrosion on ships can have significant impacts on ship performance. The U.S. Navy also indicated that it would need five years to develop a suitable alternative formulation and undergo the FIFRA approval process. Because no technically feasible alternative is currently available for this use, EPA considers it impracticable to continue prohibiting the processing and distribution of PIP (3:1) for use in this marine antifouling coating while an alternative is being developed. EPA believes there are suitable alternatives for commercial users, and so is limiting this exclusion to products that meet Department of Defense specification requirements.

In the 2016 CDR, International Paint, LLC (parent company Akzo Nobel) reported use of PIP (3:1) at two different sites as plasticizers in the paint and coating manufacturing sector (U.S. Environmental Protection Agency (EPA) 2017a). EPA identified two International Paint boat antifouling products containing PIP (3:1): Interspeed and Micron Extra Blue Antifouling (Akzo Nobel 2017).

Table 3-22: Business Statistics for Company Associated with Marine Antifouling Coatings

Company	Parent Company	NAICS	Parent Number of Employees	Revenue (2022$, Millions USD)
International Paint	Akzo Nobel Inc.	325510 Paint and Coating Manufacturing	11,000	$16,761

Source: (Experian 2023)

Articles Used in Manufacturing Equipment, including Semiconductors, Electronics, HVACR, Water Heating, and Power Generating Equipment

The Japan Machine Tool Builders' Association (JMTBA) reported to EPA that there is widespread use of PIP (3:1) throughout the manufacturing equipment (machine tool) supply chain (Japan Machine Tool Builders' Association 2021). The Association for Manufacturing Technology stated that a regulatory action limiting the use of PIP (3:1) would affect the machine tool portion of the manufacturing equipment market, as well as products such as consumables, cutting tools, advanced automation, and materials handling (Association for Manufacturing Technology 2021). According to the National Association of Manufacturers, PIP (3:1) is associated with manufacturing a wide range of products, including heating, ventilation and air conditioning systems, refrigeration equipment, life sciences and biomedical equipment, and electrical generation and transmission equipment (National Association of Manufacturers 2021). JMTBA further noted that machine tools are essential for producing products in the automotive, aerospace, military, food, pharmaceutical and medical, agriculture, energy, logistics and construction industries (Japan Machine Tool Builders' Association 2021).

PIP (3:1) used in manufacturing equipment for a variety of industries. This includes agricultural machinery (Japan Agricultural Machinery Manufacturers Association 2024), outdoor power equipment

(Outdoor Power Equipment Institute 2024), consumer technology (Add reference), automated manufacturing (Association for Advancing Automation (A3) 2024), and manufacturing equipment (Add reference). One public commenter speculated that more than 50 percent of U.S. capacity to manufacture could be idled if manufacturers lose access to PIP (3:1)-containing replacement parts (Add reference).

PIP (3:1) is also found in the supply chain for semiconductor-related manufacturing equipment, as well as semiconductor fabrication facilities' support equipment and infrastructure, such as laboratory, substrate and device (e.g., die) preparation, and assembly and test operations, including advanced packaging (SEMI 2021). In a comment on the proposed rule, the Semiconductor Industry Association (SIA) noted that tools can contain tens of thousands of parts, and each of these individual parts are highly engineered articles (Semiconductor Industry Association (SIA) 2024).

Articles in these industries often have supply chains that are complex and multi-layered. One public commenter states that electronic finished goods manufacturers have anywhere from 2,500 to upwards of well over 5,000 suppliers (Consumer Technology Association 2024). Each of those suppliers may provide the components that go into upwards of 5,000 finished goods on average. This translates to upwards of 100,000 or more individual components that go into those finished goods sourced from various suppliers.

Table 3-23: Examples of Components and Equipment Used in Semiconductor Industry that Potentially Contain PIP (3:1)

Components	Equipment
• adhesive • grease • wire terminal lugs • dust covers • wire cover repair film • a Bayonet Neill-Concelman (BNC) cover • filter • cable assembly in a PVC boot	• coater/developer system • etch system • surface preparation system • deposition system • test system • wafer bonder/debonder • SiC Epitaxial CVD system • mask writer - equipment used for photomask patterning

Source: (SEMI 2021)

This rule affects U.S. workers during the manufacturing and processing of PIP (3:1)-containing articles used in the manufacturing equipment and semiconductor industries. The types of products described above typically do not require SDS, and EPA is not able to develop a comprehensive list of associated firms that make these articles. Industries provided in Table 3-24 (listed by NAICS codes) may be considered makers of articles used in the manufacturing equipment and semiconductor industry that may contain PIP (3:1). Because the flame-retardant additive is added to the raw polymers during the plastic manufacturing process, EPA believes only workers in these sectors (in Table 3-24) would come into contact with the raw PIP (3:1). Workers in companies that assemble the manufacturing equipment would not directly handle PIP (3:1).

Table 3-24: Industry Sectors Associated with Articles Used in Manufacturing Equipment and in the Semiconductor Industry		
NAICS Code	**NAICS Description**	**Number of firms in NAICS**
Makers		
325211	Plastics Material and Resin Manufacturing	847
325991	Custom Compounding of Purchased Resins	340
333242	Semiconductor Machinery Manufacturing	153
334413	Semiconductor and Related Device Manufacturing	715
Total		2,055
Source: (U.S. Census Bureau 2020)		

The final rule also affects U.S. workers during the manufacturing and processing of PIP (3:1)-containing articles used in the other types of manufacturing, including electronics, HVACR, water heating, and power generating equipment. Several CTA, IPC and ITI member companies have identified the use of PIP (3:1) in the supply chain of electronic components and finished goods (Consumer Technology Association 2024). This includes the presence of PIP (3:1) in components that may have utility in dozens of electronic equipment applications including aerospace, automotive, defense, heavy equipment, home appliances and medical equipment as well as traditional electronic devices. Some companies have indicated that they have been receiving updated information from their supply chains regarding the presence of PIP (3:1) while other companies are may still be coordinating with their supply chain and awaiting confirmation of the presence of PIP (3:1) or its absence.

Below is a non-exhaustive list of known components as well as electronics finished goods where the use of PIP (3:1) has been confirmed:

- Components: Insulation covers / sleeves and other components used in conjunction with internal and external cables (e.g., PVC cables, ground cables, and switch intel cables) and wirings. Includes:
  - Terminal covers
  - Fuse covers
  - Cable sleeves
  - Tubes
  - Casings
  - Harnesses
  - Clamps used with cables
  - Float switch
  - Connectors (housing)
- Internal and external cables including but not limited to power cables, HDMI cables, connection cables, USB cables, etc.
- Components used to shield / protect from electromagnetic waves in conjunction with circuit boards and other components inside electronic devices. Includes:
  - Condenser covers
  - Internal tapes
  - Gaskets
  - Sheets
- Components used for the electronic designs of semiconductors
- Electronic drive units
- Adhesives / Sealants (e.g. epoxy used for encapsulation of capacitors)
- Finished Goods: Televisions
- Desktop PCs

- Blue-ray disc recorders / players
- Professional video monitors
- Displays
- Broadcast equipment
- Projectors
- Portable speakers and audio devices

Additionally, companies may produce finished goods outside of the traditional electronics category that may

- Camcorders
- Professional and consumer cameras
- Electronic microscopes
- Audio / stereo equipment and home theater equipment (e.g., audiovisual receivers, speakers)
- Professional audio / sound reinforcement equipment (e.g., digital mixers, amplifiers)
- Musical instruments (e.g., digital pianos, electric guitars, portable keyboards) as well as sound recording and reproduction technologies
- Radiation detectors
- Laser market sensors
- Office imaging equipment
- Professional monitoring and control instruments

Table 3-25 (listed by NAICS codes) may be considered consumers of articles used in the manufacturing electronics, HVACR, water heating, and power generating equipment that may contain PIP (3:1).

Table 3-25: Industry Sectors Associated with Articles Used in Manufacturing Electronics, HVACR, Water Heating, and Power Generating Equipment Industry		
NAICS Code	**NAICS Description**	**Number of firms in NAICS**
Makers		
333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	685
335999	All Other Miscellaneous Electrical Equipment and Component Manufacturing	722
333998	All Other Miscellaneous General Purpose Machinery Manufacturing	0
336999	All Other Transportation Equipment Manufacturing	389
336612	Boat Building	837
334112	Computer Storage Device Manufacturing	79
334118	Computer Terminal and Other Computer Peripheral Equipment Manufacturing	436
334111	Electronic Computer Manufacturing	304
334417	Electronic Connector Manufacturing	157
333111	Farm Machinery and Equipment Manufacturing	1,014
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	339
333413	Industrial and Commercial Fan and Blower and Air Purification Equipment Manufacturing	406
333924	Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing	323
333112	Lawn and Garden Tractor and Home Lawn and Garden Equipment Manufacturing	147
335220	Major Household Appliance Manufacturing	128
333613	Mechanical Power Transmission Equipment Manufacturing	190
334419	Other Electronic Component Manufacturing	989
333618	Other Engine Equipment Manufacturing	241
336611	Ship Building and Repairing	430
335210	Small Electrical Appliance Manufacturing	158
339920	Sporting and Athletic Goods Manufacturing	1,552
335313	Switchgear and Switchboard Apparatus Manufacturing	403
336214	Travel Trailer and Camper Manufacturing	562
Total		**10,491**
Source: (U.S. Census Bureau 2020)		

Cyanoacrylate Adhesives

Henkel uses PIP (3:1) as an intermediate processing aid in the production of cyanoacrylate (CA) monomers (Henkel Corporation 2019). These CA monomers are then formulated into CA adhesives used in consumer products such as "superglues." The PIP (3:1) is either consumed during the production process or collected as waste and drummed for incineration (Henkel Corporation 2019). Henkel's production process with respect to using PIP (3:1) as an intermediate processing aid is carried out in an automated batch distillation plant and in a well-ventilated closed system. Henkel also uses protective equipment and engineering controls to curb worker exposure, examples of which are not limited to: gloves, protective aprons, local exhaust ventilation, and general ventilation (Henkel Corporation 2019). Henkel also provides workers with APF 50 respirators. Henkel attests that employing PIP (3:1) as an intermediate processing aid provides unique benefits to the production process. These include higher production yields, reduced need for solvent clean up, and additional product benefits such as strength, cure speed and shelf life (Henkel Corporation 2019).

Under the 2021 regulation, use of PIP (3:1) as an intermediate in a closed system to produce cyanoacrylate adhesives was excluded from prohibition (see 40 CFR § 751.407(b)(1)(iv)).

Henkel is the only known company associated with this use. Therefore, in estimating the number of

entities affected by the rule, EPA assumes one company.

Table 3-26: Business Statistics for Company Associated with Cyanoacrylate Adhesives

Company	Parent Company	NAICS	Parent Number of Employees	Revenue (2022$, Millions USD)
Henkel	Henkel Corp.	325520 Adhesive Manufacturing	4,001	$2,400

Source: Experian 2023

For the use of PIP (3:1) in the manufacturing of cyanoacrylate adhesives, EPA is requiring that workers be provided with a respirator at least as protective as a NIOSH-approved APF 50 purifying respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible. According to industry stakeholders, this level of protection is industry standard for the manufacturing of cyanoacrylate adhesives.

Engine Filters for Locomotive and Marine Applications

Daikin Industries Ltd.'s subsidiary, AAF Flanders, processes PIP (3:1) to make specialized air filters that use PIP (3:1) in a gel (Daikin Industries 2019). The specific products, AmerKleen® 1200 and 2500 cartridge air filters and housing assemblies, function as engine filters in diesel locomotives, as well as energy delivery generators used in offshore marine generators and pipeline generators (Daikin Industries 2019).

In locomotive diesel engine filters, the PIP (3:1) air filters are used to clean the combustion air intake to large heavy-duty industrial diesel engines. This prevents abrasive particles from entering the engines, which can cause premature wear and damage to engines (Daikin Industries 2019). In marine settings, including in ocean vessels and in platform electrical power generation, the PIP (3:1) air filters are used to clean the combustion air intake to large heavy-duty industrial diesel engines. This prevents abrasive particles from entering the engines and causing premature wear and damage to engines that are mission-critical to maintain safe operations in severe and remote locations (Daikin Industries 2019). In these air filters, PIP (3:1) serves to provide fire protection, freezing temperature protection, and sloughing protection (Daikin Industries 2019).

Under the 2021 regulation, use of PIP (3:1) in specialized engine filters for locomotive and marine applications was excluded from prohibition (see 40 CFR § 751.407(b)(1)(v)). In response to EPA's 2023 NPRM removing the exclusion, the National Marine Manufacturers Association (NMMA) indicated that the nature of material changes in the recreational marine industry is complex and time-consuming. They, along with other commenters, requested that the Agency extend the phase-in timeframe for the processing and distribution of PIP (3:1) in lubricants and greases for new and replacement parts, in order to provide manufacturers with adequate time to research, develop, and implement alternative materials without compromising the quality and reliability of marine products (National Marine Manufacturers Association 2024). Recreational boats have a very long, useful life period of 30 to 50 years, so it is crucial to ensure that any alternative materials meet the stringent performance and safety standards necessary for harsh marine applications.

AAF Flanders is the only known company associated with this use. Therefore, in estimating the number of entities affected by the rule, EPA assumes one company.

Table 3-27: Business Statistics for Company Associated with Engine Filters for Locomotive and Marine Applications				
Company	**Parent Company**	**NAICS**	**Parent Number of Employees**	**Revenue (2022$, Millions USD)**
AAF Flanders	Daikin Industries Ltd.	423840 Industrial Supplies Merchant Wholesalers	84,870	$23,520
Source: (Dun & Bradstreet 2022)				

For the use of PIP (3:1) in the manufacturing of certain engine filters, EPA is requiring that workers be provided half or full respirators, and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible. According to stakeholders (Daikin Industries 2019), this level of protection is used as industry standard practice, in part because of the presence of formaldehyde in the engine filter manufacturing process.

Hydraulic Fluid for Aerospace Industry or to Meet Military Specifications

Aircraft use hydraulic fluids to power onboard equipment. Within the hydraulic fluid, PIP (3:1) helps with fire resistance and in achieving the appropriate bulk modulus (stiffness) of the fluid (U.S. Environmental Protection Agency (EPA) 2018b). Commercial airlines and military aircraft manufacturers are both consumers of aviation hydraulic fluid that contains PIP (3:1) (Akin Gump Strauss Hauer & Feld LLP (Akin Gump) 2017; Exxon Mobil 2017).

PIP (3:1)-containing hydraulic fluids either for the aerospace industry or to meet military specifications for safety and performance where no alternative chemical is available that meets U.S. Department of Defense specification requirements are exempted from prohibition under the 2021 regulation (40 CFR 751.407(b)(1)(i)).

Airbus uses four hydraulic fluid products: HyJet IV A+ and HyJet V by Exxon Mobil and Skydrol PE-5 and Skydrol LD-4 by Eastman. All except Skydrol LD-4 contain PIP (3:1), and this product does not meet technical specification requirements for aircraft certification and airworthiness purposes for 5,000 PSI systems (Beyderman and Goessing 2019). Airbus aircrafts use hydraulic fluids for hydraulic power generation and for distribution to hydraulic systems such as landing gear, flight controls, cargo doors, the engine thrust reverser, and the emergency electrical system.

Boeing uses the product Skydrol PE-5 in all airplanes other than their 787 aircraft model, for which Boeing uses HyJet V (Boeing 2019). Both Skydrol PE-5 and HyJet V contain PIP (3:1). According to Boeing, the three aircraft hydraulic fluids that do not contain PIP (3:1)—Skydrol 5, Skydrol 500-B4, and Skydrol LD-4—are all unusable for separable reasons: Skydrol 5 testing is still underway and does not have universal airframe manufacturer approval; Skydrol 500-B4 cause degradation of elastomer materials; and Skydrol LD-4 causes wear of internal components and there was a rapid increase in the rate of internal fluid leakage during endurance testing (Boeing 2019). Boeing also noted that the negative effects Skydrol LD-4 causes occur in hydraulic systems with a pressure of 3,000 PSI or more (Boeing 2019).

NYCO manufactures Hydraunycoil FH 19, petroleum-based hydraulic fluid that is intended primarily for use on ordnance equipment such as recoil systems and hydraulic systems for rotating weapon or aiming devices on Navy vessels (NYCO 2020a).

This regulation affects workers involved in the manufacturing and processing of PIP (3:1) for use in aviation hydraulic fluid, not the consumers. Based on the information above, the companies associated

with manufacturing and processing of PIP (3:1) for use in aviation hydraulic fluid are provided in Table 3-28.

Table 3-28: Business Statistics for Company Associated with PIP (3:1) in Hydraulic Fluid for the Aerospace Industry or to Meet Military Specifications

Company	Parent Company	NAICS	Parent Number of Employees	Revenue (2022$, Millions USD)
Eastman Chemical Company	Eastman Chemical Company	325199 All Other Basic Organic Chemical Manufacturing	14,500	$10,480
Exxon Mobil	Exxon Mobil Corporation	324110 Petroleum Refineries	62,000	$413,680
ICL-IP America	ICL Specialty Products North America Inc.	325180 Other Basic Inorganic Chemical Manufacturing	13,000	$990
Lanxess	Lanxess Services US LLC	424690 Other Chemical and Allied Products Merchant Wholesalers	14,548	$8,550
NYCO	NYCO Products Co.	324191 Petroleum Lubricating Oil and Grease Manufacturing	80	$169

Source: (Dun & Bradstreet 2022; Experian 2023)

3.4 Summary

As described in the sections above, the number of companies affected by the regulatory options are determined either by number of identified companies, when this is possible, or by number of companies in the affected industry sectors (NAICS). Numbers of companies determined by NAICS are likely to be overestimates, as not all companies within a sector will likely be using or making products or articles containing the regulated chemical. The estimated number of companies associated with the regulation of decaBDE and PIP (3:1) are provided in Table 3-29 for the final option, and Table 3-30 for the alternative option. In total, this rulemaking may affect approximately 26,800 companies under the final option.

Table 3-29: Estimated Number of Companies Affected by the Final Rule (Final Option)		
Use	**Basis**	**Number of Companies**
DecaBDE		
Plastic Shipping Pallets	Identified Companies	1
Replacement Parts for Aerospace Vehicles (makers)	NAICS	0
Replacement Parts for Motor Vehicles (makers)	NAICS	0
Wire and Cable Insulation	Identified Companies	1
All DecaBDE		***2***
PIP (3:1)		
Lubricants and Greases (except Aerospace and Turbine) (makers)	Identified Companies	5
Lubricants & Greases (Aerospace) (makers)	Identified Companies	11
New and Replacement Parts for Motor Vehicles (consumers)	NAICS	4,562
New and Replacement Parts for Motor Vehicles (makers)	NAICS	8,091
New and Replacement Parts for Aerospace Vehicles (consumers)	NAICS	324
New and Replacement Parts for Aerospace Vehicles (makers)	NAICS	1,787
Wire Harnesses and Electric circuit Boards (makers)	NAICS	1,780
Marine Antifouling Coatings	Identified Companies	1
Articles Used in Manufacturing Equipment, including semiconductor, Electronic, HVACR, Water Heating, and Power Generating Industry (makers)	NAICS	1,165
Articles Used in Manufacturing Equipment, including semiconductor, Electronic, HVACR, Water Heating, and Power Generating Industry (consumers)	NAICS	9,071
Engine Filters for Locomotive and Marine Applications	Identified Companies	1
Cyanoacrylate Adhesives [1]	Identified Companies	0
Aviation Hydraulic Fluid (makers)	Identified Companies	5
All PIP (3:1)		***26,803***
Total		***26,805***

[1] Henkel is not included since they use PIP (3:1) in a closed-loop system in the baseline.

Note: Affected entities have been adjusted down proportionately for PIP (3:1) so as not to include double counting. Totals many not sum due to rounding.

Table 3-30: Likely Number of Companies Affected by the Final Rule (Alternative Option)		
Uses	**Basis**	**Number of Companies**
DecaBDE		
Other DecaBDE-containing Plastic	NAICS	8,894
All DecaBDE Uses		***8,894***
PIP (3:1)		
Lubricants and Greases (except Aerospace and Turbine) (makers)	Identified Companies	5
Lubricants & Greases (Aerospace) (makers)	Identified Companies	11
Wire Harnesses and Electric circuit Boards (makers)	NAICS	2,077
Articles Used in Manufacturing Equipment and Semiconductor Industry (makers)	NAICS	1,462
Articles Used in Manufacturing Equipment and Semiconductor Industry (consumers)	NAICS	10,491
All PIP (3:1) Uses		***14,045***
Total		***22,939***

Note: Affected entities have been adjusted down proportionately for PIP (3:1) so as not to include double counting. Totals many not sum due to rounding.

4. Cost of the Rule to Industry

4.1 General Methodology

In general, costs of the final rule were estimated based on the assumption that costs to manufacturers and processors addressed in this analysis include:

- **Rule familiarization costs** (Section 4.2). Costs incurred by all regulated entities.
- **Prohibition costs** (Section 4.3). Costs that may result from the need to determine whether components of products may contain the regulated chemical (consumers) and to reformulate products or components so that they do not contain the prohibited substance (makers).
- **Worker Protection Costs** (Section 4.4). Costs associated with providing workers with the required personal protective equipment (e.g., respirators, and gloves).
- **Signage Costs** (Section 4.5). Costs incurred for firms to place a sign in the location where the chemical is being used.
- **Export Notification Costs** (Section 4.6). These costs include the cost to the exporter of compiling a list of their products that are subject to TSCA Section 12(b) requirements, writing or revising an export notification letter to EPA, checking the outgoing shipments, and sending the notification letters with the associated shipping costs.
- **Engineering Controls** (Section 4.7) EPA is requiring engineering controls for the use of PIP (3:1) in the manufacturing of cyanoacrylate adhesives. However, EPA believes that affected companies have already implemented the required controls, and therefore no incremental costs will be incurred.
- **Labeling Costs** (Section 4.8). Costs incurred when a product or article must be labeled to indicate that it contains the regulated chemical.
- **Costs to Prevent Releases** (Section 4.9.1). Costs associated with instituting engineering controls aimed at reducing or eliminating environmental releases of the regulated chemicals.

Section 4.9 also provides further discussion of unquantified costs and uncertainties in the cost analysis. The total quantified costs to industry are presented in Section 4.10, and EPA costs to implement the final rule are estimated in Section 4.11.

4.1.1 Time Horizon for Analysis and Annualization

In order to select an appropriate time horizon (number of years) for analysis in this Economic Analysis, it is important to select a period sufficiently long enough to capture the important effects of the costs, however, one that is not too long that it adds unnecessary uncertainty.

EPA's *Guidelines for Preparing Economic Analyses* (U.S. Environmental Protection Agency (EPA) 2014b) recommends that "the time horizon should be long enough that the net benefits for all future years (beyond the time horizon) are expected to be negligible when discounted to the present"; this implies that a fairly long-time horizon is appropriate. However, the probability that the rule becomes obsolete increases over time. For example, international regulations and chemical manufacturer agreements, or new chemical innovations, could make decaBDE or PIP (3:1) obsolete without any rule. Given this uncertainty, EPA selected a time horizon of 30 years for the analysis. A time horizon of 30 years would allow adequate time for all prohibitions of new products under this rule to come into effect (manufacture of new and replacement parts for aerospace vehicles containing PIP (3:1) is prohibition after 30 years). However, some replacement parts are permitted to contain PIP (3:1) beyond 30 years, in products with a long service life. Since the EPA believes that this rule will not cause an incremental cost in the continued

production of PIP (3:1)-containing replacement parts, EPA contends that a 30-year period of analysis is sufficient to capture the overall costs of the action.

The present discounted value for the annualized value of the stream of costs is estimated using discount rates of 2%, 3%, and 7%. Costs are discounted (for the discount rates r = 2%, r = 3%, and r = 7%) to the beginning of the n-year period (where n is 30), as follows:

$$\text{Present Discounted Value} = \sum_{t=0}^{n} \frac{(\text{Undiscounted Value})_t}{(1+r)^t} \quad (1)$$

The present discounted value costs are annualized as follows:

$$(\text{Annualized Costs}) = (\text{PDV}_{\text{n year cost stream}}) \cdot \frac{r \cdot (1+r)^n}{(1+r)^n - 1} \quad (2)$$

Chapter 4 presents the costs at 3% and 7% discount rates, while Appendix A presents the costs at a 2% discount rate.

4.1.2 Wage Rates

The final rule involves activities that may require efforts by employees in six labor classifications: managerial, professional/technical, production/clerical, attorney, industrial hygienist, and physician's assistant. Costs for each activity are calculated by estimating the number of hours required in each labor category and multiplying those burdens by the wage rate for each labor category. This section presents the estimated wage rate in each labor category.

Loaded wage rates for each labor category are derived by combining data on wages and fringe benefits with estimates of overhead rates following the methodology described in *Handbook on Valuing Changes in Time Use Induced by Regulatory Requirements and Other U.S. EPA Actions* (U.S. Environmental Protection Agency (EPA) 2020b). Wage and fringe benefit data for the manufacturing sector was calculated using the December 2022 quarterly estimates from the Employer Costs for Employee Compensation (ECEC) Supplemental Tables available on the Bureau of Labor Statistics (BLS) website (U.S. Bureau of Labor Statistics (BLS) 2022a). For attorney, industrial hygienist, and physician's assistant labor, the wage rate was taken from the BLS Occupational Employment Statistics (OES) May 2021 Occupational Employment and Wage Estimates (BLS 2022b).

Table 4-1 presents the data used to calculate the loaded wage rates for all four categories of labor, and Appendix A provides more detailed information on the estimation of these wage rates.

Table 4-1: Loaded Industry Wage Rates (2022$)

Labor Category	Base Wages[a]	Fringe Benefits[a] + Overhead Factor[b]	Loaded Wages
Manufacturing			
Managerial	$54.29	1.75	**$94.74**
Professional/Technical	$46.01	1.81	**$83.14**
Production Worker / Clerical	$23.11	1.74	**$40.13**
All Sectors			
Attorney	$71.17	1.81	**$128.76**
Industrial Hygienist	$37.86	1.81	**$68.41**
Physician's Assistant	$57.43	1.81	**$103.77**

Notes:
[a] Wage rates and fringe benefits are calculated using the December 2022 estimates from (U.S. Bureau of Labor Statistics (BLS) 2023b, and May 2021 estimate from (U.S. Bureau of Labor Statistics (BLS) 2022b). See Appendix B for calculation.

Table 4-1: Loaded Industry Wage Rates (2022$)			
Labor Category	**Base Wages[a]**	**Fringe Benefits[a] + Overhead Factor[b]**	**Loaded Wages**
[b] An overhead rate of 20% of base wages is used here, based on methodology and assumptions in (U.S. Environmental Protection Agency (EPA) 2020b).			

4.2 Recordkeeping and Rule Familiarization

4.2.1 Recordkeeping

Manufacturers, processors, and distributors of decaBDE and PIP (3:1), or of products or articles containing them, are required to maintain ordinary business records, such as invoices and bills-of-lading, related to compliance with the prohibitions, restrictions, and other provisions of this rule. These records need to be maintained for a period of five years from the date the record is generated. These records must be made available to EPA upon request.

EPA assumes firms keep these records as part of their customary business practices; therefore this requirement is not expected to add any incremental cost. In addition, the requirement that these records be made available to EPA within upon request is assumed to not add any additional cost. See Section 4.4 for recordkeeping costs related to the rule's PPE requirements. Paperwork costs related to PPE are also covered in Section 4.4.4.

4.2.2 Rule Familiarization

Rule familiarization is a cost incurred by manufacturers and processors of products containing decaBDE and PIP (3:1) as industry complies with the regulation. EPA assumes that each manufacturer (including importers) and processor of products subject to the rule who will have PPE requirements will spend 3 hours of professional/technical labor in the first year to become familiar with the requirements of the rule and to develop an understanding of what actions are necessary to comply. EPA assumes firms not subject to PPE requirements will spend 1 hour in the first year on rule familiarization. The fully loaded wage rate used to estimate these costs is $83.14, which was estimated as shown in Table 4-1.

The estimated annualized cost, per firm, for rule familiarization are shown in Table 4-2 for both no PPE and PPE scenarios at 3% and 7% discount rates.

Table 4-2: Annual Cost for Rule Familiarization, per firm (2022$)				
Activity	**First -Year Burden (hours)**	**Technical Labor (at $83.14/hour)**	**Annualized Cost (3%) (2022$)**	**Annualized Cost (7%) (2022$)**
Rule familiarization (no PPE)	1	$83.14	$4.04	$6.20
Rule familiarization (PPE)	3	$83.14	$12.11	$18.60
Notes: Values may not sum due to rounding Rule familiarization burdens follow recent TSCA rulemakings such as the proposed rules to regulate Methylene Chloride (U.S. Environmental Protection Agency (EPA) 2023e) and Carbon Tetrachloride (U.S. Environmental Protection Agency (EPA) 2023d).				

To estimate the total cost to industry of rule familiarization, it was assumed that each of the affected companies identified in Chapter 3 will incur this cost. In Table 4-3, the second column shows the estimated number of firms impacted per use, while the third and fourth columns represent the product of the number of firms and the annualized rule familiarization costs presented in Table 4-2.

As shown in Table 4-3, the annual cost to industry under the final option is approximately $212,000 at a 3% discount rate and $325,000 at a 7% discount rate, spread among the 26,805 affected companies (as noted in Chapter 3, this may be an overestimate of the number of companies as not all companies within a NAICS category may be affected). As shown in Table 4-4, the annual cost to industry under the alternative option is approximately $193,000 at a 3% discount rate and $297,000 at a 7% discount rate, for 22,939 companies.

Table 4-3: Annual Cost of Rule Familiarization to Industry (Final Option) (2022$)

Use	Number of Firms Affected[1]	Total Annualized Cost (3%) (2022$)[2]	Total Annualized Cost (7%) (2022$)[2]
DecaBDE			
Plastic Shipping Pallets	1	$12	$19
Replacement Parts for Aerospace Vehicles (makers)	0	$0	$0
Replacement Parts for Motor Vehicles (makers)	0	$0	$0
Wire and Cable Insulation	1	$4	$6
All DecaBDE Uses	***2***	***$16***	***$25***
PIP (3:1)			
Lubricants and Greases (except Aerospace and Turbine) (makers)	5	$61	$93
Lubricants & Greases (Aerospace) (makers)	11	$133	$205
New and Replacement Parts for Motor Vehicles (consumers)	4,562	$18,412	$28,287
New and Replacement Parts for Motor Vehicles (makers)	8,091	$97,967	$150,507
New and Replacement Parts for Aerospace Vehicles (consumers)	324	$1,308	$2,009
New and Replacement Parts for Aerospace Vehicles (makers)	1,787	$21,633	$33,235
Wire Harnesses and Electric circuit Boards (makers)	1,780	$21,548	$33,105
Marine Antifouling Coatings	1	$12	$19
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	1,165	$14,102	$21,665
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	9,071	$36,610	$56,244
Engine Filters for Locomotive and Marine Applications	1	$12	$19
Cyanoacrylate Adhesives [1]	0	$0	$0
Aviation Hydraulic Fluid (makers)	5	$61	$93
All PIP (3:1) Uses	***26,803***	***$211,859***	***$325,480***
Total	**26,805**	**$211,875**	**$325,505**

Sources: [1] See Table 3-29; [2] See Table 4-2
Note: Total annualized costs have been adjusted down proportionately for PIP (3:1) so as not to include double counting.
[1] Henkel is not included since they use PIP (3:1) in a closed-loop system in the baseline.

Table 4-4: Annual Cost of Rule Familiarization to Industry (Alternative Option) (2022$)

Use	Number of Firms Affected[1]	Total Annualized Cost (3%) (2022$)[2]	Total Annualized Cost (7%) (2022$)[2]
DecaBDE			
Other DecaBDE-containing Plastic	8,894	$107,684	$165,436
All DecaBDE Uses	***8,894***	***$107,684***	***$165,436***
PIP (3:1)			
Lubricants and Greases (except Aerospace and Turbine) (makers)	5	$61	$93
Lubricants & Greases (Aerospace) (makers)	11	$133	$205

Table 4-4: Annual Cost of Rule Familiarization to Industry (Alternative Option) (2022$)			
Use	**Number of Firms Affected[1]**	**Total Annualized Cost (3%) (2022$)[2]**	**Total Annualized Cost (7%) (2022$)[2]**
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	1,462	$17,695	$27,185
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	10,491	$42,340	$65,047
Wire Harnesses and Electric circuit Boards (makers)	2,077	$25,141	$38,625
All PIP (3:1) Uses	***14,045***	***$85,370***	***$131,155***
Total	**22,939**	**$193,054**	**$296,591**
Sources: [1] See Table 3-29; [2] See Table 4-2. **Note:** Total annualized costs have been adjusted down proportionately for PIP (3:1) so as not to include double counting.			

4.3 Prohibition Costs

The final option for PIP (3:1) calls for prohibition against the use of the chemical for certain activities, with various compliance timelines. The requirements (under both the final and primary alternative options) related to prohibition are:

- For lubricants and greases (excluding turbine engine and aerospace uses), the final option prohibits processing after 15 years. Lubricants and greases for turbine engine and aerospace uses will not be prohibited.
- For all lubricants and greases, the alternative option would prohibit processing after 5 years
- For new parts for motor vehicles, the final option prohibits processing after 15 years. Replacement part prohibition would take effect after 30 years.
- For new parts for aerospace vehicles, the final option prohibits processing after 30 years. Replacement part prohibition would take effect at the end of service life.
- For wire harnesses and electric circuit boards, the alternate option prohibits manufacture (including import), and processing after 20 years
    - For articles used in manufacturing equipment, semiconductors, electronic equipment, HVACR and water heating equipment, and power generating equipment, the final option prohibits manufacture (including import) and processing after 10 years. For replacement parts, the prohibitions take effect as follows:
    - Manufacturing and semiconductor equipment: service life of machine
    - Electronic Equipment: 7 years for consumer use, 25 years for industrial and commercial use, and service live for laboratory use
    - HVACR and water heating equipment: 25 years
    - Power generating equipment: 25 years
- For articles used in manufacturing equipment and semiconductors, the alternate option would prohibit manufacture (including import) and processing after 20 years.

For all articles, EPA is also prohibiting the distribution in commerce of PIP (3:1)-containing articles. Prohibitions for distribution in commerce will take effect 2 years after prohibitions of manufacturing (including import) and processing. EPA does not believe that the regulatory options result in costs to prohibition of distribution.

When the use of a chemical is prohibited, EPA expects that firms using affected articles (e.g., makers of automobiles) assess their supply chain in order to ensure that these components do not contain the prohibited chemical. Identifying the chemical in imported articles can be more challenging and is discussed below. Costs are described in Section 4.3.1.

Furthermore, EPA expects the regulated manufacturers or processors to reformulate the affected products. Reformulation costs include activities such as research and development, laboratory testing, and product re-labeling. Costs are described in Section 4.3.2.

Prohibition costs are expected to be one-time costs, likely incurred in the initial year of the rule's applicability.[20] Uses of the chemicals to be prohibited under this rule include those for which there is no current substitute chemical, which is why EPA is providing an extended timeline for the prohibition.

EPA does not believe that the regulatory options result in costs to distributors. Section 4.9.4 discusses unquantified costs and uncertainties related to prohibition.

4.3.1 Supply Chain Analysis

Based on (U.S. Environmental Protection Agency (EPA) 2014d), the following is a list of activities that a company might perform to identify specific chemicals in articles within its supply chain. These costs apply to the consumers of affected articles, not the manufacturer. This was developed based in part on ASTM F2577[21] and on example processes described in industry guidance, such as (AFIRM 2022). This list is intended to capture the general types of activities performed. Whether or not an individual company undertakes each specific listed activity, and the extent to which each is performed, likely depends on a number of factors, such as the size of the company and the complexity of its supply chain. Furthermore, as the prohibition takes effect, users of articles could expect that only imported products would contain PIP (3:1) as it will no longer be used domestically.

1) **Understand applicable requirements.** The company would read and understand the rule, within the context of the company's products. As noted in ASTM F2577-06, "The first step in any assessment is to determine what is covered by requirements, or the scope of the requirements." Frequency: this is a one-time activity.

2) **Identify the types of articles that potentially contain the chemicals subject to the rule** (i.e., PIP (3:1)). A list of the kinds of articles that the company uses that have the potential to contain the chemical can be developed based on an understanding of the uses of the subject substance; use categories for PIP (3:1) have been described. ASTM F2577-06 says to "apply a priori knowledge

[20] Reformulation costs could be spread over multiple years; for the purpose of this analysis, it is assumed that these costs are incurred as soon as possible.

[21] ASTM F2577, *Standard Guide for Assessment of Materials and Products for Declarable Substances*, provides a general description of the process of assessing materials and/or products for the content of declarable (or restricted) substances. It relies on two means for this assessment: both a priori and a posteriori knowledge. Therefore, determinations can be made based on information gleaned through logical deduction and scientific principles (a priori knowledge), as well as on observation, experience and known facts (a posteriori knowledge) including laboratory tests to verify or generate information on the concentration of a chemical substance (AFIRM 2022).

[based upon scientific principles and logical deduction] of the material and its manufacture to assess the probability whether each [regulated] substance may be present." The level of effort called for here may depend on the complexity of the product being manufactured and the article itself; an airplane, for example, has many components to consider. Frequency: an initial review of the company's supply chain would be a one-time activity; however, a company may do a similar review on each potential new article purchased to determine whether it likely contains restricted chemical substances. U.S. Environmental Protection Agency (EPA) 2009). The total burden can vary from two hours per year up to two hours per month (24 hours per year), depending on the number of products exported [imported] by the company (U.S. Environmental Protection Agency (EPA) 2009). EPA for this analysis has chosen to use the higher estimate of 24 hours.

3) **Identify all suppliers involved.** Companies may identify the suppliers from whom the articles identified in the previous step are purchased, and as appropriate, make them aware of the rule. Frequency: an initial identification of suppliers will be a one-time activity; however, a company may assess each new supplier.

   Burden for this activity was taken from (U.S. Environmental Protection Agency (EPA) 2014d). After the potentially affected articles are identified, the users may identify suppliers of the articles identified in the previous step. This involves examining the company's existing records, and potentially contacting the suppliers to make them aware of the chemical restrictions and the importer's preferred data collection method. Burden is assumed to vary depending on the number of suppliers. Burden is estimated based on the cost for supplier notification associated with reporting requirements for the Toxics Release Inventory (TRI). Under TRI reporting requirements, facilities supplying mixtures and products containing listed chemical substances must notify their customers of the contents of their products on an annual basis. This notification can be provided as a letter to the supplier that identifies the chemical and indicates its percentage by weight in the product formulation. While the TRI reporting activity is not exactly analogous to the activity performed by the users of articles in this rule, work would be similar in that the company's existing and available records would be examined to develop a set of entities. The U.S. EPA's *Economic Analysis of the Final Rule to Modify Reporting of Persistent Bioaccumulative Toxic Chemicals under EPCRA Section 313* (U.S. Environmental Protection Agency (EPA) 1999) estimates the supplier notification burden to be 7 hours of technical staff time and 17 hours of clerical staff time per facility, regardless of facility characteristics.

4) **Collect data from suppliers.** Companies may obtain verification from suppliers that the regulated chemical substance is or is not found in the article. This may be accomplished through various strategies – for example, agreements with suppliers, declarations through databases or surveys, or by using a third-party certification system. In some cases, companies may be able to leverage various reporting requirements, such as Safety Data Sheets (SDS) or the Restriction of Hazardous Substances Directive (RoHS) in Europe, to identify the presence of DecaBDE or PIP (3:1) in a supply chain. Frequency: initial data collection from suppliers will be a one-time activity, and any additional data collection a company undertakes as new products are considered and suppliers change will add to the cost. A company may also make periodic confirmations with suppliers reporting any changes in the article's content or manufacturing process.

   The burden of collecting data from suppliers depends on how frequently a user may collect information from suppliers and which suppliers they would collect information from will vary depending on an importer's experience complying with other regulations, available resources, and as due to a number of supply chain factors. Supply chains can change frequently. Users may use multiple types of articles or models within a single product line that may change over time.

Importers may also use single or multiple suppliers for certain types of articles. Many of these changes can occur throughout an article supply chain prior to the article reaching the end user. These factors could all be considerations for the user when deciding which articles to review for supplier information and how frequently. EPA (U.S. Environmental Protection Agency (EPA) 2014d) estimates that depending on these factors, data collection can take anywhere from 5 minutes to 8 hours per article. EPA uses the upper end estimate of 8 hours per article and makes the simplifying assumption of one article per company.

Burden for these steps was estimated in (U.S. Environmental Protection Agency (EPA) 2014d) and is provided in Table 4-5. For the purpose of this analysis, EPA conservatively assumes that companies have a complex supply chain.

Table 4-5: Cost to Identify Components in Supply Chain that Contain PIP (3:1) (2022$)

Activity	Hours per Company (Technical, at $83.14 per hour)	Hours per Company (Clerical, at $40.30 per hour)	Cost per Company	Annualized (3%)	Annualized (7%)
Understand applicable requirements	Included in Section 4.2.2				
Identify components that potentially contain PIP (3:1)	24		$1,995	$97	$149
Identify all suppliers	7	17	$1,264	$61	$94
Collect data from suppliers	8		$665	$32	$50
Total			**$3,925**	**$191**	**$293**

Source: Understanding the Costs Associated with Eliminating Exemptions for Articles in SNURs (U.S. Environmental Protection Agency (EPA) 2014d). This analysis assumes a complex supply chain, and that no chemical testing of articles to identify the presence of PIP (3:1) will need to be done.
Note: Wage rates are as determined in Table 4-1. Costs annualized over 30 years.

4.3.2 Reformulation

EPA is phasing in prohibitions for uses of PIP (3:1) within timeframes that EPA believes would allow industry adequate time to develop reformulated products without the chemical. These phased in timeframes are based on information received by stakeholders in public comments on the 2021 final PIP (3:1) rule and the proposal of this final rule, including:

- Uses of lubricants and greases in non-aircraft machinery and non-turbine equipment may not be subject to these same environmental stresses or safety and performance requirements from industry and government as uses in the aerospace sector. In the EA for the 2021 final PIP (3:1) rule (U.S. Environmental Protection Agency (EPA) 2021b), EPA listed potential alternatives for non-turbine, non-aerospace uses that are currently available on the market. In addition, during the March 2021 notification and comment period, stakeholders indicated that they were working to identify alternatives to and/or eliminate PIP (3:1) from lubricant and grease formulation, while acknowledging for some applications they might not be able to find a replacement. At least one stakeholder requested a 5-year transition period to move away from PIP (3:1) for their applications (National Elevator Industry 2021). Based on this information, EPA proposed a 5-year phase-in prohibition believed to be a practicable amount of time for users to research, formulate, and test alternative products for such non-aerospace, non-turbine uses. During the public comment period for the proposed rule, EPA received feedback from multiple stakeholders that 5 years was not sufficient time (Japan Electronics and Information Technology Industries Association (JEITA) 2023, Japan Auto Parts Industries Association (JAPIA) 2023, Japan

Agricultural Machinery Manufacturers Association 2024, National Marine Manufacturers Association 2024, Association for Advancing Automation (A3) 2024). Based on these comments, EPA has increased the phased in prohibition for uses of lubricants and greases in non-aircraft machinery and non-turbine equipment to 15 years for the final rule.

Stakeholders representing manufacturers of new original equipment and aftermarket components, systems, and materials for use in passenger cars, cars and light trucks indicated that that, under the assumption that an alternative to PIP (3:1) could be found in the next three to four years, the industry could transition out of using PIP (3:1) within a seven to ten year time frame (Motor & Equipment Manufacturers Associates (MEMA) and Auto Innovators 2021). EPA acknowledges that the timeframe contains many contingencies which could delay the adoption of PIP (3:1) alternatives. Nevertheless, based on the industry's own description of their experience with transitioning from a different chemical, albeit under different circumstances, and the time frames provided, EPA believes the 15-year phase-in prohibition on processing of PIP (3:1) for new parts and a 30-year phase-in prohibition for replacement parts is practicable.

- EPA believes the reasoning applied to the use of PIP (3:1) in new and replacement parts for motors vehicles also applies to the use of PIP (3:1) for new and replacement parts in aerospace vehicles. EPA acknowledges, however, that the regulatory and safety requirements for the aerospace industry can be more stringent and is therefore introducing a longer time period of 30 years for the prohibition of the manufacturing, processing and distribution in commerce of products for use in new and replacement parts for aerospace vehicles.

- One industry commenter (Boeing 2024) expressed support for 30-year prohibition, noting that the FAA recertification process that is often necessary in implementing any alternative solutions is a multiyear, unpredictable, and lengthy process. This comes after the process of qualifying an alternative, which often takes more than 10 years, in part because it requires the help of supply chain, formulators, and if applicable the DoD, to address all the stringent technical specification requirements.

- PIP (3:1) use in articles used in manufacturing equipment, in the semiconductor industry, and in HVACR, power generating, and electronic equipment was prohibited under the 2021 final rule and the compliance date was extended to October 2024 (40 CFR § 751.401(a)(2)(iii)). This rule extends the time until prohibition takes effect for these specific articles. Specifically, this final rule prohibits the processing and distribution of these PIP (3:1) and PIP (3:1)-containing articles after 10 years. Cost of prohibition was already considered for the 2021 rule[22], and the effect of this rule's compliance date extension would effectively be a cost savings for these companies. Similarly, the rule extends the compliance date for prohibition of PIP (3:1) in marine anti-fouling coatings, so this rule provides a cost savings for that use as well. Due to the compliance delay, reformulation costs would be incurred in later years than they would be incurred in the baseline and are thus discounted further. The cost savings are the differential between the reformulation costs incurred in the final rule scenario compared to the reformulation costs incurred in the baseline scenario. The cost savings are shown as negative values in the total cost estimates.

- After receiving comment on the proposed rule, EPA is expanding the phase-out of PIP (3:1) in replacement parts (Japan Electronics and Information Technology Industries Association (JEITA)

[22] In the 2021 Final Rule Economic Analysis, reformulation costs were acknowledged qualitatively and were therefore not included in the numerical total cost estimate.

2023, SEMI 2024, Outdoor Power Equipment Institute 2024, Boeing 2024, Association for Advancing Automation (A3) 2024, Chemical Users Coalition 2024, Nuclear Energy Institute 2024, AMT- The Association For Manufacturing Technology 2024, Air-Conditioning Heating and Refrigeration Institute 2024, Semiconductor Industry Association (SIA) 2024, Consumer Technology Association 2024) in articles across industries for additional years beyond the phase-in for new parts, the length of which vary depending on the type of equipment. EPA believes that it will not be necessary for firms to further reformulate replacement parts during these additional years since adequate time is given to reformulate during the initial phase-out of new parts.

In order to understand the magnitude of cost to reformulate a product without using PIP (3:1), EPA reviewed comments submitted during the public comment period for the PBT rules finalized in January 2021 (docket identification number EPA-HQ-OPPT-2019-0080) and for the additionally requested comments in March 2021 (docket identification number EPA-HQ-OPPT-2021-0202). Any information related to costs (including reformulation and testing costs) were summarized, along with any referenced studies for further review. Potential reformulation costs as described by the commenters ranged from $1 million to $100 million per product; however, information related to these cost calculations was limited and/or incomplete, and these values would require additional detail or validation to serve as a useful estimate for reformulation costs and were therefore not used in this analysis.

Alternatively, for this analysis, EPA relies on a review of available studies related to reformulation costs, including a 2006 Cheminfo Services Inc. study for Environment Canada on compliance costs associated with volatile organic compounds (VOC) emissions in automotive aftermarket products. Studies completed as part of the European Chemicals Agency (ECHA) Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) process were also considered (see Sensitivity Analysis in Chapter 7).

The 2006 study by Cheminfo Services[23] surveyed the capital costs of reformulation for 39 products including brake cleaners, lubricants, degreasers, and metal polishes (Cheminfo Services Inc. 2006). Capital costs included the research to develop new formulations, new equipment, and new packaging. Adjusted from Canadian dollars and for inflation to 2022 dollars, the study estimated a minimum reformulation cost of $0, a mean of $26,800, and a maximum of $93,500 USD. Given the expected complexity of reformulation of products containing PIP (3:1), this analysis uses the maximum cost estimated by Cheminfo. Use of the Cheminfo study is consistent with the approach used in EPA's *Final Rule– Economic Analysis of Regulation of 2 Methylene Chloride, Paint and Coating Remover under 3 TSCA Section 6(a)* (EPA Docket EPA-HQ-OPPT-2016-0231).[24] Section 8.1 examines prohibition costs using a different source for estimating the cost of prohibition in a sensitivity analysis. Specifically, the sensitivity analysis utilizes a study by the ECHA Committee for Socio-Economic Analysis on siloxanes D4/D5.

As noted above, the final regulatory option includes time-limited exclusions from prohibition that result in various lengths of time until a use of PIP (3:1) is prohibited. Having more time to reformulate the product results in lower annualized costs because the cost is assumed to be incurred further into the future. Table 4-6 shows the annualized costs for the time-limited exclusions from prohibition considered under this rulemaking, based on the average reformulation cost as estimated by Cheminfo. Not including

[23] Reference is available at: https://www.regulations.gov/document/EPA-HQ-OPPT-2016-0231-0095

[24] The economic analysis for the Methylene Chloride rule used the mean cost value given the similarity of the study chemical. In this analysis, EPA conservatively uses the high-end cost estimation.

cost savings, costs ranged from $1,925 and $980 (prohibition at 30 years) to $4,537 and $6,970 (prohibition before first year) annualized at 3 percent and 7 percent discount rates, respectively. Annualization is calculated over a time horizon of 30 years for all scenarios, as described in Section 4.1.1.

Uses that were prohibited under the 2021 final rule or uses that would be prohibited starting on October 30th, 2024, absent this rule, will realize cost savings relative to the baseline. The cost savings are estimated as the differential between incurring the costs beginning on October 30th, 2024 (without the rule) and incurring the same costs in later years when the prohibition takes place under the rule. For instance, the annualized cost savings for articles in the manufacturing equipment and the semi-conductor industry would be $3,477 - $4,537 = -$1,060.

Based on comment received on the proposed rule, EPA learned of additional industries that would be impacted by the rule. These industries include electronic equipment, HVACR equipment, and power generating equipment. As a result, new NAICS codes were added to Table 4-7 as "Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)." The addition of new industries to this analysis results in additional cost savings relative to the economic analysis for the proposed rule, as these uses were prohibited in the 2021 rule.

Table 4-6: Annualized Reformulation Costs (over 30 years)

Prohibition Timeframe	Uses	Annualized at 3%	Annualized at 7%
Prohibition before 1st year	• None	$4,537	$6,970
Prohibition at 5 years	• None	$4,031	$5,317
Prohibition at 10 years	• None	$3,477	$3,791
Prohibition at 15 years	• New and Replacement Parts for Motor Vehicles (makers) • Lubricants and Greases (except Aerospace and Turbine) (makers)	$2,999	$2,703
Prohibition at 20 years	• None	$2,587	$1,927
Prohibition at 30 years	• New and Replacement Parts for Aerospace Vehicles (makers) • Lubricants and Greases (except Aerospace and Turbine) (makers) • Lubricants & Greases (Aerospace) (makers)	$1,925	$980
Cost savings at 5 years	• Marine Antifouling Coatings	-$506	-$1,653
Cost savings at 10 years	• Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers and consumers)	-$1,060	-$3,179
Cost savings at 20 years	• Wire Harnesses and Electric Circuit Boards (makers) • Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	-$1,949	-$5,042

Note: Costs annualized over 30 years.
Source: (Cheminfo Services Inc. 2006)

4.3.3 Total Prohibition Costs

As described in Section 4.3, prohibition costs were estimated for companies that manufacture an article containing PIP (3:1) (makers, reformulation costs as estimated in 4.3.2) and for those who use those

articles (consumers, supply chain analysis as estimated in 4.3.1). Each of these types of costs depend on the number of products/articles affected.

For lubricants and greases, EPA identified 18 affected non-aerospace/turbine formulated products (see Table 3-15). These products are currently available for sale in the United States and EPA expects that the manufacturers will incur costs to reformulate and stop selling them within the prohibition timeframe. They are manufactured in the United States and are not articles. Therefore, EPA does not expect consumers of these products to research supply chains.

For new and replacement parts for motor vehicles and aerospace vehicles, the number of affected parts is unknown[25]. EPA uses the number of firms in each affected NAICS code (see Table 3-18 and Table 3-20) as a proxy for the number of parts. EPA understands that it is likely for companies who manufacture affected parts to make more than one, however it is unlikely that every company in the NAICS does make parts using PIP (3:1) so an average of 1 part per company may be reasonable. Articles[26] included in these parts may be imported, thus the consumers of the parts need to assess their supply chain to ensure that such parts are not used after the prohibition date.

Negative values indicate cost savings. Cost saving result from additional compliance delays beyond those included in the 2021 PBT rule. See the reformulation section (4.3.2) for further explanation.

Table 4-7 provides the estimated prohibition costs for the final regulatory option. Table 4-8 provides the estimated prohibition cost associated with the primary alternative option.

[25] As described in Section 3.3.2, the regulated community provided, in comments, lists of potentially affected parts but was not able to determine an exact number, as supply chain analysis is still ongoing. The Aerospace Industries Association (AIA), for example, noted that aerospace products consist of thousands of parts, so EPA believes that the order of magnitude estimated here is accurate.

[26] Article means a manufactured item (1) which is formed to a specific shape or design during manufacture, (2) which has end use function(s) dependent in whole or in part upon its shape or design during end use, and (3) which has either no change of chemical composition during its end use or only those changes of composition which have no commercial purpose separate from that of the article, and that result from a chemical reaction that occurs upon end use of other chemical substances, mixtures, or articles; except that fluids and particles are not considered articles regardless of shape or design." See https://www.epa.gov/sites/default/files/documents/articlesfactsheetforcdr_reporting_080312.pdf

Table 4-7: Prohibition Costs by Chemical and Use (Final Option) (2022$)						
Chemical and Use	Time until Prohibition (years)	Number of Products	Annualized 3%		Annualized 7%	
			Cost per Product	Total Cost	Cost per Product	Total Cost
PIP (3:1)						
Lubricants and Greases (except Aerospace and Turbine) (makers)	15	18	$2,999	$53,982	$2,703	$48,654
New and Replacement Parts for Motor Vehicles (consumers)	15	4,562	$191	$871,374	$293	$1,336,715
New and Replacement Parts for Motor Vehicles (makers)	15	8,091	$2,999	$24,266,159	$2,703	$21,871,099
New and Replacement Parts for Aerospace Vehicles (consumers)	30	324	$191	$61,884	$293	$94,932
New and Replacement Parts for Aerospace Vehicles (makers)	30	1,787	$1,925	$3,439,494	$980	$1,751,015
Marine Antifouling Coatings[1]	5	1	-$506	-$506	-$1,653	-$1,653
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)[1]	10	1,165	-$1,060	-$1,234,256	-$3,179	-$3,702,287
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)[1]	10	9,071	-$45	-$403,675	-$133	-$1,210,867
All PIP (3:1)				**$27,054,456**		**$20,187,608**

Note: Costs annualized over 30 years**.**
[1] Negative values indicate cost savings. Cost savings result from additional compliance delays beyond those included in the 2021 PBT rule. See the reformulation section (4.3.2) for further explanation.
Source: See Table 4-5 (consumers) and Table 4-6 (makers)

Table 4-8: Prohibition Costs by Chemical and Use (Alternative Option) (2022$)						
Chemical and Use	Time until Prohibition (years)	Number of Products	Annualized 3%		Annualized 7%	
			Cost per Product	Total Cost	Cost per Product	Total Cost
PIP (3:1)						
Lubricants and Greases (except Aerospace and Turbine) (makers)	5	18	$4,031	$72,558	$5,317	$95,706
Lubricants & Greases (Aerospace) (makers)	5	10	$4,031	$40,310	$5,317	$53,170
Wire Harnesses and Electric Circuit Boards (makers)[1]	20	2,077	-$1,949	-$4,048,015	-$5,042	-$10,470,681
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)[1]	20	1,462	-$1,949	-$2,849,108	-$5,042	-$7,369,564
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)[1]	20	10,491	-$82	-$858,861	-$212	-$2,221,549
All PIP (3:1)				**-$7,643,116**		**-$19,912,918**

Note: Costs annualized over 30 years.
[1] Negative values indicate cost savings. Cost savings result from additional compliance delays beyond those included in the 2021 PBT rule. See the reformulation section (4.3.2) for further explanation.
Source: See Table 4-5 (consumers) and Table 4-6 (makers)

4.4 Worker Protection Costs

Worker protection requirements related to uses of decaBDE that call for use of personal protective equipment (PPE) in the rule are as follows:

- For plastic shipping pallets, the rule requires inhalation and dermal PPE (i.e., APF 10 and chemical-resistant gloves) during the recycling process of pallets known to contain decaBDE
- For the manufacture and processing of decaBDE for use in aerospace replacement parts and the manufacture of such parts, but not the processing of parts to which decaBDE has been added, the rule requires inhalation and dermal PPE (i.e., N95, and chemical-resistant gloves)
- For the manufacture and processing of decaBDE for use in motor vehicle replacement parts and the manufacture of such parts, but not the processing of parts to which decaBDE has been added, the rule requires inhalation and dermal PPE (i.e., N95 and chemical-resistant gloves)
- For recycling of all other decaBDE-containing plastic products, the alternative option would require inhalation and dermal PPE (i.e., APF 10 and chemical-resistant gloves) during the recycling process

Requirements related to uses of PIP (3:1) that call for use of PPE are as follows for the final and alternative options:

- For lubricants and greases, the rule requires use of gloves, as well as a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator.

- For new and replacement parts for motor vehicles, the rule requires a respirator at least as protective as a N95 mask and dermal PPE (gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible) during manufacturing and processing, excluding processing of parts to which PIP (3:1) has been added.
- For new and replacement parts for aerospace vehicles, the rule requires a respirator at least as protective as an N95 masks and dermal PPE (gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible) during manufacturing and processing, excluding processing of parts to which PIP (3:1) has been added.
- For wire harnessing and electric circuit boards, the rule requires inhalation and dermal PPE (a respirator at least as protective as a APF 10 air-purifying half mask respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible).
- For marine antifouling coatings, the rule requires inhalation and dermal PPE (a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible).
- For articles used in manufacturing equipment and the semiconductor industry, as well as HVACR, power generating, and electronic equipment, the rule requires inhalation and dermal PPE (a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible), excluding processing of parts to which PIP (3:1) has been added.
- For specialized engine filters, the rule requires gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible and half or full respirator.
- For cyanoacrylate adhesives, the rule requires a respirator at least as protective as an APF 50 respirators and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible. APF 50 respirators are already being used in the baseline under this COU.
- For aviation hydraulic fluids, the rule requires a respirator at least as protective as a NIOSH-approved APF 10 air-purifying half mask respirator and gloves that are chemically resistant to PIP (3:1) with activity-specific training where dermal contact with PIP (3:1) is possible, during manufacturing and processing.

These requirements are summarized in Table 4-9. Costs associated with each of these types of protective equipment will depend on the phased-in prohibition time, as applicable (that is, PPE will only need to be used for the number of years until the use is prohibited – see Section 4.3 for description of prohibition timeframes). PPE costs are assessed in the following sections.

Table 4-9: Summary of Worker Protection Requirements (Final Option)

Chemical and Use	Inhalation Protection	Dermal Protection	Years of Use[1]
DecaBDE			
Plastic Shipping Pallets	N95	Chemical-resistant gloves	30
Replacement Parts for Aerospace Vehicles (makers)	N95	Chemical-resistant gloves	30
Replacement Parts for Motor Vehicles (makers)	N95	Chemical-resistant gloves	30
PIP (3:1)			

Table 4-9: Summary of Worker Protection Requirements (Final Option)			
Chemical and Use	**Inhalation Protection**	**Dermal Protection**	**Years of Use[1]**
Lubricants and Greases (except Aerospace and Turbine) (makers)	Air-purifying half mask	Chemical-resistant gloves	15
Lubricants & Greases (Aerospace) (makers)	Air-purifying half mask	Chemical-resistant gloves	30
New and Replacement Parts for Motor Vehicles (makers)	N95	Chemical-resistant gloves	15
New and Replacement Parts for Aerospace Vehicles (makers)	N95	Chemical-resistant gloves	30
Wire Harnesses and Electric Circuit Boards (makers)	Air-purifying half mask	Chemical-resistant gloves	30
Marine Antifouling Coatings	Air-purifying half mask	Chemical-resistant gloves	5
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	Air-purifying half mask	Chemical-resistant gloves	10
Engine Filters for Locomotive and Marine Applications	Air-purifying half mask	Chemical-resistant gloves	30
Cyanoacrylate Adhesives	APF 50	Chemical-resistant gloves	30
Aviation Hydraulic Fluid (makers)	Air-purifying half mask	Chemical-resistant gloves	30
[1] Worker protection will be required for additional years for use in replacement parts. Specifically, it will be required for 30 years in motor vehicles and aerospace vehicles; 7 years in electronic equipment for personal use; 25 years for in electronic equipment for commercial use, HVACR and water heating equipment, and power generating equipment; and service life in manufacturing equipment, including semiconductor manufacturing, and laboratory equipment.			

Table 4-10: Summary of Worker Protection Requirements (Primary Alternative Option)			
Chemical and Use	**Inhalation Protection**	**Dermal Protection**	**Years of Use**
DecaBDE			
Other DecaBDE-containing Plastic	Air-purifying half mask	Chemical-resistant gloves	30
PIP (3:1)			
Lubricants & Greases (Aerospace) (makers)	Air-purifying half mask	Chemical-resistant gloves	30
Lubricants and Greases (except Aerospace and Turbine) (makers)	Air-purifying half mask	Chemical-resistant gloves	5
Wire Harnesses and Electric Circuit Boards (makers)	Air-purifying half mask	Chemical-resistant gloves	20
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	Air-purifying half mask	Chemical-resistant gloves	20

4.4.1 Number of Affected Workers and Compliance Rates

Affected Workers

PPE costs depend on the number of workers required to use such protection. Since EPA does not have company-level data for each company affected, the Agency used assumptions about the categories of workers employed within each affected NAICS code. EPA examined U.S. BLS' Occupational Employment and Wage Statistics (OEWS), Research Estimates by State and Industry data (BLS 2022b). For the NAICS code at the highest level available (e.g., 4-digit level 3132), EPA reviewed the Standard Occupational Classification titles (SOC codes) to identify those occupations where workers are potentially using or handling the regulated chemical (see Appendix C for lists of codes and use/handling status). Whether or not a worker within the SOC code was considered likely to handle or use the chemical was based on the descriptions/examples of the occupation categories found on BLS' *2018 Standard*

Occupational Classification System webpage (BLS 2020) and EPA's understanding of the relevant industries. With the OEWS employment numbers for each SOC code, EPA calculated the percent of employees likely to handle or use the chemical for each 3- or 4-digit NAICS (see Appendix C, Table C-1 through Table C-16). EPA then applied that percentage to the average number of employees per firm (derived from SUSB data) in each relevant 6-digit NAICS code. These calculations are shown in Table F-1.

Baseline Compliance

EPA expects that some industries already provide PPE for their workers, and thus, the required respiratory and hand protection does not result in an incremental cost. EPA assumes that for Cyanoacrylate Adhesives, APF 50 respirators are already being used in the baseline.

Because the OSHA requirements (29 CFR 1910) generally do not require specific types of protective equipment, EPA looked for industry guidelines or other publications to determine the type of worker protection commonly used. For sectors for which EPA was able to determine that an industry standard exists, EPA compared the standard to the requirement to determine whether it was more or less stringent. If the protection assumed to be currently used was less stringent, EPA would determine the incremental cost for the required equipment; however, in no cases was the standard determined to be less stringent. Table 4-11 summarizes whether standard levels of worker protection were found for each industry. See Appendix D for the list of baseline PPE equipment identified and sources.

Table 4-11: Summary of Whether Standard Industry PPE was Identified for Regulated NAICS			
NAICS Code	NAICS Description	Inhalation (Respirators)	Dermal (Gloves)
3261	Plastics Product Manufacturing	yes	yes
324110	Petroleum Refineries	no	yes
324191	Petroleum Lubricating Oil and Grease Manufacturing	no	yes
325180	Other Basic Inorganic Chemical Manufacturing	yes	yes
325199	All Other Basic Organic Chemical Manufacturing	yes	yes
325211	Plastics Material and Resin Manufacturing	no	no
325510	Paint and Coating Manufacturing	yes	yes
325520	Adhesive Manufacturing	no	no
325991	Custom Compounding of Purchased Resins	no	no
326199	All Other Plastics Product Manufacturing	no	no
333242	Semiconductor Machinery Manufacturing	yes	yes
333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	no	yes
334412	Bare Printed Circuit Board Manufacturing	yes	yes
334413	Semiconductor and Related Device Manufacturing	yes	yes
334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing	yes	yes
335931	Current-Carrying Wiring Device Manufacturing	no	yes
336211	Motor Vehicle Body Manufacturing	no	yes
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	no	yes
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing	no	yes
336390	Other Motor Vehicle Parts Manufacturing	no	yes
336412	Aircraft Engine and Engine Parts Manufacturing	yes	yes
336413	Other Aircraft Part and Auxiliary Equipment Manufacturing	yes	yes
336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	yes	yes
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	yes	yes
336991	Motorcycle, Bicycle and Parts Manufacturing	no	yes
336999	All Other Transportation Equipment Manufacturing	no	yes
423120	Motor Vehicle Supplies and New Parts Merchant Wholesalers	no	yes
423840	Industrial Supplies Merchant Wholesalers	no	yes
424690	Other Chemical and Allied Products Merchant Wholesalers	no	yes
488190	Other Support Activities for Air Transportation	yes	yes
562920	Materials Recovery Facilities	yes	yes
Source: See Appendix D			

As a proxy for how likely the companies within a NAICS code are to follow the PPE standard (when a standard was found), EPA estimated the compliance rate for those sectors where current worker protection use was identified. To estimate the compliance rate, data from OSHA inspections during October 2021 to September 2022 (Occupational Safety and Health Administration (OSHA) 2023) for each NAICS code were used. For example, for NAICS 325180, there was one violation involving respiratory protection out of six inspections performed during the time period, for a rate of 16.7% noncompliance. These calculations are shown in Table 4-12. EPA assumes that noncompliant facilities will incur worker protection costs to come into compliance with the final rule. When no inspections were performed, EPA conservatively assumes 100% noncompliance.

Appendix Table F-1 and Appendix Table F-2 show how the total number of workers who need respiratory and dermal PPE were calculated for the Primary and Alternative Options, respectively.

Table 4-12: Noncompliance Rates based on OSHA Inspections, October 2021 to September 2022					
NAICS Code	Total Inspections Performed	Inspections with Respiratory Protection Citations	Percent Noncompliant - Respiratory	Inspections with Hand Protection Citations	Percent Noncompliant - Dermal
3261	229	12	5.24%	7	3.06%
324110	9	0	0.00%	1	11.11%
324191	2	0	0.00%	0	0.00%
325180	6	1	16.67%	0	0.00%
325199	6	1	16.67%	0	0.00%
325211	33	4	12.12%	1	3.03%
325510	29	5	17.24%	0	0.00%
325520	12	3	25.00%	0	0.00%
325991	8	4	50.00%	0	0.00%
325998	19	5	26.32%	0	0.00%
333242	1	0	0.00%	0	0.00%
333415	11	2	18.18%	1	9.09%
334412	0	0	100.00%	0	100.00%
334413	2	1	50.00%	0	0.00%
334418	3	0	0.00%	0	0.00%
335931	0	0	100.00%	0	100.00%
336211	12	1	8.33%	0	0.00%
336310	4	1	25.00%	0	0.00%
336320	3	0	0.00%	0	0.00%
336390	30	1	3.33%	0	0.00%
336412	4	1	25.00%	0	0.00%
336413	11	0	0.00%	0	0.00%
336415	0	0	100.00%	0	100.00%
336419	0	0	100.00%	0	100.00%
336991	0	0	100.00%	0	100.00%
336999	3	0	0.00%	0	0.00%
423120	13	1	7.69%	0	0.00%
423840	13	1	7.69%	0	0.00%
424690	13	3	23.08%	1	7.69%
532490	7	0	0.00%	0	0.00%
562920	16	1	6.25%	1	6.25%
Source: (Occupational Safety and Health Administration (OSHA) 2023)					

4.4.2 Inhalation Protection

Respirators are grouped into different classes defined by the air supply system, operating mode, and the type of facepiece. Firms may provide any respirator that meets or exceeds the requirements stipulated by the rule, however this analysis assumes the following respirator types will be used:

- **N95 Mask.** NIOSH-approved APF 10, air-purifying filtering facepiece/dust mask respirator (commonly referred to as an N95 Mask).

- **APR Half Mask (APF 10).** A NIOSH-approved Air Purifying Respirator (APR) with an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element.

The APF denotes the level of respiratory protection that a given respirator is expected to provide employees. An owner or operator may select any respirator that has an APF equal to or greater than the applicable requirement.

APF 50 respirators are required for the cyanoacrylate adhesives COU. However, APF 50 respirators are already being used in the baseline under this COU. Therefore, unit costs of APF 50 COUs are not presented.

EPA is requiring implementation of a respiratory protection program in alignment with 29 CFR 1910.134, which requires each owner or operator select respiratory protection in accordance with the guidelines for proper respirator use, maintenance, fit-testing, medical evaluation, and training.

Costs associated with inhalation PPE include those for medical evaluation, fit testing, training, and cleaning, as well as for the equipment itself. Each of these costs are detailed in the following sections.

Medical Evaluation Costs

All employees must receive a medical evaluation before they are required to wear a respirator, (including N95 masks, see (Occupational Safety and Health Administration (OSHA) 2010b). The owner or operator identifies a physician or other licensed health care professional to perform an initial medical evaluation using a medical questionnaire or a medical examination that gathers the same information as the questionnaire. Many respirator distributors are now offering medical questionnaires online. For example, 3M offers the services for $29 per employee and estimates it will take an employee about 15 minutes to complete (3M 2022). The cost to the owner or operator for this component of the medical evaluation includes the cost of the medical questionnaire service ($29), plus the loaded wage of an employee for 15 minutes to complete the questionnaire.

Any employee failing the initial medical evaluation must undergo a follow-up examination. It is estimated that 23 percent of employees fail the initial medical evaluation (Occupational Safety and Health Administration (OSHA) 2010b). The total cost of the follow-up medical examination incorporates the cost of the employee's time (time spent traveling, waiting, and being examined) and the cost of the examination. The cost of the employee's time is estimated by multiplying their loaded wage rate by travel time, wait time, and estimated duration of the follow-up medical examination. The cost of the follow-up medical examination is equal to $210, estimated as the cost presented in OSHA (Occupational Safety and Health Administration (OSHA) 2010b) and inflating the value from 1994 to 2022 dollars using the CPI for medical care services (U.S. Bureau of Labor Statistics (BLS) 2023a).

Table 4-13 presents the estimated per-employee medical evaluation costs. The cost per employee for the medical exam ($48) was estimated by inflating the cost of a partial limited medical examination ($75) and multiplying by the 23 percent of employees that fail the initial medical evaluation (Occupational Safety and Health Administration (OSHA) 2010b).

Table 4-13: Medical Evaluation Costs per Employee (2022$)			
Cost Input	**Cost Per Hour**	**Number Of Hours Per Employee**	**Cost Per Employee**
Online Medical History Questionnaire Services	-	-	$29
Cost of Medical Exam[1]	-	-	$48
Employee Time for Questionnaire	$40.13	0.25	$10
Employee Time for Exam[2]	$40.13	0.46	$18
Total Medical Evaluation Costs Per Employee			**$105**
[1] The cost per employee is estimated by inflating the cost of a partial limited medical examination ($75) and multiplying by the 23 percent of employees that fail the initial medical evaluation (Occupational Safety and Health Administration (OSHA) 2010b).			
[2] 23 percent of employees that fail the initial medical evaluation and incur a 2-hour labor burden, 23%*2 = 0.46 hours on average per employee (Occupational Safety and Health Administration (OSHA) 2010b).			

Fit Testing

Before an employee can wear a negative pressure tight-fitting mask/facepiece respirator, they must be fit tested with the same make, model, style, and size of respirator that would be used. The owner or operator must ensure that employees pass an appropriate qualitative fit test or quantitative fit test. Quantitative fit tests are needed for PAPR, SAR, and SCBA respirators. Quantitative fit test costs are not presented since there are estimated to be no incremental adaptations of these respirator types due to the rule.

Qualitative fit tests may only be used to fit test negative pressure APRs[27] that must achieve a fit factor of 100 or less (29 CFR 1910.134(f)(6)).[28] They involve a chemical test kit that uses an employee's sense of smell, taste, or reaction to an irritant to detect leakage into the mask/facepiece. It is assumed that a manager performs the qualitative fit test, in groups of four employees, and that the test takes an hour to complete per employee and 15 minutes (0.25 an hour) of a manager's time for each employee fitted (Eastern Research Group (ERG) 2003).

Table 4-14 presents the qualitative per-employee fit testing costs. These costs are annual occurrences, as required by 29 CFR 1910.134(f)(2).

Table 4-14: Annual Qualitative Respirator Fit Testing Costs per Employee (2022$)			
Cost Input	**Cost Per Hour**	**Number Of Hours Per Employee**	**Cost Per Employee**
Cost of Manager[1]	$94.74	0.25	$23.69
Cost of Employee's Time	$40.13	1	$40.13
Fit-test Materials[1]			$0.83
Cost of Qualitative Fit-Test per Employee			**$64.64**
[1] Cost estimate is an average of four online retailers.			

Training

After an employee is properly fitted for a respirator, they will receive training to ensure proper use of the equipment. Duration of training varies with the complexity of the respirator. ERG (2003) estimates that APR systems require two hours of training per year. The number of hours per employee for a manager to conduct training is 15 minutes per 1 hour of worker time because training is assumed to be conducted in groups of four (Eastern Research Group (ERG) 2003).

[27] N95 masks are considered to be negative pressure APRs and fit testing is required (Occupational Safety and Health Administration (OSHA) 2010a).

[28] Fit factor is a quantitative estimate of the fit of the respirator, and typically estimates the ratio of the concentration of a substance outside of the respirator to its concentration inside the respirator.

Table 4-15 presents the estimated hourly employee training costs for APR systems.

Table 4-15: Annual APR Training Costs per Employee (2022$)			
Employee Type	**Price/Hour**	**Number of Hours Per Employee**	**Cost/Employee**
Worker	$40.13	2	$80.26
Manager[1]	$94.74	0.5	$47.37
Total Cost of Training per Employee			**$127.63**
[1] The number of hours per employee for a manager to conduct training is 15 minutes per 1 hour of Worker time because training is assumed to be conducted in groups of four (Eastern Research Group (ERG) 2003).			

Respirator Cleaning

It is estimated that each worker will need clean their (non-disposable) respirator every other shift, or 125 times per year, requiring 5 minutes of labor per cleaning (Occupational Safety and Health Administration (OSHA) 2016a). Thus, the estimated annual labor burden for cleaning is 10.42 hours per worker. The estimated costs by industry sector are presented in Table 4-16.

Table 4-16: Annual Respirator Cleaning Costs (2022$)			
Employee Type	**Price/Hour**	**Number of Hours Per Employee**	**Cost/Employee**
Worker	$40.13	10.42	$418.15

Respirator Equipment

Estimated unit costs for respirator equipment considered in this analysis were developed by averaging the prices gathered from internet research of popular PPE distributors in 2022, as shown in Appendix E, Table E-1.

Useful life is equal to the number of years until a respirator or respirator component needs to be replaced. The annual replacement rate of a respirator or respirator component, or the annual reoccurrence of other PPE program elements, is therefore equal to 1 divided by the useful life. EPA estimated the useful lives of respirators, respirator components, training, and fit testing, as shown in Appendix E, Table E-3. As described in Appendix E, the elastomeric half masks are replaced every two years and the cartridge filters are replaced at a rate of 100 per year. N95 masks are replaced daily.

Table 4-17 presents unit costs estimates for respirators and respirator system components. Useful lives define the schedule used to discount each cost component before the estimates are annualized over 30 years. Total annual inhalation protection costs are the sum of each applicable unit cost divided by its useful life.

Table 4-17: Annualized PPE Equipment Costs per Worker, by Respirator System				
Respirator System	**Component**	**Unit Cost**	**Useful Life**	**Annual Cost**
Elastomeric	Half Mask, (APR)	$27.97	2	$14
	Cartridge Filters (APR)	$20.50	0.01	$2,050
			Total	**$2,065**
N95	Half Mask (N95 Mask)	$1.97	0. 004	$513
			Total	**$513**
Source: See Appendix E **Note:** Useful life based on 2,080 hours per year				

Total Annualized Inhalation Protection Costs

Annual cost components, as estimated in the previous sections, are summarized and totaled in Table 4-18.

Table 4-18: Total Annual Inhalation Protection Costs, per worker (2022$)

Respirator System	Annual Equipment Costs	Annual Medical Evaluation Costs	Annual Fit Test Costs	Annual Training Costs	Annual Cleaning Costs	Total Annual Costs
Elastomeric	$2,064	$105	$65	$128	$418	**$2,780**
N95	$513	$105	$65	$128	$0	**$811**

Annualized inhalation protection costs will depend on the number of years during which respirator use takes place. While the analysis timeframe is 30 years (annualization is over 30 years), requirements vary in the number of years until an activity is prohibited. For example, for PIP (3:1), processing and distribution for use in new parts for motor vehicles are prohibited after 15 years, and during that time inhalation and dermal PPE is required; there is no prohibition for PIP (3:1) in aviation hydraulic fluid, so EPA expects PPE to be used for the entire 30-year analysis period. Inhalation protection costs from Table 4-18 were annualized at both 3% and 7% discount rates over 30 years for the numbers of years until prohibition that the final and alternative options cover. These costs are provided in Table 4-19.

Table 4-19: Annualized Inhalation Protection Costs for Various Years of Use (2022$)

Respirator Type	Years of Use	Annualized Cost, 3% Discount Rate	Annualized Cost, 7% Discount Rate
Elastomeric	5	$637	$910
Elastomeric	10	$1,186	$1,558
Elastomeric	20	$2,068	$2,350
Elastomeric	30	$2,780	$2,780
N95	15	$484	$589
N95	30	$811	$811

Appendix F, Table F-3 and Table F-4, sums the costs shown in Table 4-19 for each industry sector, considering the percent of employees who may be affected and baseline compliance rate (affected workers and compliance rates were discussed in Section 4.4.1). Table 4-20 and Table 4-21 show the respiratory protection costs from Table E-1 totaled for each regulatory option (final and primary alternative options, respectively).

Table 4-20: Total Annualized Respiratory Protection Costs, by Chemical and Use (Final Option) (2022$)			
Chemical and Use	**Number of Workers who need PPE**	**Annualized Cost, 3% Discount Rate**	**Annualized Cost, 7% Discount Rate**
DecaBDE			
Plastic Shipping Pallets	0	$0	$0
Replacement Parts for Aerospace Vehicles (makers)	0	$0	$0
Replacement Parts for Motor Vehicles (makers)	0	$0	$0
PIP (3:1)			
Lubricants & Greases (except Aerospace and Turbine) (makers)	51	$90,277	$107,300
Lubricants and Greases (Aerospace) (makers)	371	$1,029,967	$1,029,967
New and Replacement Parts for Motor Vehicles (makers)	326,450	$175,312,859	$205,998,051
New and Replacement Parts for Aerospace Vehicles (makers)	19,364	$18,346,545	$18,346,545
Wire Harnesses and Electric Circuit Boards (makers)	33,102	$91,067,997	$91,067,997
Marine Antifouling Coatings	2,473	$1,574,207	$2,249,336
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	23,521	$47,586,870	$52,332,453
Engine Filters for Locomotive and Marine Applications	0	$0	$0
Cyanoacrylate Adhesives	0	$0	$0
Aviation Hydraulic Fluid (makers)	163	$453,096	$453,096
Total[1]	**405,495**	**$335,461,818**	**$371,584,745**
Note: Total annualized costs have been adjusted down proportionately for PIP (3:1) so as not to include double counting. Where applicable, the use with the highest cost for each NAICS was counted in the total.			

Table 4-21: Total Annualized Respiratory Protection Costs, by Chemical and Use (Primary Alternative Option) (2022$)			
Chemical and Use	**Number of Workers who need PPE**	**Annualized Cost, 3% Discount Rate**	**Annualized Cost, 7% Discount Rate**
DecaBDE			
Other DecaBDE-containing Plastic	234,326	**$651,425,712**	**$651,425,712**
PIP (3:1)			
Lubricants and Greases (except Aerospace and Turbine) (makers)	50	$34,718	$47,945
Lubricants & Greases (Aerospace) (makers)	389	$1,081,996	$1,081,996
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	31,498	$77,180,753	$81,147,257
Wire Harnesses and Electric Circuit Boards (makers)	32,593	$90,621,871	$90,621,871
All PIP (3:1)	**64,530**	**$168,919,338**	**$172,899,069**
Total	**298,856**	**$820,345,050**	**$824,324,781**
Note: Total annualized costs have been adjusted down proportionately for PIP (3:1) so as not to include double counting. Where applicable, the use with the highest cost for each NAICS was counted in the total.			

4.4.3 Dermal Protection

The final rule requires that facilities will provide chemical-resistant gloves that provide an impervious barrier to prevent dermal exposure during expected durations of use and normal conditions of exposure within the workplace.

In addition to costs for compliant gloves, we estimate costs for the facilities to incorporate annual training into their PPE program, as per 29 CFR 1910.132, to ensure that the employee understands how to properly use the equipment they are assigned.

Training

Owners or operators are required to train employees in proper use, maintenance, and limitations of PPE (29 CFR 1910.132). While owners or operators are only required to retrain employees if they do not demonstrate adequate skill and understanding of the PPE, or if changes in the workplace or types of PPE render the previous training obsolete, EPA assumes that owners or operators will conduct annual retraining. EPA could not identify a source that estimates the time required to conduct training. Because EPA expects that training in proper use of hand protection will be less complex than respirator use training (a minimum of 2 hours), the Agency assumes that hand protection training will require 1 hour per employee. Table 4-22 presents annual training costs per employee.

Table 4-22: Annual Hand Protection Training Costs per Employee (2022$)

Employee Type	Price/ Hour	Number Of Hours Per Employee	Cost/Employee
Worker	$40.13	1	$40.13
Manager[1]	$94.74	0.25	$23.69
Total Cost of Training per Employee			**$63.82**

[1] The number of hours per employee for a manager to conduct training is 15 minutes rather than 1 hour because training is assumed to be conducted in groups of four (Eastern Research Group (ERG) 2003).

Equipment

Gloves are manufactured to meet the needs of a range of industries and hazards, and thus vary in properties such as material and thickness. For dermal protection against hazardous chemicals, the appropriateness of any given glove will depend on the type of chemical, the type of exposure (e.g. splash protection, immersion), the length of exposure, dexterity requirements, thermal protection, and comfort. There are several commonly used materials to protect against chemical hazards, such as butyl, neoprene, nitrile, and polyvinyl chloride (Occupational Safety and Health Administration (OSHA) 2004; Grainger 2019).

OSHA's Hand Protection Standard does not provide specific guidance on appropriate hand protection for chemicals, instead only stating that "Employers shall base the selection of the appropriate hand protection on an evaluation of the performance characteristics of the hand protection relative to the task(s) to be performed, conditions present, duration of use, and the hazards and potential hazards identified" (29 CFR 1910.138). It is instead recommended that employers select gloves that are most resistant to the specific chemicals being used based on manufacturers' chemical resistance guides (Occupational Safety and Health Administration (OSHA) 2004; Grainger 2019). This is particularly important because gloves made of the same material but from different manufacturers may perform differently for a given chemical. Similarly, a material that is suitable for one chemical may not provide adequate protection against another chemical (Argonne National Laboratory 2014). For the purpose of this analysis, EPA assumes that companies will choose nitrile gloves. Nitrile gloves are often used as a general-purpose glove that provides protection against chlorinated solvents, as well as oils, greases, petroleum products, acids, caustics, and alcohols. To the extent that companies choose other types of gloves, costs will be more or less than estimated.

For disposable gloves, the number of pairs used per day will depend on the type of work being performed. Depending on the industry, an employee may work with the chemical consistently throughout the day or

they may only come into contact with the chemical once per day or once every few days. For cases where a worker will come into contact with the chemical once per day or less, a lower bound assumption is one pair of gloves per day. For cases where a worker may be in constant contact with the chemical throughout the day, it may be assumed that the worker will change gloves every 2 hours (or 4 pairs per 8-hour workday), assuming that is the average length of time a worker will work with the chemical before taking a break or switching tasks. To be conservative, EPA assumes that the worker will change gloves every 2 hours, for 260 workdays per year.

Estimated unit costs for nitrile gloves were developed by averaging the prices gathered from internet research of popular PPE distributors in 2022, as shown in Appendix E, Table E-2. Table 4-23 presents unit costs estimates for gloves. Useful life defines the schedule used to discount each cost component before the estimates are annualized over 30 years. Total annual costs of dermal protection are the sum of each applicable unit cost divided by its useful life.

Table 4-23: Dermal Protection Unit Costs per worker (2022$)

Equipment Type	Unit cost	Useful Life (Year)	Annual Cost
Nitrile Gloves (pair)	$0.17	0.000962	$174

Total Annualized Dermal Protection Costs

Total annual costs are shown in Table 4-24.

Table 4-24: Total Annual Dermal Protection Costs, per worker (2022$)

Equipment Type	Annual Equipment Costs	Annual Training Costs	Total Annual Costs
Nitrile Gloves (pair)	$174	$64	**$238**

Annualized dermal protection costs will depend on the number of years during which equipment use takes place. Dermal protection costs from Table 4-24 were annualized at both 3% and 7% discount rates over 30 years for the number of years until prohibition that the final and alternative options cover. These costs are provided in Table 4-25.

Table 4-25: Annualized Dermal Protection Costs for Various Years of Use (2022$)

Equipment Type	Years of Use	Cost Annualized at 3%	Cost Annualized at 7%
Nitrile Gloves (pair)	5	$54	$78
Nitrile Gloves (pair)	10	$102	$133
Nitrile Gloves (pair)	15	$142	$173
Nitrile Gloves (pair)	20	$177	$201
Nitrile Gloves (pair)	30	$238	$238

Appendix F, Table F-2, sums the costs shown in Table 4-25 for each industry sector under each use, considering the percent of employees who may be affected and baseline compliance rate (affected workers and compliance rates were discussed in Section 4.4.1). Table 4-26 and Table 4-27 show the dermal protection costs from totaled for each regulatory option (final and primary alternative options, respectively).

Table 4-26: Total Annualized Dermal Protection Costs, by Chemical and Use (Final Option) (2022$)		
Chemical and Use	**Annualized Cost, 3% Discount Rate**	**Annualized Cost, 7% Discount Rate**
DecaBDE		
Plastic Shipping Pallets	$0	$0
Replacement Parts for Aerospace Vehicles (makers)	$0	$0
Replacement Parts for Motor Vehicles (makers)	$0	$0
PIP (3:1)		
Lubricants & Greases (except Aerospace and Turbine) (makers)	$7,678	$7,678
Lubricants and Greases (Aerospace and Turbine) (makers)	$232	$326
New and Replacement Parts for Motor Vehicles (makers)	$24,334,986	$24,997,923
New and Replacement Parts for Aerospace Vehicles (makers)	$4,167,396	$4,167,396
Wire Harnesses and Electric Circuit Boards (makers)	$6,971,194	$6,971,194
Marine Antifouling Coatings	$0	$0
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment	$1,548,471	$1,548,471
Engine Filters for Locomotive and Marine Applications	$0	$0
Cyanoacrylate Adhesives	$0	$0
Aviation Hydraulic Fluid (makers)	$3,849	$3,849
Total[1]	**$37,033,806**	**$37,696,837**
Note: Total annualized costs have been adjusted down proportionately for PIP (3:1) so as not to include double counting. Where applicable, the use with the highest cost for each NAICS was counted in the total.		

Table 4-27: Annualized Dermal Protection Costs, by Chemical and Use (Primary Alternative Option) (2022$)		
Chemical and Use	**Annualized Cost, 3% Discount Rate**	**Annualized Cost, 7% Discount Rate**
DecaBDE		
Other DecaBDE-containing Plastic	$3,329,684	$3,329,684
PIP (3:1)		
Lubricants and Greases (except Aerospace and Turbine) (makers)	$230	$324
Lubricants & Greases (Aerospace) (makers)	$7,701	$7,701
Wire Harnesses and Electric Circuit Boards (makers)	$7,873,223	$7,873,223
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment	$3,918,935	$3,918,935
All PIP (3:1)	**$11,800,090**	**$11,800,184**
Total	**$15,129,774**	**$15,129,868**
Note: Total annualized costs have been adjusted down proportionately for PIP (3:1) so as not to include double counting. Where applicable, the use with the highest cost for each NAICS was counted in the total.		

4.4.4 PPE Documentation

EPA requires that owners and operators document respiratory protection used and PPE program implementation. As described in Section 2.4.1 and 2.4.3, the rule requires that owners and operators document in the PPE program the following information, as applicable:

> (A) The name, workplace address, work shift, job classification, and work area of each person reasonably likely to directly handle the chemical (decaBDE or PIP (3:1)) or handle equipment or materials on which the chemical may present and the type of PPE selected to be worn by each of these persons;
>
> (B) The basis for PPE selection (e.g., demonstration based on permeation testing or manufacturer specifications that each item of PPE selected provides an impervious barrier to prevent exposure

during expected duration and conditions of exposure, including the likely combinations of chemical substances to which the PPE may be exposed in the work area); and
(C) Appropriately sized PPE and training on proper application, wear, and removal of PPE, and proper care/disposal of PPE.

EPA assumes that the burden to develop this documentation is similar to the estimates for developing a written exposure control document from OSHA's *Final Economic Analysis and Final Regulatory Flexibility analysis for Occupational Exposure to Respirable Crystalline Silica* (Occupational Safety and Health Administration (OSHA) 2016b) assumes that a supervisor (manager) will develop a written plan. OSHA estimates that it will take 1 hour to develop the plan for establishments with fewer than 20 employees, 4 hours for establishments between 20 and 499 employees, and 16 hours for establishments with more than 500 employees. This analysis assumes that the plan will be developed by a certified industrial hygienist. The per-company cost at 3 and 7 percent discount rates are presented in Table 4-28.

Table 4-28: One-time Cost of Developing PPE Documentation, per company

Facility Type	Hours	Industrial Hygienist Labor (at $68.41 per hour)	Annualized (3% Discount Rate)	Annualized (7% Discount Rate)
Small Manufacturing (fewer than 20 employees)	1	$68	$3	$5
Medium Manufacturing (20 to 499 employees)	4	$274	$13	$20
Large Manufacturing (more than 500 employees)	16	$1,095	$53	$82

As shown in Appendix E, EPA used SUSB data to determine the number of firms in each of the facility size types (small, medium, and large) for each of the affected NAICS for each chemical and use. EPA then applied the appropriate cost from Table 4-28. The summed costs for each regulatory option are shown in Table 4-29 for the final option, and Table 4-30 for the primary alternative option.

Table 4-29: Annualized PPE Documentation Costs, by Chemical and Use (Final Option) (2022$)		
Chemical and Use	**Total Annualized Cost, 3% Discount Rate**	**Total Annualized Cost, 7% Discount Rate**
DecaBDE		
Plastic Shipping Pallets	$13	$20
Replacement Parts for Aerospace Vehicles (makers)	$0	$0
Replacement Parts for Motor Vehicles (makers)	$0	$0
PIP (3:1)		
Lubricants and Greases (except Aerospace and Turbine) (makers)	$64	$100
Lubricants & Greases (Aerospace) (makers)	$326	$505
New and Replacement Parts for Motor Vehicles (makers)	$92,521	$144,633
New and Replacement Parts for Aerospace Vehicles (makers)	$23,368	$36,407
Wire Harnesses and Electric Circuit Boards (makers)	$20,139	$31,390
Marine Antifouling Coatings	$53	$82
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$13,724	$21,440
Engine Filters for Locomotive and Marine Applications	$3	$5
Cyanoacrylate Adhesives	$52	$82
Aviation Hydraulic Fluid (makers)	$141	$219
All PIP (3:1)	$150,393	$234,863
Total[1]	**$150,406**	**$234,883**
Note: Total annualized costs have been adjusted down proportionately for PIP (3:1) so as not to include double counting. Where applicable, the use with the highest cost for each NAICS was counted in the total.		

Table 4-30: Annualized PPE Documentation Costs, by Option (Primary Alternative Options) (2022$)		
Chemical and Use	**Total Annualized Cost, 3% Discount Rate**	**Total Annualized Cost, 7% Discount Rate**
DecaBDE		
Other DecaBDE-containing Plastic	$89,525	$139,885
PIP (3:1)		
Lubricants and Greases (except Aerospace and Turbine) (makers)	$85	$132
Lubricants & Greases (Aerospace) (makers)	$397	$614
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$20,758	$32,381
Wire Harnesses and Electric Circuit Boards (makers)	$21,546	$33,578
All PIP (3:1) Alternative Options	***$42,786***	***$66,705***
Total[1]	**$132,311**	**$206,590**
Note: Total annualized costs have been adjusted down proportionately for PIP (3:1) so as not to include double counting. Where applicable, the use with the highest cost for each NAICS was counted in the total.		

4.4.5 Total Worker Protection Costs

Table 4-31 and Table 4-32 show the total worker protection (PPE) costs under the final and primary alternative regulatory options, respectively.

Table 4-31: Total PPE Costs, by Chemical and Use (Final Option)								
Chemical and Use	Annualized Cost, 3% Discount Rate				Annualized Cost, 7% Discount Rate			
	Respiratory	Dermal	Documentation	TOTAL	Respiratory	Dermal	Documentation	TOTAL
DecaBDE								
Plastic Shipping Pallets	$0	$0	$13	**$13**	$0	$0	$20	**$20**
Replacement Parts for Aerospace Vehicles (makers)	$0	$0	$0	**$0**	$0	$0	$0	**$0**
Replacement Parts for Motor Vehicles (makers)	$0	$0	$0	**$0**	$0	$0	$0	**$0**
PIP (3:1)								
Lubricants and Greases (except Aerospace and Turbine) (makers)	$90,277	$232	$64	**$90,573**	$107,300	$326	$100	**$107,726**
Lubricants & Greases (Aerospace) (makers)	$1,029,967	$7,678	$326	**$1,037,971**	$1,029,967	$7,678	$505	**$1,038,150**
New and Replacement Parts for Motor Vehicles (makers)	$175,312,859	$24,334,986	$92,521	**$199,740,366**	$205,998,051	$24,997,923	$144,633	**$231,140,607**
New and Replacement Parts for Aerospace Vehicles (makers)	$18,346,545	$4,167,396	$23,368	**$22,537,309**	$18,346,545	$4,167,396	$36,407	**$22,550,348**
Wire Harnesses and Electric Circuit Boards (makers)	$91,067,997	$6,971,194	$20,139	**$98,059,330**	$91,067,997	$6,971,194	$31,390	**$98,070,581**
Marine Antifouling Coatings	$1,574,207	$0	$53	**$1,574,260**	$2,249,336	$0	$82	**$2,249,418**
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$47,586,870	$1,548,471	$13,724	**$49,149,065**	$52,332,453	$1,548,471	$21,440	**$53,902,364**
Engine Filters for Locomotive and Marine Applications	$0	$0	$3	**$3**	$0	$0	$5	**$5**
Cyanoacrylate Adhesives	$0	$0	$52	**$52**	$0	$0	$82	**$82**
Aviation Hydraulic Fluid (makers)	$453,096	$3,849	$141	**$457,086**	$453,096	$3,849	$219	**$457,164**
All PIP (3:1)	**$335,461,818**	**$37,033,806**	**$150,393**	**$372,646,017**	$371,584,745	$37,696,837	$234,863	**$409,516,445**
TOTAL	**$335,461,818**	**$37,033,806**	**$150,406**	**$372,646,030**	**$371,584,745**	**$37,696,837**	**$234,883**	**$409,516,465**

Table 4-32: Total PPE Costs, by Chemical and Use (Primary Alternative Options)								
Chemical and Use	**Annualized Cost, 3% Discount Rate**				**Annualized Cost, 7% Discount Rate**			
	Respiratory	**Dermal**	**Documentation**	**TOTAL**	**Respiratory**	**Dermal**	**Documentation**	**TOTAL**
DecaBDE								
Other DecaBDE-containing Plastic	$651,425,712	$3,329,684	$89,525	**$654,844,921**	$651,425,712	$3,329,684	$139,885	**$654,895,281**
PIP (3:1)								
Lubricants and Greases (except Aerospace and Turbine) (makers)	$34,718	$230	$85	**$35,033**	$47,945	$324	$132	**$48,401**
Lubricants & Greases (Aerospace) (makers)	$1,081,996	$7,701	$397	**$1,090,094**	$1,081,996	$7,701	$614	**$1,090,311**
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$90,621,871	$7,873,223	$21,546	**$98,516,640**	$90,621,871	$7,873,223	$33,578	**$98,528,672**
Wire Harnesses and Electric Circuit Boards (makers)	$77,180,753	$3,918,935	$20,758	**$81,120,446**	$81,147,257	$3,918,935	$32,381	**$85,098,573**
All PIP (3:1) Uses	**$168,919,338**	**$11,800,090**	$42,786	**$180,762,214**	**$172,899,069**	**$11,800,184**	$66,705	**$184,765,598**
TOTAL	**$820,345,050**	**$15,129,774**	**$132,311**	**$835,607,135**	**$824,324,781**	**$15,129,868**	**$206,590**	**$839,661,239**

4.5 Signage Costs

Under the final option, firms are required to post warning signs where decaBDE-containing plastic pallets are being recycled. EPA is finalizing a signage requirement in the area where plastic pallets are recycled. This sign will provide notice to workers that PPE is required to be worn during recycling of plastic shipping pallets, which will reduce potential exposures to decaBDE. A sign must be posted at every entry point into the regulated area that clearly, prominently, in multiple languages as appropriate, and in an easily readable font size, the contain following text: "Decabromodiphenyl ether (DecaBDE) (CASRN 1163-19-5), a chemical that has been identified as persistent, bioaccumulative, and toxic (PBT) chemical by the U.S. Environmental Protection Agency, may be present in this regulated area. All persons who process plastic shipping pallets, including recycling, are required to wear personal protective equipment, per regulations at 40 CFR 751.405(e)."

To estimate signage costs, unit costs were retrieved from the RS Means 2017 dataset (RS Means 2017). The material cost is indexed to 2022 using the BLS CPI for all urban consumers, while labor costs are calculated by combing the burden from RS Means with the technical wage rate. There is only one firm (iGPS) known to recycle pallets and EPA assumes they will post 2 signs. EPA also assumes each sign will be replaced every five years during the period of the analysis, leading to a total of 12 signs.

Table 4-33: Posting Signs Cost Estimate, Annualized (2022$)

Labor or Material	Material Cost	Labor Hours	Source	Number of Signs	Cost in $2022
Labor	0	0.167	RS Means 02 83 19.22 0050	12	$27.77
Material	8.65	0	RS Means 02 83 19.22 0050	12	$20.65
Total Annualized Cost (3%):					**$10.29**
Total Annualized Cost (7%):					**$11.44**

4.6 Export Notification

EPA is requiring export notification for all persons intending to export decaBDE-containing wire and cable insulation for nuclear power generation facilities. Exporters are required to notify EPA under TSCA Section 12(b) and the provisions of subpart D in 40 CFR part 707. The 2020 TSCA Section 12(b) ICR (U.S. Environmental Protection Agency (EPA) 2020d), estimated the annual export notification cost for an exporter under the one-time export notification requirement. These costs include the cost to the exporter of compiling a list of their products that are subject to TSCA Section 12(b) requirements, writing or revising an export notification letter to EPA, checking the outgoing shipments, and sending the notification letters with the associated shipping costs.

For the purpose of this section, a notice is a package received by the EPA by one firm. Each notice may contain several products and/or countries. A notice subsequently becomes a letter of notification that EPA issues to a foreign government. As firms are given the opportunity to voluntarily submit reports electronically rather than by paper, burden estimates are based on the expectation that 63% of reports would be submitted electronically. This expectation is based on the trend witnessed for TSCA section 8(e) electronic submissions in which firms can volunteer to submit by paper or electronically. Given the limitations placed on decaBDE-containing articles, EPA assumes the export notification activities described in the following subsections will only need to be completed in the first year.

Most of the underlying data and assumptions in this section come from the 2020 TSCA Section 12(b) ICR, *ICR No.: 0795.16 [Information Collection Request for] Notification of Chemical Exports - TSCA Section 12(b) Supporting Statement for Request for OMB Review under the Paperwork Reduction Act* (U.S. Environmental Protection Agency (EPA) 2020d), with updating to current costs.

4.6.1 Compile List

Exporters need only check to determine which products exported by the firm are subject to this requirement. Given the limitations placed on decaBDE-containing articles, EPA assumes this activity will only need to be completed in the first year. Updating the list is estimated to take an average of one hour of technical time (which may also include some proportion of legal time). This could vary depending on the number of products from two hours per year up to two hours per month of technical time (which may also include some proportion of legal time). This will vary depending on the number of products exported by the firm and the number of their products subject to the requirement. EPA estimates unit burden for compiling the list estimated at an average of 9.3 hours of technical time per firm per year.

4.6.2 Write or Revise Letter

Firms that export products subject to this requirement must prepare an export notice to send to EPA. EPA expects that the time needed for initial preparation of the export notice probably varies depending on whether the firm has prior experience with this program, but this step is estimated to take an average of one hour of technical time (which may also include some proportion of legal time) per year for each firm subject to TSCA section 12(b) reporting.

4.6.3 CBI Substantiation

Firms are required to provide CBI substantiation for any claims of data confidentiality. When estimating this burden, EPA accounts for the burden associated with the substantiation of ChemID and non-ChemID claims. CBI substantiation for ChemID elements involves providing answers to questions concerning reasons that CBI status of chemical substance is to be maintained. CBI substantiation for ChemID claim is estimated to take 1.15 hours per report, including both technical and managerial A firm will claim CBI for ChemID elements when submitting a chemical that is not included in the 12(b) list. However, decaBDE is on the 12(b) list because it is subject to TSCA section 6(h). Therefore, no CBI claims are expected.

4.6.4 Check Orders and Send Notices

The firms that export products subject to this requirement must check outgoing shipments against the list of their products described above. A form letter notifying EPA is either printed out or electronically prepared detailing where the shipment is going if it is the first shipment of the year to the importing country. This process is estimated to take an estimated zero hours for the 63% of submissions received electronically, as opposed to the 6.5 hours of clerical time per firm for the remaining 37% of submissions by paper.[29] Therefore, on average, the burden is 0.63*0 + 0.37*6.5 = 2.4 hours per notice.

4.6.5 Mailing Costs

As noted above, 37% of regulated companies are estimated to submit by paper, and so will incur mailing costs for export notifications delivered to EPA. Notifications are assumed shipped via the U.S. Postal

[29] In accordance with methodology for e-reporting, the activities outside of electronic reporting are considered to be absorbed in the efficiencies of e-reporting overall.

Service (USPS) as first-class registered mail with a return receipt. The estimated per-shipment and annual mailing costs incurred by individual submitters are detailed in Table 4-34.

Table 4-34: Derivation of Total Mailing Cost per Export Notification (2022$)

Postal Service	Cost
Registered Mail, with $0 declared value	$14.65
Return Receipt (mail)	$3.25
Postage, regular First Class, up to 1 ounce	$0.60
Total Cost per Export Notice	**$18.50**

Notes: The mailing method comes from (U.S. Environmental Protection Agency (EPA) 2022).
Source: 2022 mailing rates found on Stamps.com (Stamps.com Inc. 2022).

The total cost per notice as derived in Table 4-34 is scaled by 37% for the average mailing cost per exporter per notice of $18.50.

4.6.6 Total Export Notification Costs

The burdens and associated costs for each notification activity, as described in the previous sections, are summarized in Table 4-35.

Table 4-35: TSCA 12(b) Export Notification Cost per Notification (2022$)

Cost Component	Technical Labor (at $83.14/hour)		Clerical Labor (at $40.13/hour)		Total	
	hours	cost	hours	cost	hours	cost
Compile List	9.3	$773.20	0	$0.00	9.3	$773.20
Write Letter	1	$83.14	0	$0.00	1	$83.14
Check Order and Send Notices	0	$0.00	2.4	$96.31	2.4	$96.31
Mailing Costs						$6.85
TOTAL					**12.7**	**$959.50**

Since each notice may contain several products and/or countries, EPA assumes that each company will send only one notice as a result of this rulemaking. Table 4-38 provides the total cost for export notifications for each chemical and use. This is likely an overestimate, as each company in the identified NAICS may not export decaBDE-containing products.

Table 4-36: Total Export Notification Cost (2022$)

Chemical and Use	Number of Companies	Total Cost (at $959 per Notice)	Annualized at 3%	Annualized at 7%
DecaBDE				
Wire and Cable Insulation	1	$959	$47	$72
All DecaBDE	***1***	***$959***	***$47***	***$72***

4.7 Engineering Controls

EPA is requiring engineering controls for the use of PIP (3:1) in the manufacturing of cyanoacrylate adhesives. According to stakeholders, the production process using PIP (3:1) is carried out in an automated batch distillation plant and in a well-ventilated closed system (Henkel Corporation 2019). EPA is requiring engineering controls for the use of PIP (3:1) as an intermediate in the production of cyanoacrylate adhesives such that the processing of PIP (3:1) must take place in a closed loop system and general and local area ventilation must be provided. In codifying these measures, EPA does not intend to supplant OSHA's requirements at 29 CFR 1910.134(a)(1) which require engineering controls to prevent

atmospheric contamination. Given the OSHA requirements that already exist, and the controls already in place by the affected company, EPA believes that this requirement will incur no incremental costs.

4.8 Labelling Costs

One of the requirements under the primary alternative option would require labeling of articles or parts containing the regulated chemical: for all recycled plastic articles containing decaBDE, a label would be required.

For labeling of plastic articles, a sticker label may not be appropriate. For this analysis, EPA assumes that labeling of the product's packaging is sufficient. The following factors must be considered in determining the cost impact of a package label change.

For EPA's previous *Economic Analysis of Regulation of Methylene Chloride, Paint and Coating Remover under TSCA Section 6(a)*(U.S. Environmental Protection Agency (EPA) 2019a), EPA surveyed five blenders of aerosol spray degreasers that contain trichloroethylene on what types of costs they would incur for amending labels to add additional precautions and directions to their products. Aerosol spray degreasing products are used in consumer, commercial, and industrial sectors. Respondents reported potential costs associated with disposal of pre-existing labels and packaging, graphic design, reviewing proofs, creating electronic files used to engrave the printing plates, and changing the printing plates. None of the respondents reported any incremental recurring costs for labeling. One blender estimated minimal labor costs of approximately $100 to $200 per label for graphic design changes, and $600 for the plate change[30], for total one-time costs ranging from approximately $700 to $800 per product (2014$). EPA assumes that a similar effort will be required to modify labels on the products regulated under the final rule; given the simplicity of the required change, EPA expects that the costs will be closer to the lower estimate. EPA updated these costs to 2022$ using an inflation factor developed from the Consumer Price Index for All items in U.S. city average, all urban consumers, not seasonally adjusted (U.S. Bureau of Labor Statistics (BLS) 2023a). Table 4-37 shows these estimated unit costs in 2022$. EPA expects that all labelling costs will be one-time initial costs (i.e., incurred in the first year of rule compliance).

Table 4-37: Product Labeling Cost Estimate, per product (2022$) (first year)

Estimate Type	Total Labor Cost per SKU (2014$)	Total Material Cost per SKU (2014$)	Total Labeling Cost per SKU (2022$)
Low estimate	$100	$600	**$865**
High estimate	$200	$600	**$989**
		Average	**$927**

Source: (U.S. Environmental Protection Agency (EPA) 2019a)
Note: 2014$ costs inflated to 2022$ using (U.S. Bureau of Labor Statistics (BLS) 2023a)

Table 4-38: Total Labeling Costs, by Chemical and Use (Primary Alternative Option) (2022$)

Use	Number of Firms	Labeling Cost per SKU	SKUs per company	Total Labeling Cost (First year)	Annualized (3%)	Annualized (7%)

[30] New printing plates or cylinders would need to be engraved with the redesigned label. EPA assumes only one plate is needed because the label change will only need one color.

DecaBDE						
Other DecaBDE-containing Plastic	8,894	$927	1	$8,246,119	$400,288	$614,967
				TOTAL	**$400,288**	**$614,967**

4.9 Unquantified Costs and Uncertainty

While the previous sections of this chapter describe the quantified costs of the Final Rule, there are cases in which certain costs are not quantified or uncertainty in the costs is present. The following section discusses these unquantified costs, as well as other uncertainties in the cost estimates.

4.9.1 Costs to Prevent Releases

Under the final option, EPA prohibits the release of decaBDE to water during manufacture, processing, distribution in commerce.

Under this option, all persons are required to follow all applicable regulations for preventing the release of decaBDE and decaBDE-containing products to water during use.

As mentioned in the Exposure and Use Assessment, Toxic Release Inventory (TRI) data show a decrease in releases that are reported in each industry section using decaBDE. The number of manufacturing facilities, textile manufacturing facilities, wire and cable manufacturing facilities, and other facilities reporting TRI releases had decreased from several dozen to only one manufacturer and 23 other facilities in 2016 (U.S. Environmental Protection Agency (EPA) 2021c). Specifically, the one manufacturer that released water prior to 2012 is now prohibited from manufacturing under the 2021 decaBDE final rule. According to 2021 TRI data, there were zero releases of decaBDE to water (U.S. Environmental Protection Agency (EPA) 2021c).

Furthermore, the lifecycle assessment of iGPS plastic pallets, one of the identified products containing decaBDE, indicates that water use is negligible. The document states that "water consumption during plastic pallet manufacturing operations is minimal. The only water consumption during this process if for employee use (water fountains, restrooms, etc.) and for equipment cleaning." (iGPS 2021) No specific wastewater effluent data was provided by iGPS.

For the reasons described above, EPA contends there are no known releases to water. Therefore, this analysis assumes costs to industry associated with releases to water to be zero.

4.9.2 Regulatory Threshold Level

Multiple commenters on the proposed rule expressed difficulty in tracking trace amounts of PIP (3:1) in parts and articles (SEMI 2024, American Chemistry Council 2024, American Chemistry Council 2024, Chemical Users Coalition 2024, Air-Conditioning Heating and Refrigeration Institute 2024, Semiconductor Industry Association (SIA) 2024, Association of Equipment Manufacturers (AEM) 2024, Consumer Technology Association 2024). One commenter, for example, notes the challenge of guaranteeing that no decaBDE or PIP (3:1) has been added by upstream manufacturers (SEMI 2024). They note that a regulatory threshold level would help guide due diligence efforts. Another commenter notes that without a threshold level, regulated entities would not know whether they are in compliance because detection levels of chemicals are constantly being reduced. In response to comments, EPA is establishing a regulatory threshold level of 0.1% for unintentional quantities in products and articles, not including any amounts present due to excluded or phased out uses for decaBDE and PIP (3:1). EPA acknowledges that these costs might be incurred without a regulatory threshold. However, EPA believes

the threshold is sufficient to provide companies with sufficient guidance and curtail incremental due diligence costs.

4.9.3 Manufacture by date

Some public commenters on the proposed rule noted the lag between when an article is manufactured and when it is distributed and used in the market (Japan Electronics and Information Technology Industries Association (JEITA) 2023, Association of Home Appliance Manufacturers 2024, Association for Advancing Automation (A3) 2024, Chemical Users Coalition 2024, AMT- The Association For Manufacturing Technology 2024, Air-Conditioning Heating and Refrigeration Institute 2024, Consumer Technology Association 2024). A commenter noted that the date over which manufacturers have the most control of in the manufacturing and distribution chain is the "manufactured by" date (Consumer Technology Association 2024). In response to these comments, as detailed in the preamble for this final rule, EPA does not believe, unless otherwise specified, that products and articles containing PBT chemicals should continue to be distributed without end, and therefore is not adopting a generally applicable "manufactured by" provision. It would be very difficult, if not impossible, for purchasers and compliance inspectors to tell the difference between most products based on when they were produced, and thus EPA is establishing deadlines by which products and articles may no longer be processed and distributed unless otherwise excluded for practicability reasons. This approach discourages stockpiling while still allowing meaningful flexibilities with alternative compliance deadlines where such an alternative is appropriate.

EPA acknowledges that retailers and distributors may keep some amount of stock on hand and may not have ways to track which inventory may be subject to a prohibition. EPA agrees with commenters that it would not be practicable to force retailers to dispose of stocks, disrupting supply chains and potentially be costly. Hence, for practicability reasons EPA is providing longer "sell through" dates for distribution of articles containing PIP (3:1) for those articles with a compliance date of October 31, 2024. Instead, EPA has finalized specific phase-in prohibitions or exclusions for certain PBT-containing articles and finalized an exclusion solely for the purpose of repair and maintenance of an existing article. However, to discourage stockpiling, EPA is not providing for a sell-through provision for those articles covered by a phase-in prohibition, in particular for new and replacement parts. In such cases, EPA believes it is practicable for companies to manage supply chains and stocks during the phase-ins to significantly reduce disruptions or the need to dispose of PIP (3:1)-containing items.

The provisions EPA is finalizing today do not directly prohibit the manufacturing, processing, distribution in commerce, and use of equipment and other finished goods, rather the provisions apply to the new and replacement parts that such equipment and finished goods may include. This analysis does not quantify the costs of any lost inventory beyond what is allowed for by the Final Rule.

4.9.4 Prohibition Costs

Supply Chain Analysis and Testings

Multiple commenters (Boeing 2024, AMT- The Association For Manufacturing Technology 2024, Consumer Technology Association 2024) note the difficulty in detecting the presence of PIP (3:1) in complex supply chains. For example, one public commenter in the electronics industry noted that surveying a supply chain is a substantial undertaking. They stated that electronic finished goods manufacturers have anywhere from 2,500 to upwards of well over 5,000 suppliers. Each of those suppliers may provide the components that go into upwards of 5,000 finished goods on average.

According to the commenter, the two together translates to upwards of 100,000 or more individual components that go into those finished goods sourced from various suppliers.

As discussed in Section 4.3, companies need to conduct testing to ensure newly formulated products are safe and function as intended. Products in some industries are required to meet regulatory performance and safety standards as well. Multiple commenters highlighted these testing costs (SEMI 2024, National Marine Manufacturers Association 2024, Eastman Chemical Company 2024). One commenter (Eastman Chemical Company 2024) summarized the process: "After the identification of possible alternatives through extensive research and development activities, product testing must then be performed. Following that, regulatory approvals as required by the Federal Aviation Association (FAA) and the varied Military Specifications must be met and certified. Finally, Original Equipment Manufacturers (OEM) approvals must be sought through further testing and research before circulation into use." Another commenter (National Marine Manufacturers Association 2024) noted that this can be particularly burdensome to small businesses.

While supply chain analysis and testing costs are included in the cost estimates and EPA believes these estimates reflect the reasonably ascertainable economic consequences of the rule, there is a possibility that supply chain and testing costs higher than projected. Those additional costs, were they to occur, are not quantified in the cost analysis.

Loss of Revenue

EPA established phase-in periods intended to be practicable for industry to find, test, and implement suitable alternatives. If industry is unable to find alternatives that do not contain PIP (3:1), there could loss of revenue related to the sale of those products. In some cases, substitute products that do not contain PIP (3:1) are already available. In those cases, lost revenue of PIP (3:1)-containing products might be offset at a societal level by use of non-PIP (3:1)-containing products. However, in other cases there are not alternatives currently available. There are also cases where the shift is more complicated, for example if PIP (3:1) is used in an article that is specifically intended to be part of a larger complex article (e.g. vehicles or manufacturing equipment). This scenario is discussed in the subsequent Replacement Parts section (4.9.5). Public commenters on the proposed rule suggested there would be considerable costs and disruption if industry is not able to use PIP (3:1) and viable alternatives are still not in place (Boeing 2024, AMT- The Association For Manufacturing Technology 2024, Consumer Technology Association 2024). This analysis does not include the costs of this prospective scenario.

Indirect Costs

EPA notes that while the direct costs associated with this rule (Section 4.2 - 4.8) are borne largely by the companies that make the products or articles containing a regulated chemical, these costs will likely be passed on through price increases experienced by the consumer. In many cases, the products affected by this regulation are highly specific (e.g., aviation hydraulic fluid) and thus price inelastic with respect to demand. Therefore, increases in price are more likely to be passed on to the consumer than to be borne by the processor as a loss in revenue or a shift in market volume. However, given the wide range of products, number of end-users and variability in consumer behavior, it is not possible to attribute these higher costs to end-users in this analysis.

4.9.5 Replacement Parts

A number of public commenters (Japan Electronics and Information Technology Industries Association (JEITA) 2023, SEMI 2024, Outdoor Power Equipment Institute 2024, Boeing 2024, Association for Advancing Automation (A3) 2024, Chemical Users Coalition 2024, Nuclear Energy Institute 2024, AMT-The Association For Manufacturing Technology 2024, Air-Conditioning Heating and Refrigeration

Institute 2024, Semiconductor Industry Association (SIA) 2024, Consumer Technology Association 2024) posited that PIP (3:1)-containing replacement parts are critical to additional sectors beyond motor and aerospace vehicles. For example, a commenter in the manufacturing industry argued that once the ban becomes effective, more than 50 percent of U.S. capacity to manufacture could be idled due to the inability to service the equipment with replacement parts that do not include PIP (3:1). They estimated that there is approximately $175 billion of capital stock in manufacturing technology currently in U.S. plants, and that while the percentage of the stock impacted or containing PIP (3:1) is unknown, they believe it is substantial. As such, EPA instituted longer phase-ins for replacement parts, with the intent that firms will be able to continue to service in-use equipment designed with PIP (3:1)-containing parts. EPA believes that these phase-ins are sufficient. However, in the event that these longer phase-in periods for replacement parts are not adequate and result in some loss of the use of products in inventory, these additional costs are not quantified in this analysis.

4.9.6 Downstream Notification

As noted in Section 2.4.3, EPA is also amending the downstream notification statement that must accompany shipments of PIP (3:1) or PIP (3:1) containing products to conform to the terms of the prohibitions in the final rule. EPA is providing a 3-month transition period to update SDS sheets and an 18-month transition period for updating labels. EPA believes that this transition period will allow time to clear product with old labels through channels of trade. During the 3-month transition period, downstream notification under 40 CFR 751.407(e)(1) and (2) is still required; entities may use the new information provided in new 40 CFR 751.407(e)(3) or existing notification consistent with the restrictions described in this subpart. During the 15-month period between the SDS revision date and the label revision date, manufacturers, processors or distributors are required to provide the updated SDS with the "new" information when distributing products with the "old" label.

Under the 2021 PBT final rule, each manufacturer, processor, or distributor of PIP (3:1) for any use must, prior to or concurrent with the shipment, notify companies to whom PIP (3:1) is shipped, in writing, of the prohibitions on processing and distribution, and the prohibition on releases. Notification must occur by labelling or inserting specific text (as described in the rule) in the Safety Data Sheet (SDS) provided with the PIP (3:1) or with any PIP (3:1)-containing product. The purpose of this requirement is to ensure that downstream users are aware of the activities that are prohibited so these products are not used in the prohibited applications or released to water.

In the accompanying Economic Analysis of the 2021 PBT EA, EPA estimated that it would require 1 hour of technical labor for each affected manufacturer, importer, and processor of PIP (3:1) and products that contain PIP (3:1) to make the necessary annotations to the SDSs. This activity is assumed to take place only in the first year of the rule. The costs were estimated at $78.63 per firm or a total of $2,516 (in 2018 dollars), The annualized cost for downstream notification was estimated at approximately $136 at a 3% discount rate and $195 at a 7% at a 7% discount rate also in 2018 dollars.

Providing a 3-month transition period to update SDS's and an 18-month transition period for updating labels under this final rule would allow more time to complete these modifications. Since downstream notification was required in the 2021 PIP (3:1) PBT rule, EPA generally assumes that firms have updated their product's Safety Data Sheets (SDS) in the baseline. EPA acknowledges, however, that some firms may have to update the SDSs to reflect changes associated with requirements of this final rule. EPA believes that the costs of making any minor adjustments to the SDS text needed as a result of this final rule would be minimal, but since the exact number of firms modifying their SDS is unknown, incremental downstream notification costs are not quantified .

4.10 Total Industry Costs

Summing the costs described in Sections 4.2 through 4.7 results in the total industry costs as provided in Table 4-39 (annualized at 3% discount rate) and Table 4-40 (7% discount rate) for the final option, and Table 4-41 and Table 4-42 for the alternative option. As shown in these tables, total industry costs for the rule were estimated at approximately $400 million (at a 3% discount rate, annualized over 30 years), and $430 million (at a 7% discount rate). Of the rule costs, those associated with decaBDE alone were approximately $86 at a 3% discount rate and $128 at a 7% discount rate. Costs associated with PIP (3:1) were $400 million and $430 million (at 3 and 7% discount rates, respectively.)

The total industry costs associated with the alternative option were approximately $829 million and $821 million (at 3% and 7% discount rates, respectively). Of the alternative option costs, those associated with decaBDE were $655 and $656 million (at 3% and 7%) while those for PIP (3:1) were $173 million and $165 million (at 3% and 7% discount rates, respectively).

Total costs at a 2% discount rate are presented in Appendix A.

Table 4-39: Total Industry Cost for the Final Option, annualized at 3% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Sign Posting**	**Export Notification**	**Total**
DecaBDE						
Plastic Shipping Pallets	$12	$0	$13	$10	$0	$35
Replacement Parts for Aerospace Vehicles	$0	$0	$0	$0	$0	$0
Replacement Parts for Motor Vehicles	$0	$0	$0	$0	$0	$0
Wire and Cable Insulation	$4	$0	$0	$0	$47	$51
All DecaBDE Uses	***$16***	***$0***	***$13***	***$10***	***$47***	***$86***
PIP (3:1)			$0			
Lubricants and Greases (except Aerospace and Turbine)	$61	$53,982	$90,573	$0	$0	$144,616
Lubricants & Greases (Aerospace)	$133	$0	$1,037,971	$0	$0	$1,038,105
New and Replacement Parts for Motor Vehicles (consumers)	$18,412	$871,374	$0	$0	$0	$889,786
New and Replacement Parts for Motor Vehicles (makers)	$97,967	$24,266,159	$199,740,366	$0	$0	$224,104,492
New and Replacement Parts for Aerospace Vehicles (consumers)	$1,308	$61,884	$0	$0	$0	$63,192
New and Replacement Parts for Aerospace Vehicles (makers)	$21,633	$3,439,494	$22,537,309	$0	$0	$25,998,436
Wire Harnesses and Electric Circuit Boards	$21,548	$0	$98,059,330	$0	$0	$98,080,879
Marine Antifouling Coatings	$12	-$506	$1,574,260	$0	$0	$1,573,766
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$14,102	-$1,234,256	$49,149,065	$0	$0	$47,928,912
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	$36,610	-$403,675	$0	$0	$0	-$367,065
Engine Filters for Locomotive and Marine Applications	$12	$0	$3	$0	$0	$15
Cyanoacrylate Adhesives	$0	$0	$52	$0	$0	$52
Aviation Hydraulic Fluid	$61	$0	$457,086	$0	$0	$457,147
All PIP (3:1) Uses	**$211,859**	***$27,054,456***	**$372,646,017**	***$0***	***$0***	***$399,912,332***
Total	**$211,875**	**$27,054,456**	**$372,646,030**	**$10**	**$47**	**$399,912,418**

Table 4-40: Total Industry Cost for Final Option, annualized at 7% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Sign Posting**	**Export Notification**	**Total**
DecaBDE						
Plastic Shipping Pallets	$19	$0	$20	$11	$0	$50

Table 4-40: Total Industry Cost for Final Option, annualized at 7% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Sign Posting**	**Export Notification**	**Total**
Replacement Parts for Aerospace Vehicles	$0	$0	$0	$0	$0	$0
Replacement Parts for Motor Vehicles	$0	$0	$0	$0	$0	$0
Wire and Cable Insulation	$6	$0	$0	$0	$72	$78
All DecaBDE Uses	***$25***	***$0***	***$20***	***$11***	***$72***	***$128***
PIP (3:1)						
Lubricants and Greases (except Aerospace and Turbine)	$93	$48,654	$107,726	$0	$0	$156,473
Lubricants & Greases (Aerospace)	$205	$0	$1,038,150	$0	$0	$1,038,354
New and Replacement Parts for Motor Vehicles (consumers)	$28,287	$1,336,715	$0	$0	$0	$1,365,002
New and Replacement Parts for Motor Vehicles (makers)	$150,507	$21,871,099	$231,140,607	$0	$0	$253,162,214
New and Replacement Parts for Aerospace Vehicles (consumers)	$2,009	$94,932	$0	$0	$0	$96,941
New and Replacement Parts for Aerospace Vehicles (makers)	$33,235	$1,751,015	$22,550,348	$0	$0	$24,334,599
Wire Harnesses and Electric Circuit Boards	$33,105	$0	$98,070,581	$0	$0	$98,103,686
Marine Antifouling Coatings	$19	-$1,653	$2,249,418	$0	$0	$2,247,784
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$21,665	-$3,702,287	$53,902,364	$0	$0	$50,221,742
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	$56,244	-$1,210,867	$0	$0	$0	-$1,154,623
Engine Filters for Locomotive and Marine Applications	$19	$0	$5	$0	$0	$23
Cyanoacrylate Adhesives	$0	$0	$82	$0	$0	$82
Aviation Hydraulic Fluid	$93	$0	$457,164	$0	$0	$457,257
All PIP (3:1) Uses	***$325,480***	***$20,187,608***	***$409,516,445***	***$0***	***$0***	***$430,029,534***
Total	**$325,505**	**$20,187,608**	**$409,516,465**	**$11**	**$72**	**$430,029,661**

Table 4-41: Total Industry Cost for Primary Alternative Option, annualized at 3% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Labeling**	**Export Notification**	**Total**
DecaBDE						
Other DecaBDE-containing Plastic	$107,684	$0	$654,844,921	$400,288	$0	$655,352,894
All DecaBDE Uses	**$107,684**	**$0**	**$654,844,921**	**$400,288**	**$0**	**$655,352,894**
PIP (3:1)						
Lubricants and Greases (except Aerospace and Turbine)	$61	$72,558	$35,033	$0	$0	$107,652
Lubricants & Greases (Aerospace)	$133	$40,310	$1,090,094	$0	$0	$1,130,537
Wire Harnesses and Electric Circuit Boards	$25,141	-$4,048,015	$98,516,640	$0	$0	$94,493,767
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$17,695	-$2,849,108	$81,120,446	$0	$0	$78,289,033
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	$42,340	-$858,861	$0	$0	$0	-$816,521
All PIP (3:1) Uses	**$85,370**	***-$7,643,116***	***$180,762,214***	***$0***	***$0***	***$173,204,467***
Total	**$193,054**	**-$7,643,116**	**$835,607,135**	**$400,288**	**$0**	**$828,557,361**

Table 4-42: Total Industry Cost for Primary Alternative Option, annualized at 7% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Labeling**	**Export Notification**	**Total**
DecaBDE						
Other DecaBDE-containing Plastic	$165,436	$0	$654,895,281	$614,967	$0	$655,675,684
All DecaBDE Uses	***$165,436***	***$0***	***$654,895,281***	***$614,967***	***$0***	***$655,675,684***
PIP (3:1)						
Lubricants and Greases (except Aerospace and Turbine)	$93	$95,706	$48,401	$0	$0	$144,200
Lubricants & Greases (Aerospace)	$205	$53,170	$1,090,311	$0	$0	$1,143,686
Wire Harnesses and Electric Circuit Boards	$38,625	-$10,470,681	$98,528,672	$0	$0	$88,096,616
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$27,185	-$7,369,564	$85,098,573	$0	$0	$77,756,193
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	$65,047	-$2,221,549	$0	$0	$0	-$2,156,501
All PIP (3:1) Uses	***$131,155***	***-$19,912,918***	***$184,765,958***	***$0***	***$0***	***$164,984,194***
TOTAL	**$296,591**	**-$19,912,918**	**$839,661,239**	**$614,967**	**$0**	**$820,659,879**

4.11 EPA Implementation Costs

For the economic analyses for the 2021 final rules (U.S. Environmental Protection Agency (EPA) 2021a) and (U.S. Environmental Protection Agency (EPA) 2021b). EPA estimated that it would need one full time employee (FTE) for implementation (e.g., compliance assistance and enforcement) activities under both the decaBDE and PIP (3:1) rules (two FTEs total). This rule modifies the existing rules. EPA does not expect that it will require any additional (incremental) Agency staff time to implement the rules under these revisions (final or primary alternative options). Therefore, the total EPA implementation cost of the rule is zero. Note that TSCA implementation cannot be delegated to states.

5. Benefits

This section qualitatively describes the benefits of reducing the exposure to decaBDE and PIP (3:1). This includes describing specific human and environmental health effects associated with these chemicals. Knowledge of the health effects of these chemicals is crucial to understanding the benefits of reducing exposure potential.

By definition PBT chemicals, such as decaBDE and PIP (3:1), are of particular concern to human and environmental health; they do not readily degrade in the environment, accumulate at higher levels of the food chain, and are toxic to humans and other forms of life. Once released to the environment, PBT chemicals can remain in environmental media for a long time, thereby posing risks to health for extended periods (U.S. Environmental Protection Agency (EPA) 2014a).

DecaBDE and PIP (3:1) were both identified in the 2014 update of the *TSCA Work Plan for Chemical Assessments* (U.S. Environmental Protection Agency (EPA) 2014c). In the TSCA 2014 Work Plan, EPA (U.S. Environmental Protection Agency (EPA) 2014c) used a two-step process to identify chemicals for further assessment. The first step was a search of variety of sources for chemicals that met predetermined criteria, one of which was identification as a PBT chemical. In the second step, EPA (U.S. Environmental Protection Agency (EPA) 2014c) analyzed data to assign a score ranging from 3 (high) to 1 (low) to each chemical on hazard, exposure and potential for persistence/bioaccumulation. Hazard scores were assigned using the classification criteria developed by the EPA's Design for the Environment program. They combine information on the human health and environmental endpoints associated with a chemical; the highest score for any single endpoint (e.g., neurotoxicity, acute aquatic toxicity) was taken as the overall hazard score. Exposure scores were assigned by taking into account information on a chemical's uses, exposures, and releases to the environment. Persistence and bioaccumulation scores were evaluated using measured or modeled data on half-lives and bioconcentration factors, respectively. Table 5-1 provides an overview of the conclusions on decaBDE and PIP (3:1) from the TSCA 2014 Work Plan.

Table 5-1: Summary of Data for DecaBDE and PIP (3:1) EPA's TSCA 2014 Work Plan Assessment

Chemical	Persistence Rating	Bioaccumulation Rating	Exposure Rating	Exposure Criteria Met	Hazard Rating	Hazard Criteria Met
DecaBDE	3	3	3	Has been widely used in textiles, plastics and polyurethane foam as flame retardants. Used in products for consumer commercial, and industrial use; and building and construction materials	3	Developmental toxicity, Aquatic toxicity
PIP (3:1)	3	3	3	Widely used as a flame retardant	3	Neurotoxicity, Aquatic toxicity

Note: 3 = High, 2 = Moderate, 1 = Low.
Source: EPA (U.S. Environmental Protection Agency (EPA) 2014c)

During the screening process for developing the TSCA 2014 Work Plan chemical list, EPA identified PIP (3:1) as a neurotoxicant and aquatic toxicant with high persistence and high potential for bioaccumulation. It is important to reiterate that PIP (3:1) does not contain one single chemical, but rather

exists as a mixture of as many as fifty unspecified isomers; amounts and types of isomers in PIP (3:1) vary by the commercial formulation in question (Biomonitoring California 2012).

The economic analyses of chemical regulations often include a quantitative analysis of reductions in exposures. These analyses are based on a risk evaluation.[31] However, as discussed in the first section of Chapter 1, TSCA section 6(h) did not require a risk evaluation for chemicals identified as PBT. Because EPA did not conduct risk evaluations for decaBDE and PIP (3:1), it is not possible to perform a quantitative analysis in this economic analysis of the benefits of reduced exposures resulting from the rulemaking. Therefore, this chapter presents a qualitative analysis of the health effects literature for decaBDE and PIP (3:1), with the understanding that by reducing the exposure through this rulemaking, adverse health effects will be reduced.

In terms of the potential exposure reductions resulting from the rule, EPA estimates that 405,495 workers under the final option and 298,855 workers under the alternative option will benefit from reduced inhalation exposure from wearing respirators. In addition, 209,332 workers under the final option and 63,499 workers under the alternative option will benefit from wearing the required dermal protection. These values differ due to the different baseline compliance rates for respiratory and dermal PPE use. EPA also estimates that approximately 25,019 products under the final option and 14,057 products under the alternative option will be reformulated without decaBDE or PIP (3:1). This will also reduce exposure from use of decaBDE or PIP (3:1) products.

Another consideration in evaluating the net benefit of a rulemaking is the choice of chemical substitute for decaBDE or PIP (3:1), if needed. Chemicals are primarily in products because they serve a specific function or purpose in the end product. If a chemical is banned from that use to protect public health and the environment, a substitute chemical or process modification may be needed so the product performs as well as before. The chemical substitute ultimately selected will depend on a number of factors such as inherent hazard, cost, performance, availability, and various other properties (e.g., thermal, aesthetic) in the final product. Therefore, available toxicity information on previously identified possible substitutes for decaBDE and PIP (3:1) is also summarized in this section, to reflect possible effects associated with certain example substitutes. The amount of information available on the toxicity of substitutes varies widely: for some substitutes, hazard designations are based on measured data, whereas for others they are based on modeling or professional judgment. This analysis is for comparative purposes, as these substitute chemicals may not be appropriate for the uses regulated under this rule.

Because a risk evaluation was not performed, substitute chemicals or process modifications for decaBDE or PIP (3:1) have not been assessed in a comprehensive way when compared to previous economic analyses. For this chemical, substitutes were assessed by EPA (U.S. Environmental Protection Agency (EPA) 2019b) using a similar methodology as in the TSCA 2014 Work Plan (U.S. Environmental Protection Agency (EPA) 2014c). Under this methodology, EPA substitutes a rating ranging from 1 (low) to 3 (high) for persistence, bioaccumulation, environmental hazard, human health hazard, and final hazard (U.S. Environmental Protection Agency (EPA) 2019b). Ratings were developed based on measured data and information from authoritative sources and, when needed, data estimated by modeling software. It should be noted that separate ratings for human health and environmental hazard for the PBT chemical

[31] Quantitative analysis of exposure reductions begin with an exposure assessment that estimates exposures to the chemicals(s) in question both before and after the final regulation. The next step is a critical examination of the literature on health effects associated with the chemical(s) in question. Dose-response relationships are then developed using this health effects information, allowing changes in exposure to be linked to changes in specific health effects. Lastly, these changes in health effects are monetized using data such as medical expenditures or, for fatal outcomes, the value of a statistical life.

cannot be inferred based on the hazard rating from the TSCA 2014 Work Plan assessment (EPA 2014c). This is because the hazard rating represents the highest rating for any single human health or environmental endpoint, but the endpoint on which the hazard rating is based is not specified. However, the hazard ratings for the PBT chemical from the TSCA 2014 Work Plan assessment (U.S. Environmental Protection Agency (EPA) 2014c) are directly comparable to the final hazard ratings for the substitutes from EPA (U.S. Environmental Protection Agency (EPA) 2019b).

It is important to note that, due to data limitations, it is not possible to link exposures to specific uses of decaBDE or PIP (3:1). Instead, general exposure considerations and potential health effects (cancer, non-cancer and environmental) are described for each chemical. The majority of the information on general exposure considerations and potential health effects is culled from the U.S. EPA (2020b) Exposure and Use Assessment of Five PBT Chemicals, the U.S. EPA Environmental and Human Health Hazards of Five PBT chemicals and other government documents located summarizing hazard information.

5.1 Benefits of Reduced Exposure to DecaBDE

5.1.1 Exposure Considerations

Under this action, workers that may come into contact with decaBDE associated with several uses are required to use worker protection methods (wearing N95 masks and chemical-resistant gloves).

DecaBDE is released into air, water and soil as a result of industrial processes and product use (U.S. Environmental Protection Agency (EPA) 2017f. It was formerly widely used as a flame retardant for many consumer products, plastics and textiles for household use. However, it has been banned at the state level or voluntarily phased out of many uses due to concerns over potential health risks. Currently, it can only be used in the manufacture of wires, aerospace and motor vehicle parts, and is found in recycled plastic products. Despite reductions in use, decaBDE is expected to be found throughout the environment due to its persistence. DecaBDE has the ability to partition to soils and is thus persistent in this medium (U.S. Environmental Protection Agency (EPA) 2014a). When released to air, decaBDE is expected to partition to water or soil rather than to air (U.S. Environmental Protection Agency (EPA) 2020b). In water, it is expected to adsorb to sediments and suspended particles. Hydrolysis is not expected to occur (U.S. Environmental Protection Agency (EPA) 2014a). DecaBDE is also not expected to degrade rapidly under aerobic conditions, though slow debromination may occur under anaerobic conditions (U.S. Environmental Protection Agency (EPA) 2014a). In indoor settings, it is expected to partition to dust after direct transfer from solid articles (U.S. Environmental Protection Agency (EPA) 2020b). DecaBDE has a high potential for bioaccumulation (U.S. Environmental Protection Agency (EPA) 2020b).

DecaBDE has been observed in a variety of environmental media. As expected based on its physical properties, decaBDE has been measured at the highest concentrations in indoor dust, soil and sediment (U.S. Environmental Protection Agency (EPA) 2020b). In a systematic review of international studies on decaBDE in indoor dust, Bramwell et al. (2016) found median concentrations between 106 and 2,574 ng/g and a maximum concentration of 310,000 ng/g. DecaBDE has also been observed at detectable levels in fish, terrestrial mammals, and aquatic mammals (U.S. Environmental Protection Agency (EPA) 2020b).

Individuals in the general population may be exposed to decaBDE via air and airborne dust, direct skin contact with contaminated dust or by ingestion of contaminated food or drinking water. In an exposure assessment of decaBDE, EPA (U.S. Environmental Protection Agency (EPA) 2010a) found that the dominant exposure pathways for adults and children were dust ingestion and dermal contact with dust. DecaBDE can also be transferred through the placenta and in breastmilk; infants were exposed primarily

through breastmilk (EPA 2010a). In adults, EPA (U.S. Environmental Protection Agency (EPA) 2010a) estimated daily exposure to decaBDE of 1.4×10^2 ng/day. Due to differences in behavior (e.g., increased hand-to-mouth activity), infants and children are expected to have higher exposures than adults. Other potential human exposure pathways include occupational exposures and release from consumer products such as upholstered furniture, textiles and electronic equipment (U.S. Environmental Protection Agency (EPA) 2020b). Furthermore, direct releases to water and indirect releases to water (deposition from air) from industrial facilities lead to elevated uptake and concentrations in edible fish species. Individuals who consume these fish (recreational fishers) may have increased internal dose of decaBDE (U.S. Environmental Protection Agency (EPA) 2020b). Biomonitoring studies in humans have found detectable levels of decaBDE in 66% of blood samples and 86% of other biomarkers, indicating that exposure to decaBDE is common (U.S. Environmental Protection Agency (EPA) 2018b).

EPA did not perform a systematic review of the literature to characterize the hazards of the PBT chemicals, and instead performed a limited survey of the reasonably available scientific information.

5.1.2 Health Effects Associated with the Potential for Exposure to DecaBDE

It should be noted that separate ratings for human health and environmental hazard for decaBDE cannot be inferred based on the hazard rating from the TSCA 2014 Work Plan assessment (U.S. Environmental Protection Agency (EPA) 2014c). This is because the hazard rating represents the highest rating for any single human health or environmental endpoint, but the endpoint the hazard rating is based on is not specified. However, the hazard ratings for the PBT chemicals from the TSCA 2014 Work Plan assessment (U.S. Environmental Protection Agency (EPA) 2014c) are directly comparable to the final hazard ratings for the substitutes from EPA (U.S. Environmental Protection Agency (EPA) 2019b).

It should also be noted that most of the available studies on the hazards of decaBDE are based on commercial products containing decaBDE, which consist primarily of decaBDE (77% to 98%) but may also contain congeners such as nonaBDE and octaBDE.

Cancer

In its alternatives assessment for decaBDE, EPA classified the chemical as moderately carcinogenic[32] based on a National Toxicology Program (NTP) study from 1986 that found evidence of an association between decaBDE and liver cancer and benign liver tumors in rats and mice (U.S. Environmental Protection Agency (EPA) 2014a). EPA also previously concluded that there is suggestive evidence for the carcinogenic potential of decaBDE based on this same study (U.S. Environmental Protection Agency (EPA) 2008c). No epidemiologic studies have evaluated the carcinogenic potential of decaBDE. IARC determined that decaBDE is not classifiable as to its carcinogenicity in humans based on a lack of data (International Agency for Research on Cancer (IARC) 1999)

In the NTP (National Toxicology Program (NTP) 1986) study, male rats were dosed with 0, 1,120 or 2,240 mg/kg bw/day decaBDE and female rats were dosed with 0, 1,200 or 2,550 mg/kg/day through their diets for 24 months. As stated by EPA, "statistically significant increases in the incidence of neoplastic nodules in the liver were observed at both treatment doses in males and at the high dose in females, providing some evidence of carcinogenicity of decaBDE" (U.S. Environmental Protection Agency (EPA) 2008a).[33] In addition to liver cancer, the study also found that decaBDE exposure in male

[32] Defined as limited or marginal evidence of carcinogenicity in animals and inadequate evidence in humans (U.S. EPA 2011).

[33] At the time the NTP study was conducted, the term "neoplastic nodules" was used to describe abnormal cellular masses in rat livers. Today, some would likely be classified as benign adenomas or other preneoplastic lesions. This assumes that the

rats was associated with thyroid gland follicular hyperplasia, which is considered a precursor to thyroid tumors. NTP (National Toxicology Program (NTP) 1986) also dosed male mice with 0, 3,200 or 6,650 mg/kg bw/day and female mice with 0, 3,760, 7,780 mg/kg-day for 24 months. The combined incidence of hepatocellular adenomas or carcinomas in male mice significantly increased at low dose and increased marginally at high dose (U.S. Environmental Protection Agency (EPA) 2008a).

Based on results of the NTP (National Toxicology Program (NTP) 1986)study, EPA derived oral slope factors[34] for decaBDE of 7.0 x 10^{-4} per mg/kg-day and 4.0 x 10^{-4} per mg/kg-day for the endpoints of hepatic neoplastic nodules in male and female rats, respectively (U.S. Environmental Protection Agency (EPA) 2008c). That is, daily exposure to an oral dose of 1 mg/kg of decaBDE across a lifetime is associated with an upper bound estimate of increased cancer risk between 0.04% and 0.07% (400-in-a-million and 700-in-a-million) above the baseline cancer risk. The full list of cancer slope factors derived by EPA (U.S. Environmental Protection Agency (EPA) 2008a) can be found in Table 5-2 below.

Table 5-2: Cancer Slope Factors Based on Neoplastic Effects in Chronic Rat and Mouse Studies

Endpoint	Species	Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
Neoplastic nodules in the liver	Male rat	0.0007
Neoplastic nodules or carcinomas (combined) in the liver	Male rat	0.0007
Neoplastic nodules in the liver	Female rat	0.0004
Neoplastic nodules or carcinomas (combined) in the liver	Female rat	0.0005
Follicular cell hyperplasia in the thyroid	Male mouse	0.0005
Adenomas or carcinomas (combined) in the liver	Male mouse	0.0005

Source: EPA (U.S. Environmental Protection Agency (EPA) 2008a)

Non-Cancer

Exposures to decaBDE have been associated with a number of adverse health effects in animal studies including hepatic, renal, immune, and reproductive toxicity, along with several effects on development including neurotoxicity. In the IRIS assessment of decaBDE, developmental neurotoxicity was identified as the critical effect associated with exposure (U.S. Environmental Protection Agency (EPA) 2008b). Studies in mice have shown that decaBDE exposure during development is linked to a range of adverse neurological effects, including impairments in learning (Rice et al. 2009) and decreased strength and reflexes (Rice et al. 2007). There is limited evidence to suggest that the neurological system continues to be a target of decaBDE exposure in adulthood: one study demonstrated a decrease in brain weight following 28-days of oral gavage in rats (van der Ven et al. 2006).

Hepatic and renal effects have been observed following exposures to decaBDE at different life stages. NTP (National Toxicology Program (NTP) 1986) conducted a chronic dietary study in rats and found evidence of degeneration and thrombosis in the liver. Fujimoto et al. (Fujimoto et al. 2011) exposed pregnant rats to decaBDE and observed liver and kidney histopathological changes in offspring.

Prenatal exposure to decaBDE has also been associated with immunotoxicity and reproductive effects. In a study of mice, Teshima et al. (Teshima et al. 2008) observed that exposure to decaBDE was linked to dose-dependent adverse effects on the immune system, including decreases in antibodies and

neoplastic nodules (i.e., a small abnormal growth of tissue) are equivalent to hepatic adenomas and is characterized as "a conservative interpretation" by EPA IRIS (EPA 2008a, p15).

[34] Oral slope factors provide a quantitative estimate of carcinogenic risk from oral exposure. They represent the upper bound estimate of increased cancer risk associated with lifetime exposure to a chemical via ingestion.

lymphocytes. Tseng et al. observed signs of impaired development of the male reproductive system (e.g., sperm abnormalities, decreased sperm count) in mice exposed prenatally to decaBDE. In another study of male mice, Tseng et al. noted that prenatal exposures to decaBDE were also associated with changes in thyroid hormone and hepatic enzyme activity (Tseng et al. 2008, Tseng et al. 2011). In the IRIS assessment of decaBDE, a study on developmental neurotoxicity by (Viberg et al. 2003) was used to derive a reference dose for decaBDE exposure. This found an association between decaBDE exposures and signs of neurotoxicity, including significant changes in spontaneous activity level of neonatal mice (U.S. Environmental Protection Agency (EPA) 2008a). In this study male mice were given single doses of 0, 2.22 or 20.1 mg/kg decaBDE at postnatal day (PND) 3 or 19. Mice at PND 10 received a single dose of 0, 1.34, 13.4, or 20.1 mg/kg decaBDE. Pair-wise testing in the mice treated at PND 3 demonstrated neurobehavioral impacts (e.g., differences in activity patterns for locomotion, rearing, and total activity compared with controls) at the highest dose group. Minor activity differences were seen in the lowest dose group, but these differences returned to control levels after a short period of time. No effects were seen in mice treated at PND 10 or 19. EPA concluded this implies there is a window of susceptibility for the developmental neurotoxicity of decaBDE. According to EPA, "the NOAEL in this study was 2.22 mg/kg, and the lowest-observed-adverse-effect level (LOAEL) was 20.1 mg/kg for significant changes in spontaneous motor behavior and decreased habituation capability for locomotion, rearing, and total activity, worsening with increasing age" (U.S. Environmental Protection Agency (EPA) 2008a). Based on these findings, the reference dose in IRIS was set at 7 µg/kg-day. That is, oral exposures to decaBDE at daily doses up to 7 µg/kg-day are not expected to result in adverse non-cancer health effects over the course of a lifetime.

Environmental Toxicity

Research indicates that decaBDE is acutely toxic to fish and aquatic invertebrates. Nakari and Huhtala (Nakari and Huhtala 2010) found that exposure to a commercial mixture of decaBDE was associated with a 96-hour LOEC of 0.0125 mg/L for hatching in zebrafish and a 48-hour EC_{50} of 0.019 mg/L for immobilization in *Daphnia*. Several adverse effects have also been observed following chronic exposures to decaBDE. DecaBDE exposure has been associated with impaired growth in both aquatic and terrestrial species. Chronic exposure to decaBDE in aquatic organisms has also been linked to effects such as disruption of thyroid hormone (Qin et al. 2010) and oxidative stress (Feng et al. 2013). DecaBDE appears to be less toxic to plant than animal species: a study by Walsh et al. 1987) found that it did not inhibit growth of algae.

A public commenter (The Yurok Tribe et al. 2024) noted that adverse effects from decaBDE and other polybrominated diphenyl ethers (PBDEs) that threaten the recovery prospects of Chinook salmon populations that are protected by the Endangered Species Act. The commenter added that chronic exposure to PBDE flame retardants such as decaBDE also harms steelhead, which are a primary subsistence species of the Tribal government.

Summary

The information in this section does not represent an exhaustive literature review nor is it an analysis of relative importance or comparative dose-response among hazards.

The carcinogenic effects of decaBDE in humans remain unclear[35], but evidence from animal studies suggests that reductions in exposure to decaBDE may lead to decreases in the incidence of liver cancer. In

35 This descriptor of the database is appropriate when the weight of evidence is suggestive of carcinogenicity and a concern for potential carcinogenic effects in humans is raised, but the data are judged not sufficient for a stronger conclusion. This descriptor covers a spectrum

addition, reductions in the exposures to decaBDE may lead to reductions in developmental neurotoxicity, as well as hepatic, renal, immune and reproductive toxicity. As noted above, EPA's hazard characterization is not definitive or comprehensive. Decreases of decaBDE in the environment may be beneficial for growth and other endpoints in fish, aquatic invertebrates, and terrestrial invertebrates.

5.1.3 Substitutes Considerations

In its alternatives assessment for decaBDE, EPA (U.S. Environmental Protection Agency (EPA) 2014a) identified 29 potential chemical substitutes for decaBDE. Table 5-3 summarizes the potential health, bioaccumulation, persistence and environmental risks for each pertinent alternative from EPA's alternatives assessment for decaBDE, as well as potential uses in industry. In this section, this analysis does not include all of chemicals included in the alternatives assessment for several reasons. Firstly, several of the potential substitutes in the alternatives assessment were suitable only for uses of decaBDE that have been discontinued (e.g., for flame retardant properties in mattresses and other furniture). In addition, several of the chemicals are synergists: they are intended to enhance the flame retardant capacity of decaBDE and thereby decrease its use, but have no inherent flame retardant properties when used alone. Since the regulatory options under consideration involve a complete ban of decaBDE, synergists may no longer be used as potential substitutes for decaBDE.

As shown in the table, there are alternatives for a range of potential industry uses that have low ratings for human and environmental toxicity across all endpoints, based on the Design for the Environment ratings for health endpoints (e.g., moderate, high) in the alternatives assessment for decaBDE. These ratings are based on authoritative sources such as the UN's Globally Harmonized System for the Classification and Labeling of Chemicals and U.S. EPA programs such as EPA's IRIS assessment. For the majority of endpoints, no observed (or lowest observed) adverse effect levels are compared to pre-defined criteria to rank each chemical against one another. For other endpoints an evaluation of the presence or absence of adverse effects in the body of literature on if an endpoint (i.e., cancer or genotoxicity) is conducted to determine where the chemical ranks in comparison with the pre-determined criteria.

of evidence associated with varying levels of concern for carcinogenicity, ranging from a positive cancer result in the only study on an agent to a single positive cancer result in an extensive database that includes negative studies in other species.

Table 5-3: Summary of DecaBDE and Potential Chemical Substitutes Hazards and Uses

Substance Name and CAS Number	Human Health Effects[1]											Aquatic Toxicity[1]		Persistence[1]	Bioaccumulation[1]	Potential Industry Uses
	Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic			
VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard – Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics *(VL, L, M, H,* and *VH)* were assigned using values from estimation software and professional judgment.																
DecaBDE 1163-19-5	L	M	L	L	H	*L*	M	L	-	L	L	*L*	*L*	VH	*H*	See section 2.2 for detailed use profile
Known Direct Chemical Substitutes																
Decabromodiphenyl ethane[2] 84852-53-9	L	*M*	L	L	*H*	*L*	L	L	-	VL	VL	L	*L*	VH	*H*	Electronics; Wire and Cable; Public Buildings; Construction Materials; Automotive; Storage and Distribution; Products; Textiles; Waterborne emissions & coatings
Unconfirmed Potential Substitutes																
Aluminum diethylphosphinate 225789-38-8	L	*L*	L	VL	*M*	*M*	*M*	L	-	L	VL	M	M	*H*	*L*	Electronics; Wire and Cable; Automotive; Aviation; Textiles
Aluminum hydroxide 21645-51-2	L	*L*	L	*L*	L	M	*M*	L	-	VL	VL	*M*	*M*	*H*	*L*	Electronics; Wire and Cable; Public Buildings; Construction Materials; Automotive; Aerospace; Textiles; Waterborne emissions & coatings
Ammonium polyphosphate 68333-79-9	L	*L*	*L*	*L*	*L*	*L*	*L*	L	-	VL	L	*L*	*L*	*VH*	*L*	Electronics; Wire and Cable; Public Buildings; Construction Materials; Automotive; Aerospace; Storage and Distribution; Products; Textiles;

Table 5-3: Summary of DecaBDE and Potential Chemical Substitutes Hazards and Uses																
Substance Name and CAS Number	**Human Health Effects[1]**											**Aquatic Toxicity[1]**		**Persistence[1]**	**Bioaccumulation[1]**	**Potential Industry Uses**
	Acute Toxicity	**Carcinogenicity**	**Genotoxicity**	**Reproductive**	**Developmental**	**Neurological**	**Repeated Dose**	**Skin Sensitization**	**Respiratory Sensitization**	**Eye Irritation**	**Dermal Irritation**	**Acute**	**Chronic**			
																Waterborne emissions & coatings
Bis (hexachlorocyclopentadieno) cyclooctane 13560-89-9	L	*M*	*M*	VL	VL	L	M	L	-	VL	*L*	*L*	*L*	VH	H	Electronics; Wire and Cable; Public Buildings; Construction Materials; Waterborne emissions & coatings
Bisphenol A bis-(diphenyl phosphate) 181028-79-5	L	*M*	L	*L*	*L*	*L*	L	L	-	L	L	L	L	H	*H*	Electronics
Brominated Epoxy Polymer(s)[3] 68928-70-1	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	-	*L*	*L*	*L*	*L*	*VH*	*L*	Electronics; Public Buildings; Construction Materials; Automotive; Storage and Distribution Products
Mixture of Brominated Epoxy Polymer(s) and Bromobenzyl Acrylate[4]	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	-	*L*	*L*	*L*	*L*	*VH*	*L*	Electronics; Storage and Distribution Products
Brominated epoxy resin endcapped with tribromophenol 135229-48-0	*L*	*L*	*L*	*L*	*L*	*L*	*L*	L	-	L	VL	*L*	*L*	*VH*	*L*	Electronics; Public Buildings; Construction Materials; Automotive
Brominated polyacrylate 59447-57-3	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	-	*L*	*L*	*L*	*L*	*VH*	*L*	Electronics; Automotive; Storage and Distribution Products
Brominated poly(phenylether)[4]	L	*L*	L	VL	*M*	*L*	L	L	-	L	VL	L	*L*	VH	*H*	Electronics; Wire and Cable; Public Buildings; Construction Materials; Automotive; Storage and Distribution Products; Textiles; Waterborne emissions & coatings
Brominated polystyrene[3]	L	*L*	*L*	*L*	*L*	*L*	*L*	*L*	-	L	*L*	*L*	*L*	*VH*	*L*	Electronics; Automotive

Table 5-3: Summary of DecaBDE and Potential Chemical Substitutes Hazards and Uses																
Substance Name and CAS Number	**Human Health Effects[1]**											**Aquatic Toxicity[1]**		**Persistence[1]**	**Bioaccumulation[1]**	**Potential Industry Uses**
	Acute Toxicity	**Carcinogenicity**	**Genotoxicity**	**Reproductive**	**Developmental**	**Neurological**	**Repeated Dose**	**Skin Sensitization**	**Respiratory Sensitization**	**Eye Irritation**	**Dermal Irritation**	**Acute**	**Chronic**			
88497-56-7																
Ethylene bistetrabromophthalimide 32588-76-4	L	*M*	L	*L*	*M*	*L*	L	*L*	-	VL	VL	*L*	*L*	VH	H	Electronics; Wire and Cable; Public Buildings; Construction Materials; Automotive; Storage and Distribution Products; Waterborne emissions & coatings
Magnesium hydroxide 1309-42-8	L	L	L	L	*L*	*L*	L	*L*	-	M	L	*L*	*L*	*H*	H	Electronics; Wire and Cable; Public Buildings; Construction Materials; Automotive; Aerospace; Storage and Distribution Products; Waterborne emissions & coatings
Melamine cyanurate 37640-57-6	*L*	*M*	*M*	*M*	*M*	*L*	H	*L*	-	*L*	*L*	*L*	*L*	VH	*L*	Electronics; Wire and Cable; Public Buildings; Construction Materials; Automotive; Aerospace; Textiles; Waterborne emissions & coatings
Melamine polyphosphate 15541-60-3	L	*M*	*M*	*L*	*L*	*L*	*M*	*L*	-	L	VL	L	L	H	*L*	Electronics; Wire and Cable; Public Buildings; Construction Materials; Automotive; Aerospace; Storage and Distribution Products; Waterborne emissions & coatings
N-alkoxy hindered amine reaction products 191680-81-6	L	*M*	L	*H*	*H*	*L*	*H*	L	-	L	VL	*H*	*H*	H	*H*	Construction Materials; Textiles

Table 5-3: Summary of DecaBDE and Potential Chemical Substitutes Hazards and Uses																
Substance Name and CAS Number	**Human Health Effects[1]**											**Aquatic Toxicity[1]**		**Persistence[1]**	**Bioaccumulation[1]**	**Potential Industry Uses**
	Acute Toxicity	**Carcinogenicity**	**Genotoxicity**	**Reproductive**	**Developmental**	**Neurological**	**Repeated Dose**	**Skin Sensitization**	**Respiratory Sensitization**	**Eye Irritation**	**Dermal Irritation**	**Acute**	**Chronic**			
Phosphonate oligomer 68664-06-2	L	*M*	*L*	*L*	*L*	*M*	*L*	*L*	-	*M*	*M*	L	*H*	*VH*	*H*	Electronics; Public Buildings; Construction Materials
Phosphoric acid, mixed esters with [1,1‟-bisphenol-4,4‟-diol] and phenol 1003300-73-9	L	*M*	L	*L*	*L*	L	L	L	-	VL	VL	*H*	*H*	H	*M*	Electronics; Automotive; Aerospace
Polyphosphonate 68664-06-2	L	*L*	*L*	*L*	*L*	*L*	*L*	*L*	-	*M*	*M*	L	*H*	*VH*	*H*	Electronics; Wire and Cable; Public Buildings; Construction Materials; Automotive; Aerospace; Textiles
Poly[phosphonate-cocarbonate] 77226-90-5	L	*L*	*L*	*L*	*L*	*L*	*L*	*L*	-	*L*	*L*	*L*	*L*	*VH*	*L*	Electronics; Wire and Cable; Public Buildings; Construction Materials; Automotive; Aerospace
Red phosphorus 7723-14-0	L	*L*	M	*L*	*L*	*L*	*L*	L	-	M	M	L	L	H	*L*	Electronics; Wire and Cable; Automotive; Aerospace; Waterborne emissions & coatings
Resorcinol bisdiphenylphosphate 125997-21-9	L	M	L	L	M	M	M	*L*	-	L	VL	VH	VH	M	*H*	Electronics
Substituted amine phosphate mixture[4]	*H*	*M*	*M*	*M*	*M*	*L*	*M*	L	*M*	M	VL	*M*	*L*	*H*	*L*	Electronics; Wire and Cable; Public Buildings; Construction Materials; Automotive; Aerospace; Storage and Distribution Products

Table 5-3: Summary of DecaBDE and Potential Chemical Substitutes Hazards and Uses																
Substance Name and CAS Number	**Human Health Effects[1]**											**Aquatic Toxicity[1]**		**Persistence[1]**	**Bioaccumulation[1]**	**Potential Industry Uses**
	Acute Toxicity	**Carcinogenicity**	**Genotoxicity**	**Reproductive**	**Developmental**	**Neurological**	**Repeated Dose**	**Skin Sensitization**	**Respiratory Sensitization**	**Eye Irritation**	**Dermal Irritation**	**Acute**	**Chronic**			
Tetrabromobisphenol A bis (2,3-dibromopropyl ether)[3] 21850-44-2	L	*M*	M	*M*	*M*	*L*	*M*	L	-	L	L	L	*L*	VH	*H*	Electronics; Public Buildings; Construction Materials; Automotive
Triphenyl phosphate 115-86-6	L	*M*	L	L	L	L	H	L	-	L	VL	VH	VH	L	M	Electronics
Tris(tribromoneopentyl) phosphate[3] 19186-97-1	*M*	*M*	L	*M*	*M*	*H*	L	L	-	*L*	*L*	*L*	*L*	*H*	*M*	Electronics; Public Buildings; Construction Materials; Textiles
Tris(tribromophenoxy) triazine[3] 25713-60-4	L	*L*	L	*L*	*L*	*L*	L	L	-	L	VL	*L*	*L*	VH	*H*	Electronics

Notes:
[1] Hazard classifications (e.g., high, moderate) are based on the Design for the Environment (DfE) criteria for alternatives assessment.
[2] Decabromodiphenyl ethane (DBDPE) is structurally very similar to decaBDE and is known to already have substituted decaBDE in some products and uses, though it may not be an appropriate substitute for all potential uses listed.
[3] Based on structure, chemical is considered a likely potential substitute for decaBDE.
[4] CAS number for potential alternative is confidential.

Sources:
ILEPA (2007); EPA (2014a)

5.1.4 Effects of Final Regulatory Action and Primary Alternative

Under EPA's final regulatory action, inhalation and dermal PPE are required during the recycling process of pallets containing decaBDE, and during the manufacturing and processing of decaBDE and decaBDE-containing replacement parts for use in aerospace or motor vehicles. Additionally, all persons who process, including recycle, decaBDE-containing plastic shipping pallets must place signs at every entry point into the regulated area, and releases of decaBDE to water is prohibited during the manufacture, processing, or distribution in commerce. Individuals who may be occupationally exposed in the sectors that use decaBDE under these regulated conditions will experience reduced exposures as a result of the final action. Where the compliance date for prohibition has been extended (i.e., for processing and distribution in commerce of decaBDE for use in wire and cable insulation in nuclear power generation facilities) the benefits of the regulation will be delayed.

The alternative option would further reduce aggregate exposure to decaBDE by including the requirement for inhalation and dermal PPE during all recycling processes of plastics and requiring a label on all recycled plastic articles containing decaBDE. Individuals who may be occupationally exposed in the sectors that use decaBDE under these additional regulated conditions would experience further reduced exposures as a result of the alternative option.

5.2 Benefits of Reduced Exposure to PIP (3:1)

5.2.1 Exposure Considerations

Under the final action, certain uses of PIP (3:1) will be phased out over the next 30 years and worker personal protective equipment (masks/respirators and gloves) are required during the manufacturing and processing of PIP (3:1) in uses that are not prohibited. For the processing of PIP (3:1) in the manufacturing of cyanoacrylate adhesives, other industry best practices for engineering controls and exhaust ventilation are also required.

PIP (3:1) is used for a variety of industrial purposes: it is a component of many products and formulations, and is also used as a manufacturing aid (U.S. Environmental Protection Agency (EPA) 2020b). It has been found in products ranging from hydraulic fluid for airplanes to plastic children's toys (U.S. Environmental Protection Agency (EPA) 2020b). Releases to air, land, and water from manufacture, processing, distribution and use of PIP (3:1) are possible (EPA 2020b). When released to air, a fraction of PIP (3:1) is expected to partition to soil or water, based on its Henry's Law constant (EPA 2020b). PIP (3:1) remaining in air is either decomposed by reaction with hydroxyl radicals, or removed via wet and dry deposition (NLM 2015b).

In soil, PIP (3:1) is expected to adsorb to organic matter and to have limited mobility (EPA 2020b). PIP (3:1) in water is also expected to adsorb to suspended soils and sediments (NLM 2015a). Due to its low solubility, low vapor pressure, and ability to adsorb to organic particles, volatilization is not expected after release to water or soil (NLM 2015b). Although there are no available studies on its biodegradation potential, studies of similar chemicals suggest that PIP (3:1) is not easily biodegradable (NLM 2015b).

In the indoor environment, PIP (3:1) is expected to be found primarily in dust rather than air (EPA 2020b). Exposure to PIP (3:1) can occur through inhalation or ingestion (EPA 2020b). Environmental monitoring data on PIP (3:1) are limited; however, since triphenyl phosphate is often found in the same commercial formulations as PIP (3:1), environmental monitoring studies of this chemical can also provide insight into expected patterns of PIP (3:1) (EPA 2020b). PIP (3:1) has been identified in ambient air, water, soil and sediment (EPA 2020b). Although no studies of PIP (3:1) in

indoor air and dust have been identified to date, the presence of PIP (3:1) is also expected in these media based on studies of triphenyl phosphate (EPA 2020b).

Occupational exposures to PIP (3:1) may occur via dermal contact or inhalation (NLM 2015b). No biomonitoring studies on PIP (3:1) have been identified to date, but several studies have detected triphenyl phosphate in human biomonitoring samples (Cequier et al. 2015; Fromme et al. 2014; Henriquez-Hernandez et al. 2017). Based on evidence from biomonitoring studies of triphenyl phosphate, children are expected to have higher average daily doses to PIP (3:1) than adults (EPA 2020b).

EPA did not perform a systematic review of the literature to characterize the hazards of the PBT chemicals, and instead performed a limited survey of the reasonably available scientific information.

5.2.2 Health Effects Associated with Exposure

Cancer

PIP (3:1) has not been classified by the International Agency on Cancer Research, and does not have a carcinogenicity assessment in EPA's IRIS. Laboratory studies on the carcinogenicity of PIP (3:1) are not available (NLM 2015b). However, in one longitudinal cohort study of 850 exposed workers, no significant increases in cancer risk or mortality were observed (NLM 2015b).

Non-Cancer

PIP (3:1) is toxic to aquatic plants, aquatic invertebrates, sediment invertebrates, and fish. In vitro and animal studies indicate it may be toxic to humans. The specific adverse health effects will depend on the formulation of PIP (3:1) under consideration. In OECD guideline studies submitted by manufacturers and summarized by the European Chemicals Agency (ECHA) in the REACH Registration Dossier, PIP (3:1) exposure in rats has been associated with a number of adverse effects on reproduction and development, including reduced fertility, reduced litter sizes, damage to ovaries and increased ovary weights (ECHA 2023). These studies also show changes and increases in other organ and gland weights, such as the liver, thyroid, and adrenals (ECHA 2023). Additionally, "decreased serum albumin/globulin ratio, increased relative liver weights, and decreased serum albumin concentration, decreased creatine levels, decreased terminal body weights, and increased absolute liver weights" were seen in rats exposed once daily for four days (Auerbach et al. 2022). Additionally, neurological effects have been observed in laboratory animals, but this evidence is mixed. Studies of subacute and subchronic exposures in hens have found indicators of neurotoxicity such as ataxia (loss of control of body movements), neurological lesions, and degeneration of the spinal cord (NLM 2015b).There is one case report of neurotoxic effects of PIP (3:1) in one exposed worker, finding decreases in number of nerve potentials and in nerve conduction velocities. In an inhalation study in rabbits, PIP (3:1) exposure proved to be lethal at high doses (ECHA 2018). One surveillance study in multiple workers did not observe increased morbidity or mortality when comparing rates in the workers to morbidity and mortality rates in what they describe as the comparable segment of the U.S. population (NLM 2015b).

Environmental Toxicity

The aquatic toxicity of PIP (3:1) is dependent on the exact composition of the substance. According to ECHA (2018), if PIP (3:1) is composed of greater than 5% triphenyl phosphate, it is expected to be an aquatic toxicant. Acute lethality after exposure to PIP (3:1) has been observed in various species of fish, with 96-hour LC_{50}s ranging from 1.6 to over 1,000 mg/L depending on the species and composition of PIP (3:1) (EPA 2020b). Acute exposures to PIP (3:1) in minnows have also been associated with increases in hemorrhages and abnormal behavior, while chronic exposures significantly decrease survival rates and growth (ECHA 2017). In a chronic study of exposure to aquatic invertebrates, decreased growth

and reproductive capabilities were observed (ECHA 2017). Adverse effects on growth have also been observed in algae (ECHA 2017). Limited information is available on the terrestrial toxicity of PIP (3:1), but reductions in growth and impaired reproduction have been observed in earthworms (EPA 2020b).

Summary

The information in this section does not represent an exhaustive literature review, nor is it an analysis of relative importance or comparative dose-response among hazards.

There are currently no data to suggest that PIP (3:1) is a carcinogen; no cancer-related benefits are expected as a result of decreases in exposure. However, reductions in the exposures to PIP (3:1) may lead to reductions in the potential for noncancer health concerns. Depending on the composition of PIP (3:1), decreases in exposure may increase survival rates, growth and reproductive capabilities in aquatic and terrestrial organisms.

5.2.3 Substitutes Considerations

This section presents information on the toxicity of substitutes for PIP (3:1). Two of the substitutes – 2-ethylhexyl diphenyl phosphate ester and isodecyl diphenyl phosphate – have the same final hazard rating as PIP (3:1), though persistence and bioaccumulation are expected to be lower. On the other hand, the triaryl phosphates isobutylenated (Phenol, isobutylenated, phosphate (3:1)) substitute is rated as less hazardous than PIP (3:1) but has the same ratings as PIP (3:1) for persistence and bioaccumulation.

Assuming that the exposures to the substitutes are equivalent to the exposures to PIP (3:1), to the extent that this regulation results in use of substitutes, EPA anticipates that hazards and exposures will be at most equivalent (if not less) than the hazards and exposures in the absence of this regulation.

Table 5-4. Persistence, Bioaccumulation and Hazard Ratings for Potential Chemical Substitutes Hazards and Uses for PIP (3:1)

Substance Name	CAS Number	Persistence Rating	Bioaccumulation Rating	Environmental Hazard Rating	Human Health Hazard Rating	Final Hazard Rating
2-ethylhexyl diphenyl phosphate ester	1241-94-7	1	1	3	2	3
Triaryl Phosphates isobutylenated (Phenol, isobutylenated, phosphate (3:1))	68937-40-6	3	3	1	2	2
Isodecyl diphenyl phosphate	29761-21-5	1	1	3	2	3

Note(s):
3 = High, 2 = Moderate, 1 = Low. Unknown (U) indicates that EpiSuite and ECOSAR (v2.0) could not be used to predict the chemical's persistence and bioaccumulative properties and environmental hazard, respectively.

The Persistence, Bioaccumulation and Hazard Ratings for PIP (3:1) are presented in Table 5-1.

Source(s): EPA (2014c, 2019b)

5.2.4 Effects of Final Action and Primary Alternative

Under the final regulatory action, prohibitions on the processing and distribution for various uses of PIP (3:1) will be phased in: non-turbine/non-aerospace uses of lubricants and greases (5-year phase-in), new/replacement motor vehicle parts (15-year phase-in with additional 15 years for distribution), aerospace (30-year phase-in), and articles in manufacturing equipment and semiconductors (10-year phase-in). Additionally, worker personal protective equipment (masks/respirators and gloves) is required during the manufacturing and processing of PIP (3:1) in uses that are not prohibited. Individuals who may be occupationally exposed in the sectors that use PIP (3:1) under these regulated conditions will experience reduced exposures as a result of the final action. Where the compliance date for prohibition has been extended (i.e., for use of PIP (3:1) in FIFRA approved marine antifouling coatings) the benefits of the regulation will be delayed.

Under the primary alternative option, EPA would prohibit PIP (3:1) in all lubricants and greases (5-year phase-in) and in articles in manufacturing equipment and semiconductors (20-year phase-in). To the extent that prohibition is delayed under the primary alternative option, benefits would be reduced. However, exposure would be mitigated to the extent that personal protective equipment is required until the use is prohibited.

5.3 Conclusion on Benefits of Regulating DecaBDE and PIP (3:1)

Exposure to decaBDE or PIP (3:1) to the workers and the environment is likely under the conditions of use regulated under the final action. In this section, a summary of the health and environmental effects of the chemicals is presented, along with a discussion of how the final regulatory option reduces exposures and risks. Since decaBDE and PIP (3:1) are persistent in the environment, it is important to note that, though exposure is expected to decrease as a result of the regulatory action, it is not expected to immediately cease after the 30-year prohibition phase-in period. It should also be noted that data on the effects of exposure to these chemicals are still lacking for many endpoints; additional health and environmental hazards may be associated with the chemical. On the other hand, since data on the potential alternatives are not always complete in many cases, it is often also not possible to fully characterize the degree of risk associated with exposures to any substitute chemicals.[36]

DecaBDE is a potential human carcinogen that is persistent and bioaccumulative. DecaBDE is additionally associated with developmental neurotoxicity, hepatic toxicity, and several other adverse non-cancer health effects in humans, as well as with toxicity in aquatic organisms. The final regulation requires PPE to reduce exposures to the occupationally exposed population, thereby reducing the aforementioned adverse effects of decaBDE. The primary alternative option would provide additional protection for workers recycling all decaBDE-containing plastic, but less protection for workers manufacturing and processing of decaBDE and decaBDE-containing replacement parts for use in aerospace or motor vehicles. Since there are numerous potential substitutes for decaBDE – some of which may pose greater or equal risk than decaBDE – substitute chemicals should be carefully selected to realize benefits to human health and the environment.

PIP (3:1) is toxic to aquatic plants, aquatic invertebrates, sediment invertebrates, and fish. Data indicate the potential for reproductive and developmental effects, neurological effects and effects on systemic organs. In addition, PIP (3:1) has high persistence and high potential for bioaccumulation. It is prohibited under the final regulatory option, with the exception of uses in aviation hydraulic fluid, turbine and

[36] In general, regulatory analysis is strengthened by considering how alternatives potentially impact human health and the environment.

aerospace lubricants and greases, cyanoacrylate adhesives, certain specialty engine filters, articles made from recycled materials, and for wire harnessing and electric circuit boards. Personal protective equipment is required for uses that are not prohibited. Therefore, the potential for occupational exposures to PIP (3:1) is either reduced or eliminated, depending on the industry in question. Under the primary alternative option, certain phase-in timeframes would be extended, so benefits would decrease compared to the final option to the extent that the reduction in exposures lessens. Since several of the potential alternatives identified posed a comparable hazard to human and environmental health to PIP (3:1), the choice of alternatives will inform and affect benefits of the rule.

Further research would help characterize the full set of health hazards and environmental concerns associated with decaBDE and PIP (3:1). Since the chemicals are persistent and bioaccumulative, they are expected to remain in the environment for long periods of time; preventing the potential for initial releases to air, land and water through manufacture and/or use of these chemicals protects human health and the environment. The final action is expected to reduce the exposures to decaBDE and PIP (3:1) and thus have benefits for human health and the environment. Careful selection of substitutes for the chemical will help ensure that these benefits are realized.

6. Small Entity Impact Analysis

This chapter estimates the impact that the final rule may have on small entities by examining the relationship between the compliance costs and company sales for small companies.

The Regulatory Flexibility Act (RFA) of 1980, as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996, requires regulators to assess the effects of regulations on small entities, including businesses, nonprofit organizations, and governments. In some instances, agencies also are required to examine regulatory alternatives that may reduce adverse economic effects on significantly impacted small entities. The RFA requires agencies to prepare an initial and final regulatory flexibility analysis for each rule unless the Agency certifies that the rule will not have a significant economic impact on a substantial number of small entities (SISNOSE). The RFA, however, does not specifically define "a significant economic impact on a substantial number" of small entities. Sections 603 and 604 of the RFA require that regulatory flexibility analyses identify the types, and estimate the numbers, of small entities to which the rule will apply; and describe the rule requirements to which small entities are subject and any regulatory alternatives, including compliance delays and deferral, that lessen the rule's burden on small entities.

This analysis follows EPA guidance on RFA and SBREFA analyses guidance (EPA 2006b). Per this guidance document, the preferred measure of economic impacts is the "sales test:" annualized compliance costs as a percentage of sales (or revenue or receipts when sales data are not readily available). This measure is termed "cost impact percentage" in the small entity analysis. Also consistent with this guidance (EPA 2006b), this analysis only considers the impacts of the rule on regulated entities (manufacturers, processors, and distributors) and not the downstream impacts on consumers or other end-users of the products.

The major steps followed in the analysis are described below.

6.1 Select a Relevant Small Business Definition

The RFA relies on the definition of "small business" found in the Small Business Act, which authorizes the Small Business Administration (SBA) to develop definitions for "small business" for industries in each North American Industry Classification System (NAICS) code. These definitions can be based either on a company's number of employees or its revenue, depending on SBA's criteria for that industry.

The small business thresholds for the NAICS codes associated with each use were identified using the SBA Table of Small Business Size Standards (SBA 2023) and the parent company's NAICS code. Small businesses associated with each chemical are identified.

6.2 Identify the Small Businesses

6.2.1 By Identified Companies

EPA identified 19 specific parent companies affected by the final regulation, as shown in Section 3.2.2 for decaBDE and Section 3.3.2 for PIP (3:1). To determine the number of identified firms that are subject to the rule and considered small under SBA size standards, EPA compared the appropriate SBA size definition to the company's revenue or number of employees, as identified using D&B Hoovers or Experian.

Table 6-1 presents the companies EPA has identified as using decaBDE or PIP (3:1) for the regulated activities under the final rule. For each company, Table 6-1 provides the NAICS code of the parent company, the relevant SBA small business definition, and whether or not the company was determined to be a small business based on the business statistics reported in Section 3.2.2 for decaBDE and Section 3.3.2 for PIP (3:1). Three of the identified companies, highlighted in the table below, are considered to be small. These companies will be affected under the final rule.

Table 6-1: Small Business Determinations for Companies Associated with the Use of PIP (3:1)

Parent Company	Parent Primary NAICS Code	SBA Small Business Definition	Small Business Status
Akzo Nobel Inc.	325510 Paint and Coating Manufacturing	1,000 employees	no
American Air Filter Co Inc	423840 Industrial Supplies Merchant Wholesalers	125 employees	no
Berkshire Hathaway Inc	335921 Fiber Optic Cable Manufacturing	1,000 employees	no
BP America Inc.	324110 Petroleum Refineries4	1,500 employees	no
Cool Air Products LLC	333415 Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	1,250 employees	**yes**
Eastman Chemical Company	325199 All Other Basic Organic Chemical Manufacturing	1,250 employees	no
Exxon Mobil Corporation	324110 Petroleum Refineries	1,500 employees	no
Fuchs Lubricants Corporation	324191 Petroleum Lubricating Oil and Grease Manufacturing	900 employees	no
Henkel Corp	325520 Adhesive Manufacturing	550 employees	no
ICL Specialty Products North America Inc.	325180 Other Basic Inorganic Chemical Manufacturing	1,000 employees	no
iGPS Logistics LLC	532490 Other Commercial and Industrial Machinery and Equipment Rental and Leasing	$40 million revenue	no
Kluber Lubrication NA LP	324191 Petroleum Lubricating Oil and Grease Manufacturing	900 employees	no
Lanxess Services US LLC	424690 Other Chemical and Allied Products Merchant Wholesalers	175 employees	no
NYCO Products Co	324191 Petroleum Lubricating Oil and Grease Manufacturing	900 employees	**yes**
Nye Lubricants, Inc.	324191 Petroleum Lubricating Oil and Grease Manufacturing	900 employees	no
Quaker Chemical Corporation	324191 Petroleum Lubricating Oil and Grease Manufacturing	900 employees	no
Shell Oil Co.	324110 Petroleum Refineries	1,500 employees	no
Tire Seal, Inc.	423120 Motor Vehicle Supplies and New Parts Merchant Wholesalers	200 employees	**yes**
Walter Surface Technologies Incorporated	423840 Industrial Supplies Merchant Wholesalers	125 employees	no

6.2.2 By NAICS

For uses where the regulated companies have not been directly identified, the number of companies assessed is based on the number of firms in the relevant NAICS code. Table 6-2 presents an industry-level view of the small businesses in each industry (defined by NAICS code) that might be affected by the rule. The two rightmost columns identify the number of small businesses in each NAICS as well as the percent of business in each NAICS classified as small. As noted earlier in this economic

analysis, the extent to which companies in a listed NAICS code will actually be affected by the final rule will depend on the extent to which the chemicals are actually being used, and how they are used.

Summary Table 6-3 presents the total number of small businesses associated with each condition of use identified in Table 6-2.

Table 6-2: Small Business Data by NAICS for Industries Associated with Final Rule

NAICS Code	NAICS Description	SBA Threshold (2023)	Number of Small Businesses in NAICS	Percent of NAICS Classified as a Small Business.
DecaBDE[1]				
326111	Plastics Bag and Pouch Manufacturing	750 employees	240	88.2%
326112	Plastics Packaging Film and Sheet (including Laminated) Manufacturing	1000 employees	278	88.3%
326113	Unlaminated Plastics Film and Sheet (except Packaging) Manufacturing	750 employees	341	88.6%
326121	Unlaminated Plastics Profile Shape Manufacturing	600 employees	273	88.1%
326122	Plastics Pipe and Pipe Fitting Manufacturing	750 employees	228	87.0%
326130	Laminated Plastics Plate, Sheet (except Packaging), and Shape Manufacturing	650 employees	178	84.8%
326140	Polystyrene Foam Product Manufacturing	1000 employees	275	91.4%
326150	Urethane and Other Foam Product (except Polystyrene) Manufacturing	750 employees	404	90.2%
326160	Plastics Bottle Manufacturing	1250 employees	179	92.3%
326191	Plastics Plumbing Fixture Manufacturing	750 employees	274	96.5%
326199	All Other Plastics Product Manufacturing	750 employees	4,577	94.2%
325991	Custom Compounding of Purchased Resins	600 employees	296	87.1%
562920	Materials Recovery Facilities	$25 million revenue	910	90.6%
PIP (3:1)				
325211	Plastics Material and Resin Manufacturing	1250 employees	757	89.4%
325520	Adhesive Manufacturing	550 employees	327	85.4%
325991	Custom Compounding of Purchased Resins	600 employees	296	87.1%
326199	All Other Plastics Product Manufacturing	750 employees	4,577	94.2%
333111	Farm Machinery and Equipment Manufacturing	1250 employees	989	97.5%
333112	Lawn and Garden Tractor and Home Lawn and Garden Equipment Manufacturing	1500 employees	131	89.1%
333120	Construction Machinery Manufacturing	1250 employees	589	94.2%
333131	Mining Machinery and Equipment Manufacturing	900 employees	203	91.0%
333242	Semiconductor Machinery Manufacturing	1500 employees	132	86.3%

Table 6-2: Small Business Data by NAICS for Industries Associated with Final Rule				
NAICS Code	NAICS Description	SBA Threshold (2023)	Number of Small Businesses in NAICS	Percent of NAICS Classified as a Small Business.
333413	Industrial and Commercial Fan and Blower and Air Purification Equipment Manufacturing	500 employees	378	93.1%
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	500 employees	314	92.6%
333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	1250 employees	631	92.1%
333613	Mechanical Power Transmission Equipment Manufacturing	750 employees	159	83.7%
333618	Other Engine Equipment Manufacturing	1500 employees	206	85.5%
333924	Industrial Truck, Tractor, Trailer and Stacker Machinery Manufacturing	900 employees	296	91.6%
333998	All Other Miscellaneous General Purpose Machinery Manufacturing	700 employees	1,292	93.6%
334111	Electronic Computer Manufacturing	1250 employees	283	93.1%
334112	Computer Storage Device Manufacturing	1250 employees	59	74.7%
334118	Computer Terminal and Other Computer Peripheral Equipment Manufacturing	1000 employees	406	93.1%
334290	Other Communications Equipment Manufacturing	800 employees	296	93.4%
334412	Bare Printed Circuit Board Manufacturing	750 employees	383	94.3%
334413	Semiconductor and Related Device Manufacturing	1250 employees	662	92.6%
334417	Electronic Connector Manufacturing	1000 employees	138	87.9%
334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing	750 employees	684	94.7%
334419	Other Electronic Component Manufacturing	750 employees	926	93.6%
335210	Small Electrical Appliance Manufacturing	1500 employees	138	87.3%
335220	Major Household Appliance Manufacturing	1500 employees	98	76.6%
335313	Switchgear and Switchboard Apparatus Manufacturing	1250 employees	381	94.5%
335931	Current-Carrying Wiring Device Manufacturing	600 employees	316	89.0%
335999	All Other Miscellaneous Electrical Equipment and Component Manufacturing	600 employees	665	92.1%
336110	Automobile and Light Duty Motor Vehicle Manufacturing	1500 employees	147	74.2%
336120	Heavy Duty Truck Manufacturing	1500 employees	52	68.4%
336211	Motor Vehicle Body Manufacturing	1000 employees	569	93.4%
336214	Travel Trailer and Camper Manufacturing	1000 employees	547	97.3%

Table 6-2: Small Business Data by NAICS for Industries Associated with Final Rule				
NAICS Code	NAICS Description	SBA Threshold (2023)	Number of Small Businesses in NAICS	Percent of NAICS Classified as a Small Business.
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	1050 employees	607	92.5%
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing	1000 employees	479	90.7%
336390	Other Motor Vehicle Parts Manufacturing	1000 employees	984	90.3%
336411	Aircraft Manufacturing	1500 employees	264	89.5%
336412	Aircraft Engine and Engine Parts Manufacturing	1500 employees	291	90.7%
336413	Other Aircraft Part and Auxiliary Equipment Manufacturing7	1250 employees	678	91.9%
336414	Guided Missile and Space Vehicle Manufacturing	1300 employees	10	34.5%
336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	1250 employees	3	17.6%
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	1050 employees	18	58.1%
336611	Ship Building and Repairing	1300 employees	411	95.6%
336612	Boat Building	1000 employees	819	97.8%
336991	Motorcycle, Bicycle and Parts Manufacturing	1050 employees	366	96.8%
336999	All Other Transportation Equipment Manufacturing	1000 employees	371	95.4%
339920	Sporting and Athletic Goods Manufacturing	750 employees	1,533	98.8%

[1] For purposes of accounting for use of DecaBDE in NAICS 3261 in the small entity analysis, this table shows all 6-digit codes in NAICS 3261 instead of 3261 as a whole.

Table 6-3: Small Businesses by Chemical and Use	
Chemical and Use	Number of Small Businesses
DecaBDE (Final)	
Plastic Shipping Pallets	0
Replacement Parts for Aerospace Vehicles (makers)	0
Replacement Parts for Motor Vehicles (makers)	0
Wire and Cable Insulation	0
All DecaBDE Uses	**0**
PIP (3:1) (Final)	
Lubricants and Greases (except Aerospace and Turbine) (makers)	2
Lubricants & Greases (Aerospace) (makers)	1
New and Replacement Parts for Motor Vehicles (consumers)	6,030
New and Replacement Parts for Motor Vehicles (makers)	9,006
New and Replacement Parts for Aerospace Vehicles (consumers)	274
New and Replacement Parts for Aerospace Vehicles (makers)	2,370
Wire Harnesses and Electric circuit Boards (makers)	2,436

Marine Antifouling Coatings	0
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	2,843
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	9,879
Engine Filters for Locomotive and Marine Applications	0
Cyanoacrylate Adhesives	0
Aviation Hydraulic Fluid (makers)	1
All PIP (3:1) Uses	***24,865***

6.3 Estimate the Cost-to-Revenue Ratio for Small Companies

This analysis uses *cost impact percentages* to measure potential impacts on small parent entities affected by the rule as a percentage of annual revenues, a commonly available and objective measure of a company's business volume. As is the expected case for this rule, when regulatory costs represent a small fraction of a typical entity's revenue, the impacts of the regulation are minimal.

To determine the magnitude of any potential adverse impact of the rule on small entities, annualized per-company compliance costs were compared to annual revenue.

The cost analysis detailed in Chapter 4 estimated the unit costs for complying with the rule. Some costs are incurred on a per worker basis and others are per facility. These costs are summarized in Table 6-4.

As discussed in Section 4.3, negative costs represent cost savings. Cost savings are expected to occur for PIP (3:1) in circumstances where the final rule is less stringent than the 2021 PIP (3:1) final rule. In addition, EPA expects there to be no costs for firms or entities where there are no rule requirements.

Table 6-4: Compliance Costs, by Chemical and Use				
Chemical and Use	Cost Basis	Requirement	Annualized Costs[9]	
			3%	7%
DecaBDE (Final)				
Plastic Shipping Pallets	per firm	Posting sign near where use occurs	$10	$11
Plastic Shipping Pallets	per worker	PPE	$0	$0
Replacement Parts for Aerospace Vehicles (makers)	per worker	PPE	$0	$0
Replacement Parts for Motor Vehicles (makers)	per worker	PPE	$0	$0
PIP (3:1) (Final)				
Lubricants & Greases (Aerospace) (makers)	per worker	PPE	$3,018	$3,018
Lubricants and Greases (except Aerospace and Turbine) (makers)	per worker	PPE	$1,801	$2,193
Lubricants and Greases (except Aerospace and Turbine) (makers)	per firm	Prohibition (after 5 years)	$2,999	$2,703
New and Replacement Parts for Motor Vehicles (consumers)	per firm	Prohibition (after 15 years)	$191	$293
New and Replacement Parts for Motor Vehicles (makers)	per firm	Prohibition (after 15 years)	$2,999	$2,703
New and Replacement Parts for Motor Vehicles (makers)	per worker	PPE	$668	$791
New and Replacement Parts for Aerospace Vehicles (makers)	per firm	Prohibition (after 30 years)	$1,925	$980
New and Replacement Parts for Aerospace Vehicles (makers)	per worker	PPE	$1,049	$980
New and Replacement Parts for Aerospace Vehicles (consumers)	per firm	Prohibition (after 30 years)	$191	$293
Wire Harnesses and Electric circuit Boards (makers)	per worker	PPE	$3,018	$3,018
Marine Antifouling Coatings	per firm	Exclusion from prohibition (for 5 years)	-$506	-$1,653
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	per firm	Prohibition (after 10 years)	-$1,060	-$3,179
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	per worker	PPE	$1,621	$1,974
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	per firm	Prohibition (after 10 years)	-$45	-$133

Table 6-4: Compliance Costs, by Chemical and Use				
Chemical and Use	Cost Basis	Requirement	Annualized Costs[9]	
			3%	7%
Engine Filters for Locomotive and Marine Applications	per worker	PPE	$0	$0
Cyanoacrylate Adhesives	per firm	Engineering controls & local exhaust ventilation and general ventilation	$0	$0
Cyanoacrylate Adhesives	per worker	PPE	$0	$0
Aviation Hydraulic Fluid (makers)	per worker	PPE	$3,018	$3,018

6.3.1 By Identified Companies

To determine whether any of the small companies identified in Table 6-1 are impacted at the 1% or 3% level, EPA compared their revenue to the compliance cost under the final rule. Compliance costs were calculated by multiplying the per-worker costs by the number of employees per firm and adding to the per-firm costs. For each small company, compliance costs were divided by the revenue. As shown in Table 6-5, none of the small companies are impacted at 1% or greater, at either a 3 or 7 percent discount rate under the final rule.

Table 6-5: Impacts on Small Businesses Subject to the Final Rule								
Parent Company Name	**Chemical and Use**	**per-firm cost**	**per-worker cost**	**Compliance Cost**	**Revenue**	**Cost to Revenue Ratio**	**Impact at 1% or greater**	**Impact at 3% or greater**
3% Discount Rate								
Cool Air Products LLC	Lubricants and Greases (except Aerospace and Turbine) (makers)	$2,999	$1,801	$21,009	$2,000,000	1.05%	Yes	No
NYCO Products Co	Lubricants & Greases (Aerospace) (makers) and Aviation Hydraulic Fluid (makers)	$0	$3,018	$241,440	$169,109,000	0.14%	No	No
Tire Seal, Inc.	Lubricants and Greases (except Aerospace and Turbine) (makers)	$2,999	$1,801	$15,606	$6,010,000	0.26%	No	No
7% Discount Rate								
Cool Air Products LLC	Lubricants and Greases (except Aerospace and Turbine) (makers)	$2,999	$1,801	$21,009	$2,000,000	1.05%	Yes	No
NYCO Products Co	Lubricants & Greases (Aerospace) (makers) and Aviation Hydraulic Fluid (makers)	$0	$3,018	$241,440	$169,109,000	0.14%	No	No
Tire Seal, Inc.	Lubricants and Greases (except Aerospace and Turbine) (makers)	$2,999	$1,801	$15,606	$6,010,000	0.26%	No	No

6.3.2 By NAICS

For uses where the potentially affected companies have not been directly identified, an estimate of SISNOSE is obtained by comparing compliance costs against the 1% and 3% revenue thresholds for each NAICS identified in Table 6-2.

To make this comparison, we use data on number of employees and total revenue from SUSB. For each NAICS code/employment size category pairing in the SUSB dataset, we use the average revenue per firm[37]. Per-firm compliance costs for each category were calculated by multiplying the per-worker costs, by the average number of employees per firm[38], and adding to the per-firm costs. 1% and 3% of the per-firm revenue is compared to the per-firm compliance cost and whether the threshold is exceeded is indicated in Table 6-6. Due to space limitations, only NAICS code/employment size categories with small businesses that are impacted at the threshold levels are shown in Table 6-6.

SISNOSE determination depends both on the degree to which compliance costs exceed thresholds that trigger a 1% revenue impact and the total number of small firms at risk for a 1% impact. In many cases firms belonging to a given 6-digit NAICS may not be impacted by the rule because they are not involved with activities related to the PBT chemicals. Based on Table 6-6, a high-end estimate of the total number of firms potentially affected at the 1% threshold is 860 firms (at both 3% and 7% discount rates). There were no firms affected at the 3% threshold level (see Table 6-6).

Table 6-6: Per-Firm Cost Impacts for 1% and 3% Cost-to-Revenue Thresholds for Industries Associated with Final Rule

Chemical and Use	NAICS Code	NAICS Description	Employment Size	Firms	Average Employees Per Firm	Average Revenue per firm (USD)	1% Threshold Cost per firm	3% Threshold Cost per firm	Total Compliance Costs per Firm	Costs Exceed 1% Threshold	Costs Exceed 3% Threshold
3% Discount Rate											
Wire Harnesses and Electric Circuit Boards	335931	Current-Carrying Wiring Device Manufacturing	04:10-14 employees	27	11	$2,976,543	$29,765	$89,296	$33,201	Yes	No
			05: 15-19 employees	22	17	$4,084,106	$40,841	$122,523	$51,309	Yes	No

[37] The SUSB receipts were inflated to 2022$ and divided by the number of firms.

[38] The average number of employees per form was obtained by dividing the SUSB employment number by the number of firms.

Table 6-6: Per-Firm Cost Impacts for 1% and 3% Cost-to-Revenue Thresholds for Industries Associated with Final Rule											
Chemical and Use	NAICS Code	NAICS Description	Employment Size	Firms	Average Employees Per Firm	Average Revenue per firm (USD)	1% Threshold Cost per firm	3% Threshold Cost per firm	Total Compliance Costs per Firm	Costs Exceed 1% Threshold	Costs Exceed 3% Threshold
			07: 20-24 employees	21	20	$5,503,218	$55,032	$165,097	$60,373	Yes	No
			09: 30-34 employees	13	32	$9,237,238	$92,372	$277,117	$96,589	Yes	No
			11: 40-49 employees	18	42	$9,917,706	$99,177	$297,531	$126,769	Yes	No
			12: 50-74 employees	23	59	$13,952,118	$139,521	$418,564	$178,075	Yes	No
			13: 75-99 employees	17	91	$21,002,459	$210,025	$630,074	$274,651	Yes	No
			15: 150-199 employees	11	140	$33,287,465	$332,875	$998,624	$422,533	Yes	No
	334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing	03: 5-9 employees	99	7	$2,086,818	$20,868	$62,605	$21,129	Yes	No
			04:10-14 employees	52	12	$3,330,453	$33,305	$99,914	$36,219	Yes	No
			05: 15-19 employees	43	17	$5,095,294	$50,953	$152,859	$51,309	Yes	No
			07: 20-24 employees	38	21	$4,874,830	$48,748	$146,245	$63,391	Yes	No
			08: 25-29 employees	32	27	$4,964,812	$49,648	$148,944	$81,499	Yes	No
			09: 30-34 employees	24	32	$7,581,755	$75,818	$227,453	$96,589	Yes	No
			10: 35-39 employees	21	36	$8,187,099	$81,871	$245,613	$108,661	Yes	No
			11: 40-49 employees	31	43	$10,798,483	$107,985	$323,955	$129,787	Yes	No
			12: 50-74 employees	54	59	$14,212,876	$142,129	$426,386	$178,075	Yes	No
			13: 75-99 employees	30	78	$19,771,720	$197,717	$593,152	$235,417	Yes	No

Table 6-6: Per-Firm Cost Impacts for 1% and 3% Cost-to-Revenue Thresholds for Industries Associated with Final Rule											
Chemical and Use	NAICS Code	NAICS Description	Employment Size	Firms	Average Employees Per Firm	Average Revenue per firm (USD)	1% Threshold Cost per firm	3% Threshold Cost per firm	Total Compliance Costs per Firm	Costs Exceed 1% Threshold	Costs Exceed 3% Threshold
			14: 100-149 employees	39	101	$24,447,212	$244,472	$733,416	$304,831	Yes	No
			15: 150-199 employees	17	159	$40,714,433	$407,144	$1,221,433	$479,875	Yes	No
			17: 300-399 employees	12	317	$76,965,825	$769,658	$2,308,975	$956,719	Yes	No
	334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing	04:10-14 employees	27	12	$2,763,741	$27,637	$82,912	$36,219	Yes	No
			05: 15-19 employees	25	17	$2,911,499	$29,115	$87,345	$51,309	Yes	No
			07: 20-24 employees	20	21	$3,172,164	$31,722	$95,165	$63,391	Yes	No
			08: 25-29 employees	14	26	$5,485,572	$54,856	$164,567	$78,481	Yes	No
			09: 30-34 employees	12	31	$5,012,891	$50,129	$150,387	$93,571	Yes	No
			10: 35-39 employees	13	37	$6,068,854	$60,689	$182,066	$111,679	Yes	No
			11: 40-49 employees	19	44	$7,344,337	$73,443	$220,330	$132,805	Yes	No
			12: 50-74 employees	23	57	$12,023,400	$120,234	$360,702	$172,039	Yes	No
			13: 75-99 employees	20	83	$18,234,276	$182,343	$547,028	$250,507	Yes	No
			14: 100-149 employees	20	115	$24,395,494	$243,955	$731,865	$347,083	Yes	No
			15: 150-199 employees	8	172	$35,758,619	$357,586	$1,072,759	$519,109	Yes	No
			16: 200-299 employees	9	194	$41,225,482	$412,255	$1,236,764	$585,505	Yes	No
			17: 300-399 employees	6	232	$43,749,598	$437,496	$1,312,488	$700,189	Yes	No

Table 6-6: Per-Firm Cost Impacts for 1% and 3% Cost-to-Revenue Thresholds for Industries Associated with Final Rule											
Chemical and Use	**NAICS Code**	**NAICS Description**	**Employment Size**	**Firms**	**Average Employees Per Firm**	**Average Revenue per firm (USD)**	**1% Threshold Cost per firm**	**3% Threshold Cost per firm**	**Total Compliance Costs per Firm**	**Costs Exceed 1% Threshold**	**Costs Exceed 3% Threshold**
Total:				**860**							
7% Discount Rate											
Wire Harnesses and Electric Circuit Boards	335931	Current-Carrying Wiring Device Manufacturing	04:10-14 employees	27	11	$2,976,543	$29,765	$89,296	$33,203	yes	no
			05: 15-19 employees	22	17	$4,084,106	$40,841	$122,523	$51,311	yes	no
			07: 20-24 employees	21	20	$5,503,218	$55,032	$165,097	$60,380	yes	no
			09: 30-34 employees	13	32	$9,237,238	$92,372	$277,117	$96,596	yes	no
			11: 40-49 employees	18	42	$9,917,706	$99,177	$297,531	$126,776	yes	no
			12: 50-74 employees	23	59	$13,952,118	$139,521	$418,564	$178,082	yes	no
			13: 75-99 employees	17	91	$21,002,459	$210,025	$630,074	$274,658	yes	no
			15: 150-199 employees	11	140	$33,287,465	$332,875	$998,624	$422,540	yes	no
	334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing	03: 5-9 employees	99	7	$2,086,818	$20,868	$62,605	$21,131	yes	no
			04:10-14 employees	52	12	$3,330,453	$33,305	$99,914	$36,221	yes	no
			05: 15-19 employees	43	17	$5,095,294	$50,953	$152,859	$51,311	yes	no
			07: 20-24 employees	38	21	$4,874,830	$48,748	$146,245	$63,398	yes	no
			08: 25-29 employees	32	27	$4,964,812	$49,648	$148,944	$81,506	yes	no
			09: 30-34 employees	24	32	$7,581,755	$75,818	$227,453	$96,596	yes	no

Table 6-6: Per-Firm Cost Impacts for 1% and 3% Cost-to-Revenue Thresholds for Industries Associated with Final Rule											
Chemical and Use	NAICS Code	NAICS Description	Employment Size	Firms	Average Employees Per Firm	Average Revenue per firm (USD)	1% Threshold Cost per firm	3% Threshold Cost per firm	Total Compliance Costs per Firm	Costs Exceed 1% Threshold	Costs Exceed 3% Threshold
			10: 35-39 employees	21	36	$8,187,099	$81,871	$245,613	$108,668	yes	no
			11: 40-49 employees	31	43	$10,798,483	$107,985	$323,955	$129,794	yes	no
			12: 50-74 employees	54	59	$14,212,876	$142,129	$426,386	$178,082	yes	no
			13: 75-99 employees	30	78	$19,771,720	$197,717	$593,152	$235,424	yes	no
			14: 100-149 employees	39	101	$24,447,212	$244,472	$733,416	$304,838	yes	no
			15: 150-199 employees	17	159	$40,714,433	$407,144	$1,221,433	$479,882	yes	no
			17: 300-399 employees	12	317	$76,965,825	$769,658	$2,308,975	$956,726	yes	no
	334412	Bare Printed Circuit Board Manufacturing	04:10-14 employees	27	12	$2,763,741	$27,637	$82,912	$36,221	yes	no
			05: 15-19 employees	25	17	$2,911,499	$29,115	$87,345	$51,311	yes	no
			07: 20-24 employees	20	21	$3,172,164	$31,722	$95,165	$63,398	yes	no
			08: 25-29 employees	14	26	$5,485,572	$54,856	$164,567	$78,488	yes	no
			09: 30-34 employees	12	31	$5,012,891	$50,129	$150,387	$93,578	yes	no
			10: 35-39 employees	13	37	$6,068,854	$60,689	$182,066	$111,686	yes	no
			11: 40-49 employees	19	44	$7,344,337	$73,443	$220,330	$132,812	yes	no
			12: 50-74 employees	23	57	$12,023,400	$120,234	$360,702	$172,046	yes	no
			13: 75-99 employees	20	83	$18,234,276	$182,343	$547,028	$250,514	yes	no

Table 6-6: Per-Firm Cost Impacts for 1% and 3% Cost-to-Revenue Thresholds for Industries Associated with Final Rule											
Chemical and Use	**NAICS Code**	**NAICS Description**	**Employment Size**	**Firms**	**Average Employees Per Firm**	**Average Revenue per firm (USD)**	**1% Threshold Cost per firm**	**3% Threshold Cost per firm**	**Total Compliance Costs per Firm**	**Costs Exceed 1% Threshold**	**Costs Exceed 3% Threshold**
			14: 100-149 employees	20	115	$24,395,494	$243,955	$731,865	$347,090	yes	no
			15: 150-199 employees	8	172	$35,758,619	$357,586	$1,072,759	$519,116	yes	no
			16: 200-299 employees	9	194	$41,225,482	$412,255	$1,236,764	$585,512	yes	no
			17: 300-399 employees	6	232	$43,749,598	$437,496	$1,312,488	$700,196	yes	no
Total:				**860**							

6.4 SISNOSE Screening

The Regulatory Flexibility Act (RFA) requires an assessment of whether a rule results in "significant (economic) impact on a substantial number of small entities" (SISNOSE) but does not mandate the method to be used for calculating economic impacts nor define the terms "significant" or "substantial." The EPA guidance document (EPA 2006b) does not provide a single preferred method for assessing whether the economic impacts are *significant* or whether the number of entities affected is *substantial*, but generally recommends examining rule compliance costs in relation to resources available to determine the significance of the impacts, and a number and/or percentage measure to determine the extent of the impacts across small entities. The small entity analysis above demonstrates that of the 24,865 small entities assessed, at both 3% and 7% discount rates, 860 (3.46%) firms are expected to incur negative impacts of 1% or greater, under the final action all of which were for PIP (3:1) and none for decaBDE. The cost per small entity of firms impacted above the threshold ranged from $21,129 – $956,719 at a 3% discount rate and ranged from $21,131 – $956,726 at a 7% discount rate. No entities for either chemical are expected to incur negative impacts at 3% or greater.

For the firms included in this screening assessment, the extent to which companies are affected by the final rule will depend on whether the chemicals are actually being used, and how they are used. Furthermore, recent uses of PIP (3:1) are likely being phased out. Therefore, many companies or perhaps entire NAICS categories included may not use the chemicals at all. Therefore, EPA believes that number of firms actually impacted at this level is lower. Table 6-8 presents the NAICS that are estimated to have an impact above 1%. Impacts are concentrated within these industries At both 3% and 7% discount rates, there are expected to be 1,483 firms impacted across three industries, of which approximately 860 are impacted above 1% of revenue and 0 are impacted above 3% of revenue.

Table 6-7: SISNOSE Determination Summary							
Annualization Discount Rate	Affected Businesses	Affected Small Businesses	Range of Costs to Small Businesses	1% Threshold		3% Threshold	
				Number	Percent	Number	Percent
TOTAL							
3% discount rate	26,805	24,865	-$42 – $1,146,853	860	3.46%	0	0%
7% discount rate	26,805	24,865	-$128 – $1,272,107	860	3.46%	0	0%
PIP (3:1)							
3% discount rate	26,803	24,865	-$42 – $1,146,853	860	3.46%	0	0%
7% discount rate	26,803	24,865	-$128 – $1,272,107	860	3.46%	0	0%
DecaBDE							
3% discount rate	2	0	$0	0	0%	0	0%
7% discount rate	2	0	$0	0	0%	0	0%

Table 6-8: SISNOSE Determination Summary of Industries with Impacts above 1% Threshold						
Industry	Affected Businesses	Per-Firm Compliance Cost	1% Threshold		3% Threshold	
			Number	Percent	Number	Percent
3%						
Current-Carrying Wiring Device Manufacturing (335931)	355	$33,201 - $422,533	152	42.82%	0	0%
Printed Circuit Assembly (Electronic Assembly) Manufacturing (334418)	722	$21,129 - $956,719	492	68.14%	0	0%
Bare Printed Circuit Board Manufacturing (334412)	406	$36,219 - $700,189	216	53.20%		
Totals:	**1,483**	**$21,129 - $956,719**	**860**	**57.99%**	**0**	**0%**
7%						
Current-Carrying Wiring Device Manufacturing (335931)	355	$33,203 - $422,540	152	42.82%	0	0%
Printed Circuit Assembly (Electronic Assembly) Manufacturing (334418)	722	$21,131 - $956,726	492	68.14%	0	0%
Bare Printed Circuit Board Manufacturing (334412)	406	$36,221 - $700,196	216	53.20%	0	0%
Totals:	**1,483**	**$21,131 - $956,726**	**860**	**57.99%**	**0**	**0%**

7. Other Economic Impact Analyses

In addition to the cost and benefits analyses presented in Chapters 4 and 5, several other types of impacts are important to consider in evaluating the effects of a regulation. This chapter presents the incremental impact of the final rule on:

- The environmental health risk or safety risk to children due to the regulation, as required by Executive Order 13045–Protection of Children from Environmental Health & Safety Risks (Section 7.2);
- Employment Impact Analysis (Section 7.3);
- Paperwork burden, as required by the Paperwork Reduction Act (Section 7.4);
- State and Local Governments, as required by the Unfunded Mandates Reform Act (Section 7.5);
- Environmental Justice, as required by Executive Order 12898 and Executive Order 14096–Environmental Justice (Section 7.6);
- Impacts on Technological Innovation and the National Economy (Section 7.7);
- Federalism, as required by Executive Order 13132 (Section 7.8); and
- Tribal governments, as required by Executive Order 13175 (Section 7.9).

7.1 Executive Orders 12866: Regulatory Planning and Review and 14094: Modernizing Regulatory Review

This action is a "significant regulatory action" as defined under section 3(f)(1) of Executive Order 12866 (58 FR 51735, October 4, 1993), as amended by Executive Order 14094 (88 FR 21879, April 11, 2023). Accordingly, EPA, submitted this action to OMB for review under Executive Order 12866. Documentation of any changes made in response to the Executive Order 12866 review is available in the docket.

7.2 Executive Order 13045: Protection of Children

Executive Order 13045 applies if the regulatory action is economically significant and concerns an environmental health risk or safety risk that may disproportionately affect children. This action is subject to Executive Order 13045 because it is a significant regulatory action as defined in section 3(f)(1) of Executive Order 12866 (as amended by Executive Order 14094). In addition, the Agency's 1995 Policy on Evaluating Health Risks to Children applies (EPA 1995). This policy, as reaffirmed in October 2018 by then Acting Administrator Wheeler (U.S. Environmental Protection Agency (EPA) 2018a), is to consider the risks to infants and children consistently and explicitly during its decision-making process. This regulation will reduce the exposure that could occur from activities now prohibited under this final rule to decaBDE and PIP (3:1) for the general population and for potentially exposed or susceptible subpopulations such as children. Certain exclusions and extensions of compliance dates beyond the 2021 PBT final rules, however, may partially delay these reductions in exposure. More information can be found in the Exposure and Use Assessment (EPA 2020b).

7.3 Employment Impact Analysis

This section discusses the anticipated employment impacts of this rule. To the extent possible, it describes the characteristics and labor market conditions of potentially affected workers, occupations, industries, and geographic areas. Employment impacts of environmental regulations include a mix of potential declines and gains in different sectors of the economy over time. Impacts on employment can vary according to labor market conditions and may differ across occupations, industries, and regions. Isolating employment impacts of regulation is difficult as they are a challenge to disentangle from employment impacts caused by a wide variety of ongoing concurrent economic changes. This analysis qualitatively considers the employment impacts of the rule, including on regulated sectors, sectors producing substitutes, and related sectors, upstream and downstream.

In the long run, environmental regulation is expected to cause a shift of employment among employers rather than affect the general employment level (Arrow et al. 1996). Even if they are mitigated by long-run market adjustments to full employment, many regulatory actions have transitional effects in the short run (OMB 2015). These movements of workers in and out of jobs in response to environmental regulation are potentially important distributional impacts of interest to policy makers. Of particular concern are transitional job losses experienced by workers operating in declining industries, exhibiting low migration rates, or living in communities or regions where unemployment rates are high.

Compliance with environmental regulation can result in increased demand for the inputs or factors (including labor) used in the production of environmental protection. However, the regulated sector generally relies on revenues generated by their other market outputs to cover the costs of supplying increased environmental quality. This can lead to reduced demand for labor and other factors of production used to produce the market output. Employment impacts, both positive and negative, in sectors upstream and downstream from the regulated sector, or in sectors producing substitute or complimentary products, may also occur.

The requirements of the final regulatory action vary by condition of use, and there are a variety of compliance costs companies might incur due to the rule. These include reformulation and supply chain analysis costs due to prohibition; equipment, fit test, medical exam, cleaning, and training costs for respiratory PPE; equipment and training costs for dermal PPE; documentation costs for respiratory and dermal PPE; rule familiarization costs; labeling costs; and export notification costs.

Costs incurred on a per worker basis, such as PPE equipment (e.g. respirators and gloves) costs may increase the marginal cost of labor. However, in these cases firms may experience some cost savings from improving health outcomes for their employees, including improved retention and reduced spending on workers compensation and other healthcare-related fringe benefits. Other costs, such as reformulation and supply chain analysis costs, will increase overall costs for affected companies and could potentially affect employment. Some of these costs may be passed on to downstream users, though the exact amount depends on the demand and supply elasticities specific to each affected market.

7.4 Paperwork Burden Analysis

This section presents a summary of the burden and associated costs for the respondents associated with the recordkeeping and reporting requirements of the final action. The paperwork burden analysis is also presented in the information collection request (ICR) supporting statement for this rulemaking. It provides the average annual burden and cost estimates for the next three years of the program.

The paperwork burden and associated costs include the following activity types: rule familiarization, export notification, recordkeeping, and PPE documentation. Note that not all entities will incur burden or costs from these activities because they may already be meeting the requirements under as part of their usual business practices.

- **Rule Familiarization**: Firms incur a 3-hour burden in the first year of the rule, averaging to 1-hour per year over the first 3 years of the rule.

- **Export Notification:** EPA is requiring that all persons intending to export decaBDE or decaBDE-containing wire and cable for nuclear power generation facilities be required to notify EPA under TSCA section 12(b). EPA estimates export notification will take approximately 13 hours per firm.

- **PPE Documentation:** Under some conditions of use, the final rule requires that companies provide respiratory and dermal personal protective equipment (PPE) to workers. There are also documentation costs associated with PPE requirements, listed below. EPA estimates that PPE documentation will take small firms (less than 20 employees) 1 hour, medium firms (20-499 employees) 4 hours, and large firms (more than 500 employees) 16 hours in the first year of the rule.

    - (A) The name, workplace address, work shift, job classification, and work area of each person reasonably likely to directly handle the chemical (decaBDE or PIP (3:1)) or handle equipment or materials on which the chemical may present and the type of PPE selected to be worn by each of these persons;

    - (B) The basis for PPE selection (e.g., demonstration based on permeation testing or manufacturer specifications that each item of PPE selected provides an impervious barrier to prevent exposure during expected duration and conditions of exposure, including the likely combinations of chemical substances to which the PPE may be exposed in the work area) and

    - (C) Appropriately sized PPE and training on proper application, wear, and removal of PPE, and proper care/disposal of PPE

Table 7-1 presents the paperwork burden and associated costs for rule familiarization, export notification, recordkeeping, and PPE documentation.

Table 7-1: Paperwork Burden and Cost Associated with Rule Familiarization, Export Notification, Recordkeeping, and PPE Documentation						
Activity	**Number of Respondents**	**Number of Workers**	**Annual Per Respondent Burden (per hour, excludes burden estimated on a per-worker basis)[1]**	**Annual Per-Worker Labor Burden**	**Average Annual Total Burden**	**Average Annual Total Cost**
Rule Familiarization	26,805	-	1.0	-	26,805	$2,228,568
Export Notification (DecaBDE Wires and Cables)	1	-	4.2	-	4	$318
PPE Documentation (Small Manufacturers)[2]	7,573	-	1.0	-	2,524	$172,690
PPE Documentation (Medium Manufacturers)[2]	4,729	-	4.0	-	6,305	$431,348
PPE Documentation (Large Manufacturers)[2]	1,249	-	16.0	-	6,661	$455,702
Total					**42,300**	**$3,288,625**

Burden estimates presented in Section 4.
Wage rages utilized include $83.14 (Technical Labor in Manufacturing Industry, Rule Familiarization and Export Notification), $40.13 (Clerical Labor in Manufacturing Industry, Export Notification), and $68.41 (Industrial Hygienist, PPE Documentation).
[1] Note that all paperwork costs are per respondent, not per worker.
[2] Burden incurred in first year only.

7.5 Unfunded Mandate Reform Act (UMRA)

Title II of the Unfunded Mandates Reform Act of 1995, Pub. L. 104-4, establishes requirements for Federal agencies to assess the effects of their regulatory actions on state, local, and Tribal governments, and the private sector. Under section 202 of the UMRA, EPA generally must prepare a written statement, including a cost-benefit analysis, for proposed and final rules with "Federal mandates" that might result in expenditures by state, local, and Tribal governments, in the aggregate, or by the private sector, of $100 million or more (when adjusted annually for inflation) in any one year. The rule is not expected to affect state, local, or Tribal governments because the rule affects entities that manufacture (including import), process, distribute in commerce, use, or dispose decaBDE and PIP (3:1), and state, local, or Tribal government entities are not engaged in these activities.

7.6 Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations and Executive Order 14096: Revitalizing Our Nation's Commitment to Environmental Justice for All

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (59 FR 7629, February 16, 1994) establishes Federal executive policy on Environmental Justice (EJ). Its main provision directs Federal agencies, to the greatest extent practicable and permitted by law, to make EJ part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and actions on minority populations and low-income populations in the United States. Executive Order 14096 (88 FR 25251, April 26, 2023) builds on and supplements E.O. 12898 by directing the Federal Government to build upon and strengthen its commitment to deliver environmental justice to all communities across America through an approach that is informed by scientific research, high-quality data, and meaningful Federal engagement with communities with environmental justice concerns.

Since a risk evaluation was not conducted (as discussed in Section 1.1), EPA's understanding of the extent to which reductions in exposure might reduce risks for communities with environmental justice concerns is limited. Data are not sufficiently comprehensive to estimate the extent to which the final rule reduces existing disproportionate impacts on communities with environmental justice concerns. EPA cannot confirm which specific subpopulations are at unreasonable risk from exposure nor make quantified estimate of the change in exposure that will result from the rule. In addition, only a small subset of the specific facilities using decaBDE and PIP (3:1) have been identified, so a proximity analysis examining the characteristics of the communities surrounding the known facilities might not be representative of all exposed communities. EPA believes, however, that the restrictions placed on decaBDE and PIP (3:1) through this rule reduces the potential hazards and risks associated with the manufacture, processing and use of these chemicals. Data on the worker composition of affected industries, presented in Sections 7.6.1 and 7.6.2, provide a general indication of how different demographic groups in the worker population may be affected. Particularly, the data indicate that American Indian/Alaska Native affected workers may realize a larger share of the rule's exposure reductions and benefits relative to their overall population size. Certain exclusions and extensions of compliance dates beyond the onset of the rule may partially delay addressing impacts to communities with environmental justice concerns.

EPA believes that the final rule will not create any new disproportionate impacts or exacerbate any existing disproportionate impacts on communities with environmental justice concerns. Some workers will receive PPE due to the rule, while others will no longer be exposed to decaBDE and PIP (3:1). As companies reformulate with chemical alternatives, some workers may be exposed to these alternatives. Local communities will be also less exposed to decaBDE and PIP (3:1), though exposure to chemical alternatives may increase. EPA does not know which chemical alternatives industry will ultimately use. Some alternatives are less toxic and some are comparably toxic to decaBDE and PIP (3:1). See Sections 5.1.3 and 5.2.3 for more information on the chemical properties of decaBDE and PIP (3:1) alternatives.

The remainder of this section summarizes the demographic characteristics of the workers potentially exposed to decaBDE or PIP (3:1). Specifically, the ACS 1-year estimates public use microdata sample was used. The ACS is a nationwide survey designed to provide communities with reliable and timely social, economic, housing, and demographic data every year. The 2022 ACS Public Use Microdata Sample (PUMS) includes a subsample of the ACS microdata, devoid of personalized information. The PUMS represents about two-thirds of the responses collected in the ACS in a specific year. The industry level data in the ACS has it's own classification system, but is cross-walked to the North American Industry Classification System (NAICS).[39] For comparison with each identified industry, Table 7-2 provides the demographic statistics for the total labor force in the United States.

Table 7-2: Total U.S. Labor Force Statistics (2022)

Number of Employees	% Female	% AIAN[1]	% Asian	% Black	% Hispanic	% NHPI[2]	% White	% Other	% MOR[3]
190,491,583	48.7%	0.9%	6.1%	10.8%	35.7%	0.2%	62.7%	6.8%	10.7%

Source: (U.S. Census Bureau 2021)
[1] American Indian and Alaska Native
[2] Native Hawaiian and Pacific Islander
[3] Two or more races

7.6.1 Demographics by Use: DecaBDE

Table 7-3 presents breakouts of employment by sex and race in industries affected by the rule. The second and third columns present the NAICS code and description of the impacted industries. These NAICS codes are mapped to each condition of use in Section 3.2.2. Since the American Community Survey does not contain data on specific NAICS codes, the fourth column presents the industry code mapped to each NAICS. The ACS industries are well-aligned to the NAICS; however the ACS industry categories are generally larger than 6-digit NAICS. The fifth through twelfth columns present data on a set of demographic identities. They present the percentage of the workforce in given industry of each identity. The percentages do not sum to 100 as respondents may report more than one race and/or ethnicity. The bolded figures in Table 7-3 represent a comparison of industry breakouts with the averages for the employed population presented in Table 7-2. A figure that is bolded indicates that that percentage is higher than the employed national average.

For decaBDE, American Indian/Alaska Native workers are over-represented in 3 of the 15 industries,

[39] This analysis uses the ACS industry category that most closely matches the name of the NAICS code. When there was no match, EPA looked for a match with the next NAICS level up, e.g., the 4-digit code if there was no match with the 6-digit code.

and Asian workers are over-represented in 5 of the 15 industries. Female workers are under-represented in all of the affected industries. Black workers are over-represented in 6 of the 15 industries.

This data is imperfect because it does not capture the universe of firms that use decaBDE, but rather the industry as a whole. The data also does not capture the specific occupation of affected workers. For instance, office staff may be less likely to be exposed to one of the chemicals.

Table 7-3: DecaBDE Worker Composition by Demographic Indicator											
NAICS Code	NAICS Description	ACS Industry Crosswalk	% Female	% AIAN	% Asian	% Black	% Hispanic	% NHPI	% White	% Other Race	% Two or More
3261	Plastics Product Manufacturing	MFG-Plastics Product	17.9%	**1.2%**	4.9%	9.0%	14.4%	0.2%	**66.8%**	**8.2%**	8.9%
325991	Custom Compounding of Purchased Resins	MFG-Resin, Synthetic Rubber, And Fibers And Filaments	31.6%	0.7%	3.4%	8.0%	17.9%	0.2%	**67.6%**	6.7%	**12.2%**
562920	Materials Recovery Facilities	WHL-Recyclable Material Merchant Wholesalers	34.3%	0.7%	2.2%	6.5%	19.7%	0.0%	**65.6%**	**9.5%**	**13.5%**
335921	Fiber Optic Cable Manufacturing	MFG-Electronic Component And Product, N.E.C.	43.3%	0.7%	**22.7%**	5.1%	12.6%	0.1%	57.3%	4.5%	9.4%
336412	Aircraft Engine and Engine Parts Manufacturing	MFG-Aircraft And Parts	48.2%	0.6%	**8.7%**	6.2%	11.5%	0.2%	**68.7%**	4.7%	10.6%
336413	Other Aircraft Part and Auxiliary Equipment Manufacturing7	MFG-Aircraft And Parts	48.2%	0.6%	**8.7%**	6.2%	11.5%	0.2%	**68.7%**	4.7%	10.6%
336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	MFG-Aerospace Products And Parts	**71.1%**	**1.0%**	**8.3%**	6.3%	15.4%	0.0%	**67.6%**	6.5%	9.5%
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	MFG-Aerospace Products And Parts	**71.1%**	**1.0%**	**8.3%**	6.3%	15.4%	0.0%	**67.6%**	6.5%	9.5%
336211	Motor Vehicle Body Manufacturing	MFG-Motor Vehicles And Motor Vehicle Equipment	36.4%	0.7%	5.7%	**14.5%**	13.0%	0.2%	**66.1%**	4.0%	7.8%
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	MFG-Motor Vehicles And Motor Vehicle Equipment	36.4%	0.7%	5.7%	**14.5%**	13.0%	0.2%	**66.1%**	4.0%	7.8%
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing	MFG-Motor Vehicles And Motor Vehicle Equipment	36.4%	0.7%	5.7%	**14.5%**	13.0%	0.2%	**66.1%**	4.0%	7.8%
336390	Other Motor Vehicle Parts Manufacturing	MFG-Motor Vehicles And Motor Vehicle Equipment	36.4%	0.7%	5.7%	**14.5%**	13.0%	0.2%	**66.1%**	4.0%	7.8%

Table 7-3: DecaBDE Worker Composition by Demographic Indicator											
NAICS Code	NAICS Description	ACS Industry Crosswalk	% Female	% AIAN	% Asian	% Black	% Hispanic	% NHPI	% White	% Other Race	% Two or More
336991	Motorcycle, Bicycle and Parts Manufacturing	MFG-Motor Vehicles And Motor Vehicle Equipment	36.4%	0.7%	5.7%	**14.5%**	13.0%	0.2%	**66.1%**	4.0%	7.8%
336999	All Other Transportation Equipment Manufacturing	MFG-Other Transportation Equipment	45.6%	0.1%	2.2%	**11.8%**	22.2%	0.0%	**74.7%**	3.6%	6.4%
532490	Other Commercial and Industrial Machinery and Equipment Rental and Leasing	FIN-Commercial, Industrial, And Other Intangible Assets Rental And Leasing	26.3%	0.6%	4.7%	6.0%	10.0%	0.1%	**72.5%**	5.8%	9.5%
Employed Population Averages:			**48.7%**	**0.9%**	**6.1%**	**10.8%**	**35.7%**	**0.2%**	**62.7%**	**6.8%**	**10.7%**

7.6.2 Demographics by Use: PIP (3:1)

Table 7-4 presents breakouts of employment by sex, race, and ethnicity in industries affected by the rule. Columns two and three present the NAICS code and description of the impacted industries. These NAICS codes are mapped to each condition of use in Section 3.2.2. Since the American Community Survey does not contain data on specific NAICS codes, the third column presents the industry code mapped to each NAICS. The ACS industries are well-aligned to the NAICS; however the ACS industry categories are generally larger than 6-digit NAICS. The fifth through twelfth columns present data on a set of demographic characteristics. They present the percentage of the workforce in given industry of each characteristic. The percentages do not sum to 100 as respondents may report more than one race and/or ethnicity. The bolded figures in Table 7-4 represent a comparison of industry breakouts with the averages for the employed population presented in Table 7-2. A figure that is bolded indicates a percentage is higher than the employed population average.

For PIP (3:1), American Indian/Alaska Native workers are over-represented in 17 of the 60 industries when compared to the employed population, while Asian and Black workers are over-represented in 23 and 21 of the 60 industries, respectively. Native Hawaiian and Pacific Islander workers are over-represented in 26 industries.

This data is imperfect because it does not capture the universe of firms that use PIP (3:1), but rather the industry as a whole. The data also does not capture the specific occupation of affected workers. For instance, office staff may be less likely to be exposed to one of the chemicals.

Table 7-4: PIP (3:1) Worker Composition by Socioeconomic Indicator												
NAICS Code	NAICS Description	ACS Industry Crosswalk	% Female	% AIAN	% Asian	% Black	% Hispanic	% NHPI	% White	% Other Race	% Two or More
324110	Petroleum Refineries	MFG-Petroleum Refining	47.01%	0.72%	5.95%	8.79%	12.52%	0.09%	**64.58%**	4.54%	**15.09%**
324191	Petroleum Lubricating Oil and Grease Manufacturing	MFG-Miscellaneous Petroleum And Coal Products	24.04%	0.86%	1.43%	8.05%	10.92%	0.00%	**76.68%**	4.00%	8.38%
325180	Other Basic Inorganic Chemical Manufacturing	MFG-Industrial And Miscellaneous Chemicals	14.69%	0.51%	5.57%	9.71%	12.23%	0.12%	**71.92%**	3.87%	7.95%
325199	All Other Basic Organic Chemical Manufacturing	MFG-Industrial And Miscellaneous Chemicals	14.69%	0.51%	5.57%	9.71%	12.23%	0.12%	**71.92%**	3.87%	7.95%
325211	Plastics Material and Resin Manufacturing	MFG-Plastics Product	17.93%	**1.21%**	4.94%	9.00%	14.41%	**0.17%**	**66.77%**	8.15%	8.87%
325510	Paint and Coating Manufacturing	MFG-Paint, Coating, And Adhesive	25.68%	**1.58%**	4.38%	8.87%	21.25%	0.00%	**71.64%**	5.36%	7.93%
325520	Adhesive Manufacturing	MFG-Paint, Coating, And Adhesive	25.68%	**1.58%**	4.38%	8.87%	21.25%	0.00%	**71.64%**	5.36%	7.93%
325520	Adhesive Manufacturing	MFG-Paint, Coating, And Adhesive	25.68%	**1.58%**	4.38%	8.87%	21.25%	0.00%	**71.64%**	5.36%	7.93%
325613	Surface Active Agent Manufacturing	MFG-Industrial And Miscellaneous Chemicals	14.69%	0.51%	5.57%	9.71%	12.23%	0.12%	**71.92%**	3.87%	7.95%
325991	Custom Compounding of Purchased Resins	MFG-Resin, Synthetic Rubber, And Fibers And Filaments	31.63%	0.73%	3.44%	8.00%	17.92%	0.16%	**67.62%**	6.65%	**12.23%**
325991	Custom Compounding of Purchased Resins	MFG-Resin, Synthetic Rubber, And Fibers And Filaments	31.63%	0.73%	3.44%	8.00%	17.92%	0.16%	**67.62%**	6.65%	**12.23%**
326199	All Other Plastics Product Manufacturing	MFG-Plastics Product	17.93%	**1.21%**	4.94%	9.00%	14.41%	**0.17%**	**66.77%**	**8.15%**	8.87%
333111	Farm Machinery and Equipment Manufacturing	MFG-Not Specified Manufacturing Industries	19.90%	**1.22%**	5.50%	**15.77%**	13.06%	0.14%	53.91%	**10.40%**	**11.51%**

Table 7-4: PIP (3:1) Worker Composition by Socioeconomic Indicator											
NAICS Code	NAICS Description	ACS Industry Crosswalk	% Female	% AIAN	% Asian	% Black	% Hispanic	% NHPI	% White	% Other Race	% Two or More
333112	Lawn and Garden Tractor and Home Lawn and Garden Equipment Manufacturing	MFG-Not Specified Manufacturing Industries	19.90%	**1.22%**	5.50%	**15.77%**	13.06%	0.14%	53.91%	**10.40%**	**11.51%**
333120	Construction Machinery Manufacturing	MFG-Construction, And Mining And Oil And Gas Field Machinery	**48.91%**	0.37%	4.20%	5.95%	17.18%	**0.28%**	74.29%	4.34%	9.94%
333131	Mining Machinery and Equipment Manufacturing	MFG-Construction, And Mining And Oil And Gas Field Machinery	**48.91%**	0.37%	4.20%	5.95%	17.18%	**0.28%**	74.29%	4.34%	9.94%
333242	Semiconductor Machinery Manufacturing	MFG-Electronic Component And Product, N.E.C.	43.28%	0.68%	**22.71%**	5.06%	12.56%	0.08%	57.25%	4.51%	9.39%
333413	Industrial and Commercial Fan and Blower and Air Purification Equipment Manufacturing	MFG-Electric Lighting And Electrical Equipment, And Other Electrical Component, N.E.C.	35.96%	0.75%	**7.93%**	7.82%	33.61%	0.10%	66.18%	5.85%	10.32%
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	MFG-Electric Lighting And Electrical Equipment, And Other Electrical Component, N.E.C.	35.96%	0.75%	**7.93%**	7.82%	33.61%	0.10%	66.18%	5.85%	10.32%
333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	MFG-Electric Lighting And Electrical Equipment, And Other Electrical Component, N.E.C.	35.96%	0.75%	**7.93%**	7.82%	33.61%	0.10%	66.18%	5.85%	10.32%
333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	MFG-Not Specified Manufacturing Industries	19.90%	1.22%	5.50%	**15.77%**	13.06%	0.14%	53.91%	**10.40%**	**11.51%**
333613	Mechanical Power Transmission Equipment Manufacturing	MFG-Engine, Turbine, And Power Transmission Equipment	24.98%	0.51%	5.13%	**10.88%**	15.25%	0.11%	70.06%	4.27%	8.61%

Table 7-4: PIP (3:1) Worker Composition by Socioeconomic Indicator												
NAICS Code	NAICS Description	ACS Industry Crosswalk	% Female	% AIAN	% Asian	% Black	% Hispanic	% NHPI	% White	% Other Race	% Two or More
333618	Other Engine Equipment Manufacturing	MFG-Engine, Turbine, And Power Transmission Equipment	24.98%	0.51%	5.13%	**10.88%**	15.25%	0.11%	70.06%	4.27%	8.61%
333924	Industrial Truck, Tractor, Trailer and Stacker Machinery Manufacturing	MFG-Motor Vehicles And Motor Vehicle Equipment	36.38%	0.65%	5.71%	**14.49%**	13.01%	0.16%	66.10%	3.95%	7.81%
333998	All Other Miscellaneous General Purpose Machinery Manufacturing	MFG-Not Specified Manufacturing Industries	19.90%	**1.22%**	5.50%	**15.77%**	13.06%	0.14%	53.91%	**10.40%**	**11.51%**
334111	Electronic Computer Manufacturing	MFG-Computer And Peripheral Equipment	16.05%	**1.35%**	**24.46%**	8.19%	15.30%	**0.49%**	51.08%	5.09%	8.50%
334112	Computer Storage Device Manufacturing	MFG-Computer And Peripheral Equipment	16.05%	**1.35%**	**24.46%**	8.19%	15.30%	**0.49%**	51.08%	5.09%	8.50%
334118	Computer Terminal and Other Computer Peripheral Equipment Manufacturing	MFG-Computer And Peripheral Equipment	16.05%	**1.35%**	**24.46%**	8.19%	15.30%	**0.49%**	51.08%	5.09%	8.50%
334290	Other Communications Equipment Manufacturing	MFG-Not Specified Manufacturing Industries	19.90%	**1.22%**	5.50%	**15.77%**	13.06%	0.14%	53.91%	10.40%	**11.51%**
334412	Bare Printed Circuit Board Manufacturing	MFG-Electronic Component And Product, N.E.C.	43.28%	0.68%	**22.71%**	5.06%	12.56%	0.08%	57.25%	4.51%	9.39%
334413	Semiconductor and Related Device Manufacturing	MFG-Electronic Component And Product, N.E.C.	43.28%	0.68%	**22.71%**	5.06%	12.56%	0.08%	57.25%	4.51%	9.39%
334417	Electronic Connector Manufacturing	MFG-Electronic Component And Product, N.E.C.	43.28%	0.68%	**22.71%**	5.06%	12.56%	0.08%	57.25%	4.51%	9.39%
334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing	MFG-Electronic Component And Product, N.E.C.	43.28%	0.68%	**22.71%**	5.06%	12.56%	0.08%	57.25%	4.51%	9.39%
334419	Other Electronic Component Manufacturing	MFG-Electronic Component And Product, N.E.C.	43.28%	0.68%	**22.71%**	5.06%	12.56%	0.08%	57.25%	4.51%	9.39%
335210	Small Electrical Appliance Manufacturing	MFG-Household Appliance	30.01%	0.22%	4.50%	**15.32%**	20.90%	**0.26%**	66.60%	5.95%	6.36%

Table 7-4: PIP (3:1) Worker Composition by Socioeconomic Indicator											
NAICS Code	NAICS Description	ACS Industry Crosswalk	% Female	% AIAN	% Asian	% Black	% Hispanic	% NHPI	% White	% Other Race	% Two or More
335220	Major Household Appliance Manufacturing	MFG-Household Appliance	30.01%	0.22%	4.50%	**15.32%**	20.90%	**0.26%**	66.60%	5.95%	6.36%
335313	Switchgear and Switchboard Apparatus Manufacturing	MFG-Electronic Component And Product, N.E.C.	43.28%	0.68%	**22.71%**	5.06%	12.56%	0.08%	57.25%	4.51%	9.39%
335931	Current-Carrying Wiring Device Manufacturing	MFG-Electronic Component And Product, N.E.C.	43.28%	0.68%	**22.71%**	5.06%	12.56%	0.08%	57.25%	4.51%	9.39%
335999	All Other Miscellaneous Electrical Equipment and Component Manufacturing	MFG-Electric Lighting And Electrical Equipment, And Other Electrical Component, N.E.C.	35.96%	0.75%	**7.93%**	7.82%	33.61%	0.10%	**66.18%**	5.85%	10.32%
336110	Automobile and Light Duty Motor Vehicle Manufacturing	MFG-Motor Vehicles And Motor Vehicle Equipment	36.38%	0.65%	5.71%	**14.49%**	13.01%	0.16%	**66.10%**	3.95%	7.81%
336120	Heavy Duty Truck Manufacturing	MFG-Motor Vehicles And Motor Vehicle Equipment	36.38%	0.65%	5.71%	**14.49%**	13.01%	0.16%	**66.10%**	3.95%	7.81%
336211	Motor Vehicle Body Manufacturing	MFG-Motor Vehicles And Motor Vehicle Equipment	36.38%	0.65%	5.71%	**14.49%**	13.01%	0.16%	**66.10%**	3.95%	7.81%
336214	Travel Trailer and Camper Manufacturing	MFG-Motor Vehicles And Motor Vehicle Equipment	36.38%	0.65%	5.71%	**14.49%**	13.01%	0.16%	**66.10%**	3.95%	7.81%
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	MFG-Motor Vehicles And Motor Vehicle Equipment	36.38%	0.65%	5.71%	**14.49%**	13.01%	0.16%	**66.10%**	3.95%	7.81%
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing	MFG-Motor Vehicles And Motor Vehicle Equipment	36.38%	0.65%	5.71%	**14.49%**	13.01%	0.16%	**66.10%**	3.95%	7.81%
336390	Other Motor Vehicle Parts Manufacturing	MFG-Motor Vehicles And Motor Vehicle Equipment	36.38%	0.65%	5.71%	**14.49%**	13.01%	0.16%	**66.10%**	3.95%	7.81%
336411	Aircraft Manufacturing	MFG-Aircraft And Parts	48.18%	0.58%	**8.70%**	6.24%	11.54%	**0.23%**	**68.66%**	4.68%	10.61%
336412	Aircraft Engine and Engine Parts Manufacturing	MFG-Aircraft And Parts	48.18%	0.58%	**8.70%**	6.24%	11.54%	**0.23%**	**68.66%**	4.68%	10.61%

Table 7-4: PIP (3:1) Worker Composition by Socioeconomic Indicator											
NAICS Code	NAICS Description	ACS Industry Crosswalk	% Female	% AIAN	% Asian	% Black	% Hispanic	% NHPI	% White	% Other Race	% Two or More
336413	Other Aircraft Part and Auxiliary Equipment Manufacturing7	MFG-Aircraft And Parts	48.18%	0.58%	**8.70%**	6.24%	11.54%	**0.23%**	**68.66%**	4.68%	10.61%
336414	Guided Missile and Space Vehicle Manufacturing	MFG-Aerospace Products And Parts	**71.12%**	**0.98%**	**8.34%**	6.33%	15.36%	0.04%	**67.64%**	6.50%	9.45%
336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	MFG-Aerospace Products And Parts	**71.12%**	**0.98%**	**8.34%**	6.33%	15.36%	0.04%	**67.64%**	6.50%	9.45%
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	MFG-Aerospace Products And Parts	**71.12%**	**0.98%**	**8.34%**	6.33%	15.36%	0.04%	**67.64%**	6.50%	9.45%
336611	Ship Building and Repairing	MFG-Ship And Boat Building	10.86%	0.79%	4.20%	**13.69%**	13.49%	**0.46%**	**66.49%**	6.15%	6.97%
336612	Boat Building	MFG-Ship And Boat Building	10.86%	0.79%	4.20%	**13.69%**	13.49%	**0.46%**	**66.49%**	6.15%	6.97%
336991	Motorcycle, Bicycle and Parts Manufacturing	MFG-Motor Vehicles And Motor Vehicle Equipment	36.38%	0.65%	5.71%	**14.49%**	13.01%	0.16%	**66.10%**	3.95%	7.81%
336999	All Other Transportation Equipment Manufacturing	MFG-Other Transportation Equipment	45.56%	0.13%	2.23%	**11.82%**	22.21%	0.00%	**74.72%**	3.61%	6.44%
339920	Sporting and Athletic Goods Manufacturing	MFG-Sporting And Athletic Goods, And Doll, Toy And Game	28.58%	**0.94%**	**7.00%**	7.57%	13.56%	0.03%	**68.65%**	6.67%	8.68%
423840	Industrial Supplies Merchant Wholesalers	WHL-Machinery, Equipment, And Supplies Merchant Wholesalers	43.05%	0.54%	3.92%	4.37%	14.33%	0.09%	**77.21%**	4.41%	8.69%
424690	Other Chemical and Allied Products Merchant Wholesalers	WHL-Drugs, Sundries, And Chemical And Allied Products Merchant Wholesalers	37.56%	0.60%	**7.78%**	8.19%	21.27%	0.13%	**66.96%**	5.18%	**10.92%**
Employed Population Averages:			**48.67%**	**0.89%**	**6.07%**	**10.83%**	**35.67%**	**0.16%**	**62.66%**	**6.80%**	**10.72%**

7.7 Impacts on Technological Innovation and the National Economy

The rule is not expected to have significant impacts on technological innovation or the national economy. However, in the case of a prohibition or restriction of decaBDE or PIP (3:1), the rule may create some incentives for chemical manufacturers to develop new chemicals alternatives for the associated activities involving these chemicals.

Guidance issued by the Office of Management and Budget indicates that the economic impact of a regulation on the national economy becomes measurable only if the economic impact of the regulation reaches 0.25% to 0.5% of Gross Domestic Product (GDP) (Katzen 1995). Given the current GDP of $20.66 trillion (Bureau of Economic Analysis 2018), this is equivalent to a cost of $52 billion to $103 billion. Therefore, EPA has concluded that this rule is highly unlikely to have any measurable effect on the national economy.

7.8 Executive Order 13132: Federalism

Executive Order 13132, entitled *Federalism* (64 FR 43255, August 10, 1999), directs federal agencies to consider whether a rule has federalism implications (i.e., whether it has substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government, as specified in Executive Order 13132).

EPA has concluded that this action does not have has federalism implications. This regulation does not preempt state law. In addition, no state or local governments are expected to engage in the manufacture, import, sale, or use of decaBDE or PIP (3:1), and thus state and local governments will not incur direct compliance costs as a result of the rule.

7.9 Executive Order 13175: Tribal Implications

Executive Order 13175, entitled *Consultation and Coordination with Indian Tribal Governments* (59 FR 22951, November 6, 2000), directs federal agencies to consider whether a rule has Tribal implications (i.e., whether it has substantial direct effects on tribal governments, on the relationship between the Federal government and the Indian Tribes, or on the distribution of power and responsibilities between the Federal government and Indian Tribes). No Tribal government is expected to engage in the manufacture, import, sale, or use of decaBDE or PIP (3:1), and thus tribal governments will not incur direct compliance costs as a result of the rule. The rule does not change the relationship between the Federal government and Indian Tribes, or change the distribution of power.

7.10 Executive Order 13211. Actions Concerning Regulations that Significantly Affect Energy Supply, Distribution, or Use

This action is not a “significant energy action” as defined in Executive Order 13211 (66 FR 28355, May 22, 2001) because it is not likely to have a significant adverse effect on the supply, distribution, or use of energy and has not been designated by the Administrator of the Office of Information and Regulatory Affairs of the Office of Management and Budget as a significant energy action.

7.11 Congressional Review Act (CRA)

This action is subject to the CRA, 5 U.S.C. 801 et seq., and EPA will submit a rule report to each House of the Congress and to the Comptroller General of the United States. This action is not a "major rule" as defined by 5 U.S.C. 804(2).

8. Uncertainties and Sensitivity Analyses

As discussed in earlier chapters, several factors contribute to the uncertainty of the cost estimates presented in this report. The subsections below assess how modifying key parameters used in cost analysis for PIP (3:1) and decaBDE options affect the estimated total cost of the final rule. Given these uncertainties, sensitivity analyses were performed by adjusting these variables. These sensitivity analyses illustrate the degree to which the modifications to these parameters affect the cost estimates presented in Chapter 4. There are two sensitivity analyses presented in this chapter. The first pertains to the cost of reformulation needed as a result of prohibitions and is presented in Section 8.1. The second pertains to the source of baseline PPE for respirators and is presented in Section 8.2.

Uncertainties with respect to the cost analysis are also discussed in Section 4.9.

These specific sensitivity analyses were selected based on the level of uncertainty of the variables utilized in the main economic analysis, the extent to which the variables utilized in the main economic analysis drive the overall results, and the availability of alternative data sources that could be used as a comparison.

8.1 Reformulation Cost Sensitivity Analysis

The first data source assessed in this sensitivity analysis pertains to the cost of reformulation needed as a result of prohibitions. As noted in Section 4.3.2, a study by Cheminfo Services Inc. conducted for Environment Canada on compliance costs associated with volatile organic compounds (VOC) emissions in automotive aftermarket products was utilized as a basis for reformulations cost of PIP (3:1) (Cheminfo Services Inc. 2006). While useful in providing a general range of reformulation costs based on different chemicals, Cheminfo has several shortcomings. The study focused on automotive products, which may not adequately reflect the costs associated with the various industries impacted by the final PIP (3:1) options. Certain industries impacted by the final PIP (3:1) options, for example aerospace, follow stringent standards for the performance of flame retardants, which may result in costs of reformulation and the testing of reformulation higher than the estimates derived in Cheminfo. In practice, reformulation costs would be product-specific and dependent on factors such as prior knowledge of feasible substitutes, ease of substitutability, and extensiveness of laboratory testing.

The ECHA Committee for Socio-Economic Analysis evaluates the socio-economic impacts of possible legislative actions proposing restriction on manufacture, sale, or use of certain chemicals. The estimated costs are based on best available information, which typically includes market surveys or industry stakeholder interviews to determine cost assumptions for the analysis. A 2016 ECHA study includes summaries of costs of restrictions for 16 different substances (European Chemicals Agency (ECHA) 2016b). While no decaBDE users are incurring reformulation costs due to this rule, decaBDE was one of the 16 substances included in this study for its use as a flame retardant in plastics and textiles. Another chemical covered by the ECHA study, siloxanes D4/D5 can serve as proxy chemicals for estimating PIP (3:1) reformulation costs due to their similar properties. While other chemicals covered in the ECHA study, such as PFOA, may be more relevant from a use perspective, they currently have viable substitutes and would require substitution costs only. Based on the ECHA study for siloxanes D4/D5, the cost to reformulate product formulations was €50,000 to €500,000 ($67,500 to $675,000 in 2022 USD) per product (European Chemicals Agency (ECHA) 2016c, 2016a). EPA used the midpoints of the cost range. As shown in Table 8-1, the reformulation cost is $371,171 per product.

Table 8-1: Reformulation Cost Estimation (per product)	
Study	**Cost Estimate**
Cheminfo (estimate used in cost chapter)	$93,456
ECHA Siloxanes D4/D5 (estimate used in sensitivity analysis)	$371,171

Table 8-2 and Table 8-3 present the total prohibition costs using the ECHA Siloxanes D4/D5 formulation cost presented in Table 8-1. Total prohibition costs and total annual costs of the final option are approximately $106 million or $80 million at 3% and 7% discount rates, a increase of $79 and $59 million, respectively, from the costs estimated in Chapter 4. For the primary alternative option, total annual cost savings would change to -$28 million and -$72 million, an decrease by approximately $20 million or $53 million at 3% and 7% discount rates above the cost estimates in Chapter 4.

Negative values indicate cost savings. Cost savings result from additional compliance delays for uses prohibited in the 2021 Final Rule. See the reformulation section (4.3.2) for further explanation.

Table 8-2: Prohibition Costs by Chemical and Use for Reformulation Sensitivity (Final Option) (2022$)

Chemical and Use	Time until Prohibition (years)	Number of Products	Annualized 3%		Annualized 7%	
			Cost per Product	Total Cost	Cost per Product	Total Cost
PIP (3:1)						
Lubricants and Greases (except Aerospace and Turbine) (makers)	15	18	$11,912	$214,416	$10,735	$193,230
New and Replacement Parts for Motor Vehicles (consumers)	15	4,562	$191	$871,374	$293	$1,336,715
New and Replacement Parts for Motor Vehicles (makers)	15	8,091	$11,912	$96,384,955	$10,735	$86,861,358
New and Replacement Parts for Aerospace Vehicles (consumers)	30	324	$191	$61,884	$293	$94,932
New and Replacement Parts for Aerospace Vehicles (makers)	30	1,787	$7,646	$13,661,491	$3,891	$6,952,244
Marine Antifouling Coatings[1]	5	1	-$2,009	-$2,009	-$6,563	-$6,563
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)[1]	10	1,165	-$4,209	-$4,901,986	-$12,624	-$14,704,053
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumer)[1]	10	9,071	-$45	-$403,675	-$133	-$1,210,867
All PIP (3:1)				**$105,886,450**		**$79,516,995**

Note: Costs annualized over 30 years.

[1] Negative values indicate cost savings. Cost saving result from additional compliance delays beyond those included in the 2021 PBT rule. See the reformulation section (4.3.2) for further explanation.

Table 8-3: Prohibition Costs by Chemical and Use for Reformulation Sensitivity (Alternative Option) (2022$)						
Chemical and Use	Time until Prohibition (years)	Number of Products	Annualized 3%		Annualized 7%	
			Cost per Product	Total Cost	Cost per Product	Total Cost
PIP (3:1)						
Lubricants and Greases (except Aerospace and Turbine) (makers)	5	18	$16,008	$288,144	$21,117	$380,106
Lubricants & Greases (Aerospace) (makers)	5	10	$16,008	$160,080	$21,117	$211,170
Wire Harnesses and Electric Circuit Boards (makers)[1]	20	2,077	-$7,742	-$16,077,148	-$20,027	-$41,585,495
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)[1]	20	1,462	-$7,742	-$11,315,556	-$20,027	-$29,269,059
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)[1]	20	10,491	-$82	-$858,861	-$212	-$2,221,549
All PIP (3:1)				**-$27,803,341**		**-$72,484,826**

Note: Costs annualized over 30 years.

[1] Negative values indicate cost savings. Cost saving result from additional compliance delays beyond those included in the 2021 PBT rule. See the reformulation section (4.3.2) for further explanation.

Table 8-4 through Table 8-7 present the total costs of the rule assuming the reformulation cost presented in Table 8-1. As shown, the total costs of the final and primary alternative options at 3% and 7% discount rates. Total costs changed to approximately $479 million (3%) and $489 million (7%) in the final option, a increase of $79 and $59 million respectively. Costs change to approximately $809 million (3%) and $769 million (7%) in the primary alternative option, a decrease of $20 million and $53 million, respectively.

Table 8-8 compares the total costs in the main analysis to the costs in this sensitivity analysis.

Table 8-4: Total Industry Cost for Reformulation Sensitivity (Final Option), annualized at 3% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Labeling**	**Export Notification**	**Total**
DecaBDE						
Plastic Shipping Pallets	$12	$0	$13	$10	$0	$35
Replacement Parts for Aerospace Vehicles	$0	$0	$0	$0	$0	$0
Replacement Parts for Motor Vehicles	$0	$0	$0	$0	$0	$0
Wire and Cable Insulation	$4	$0	$0	$0	$47	$51
All DecaBDE Uses	***$16***	***$0***	***$13***	***$10***	***$47***	***$86***
PIP (3:1)			$0			
Lubricants and Greases (except Aerospace and Turbine)	$61	$214,416	$90,573	$0	$0	$305,050
Lubricants & Greases (Aerospace)	$133	$0	$1,037,971	$0	$0	$1,038,105
New and Replacement Parts for Motor Vehicles (consumers)	$18,412	$871,374	$0	$0	$0	$889,786
New and Replacement Parts for Motor Vehicles (makers)	$97,967	$96,384,955	$199,740,366	$0	$0	$296,223,288
New and Replacement Parts for Aerospace Vehicles (consumers)	$1,308	$61,884	$0	$0	$0	$63,192
New and Replacement Parts for Aerospace Vehicles (makers)	$21,633	$13,661,491	$22,537,309	$0	$0	$36,220,432
Wire Harnesses and Electric Circuit Boards	$21,548	$0	$98,059,330	$0	$0	$98,080,879
Marine Antifouling Coatings	$12	-$2,009	$1,574,260	$0	$0	$1,572,263
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$14,102	-$4,901,986	$49,149,065	$0	$0	$44,261,182
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	$36,610	-$403,675	$0	$0	$0	-$367,065
Engine Filters for Locomotive and Marine Applications	$12	$0	$3	$0	$0	$15
Cyanoacrylate Adhesives	$0	$0	$52	$0	$0	$52
Aviation Hydraulic Fluid	$61	$0	$457,086	$0	$0	$457,147
All PIP (3:1) Uses	**$211,859**	***$105,886,450***	**$372,646,017**	***$0***	***$0***	***$478,744,326***
Total	**$211,875**	**$105,886,450**	**$372,646,030**	**$10**	**$47**	**$478,744,412**

Table 8-5: Total Industry Cost for Reformulation Sensitivity (Final Option), annualized at 7% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Labeling**	**Export Notification**	**Total**
DecaBDE						
Plastic Shipping Pallets	$19	$0	$20	$11	$0	$50
Replacement Parts for Aerospace Vehicles	$0	$0	$0	$0	$0	$0
Replacement Parts for Motor Vehicles	$0	$0	$0	$0	$0	$0
Wire and Cable Insulation	$6	$0	$0	$0	$72	$78
All DecaBDE Uses	***$25***	***$0***	***$20***	***$11***	***$72***	***$128***
PIP (3:1)						
Lubricants and Greases (except Aerospace and Turbine)	$93	$193,230	$107,726	$0	$0	$301,049
Lubricants & Greases (Aerospace)	$205	$0	$1,038,150	$0	$0	$1,038,354
New and Replacement Parts for Motor Vehicles (consumers)	$28,287	$1,336,715	$0	$0	$0	$1,365,002
New and Replacement Parts for Motor Vehicles (makers)	$150,507	$86,861,358	$231,140,607	$0	$0	$318,152,473
New and Replacement Parts for Aerospace Vehicles (consumers)	$2,009	$94,932	$0	$0	$0	$96,941
New and Replacement Parts for Aerospace Vehicles (makers)	$33,235	$6,952,244	$22,550,348	$0	$0	$29,535,828
Wire Harnesses and Electric Circuit Boards	$33,105	$0	$98,070,581	$0	$0	$98,103,686
Marine Antifouling Coatings	$19	-$6,563	$2,249,418	$0	$0	$2,242,873
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$21,665	-$14,704,053	$53,902,364	$0	$0	$39,219,977
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	$56,244	-$1,210,867	$0	$0	$0	-$1,154,623
Engine Filters for Locomotive and Marine Applications	$19	$0	$5	$0	$0	$23
Cyanoacrylate Adhesives	$0	$0	$82	$0	$0	$82
Aviation Hydraulic Fluid	$93	$0	$457,164	$0	$0	$457,257
All PIP (3:1) Uses	***$325,480***	***$79,516,995***	***$409,516,445***	***$0***	***$0***	***$489,358,921***
Total	**$325,505**	**$79,516,995**	**$409,516,465**	**$11**	**$72**	**$489,359,049**

Table 8-6: Total Industry Cost for Reformulation Sensitivity (Primary Alternative Option), annualized at 3% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Labeling**	**Export Notification**	**Total**
DecaBDE						
Other DecaBDE-containing Plastic	$107,684	$0	$654,844,921	$400,288	$0	$655,352,894
All DecaBDE Uses	**$107,684**	**$0**	**$654,844,921**	**$400,288**	**$0**	**$655,352,894**
PIP (3:1)						
Lubricants and Greases (except Aerospace and Turbine)	$61	$288,144	$35,033	$0	$0	$323,238
Lubricants & Greases (Aerospace)	$133	$160,080	$1,090,094	$0	$0	$1,250,307
Wire Harnesses and Electric Circuit Boards	$25,141	-$16,077,148	$98,624,143	$0	$0	$82,572,136
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$17,695	-$11,315,556	$82,024,286	$0	$0	$70,726,425
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	$42,340	-$858,861	$0	$0	$0	-$816,521
All PIP (3:1) Uses	**$85,370**	***-$27,803,341***	***$181,773,557***	***$0***	***$0***	***$154,055,585***
Total	**$193,054**	**-$27,803,341**	**$836,618,478**	**$400,288**	**$0**	**$809,408,479**

Table 8-7: Total Industry Cost for Reformulation Sensitivity (Primary Alternative Option), annualized at 7% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Labeling**	**Export Notification**	**Total**
DecaBDE						
Other DecaBDE-containing Plastic	$165,436	$0	$654,895,281	$614,967	$0	$655,675,684
All DecaBDE Uses	***$165,436***	***$0***	***$654,895,281***	***$614,967***	***$0***	***$655,675,684***
PIP (3:1)						
Lubricants and Greases (except Aerospace and Turbine)	$93	$380,106	$48,401	$0	$0	$428,600
Lubricants & Greases (Aerospace)	$205	$211,170	$1,090,311	$0	$0	$1,301,686
Wire Harnesses and Electric Circuit Boards	$38,625	-$41,585,495	$98,636,175	$0	$0	$57,089,305
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$27,185	-$29,269,059	$85,744,414	$0	$0	$56,502,540
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	$65,047	-$2,221,549	$0	$0	$0	-$2,156,501
All PIP (3:1) Uses	***$131,155***	***-$72,484,826***	***$185,519,302***	***$0***	***$0***	***$113,165,631***
Total	**$296,591**	**-$72,484,826**	**$840,414,583**	**$614,967**	**$0**	**$768,841,315**

Table 8-8: Comparison of Total Cost Estimates for Reformulation Sensitivity Analysis							
3% Discount Rate				**7% Discount Rate**			
Final Option		**Alternative Option**		**Final Option**		**Alternative Option**	
Cost	**Sensitivity**	**Cost**	**Sensitivity**	**Cost**	**Sensitivity**	**Cost**	**Sensitivity**
$399,912,418	$478,744,412	$829,568,704	$809,408,479	$430,029,661	$489,359,049	$821,413,223	$768,841,315

8.2 Baseline Respiratory PPE Sensitivity Analysis

The second parameter assessed in this chapter examines baseline respirator use. As noted in Section 4.4.1, data from OSHA inspections are used as the basis for estimating baseline respirator use in industries impacted by the final rule. Data from OSHA inspections may underestimate baseline PPE use because there are likely many workers who do not use respirators that are not cited for OSHA violations. Or, a high number of violations in one time period may not be representative of the entire industry. In this sensitivity analysis, an alternative estimate for baseline PPE usages is based on results from the Respirators Usage in Private Sector Firms (RUPS) Survey.

Note that this analysis holds all other methodological steps presented in Chapter 4 constant, including use of reformulation costs from Cheminfo Services Inc. Results presented in this sensitivity analysis should therefore be compared to the mainline economic analysis, not the analysis presented in Section 8.1.

In the main analysis for industries where EPA located a specific industry standard, EPA determined the baseline use of respirators based on data from OSHA inspections during October 2021 to September 2022. For industries where EPA was unable to locate a specific industry standard EPA assumed no baseline use of respirators. See Section 4.4.1 for a full explanation of baseline respirator use in the main analysis.

The RUPS Survey was conducted by the National Institute for Occupational Safety and Health (NIOSH) and the U.S. Department of Labor's Bureau of Labor Statistics (BLS) as a voluntary survey of U.S. employers regarding the use of respiratory protective devices (U.S. Bureau of Labor Statistics (BLS) 2003). The survey was conducted between August 2000 and January 2001 and collected data on the number of private sector establishments that use respirators, as well as the types of respirators they use. The survey was sent to a sample of 40,002 establishments (75.5 percent response rate) that is representative of all private sector establishments (U.S. Bureau of Labor Statistics (BLS) 2003).

The RUPS survey data provides respiratory usage data at a higher level than the 6-digit NAICS level. Specifically, RUPS provides data on the following categories: Agriculture, forestry, and fishing; Mining; Construction; Manufacturing; Transportation and public utilities; Wholesale trade; Retail trade; Finance, insurance, and real estate; and Services. The RUPS survey is a representative sample that includes both NAICS codes where there are and are not industry standards, therefore in this sensitivity analysis RUPS data is used regardless of whether EPA located an industry standard for a given NAICS.

Table 8-9 presents the RUPS non-use rates for each NAICS code. In the third column, NAICS codes were mapped to the eight categories listed in the preceding paragraph.

Table 8-9: RUPS Use Rates by NAICS Code

NAICS	NAICS Description	RUPS Industry Map	Percent Noncompliant
3261	Plastics Product Manufacturing	Manufacturing	71.73%
324110	Petroleum Refineries	Manufacturing	71.73%
324191	Petroleum Lubricating Oil and Grease Manufacturing	Manufacturing	71.73%
325180	Other Basic Inorganic Chemical Manufacturing	Manufacturing	71.73%
325199	All Other Basic Organic Chemical Manufacturing	Manufacturing	71.73%
325211	Plastics Material and Resin Manufacturing	Manufacturing	71.73%

Table 8-9: RUPS Use Rates by NAICS Code			
NAICS	NAICS Description	RUPS Industry Map	Percent Noncompliant
325510	Paint and Coating Manufacturing	Manufacturing	71.73%
325520	Adhesive Manufacturing	Manufacturing	71.73%
325991	Custom Compounding of Purchased Resins	Manufacturing	71.73%
326199	All Other Plastics Product Manufacturing	Manufacturing	71.73%
333242	Semiconductor Machinery Manufacturing	Manufacturing	71.73%
333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	Manufacturing	71.73%
334412	Bare Printed Circuit Board Manufacturing	Manufacturing	71.73%
334413	Semiconductor and Related Device Manufacturing	Manufacturing	71.73%
334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing	Manufacturing	71.73%
335931	Current-Carrying Wiring Device Manufacturing	Manufacturing	71.73%
336211	Motor Vehicle Body Manufacturing	Manufacturing	71.73%
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	Manufacturing	71.73%
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing	Manufacturing	71.73%
336390	Other Motor Vehicle Parts Manufacturing	Manufacturing	71.73%
336412	Aircraft Engine and Engine Parts Manufacturing	Manufacturing	71.73%
336413	Other Aircraft Part and Auxiliary Equipment Manufacturing	Manufacturing	71.73%
336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	Manufacturing	71.73%
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	Manufacturing	71.73%
336991	Motorcycle, Bicycle and Parts Manufacturing	Manufacturing	71.73%
336999	All Other Transportation Equipment Manufacturing	Manufacturing	71.73%
423120	Motor Vehicle Supplies and New Parts Merchant Wholesalers	Wholesale trade	85.19%
423840	Industrial Supplies Merchant Wholesalers	Wholesale trade	85.19%
424690	Other Chemical and Allied Products Merchant Wholesalers	Wholesale trade	85.19%
532490	Other Commercial and Industrial Machinery and Equipment Rental and Leasing	Wholesale trade	85.19%
562920	Materials Recovery Facilities	Transportation and public utilities	88.19%

Table 8-10 and Table 8-11 present the total respiratory protection costs using the baseline non-use rates presented in Table 8-9 for this sensitivity analysis. Total respiratory protection costs of the final option are estimated at approximately $343 million and $377 million at 3% and 7% discount rates, a increase of $8 and $6 million, respectively, from the costs estimated in Chapter 4. For the primary alternative option,

total annual costs are $652 million and $658 million, a decrease of approximately $169 million or $167 million at 3% and 7% discount rates from the cost estimates in Chapter 4.

Table 8-10: Total Annualized Respiratory Protection Costs, by Chemical and Use (Final Option) (2022$)

Chemical and Use	Annualized Cost, 3% Discount Rate	Annualized Cost, 7% Discount Rate
DecaBDE		
Plastic Shipping Pallets	$0	$0
Replacement Parts for Aerospace Vehicles (makers)	$0	$0
Replacement Parts for Motor Vehicles (makers)	$0	$0
PIP (3:1)		
Lubricants & Greases (except Aerospace and Turbine) (makers)	$76,910	$89,256
Lubricants and Greases (Aerospace) (makers)	$785,572	$785,572
New and Replacement Parts for Motor Vehicles (makers)	$131,314,617	$153,993,695
New and Replacement Parts for Aerospace Vehicles (makers)	$34,433,515	$34,433,515
Wire Harnesses and Electric Circuit Boards (makers)	$107,982,748	$107,982,748
Marine Antifouling Coatings	$6,548,858	$9,357,461
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$61,719,040	$70,107,754
Engine Filters for Locomotive and Marine Applications	$0	$0
Cyanoacrylate Adhesives	$0	$0
Aviation Hydraulic Fluid (makers)	$371,806	$371,806
Total[1]	**$343,233,066**	**$377,121,807**

Note: Total annualized costs have been adjusted down proportionately for PIP (3:1) so as not to include double counting. Where applicable, the use with the highest cost for each NAICS was counted in the total.

Table 8-11: Total Annualized Respiratory Protection Costs, by Chemical and Use (Primary Alternative Option) (2022$)

Chemical and Use	Annualized Cost, 3% Discount Rate	Annualized Cost, 7% Discount Rate
DecaBDE		
Other DecaBDE-containing Plastic	**$467,861,398**	**$467,861,398**
PIP (3:1)		
Lubricants and Greases (except Aerospace and Turbine) (makers)	$33,807	$43,445
Lubricants & Greases (Aerospace) (makers)	$871,707	$871,707
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$85,700,174	$92,255,656
Wire Harnesses and Electric Circuit Boards (makers)	$97,416,386	$97,416,386
All PIP (3:1)	**$184,022,074**	**$190,587,194**
Total	**$651,883,472**	**$658,448,592**

Note: Total annualized costs have been adjusted down proportionately for PIP (3:1) so as not to include double counting. Where applicable, the use with the highest cost for each NAICS was counted in the total.

Table 8-12 through Table 8-15 present the total costs of the rule using the baseline non-use rates presented in Table 8-9. Total costs increase to approximately $408 million (3%) and $436 million (7%) in the final option, an increase of $8 and $6 million respectively from the results presented in main analysis. The total costs range from approximately $660 million (3%) and $655 million (7%) in the primary alternative option, a decrease of $169 million and $167 million, respectively. Table 8-16 compares the total costs in the main analysis to the costs in this sensitivity analysis.

Table 8-12: Total Industry Cost for Baseline PPE Sensitivity (Final Option), annualized at 3% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Signage**	**Export Notification**	**Total**
DecaBDE						
Plastic Shipping Pallets	$12	$0	$13	$10	$0	$35
Replacement Parts for Aerospace Vehicles	$0	$0	$0	$0	$0	$0
Replacement Parts for Motor Vehicles	$0	$0	$0	$0	$0	$0
Wire and Cable Insulation	$4	$0	$0	$0	$47	$51
All DecaBDE Uses	***$16***	***$0***	***$13***	***$10***	***$47***	***$86***
PIP (3:1)			$0			
Lubricants and Greases (except Aerospace and Turbine)	$61	$53,982	$77,206	$0	$0	$131,249
Lubricants & Greases (Aerospace)	$133	$0	$793,576	$0	$0	$793,710
New and Replacement Parts for Motor Vehicles (consumers)	$18,412	$871,374	$0	$0	$0	$889,786
New and Replacement Parts for Motor Vehicles (makers)	$97,967	$24,266,159	$155,742,124	$0	$0	$180,106,250
New and Replacement Parts for Aerospace Vehicles (consumers)	$1,308	$61,884	$0	$0	$0	$63,192
New and Replacement Parts for Aerospace Vehicles (makers)	$21,633	$3,439,494	$38,624,279	$0	$0	$42,085,406
Wire Harnesses and Electric Circuit Boards	$21,548	$0	$114,974,081	$0	$0	$114,995,630
Marine Antifouling Coatings	$12	-$506	$6,548,911	$0	$0	$6,548,417
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$14,102	-$1,234,256	$63,281,235	$0	$0	$62,061,082
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	$36,610	-$403,675	$0	$0	$0	-$367,065
Engine Filters for Locomotive and Marine Applications	$12	$0	$3	$0	$0	$15
Cyanoacrylate Adhesives	$0	$0	$52	$0	$0	$52
Aviation Hydraulic Fluid	$61	$0	$375,796	$0	$0	$375,857
All PIP (3:1) Uses	**$211,859**	***$27,054,456***	**$380,417,265**	***$0***	***$0***	***$407,683,580***
Total	**$211,875**	**$27,054,456**	**$380,417,278**	**$10**	**$47**	**$407,683,666**

Table 8-13: Total Industry Cost for Reformulation Sensitivity (Final Option), annualized at 7% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Labeling**	**Export Notification**	**Total**
DecaBDE						
Plastic Shipping Pallets	$19	$0	$20	$11	$0	$50
Replacement Parts for Aerospace Vehicles	$0	$0	$0	$0	$0	$0
Replacement Parts for Motor Vehicles	$0	$0	$0	$0	$0	$0
Wire and Cable Insulation	$6	$0	$0	$0	$72	$78
All DecaBDE Uses	***$25***	***$0***	***$20***	***$11***	***$72***	***$128***
PIP (3:1)						
Lubricants and Greases (except Aerospace and Turbine)	$93	$48,654	$89,682	$0	$0	$138,429
Lubricants & Greases (Aerospace)	$205	$0	$793,755	$0	$0	$793,959
New and Replacement Parts for Motor Vehicles (consumers)	$28,287	$1,336,715	$0	$0	$0	$1,365,002
New and Replacement Parts for Motor Vehicles (makers)	$150,507	$21,871,099	$179,136,251	$0	$0	$201,157,858
New and Replacement Parts for Aerospace Vehicles (consumers)	$2,009	$94,932	$0	$0	$0	$96,941
New and Replacement Parts for Aerospace Vehicles (makers)	$33,235	$1,751,015	$38,637,318	$0	$0	$40,421,569
Wire Harnesses and Electric Circuit Boards	$33,105	$0	$114,985,332	$0	$0	$115,018,437
Marine Antifouling Coatings	$19	-$1,653	$9,357,543	$0	$0	$9,355,909
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$21,665	-$3,702,287	$71,677,665	$0	$0	$67,997,043
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	$56,244	-$1,210,867	$0	$0	$0	-$1,154,623
Engine Filters for Locomotive and Marine Applications	$19	$0	$5	$0	$0	$23
Cyanoacrylate Adhesives	$0	$0	$82	$0	$0	$82
Aviation Hydraulic Fluid	$93	$0	$375,874	$0	$0	$375,967
All PIP (3:1) Uses	***$325,480***	***$20,187,608***	***$415,053,507***	***$0***	***$0***	***$435,566,596***
Total	**$325,505**	**$20,187,608**	**$415,053,527**	**$11**	**$72**	**$435,566,723**

Table 8-14: Total Industry Cost for Reformulation Sensitivity (Primary Alternative Option), annualized at 3% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Labeling**	**Export Notification**	**Total**
DecaBDE						
Other DecaBDE-containing Plastic	$107,684	$0	$471,280,607	$400,288	$0	$471,788,580
All DecaBDE Uses	**$107,684**	**$0**	**$471,280,607**	**$400,288**	**$0**	**$471,788,580**
PIP (3:1)						
Lubricants and Greases (except Aerospace and Turbine)	$61	$72,558	$34,122	$0	$0	$106,741
Lubricants & Greases (Aerospace)	$133	$40,310	$879,805	$0	$0	$920,248
Wire Harnesses and Electric Circuit Boards	$25,141	-$4,048,015	$105,311,155	$0	$0	$101,288,282
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$17,695	-$2,849,108	$89,639,867	$0	$0	$86,808,454
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	$42,340	-$858,861	$0	$0	$0	-$816,521
All PIP (3:1) Uses	**$85,370**	***-$7,643,116***	***$195,864,950***	***$0***	***$0***	***$188,307,203***
Total	**$193,054**	**-$7,643,116**	**$667,145,557**	**$400,288**	**$0**	**$660,095,783**

Table 8-15: Total Industry Cost for Reformulation Sensitivity (Primary Alternative Option), annualized at 7% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Labeling**	**Export Notification**	**Total**
DecaBDE						
Other DecaBDE-containing Plastic	$165,436	$0	$471,330,967	$614,967	$0	$472,111,370
All DecaBDE Uses	***$165,436***	***$0***	***$471,330,967***	***$614,967***	***$0***	***$472,111,370***
PIP (3:1)						
Lubricants and Greases (except Aerospace and Turbine)	$93	$95,706	$43,901	$0	$0	$139,700
Lubricants & Greases (Aerospace)	$205	$53,170	$880,022	$0	$0	$933,397
Wire Harnesses and Electric Circuit Boards	$38,625	-$10,470,681	$105,323,187	$0	$0	$94,891,131
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$27,185	-$7,369,564	$96,206,972	$0	$0	$88,864,592
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	$65,047	-$2,221,549	$0	$0	$0	-$2,156,501
All PIP (3:1) Uses	***$131,155***	***-$19,912,918***	***$202,454,083***	***$0***	***$0***	***$182,672,319***
Total	**$296,591**	**-$19,912,918**	**$673,785,050**	**$614,967**	**$0**	**$654,783,690**

Table 8-16: Comparison of Total Cost Estimates for Baseline PPE Sensitivity Analysis							
3% Discount Rate				**7% Discount Rate**			
Final Option		**Alternative Option**		**Final Option**		**Alternative Option**	
Cost	**Sensitivity**	**Cost**	**Sensitivity**	**Cost**	**Sensitivity**	**Cost**	**Sensitivity**
$399,912,418	$407,683,666	$829,568,704	$660,095,783	$430,029,661	$435,566,723	$821,413,223	$654,783,690

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Rule

Appendix A Costs at 2% Discount Rate

This appendix presents the costs of the rule calculated using a 2% discount rate. In November 2023, OMB released an update to its guidance for conducting regulatory analysis under E.O. 12866, known as Circular A-4. Previously, Circular A-4 recommended discounting social benefits and social costs at both a 3% consumption discount rate and a 7% social opportunity cost of capital. The updated Circular A-4 recommends using a 2% consumption discount rate for the main analysis.

The effective dates for implementing the 2023 Circular A-4 recommendations are provided on page 93 of the document. These dates are:

1. "March 1, 2024 for regulatory analyses received by OMB in support of proposed rules, interim final rules, and direct final rules, and…"

2. "January 1, 2025, for regulatory analyses received by OMB in support of other final rules."

As this is a final rule received by OMB prior to January 1, 2025, costs in the mainline analysis are presented in accordance with previous guidance, using 3% and 7% discount rates. However, this appendix serves to provide total costs using a 2% discount rate. It holds all other methodological steps presented in the EA constant.

Table A-1: Total Industry Cost for the Final Option, annualized at 2% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Labeling**	**Export Notification**	**Total**
DecaBDE						
Plastic Shipping Pallets	$11	$0	$12	$10	$0	$33
Replacement Parts for Aerospace Vehicles	$0	$0	$0	$0	$0	$0
Replacement Parts for Motor Vehicles	$0	$0	$0	$0	$0	$0
Wire and Cable Insulation	$4	$0	$0	$0	$41	$45
All DecaBDE Uses	***$14***	***$0***	***$12***	***$10***	***$41***	***$77***
PIP (3:1)			$0			
Lubricants and Greases (except Aerospace and Turbine)	$53	$54,486	$85,506	$0	$0	$140,045
Lubricants & Greases (Aerospace)	$117	$0	$1,038,050	$0	$0	$1,038,168
New and Replacement Parts for Motor Vehicles (consumers)	$16,212	$766,444	$0	$0	$0	$782,656
New and Replacement Parts for Motor Vehicles (makers)	$86,259	$24,492,718	$189,604,704	$0	$0	$214,183,681
New and Replacement Parts for Aerospace Vehicles (consumers)	$1,151	$54,432	$0	$0	$0	$55,583
New and Replacement Parts for Aerospace Vehicles (makers)	$19,048	$4,018,401	$22,820,195	$0	$0	$26,857,644
Wire Harnesses and Electric Circuit Boards	$18,973	$0	$99,101,325	$0	$0	$99,120,298
Marine Antifouling Coatings	$11	-$304	$1,412,758	$0	$0	$1,412,464
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$12,417	-$759,502	$46,770,650	$0	$0	$46,023,564
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	$32,235	-$248,402	$0	$0	$0	-$216,168
Engine Filters for Locomotive and Marine Applications	$11	$0	$3	$0	$0	$13
Cyanoacrylate Adhesives	$0	$0	$47	$0	$0	$47
Aviation Hydraulic Fluid	$53	$0	$457,186	$0	$0	$457,240
All PIP (3:1) Uses	**$186,540**	***$28,378,272***	**$361,290,422**	***$0***	***$0***	***$389,855,235***
Total	**$186,554**	**$28,378,272**	**$361,290,434**	**$10**	**$41**	**$389,855,312**

Table A-2: Total Industry Cost for Primary Alternative Option, annualized at 2% discount rate (2022$)						
Chemical and Use	**Rule Familiarization**	**Prohibition Costs**	**PPE Costs**	**Labeling**	**Export Notification**	**Total**
DecaBDE						
Other DecaBDE-containing Plastic	$94,815	$0	$654,838,051	$352,452	$0	$655,285,318
All DecaBDE Uses	**$94,815**	**$0**	**$654,838,051**	**$352,452**	**$0**	**$655,285,318**
PIP (3:1)						
Lubricants and Greases (except Aerospace and Turbine)	$53	$66,420	$31,508	$0	$0	$97,981
Lubricants & Greases (Aerospace)	$117	$36,900	$1,090,381	$0	$0	$1,127,398
Wire Harnesses and Electric Circuit Boards	$22,137	-$2,600,893	$98,490,644	$0	$0	$95,911,888
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	$15,580	-$1,830,583	$81,021,915	$0	$0	$79,206,913
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (consumers)	$37,280	-$551,828	$0	$0	$0	-$514,548
All PIP (3:1) Uses	**$75,168**	***-$4,879,984***	***$180,634,448***	***$0***	***$0***	***$175,829,632***
Total	**$169,983**	**-$4,879,984**	**$835,472,499**	**$352,452**	**$0**	**$831,114,950**

Appendix B Wage Rate Derivation

This appendix describes the derivation of the fully loaded wage rates used in calculating costs of labor in regulatory economic analyses and other cost estimations involving work time (tasks completed while working for pay). This approach is developed consistent with EPA's *Handbook on Valuing Changes in Time Use Induced by Regulatory Requirements and Other U.S. EPA Actions* (EPA 2020c). All cost estimates are presented in 2020 dollars.

Derivation of Industry Unit Wage Rates

Wage and fringe benefit data for each labor category (e.g., managerial, professional/technical, and clerical labor) are taken from the U.S. Bureau of Labor Statistics (BLS) Employer Costs for Employee Compensation (ECEC) Supplementary Tables (BLS 2023b). In the BLS report, wages are represented by the "wages and salaries" cost component and fringe benefits are represented by "total benefits."

Overhead costs are assumed to equal 20% of the sum of wages plus fringe benefits. This loading factor is described in *Handbook on Valuing Changes in Time Use Induced by Regulatory Requirements and Other U.S. EPA Actions* (EPA 2020c) and is reflective of multiplier values used in prior EPA RIAs and ICRs that are based on industry- and occupation-specific overhead rates affected by EPA regulations. This overhead loading factor is multiplied by the total compensation (wages plus fringe benefits). For example, the December 2022 fully loaded wage for professional/technical labor is ($46.01 + $23.27) * 1.2 = $83.14. Fully loaded costs for managerial and clerical labor are calculated in a similar manner. The calculated overhead costs (20% of the total compensation) are shown in Table B-1 as well as the total hourly loaded wages.

Table B-1: Industry Wage Rates Derivation (2022$)								
Labor Category	**Data Series [a]**	**Period**	**Wage ($/hour)**	**Fringe Benefit**	**Total Compensation**	**Overhead as % of Total Compensation[b]**	**Overhead**	**Hourly Loaded Wages[c]**
			(a)	*(b)*	*(c) =(b)+(a)*	*(d)*	*(e)=(c)*(d)*	*(f)=(c)+(e)*
Manufacturing								
Managerial	BLS ECEC, Private Manufacturing industries, "Mgt, Business, and Financial"	2022 Q4	$54.29	$24.66	$78.95	20%	$15.79	$94.74
Professional / Technical	BLS ECEC, Private Manufacturing industries, "Professional and related"	2022 Q4	$46.01	$23.27	$69.28	20%	$13.86	$83.14
Production Worker / Clerical	BLS ECEC, Private Manufacturing industries, "Office and Administrative Support"	2022 Q4	$23.11	$10.33	$33.44	20%	$6.69	$40.13
All Sectors								
Attorney	Wage: BLS OES Occupat. Employ. and Wages, Lawyers (SOC 23-1011) Fringes (as percent): BLS ECEC, Private Manufacturing industries, "Professional and related"	May 21	$71.17	$35.99	$107.16	20%	$21.43	$128.60
Industrial Hygienist	Wage: BLS OES Occupat. Employ. and Wages, Occup. Health and Safety Specialists (SOC 19-5011) Fringes (as percent): BLS ECEC, Private Manufacturing industries, "Professional and related"	May 21	$37.86	$19.15	$57.01	20%	$11.40	$68.41
Physician's Assistant	Wage: BLS OES Occupat. Employ. and Wages, for Physician Assistants (SOC 29-1071) Fringes (as percent): BLS ECEC, Private Manufacturing industries, "Professional and related"	May 21	$57.43	$29.05	$86.48	20%	$17.30	$103.77

Footnotes

[a] Sources: Employer Costs for Employee Compensation: Private Industry Dataset (U.S. Bureau of Labor Statistics (BLS) 2022a); Occupational Employment and Wage Statistics, Occupational Employment and Wages, May 2021 (U.S. Bureau of Labor Statistics (BLS) 2022b)

[b] An overhead rate of 20% is used based on assumptions in *Handbook on Valuing Changes in Time Use Induced by Regulatory Requirements and Other U.S. EPA Actions (EPA2020c)*

[c] Wage data are rounded to the closest cent in this analysis.

Appendix C Affected Workers

To determine the number of workers within a NAICS code potentially needing to use worker protection equipment under the final rule, EPA examined May 2021 U.S. BLS' Occupational Employment and Wage Statistics, Research Estimates by State and Industry data (BLS 2022b). For the NAICS code at the highest level available in the BLS data (e.g., 4-digit level 3132), EPA reviewed the Standard Occupational Classification titles to identify those occupations (SOC codes) where workers are potentially exposed to the regulated chemical.

Table C-1 through Table C-15 present the SOC code and EPA's determination of whether the occupation is considered an exposed worker, for each of the relevant 3- or 4-digit NAICS codes ("yes" or "no"). This determination was based on EPA's understanding of the industry and descriptions/examples of the occupation categories found in on BLS' *2018 Standard Occupational Classification System* webpage (BLS 2020). In each of these tables, the percent of potentially workers is calculated by summing the number of workers in each "yes" occupation category and dividing by the total (provided as the employment number for the "00-0000 All Occupations" category.

Table C-16 provides a summary of the percent of workers potentially exposed (and therefore potentially needing PPE under the final rule) for each affected NAICS code.

Table C-1: Exposure Designations for Occupations in NAICS 3241, Petroleum and Coal Products Manufacturing

SOC Code	Description	Potential Exposure	Employment
00-0000	All Occupations	n	103,490
11-0000	Management Occupations	n	7,200
11-1021	General and Operations Managers	n	1,560
11-2022	Sales Managers	n	290
11-3012	Administrative Services Managers	n	90
11-3013	Facilities Managers	n	210
11-3031	Financial Managers	n	70
11-3051	Industrial Production Managers	y	1,550
11-3071	Transportation, Storage, and Distribution Managers	y	120
11-3121	Human Resources Managers	n	60
11-9021	Construction Managers	n	40
11-9041	Architectural and Engineering Managers	n	340
11-9199	Managers, All Other	n	620
13-0000	Business and Financial Operations Occupations	n	4,950
13-1020	Buyers and Purchasing Agents	n	330
13-1041	Compliance Officers	n	120
13-1071	Human Resources Specialists	n	210
13-1081	Logisticians	n	630
13-1082	Project Management Specialists	n	340
13-1111	Management Analysts	n	60
13-1151	Training and Development Specialists	n	200
13-1161	Market Research Analysts and Marketing Specialists	n	40
13-1199	Business Operations Specialists, All Other	n	800
13-2011	Accountants and Auditors	n	550
13-2051	Financial and Investment Analysts	n	50
15-0000	Computer and Mathematical Occupations	n	620
15-1211	Computer Systems Analysts	n	80

Table C-1: Exposure Designations for Occupations in NAICS 3241, Petroleum and Coal Products Manufacturing			
SOC Code	Description	Potential Exposure	Employment
15-1252	Software Developers	n	40
15-1299	Computer Occupations, All Other	n	40
17-0000	Architecture and Engineering Occupations	n	5,830
17-2041	Chemical Engineers	n	540
17-2071	Electrical Engineers	n	50
17-2081	Environmental Engineers	n	170
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	n	130
17-2112	Industrial Engineers	n	980
17-2141	Mechanical Engineers	n	300
17-2171	Petroleum Engineers	n	970
17-2199	Engineers, All Other	n	190
17-3023	Electrical and Electronic Engineering Technologists and Technicians	n	130
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	n	30
17-3025	Environmental Engineering Technologists and Technicians	n	30
17-3027	Mechanical Engineering Technologists and Technicians	n	100
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	n	140
19-0000	Life, Physical, and Social Science Occupations	n	3,400
19-2031	Chemists	n	660
19-2041	Environmental Scientists and Specialists, Including Health	n	70
19-4031	Chemical Technicians	n	1,120
19-4099	Life, Physical, and Social Science Technicians, All Other	n	60
19-5011	Occupational Health and Safety Specialists	n	480
23-0000	Legal Occupations	n	40
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	n	40
33-0000	Protective Service Occupations	n	30
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	0
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	0
41-0000	Sales and Related Occupations	n	2,000
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	n	0
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	n	1,130
41-9031	Sales Engineers	n	0
43-0000	Office and Administrative Support Occupations	n	5,950
43-1011	First-Line Supervisors of Office and Administrative Support Workers	n	190
43-3021	Billing and Posting Clerks	n	40
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	410
43-4051	Customer Service Representatives	n	240
43-5061	Production, Planning, and Expediting Clerks	n	830
43-5071	Shipping, Receiving, and Inventory Clerks	n	570
43-6011	Executive Secretaries and Executive Administrative Assistants	n	140
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	n	560
43-9061	Office Clerks, General	n	570
47-0000	Construction and Extraction Occupations	n	6,020
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	n	340

Table C-1: Exposure Designations for Occupations in NAICS 3241, Petroleum and Coal Products Manufacturing			
SOC Code	**Description**	**Potential Exposure**	**Employment**
47-2061	Construction Laborers	n	1,390
47-2071	Paving, Surfacing, and Tamping Equipment Operators	n	840
47-2073	Operating Engineers and Other Construction Equipment Operators	n	660
47-2111	Electricians	n	950
47-2152	Plumbers, Pipefitters, and Steamfitters	n	80
49-0000	Installation, Maintenance, and Repair Occupations	n	9,120
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	n	1,640
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	n	90
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	n	130
49-9041	Industrial Machinery Mechanics	n	3,980
49-9043	Maintenance Workers, Machinery	n	60
49-9044	Millwrights	n	110
49-9071	Maintenance and Repair Workers, General	n	1,130
49-9099	Installation, Maintenance, and Repair Workers, All Other	n	160
51-0000	Production Occupations	n	43,040
51-1011	First-Line Supervisors of Production and Operating Workers	y	5,530
51-2090	Miscellaneous Assemblers and Fabricators	y	330
51-4041	Machinists	y	1,440
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	n	130
51-4121	Welders, Cutters, Solderers, and Brazers	n	370
51-8091	Chemical Plant and System Operators	y	3,050
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	y	13,700
51-8099	Plant and System Operators, All Other	y	1,080
51-9011	Chemical Equipment Operators and Tenders	y	260
51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	y	130
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	y	4,930
51-9051	Furnace, Kiln, Oven, Drier, and Kettle Operators and Tenders	y	200
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	1,690
51-9111	Packaging and Filling Machine Operators and Tenders	y	730
51-9161	Computer Numerically Controlled Tool Operators	n	0
51-9198	Helpers--Production Workers	y	60
51-9199	Production Workers, All Other	y	910
53-0000	Transportation and Material Moving Occupations	n	8,490
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	y	210
53-3032	Heavy and Tractor-Trailer Truck Drivers	n	1,800
53-7011	Conveyor Operators and Tenders	y	60
53-7041	Hoist and Winch Operators	n	30
53-7051	Industrial Truck and Tractor Operators	n	1,270
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	y	1,680
53-7065	Stockers and Order Fillers	y	170
53-7072	Pump Operators, Except Wellhead Pumpers	n	200
53-7121	Tank Car, Truck, and Ship Loaders	y	150
		Total Potentially Exposed	**37,980**
		Percent of workers	**36.7%**

Table C-2: Exposure Designations for Occupations in NAICS 325, Chemical Manufacturing			
SOC Code	Description	Exposure	Employment
00-0000	All Occupations	n	858,540
11-0000	Management Occupations	n	78,210
11-1011	Chief Executives	n	1,470
11-1021	General and Operations Managers	n	18,880
11-2021	Marketing Managers	n	2,360
11-2022	Sales Managers	n	3,860
11-2032	Public Relations Managers	n	120
11-3012	Administrative Services Managers	n	1,270
11-3013	Facilities Managers	n	1,420
11-3021	Computer and Information Systems Managers	n	2,710
11-3031	Financial Managers	n	4,460
11-3051	Industrial Production Managers	y	16,360
11-3061	Purchasing Managers	n	1,300
11-3071	Transportation, Storage, and Distribution Managers	y	2,170
11-3121	Human Resources Managers	n	1,750
11-3131	Training and Development Managers	n	200
11-9041	Architectural and Engineering Managers	n	4,430
11-9111	Medical and Health Services Managers	n	240
11-9121	Natural Sciences Managers	n	4,750
11-9199	Managers, All Other	n	5,580
13-0000	Business and Financial Operations Occupations	n	52,800
13-1020	Buyers and Purchasing Agents	n	7,480
13-1041	Compliance Officers	n	5,590
13-1051	Cost Estimators	n	90
13-1071	Human Resources Specialists	n	4,810
13-1081	Logisticians	n	5,320
13-1082	Project Management Specialists	n	3,590
13-1111	Management Analysts	n	1,570
13-1121	Meeting, Convention, and Event Planners	n	40
13-1141	Compensation, Benefits, and Job Analysis Specialists	n	130
13-1151	Training and Development Specialists	n	2,670
13-1161	Market Research Analysts and Marketing Specialists	n	4,510
13-1199	Business Operations Specialists, All Other	n	3,700
13-2011	Accountants and Auditors	n	8,200
13-2031	Budget Analysts	n	40
13-2041	Credit Analysts	n	50
13-2051	Financial and Investment Analysts	n	1,010
15-0000	Computer and Mathematical Occupations	n	15,150
15-1211	Computer Systems Analysts	n	2,110
15-1231	Computer Network Support Specialists	n	350
15-1232	Computer User Support Specialists	n	1,880
15-1241	Computer Network Architects	n	270
15-1242	Database Administrators	n	120
15-1244	Network and Computer Systems Administrators	n	1,530
15-1251	Computer Programmers	n	110
15-1252	Software Developers	n	1,470
15-1253	Software Quality Assurance Analysts and Testers	n	350
15-1254	Web Developers	n	50
15-1255	Web and Digital Interface Designers	n	0
15-1299	Computer Occupations, All Other	n	880

Table C-2: Exposure Designations for Occupations in NAICS 325, Chemical Manufacturing			
SOC Code	Description	Exposure	Employment
15-2031	Operations Research Analysts	n	120
15-2041	Statisticians	n	110
15-2051	Data Scientists	n	380
17-0000	Architecture and Engineering Occupations	n	48,390
17-2031	Bioengineers and Biomedical Engineers	n	890
17-2041	Chemical Engineers	n	8,570
17-2051	Civil Engineers	n	120
17-2071	Electrical Engineers	n	590
17-2072	Electronics Engineers, Except Computer	n	170
17-2081	Environmental Engineers	n	280
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	n	660
17-2112	Industrial Engineers	n	17,290
17-2131	Materials Engineers	n	480
17-2141	Mechanical Engineers	n	3,570
17-2199	Engineers, All Other	n	2,370
17-3019	Drafters, All Other	n	70
17-3023	Electrical and Electronic Engineering Technologists and Technicians	n	1,240
17-3025	Environmental Engineering Technologists and Technicians	n	120
17-3026	Industrial Engineering Technologists and Technicians	n	4,430
17-3027	Mechanical Engineering Technologists and Technicians	n	510
17-3028	Calibration Technologists and Technicians	n	180
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	n	1,030
19-0000	Life, Physical, and Social Science Occupations	n	75,600
19-1012	Food Scientists and Technologists	n	40
19-1021	Biochemists and Biophysicists	n	5,290
19-1022	Microbiologists	n	2,520
19-1029	Biological Scientists, All Other	n	1,400
19-1042	Medical Scientists, Except Epidemiologists	n	2,890
19-1099	Life Scientists, All Other	n	30
19-2031	Chemists	n	26,830
19-2032	Materials Scientists	n	230
19-2041	Environmental Scientists and Specialists, Including Health	n	170
19-4021	Biological Technicians	n	5,300
19-4031	Chemical Technicians	n	18,930
19-4042	Environmental Science and Protection Technicians, Including Health	n	70
19-4044	Hydrologic Technicians	n	260
19-4099	Life, Physical, and Social Science Technicians, All Other	n	920
19-5011	Occupational Health and Safety Specialists	n	2,830
19-5012	Occupational Health and Safety Technicians	n	350
23-0000	Legal Occupations	n	790
23-1011	Lawyers	n	540
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	n	3,170
27-1024	Graphic Designers	n	1,080
27-3031	Public Relations Specialists	n	390
27-3042	Technical Writers	n	430
29-0000	Healthcare Practitioners and Technical Occupations	n	1,440
29-1051	Pharmacists	n	140
29-1141	Registered Nurses	n	100
29-2010	Clinical Laboratory Technologists and Technicians	n	40

Table C-2: Exposure Designations for Occupations in NAICS 325, Chemical Manufacturing			
SOC Code	Description	Exposure	Employment
29-2052	Pharmacy Technicians	n	110
31-0000	Healthcare Support Occupations	n	250
31-9096	Veterinary Assistants and Laboratory Animal Caretakers	n	160
33-0000	Protective Service Occupations	n	510
33-9032	Security Guards	n	430
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	5,160
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	4,660
39-0000	Personal Care and Service Occupations	n	0
41-0000	Sales and Related Occupations	n	25,360
41-1011	First-Line Supervisors of Retail Sales Workers	n	40
41-1012	First-Line Supervisors of Non-Retail Sales Workers	n	950
41-2031	Retail Salespersons	n	220
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	n	670
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	n	5,070
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	n	15,320
41-9031	Sales Engineers	n	150
41-9099	Sales and Related Workers, All Other	n	190
43-0000	Office and Administrative Support Occupations	n	76,340
43-1011	First-Line Supervisors of Office and Administrative Support Workers	n	5,160
43-3011	Bill and Account Collectors	n	30
43-3021	Billing and Posting Clerks	n	360
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	6,700
43-3051	Payroll and Timekeeping Clerks	n	230
43-3061	Procurement Clerks	n	340
43-4051	Customer Service Representatives	n	12,230
43-4071	File Clerks	n	240
43-4151	Order Clerks	n	550
43-4161	Human Resources Assistants, Except Payroll and Timekeeping	n	260
43-4171	Receptionists and Information Clerks	n	720
43-4199	Information and Record Clerks, All Other	n	120
43-5032	Dispatchers, Except Police, Fire, and Ambulance	n	70
43-5061	Production, Planning, and Expediting Clerks	n	9,330
43-5071	Shipping, Receiving, and Inventory Clerks	n	16,840
43-5111	Weighers, Measurers, Checkers, and Samplers, Recordkeeping	y	1,080
43-6011	Executive Secretaries and Executive Administrative Assistants	n	2,260
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	n	6,100
43-9061	Office Clerks, General	n	7,900
43-9199	Office and Administrative Support Workers, All Other	n	0
45-0000	Farming, Fishing, and Forestry Occupations	n	140
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	n	90
45-2093	Farmworkers, Farm, Ranch, and Aquacultural Animals	n	0
47-0000	Construction and Extraction Occupations	n	4,060
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	n	90
47-2031	Carpenters	n	30
47-2073	Operating Engineers and Other Construction Equipment Operators	n	590
47-2111	Electricians	n	1,670
47-2152	Plumbers, Pipefitters, and Steamfitters	n	120

Table C-2: Exposure Designations for Occupations in NAICS 325, Chemical Manufacturing			
SOC Code	Description	Exposure	Employment
49-0000	Installation, Maintenance, and Repair Occupations	n	54,750
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	n	5,800
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	n	1,300
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	n	220
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	n	50
49-9041	Industrial Machinery Mechanics	n	24,010
49-9043	Maintenance Workers, Machinery	n	1,820
49-9044	Millwrights	n	170
49-9069	Precision Instrument and Equipment Repairers, All Other	n	60
49-9071	Maintenance and Repair Workers, General	n	17,770
49-9098	Helpers--Installation, Maintenance, and Repair Workers	n	70
49-9099	Installation, Maintenance, and Repair Workers, All Other	n	210
51-0000	Production Occupations	n	351,600
51-1011	First-Line Supervisors of Production and Operating Workers	y	39,700
51-2090	Miscellaneous Assemblers and Fabricators	y	8,880
51-4021	Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic	y	1,450
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	y	50
51-4041	Machinists	y	1,260
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	y	750
51-4111	Tool and Die Makers	n	30
51-4121	Welders, Cutters, Solderers, and Brazers	n	490
51-5112	Printing Press Operators	n	170
51-6031	Sewing Machine Operators	n	40
51-6064	Textile Winding, Twisting, and Drawing Out Machine Setters, Operators, and Tenders	n	830
51-6091	Extruding and Forming Machine Setters, Operators, and Tenders, Synthetic and Glass Fibers	y	2,990
51-8021	Stationary Engineers and Boiler Operators	n	140
51-8031	Water and Wastewater Treatment Plant and System Operators	n	250
51-8091	Chemical Plant and System Operators	n	15,570
51-8099	Plant and System Operators, All Other	n	40
51-9011	Chemical Equipment Operators and Tenders	y	98,690
51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	y	6,250
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	y	250
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	y	40,420
51-9032	Cutting and Slicing Machine Setters, Operators, and Tenders	y	270
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	y	3,800
51-9051	Furnace, Kiln, Oven, Drier, and Kettle Operators and Tenders	y	50
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	30,550
51-9111	Packaging and Filling Machine Operators and Tenders	y	63,770
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	n	1,340
51-9161	Computer Numerically Controlled Tool Operators	n	490
51-9162	Computer Numerically Controlled Tool Programmers	n	30

Table C-2: Exposure Designations for Occupations in NAICS 325, Chemical Manufacturing			
SOC Code	**Description**	**Exposure**	**Employment**
51-9192	Cleaning, Washing, and Metal Pickling Equipment Operators and Tenders	n	560
51-9198	Helpers--Production Workers	y	2,330
51-9199	Production Workers, All Other	y	8,910
53-0000	Transportation and Material Moving Occupations	n	60,020
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	y	3,850
53-3032	Heavy and Tractor-Trailer Truck Drivers	n	7,640
53-3033	Light Truck Drivers	n	1,550
53-7011	Conveyor Operators and Tenders	y	60
53-7051	Industrial Truck and Tractor Operators	n	7,890
53-7061	Cleaners of Vehicles and Equipment	n	520
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	y	22,830
53-7063	Machine Feeders and Offbearers	y	150
53-7064	Packers and Packagers, Hand	y	6,140
53-7065	Stockers and Order Fillers	y	4,110
53-7121	Tank Car, Truck, and Ship Loaders	y	140
		Potentially exposed occupations	**367,260**
		Percent of workers	**42.8%**

Table C-3: Exposure Designations for Occupations in NAICS 3261, Plastics Product Manufacturing			
SOC Code	Description	Exposure	Employment
00-0000	All Occupations	n	582,180
11-0000	Management Occupations	n	27,690
11-1011	Chief Executives	n	350
11-1021	General and Operations Managers	n	8,370
11-2021	Marketing Managers	n	280
11-2022	Sales Managers	n	1,640
11-3012	Administrative Services Managers	n	200
11-3013	Facilities Managers	n	270
11-3021	Computer and Information Systems Managers	n	400
11-3031	Financial Managers	n	1,510
11-3051	Industrial Production Managers	y	7,660
11-3061	Purchasing Managers	n	180
11-3071	Transportation, Storage, and Distribution Managers	y	420
11-3121	Human Resources Managers	n	620
11-9041	Architectural and Engineering Managers	n	1,240
11-9199	Managers, All Other	n	430
13-0000	Business and Financial Operations Occupations	n	18,990
13-1020	Buyers and Purchasing Agents	n	3,330
13-1041	Compliance Officers	n	70
13-1051	Cost Estimators	n	440
13-1071	Human Resources Specialists	n	3,280
13-1081	Logisticians	n	1,180
13-1082	Project Management Specialists	n	750
13-1111	Management Analysts	n	230
13-1151	Training and Development Specialists	n	1,000
13-1161	Market Research Analysts and Marketing Specialists	n	1,250
13-1199	Business Operations Specialists, All Other	n	660
13-2011	Accountants and Auditors	n	3,040
13-2051	Financial and Investment Analysts	n	90
15-0000	Computer and Mathematical Occupations	n	4,130
15-1211	Computer Systems Analysts	n	340
15-1231	Computer Network Support Specialists	n	40
15-1232	Computer User Support Specialists	n	510
15-1242	Database Administrators	n	120
15-1244	Network and Computer Systems Administrators	n	520
15-1251	Computer Programmers	n	40
15-1252	Software Developers	n	420
15-1254	Web Developers	n	50
15-1299	Computer Occupations, All Other	n	60
15-2051	Data Scientists	n	40
17-0000	Architecture and Engineering Occupations	n	22,950
17-2041	Chemical Engineers	n	0
17-2071	Electrical Engineers	n	30
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	n	30
17-2112	Industrial Engineers	n	10,400
17-2131	Materials Engineers	n	480
17-2141	Mechanical Engineers	n	2,360
17-2199	Engineers, All Other	n	510
17-3013	Mechanical Drafters	n	470

Table C-3: Exposure Designations for Occupations in NAICS 3261, Plastics Product Manufacturing			
SOC Code	Description	Exposure	Employment
17-3023	Electrical and Electronic Engineering Technologists and Technicians	n	30
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	n	70
17-3026	Industrial Engineering Technologists and Technicians	n	3,180
17-3027	Mechanical Engineering Technologists and Technicians	n	350
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	n	300
19-0000	Life, Physical, and Social Science Occupations	n	1,420
19-2031	Chemists	n	90
19-2032	Materials Scientists	n	60
19-4031	Chemical Technicians	n	100
19-5011	Occupational Health and Safety Specialists	n	400
23-0000	Legal Occupations	n	40
23-1011	Lawyers	n	0
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	n	1,030
27-1021	Commercial and Industrial Designers	n	420
27-1024	Graphic Designers	n	220
33-0000	Protective Service Occupations	n	60
33-9032	Security Guards	n	30
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	2,480
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	2,360
41-0000	Sales and Related Occupations	n	11,120
41-1012	First-Line Supervisors of Non-Retail Sales Workers	n	190
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	n	140
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	n	310
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	n	9,080
41-9031	Sales Engineers	n	170
43-0000	Office and Administrative Support Occupations	n	45,350
43-1011	First-Line Supervisors of Office and Administrative Support Workers	n	2,960
43-3011	Bill and Account Collectors	n	0
43-3021	Billing and Posting Clerks	n	240
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	3,310
43-3051	Payroll and Timekeeping Clerks	n	80
43-3061	Procurement Clerks	n	150
43-4051	Customer Service Representatives	n	5,860
43-4151	Order Clerks	n	160
43-4161	Human Resources Assistants, Except Payroll and Timekeeping	n	270
43-4171	Receptionists and Information Clerks	n	350
43-5032	Dispatchers, Except Police, Fire, and Ambulance	n	30
43-5061	Production, Planning, and Expediting Clerks	n	5,510
43-5071	Shipping, Receiving, and Inventory Clerks	n	14,770
43-5111	Weighers, Measurers, Checkers, and Samplers, Recordkeeping	n	60
43-6011	Executive Secretaries and Executive Administrative Assistants	n	120
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	n	2,000
43-9021	Data Entry Keyers	n	30
43-9061	Office Clerks, General	n	4,660
47-0000	Construction and Extraction Occupations	n	1,250
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	n	40
47-2111	Electricians	n	450

Table C-3: Exposure Designations for Occupations in NAICS 3261, Plastics Product Manufacturing			
SOC Code	Description	Exposure	Employment
47-2121	Glaziers	n	0
49-0000	Installation, Maintenance, and Repair Occupations	n	35,260
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	n	2,710
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	n	270
49-9041	Industrial Machinery Mechanics	n	12,470
49-9043	Maintenance Workers, Machinery	n	1,740
49-9071	Maintenance and Repair Workers, General	n	13,700
49-9098	Helpers--Installation, Maintenance, and Repair Workers	n	100
49-9099	Installation, Maintenance, and Repair Workers, All Other	n	770
51-0000	Production Occupations	n	341,000
51-1011	First-Line Supervisors of Production and Operating Workers	y	29,500
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	n	0
51-2041	Structural Metal Fabricators and Fitters	n	60
51-2051	Fiberglass Laminators and Fabricators	n	1,890
51-2090	Miscellaneous Assemblers and Fabricators	y	53,100
51-4021	Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic	y	26,470
51-4022	Forging Machine Setters, Operators, and Tenders, Metal and Plastic	y	140
51-4023	Rolling Machine Setters, Operators, and Tenders, Metal and Plastic	y	1,770
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	y	11,790
51-4032	Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	40
51-4033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	2,340
51-4035	Milling and Planing Machine Setters, Operators, and Tenders, Metal and Plastic	y	140
51-4041	Machinists	y	3,850
51-4061	Model Makers, Metal and Plastic	y	250
51-4071	Foundry Mold and Coremakers	n	220
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	n	80,350
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	12,810
51-4111	Tool and Die Makers	n	3,400
51-4121	Welders, Cutters, Solderers, and Brazers	n	320
51-4191	Heat Treating Equipment Setters, Operators, and Tenders, Metal and Plastic	y	260
51-4192	Layout Workers, Metal and Plastic	y	40
51-4193	Plating Machine Setters, Operators, and Tenders, Metal and Plastic	y	0
51-4199	Metal Workers and Plastic Workers, All Other	y	910
51-5111	Prepress Technicians and Workers	y	440
51-5112	Printing Press Operators	n	3,530
51-6031	Sewing Machine Operators	n	520
51-6062	Textile Cutting Machine Setters, Operators, and Tenders	n	90
51-6091	Extruding and Forming Machine Setters, Operators, and Tenders, Synthetic and Glass Fibers	y	240
51-7011	Cabinetmakers and Bench Carpenters	n	50
51-7041	Sawing Machine Setters, Operators, and Tenders, Wood	n	0
51-7042	Woodworking Machine Setters, Operators, and Tenders, Except Sawing	n	0

Table C-3: Exposure Designations for Occupations in NAICS 3261, Plastics Product Manufacturing			
SOC Code	Description	Exposure	Employment
51-9011	Chemical Equipment Operators and Tenders	y	110
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	y	50
51-9022	Grinding and Polishing Workers, Hand	y	240
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	y	2,220
51-9031	Cutters and Trimmers, Hand	y	180
51-9032	Cutting and Slicing Machine Setters, Operators, and Tenders	y	1,990
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	y	5,260
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	30,480
51-9111	Packaging and Filling Machine Operators and Tenders	y	8,750
51-9123	Painting, Coating, and Decorating Workers	n	120
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	n	1,920
51-9161	Computer Numerically Controlled Tool Operators	n	3,390
51-9162	Computer Numerically Controlled Tool Programmers	n	690
51-9191	Adhesive Bonding Machine Operators and Tenders	y	1,140
51-9192	Cleaning, Washing, and Metal Pickling Equipment Operators and Tenders	n	0
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	n	200
51-9196	Paper Goods Machine Setters, Operators, and Tenders	n	0
51-9198	Helpers--Production Workers	y	4,210
51-9199	Production Workers, All Other	y	6,300
53-0000	Transportation and Material Moving Occupations	n	65,940
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	y	2,170
53-3032	Heavy and Tractor-Trailer Truck Drivers	n	2,630
53-3033	Light Truck Drivers	n	570
53-7051	Industrial Truck and Tractor Operators	n	8,260
53-7061	Cleaners of Vehicles and Equipment	n	80
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	y	22,010
53-7063	Machine Feeders and Offbearers	y	1,110
53-7064	Packers and Packagers, Hand	y	22,410
53-7065	Stockers and Order Fillers	y	3,230
	Potentially exposed occupations		**264,030**
	Percent of workers		**45.4%**

Table C-4: Exposure Designations for Occupations in NAICS 333, Machinery Manufacturing			
SOC Code	Description	Exposure	Employment
00-0000	All Occupations	n	1,036,820
11-0000	Management Occupations	n	75,490
11-1011	Chief Executives	n	1,170
11-1021	General and Operations Managers	n	23,380
11-2021	Marketing Managers	n	1,930
11-2022	Sales Managers	n	6,100
11-3012	Administrative Services Managers	n	890
11-3013	Facilities Managers	n	420
11-3021	Computer and Information Systems Managers	n	2,450
11-3031	Financial Managers	n	4,630
11-3051	Industrial Production Managers	y	14,170
11-3061	Purchasing Managers	n	1,900
11-3071	Transportation, Storage, and Distribution Managers	y	1,270
11-3121	Human Resources Managers	n	1,440
11-3131	Training and Development Managers	n	60
11-9021	Construction Managers	n	90
11-9041	Architectural and Engineering Managers	n	9,750
11-9141	Property, Real Estate, and Community Association Managers	n	30
11-9199	Managers, All Other	n	2,020
13-0000	Business and Financial Operations Occupations	n	57,490
13-1020	Buyers and Purchasing Agents	n	13,960
13-1041	Compliance Officers	n	340
13-1051	Cost Estimators	n	1,640
13-1071	Human Resources Specialists	n	5,180
13-1081	Logisticians	n	3,930
13-1082	Project Management Specialists	n	6,280
13-1111	Management Analysts	n	1,260
13-1141	Compensation, Benefits, and Job Analysis Specialists	n	130
13-1151	Training and Development Specialists	n	1,570
13-1161	Market Research Analysts and Marketing Specialists	n	4,720
13-1199	Business Operations Specialists, All Other	n	3,170
13-2011	Accountants and Auditors	n	10,690
13-2031	Budget Analysts	n	40
13-2041	Credit Analysts	n	40
13-2051	Financial and Investment Analysts	n	570
15-0000	Computer and Mathematical Occupations	n	24,220
15-1211	Computer Systems Analysts	n	1,280
15-1212	Information Security Analysts	n	40
15-1231	Computer Network Support Specialists	n	370
15-1232	Computer User Support Specialists	n	3,180
15-1241	Computer Network Architects	n	320
15-1242	Database Administrators	n	150
15-1243	Database Architects	n	40
15-1244	Network and Computer Systems Administrators	n	2,000
15-1251	Computer Programmers	n	790
15-1252	Software Developers	n	9,230
15-1253	Software Quality Assurance Analysts and Testers	n	570
15-1254	Web Developers	n	130
15-1299	Computer Occupations, All Other	n	700
15-2031	Operations Research Analysts	n	270

Table C-4: Exposure Designations for Occupations in NAICS 333, Machinery Manufacturing			
SOC Code	Description	Exposure	Employment
15-2051	Data Scientists	n	60
17-0000	Architecture and Engineering Occupations	n	109,290
17-2041	Chemical Engineers	n	370
17-2051	Civil Engineers	n	40
17-2061	Computer Hardware Engineers	n	270
17-2071	Electrical Engineers	n	7,250
17-2072	Electronics Engineers, Except Computer	n	1,220
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	n	370
17-2112	Industrial Engineers	n	26,300
17-2131	Materials Engineers	n	620
17-2141	Mechanical Engineers	n	40,750
17-2171	Petroleum Engineers	n	350
17-2199	Engineers, All Other	n	3,700
17-3011	Architectural and Civil Drafters	n	0
17-3012	Electrical and Electronics Drafters	n	140
17-3013	Mechanical Drafters	n	7,560
17-3019	Drafters, All Other	n	350
17-3021	Aerospace Engineering and Operations Technologists and Technicians	n	40
17-3023	Electrical and Electronic Engineering Technologists and Technicians	n	2,510
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	n	610
17-3026	Industrial Engineering Technologists and Technicians	n	4,320
17-3027	Mechanical Engineering Technologists and Technicians	n	3,880
17-3028	Calibration Technologists and Technicians	n	0
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	n	1,130
19-0000	Life, Physical, and Social Science Occupations	n	2,470
19-2031	Chemists	n	130
19-2032	Materials Scientists	n	0
19-4031	Chemical Technicians	n	160
19-4099	Life, Physical, and Social Science Technicians, All Other	n	40
19-5011	Occupational Health and Safety Specialists	n	870
19-5012	Occupational Health and Safety Technicians	n	170
23-0000	Legal Occupations	n	260
23-1011	Lawyers	n	150
23-2011	Paralegals and Legal Assistants	n	30
25-0000	Educational Instruction and Library Occupations	n	70
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	n	3,760
27-1021	Commercial and Industrial Designers	n	770
27-1024	Graphic Designers	n	340
27-3031	Public Relations Specialists	n	200
27-3042	Technical Writers	n	950
29-0000	Healthcare Practitioners and Technical Occupations	n	90
29-1141	Registered Nurses	n	0
33-0000	Protective Service Occupations	n	120
33-9032	Security Guards	n	70
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	3,300
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	3,120
37-3011	Landscaping and Groundskeeping Workers	n	0
41-0000	Sales and Related Occupations	n	39,190
41-1012	First-Line Supervisors of Non-Retail Sales Workers	n	1,810

Table C-4: Exposure Designations for Occupations in NAICS 333, Machinery Manufacturing			
SOC Code	Description	Exposure	Employment
41-2022	Parts Salespersons	n	610
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	n	1,080
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	n	2,250
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	n	28,270
41-9031	Sales Engineers	n	2,710
41-9099	Sales and Related Workers, All Other	n	90
43-0000	Office and Administrative Support Occupations	n	92,260
43-1011	First-Line Supervisors of Office and Administrative Support Workers	n	6,040
43-3021	Billing and Posting Clerks	n	540
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	10,420
43-3051	Payroll and Timekeeping Clerks	n	530
43-3061	Procurement Clerks	n	740
43-4051	Customer Service Representatives	n	12,130
43-4071	File Clerks	n	100
43-4151	Order Clerks	n	870
43-4161	Human Resources Assistants, Except Payroll and Timekeeping	n	390
43-4171	Receptionists and Information Clerks	n	1,430
43-4199	Information and Record Clerks, All Other	n	30
43-5061	Production, Planning, and Expediting Clerks	n	11,030
43-5071	Shipping, Receiving, and Inventory Clerks	n	22,130
43-6011	Executive Secretaries and Executive Administrative Assistants	n	1,220
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	n	6,930
43-9021	Data Entry Keyers	n	90
43-9061	Office Clerks, General	n	12,790
43-9199	Office and Administrative Support Workers, All Other	n	50
47-0000	Construction and Extraction Occupations	n	9,260
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	n	160
47-2031	Carpenters	n	30
47-2061	Construction Laborers	n	90
47-2111	Electricians	n	2,820
47-2141	Painters, Construction and Maintenance	n	150
47-2152	Plumbers, Pipefitters, and Steamfitters	n	990
47-2211	Sheet Metal Workers	n	1,090
47-2221	Structural Iron and Steel Workers	n	30
47-5013	Service Unit Operators, Oil and Gas	n	190
47-5071	Roustabouts, Oil and Gas	n	150
49-0000	Installation, Maintenance, and Repair Occupations	n	47,770
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	n	3,930
49-2092	Electric Motor, Power Tool, and Related Repairers	n	40
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	n	670
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	n	220
49-3041	Farm Equipment Mechanics and Service Technicians	n	540
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	n	510
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	n	50
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	n	2,160
49-9041	Industrial Machinery Mechanics	n	17,200

Table C-4: Exposure Designations for Occupations in NAICS 333, Machinery Manufacturing			
SOC Code	Description	Exposure	Employment
49-9043	Maintenance Workers, Machinery	n	2,080
49-9044	Millwrights	n	290
49-9071	Maintenance and Repair Workers, General	n	12,260
49-9091	Coin, Vending, and Amusement Machine Servicers and Repairers	n	0
49-9096	Riggers	n	70
49-9098	Helpers--Installation, Maintenance, and Repair Workers	n	160
49-9099	Installation, Maintenance, and Repair Workers, All Other	n	1,260
51-0000	Production Occupations	n	527,240
51-1011	First-Line Supervisors of Production and Operating Workers	y	40,200
51-2021	Coil Winders, Tapers, and Finishers	y	100
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	y	21,860
51-2031	Engine and Other Machine Assemblers	y	9,110
51-2041	Structural Metal Fabricators and Fitters	y	4,990
51-2051	Fiberglass Laminators and Fabricators	n	0
51-2090	Miscellaneous Assemblers and Fabricators	y	129,800
51-4021	Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic	y	610
51-4023	Rolling Machine Setters, Operators, and Tenders, Metal and Plastic	y	280
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	y	16,260
51-4032	Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	610
51-4033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	9,070
51-4034	Lathe and Turning Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	2,930
51-4035	Milling and Planing Machine Setters, Operators, and Tenders, Metal and Plastic	y	900
51-4041	Machinists	y	65,500
51-4051	Metal-Refining Furnace Operators and Tenders	n	170
51-4052	Pourers and Casters, Metal	n	40
51-4061	Model Makers, Metal and Plastic	y	50
51-4062	Patternmakers, Metal and Plastic	y	140
51-4071	Foundry Mold and Coremakers	n	600
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	n	9,980
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	13,280
51-4111	Tool and Die Makers	n	15,430
51-4121	Welders, Cutters, Solderers, and Brazers	n	66,440
51-4122	Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders	n	3,970
51-4191	Heat Treating Equipment Setters, Operators, and Tenders, Metal and Plastic	n	380
51-4193	Plating Machine Setters, Operators, and Tenders, Metal and Plastic	n	960
51-4194	Tool Grinders, Filers, and Sharpeners	n	270
51-4199	Metal Workers and Plastic Workers, All Other	y	610
51-5112	Printing Press Operators	n	130
51-6031	Sewing Machine Operators	n	180
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	y	250

Table C-4: Exposure Designations for Occupations in NAICS 333, Machinery Manufacturing			
SOC Code	**Description**	**Exposure**	**Employment**
51-9022	Grinding and Polishing Workers, Hand	y	420
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	y	350
51-9032	Cutting and Slicing Machine Setters, Operators, and Tenders	y	260
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	y	120
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	27,030
51-9083	Ophthalmic Laboratory Technicians	n	2,120
51-9111	Packaging and Filling Machine Operators and Tenders	y	590
51-9123	Painting, Coating, and Decorating Workers	n	310
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	n	12,100
51-9161	Computer Numerically Controlled Tool Operators	n	31,780
51-9162	Computer Numerically Controlled Tool Programmers	n	4,640
51-9191	Adhesive Bonding Machine Operators and Tenders	y	40
51-9192	Cleaning, Washing, and Metal Pickling Equipment Operators and Tenders	n	40
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	n	30
51-9198	Helpers--Production Workers	y	5,450
51-9199	Production Workers, All Other	y	4,150
53-0000	Transportation and Material Moving Occupations	n	42,130
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	y	1,580
53-2012	Commercial Pilots	n	50
53-3032	Heavy and Tractor-Trailer Truck Drivers	n	2,390
53-3033	Light Truck Drivers	n	730
53-7021	Crane and Tower Operators	n	30
53-7051	Industrial Truck and Tractor Operators	n	6,190
53-7061	Cleaners of Vehicles and Equipment	n	40
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	y	19,770
53-7063	Machine Feeders and Offbearers	y	270
53-7064	Packers and Packagers, Hand	y	2,430
53-7065	Stockers and Order Fillers	y	5,090
53-7199	Material Moving Workers, All Other	y	130
	Total Potentially Exposed		**399,670**
	Percent of workers		**38.5%**

Table C-5: Exposure Designations for Occupations in NAICS 3344, Semiconductor and Other Electronic Component Manufacturing			
SOC Code	Description	Exposure	Employment
00-0000	All Occupations	n	354,390
11-1011	Chief Executives	n	330
11-0000	Management Occupations	n	32,200
11-1021	General and Operations Managers	n	6,220
11-2021	Marketing Managers	n	1,000
11-2022	Sales Managers	n	1,630
11-3012	Administrative Services Managers	n	280
11-3013	Facilities Managers	n	160
11-3021	Computer and Information Systems Managers	n	2,580
11-3031	Financial Managers	n	1,990
11-3051	Industrial Production Managers	y	3,890
11-3061	Purchasing Managers	n	840
11-3071	Transportation, Storage, and Distribution Managers	n	320
11-3111	Compensation and Benefits Managers	n	40
11-3121	Human Resources Managers	n	600
11-3131	Training and Development Managers	n	70
11-9041	Architectural and Engineering Managers	n	7,000
11-9141	Property, Real Estate, and Community Association Managers	n	0
11-9199	Managers, All Other	n	1,190
13-0000	Business and Financial Operations Occupations	n	25,840
13-1020	Buyers and Purchasing Agents	n	5,220
13-1041	Compliance Officers	n	360
13-1051	Cost Estimators	n	130
13-1071	Human Resources Specialists	n	1,810
13-1081	Logisticians	n	1,840
13-1082	Project Management Specialists	n	2,490
13-1111	Management Analysts	n	500
13-1141	Compensation, Benefits, and Job Analysis Specialists	n	130
13-1151	Training and Development Specialists	n	580
13-1161	Market Research Analysts and Marketing Specialists	n	1,780
13-1199	Business Operations Specialists, All Other	n	1,460
13-2011	Accountants and Auditors	n	3,850
13-2031	Budget Analysts	n	60
13-2051	Financial and Investment Analysts	n	1,830
13-2099	Financial Specialists, All Other	n	80
15-0000	Computer and Mathematical Occupations	n	24,540
15-1211	Computer Systems Analysts	n	1,080
15-1212	Information Security Analysts	n	340
15-1221	Computer and Information Research Scientists	n	480
15-1231	Computer Network Support Specialists	n	240
15-1232	Computer User Support Specialists	n	950
15-1241	Computer Network Architects	n	480
15-1242	Database Administrators	n	110
15-1243	Database Architects	n	130
15-1244	Network and Computer Systems Administrators	n	920
15-1251	Computer Programmers	n	780
15-1252	Software Developers	n	11,570
15-1253	Software Quality Assurance Analysts and Testers	n	1,850
15-1255	Web and Digital Interface Designers	n	100
15-1299	Computer Occupations, All Other	n	990

Table C-5: Exposure Designations for Occupations in NAICS 3344, Semiconductor and Other Electronic Component Manufacturing			
SOC Code	Description	Exposure	Employment
15-2031	Operations Research Analysts	n	260
15-2051	Data Scientists	n	480
17-0000	Architecture and Engineering Occupations	n	72,750
17-2041	Chemical Engineers	n	80
17-2061	Computer Hardware Engineers	n	8,610
17-2071	Electrical Engineers	n	7,280
17-2072	Electronics Engineers, Except Computer	n	10,240
17-2081	Environmental Engineers	n	40
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	n	60
17-2112	Industrial Engineers	n	14,370
17-2131	Materials Engineers	n	620
17-2141	Mechanical Engineers	n	4,260
17-2199	Engineers, All Other	n	2,630
17-3012	Electrical and Electronics Drafters	n	690
17-3013	Mechanical Drafters	n	220
17-3023	Electrical and Electronic Engineering Technologists and Technicians	n	11,590
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	n	50
17-3026	Industrial Engineering Technologists and Technicians	n	6,330
17-3027	Mechanical Engineering Technologists and Technicians	n	180
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	n	1,060
19-0000	Life, Physical, and Social Science Occupations	n	1,430
19-2031	Chemists	n	60
19-2032	Materials Scientists	n	50
19-4031	Chemical Technicians	n	340
19-4099	Life, Physical, and Social Science Technicians, All Other	n	30
19-5011	Occupational Health and Safety Specialists	n	110
23-0000	Legal Occupations	n	550
23-1011	Lawyers	n	340
23-2011	Paralegals and Legal Assistants	n	60
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	n	800
27-1021	Commercial and Industrial Designers	n	230
27-1024	Graphic Designers	n	60
27-3031	Public Relations Specialists	n	110
27-3042	Technical Writers	n	180
33-0000	Protective Service Occupations	n	0
33-9032	Security Guards	n	0
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	470
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	460
41-0000	Sales and Related Occupations	n	8,460
41-1012	First-Line Supervisors of Non-Retail Sales Workers	n	60
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	n	110
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	n	2,540
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	n	2,710
41-9031	Sales Engineers	n	1,560
41-9099	Sales and Related Workers, All Other	n	100
43-0000	Office and Administrative Support Occupations	n	22,750
43-1011	First-Line Supervisors of Office and Administrative Support Workers	n	1,040

Table C-5: Exposure Designations for Occupations in NAICS 3344, Semiconductor and Other Electronic Component Manufacturing			
SOC Code	Description	Exposure	Employment
43-3021	Billing and Posting Clerks	n	170
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	2,060
43-3051	Payroll and Timekeeping Clerks	n	110
43-3061	Procurement Clerks	n	240
43-4051	Customer Service Representatives	n	1,920
43-4151	Order Clerks	n	110
43-4161	Human Resources Assistants, Except Payroll and Timekeeping	n	180
43-4171	Receptionists and Information Clerks	n	130
43-5061	Production, Planning, and Expediting Clerks	n	4,490
43-5071	Shipping, Receiving, and Inventory Clerks	n	4,620
43-6011	Executive Secretaries and Executive Administrative Assistants	n	690
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	n	1,510
43-9061	Office Clerks, General	n	2,230
47-0000	Construction and Extraction Occupations	n	80
47-2111	Electricians	n	40
49-0000	Installation, Maintenance, and Repair Occupations	n	8,770
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	n	420
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	n	0
49-9041	Industrial Machinery Mechanics	n	2,990
49-9043	Maintenance Workers, Machinery	n	310
49-9071	Maintenance and Repair Workers, General	n	3,610
49-9099	Installation, Maintenance, and Repair Workers, All Other	n	0
51-0000	Production Occupations	n	142,120
51-1011	First-Line Supervisors of Production and Operating Workers	y	9,870
51-2021	Coil Winders, Tapers, and Finishers	y	490
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	y	47,450
51-2051	Fiberglass Laminators and Fabricators	n	0
51-2090	Miscellaneous Assemblers and Fabricators	y	11,050
51-4021	Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic	y	80
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	y	170
51-4032	Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	370
51-4033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	530
51-4034	Lathe and Turning Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	380
51-4035	Milling and Planing Machine Setters, Operators, and Tenders, Metal and Plastic	y	550
51-4041	Machinists	n	3,430
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	y	460
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	490
51-4111	Tool and Die Makers	n	260
51-4121	Welders, Cutters, Solderers, and Brazers	y	1,900
51-4122	Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders	y	1,540

Table C-5: Exposure Designations for Occupations in NAICS 3344, Semiconductor and Other Electronic Component Manufacturing			
SOC Code	**Description**	**Exposure**	**Employment**
51-4191	Heat Treating Equipment Setters, Operators, and Tenders, Metal and Plastic	y	150
51-4193	Plating Machine Setters, Operators, and Tenders, Metal and Plastic	y	1,290
51-5112	Printing Press Operators	n	180
51-9011	Chemical Equipment Operators and Tenders	y	240
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	y	0
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	y	620
51-9032	Cutting and Slicing Machine Setters, Operators, and Tenders	y	130
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	16,950
51-9111	Packaging and Filling Machine Operators and Tenders	n	80
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	y	460
51-9141	Semiconductor Processing Technicians	y	18,830
51-9161	Computer Numerically Controlled Tool Operators	n	2,070
51-9162	Computer Numerically Controlled Tool Programmers	n	100
51-9194	Etchers and Engravers	y	40
51-9198	Helpers--Production Workers	y	350
51-9199	Production Workers, All Other	y	2,340
53-0000	Transportation and Material Moving Occupations	n	6,480
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	n	150
53-3033	Light Truck Drivers	n	130
53-7051	Industrial Truck and Tractor Operators	n	50
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	n	2,580
53-7063	Machine Feeders and Offbearers	n	0
53-7064	Packers and Packagers, Hand	n	180
53-7065	Stockers and Order Fillers	n	1,960
	Total Potentially Exposed		**120,620**
	Percent of workers		**34.0%**

Table C-6: Exposure Designations for Occupations in NAICS 335, Electrical Equipment, Appliance, and Component Manufacturing			
SOC Code	Description	Exposure	Employment
00-0000	All Occupations	n	381,730
11-0000	Management Occupations	n	28,820
11-1011	Chief Executives	n	210
11-1021	General and Operations Managers	n	7,730
11-2021	Marketing Managers	n	1,300
11-2022	Sales Managers	n	2,090
11-3012	Administrative Services Managers	n	180
11-3013	Facilities Managers	n	40
11-3021	Computer and Information Systems Managers	n	900
11-3031	Financial Managers	n	1,550
11-3051	Industrial Production Managers	y	4,300
11-3061	Purchasing Managers	n	800
11-3071	Transportation, Storage, and Distribution Managers	y	580
11-3121	Human Resources Managers	n	480
11-9041	Architectural and Engineering Managers	n	3,410
11-9199	Managers, All Other	n	1,020
13-0000	Business and Financial Operations Occupations	n	22,860
13-1020	Buyers and Purchasing Agents	n	4,810
13-1041	Compliance Officers	n	100
13-1051	Cost Estimators	n	390
13-1071	Human Resources Specialists	n	1,730
13-1081	Logisticians	n	1,530
13-1082	Project Management Specialists	n	2,070
13-1111	Management Analysts	n	430
13-1151	Training and Development Specialists	n	240
13-1161	Market Research Analysts and Marketing Specialists	n	2,210
13-1199	Business Operations Specialists, All Other	n	1,210
13-2011	Accountants and Auditors	n	3,500
13-2051	Financial and Investment Analysts	n	260
13-2099	Financial Specialists, All Other	n	30
15-0000	Computer and Mathematical Occupations	n	8,860
15-1211	Computer Systems Analysts	n	500
15-1212	Information Security Analysts	n	40
15-1231	Computer Network Support Specialists	n	70
15-1232	Computer User Support Specialists	n	790
15-1241	Computer Network Architects	n	90
15-1242	Database Administrators	n	50
15-1244	Network and Computer Systems Administrators	n	640
15-1251	Computer Programmers	n	70
15-1252	Software Developers	n	3,190
15-1253	Software Quality Assurance Analysts and Testers	n	110
15-1299	Computer Occupations, All Other	n	300
15-2031	Operations Research Analysts	n	40
17-0000	Architecture and Engineering Occupations	n	39,690
17-2061	Computer Hardware Engineers	n	50
17-2071	Electrical Engineers	n	8,700
17-2072	Electronics Engineers, Except Computer	n	1,110
17-2112	Industrial Engineers	n	8,410
17-2131	Materials Engineers	n	140
17-2141	Mechanical Engineers	n	6,440

Table C-6: Exposure Designations for Occupations in NAICS 335, Electrical Equipment, Appliance, and Component Manufacturing			
SOC Code	Description	Exposure	Employment
17-2199	Engineers, All Other	n	800
17-3012	Electrical and Electronics Drafters	n	680
17-3013	Mechanical Drafters	n	750
17-3023	Electrical and Electronic Engineering Technologists and Technicians	n	3,520
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	n	70
17-3026	Industrial Engineering Technologists and Technicians	n	1,460
17-3027	Mechanical Engineering Technologists and Technicians	n	700
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	n	390
19-0000	Life, Physical, and Social Science Occupations	n	860
19-2031	Chemists	n	30
19-4031	Chemical Technicians	n	40
19-5011	Occupational Health and Safety Specialists	n	120
23-0000	Legal Occupations	n	0
23-1011	Lawyers	n	0
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	n	1,270
27-1021	Commercial and Industrial Designers	n	260
27-1024	Graphic Designers	n	140
27-3031	Public Relations Specialists	n	90
33-0000	Protective Service Occupations	n	30
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	790
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	740
41-0000	Sales and Related Occupations	n	12,870
41-1012	First-Line Supervisors of Non-Retail Sales Workers	n	470
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	n	90
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	n	1,830
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	n	8,250
41-9031	Sales Engineers	n	810
41-9099	Sales and Related Workers, All Other	n	60
43-0000	Office and Administrative Support Occupations	n	33,060
43-1011	First-Line Supervisors of Office and Administrative Support Workers	n	2,190
43-3021	Billing and Posting Clerks	n	160
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	3,030
43-3051	Payroll and Timekeeping Clerks	n	60
43-3061	Procurement Clerks	n	30
43-4051	Customer Service Representatives	n	6,290
43-4151	Order Clerks	n	130
43-4161	Human Resources Assistants, Except Payroll and Timekeeping	n	60
43-4171	Receptionists and Information Clerks	n	190
43-5061	Production, Planning, and Expediting Clerks	n	3,470
43-5071	Shipping, Receiving, and Inventory Clerks	n	6,840
43-5111	Weighers, Measurers, Checkers, and Samplers, Recordkeeping	n	60
43-6011	Executive Secretaries and Executive Administrative Assistants	n	260
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	n	2,010
43-9061	Office Clerks, General	n	3,710
47-0000	Construction and Extraction Occupations	n	1,910
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	n	0
47-2111	Electricians	n	1,520

Table C-6: Exposure Designations for Occupations in NAICS 335, Electrical Equipment, Appliance, and Component Manufacturing			
SOC Code	Description	Exposure	Employment
47-2211	Sheet Metal Workers	n	60
49-0000	Installation, Maintenance, and Repair Occupations	n	13,130
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	n	740
49-2092	Electric Motor, Power Tool, and Related Repairers	n	70
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	n	810
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	n	70
49-9041	Industrial Machinery Mechanics	n	3,140
49-9043	Maintenance Workers, Machinery	n	940
49-9071	Maintenance and Repair Workers, General	n	3,410
49-9098	Helpers--Installation, Maintenance, and Repair Workers	n	40
49-9099	Installation, Maintenance, and Repair Workers, All Other	n	110
51-0000	Production Occupations	n	192,370
51-1011	First-Line Supervisors of Production and Operating Workers	y	12,440
51-2021	Coil Winders, Tapers, and Finishers	y	3,490
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	y	65,060
51-2031	Engine and Other Machine Assemblers	y	1,280
51-2041	Structural Metal Fabricators and Fitters	y	890
51-2090	Miscellaneous Assemblers and Fabricators	y	43,680
51-4021	Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic	y	2,600
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	y	2,160
51-4033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	500
51-4034	Lathe and Turning Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	230
51-4035	Milling and Planing Machine Setters, Operators, and Tenders, Metal and Plastic	y	40
51-4041	Machinists	y	8,280
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	y	2,160
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	4,510
51-4111	Tool and Die Makers	n	1,220
51-4121	Welders, Cutters, Solderers, and Brazers	y	4,800
51-4122	Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders	y	390
51-4191	Heat Treating Equipment Setters, Operators, and Tenders, Metal and Plastic	y	0
51-4193	Plating Machine Setters, Operators, and Tenders, Metal and Plastic	y	150
51-4199	Metal Workers and Plastic Workers, All Other	y	350
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	y	90
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	11,700
51-9111	Packaging and Filling Machine Operators and Tenders	y	230
51-9123	Painting, Coating, and Decorating Workers	n	220
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	n	2,210
51-9161	Computer Numerically Controlled Tool Operators	n	2,220
51-9162	Computer Numerically Controlled Tool Programmers	n	110

Table C-6: Exposure Designations for Occupations in NAICS 335, Electrical Equipment, Appliance, and Component Manufacturing			
SOC Code	**Description**	**Exposure**	**Employment**
51-9191	Adhesive Bonding Machine Operators and Tenders	y	40
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	y	180
51-9198	Helpers--Production Workers	y	690
51-9199	Production Workers, All Other	y	1,140
53-0000	Transportation and Material Moving Occupations	n	18,570
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	y	580
53-3032	Heavy and Tractor-Trailer Truck Drivers	n	120
53-3033	Light Truck Drivers	n	120
53-7051	Industrial Truck and Tractor Operators	n	1,410
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	y	9,080
53-7064	Packers and Packagers, Hand	y	880
53-7065	Stockers and Order Fillers	y	2,110
		Total Potentially Exposed	**184,610**
		Percent of workers	**48.4%**

Table C-7: Exposure Designations for Occupations in NAICS 3362, Motor Vehicle Body and Trailer Manufacturing			
SOC Code	Description	Exposure	Employment
00-0000	All Occupations	n	155,080
11-0000	Management Occupations	n	5,420
11-1021	General and Operations Managers	n	1,820
11-2022	Sales Managers	n	240
11-3031	Financial Managers	n	50
11-3051	Industrial Production Managers	y	1,170
11-3061	Purchasing Managers	n	60
11-3121	Human Resources Managers	n	80
11-9041	Architectural and Engineering Managers	n	180
13-0000	Business and Financial Operations Occupations	n	3,770
13-1020	Buyers and Purchasing Agents	n	1,250
13-1071	Human Resources Specialists	n	300
13-1081	Logisticians	n	40
13-1151	Training and Development Specialists	n	0
13-1161	Market Research Analysts and Marketing Specialists	n	50
13-2011	Accountants and Auditors	n	410
15-0000	Computer and Mathematical Occupations	n	430
15-1211	Computer Systems Analysts	n	50
15-1232	Computer User Support Specialists	n	140
17-0000	Architecture and Engineering Occupations	n	3,580
17-2112	Industrial Engineers	n	1,100
17-2141	Mechanical Engineers	n	970
17-2199	Engineers, All Other	n	50
17-3013	Mechanical Drafters	n	360
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	n	30
17-3026	Industrial Engineering Technologists and Technicians	n	70
19-0000	Life, Physical, and Social Science Occupations	n	80
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	n	140
27-1024	Graphic Designers	n	40
33-0000	Protective Service Occupations	n	100
33-9032	Security Guards	n	100
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	410
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	350
37-3011	Landscaping and Groundskeeping Workers	n	30
41-0000	Sales and Related Occupations	n	3,740
41-2022	Parts Salespersons	n	50
41-2031	Retail Salespersons	n	80
41-4011	Sales Reps, Wholesale and Manufacturing, Technical and Scientific Products	n	50
41-4012	Sales Reps, Wholesale and Manuf, Except Tech and Scientific Products	n	2,850
43-0000	Office and Administrative Support Occupations	n	9,840
43-1011	First-Line Supervisors of Office and Administrative Support Workers	n	210
43-3021	Billing and Posting Clerks	n	60
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	590
43-4051	Customer Service Representatives	n	1,050
43-5061	Production, Planning, and Expediting Clerks	n	880
43-5071	Shipping, Receiving, and Inventory Clerks	n	2,360
43-6014	Secretaries and Admin Assistants, Except Legal, Medical, and Executive	n	190
43-9061	Office Clerks, General	n	1,430
47-0000	Construction and Extraction Occupations	n	3,990

Table C-7: Exposure Designations for Occupations in NAICS 3362, Motor Vehicle Body and Trailer Manufacturing			
SOC Code	Description	Exposure	Employment
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	n	70
47-2031	Carpenters	n	700
47-2111	Electricians	n	840
47-2152	Plumbers, Pipefitters, and Steamfitters	n	550
47-2211	Sheet Metal Workers	n	1,380
49-0000	Installation, Maintenance, and Repair Occupations	n	6,820
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	n	220
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	n	0
49-3021	Automotive Body and Related Repairers	n	100
49-3023	Automotive Service Technicians and Mechanics	n	40
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	n	170
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	n	80
49-3092	Recreational Vehicle Service Technicians	n	410
49-9041	Industrial Machinery Mechanics	n	640
49-9043	Maintenance Workers, Machinery	n	30
49-9071	Maintenance and Repair Workers, General	n	1,870
49-9098	Helpers--Installation, Maintenance, and Repair Workers	n	80
51-0000	Production Occupations	n	104,710
51-1011	First-Line Supervisors of Production and Operating Workers	y	5,640
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	y	740
51-2041	Structural Metal Fabricators and Fitters	n	1,740
51-2051	Fiberglass Laminators and Fabricators	n	1,010
51-2090	Miscellaneous Assemblers and Fabricators	y	43,950
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	y	3,030
51-4033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	400
51-4041	Machinists	y	380
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	570
51-4111	Tool and Die Makers	n	160
51-4121	Welders, Cutters, Solderers, and Brazers	y	23,770
51-4122	Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders	y	660
51-7011	Cabinetmakers and Bench Carpenters	n	2,500
51-7041	Sawing Machine Setters, Operators, and Tenders, Wood	n	60
51-9022	Grinding and Polishing Workers, Hand	y	40
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	y	90
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	3,240
51-9123	Painting, Coating, and Decorating Workers	n	90
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	n	5,680
51-9161	Computer Numerically Controlled Tool Operators	n	460
51-9162	Computer Numerically Controlled Tool Programmers	n	30
51-9198	Helpers--Production Workers	y	1,890
51-9199	Production Workers, All Other	y	300
53-0000	Transportation and Material Moving Occupations	n	8,790
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	n	100
53-3032	Heavy and Tractor-Trailer Truck Drivers	n	670
53-3033	Light Truck Drivers	n	190

Table C-7: Exposure Designations for Occupations in NAICS 3362, Motor Vehicle Body and Trailer Manufacturing			
SOC Code	**Description**	**Exposure**	**Employment**
53-7051	Industrial Truck and Tractor Operators	n	1,470
53-7061	Cleaners of Vehicles and Equipment	n	260
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	y	3,290
53-7065	Stockers and Order Fillers	y	460
	Total Potentially Exposed		**89,620**
	Percent of workers		**57.8%**

Table C-8: Exposure Designations for Occupations in NAICS 3363, Motor Vehicle Parts Manufacturing			
SOC Code	Description	Exposure	Employment
00-0000	All Occupations	n	537,590
11-0000	Management Occupations	n	22,910
11-1011	Chief Executives	n	120
11-1021	General and Operations Managers	n	4,320
11-2021	Marketing Managers	n	130
11-2022	Sales Managers	n	710
11-3012	Administrative Services Managers	n	190
11-3013	Facilities Managers	n	310
11-3021	Computer and Information Systems Managers	n	360
11-3031	Financial Managers	n	1,120
11-3051	Industrial Production Managers	y	7,570
11-3061	Purchasing Managers	n	570
11-3071	Transportation, Storage, and Distribution Managers	y	280
11-3121	Human Resources Managers	n	800
11-9041	Architectural and Engineering Managers	n	2,890
11-9199	Managers, All Other	n	550
13-0000	Business and Financial Operations Occupations	n	17,600
13-1020	Buyers and Purchasing Agents	n	3,210
13-1041	Compliance Officers	n	70
13-1051	Cost Estimators	n	130
13-1071	Human Resources Specialists	n	2,700
13-1081	Logisticians	n	1,720
13-1082	Project Management Specialists	n	1,440
13-1111	Management Analysts	n	270
13-1141	Compensation, Benefits, and Job Analysis Specialists	n	60
13-1151	Training and Development Specialists	n	720
13-1161	Market Research Analysts and Marketing Specialists	n	450
13-1199	Business Operations Specialists, All Other	n	1,070
13-2011	Accountants and Auditors	n	2,360
13-2051	Financial and Investment Analysts	n	360
15-0000	Computer and Mathematical Occupations	n	4,470
15-1211	Computer Systems Analysts	n	420
15-1231	Computer Network Support Specialists	n	50
15-1232	Computer User Support Specialists	n	730
15-1244	Network and Computer Systems Administrators	n	700
15-1251	Computer Programmers	n	40
15-1252	Software Developers	n	1,080
15-1253	Software Quality Assurance Analysts and Testers	n	50
15-1299	Computer Occupations, All Other	n	70
17-0000	Architecture and Engineering Occupations	n	35,720
17-2071	Electrical Engineers	n	940
17-2072	Electronics Engineers, Except Computer	n	300
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	n	70
17-2112	Industrial Engineers	n	15,820
17-2131	Materials Engineers	n	250
17-2141	Mechanical Engineers	n	7,240
17-2199	Engineers, All Other	n	420
17-3013	Mechanical Drafters	n	440
17-3023	Electrical and Electronic Engineering Technologists and Technicians	n	220

Table C-8: Exposure Designations for Occupations in NAICS 3363, Motor Vehicle Parts Manufacturing			
SOC Code	Description	Exposure	Employment
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	n	160
17-3026	Industrial Engineering Technologists and Technicians	n	2,630
17-3027	Mechanical Engineering Technologists and Technicians	n	1,690
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	n	840
19-0000	Life, Physical, and Social Science Occupations	n	880
19-5011	Occupational Health and Safety Specialists	n	460
19-5012	Occupational Health and Safety Technicians	n	40
23-0000	Legal Occupations	n	80
23-1011	Lawyers	n	70
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	n	320
27-1021	Commercial and Industrial Designers	n	40
29-0000	Healthcare Practitioners and Technical Occupations	n	60
29-1141	Registered Nurses	n	60
33-0000	Protective Service Occupations	n	120
33-9032	Security Guards	n	110
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	770
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	730
41-0000	Sales and Related Occupations	n	5,380
41-1012	First-Line Supervisors of Non-Retail Sales Workers	n	110
41-2022	Parts Salespersons	n	70
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	n	0
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	n	0
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	n	4,120
41-9031	Sales Engineers	n	60
43-0000	Office and Administrative Support Occupations	n	28,850
43-1011	First-Line Supervisors of Office and Administrative Support Workers	n	1,540
43-3021	Billing and Posting Clerks	n	120
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	2,020
43-3051	Payroll and Timekeeping Clerks	n	100
43-3061	Procurement Clerks	n	50
43-4051	Customer Service Representatives	n	2,150
43-4151	Order Clerks	n	80
43-4161	Human Resources Assistants, Except Payroll and Timekeeping	n	100
43-4171	Receptionists and Information Clerks	n	30
43-5061	Production, Planning, and Expediting Clerks	n	6,380
43-5071	Shipping, Receiving, and Inventory Clerks	n	7,840
43-5111	Weighers, Measurers, Checkers, and Samplers, Recordkeeping	n	50
43-6011	Executive Secretaries and Executive Administrative Assistants	n	230
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	n	1,260
43-9021	Data Entry Keyers	n	40
43-9061	Office Clerks, General	n	3,390
47-0000	Construction and Extraction Occupations	n	4,900
47-2031	Carpenters	n	50
47-2111	Electricians	n	3,660
47-2152	Plumbers, Pipefitters, and Steamfitters	n	710
47-2211	Sheet Metal Workers	n	0
49-0000	Installation, Maintenance, and Repair Occupations	n	30,240

Table C-8: Exposure Designations for Occupations in NAICS 3363, Motor Vehicle Parts Manufacturing			
SOC Code	Description	Exposure	Employment
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	n	2,400
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	n	150
49-3023	Automotive Service Technicians and Mechanics	n	640
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	n	210
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	n	50
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	n	130
49-9041	Industrial Machinery Mechanics	n	11,590
49-9043	Maintenance Workers, Machinery	n	3,220
49-9044	Millwrights	n	1,380
49-9071	Maintenance and Repair Workers, General	n	8,020
51-0000	Production Occupations	n	344,500
51-1011	First-Line Supervisors of Production and Operating Workers	y	20,920
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	y	11,840
51-2031	Engine and Other Machine Assemblers	y	17,160
51-2041	Structural Metal Fabricators and Fitters	y	40
51-2051	Fiberglass Laminators and Fabricators	n	60
51-2090	Miscellaneous Assemblers and Fabricators	y	119,550
51-4021	Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic	y	210
51-4022	Forging Machine Setters, Operators, and Tenders, Metal and Plastic	y	110
51-4023	Rolling Machine Setters, Operators, and Tenders, Metal and Plastic	y	130
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	y	32,200
51-4032	Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	150
51-4033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	2,770
51-4034	Lathe and Turning Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	930
51-4035	Milling and Planing Machine Setters, Operators, and Tenders, Metal and Plastic	y	40
51-4041	Machinists	y	15,470
51-4051	Metal-Refining Furnace Operators and Tenders	y	200
51-4061	Model Makers, Metal and Plastic	y	180
51-4071	Foundry Mold and Coremakers	n	180
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	y	8,440
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	17,940
51-4111	Tool and Die Makers	n	11,490
51-4121	Welders, Cutters, Solderers, and Brazers	y	11,250
51-4122	Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders	y	3,530
51-4191	Heat Treating Equipment Setters, Operators, and Tenders, Metal and Plastic	y	520
51-4193	Plating Machine Setters, Operators, and Tenders, Metal and Plastic	y	710
51-4194	Tool Grinders, Filers, and Sharpeners	y	180
51-4199	Metal Workers and Plastic Workers, All Other	y	80
51-6031	Sewing Machine Operators	y	1,430
51-6051	Sewers, Hand	y	40

Table C-8: Exposure Designations for Occupations in NAICS 3363, Motor Vehicle Parts Manufacturing			
SOC Code	Description	Exposure	Employment
51-6093	Upholsterers	y	1,920
51-7041	Sawing Machine Setters, Operators, and Tenders, Wood	n	50
51-7042	Woodworking Machine Setters, Operators, and Tenders, Except Sawing	n	370
51-8021	Stationary Engineers and Boiler Operators	n	50
51-8031	Water and Wastewater Treatment Plant and System Operators	n	30
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	y	370
51-9022	Grinding and Polishing Workers, Hand	y	0
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	y	120
51-9032	Cutting and Slicing Machine Setters, Operators, and Tenders	y	30
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	y	190
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	21,600
51-9111	Packaging and Filling Machine Operators and Tenders	y	530
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	n	2,840
51-9161	Computer Numerically Controlled Tool Operators	n	5,720
51-9162	Computer Numerically Controlled Tool Programmers	n	390
51-9192	Cleaning, Washing, and Metal Pickling Equipment Operators and Tenders	n	80
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	n	150
51-9198	Helpers--Production Workers	y	1,050
51-9199	Production Workers, All Other	y	2,520
53-0000	Transportation and Material Moving Occupations	n	34,700
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	y	910
53-3032	Heavy and Tractor-Trailer Truck Drivers	n	460
53-3033	Light Truck Drivers	n	100
53-7021	Crane and Tower Operators	n	50
53-7051	Industrial Truck and Tractor Operators	n	8,030
53-7061	Cleaners of Vehicles and Equipment	n	50
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	y	19,500
53-7063	Machine Feeders and Offbearers	y	170
53-7064	Packers and Packagers, Hand	y	1,680
53-7065	Stockers and Order Fillers	y	2,720
	Total Potentially Exposed		**327,180**
	Percent of workers		**60.9%**

Table C-9: Exposure Designations for Occupations in NAICS 3364, Aerospace Product and Parts Manufacturing			
SOC Code	Description	Exposure	Employment
00-0000	All Occupations	n	430,860
11-0000	Management Occupations	n	26,200
11-1011	Chief Executives	n	260
11-1021	General and Operations Managers	n	4,530
11-2021	Marketing Managers	n	460
11-2022	Sales Managers	n	700
11-3012	Administrative Services Managers	n	200
11-3013	Facilities Managers	n	200
11-3021	Computer and Information Systems Managers	n	2,220
11-3031	Financial Managers	n	1,240
11-3051	Industrial Production Managers	y	4,410
11-3061	Purchasing Managers	n	1,780
11-3071	Transportation, Storage, and Distribution Managers	y	260
11-3121	Human Resources Managers	n	440
11-9041	Architectural and Engineering Managers	n	5,470
11-9121	Natural Sciences Managers	n	40
11-9199	Managers, All Other	n	2,010
13-0000	Business and Financial Operations Occupations	n	36,670
13-1020	Buyers and Purchasing Agents	n	10,790
13-1041	Compliance Officers	n	590
13-1051	Cost Estimators	n	1,370
13-1071	Human Resources Specialists	n	2,250
13-1081	Logisticians	n	3,850
13-1082	Project Management Specialists	n	2,220
13-1111	Management Analysts	n	2,910
13-1141	Compensation, Benefits, and Job Analysis Specialists	n	90
13-1151	Training and Development Specialists	n	850
13-1161	Market Research Analysts and Marketing Specialists	n	680
13-1199	Business Operations Specialists, All Other	n	3,980
13-2011	Accountants and Auditors	n	2,280
13-2031	Budget Analysts	n	250
13-2051	Financial and Investment Analysts	n	1,850
13-2099	Financial Specialists, All Other	n	80
15-0000	Computer and Mathematical Occupations	n	26,090
15-1211	Computer Systems Analysts	n	7,460
15-1212	Information Security Analysts	n	1,500
15-1231	Computer Network Support Specialists	n	120
15-1232	Computer User Support Specialists	n	610
15-1241	Computer Network Architects	n	840
15-1242	Database Administrators	n	180
15-1244	Network and Computer Systems Administrators	n	420
15-1251	Computer Programmers	n	230
15-1252	Software Developers	n	11,680
15-1253	Software Quality Assurance Analysts and Testers	n	570
15-1299	Computer Occupations, All Other	n	620
15-2031	Operations Research Analysts	n	340
15-2051	Data Scientists	n	160
17-0000	Architecture and Engineering Occupations	n	76,940
17-2011	Aerospace Engineers	n	12,650
17-2051	Civil Engineers	n	560

Table C-9: Exposure Designations for Occupations in NAICS 3364, Aerospace Product and Parts Manufacturing			
SOC Code	Description	Exposure	Employment
17-2061	Computer Hardware Engineers	n	910
17-2071	Electrical Engineers	n	3,150
17-2072	Electronics Engineers, Except Computer	n	2,830
17-2081	Environmental Engineers	n	120
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	n	550
17-2112	Industrial Engineers	n	17,490
17-2131	Materials Engineers	n	780
17-2141	Mechanical Engineers	n	11,790
17-2199	Engineers, All Other	n	6,810
17-3013	Mechanical Drafters	n	540
17-3021	Aerospace Engineering and Operations Technologists and Technicians	n	3,090
17-3022	Civil Engineering Technologists and Technicians	n	0
17-3023	Electrical and Electronic Engineering Technologists and Technicians	n	1,570
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	n	30
17-3025	Environmental Engineering Technologists and Technicians	n	50
17-3026	Industrial Engineering Technologists and Technicians	n	2,150
17-3027	Mechanical Engineering Technologists and Technicians	n	940
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	n	1,170
19-0000	Life, Physical, and Social Science Occupations	n	1,560
19-2099	Physical Scientists, All Other	n	360
19-4031	Chemical Technicians	n	0
19-5011	Occupational Health and Safety Specialists	n	280
23-0000	Legal Occupations	n	210
23-1011	Lawyers	n	140
23-2011	Paralegals and Legal Assistants	n	30
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	n	1,620
27-1021	Commercial and Industrial Designers	n	60
27-1024	Graphic Designers	n	30
27-3031	Public Relations Specialists	n	80
27-3041	Editors	n	70
27-3042	Technical Writers	n	440
29-0000	Healthcare Practitioners and Technical Occupations	n	60
29-1229	Physicians, All Other	n	50
33-0000	Protective Service Occupations	n	480
33-1099	First-Line Supervisors of Protective Service Workers, All Other	n	40
33-9032	Security Guards	n	40
33-9099	Protective Service Workers, All Other	n	70
35-0000	Food Preparation and Serving Related Occupations	n	50
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	520
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	500
41-0000	Sales and Related Occupations	n	3,380
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	n	40
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	n	320
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	n	1,300
41-9031	Sales Engineers	n	60
41-9099	Sales and Related Workers, All Other	n	30
43-0000	Office and Administrative Support Occupations	n	25,250

Table C-9: Exposure Designations for Occupations in NAICS 3364, Aerospace Product and Parts Manufacturing			
SOC Code	Description	Exposure	Employment
43-1011	First-Line Supervisors of Office and Administrative Support Workers	n	1,090
43-3021	Billing and Posting Clerks	n	130
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	910
43-3051	Payroll and Timekeeping Clerks	n	60
43-3061	Procurement Clerks	n	470
43-4051	Customer Service Representatives	n	1,060
43-4151	Order Clerks	n	80
43-4161	Human Resources Assistants, Except Payroll and Timekeeping	n	90
43-4171	Receptionists and Information Clerks	n	50
43-5032	Dispatchers, Except Police, Fire, and Ambulance	n	120
43-5061	Production, Planning, and Expediting Clerks	n	6,110
43-5071	Shipping, Receiving, and Inventory Clerks	n	3,980
43-5111	Weighers, Measurers, Checkers, and Samplers, Recordkeeping	n	120
43-6011	Executive Secretaries and Executive Administrative Assistants	n	870
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	n	1,530
43-9061	Office Clerks, General	n	1,530
47-0000	Construction and Extraction Occupations	n	2,350
47-2111	Electricians	n	740
47-2141	Painters, Construction and Maintenance	n	110
47-2152	Plumbers, Pipefitters, and Steamfitters	n	120
47-2211	Sheet Metal Workers	n	330
49-0000	Installation, Maintenance, and Repair Occupations	n	19,770
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	n	810
49-2091	Avionics Technicians	n	2,370
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	n	310
49-3011	Aircraft Mechanics and Service Technicians	n	9,390
49-3023	Automotive Service Technicians and Mechanics	n	30
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	n	50
49-9041	Industrial Machinery Mechanics	n	1,900
49-9043	Maintenance Workers, Machinery	n	260
49-9071	Maintenance and Repair Workers, General	n	2,860
49-9099	Installation, Maintenance, and Repair Workers, All Other	n	40
51-0000	Production Occupations	n	152,460
51-1011	First-Line Supervisors of Production and Operating Workers	y	9,430
51-2011	Aircraft Structure, Surfaces, Rigging, and Systems Assemblers	y	17,570
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	y	2,180
51-2031	Engine and Other Machine Assemblers	y	750
51-2041	Structural Metal Fabricators and Fitters	y	190
51-2051	Fiberglass Laminators and Fabricators	y	870
51-2090	Miscellaneous Assemblers and Fabricators	y	14,990
51-4023	Rolling Machine Setters, Operators, and Tenders, Metal and Plastic	y	40
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	y	1,730
51-4032	Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	0
51-4033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	3,580

Table C-9: Exposure Designations for Occupations in NAICS 3364, Aerospace Product and Parts Manufacturing			
SOC Code	**Description**	**Exposure**	**Employment**
51-4034	Lathe and Turning Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	690
51-4035	Milling and Planing Machine Setters, Operators, and Tenders, Metal and Plastic	y	170
51-4041	Machinists	y	17,210
51-4061	Model Makers, Metal and Plastic	y	70
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	y	950
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	1,400
51-4111	Tool and Die Makers	n	1,160
51-4121	Welders, Cutters, Solderers, and Brazers	n	3,130
51-4122	Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders	n	120
51-4191	Heat Treating Equipment Setters, Operators, and Tenders, Metal and Plastic	y	260
51-4193	Plating Machine Setters, Operators, and Tenders, Metal and Plastic	y	170
51-4194	Tool Grinders, Filers, and Sharpeners	y	60
51-4199	Metal Workers and Plastic Workers, All Other	y	140
51-6093	Upholsterers	y	50
51-9022	Grinding and Polishing Workers, Hand	y	50
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	y	0
51-9051	Furnace, Kiln, Oven, Drier, and Kettle Operators and Tenders	n	130
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	21,390
51-9111	Packaging and Filling Machine Operators and Tenders	y	190
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	n	4,060
51-9161	Computer Numerically Controlled Tool Operators	n	10,070
51-9162	Computer Numerically Controlled Tool Programmers	n	1,670
51-9198	Helpers--Production Workers	y	730
51-9199	Production Workers, All Other	y	770
53-0000	Transportation and Material Moving Occupations	n	8,640
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	y	120
53-2012	Commercial Pilots	n	210
53-3032	Heavy and Tractor-Trailer Truck Drivers	n	310
53-3033	Light Truck Drivers	n	200
53-6051	Transportation Inspectors	n	770
53-7051	Industrial Truck and Tractor Operators	n	110
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	y	1,810
53-7065	Stockers and Order Fillers	y	1,440
	Total Potentially Exposed		**103,670**
	Percent of workers		**24.1%**

Table C-10: Exposure Designations for Occupations in NAICS 3369, Other Transportation Equipment Manufacturing			
SOC Code	Description	Exposure	Employment
00-0000	All Occupations	n	28,540
11-0000	Management Occupations	n	1,210
11-1021	General and Operations Managers	n	380
11-3051	Industrial Production Managers	y	90
13-0000	Business and Financial Operations Occupations	n	810
13-1020	Buyers and Purchasing Agents	n	140
13-1161	Market Research Analysts and Marketing Specialists	n	60
13-2011	Accountants and Auditors	n	30
15-0000	Computer and Mathematical Occupations	n	190
17-0000	Architecture and Engineering Occupations	n	1,740
17-2071	Electrical Engineers	n	40
17-2112	Industrial Engineers	n	230
17-2141	Mechanical Engineers	n	470
17-2199	Engineers, All Other	n	80
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	n	100
27-1021	Commercial and Industrial Designers	n	40
27-1024	Graphic Designers	n	50
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	40
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	40
41-0000	Sales and Related Occupations	n	560
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	n	400
43-0000	Office and Administrative Support Occupations	n	1,860
43-3021	Billing and Posting Clerks	n	30
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	50
43-4051	Customer Service Representatives	n	120
43-5061	Production, Planning, and Expediting Clerks	n	100
43-5071	Shipping, Receiving, and Inventory Clerks	n	160
43-9061	Office Clerks, General	n	0
49-0000	Installation, Maintenance, and Repair Occupations	n	2,330
49-3052	Motorcycle Mechanics	n	0
49-9041	Industrial Machinery Mechanics	n	100
49-9043	Maintenance Workers, Machinery	n	80
49-9071	Maintenance and Repair Workers, General	n	540
49-9099	Installation, Maintenance, and Repair Workers, All Other	n	50
51-0000	Production Occupations	n	14,840
51-1011	First-Line Supervisors of Production and Operating Workers	y	480
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	y	80
51-2031	Engine and Other Machine Assemblers	y	140
51-2041	Structural Metal Fabricators and Fitters	n	40
51-2090	Miscellaneous Assemblers and Fabricators	y	5,100
51-4033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	90
51-4041	Machinists	n	270
51-4121	Welders, Cutters, Solderers, and Brazers	y	1,960
51-6031	Sewing Machine Operators	n	220
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	460
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	n	260
51-9161	Computer Numerically Controlled Tool Operators	n	460

Table C-10: Exposure Designations for Occupations in NAICS 3369, Other Transportation Equipment Manufacturing			
SOC Code	**Description**	**Exposure**	**Employment**
51-9162	Computer Numerically Controlled Tool Programmers	n	40
53-0000	Transportation and Material Moving Occupations	n	1,500
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	n	60
53-3032	Heavy and Tractor-Trailer Truck Drivers	n	0
53-7051	Industrial Truck and Tractor Operators	n	130
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	y	760
53-7064	Packers and Packagers, Hand	y	50
53-7065	Stockers and Order Fillers	y	50
		Total Potentially Exposed	**9,260**
		Percent of workers	**32.4%**

Table C-11: Exposure Designations for Occupations in NAICS 4231, Motor Vehicle and Motor Vehicle Parts and Supplies Merchant Wholesalers			
SOC Code	Description	Exposure	Employment
00-0000	All Occupations	n	341,260
11-0000	Management Occupations	n	24,990
11-1011	Chief Executives	n	110
11-1021	General and Operations Managers	n	12,700
11-2021	Marketing Managers	n	520
11-2022	Sales Managers	n	3,300
11-3012	Administrative Services Managers	n	110
11-3021	Computer and Information Systems Managers	n	180
11-3031	Financial Managers	n	970
11-3051	Industrial Production Managers	y	40
11-3061	Purchasing Managers	n	210
11-3071	Transportation, Storage, and Distribution Managers	y	1,940
11-3121	Human Resources Managers	n	100
11-9041	Architectural and Engineering Managers	n	390
11-9199	Managers, All Other	n	340
13-0000	Business and Financial Operations Occupations	n	13,310
13-1020	Buyers and Purchasing Agents	n	2,700
13-1041	Compliance Officers	n	110
13-1051	Cost Estimators	n	40
13-1071	Human Resources Specialists	n	740
13-1081	Logisticians	n	190
13-1082	Project Management Specialists	n	480
13-1111	Management Analysts	n	60
13-1151	Training and Development Specialists	n	140
13-1161	Market Research Analysts and Marketing Specialists	n	1,490
13-1199	Business Operations Specialists, All Other	n	790
13-2011	Accountants and Auditors	n	2,240
13-2051	Financial and Investment Analysts	n	40
13-2072	Loan Officers	n	40
13-2099	Financial Specialists, All Other	n	70
15-0000	Computer and Mathematical Occupations	n	3,410
15-1211	Computer Systems Analysts	n	70
15-1212	Information Security Analysts	n	0
15-1231	Computer Network Support Specialists	n	30
15-1232	Computer User Support Specialists	n	470
15-1242	Database Administrators	n	60
15-1244	Network and Computer Systems Administrators	n	220
15-1252	Software Developers	n	250
15-1254	Web Developers	n	50
15-1299	Computer Occupations, All Other	n	110
15-2051	Data Scientists	n	40
17-0000	Architecture and Engineering Occupations	n	3,560
17-2071	Electrical Engineers	n	0
17-2072	Electronics Engineers, Except Computer	n	0
17-2112	Industrial Engineers	n	440
17-2141	Mechanical Engineers	n	1,220
17-2199	Engineers, All Other	n	40
17-3013	Mechanical Drafters	n	0
17-3027	Mechanical Engineering Technologists and Technicians	n	0
23-0000	Legal Occupations	n	100

Table C-11: Exposure Designations for Occupations in NAICS 4231, Motor Vehicle and Motor Vehicle Parts and Supplies Merchant Wholesalers			
SOC Code	Description	Exposure	Employment
23-1011	Lawyers	n	0
23-2093	Title Examiners, Abstractors, and Searchers	n	60
23-2099	Legal Support Workers, All Other	n	40
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	n	800
27-1024	Graphic Designers	n	270
27-4021	Photographers	n	90
33-0000	Protective Service Occupations	n	60
33-9032	Security Guards	n	0
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	790
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	710
41-0000	Sales and Related Occupations	n	71,490
41-1011	First-Line Supervisors of Retail Sales Workers	n	2,980
41-1012	First-Line Supervisors of Non-Retail Sales Workers	n	3,020
41-2011	Cashiers	n	230
41-2021	Counter and Rental Clerks	n	3,450
41-2022	Parts Salespersons	n	21,000
41-2031	Retail Salespersons	n	4,280
41-3031	Securities, Commodities, and Financial Services Sales Agents	n	40
41-3091	Sales Reps of Services, Except Ad, Insurance, Fin Services, and Travel	n	410
41-4011	Sales Reps, Wholesale and Manufacturing, Technical and Scientific Products	n	990
41-4012	Sales Reps, Wholesale and Manufacturing, Except Tech and Sci Products	n	30,790
41-9031	Sales Engineers	n	0
41-9041	Telemarketers	n	500
41-9099	Sales and Related Workers, All Other	n	430
43-0000	Office and Administrative Support Occupations	n	52,190
43-1011	First-Line Supervisors of Office and Administrative Support Workers	n	3,900
43-3011	Bill and Account Collectors	n	280
43-3021	Billing and Posting Clerks	n	140
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	6,710
43-3051	Payroll and Timekeeping Clerks	n	40
43-3061	Procurement Clerks	n	90
43-4051	Customer Service Representatives	n	8,270
43-4151	Order Clerks	n	1,220
43-4171	Receptionists and Information Clerks	n	610
43-5032	Dispatchers, Except Police, Fire, and Ambulance	n	460
43-5061	Production, Planning, and Expediting Clerks	n	1,050
43-5071	Shipping, Receiving, and Inventory Clerks	n	8,330
43-5111	Weighers, Measurers, Checkers, and Samplers, Recordkeeping	n	0
43-6011	Executive Secretaries and Executive Administrative Assistants	n	160
43-6014	Secretaries and Admin Assistants, Except Legal, Medical, and Executive	n	3,430
43-9021	Data Entry Keyers	n	30
43-9061	Office Clerks, General	n	9,740
43-9199	Office and Administrative Support Workers, All Other	n	420
47-0000	Construction and Extraction Occupations	n	30
49-0000	Installation, Maintenance, and Repair Occupations	n	52,090
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	n	4,870
49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	n	0
49-3021	Automotive Body and Related Repairers	n	1,660

Table C-11: Exposure Designations for Occupations in NAICS 4231, Motor Vehicle and Motor Vehicle Parts and Supplies Merchant Wholesalers			
SOC Code	**Description**	**Exposure**	**Employment**
49-3022	Automotive Glass Installers and Repairers	n	60
49-3023	Automotive Service Technicians and Mechanics	n	12,500
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	n	22,820
49-3092	Recreational Vehicle Service Technicians	n	170
49-3093	Tire Repairers and Changers	n	1,900
49-9041	Industrial Machinery Mechanics	n	0
49-9071	Maintenance and Repair Workers, General	n	1,220
49-9098	Helpers--Installation, Maintenance, and Repair Workers	n	30
49-9099	Installation, Maintenance, and Repair Workers, All Other	n	980
51-0000	Production Occupations	n	12,570
51-1011	First-Line Supervisors of Production and Operating Workers	y	710
51-2028	Electrical, Electronic, and Electromech Assemblers	y	90
51-2041	Structural Metal Fabricators and Fitters	y	120
51-2090	Miscellaneous Assemblers and Fabricators	y	3,100
51-4041	Machinists	y	220
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	0
51-4111	Tool and Die Makers	n	0
51-4121	Welders, Cutters, Solderers, and Brazers	n	1,170
51-5112	Printing Press Operators	n	0
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	1,370
51-9111	Packaging and Filling Machine Operators and Tenders	y	0
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	n	460
51-9198	Helpers--Production Workers	y	130
51-9199	Production Workers, All Other	y	40
53-0000	Transportation and Material Moving Occupations	n	100,070
53-1047	1st-Line Superv of Transp and Matl Moving Workers	y	4,940
53-3031	Driver/Sales Workers	n	6,230
53-3032	Heavy and Tractor-Trailer Truck Drivers	n	6,020
53-3033	Light Truck Drivers	n	28,700
53-3051	Bus Drivers, School	n	80
53-3053	Shuttle Drivers and Chauffeurs	n	0
53-3099	Motor Vehicle Operators, All Other	n	1,150
53-6021	Parking Attendants	n	390
53-6031	Automotive and Watercraft Service Attendants	n	0
53-7051	Industrial Truck and Tractor Operators	n	1,540
53-7061	Cleaners of Vehicles and Equipment	n	2,450
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	y	19,640
53-7064	Packers and Packagers, Hand	y	150
53-7065	Stockers and Order Fillers	y	20,410
53-7199	Material Moving Workers, All Other	y	360
	Total Potentially Exposed		**53,260**
	Percent of workers		**15.6%**

Table C-12: Exposure Designations for Occupations in NAICS 4238, Machinery, Equipment, and Supplies Merchant Wholesalers			
SOC Code	Description	Exposure	Employment
00-0000	All Occupations	n	680,330
11-0000	Management Occupations	n	59,100
11-1011	Chief Executives	n	830
11-1021	General and Operations Managers	n	34,150
11-2021	Marketing Managers	n	870
11-2022	Sales Managers	n	9,670
11-3012	Administrative Services Managers	n	560
11-3013	Facilities Managers	n	30
11-3021	Computer and Information Systems Managers	n	590
11-3031	Financial Managers	n	2,690
11-3051	Industrial Production Managers	y	860
11-3061	Purchasing Managers	n	550
11-3071	Transportation, Storage, and Distribution Managers	y	1,040
11-3121	Human Resources Managers	n	360
11-3131	Training and Development Managers	n	40
11-9041	Architectural and Engineering Managers	n	480
11-9141	Property, Real Estate, and Community Association Managers	n	0
11-9199	Managers, All Other	n	1,170
13-0000	Business and Financial Operations Occupations	n	31,630
13-1020	Buyers and Purchasing Agents	n	6,620
13-1041	Compliance Officers	n	360
13-1051	Cost Estimators	n	390
13-1071	Human Resources Specialists	n	2,200
13-1081	Logisticians	n	910
13-1082	Project Management Specialists	n	1,730
13-1111	Management Analysts	n	230
13-1141	Compensation, Benefits, and Job Analysis Specialists	n	40
13-1151	Training and Development Specialists	n	910
13-1161	Market Research Analysts and Marketing Specialists	n	3,570
13-1199	Business Operations Specialists, All Other	n	2,200
13-2011	Accountants and Auditors	n	7,020
13-2041	Credit Analysts	n	40
15-0000	Computer and Mathematical Occupations	n	9,990
15-1211	Computer Systems Analysts	n	200
15-1231	Computer Network Support Specialists	n	130
15-1232	Computer User Support Specialists	n	2,260
15-1242	Database Administrators	n	330
15-1244	Network and Computer Systems Administrators	n	930
15-1251	Computer Programmers	n	40
15-1252	Software Developers	n	2,570
15-1254	Web Developers	n	50
15-1255	Web and Digital Interface Designers	n	0
15-1299	Computer Occupations, All Other	n	190
15-2051	Data Scientists	n	40
17-0000	Architecture and Engineering Occupations	n	13,890
17-2011	Aerospace Engineers	n	0
17-2071	Electrical Engineers	n	80
17-2072	Electronics Engineers, Except Computer	n	60
17-2112	Industrial Engineers	n	1,500
17-2141	Mechanical Engineers	n	4,470

Table C-12: Exposure Designations for Occupations in NAICS 4238, Machinery, Equipment, and Supplies Merchant Wholesalers			
SOC Code	Description	Exposure	Employment
17-2199	Engineers, All Other	n	630
17-3011	Architectural and Civil Drafters	n	40
17-3013	Mechanical Drafters	n	150
17-3023	Electrical and Electronic Engineering Technologists and Technicians	n	100
17-3026	Industrial Engineering Technologists and Technicians	n	0
17-3027	Mechanical Engineering Technologists and Technicians	n	90
19-0000	Life, Physical, and Social Science Occupations	n	260
19-2031	Chemists	n	0
19-4031	Chemical Technicians	n	0
19-5011	Occupational Health and Safety Specialists	n	240
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	n	690
27-1021	Commercial and Industrial Designers	n	150
27-1024	Graphic Designers	n	140
27-3031	Public Relations Specialists	n	0
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	2,060
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	1,370
37-3011	Landscaping and Groundskeeping Workers	n	130
41-0000	Sales and Related Occupations	n	172,640
41-1011	First-Line Supervisors of Retail Sales Workers	n	4,510
41-1012	First-Line Supervisors of Non-Retail Sales Workers	n	8,320
41-2011	Cashiers	n	50
41-2021	Counter and Rental Clerks	n	4,730
41-2022	Parts Salespersons	n	23,220
41-2031	Retail Salespersons	n	6,630
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	n	1,180
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	n	7,670
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	n	105,820
41-9011	Demonstrators and Product Promoters	n	0
41-9031	Sales Engineers	n	1,540
41-9099	Sales and Related Workers, All Other	n	540
43-0000	Office and Administrative Support Occupations	n	112,930
43-1011	First-Line Supervisors of Office and Administrative Support Workers	n	8,080
43-3011	Bill and Account Collectors	n	350
43-3021	Billing and Posting Clerks	n	970
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	17,250
43-3051	Payroll and Timekeeping Clerks	n	100
43-3061	Procurement Clerks	n	520
43-3099	Financial Clerks, All Other	n	0
43-4041	Credit Authorizers, Checkers, and Clerks	n	40
43-4051	Customer Service Representatives	n	20,570
43-4071	File Clerks	n	50
43-4151	Order Clerks	n	2,180
43-4171	Receptionists and Information Clerks	n	2,020
43-5032	Dispatchers, Except Police, Fire, and Ambulance	n	800
43-5061	Production, Planning, and Expediting Clerks	n	2,760
43-5071	Shipping, Receiving, and Inventory Clerks	n	14,130
43-5111	Weighers, Measurers, Checkers, and Samplers, Recordkeeping	n	120
43-6011	Executive Secretaries and Executive Administrative Assistants	n	900

Table C-12: Exposure Designations for Occupations in NAICS 4238, Machinery, Equipment, and Supplies Merchant Wholesalers			
SOC Code	Description	Exposure	Employment
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	n	10,180
43-9021	Data Entry Keyers	n	130
43-9061	Office Clerks, General	n	23,430
43-9199	Office and Administrative Support Workers, All Other	n	670
47-0000	Construction and Extraction Occupations	n	1,390
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	n	30
47-2061	Construction Laborers	n	40
47-2111	Electricians	n	40
47-4021	Elevator and Escalator Installers and Repairers	n	0
47-5071	Roustabouts, Oil and Gas	n	0
49-0000	Installation, Maintenance, and Repair Occupations	n	147,530
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	n	12,640
49-2091	Avionics Technicians	n	120
49-2092	Electric Motor, Power Tool, and Related Repairers	n	40
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	n	70
49-2098	Security and Fire Alarm Systems Installers	n	420
49-3011	Aircraft Mechanics and Service Technicians	n	350
49-3023	Automotive Service Technicians and Mechanics	n	1,550
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	n	4,630
49-3041	Farm Equipment Mechanics and Service Technicians	n	25,240
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	n	36,910
49-3051	Motorboat Mechanics and Service Technicians	n	0
49-3053	Outdoor Power Equipment and Other Small Engine Mechanics	n	1,180
49-3093	Tire Repairers and Changers	n	0
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	n	800
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	n	0
49-9031	Home Appliance Repairers	n	0
49-9041	Industrial Machinery Mechanics	n	38,130
49-9043	Maintenance Workers, Machinery	n	790
49-9044	Millwrights	n	120
49-9071	Maintenance and Repair Workers, General	n	4,920
49-9096	Riggers	n	0
49-9098	Helpers--Installation, Maintenance, and Repair Workers	n	1,000
49-9099	Installation, Maintenance, and Repair Workers, All Other	n	4,540
51-0000	Production Occupations	n	40,750
51-1011	First-Line Supervisors of Production and Operating Workers	y	2,940
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	y	140
51-2031	Engine and Other Machine Assemblers	y	0
51-2041	Structural Metal Fabricators and Fitters	y	0
51-2090	Miscellaneous Assemblers and Fabricators	y	9,730
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	y	400
51-4033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	40
51-4041	Machinists	y	3,380
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	y	60
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	y	0

Table C-12: Exposure Designations for Occupations in NAICS 4238, Machinery, Equipment, and Supplies Merchant Wholesalers			
SOC Code	**Description**	**Exposure**	**Employment**
51-4121	Welders, Cutters, Solderers, and Brazers	y	5,760
51-5112	Printing Press Operators	n	50
51-6031	Sewing Machine Operators	n	0
51-9032	Cutting and Slicing Machine Setters, Operators, and Tenders	y	0
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	2,910
51-9111	Packaging and Filling Machine Operators and Tenders	y	50
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	y	620
51-9161	Computer Numerically Controlled Tool Operators	n	30
51-9162	Computer Numerically Controlled Tool Programmers	n	60
51-9198	Helpers--Production Workers	y	530
51-9199	Production Workers, All Other	y	350
53-0000	Transportation and Material Moving Occupations	n	80,030
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	y	4,950
53-3031	Driver/Sales Workers	n	750
53-3032	Heavy and Tractor-Trailer Truck Drivers	n	11,490
53-3033	Light Truck Drivers	n	11,040
53-7021	Crane and Tower Operators	n	0
53-7051	Industrial Truck and Tractor Operators	n	3,630
53-7061	Cleaners of Vehicles and Equipment	n	640
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	y	24,450
53-7064	Packers and Packagers, Hand	y	620
53-7065	Stockers and Order Fillers	y	15,330
53-7071	Gas Compressor and Gas Pumping Station Operators	n	130
		Total Potentially Exposed	**74,160**
		Percent of workers	**10.9%**

Table C-13: Exposure Designations for Occupations in NAICS 424, Merchant Wholesalers, Nondurable Goods			
SOC Code	Description	Exposure	Employment
00-0000	All Occupations	n	2,044,840
11-0000	Management Occupations	n	173,720
11-1011	Chief Executives	n	3,600
11-1021	General and Operations Managers	n	76,690
11-2011	Advertising and Promotions Managers	n	40
11-2021	Marketing Managers	n	8,850
11-2022	Sales Managers	n	35,370
11-2032	Public Relations Managers	n	180
11-3012	Administrative Services Managers	n	2,650
11-3013	Facilities Managers	n	760
11-3021	Computer and Information Systems Managers	n	3,220
11-3031	Financial Managers	n	9,980
11-3051	Industrial Production Managers	y	3,610
11-3061	Purchasing Managers	n	2,640
11-3071	Transportation, Storage, and Distribution Managers	y	9,730
11-3121	Human Resources Managers	n	2,340
11-3131	Training and Development Managers	n	490
11-9013	Farmers, Ranchers, and Other Agricultural Managers	n	270
11-9041	Architectural and Engineering Managers	n	30
11-9111	Medical and Health Services Managers	n	930
11-9121	Natural Sciences Managers	n	810
11-9141	Property, Real Estate, and Community Association Managers	n	190
11-9199	Managers, All Other	n	4,800
13-0000	Business and Financial Operations Occupations	n	114,470
13-1020	Buyers and Purchasing Agents	n	22,800
13-1041	Compliance Officers	n	3,620
13-1051	Cost Estimators	n	280
13-1071	Human Resources Specialists	n	8,600
13-1081	Logisticians	n	8,560
13-1082	Project Management Specialists	n	2,900
13-1111	Management Analysts	n	3,610
13-1121	Meeting, Convention, and Event Planners	n	140
13-1141	Compensation, Benefits, and Job Analysis Specialists	n	290
13-1151	Training and Development Specialists	n	3,300
13-1161	Market Research Analysts and Marketing Specialists	n	21,230
13-1199	Business Operations Specialists, All Other	n	11,480
13-2011	Accountants and Auditors	n	19,820
13-2041	Credit Analysts	n	430
13-2051	Financial and Investment Analysts	n	1,360
13-2054	Financial Risk Specialists	n	50
13-2099	Financial Specialists, All Other	n	440
15-0000	Computer and Mathematical Occupations	n	23,490
15-1211	Computer Systems Analysts	n	1,910
15-1212	Information Security Analysts	n	30
15-1231	Computer Network Support Specialists	n	400
15-1232	Computer User Support Specialists	n	5,040
15-1241	Computer Network Architects	n	240
15-1242	Database Administrators	n	550
15-1243	Database Architects	n	100
15-1244	Network and Computer Systems Administrators	n	2,420

Table C-13: Exposure Designations for Occupations in NAICS 424, Merchant Wholesalers, Nondurable Goods			
SOC Code	Description	Exposure	Employment
15-1251	Computer Programmers	n	390
15-1252	Software Developers	n	2,800
15-1253	Software Quality Assurance Analysts and Testers	n	60
15-1254	Web Developers	n	710
15-1255	Web and Digital Interface Designers	n	460
15-1299	Computer Occupations, All Other	n	2,070
15-2031	Operations Research Analysts	n	480
15-2051	Data Scientists	n	430
17-0000	Architecture and Engineering Occupations	n	4,830
17-2031	Bioengineers and Biomedical Engineers	n	0
17-2041	Chemical Engineers	n	120
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	n	90
17-2112	Industrial Engineers	n	1,380
17-2171	Petroleum Engineers	n	370
17-2199	Engineers, All Other	n	90
19-0000	Life, Physical, and Social Science Occupations	n	13,320
19-1011	Animal Scientists	n	0
19-1012	Food Scientists and Technologists	n	300
19-1013	Soil and Plant Scientists	n	1,300
19-1021	Biochemists and Biophysicists	n	120
19-1042	Medical Scientists, Except Epidemiologists	n	820
19-2031	Chemists	n	1,640
19-2041	Environmental Scientists and Specialists, Including Health	n	0
19-4012	Agricultural Technicians	n	730
19-4013	Food Science Technicians	n	170
19-4031	Chemical Technicians	n	1,460
19-4099	Life, Physical, and Social Science Technicians, All Other	n	50
19-5011	Occupational Health and Safety Specialists	n	650
19-5012	Occupational Health and Safety Technicians	n	60
21-0000	Community and Social Service Occupations	n	50
21-1091	Health Education Specialists	n	0
23-0000	Legal Occupations	n	870
23-1011	Lawyers	n	710
23-2011	Paralegals and Legal Assistants	n	30
25-0000	Educational Instruction and Library Occupations	n	280
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	n	66,390
27-1011	Art Directors	n	460
27-1021	Commercial and Industrial Designers	n	200
27-1022	Fashion Designers	n	7,020
27-1023	Floral Designers	n	300
27-1024	Graphic Designers	n	7,720
27-1025	Interior Designers	n	0
27-1026	Merchandise Displayers and Window Trimmers	n	44,300
27-1029	Designers, All Other	n	320
27-3031	Public Relations Specialists	n	1,570
27-3041	Editors	n	110
27-3042	Technical Writers	n	50
27-3043	Writers and Authors	n	70
27-4021	Photographers	n	40

Table C-13: Exposure Designations for Occupations in NAICS 424, Merchant Wholesalers, Nondurable Goods			
SOC Code	Description	Exposure	Employment
27-4031	Camera Operators, Television, Video, and Film	n	0
29-0000	Healthcare Practitioners and Technical Occupations	n	17,580
29-1051	Pharmacists	n	4,570
29-1141	Registered Nurses	n	370
29-1299	Healthcare Diagnosing or Treating Practitioners, All Other	n	50
29-2010	Clinical Laboratory Technologists and Technicians	n	0
29-2052	Pharmacy Technicians	n	8,520
29-2072	Medical Records Specialists	n	100
33-0000	Protective Service Occupations	n	690
33-9032	Security Guards	n	630
35-0000	Food Preparation and Serving Related Occupations	n	5,820
35-1012	First-Line Supervisors of Food Preparation and Serving Workers	n	260
35-2012	Cooks, Institution and Cafeteria	n	150
35-2014	Cooks, Restaurant	n	40
35-2015	Cooks, Short Order	n	60
35-2021	Food Preparation Workers	n	1,710
35-3011	Bartenders	n	250
35-3023	Fast Food and Counter Workers	n	1,470
35-3031	Waiters and Waitresses	n	90
35-9021	Dishwashers	n	0
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	17,290
37-1011	First-Line Supervisors of Housekeeping and Janitorial Workers	n	50
37-1012	First-Line Supervisors of Landscaping, Lawn Service, and Groundskeeping Workers	n	90
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	8,360
37-2012	Maids and Housekeeping Cleaners	n	40
37-3011	Landscaping and Groundskeeping Workers	n	390
37-3012	Pesticide Handlers, Sprayers, and Applicators, Vegetation	n	6,360
39-0000	Personal Care and Service Occupations	n	220
39-2021	Animal Caretakers	n	50
39-5012	Hairdressers, Hairstylists, and Cosmetologists	n	0
41-0000	Sales and Related Occupations	n	380,680
41-1011	First-Line Supervisors of Retail Sales Workers	n	4,550
41-1012	First-Line Supervisors of Non-Retail Sales Workers	n	23,130
41-2011	Cashiers	n	10,350
41-2021	Counter and Rental Clerks	n	320
41-2022	Parts Salespersons	n	90
41-2031	Retail Salespersons	n	18,480
41-3031	Securities, Commodities, and Financial Services Sales Agents	n	50
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	n	5,420
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	n	47,230
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	n	259,610
41-9011	Demonstrators and Product Promoters	n	1,050
41-9031	Sales Engineers	n	280
41-9041	Telemarketers	n	340
41-9099	Sales and Related Workers, All Other	n	3,880
43-0000	Office and Administrative Support Occupations	n	308,280
43-1011	First-Line Supervisors of Office and Administrative Support Workers	n	26,030

Table C-13: Exposure Designations for Occupations in NAICS 424, Merchant Wholesalers, Nondurable Goods			
SOC Code	Description	Exposure	Employment
43-3011	Bill and Account Collectors	n	1,890
43-3021	Billing and Posting Clerks	n	5,920
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	41,560
43-3051	Payroll and Timekeeping Clerks	n	1,290
43-3061	Procurement Clerks	n	2,590
43-3099	Financial Clerks, All Other	n	30
43-4041	Credit Authorizers, Checkers, and Clerks	n	220
43-4051	Customer Service Representatives	n	56,050
43-4071	File Clerks	n	60
43-4111	Interviewers, Except Eligibility and Loan	n	100
43-4151	Order Clerks	n	10,740
43-4161	Human Resources Assistants, Except Payroll and Timekeeping	n	800
43-4171	Receptionists and Information Clerks	n	3,900
43-4199	Information and Record Clerks, All Other	n	70
43-5011	Cargo and Freight Agents	n	90
43-5021	Couriers and Messengers	n	0
43-5032	Dispatchers, Except Police, Fire, and Ambulance	n	4,130
43-5061	Production, Planning, and Expediting Clerks	n	10,730
43-5071	Shipping, Receiving, and Inventory Clerks	n	46,710
43-5111	Weighers, Measurers, Checkers, and Samplers, Recordkeeping	n	3,070
43-6011	Executive Secretaries and Executive Administrative Assistants	n	4,270
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	n	24,810
43-9021	Data Entry Keyers	n	2,500
43-9051	Mail Clerks and Mail Machine Operators, Except Postal Service	n	90
43-9061	Office Clerks, General	n	51,320
43-9199	Office and Administrative Support Workers, All Other	n	730
45-0000	Farming, Fishing, and Forestry Occupations	n	38,820
45-1011	First-Line Supervisors of Farming, Fishing, and Forestry Workers	n	2,070
45-2011	Agricultural Inspectors	n	480
45-2041	Graders and Sorters, Agricultural Products	n	1,980
45-2091	Agricultural Equipment Operators	n	6,730
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	n	17,100
45-2093	Farmworkers, Farm, Ranch, and Aquacultural Animals	n	7,240
45-2099	Agricultural Workers, All Other	n	390
47-0000	Construction and Extraction Occupations	n	1,700
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	n	40
47-2111	Electricians	n	90
47-2152	Plumbers, Pipefitters, and Steamfitters	n	80
47-5032	Explosives Workers, Ordnance Handling Experts, and Blasters	n	150
47-5071	Roustabouts, Oil and Gas	n	0
49-0000	Installation, Maintenance, and Repair Occupations	n	44,670
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	n	3,270
49-2011	Computer, Automated Teller, and Office Machine Repairers	n	60
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	n	40
49-3023	Automotive Service Technicians and Mechanics	n	680
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	n	6,190
49-3041	Farm Equipment Mechanics and Service Technicians	n	550
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	n	360
49-3053	Outdoor Power Equipment and Other Small Engine Mechanics	n	40

Table C-13: Exposure Designations for Occupations in NAICS 424, Merchant Wholesalers, Nondurable Goods			
SOC Code	Description	Exposure	Employment
49-3093	Tire Repairers and Changers	n	170
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	n	180
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	n	630
49-9031	Home Appliance Repairers	n	90
49-9041	Industrial Machinery Mechanics	n	3,920
49-9043	Maintenance Workers, Machinery	n	470
49-9071	Maintenance and Repair Workers, General	n	15,360
49-9091	Coin, Vending, and Amusement Machine Servicers and Repairers	n	2,120
49-9098	Helpers--Installation, Maintenance, and Repair Workers	n	40
49-9099	Installation, Maintenance, and Repair Workers, All Other	n	2,920
51-0000	Production Occupations	n	98,320
51-1011	First-Line Supervisors of Production and Operating Workers	y	9,710
51-2090	Miscellaneous Assemblers and Fabricators	y	6,520
51-3011	Bakers	n	650
51-3021	Butchers and Meat Cutters	n	2,900
51-3022	Meat, Poultry, and Fish Cutters and Trimmers	n	3,230
51-3023	Slaughterers and Meat Packers	n	1,060
51-3091	Food and Tobacco Roasting, Baking, and Drying Machine Operators and Tenders	n	440
51-3092	Food Batchmakers	n	1,790
51-3093	Food Cooking Machine Operators and Tenders	n	210
51-3099	Food Processing Workers, All Other	n	1,000
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	y	0
51-4041	Machinists	y	210
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	y	60
51-4121	Welders, Cutters, Solderers, and Brazers	y	630
51-5112	Printing Press Operators	n	2,010
51-6031	Sewing Machine Operators	n	2,390
51-6042	Shoe Machine Operators and Tenders	n	90
51-6051	Sewers, Hand	n	0
51-6052	Tailors, Dressmakers, and Custom Sewers	n	0
51-6062	Textile Cutting Machine Setters, Operators, and Tenders	n	80
51-6092	Fabric and Apparel Patternmakers	n	0
51-6099	Textile, Apparel, and Furnishings Workers, All Other	n	70
51-8092	Gas Plant Operators	n	90
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	n	1,420
51-8099	Plant and System Operators, All Other	y	0
51-9011	Chemical Equipment Operators and Tenders	y	120
51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	y	480
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	y	870
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	y	5,370
51-9031	Cutters and Trimmers, Hand	y	0
51-9032	Cutting and Slicing Machine Setters, Operators, and Tenders	y	140
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	y	40
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	9,420
51-9111	Packaging and Filling Machine Operators and Tenders	y	15,400

Table C-13: Exposure Designations for Occupations in NAICS 424, Merchant Wholesalers, Nondurable Goods			
SOC Code	**Description**	**Exposure**	**Employment**
51-9161	Computer Numerically Controlled Tool Operators	n	250
51-9193	Cooling and Freezing Equipment Operators and Tenders	n	130
51-9196	Paper Goods Machine Setters, Operators, and Tenders	n	860
51-9198	Helpers--Production Workers	y	300
51-9199	Production Workers, All Other	y	2,500
53-0000	Transportation and Material Moving Occupations	n	721,890
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	y	44,470
53-2012	Commercial Pilots	n	80
53-3031	Driver/Sales Workers	n	87,540
53-3032	Heavy and Tractor-Trailer Truck Drivers	n	152,790
53-3033	Light Truck Drivers	n	61,600
53-3053	Shuttle Drivers and Chauffeurs	n	180
53-3099	Motor Vehicle Operators, All Other	n	60
53-6031	Automotive and Watercraft Service Attendants	n	220
53-6099	Transportation Workers, All Other	n	240
53-7011	Conveyor Operators and Tenders	n	3,400
53-7051	Industrial Truck and Tractor Operators	n	33,510
53-7061	Cleaners of Vehicles and Equipment	n	1,660
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	y	160,380
53-7064	Packers and Packagers, Hand	y	31,240
53-7065	Stockers and Order Fillers	y	135,520
53-7071	Gas Compressor and Gas Pumping Station Operators	n	110
53-7072	Pump Operators, Except Wellhead Pumpers	n	330
53-7073	Wellhead Pumpers	n	0
53-7121	Tank Car, Truck, and Ship Loaders	y	970
53-7199	Material Moving Workers, All Other	y	0
	Total Potentially Exposed		**437,690**
	Percent of workers		**21.4%**

Table C- 14: Exposure Designations for Occupations in NAICS 532, Rental and Leasing Services			
SOC Code	Description	Exposure	Employment
00-0000	All Occupations	n	470,960
11-0000	Management Occupations	n	40,910
11-1011	Chief Executives	n	250
11-1021	General and Operations Managers	n	27,130
11-2021	Marketing Managers	n	550
11-2022	Sales Managers	n	2,380
11-3012	Administrative Services Managers	n	210
11-3013	Facilities Managers	n	0
11-3021	Computer and Information Systems Managers	n	190
11-3031	Financial Managers	n	870
11-3061	Purchasing Managers	n	30
11-3071	Transportation, Storage, and Distribution Managers	y	4,520
11-3121	Human Resources Managers	n	110
11-9021	Construction Managers	n	60
11-9141	Property, Real Estate, and Community Association Managers	n	80
11-9199	Managers, All Other	n	940
13-0000	Business and Financial Operations Occupations	n	14,050
13-1020	Buyers and Purchasing Agents	n	910
13-1041	Compliance Officers	n	190
13-1051	Cost Estimators	n	50
13-1071	Human Resources Specialists	n	460
13-1081	Logisticians	n	610
13-1082	Project Management Specialists	n	630
13-1111	Management Analysts	n	140
13-1121	Meeting, Convention, and Event Planners	n	0
13-1151	Training and Development Specialists	n	280
13-1161	Market Research Analysts and Marketing Specialists	n	580
13-1199	Business Operations Specialists, All Other	n	2,290
13-2011	Accountants and Auditors	n	2,930
13-2041	Credit Analysts	n	0
15-0000	Computer and Mathematical Occupations	n	2,240
15-1232	Computer User Support Specialists	n	670
15-1244	Network and Computer Systems Administrators	n	110
15-1251	Computer Programmers	n	0
15-1252	Software Developers	n	270
15-1299	Computer Occupations, All Other	n	100
17-0000	Architecture and Engineering Occupations	n	310
17-2071	Electrical Engineers	n	0
17-2141	Mechanical Engineers	n	40
17-2199	Engineers, All Other	n	30
19-0000	Life, Physical, and Social Science Occupations	n	230
19-5011	Occupational Health and Safety Specialists	n	190
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	n	8,970
27-1024	Graphic Designers	n	0
27-3031	Public Relations Specialists	n	150
27-4011	Audio and Video Technicians	n	7,000
27-4014	Sound Engineering Technicians	n	0
27-4015	Lighting Technicians	n	30
27-4099	Media and Communication Equipment Workers, All Other	n	0
29-0000	Healthcare Practitioners and Technical Occupations	n	2,230

Table C- 14: Exposure Designations for Occupations in NAICS 532, Rental and Leasing Services			
SOC Code	Description	Exposure	Employment
29-1126	Respiratory Therapists	n	1,790
29-1141	Registered Nurses	n	40
29-2099	Health Technologists and Technicians, All Other	n	0
31-0000	Healthcare Support Occupations	n	140
31-9093	Medical Equipment Preparers	n	130
33-0000	Protective Service Occupations	n	0
33-9032	Security Guards	n	0
35-0000	Food Preparation and Serving Related Occupations	n	280
35-3011	Bartenders	n	40
35-9021	Dishwashers	n	100
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	4,260
37-1012	First-Line Supervisors of Landscaping, Lawn Service, and Groundskeeping Workers	n	70
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	3,610
37-2012	Maids and Housekeeping Cleaners	n	40
37-3011	Landscaping and Groundskeeping Workers	n	30
39-0000	Personal Care and Service Occupations	n	1,030
39-3091	Amusement and Recreation Attendants	n	610
39-7010	Tour and Travel Guides	n	0
39-9032	Recreation Workers	n	150
41-0000	Sales and Related Occupations	n	128,730
41-1011	First-Line Supervisors of Retail Sales Workers	n	14,180
41-1012	First-Line Supervisors of Non-Retail Sales Workers	n	1,270
41-2011	Cashiers	n	350
41-2021	Counter and Rental Clerks	n	84,670
41-2022	Parts Salespersons	n	990
41-2031	Retail Salespersons	n	5,550
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	n	12,140
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	n	530
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	n	6,880
41-9099	Sales and Related Workers, All Other	n	370
43-0000	Office and Administrative Support Occupations	n	61,050
43-1011	First-Line Supervisors of Office and Administrative Support Workers	n	4,630
43-3011	Bill and Account Collectors	n	1,200
43-3021	Billing and Posting Clerks	n	1,840
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	8,020
43-3051	Payroll and Timekeeping Clerks	n	150
43-3061	Procurement Clerks	n	30
43-4041	Credit Authorizers, Checkers, and Clerks	n	0
43-4051	Customer Service Representatives	n	19,180
43-4071	File Clerks	n	30
43-4151	Order Clerks	n	360
43-4171	Receptionists and Information Clerks	n	490
43-4199	Information and Record Clerks, All Other	n	130
43-5032	Dispatchers, Except Police, Fire, and Ambulance	n	1,370
43-5061	Production, Planning, and Expediting Clerks	n	360
43-5071	Shipping, Receiving, and Inventory Clerks	n	1,540
43-6011	Executive Secretaries and Executive Administrative Assistants	n	710

Table C- 14: Exposure Designations for Occupations in NAICS 532, Rental and Leasing Services			
SOC Code	Description	Exposure	Employment
43-6013	Medical Secretaries and Administrative Assistants	n	720
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	n	3,760
43-9021	Data Entry Keyers	n	40
43-9041	Insurance Claims and Policy Processing Clerks	n	60
43-9061	Office Clerks, General	n	9,550
43-9199	Office and Administrative Support Workers, All Other	n	0
45-0000	Farming, Fishing, and Forestry Occupations	n	230
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	n	120
47-0000	Construction and Extraction Occupations	n	6,840
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	n	620
47-2031	Carpenters	n	0
47-2061	Construction Laborers	n	1,230
47-2073	Operating Engineers and Other Construction Equipment Operators	n	430
47-2141	Painters, Construction and Maintenance	n	50
47-4031	Fence Erectors	n	100
47-5013	Service Unit Operators, Oil and Gas	n	510
47-5071	Roustabouts, Oil and Gas	n	0
49-0000	Installation, Maintenance, and Repair Occupations	n	70,680
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	n	6,680
49-2011	Computer, Automated Teller, and Office Machine Repairers	n	370
49-2097	Audiovisual Equipment Installers and Repairers	n	0
49-3021	Automotive Body and Related Repairers	n	250
49-3023	Automotive Service Technicians and Mechanics	n	5,340
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	n	14,790
49-3041	Farm Equipment Mechanics and Service Technicians	n	70
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	n	16,120
49-3051	Motorboat Mechanics and Service Technicians	n	0
49-3053	Outdoor Power Equipment and Other Small Engine Mechanics	n	560
49-3091	Bicycle Repairers	n	90
49-3092	Recreational Vehicle Service Technicians	n	170
49-3093	Tire Repairers and Changers	n	270
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	n	150
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	n	110
49-9041	Industrial Machinery Mechanics	n	2,900
49-9043	Maintenance Workers, Machinery	n	210
49-9062	Medical Equipment Repairers	n	2,320
49-9071	Maintenance and Repair Workers, General	n	6,270
49-9096	Riggers	n	0
49-9098	Helpers--Installation, Maintenance, and Repair Workers	n	310
49-9099	Installation, Maintenance, and Repair Workers, All Other	n	2,660
51-0000	Production Occupations	n	5,440
51-1011	First-Line Supervisors of Production and Operating Workers	y	180
51-2090	Miscellaneous Assemblers and Fabricators	y	150
51-4041	Machinists	y	400
51-4121	Welders, Cutters, Solderers, and Brazers	y	640
51-6011	Laundry and Dry-Cleaning Workers	n	460
51-6031	Sewing Machine Operators	n	0
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	210
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	n	0

Table C- 14: Exposure Designations for Occupations in NAICS 532, Rental and Leasing Services			
SOC Code	**Description**	**Exposure**	**Employment**
51-9198	Helpers--Production Workers	y	0
51-9199	Production Workers, All Other	y	0
53-0000	Transportation and Material Moving Occupations	n	111,630
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	y	4,100
53-3031	Driver/Sales Workers	n	2,670
53-3032	Heavy and Tractor-Trailer Truck Drivers	n	18,210
53-3033	Light Truck Drivers	n	19,740
53-3052	Bus Drivers, Transit and Intercity	n	0
53-3053	Shuttle Drivers and Chauffeurs	n	740
53-3099	Motor Vehicle Operators, All Other	n	3,010
53-5011	Sailors and Marine Oilers	n	0
53-5021	Captains, Mates, and Pilots of Water Vessels	n	160
53-5022	Motorboat Operators	n	0
53-6021	Parking Attendants	n	1,090
53-6031	Automotive and Watercraft Service Attendants	n	150
53-6099	Transportation Workers, All Other	n	50
53-7021	Crane and Tower Operators	n	780
53-7051	Industrial Truck and Tractor Operators	n	470
53-7061	Cleaners of Vehicles and Equipment	n	18,460
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	y	22,870
53-7065	Stockers and Order Fillers	y	3,140
53-7199	Material Moving Workers, All Other	y	1,690
	Total Potentially Exposed		**37,900**
	Percent of workers		**8.0%**

Table C-15: Exposure Designations for Occupations in NAICS 5629, Remediation and Other Waste Management Services			
SOC Code	Description	Exposure	Employment
00-0000	All Occupations	n	158,790
11-0000	Management Occupations	n	10,200
11-1011	Chief Executives	n	50
11-1021	General and Operations Managers	n	6,660
11-2022	Sales Managers	n	70
11-3012	Administrative Services Managers	n	50
11-3031	Financial Managers	n	110
11-3071	Transportation, Storage, and Distribution Managers	y	30
11-9021	Construction Managers	n	790
11-9041	Architectural and Engineering Managers	n	40
11-9199	Managers, All Other	n	250
13-0000	Business and Financial Operations Occupations	n	8,660
13-1020	Buyers and Purchasing Agents	n	60
13-1041	Compliance Officers	n	40
13-1051	Cost Estimators	n	1,390
13-1071	Human Resources Specialists	n	190
13-1082	Project Management Specialists	n	2,570
13-1161	Market Research Analysts and Marketing Specialists	n	290
13-1199	Business Operations Specialists, All Other	n	410
13-2011	Accountants and Auditors	n	820
15-0000	Computer and Mathematical Occupations	n	270
15-1252	Software Developers	n	0
15-1299	Computer Occupations, All Other	n	0
17-0000	Architecture and Engineering Occupations	n	1,480
17-2081	Environmental Engineers	n	680
17-3025	Environmental Engineering Technologists and Technicians	n	80
19-0000	Life, Physical, and Social Science Occupations	n	1,830
19-2041	Environmental Scientists and Specialists, Including Health	n	40
19-2042	Geoscientists, Except Hydrologists and Geographers	n	70
19-4042	Environmental Science and Protection Technicians, Including Health	n	280
19-5011	Occupational Health and Safety Specialists	n	240
33-0000	Protective Service Occupations	n	60
33-9091	Crossing Guards and Flaggers	n	50
37-0000	Building and Grounds Cleaning and Maintenance Occupations	n	2,910
37-1011	First-Line Supervisors of Housekeeping and Janitorial Workers	n	0
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	n	2,030
41-0000	Sales and Related Occupations	n	3,470
41-2011	Cashiers	n	30
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	n	2,640
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	n	40
43-0000	Office and Administrative Support Occupations	n	18,490
43-1011	First-Line Supervisors of Office and Administrative Support Workers	n	1,310
43-3021	Billing and Posting Clerks	n	40
43-3031	Bookkeeping, Accounting, and Auditing Clerks	n	2,160
43-3051	Payroll and Timekeeping Clerks	n	40
43-4051	Customer Service Representatives	n	680
43-4171	Receptionists and Information Clerks	n	180
43-4199	Information and Record Clerks, All Other	n	0
43-5032	Dispatchers, Except Police, Fire, and Ambulance	n	440

Table C-15: Exposure Designations for Occupations in NAICS 5629, Remediation and Other Waste Management Services			
SOC Code	Description	Exposure	Employment
43-5061	Production, Planning, and Expediting Clerks	n	70
43-5071	Shipping, Receiving, and Inventory Clerks	n	100
43-5111	Weighers, Measurers, Checkers, and Samplers, Recordkeeping	n	220
43-6011	Executive Secretaries and Executive Administrative Assistants	n	240
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	n	3,230
43-9061	Office Clerks, General	n	6,180
47-0000	Construction and Extraction Occupations	n	68,970
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	n	9,010
47-2031	Carpenters	n	320
47-2061	Construction Laborers	n	6,280
47-2073	Operating Engineers and Other Construction Equipment Operators	n	1,150
47-2111	Electricians	n	0
47-2132	Insulation Workers, Mechanical	n	140
47-2152	Plumbers, Pipefitters, and Steamfitters	n	790
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	n	80
47-4011	Construction and Building Inspectors	n	0
47-4041	Hazardous Materials Removal Workers	n	28,430
47-4071	Septic Tank Servicers and Sewer Pipe Cleaners	n	14,740
47-5022	Excavating and Loading Machine and Dragline Operators, Surface Mining	n	0
47-5023	Earth Drillers, Except Oil and Gas	n	0
49-0000	Installation, Maintenance, and Repair Occupations	n	4,520
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	n	90
49-3023	Automotive Service Technicians and Mechanics	n	90
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	n	830
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	n	0
49-9041	Industrial Machinery Mechanics	n	150
49-9071	Maintenance and Repair Workers, General	n	890
49-9098	Helpers--Installation, Maintenance, and Repair Workers	n	140
49-9099	Installation, Maintenance, and Repair Workers, All Other	n	620
51-0000	Production Occupations	n	2,240
51-1011	First-Line Supervisors of Production and Operating Workers	y	170
51-2090	Miscellaneous Assemblers and Fabricators	y	0
51-4121	Welders, Cutters, Solderers, and Brazers	n	50
51-8031	Water and Wastewater Treatment Plant and System Operators	n	30
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	y	180
51-9199	Production Workers, All Other	y	260
53-0000	Transportation and Material Moving Occupations	n	30,390
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	y	1,560
53-3032	Heavy and Tractor-Trailer Truck Drivers	n	9,860
53-3033	Light Truck Drivers	n	740
53-3099	Motor Vehicle Operators, All Other	n	0
53-7051	Industrial Truck and Tractor Operators	n	850
53-7061	Cleaners of Vehicles and Equipment	n	530
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	y	9,100
53-7063	Machine Feeders and Offbearers	y	0
53-7065	Stockers and Order Fillers	y	140
53-7072	Pump Operators, Except Wellhead Pumpers	n	220
53-7081	Refuse and Recyclable Material Collectors	y	2,220
	Total Potentially Exposed		**13,660**

Table C-15: Exposure Designations for Occupations in NAICS 5629, Remediation and Other Waste Management Services			
SOC Code	Description	Exposure	Employment
		Percent of workers	8.6%

Table C-16: Percent of Workers Potentially Exposed, Based on OEWS by Industry	
NAICS	**Percent**
3241	36.7%
325	42.8%
3261	45.4%
333	38.5%
3344	34.0%
335	48.4%
3362	57.8%
3363	60.9%
3364	24.1%
3369	32.4%
4231	15.6%
4238	10.9%
424	21.4%
532	8.0%
5629	8.6%
Source: U.S. May 2021 BLS Occupational Employment and Wage Statistics (see Table C-1 through Table C-15 for derivation)	

Appendix D Baseline PPE

EPA looked for industry guidelines or other publications to determine the type of worker protection commonly used. For sectors for which EPA was able to determine that an industry standard exists.

Table D-1: Standard Industry Practice for PPE			
NAICS Code	**Respiratory**	**Dermal (Gloves)**	**Sources**
3261	particulate respirator, dust/mist respirator, dust mask.	gloves and sleeves	Labor Occupational Health Program (LOHP) at UC Berkeley 2013; Plastic Processing Equipment Inc. n.d.
324110	Not found	chemical-resistant gloves with multi-layer acid, chemical, hydrocarbon defences, grip treatment - extended safety cuffs. Chemical resistant acrylic lined gloves - extended safety cuffs.	Safety Skills 2023; MCR Safety 2023b
324191	Not found	chemical-resistant gloves with multi-layer acid, chemical, hydrocarbon defences, grip treatment - extended safety cuffs. Chemical resistant acrylic lined gloves - extended safety cuffs.	Safety Skills 2023; MCR Safety 2023b
325180	full-face respirators	neoprene, nitrile, vinyl and rubber gloves, highly chemical-resistant gloves	Ansell 2023c; Grainger 2020
325199	full-face respirators	highly chemical-resistant gloves	Ansell 2023c; Grainger 2020
325211	Not found	Not found	Not found
325613	Not found	Not found	Not found
325991	Not found	Not found	Not foundHesperian Health Guides 2023b; Hesperian Health Guides 2023a; Showa Gloves 2023
326199	Not found	Not found	Not found
333242	respirators	electrical insulating gloves (natural rubber and latex formation)	International Enviroguard 2023
333415	Not found	inner nitrile gloves, outer HVAC work gloves	HVARC 2023;
334413	respirators	electrical insulating gloves (natural rubber and latex formation)	International Enviroguard 2023
335931	Not found	high-voltage electrical protection gloves (natural rubber and latex formation) class 4, flame and cut resistant gloves	Ansell 2023d
336211	Not found	cut, abrasion, puncture resistant gloves, high impact.	MCR Safety 2023a
336310	Not found	cut, abrasion, puncture resistant gloves, high impact.	MCR Safety 2023a

Table D-1: Standard Industry Practice for PPE			
NAICS Code	Respiratory	Dermal (Gloves)	Sources
336320	Not found	electrical insulating gloves (natural rubber and latex formation), heat-resistant industrial gloves (leather), flame-resistant gloves with arc flash and cut protection	Automotive Industries (AI) 2007; Ansell 2023a
336390	Not found	cut, abrasion, puncture resistant gloves, high impact.	MCR Safety 2023a
336412	respirators	rubber gloves, heavy duty gloves (protection from cuts and scrapes)	National Business Aviation Association (NBAA) 2017b; National Business Aviation Association (NBAA) 2017a; Japan Super Interceptor (JSI) 2023; North Central Institute 2022; National Aviation Academy 2023
336413	respirators	rubber gloves, heavy duty gloves (protection from cuts and scrapes)	National Business Aviation Association (NBAA) 2017b; National Business Aviation Association (NBAA) 2017a; Japan Super Interceptor (JSI) 2023; North Central Institute 2022; National Aviation Academy 2023
336415	respirators	rubber gloves, heavy duty gloves (protection from cuts and scrapes)	National Business Aviation Association (NBAA) 2017b; National Business Aviation Association (NBAA) 2017a; North Central Institute 2022; National Aviation Academy 2023
336419	respirators	rubber gloves, heavy duty gloves (protection from cuts and scrapes)	National Business Aviation Association (NBAA) 2017b; National Business Aviation Association (NBAA) 2017a; North Central Institute 2022; National Aviation Academy 2023
336991	Not found	cut, abrasion, puncture resistant gloves, high impact.	MCR Safety 2023a
336999	Not found	electrical insulating gloves (natural rubber and latex formation), heat-resistant industrial gloves (leather), flame-resistant gloves with arc flash and cut protection	Automotive Industries (AI) 2007; Ansell 2023a
423120	Not found	light weight gloves with cut and oil protection, grip performance	Ansell 2023b; MCR Safety 2023a
423840	Not found	light weight gloves with cut and oil protection, grip performance	Ansell 2023b
424690	Not found	light weight gloves with cut and oil protection, grip performance	Ansell 2023b
488190	respirators	rubber gloves, heavy duty gloves (protection from cuts and scrapes)	National Business Aviation Association (NBAA) 2017b; National Business Aviation Association (NBAA) 2017a; Japan Super Interceptor (JSI) 2023; North Central Institute 2022; National Aviation Academy 2023

Table D-1: Standard Industry Practice for PPE			
NAICS Code	**Respiratory**	**Dermal (Gloves)**	**Sources**
562920	face mask	rubber or other protective gloves	Labor Occupational Health Program (LOHP) at UC Berkeley 2013; North Central Institute 2022

Appendix E PPE Cost Estimations

E.1 Equipment Unit Costs

Table E-1 presents the estimated unit costs for each respirator system considered in this analysis. Table E-2 presents the estimated unit costs for nitrile gloves. These costs were developed by averaging the prices gathered from internet research of popular PPE distributors in 2022. The survey is not meant to be comprehensive, rather a sample of prices of available equipment. Choosing the distributors for the price quotes was predominately a factor of who carries the equipment of interest. Efforts were made to keep cost estimates reflective of those experienced by consumers and commercial users.

Table E-1: Average Cost of Respirator Types (APF 10) (2022$)

Respirator Type	Component	Respirator and Accessories Descriptions	Cost
Air-Purifying Respirator – Half Mask	APR System with Half Mask	Half Mask Respirator - North by Honeywell, Silicone, Model 770030	$39.20
		Half Mask Respirator - North by Honeywell, Thermoplastic Elastomer, Model 550030	$14.54
		Half Mask Respirator - 3M, Silicone, Model 6503	$23.20
		Half Mask Respirator - 3M, Silicone, Model 7503	$34.95
		Total Average Cost (Mask):	**$27.97**
	Cartridge	Organic Vapor (Black) Respirator Cartridge, pair, North by Honeywell, Model N75001 (Pair)	$7.07
		North by Honeywell Respirator Cartridge, Yellow/Magenta (P100/OV), Pr, Model 7583P100L	$20.31
		Organic Vapor (Black) Respirator Cartridge, pair, 3M, Model 6001	$15.00
		OV/FM/P100 Combination Respirator Cartridge, pair, 3M, Model 60925	$33.32
		Scott 742 Series Twin Organic Vapors Respirator Cartridges, 2/Pack (Used as pairs)	$18.28
		Scott 742 Series Twin Organic Vapors/P100 Respirator Cartridges, 2/Pack (Used as pairs)	$35.14
		North N7581P100 Organic Vapor Cartridge & P100 Filters Combo (2/pack)	$28.29
		3M 6001 Respirator Cartridge (2/pack)	$13.99
		3M 6001 Organic Vapor Cartridge (1 Pair)	$13.09
		Total Average Cost (Cartridge):	**$20.50**
Air-Purifying Respirator – Half Mask (N95)	Mask	3M™ Particulate Respirator 8511, N95 (Distributed by Stauffer Glove & Safety)	$2.24
		3M™ Particulate Respirator 8511, N95 (Distributed by Industrial Safety Products)	$2.11
		3M™ Particulate Respirator 8511, N95 (Distributed by Maxwell Products Corp.)	$1.90
		3M™ Particulate Respirator 8511, N95 (Distributed by Abatix)	$2.02
		3M™ Particulate Respirator 8511, N95 (Distributed by American Producers Supply Co.)	$1.98
		BNX N95 Mask, Model F95W	$1.53
		3M 9205 B95 Aura Particulate Respirator	$2.05
		Total Average Cost (Mask):	**$1.97**

Table E-2: Average Cost of Nitrile Gloves (2022$)				
Glove Type	**Glove Description**	**Price of Unit**	**Gloves per Unit**	**Price per Pair**
Nitrile	Sunline Black Nitrile Disposable Gloves (6mil)	$89.90	1000	$0.18
	Sunline Blue Nitrile Medical/Industrial Use Gloves (3.2 mil)	$179.99	3000	$0.12
	4 mil Nitrile Gloves	$39.00	1000	$0.08
	5 mil Nitrile Gloves	$79.00	1000	$0.16
	6 mil Nitrile Gloves	$89.00	1000	$0.18
	6.5 mil Nitrile Gloves	$89.00	1000	$0.18
	7 mil Nitrile Gloves	$89.00	1000	$0.18
	High Five Onyx Nitrile Exam Gloves Case	$109.99	1000	$0.22
	GripProtect Precise Black Nitrile Exam Gloves (1000 ct)	$109.98	1000	$0.22
			Total Average Cost (per pair)	**$0.17**

E.2 Useful Life Estimations

Useful life is equal to the number of years until a respirator or respirator component needs to be replaced, as well as the number of years until a medical evaluation, fit testing, or training is required. The annual replacement rate of a respirator or respirator component, or the annual reoccurrence of other PPE program elements, is therefore equal to 1 divided by the useful life. Table E-3 presents the useful lives of respirators, respirator components, training, and fit testing.

Respirator useful lives are presented as those of the individual respirator system components (e.g., mask, pump, breathing tube, etc.) or as the useful life of a full respiratory system or system components kit (if the components in the kit have similar useful lives). Individual respirator components are listed if they have different useful lives. The table also includes the sources and assumptions underlying the useful life estimates.

The useful life for some components depends on a variety of factors, making it difficult to identify a representative estimate. In these cases, assumptions are made about the component's useful life using available literature. For example, the filter cartridge replacement rate varies with a multitude of factors, including humidity, temperature, and atmospheric pressure. The analysis assumes a cartridge replacement rate of 100 times per year for an APR, consistent with the rates used in ERG (2003).[40]

[40] EPA also reviewed the cartridge replacement frequency estimations predicted by 3M's online software application (3M 2015). The range of expected lives predicted by the 3M replacement frequency estimator software varies greatly. For example, the NIOSH-approved GVP 401 cartridges have an estimated service life of 127 minutes in an environment of >95% humidity and 86 degrees Fahrenheit. However, the useful life jumps to 197 hours when used in an environment of <65% humidity and 32 degrees Fahrenheit. The 3M software confirms that replacement rate estimates are highly dependent on factors that vary nationally, and that it is up to each facility to replace cartridges as required by their environmental parameters. The analysis also used the 3M software to confirm that the replacement rate estimates from ERG (2003) of 100 times per year for APR fall within the predicted range and are thus reasonable estimates.

Note that useful life expectancies and costs are estimates and may vary by industry, facility, and or/geographic location. Therefore, estimated costs are expected to represent a typical facility – actual costs for a specific facility may be higher or lower.

Table E-3: PPE Useful Life

Equipment	Component	Useful Life (years)	Description / Source
APR, Half Mask (N95)	Half Mask (N95 Mask)	0.0038	Assume one mask is used per day, for 260 workdays per year
APR, Half Mask	Half Mask, APR	2	Estimate based on the equipment service life of an APR, full facepiece respirator (ERG 2003)
	Cartridge Filters, APR	0.01	Assume APR cartridges are replaced at a rate of 100 per year (ERG 2003)
	Qualitative Fit Testing	1	According to 29 CFR 1910.134(f)(2)
Gloves	Nitrile Gloves	0.00096	Assumes that the worker will change gloves every 2 hours (or 4 pairs per 8-hour day), for 260 workdays per year
All	Training	1	ERG (2003)

E.3 PPE Documentation Cost Estimation

Table E-4: Derivation of Costs for PPE Documentation by NAICS

Chemical and Use	NAICS	Facility Type	Employee Number Basis	Number of Firms	Annualized (3% Discount Rate)		Annualized (7% Discount Rate)	
					Annualized Cost Per Company	Total Cost	Annualized Cost Per Company	Total Cost
DecaBDE								
Plastic Shipping Pallets	532490	Medium	Identified Companies	1	$13	$13	$20	$20
Other DecaBDE-containing Plastic	325991	Small	NAICS	180	$3	$540	$5	$900
Other DecaBDE-containing Plastic	325991	Medium	NAICS	117	$13	$1,521	$20	$2,340
Other DecaBDE-containing Plastic	325991	Large	NAICS	43	$53	$2,279	$82	$3,526
Other DecaBDE-containing Plastic	3261	Small	NAICS	4,001	$3	$12,003	$5	$20,005
Other DecaBDE-containing Plastic	3261	Medium	NAICS	3,051	$13	$39,663	$20	$61,020
Other DecaBDE-containing Plastic	3261	Large	NAICS	498	$53	$26,394	$82	$40,836
Other DecaBDE-containing Plastic	562920	Small	NAICS	724	$3	$2,172	$5	$3,620
Other DecaBDE-containing Plastic	562920	Medium	NAICS	222	$13	$2,886	$20	$4,440
Other DecaBDE-containing Plastic	562920	Large	NAICS	39	$53	$2,067	$82	$3,198
PIP (3:1)								
Lubricants & Greases (Aerospace) (makers)	324110	Large	Identified Companies	2	$53	$106	$82	$164
Lubricants & Greases (Aerospace) (makers)	325199	Large	Identified Companies	1	$53	$53	$82	$82
Lubricants & Greases (Aerospace) (makers)	325180	Large	Identified Companies	1	$53	$53	$82	$82
Lubricants & Greases (Aerospace) (makers)	424690	Large	Identified Companies	1	$53	$53	$82	$82
Lubricants & Greases (Aerospace) (makers)	324191	Medium	Identified Companies	6	$13	$78	$20	$120
Lubricants and Greases (except Aerospace and Turbine) (makers)	324110	Large	Identified Companies	0	$53	$0	$82	$0
Lubricants and Greases (except Aerospace and Turbine) (makers)	324191	Large	Identified Companies	0	$53	$0	$82	$0

Table E-4: Derivation of Costs for PPE Documentation by NAICS								
Chemical and Use	NAICS	Facility Type	Employee Number Basis	Number of Firms	Annualized (3% Discount Rate)		Annualized (7% Discount Rate)	
					Annualized Cost Per Company	Total Cost	Annualized Cost Per Company	Total Cost
Lubricants and Greases (except Aerospace and Turbine) (makers)	325180	Large	Identified Companies	1	$53	$53	$82	$82
Lubricants and Greases (except Aerospace and Turbine) (makers)	333415	Small	Identified Companies	1	$3	$3	$5	$5
Lubricants and Greases (except Aerospace and Turbine) (makers)	423120	Small	Identified Companies	1	$3	$3	$5	$5
Lubricants and Greases (except Aerospace and Turbine) (makers)	423840	Medium	Identified Companies	1	$13	$13	$20	$20
Lubricants and Greases (except Aerospace and Turbine) (makers)	424690	Large	Identified Companies	1	$53	$53	$82	$82
New and Replacement Parts for Motor Vehicles (makers)	326199	Small	NAICS	2,621	$3	$7,863	$5	$13,105
New and Replacement Parts for Motor Vehicles (makers)	326199	Medium	NAICS	1,885	$13	$24,505	$20	$37,700
New and Replacement Parts for Motor Vehicles (makers)	326199	Large	NAICS	351	$53	$18,603	$82	$28,782
New and Replacement Parts for Motor Vehicles (makers)	325211	Small	NAICS	359	$3	$1,077	$5	$1,795
New and Replacement Parts for Motor Vehicles (makers)	325211	Medium	NAICS	360	$13	$4,680	$20	$7,200
New and Replacement Parts for Motor Vehicles (makers)	325211	Large	NAICS	128	$53	$6,784	$82	$10,496
New and Replacement Parts for Motor Vehicles (makers)	325991	Small	NAICS	180	$3	$540	$5	$900
New and Replacement Parts for Motor Vehicles (makers)	325991	Medium	NAICS	117	$13	$1,521	$20	$2,340
New and Replacement Parts for Motor Vehicles (makers)	325991	Large	NAICS	43	$53	$2,279	$82	$3,526
New and Replacement Parts for Motor Vehicles (makers)	336211	Small	NAICS	324	$3	$972	$5	$1,620
New and Replacement Parts for Motor Vehicles (makers)	336211	Medium	NAICS	242	$13	$3,146	$20	$4,840

Table E-4: Derivation of Costs for PPE Documentation by NAICS								
Chemical and Use	NAICS	Facility Type	Employee Number Basis	Number of Firms	Annualized (3% Discount Rate)		Annualized (7% Discount Rate)	
					Annualized Cost Per Company	Total Cost	Annualized Cost Per Company	Total Cost
New and Replacement Parts for Motor Vehicles (makers)	336211	Large	NAICS	43	$53	$2,279	$82	$3,526
New and Replacement Parts for Motor Vehicles (makers)	336310	Small	NAICS	469	$3	$1,407	$5	$2,345
New and Replacement Parts for Motor Vehicles (makers)	336310	Medium	NAICS	126	$13	$1,638	$20	$2,520
New and Replacement Parts for Motor Vehicles (makers)	336310	Large	NAICS	61	$53	$3,233	$82	$5,002
New and Replacement Parts for Motor Vehicles (makers)	336320	Small	NAICS	310	$3	$930	$5	$1,550
New and Replacement Parts for Motor Vehicles (makers)	336320	Medium	NAICS	157	$13	$2,041	$20	$3,140
New and Replacement Parts for Motor Vehicles (makers)	336320	Large	NAICS	61	$53	$3,233	$82	$5,002
New and Replacement Parts for Motor Vehicles (makers)	336390	Small	NAICS	599	$3	$1,797	$5	$2,995
New and Replacement Parts for Motor Vehicles (makers)	336390	Medium	NAICS	341	$13	$4,433	$20	$6,820
New and Replacement Parts for Motor Vehicles (makers)	336390	Large	NAICS	150	$53	$7,950	$82	$12,300
New and Replacement Parts for Motor Vehicles (makers)	336991	Small	NAICS	319	$3	$957	$5	$1,595
New and Replacement Parts for Motor Vehicles (makers)	336991	Medium	NAICS	53	$13	$689	$20	$1,060
New and Replacement Parts for Motor Vehicles (makers)	336991	Large	NAICS	6	$53	$318	$82	$492
New and Replacement Parts for Motor Vehicles (makers)	336999	Small	NAICS	315	$3	$945	$5	$1,575
New and Replacement Parts for Motor Vehicles (makers)	336999	Medium	NAICS	64	$13	$832	$20	$1,280
New and Replacement Parts for Motor Vehicles (makers)	336999	Large	NAICS	10	$53	$530	$82	$820

Table E-4: Derivation of Costs for PPE Documentation by NAICS								
Chemical and Use	NAICS	Facility Type	Employee Number Basis	Number of Firms	Annualized (3% Discount Rate)		Annualized (7% Discount Rate)	
					Annualized Cost Per Company	Total Cost	Annualized Cost Per Company	Total Cost
New and Replacement Parts for Aerospace Vehicles (makers)	325211	Small	NAICS	359	$3	$1,077	$5	$1,795
New and Replacement Parts for Aerospace Vehicles (makers)	325211	Medium	NAICS	360	$13	$4,680	$20	$7,200
New and Replacement Parts for Aerospace Vehicles (makers)	325211	Large	NAICS	128	$53	$6,784	$82	$10,496
New and Replacement Parts for Aerospace Vehicles (makers)	325520	Small	NAICS	212	$3	$636	$5	$1,060
New and Replacement Parts for Aerospace Vehicles (makers)	325520	Medium	NAICS	115	$13	$1,495	$20	$2,300
New and Replacement Parts for Aerospace Vehicles (makers)	325520	Large	NAICS	56	$53	$2,968	$82	$4,592
New and Replacement Parts for Aerospace Vehicles (makers)	325991	Small	NAICS	180	$3	$540	$5	$900
New and Replacement Parts for Aerospace Vehicles (makers)	325991	Medium	NAICS	117	$13	$1,521	$20	$2,340
New and Replacement Parts for Aerospace Vehicles (makers)	325991	Large	NAICS	43	$53	$2,279	$82	$3,526
New and Replacement Parts for Aerospace Vehicles (makers)	336412	Small	NAICS	145	$3	$435	$5	$725
New and Replacement Parts for Aerospace Vehicles (makers)	336412	Medium	NAICS	134	$13	$1,742	$20	$2,680
New and Replacement Parts for Aerospace Vehicles (makers)	336412	Large	NAICS	42	$53	$2,226	$82	$3,444
New and Replacement Parts for Aerospace Vehicles (makers)	336413	Small	NAICS	406	$3	$1,218	$5	$2,030
New and Replacement Parts for Aerospace Vehicles (makers)	336413	Medium	NAICS	258	$13	$3,354	$20	$5,160
New and Replacement Parts for Aerospace Vehicles (makers)	336413	Large	NAICS	74	$53	$3,922	$82	$6,068
New and Replacement Parts for Aerospace Vehicles (makers)	336415	Small	NAICS	3	$3	$9	$5	$15

Table E-4: Derivation of Costs for PPE Documentation by NAICS								
Chemical and Use	NAICS	Facility Type	Employee Number Basis	Number of Firms	Annualized (3% Discount Rate)		Annualized (7% Discount Rate)	
					Annualized Cost Per Company	Total Cost	Annualized Cost Per Company	Total Cost
New and Replacement Parts for Aerospace Vehicles (makers)	336415	Medium	NAICS	4	$13	$52	$20	$80
New and Replacement Parts for Aerospace Vehicles (makers)	336415	Large	NAICS	10	$53	$530	$82	$820
New and Replacement Parts for Aerospace Vehicles (makers)	336419	Small	NAICS	11	$3	$33	$5	$55
New and Replacement Parts for Aerospace Vehicles (makers)	336419	Medium	NAICS	12	$13	$156	$20	$240
New and Replacement Parts for Aerospace Vehicles (makers)	336419	Large	NAICS	8	$53	$424	$82	$656
Wire Harnesses and Electric Circuit Boards (makers)	334418	Small	NAICS	353	$3	$1,059	$5	$1,765
Wire Harnesses and Electric Circuit Boards (makers)	334418	Medium	NAICS	324	$13	$4,212	$20	$6,480
Wire Harnesses and Electric Circuit Boards (makers)	334418	Large	NAICS	45	$53	$2,385	$82	$3,690
Wire Harnesses and Electric Circuit Boards (makers)	334412	Small	NAICS	219	$3	$657	$5	$1,095
Wire Harnesses and Electric Circuit Boards (makers)	334412	Medium	NAICS	166	$13	$2,158	$20	$3,320
Wire Harnesses and Electric Circuit Boards (makers)	334412	Large	NAICS	21	$53	$1,113	$82	$1,722
Wire Harnesses and Electric Circuit Boards (makers)	335931	Small	NAICS	176	$3	$528	$5	$880
Wire Harnesses and Electric Circuit Boards (makers)	335931	Medium	NAICS	142	$13	$1,846	$20	$2,840
Wire Harnesses and Electric Circuit Boards (makers)	335931	Large	NAICS	37	$53	$1,961	$82	$3,034
Wire Harnesses and Electric Circuit Boards (makers)	325211	Small	NAICS	359	$3	$1,077	$5	$1,795
Wire Harnesses and Electric Circuit Boards (makers)	325211	Medium	NAICS	360	$13	$4,680	$20	$7,200

Table E-4: Derivation of Costs for PPE Documentation by NAICS								
Chemical and Use	NAICS	Facility Type	Employee Number Basis	Number of Firms	Annualized (3% Discount Rate)		Annualized (7% Discount Rate)	
					Annualized Cost Per Company	Total Cost	Annualized Cost Per Company	Total Cost
Wire Harnesses and Electric Circuit Boards (makers)	325211	Large	NAICS	128	$53	$6,784	$82	$10,496
Wire Harnesses and Electric Circuit Boards (makers)	325991	Small	NAICS	180	$3	$540	$5	$900
Wire Harnesses and Electric Circuit Boards (makers)	325991	Medium	NAICS	117	$13	$1,521	$20	$2,340
Wire Harnesses and Electric Circuit Boards (makers)	325991	Large	NAICS	43	$53	$2,279	$82	$3,526
Marine Antifouling Coatings	325510	large	Identified Companies	1	$53	$53	$82	$82
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325211	Small	NAICS	359	$3	$1,077	$5	$1,795
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325211	Medium	NAICS	360	$13	$4,680	$20	$7,200
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325211	Large	NAICS	128	$53	$6,784	$82	$10,496
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325991	Small	NAICS	180	$3	$540	$5	$900
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325991	Medium	NAICS	117	$13	$1,521	$20	$2,340
Articles Used in Manufacturing Equipment, Semiconductor Industry,	325991	Large	NAICS	43	$53	$2,279	$82	$3,526

Table E-4: Derivation of Costs for PPE Documentation by NAICS								
Chemical and Use	NAICS	Facility Type	Employee Number Basis	Number of Firms	Annualized (3% Discount Rate)		Annualized (7% Discount Rate)	
					Annualized Cost Per Company	Total Cost	Annualized Cost Per Company	Total Cost
and HVACR, Power Generating, and Electronic Equipment (makers)								
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	333242	Small	NAICS	86	$3	$258	$5	$430
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	333242	Medium	NAICS	41	$13	$533	$20	$820
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	333242	Large	NAICS	26	$53	$1,378	$82	$2,132
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	334413	Small	NAICS	464	$3	$1,392	$5	$2,320
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	334413	Medium	NAICS	184	$13	$2,392	$20	$3,680
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	334413	Large	NAICS	67	$53	$3,551	$82	$5,494
Engine Filters for Locomotive and Marine Applications	333415	Large	Identified Companies	1	$53	$53	$82	$82
Cyanoacrylate Adhesives	325520	Large	Identified Companies	1	$53	$53	$82	$82
Aviation Hydraulic Fluid (makers)	325199	Large	Identified Companies	1	$53	$53	$82	$82

Table E-4: Derivation of Costs for PPE Documentation by NAICS								
Chemical and Use	NAICS	Facility Type	Employee Number Basis	Number of Firms	Annualized (3% Discount Rate)		Annualized (7% Discount Rate)	
					Annualized Cost Per Company	Total Cost	Annualized Cost Per Company	Total Cost
Aviation Hydraulic Fluid (makers)	324110	Large	Identified Companies	1	$53	$53	$82	$82
Aviation Hydraulic Fluid (makers)	424690	Large	Identified Companies	1	$53	$53	$82	$82
Aviation Hydraulic Fluid (makers)	325180	Large	Identified Companies	1	$53	$53	$82	$82
Aviation Hydraulic Fluid (makers)	324191	Medium	Identified Companies	1	$13	$13	$20	$20
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325211	Small	NAICS	359	$3	$1,077	$5	$1,795
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325211	Medium	NAICS	360	$13	$4,680	$20	$7,200
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325211	Large	NAICS	128	$53	$6,784	$82	$10,496
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325991	Small	NAICS	180	$3	$540	$5	$900
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325991	Medium	NAICS	117	$13	$1,521	$20	$2,340
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325991	Large	NAICS	43	$53	$2,279	$82	$3,526

Table E-4: Derivation of Costs for PPE Documentation by NAICS								
Chemical and Use	NAICS	Facility Type	Employee Number Basis	Number of Firms	Annualized (3% Discount Rate)		Annualized (7% Discount Rate)	
					Annualized Cost Per Company	Total Cost	Annualized Cost Per Company	Total Cost
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	333242	Small	NAICS	86	$3	$258	$5	$430
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	333242	Medium	NAICS	41	$13	$533	$20	$820
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	333242	Large	NAICS	26	$53	$1,378	$82	$2,132
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	334413	Small	NAICS	464	$3	$1,392	$5	$2,320
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	334413	Medium	NAICS	184	$13	$2,392	$20	$3,680
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	334413	Large	NAICS	67	$53	$3,551	$82	$5,494
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325211	Small	NAICS	359	$3	$1,077	$5	$1,795
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325211	Medium	NAICS	360	$13	$4,680	$20	$7,200

Table E-4: Derivation of Costs for PPE Documentation by NAICS								
Chemical and Use	NAICS	Facility Type	Employee Number Basis	Number of Firms	Annualized (3% Discount Rate)		Annualized (7% Discount Rate)	
					Annualized Cost Per Company	Total Cost	Annualized Cost Per Company	Total Cost
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325211	Large	NAICS	128	$53	$6,784	$82	$10,496
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325991	Small	NAICS	180	$3	$540	$5	$900
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325991	Medium	NAICS	117	$13	$1,521	$20	$2,340
Articles Used in Manufacturing Equipment, Semiconductor Industry, and HVACR, Power Generating, and Electronic Equipment (makers)	325991	Large	NAICS	43	$53	$2,279	$82	$3,526
Lubricants and Greases (except Aerospace and Turbine) (makers)	324110	Large	Identified Companies	0	$53	$0	$82	$0
Lubricants and Greases (except Aerospace and Turbine) (makers)	324191	Large	Identified Companies	0	$53	$0	$82	$0
Lubricants and Greases (except Aerospace and Turbine) (makers)	325180	Large	Identified Companies	1	$53	$53	$82	$82
Lubricants and Greases (except Aerospace and Turbine) (makers)	333415	Small	Identified Companies	1	$3	$3	$5	$5
Lubricants and Greases (except Aerospace and Turbine) (makers)	423120	Small	Identified Companies	1	$3	$3	$5	$5
Lubricants and Greases (except Aerospace and Turbine) (makers)	423840	Medium	Identified Companies	1	$13	$13	$20	$20
Lubricants and Greases (except Aerospace and Turbine) (makers)	424690	Large	Identified Companies	1	$53	$53	$82	$82
Lubricants & Greases (Aerospace) (makers)	324110	Large	Identified Companies	2	$53	$106	$82	$164

Table E-4: Derivation of Costs for PPE Documentation by NAICS								
Chemical and Use	NAICS	Facility Type	Employee Number Basis	Number of Firms	Annualized (3% Discount Rate)		Annualized (7% Discount Rate)	
					Annualized Cost Per Company	Total Cost	Annualized Cost Per Company	Total Cost
Lubricants & Greases (Aerospace) (makers)	325199	Large	Identified Companies	6	$53	$318	$82	$492
Lubricants & Greases (Aerospace) (makers)	325180	Large	Identified Companies	1	$53	$53	$82	$82
Lubricants & Greases (Aerospace) (makers)	424690	Large	Identified Companies	1	$53	$53	$82	$82
Lubricants & Greases (Aerospace) (makers)	324191	Medium	Identified Companies	1	$13	$13	$20	$20
Wire Harnesses and Electric Circuit Boards (makers)	334412	Small	NAICS	219	$3	$657	$5	$1,095
Wire Harnesses and Electric Circuit Boards (makers)	334412	Medium	NAICS	166	$13	$2,158	$20	$3,320
Wire Harnesses and Electric Circuit Boards (makers)	334412	Large	NAICS	21	$53	$1,113	$82	$1,722
Wire Harnesses and Electric Circuit Boards (makers)	334418	Small	NAICS	353	$3	$1,059	$5	$1,765
Wire Harnesses and Electric Circuit Boards (makers)	334418	Medium	NAICS	324	$13	$4,212	$20	$6,480
Wire Harnesses and Electric Circuit Boards (makers)	334418	Large	NAICS	45	$53	$2,385	$82	$3,690
Wire Harnesses and Electric Circuit Boards (makers)	335931	Small	NAICS	176	$3	$528	$5	$880
Wire Harnesses and Electric Circuit Boards (makers)	335931	Medium	NAICS	142	$13	$1,846	$20	$2,840
Wire Harnesses and Electric Circuit Boards (makers)	335931	Large	NAICS	37	$53	$1,961	$82	$3,034
Wire Harnesses and Electric Circuit Boards (makers)	325211	Small	NAICS	359	$3	$1,077	$5	$1,795
Wire Harnesses and Electric Circuit Boards (makers)	325211	Medium	NAICS	360	$13	$4,680	$20	$7,200
Wire Harnesses and Electric Circuit Boards (makers)	325211	Large	NAICS	128	$53	$6,784	$82	$10,496

Table E-4: Derivation of Costs for PPE Documentation by NAICS								
Chemical and Use	NAICS	Facility Type	Employee Number Basis	Number of Firms	Annualized (3% Discount Rate)		Annualized (7% Discount Rate)	
					Annualized Cost Per Company	Total Cost	Annualized Cost Per Company	Total Cost
Wire Harnesses and Electric Circuit Boards (makers)	325991	Small	NAICS	180	$3	$540	$5	$900
Wire Harnesses and Electric Circuit Boards (makers)	325991	Medium	NAICS	117	$13	$1,521	$20	$2,340
Wire Harnesses and Electric Circuit Boards (makers)	325991	Large	NAICS	43	$53	$2,279	$82	$3,526

Appendix F Worker Protection Cost Calculations

This appendix contains the worker protection cost calculations. Table F-1 and Table F-2 show how the number of workers who need Respiratory and Dermal PPE were calculated for each affected industry for the primary and alternative options. Table F-3 and Table F-4 show the cost calculations based on the number of affected workers and the unit costs for each affected industry.

Table F-1: Number of Workers Incurring PPE Costs Worker Protection Cost Calculations Primary Option by NAICS (2022$)											
NAICS	Employee Number Basis	Firms	Average Employees Per Establishment in NAICS	Percent of Employees who May be Affected	Workers Affected	Standard Industry Respiratory PPE Identified	Respirator Baseline Percent Non-compliant	Workers Needing Respira-tory PPE	Standard Industry Dermal PPE Identified	Dermal Baseline Percent Non-compliant	Workers Needing Dermal PPE
DecaBDE											
532490	Identified Companies	1	13	8%	1	yes	0%	0	yes	0%	0
Total DecaBDE:		***1***			***1***			***0***			***0***
PIP (3:1)											
324110	Identified Companies	3	394	37%	434	unknown	100%	434	yes	11%	48
325199	Identified Companies	1	82	43%	35	yes	17%	6	yes	0%	0
325180	Identified Companies	1	63	43%	27	yes	17%	4	yes	0%	0
424690	Identified Companies	1	14	21%	3	unknown	100%	3	yes	8%	0
324191	Identified Companies	5	48	37%	88	unknown	100%	88	yes	0%	0
333415	Identified Companies	1	115	39%	44	unknown	100%	44	yes	9%	4
423120	Identified Companies	1	18	16%	3	unknown	100%	3	yes	0%	0
423840	Identified Companies	2	12	11%	3	unknown	100%	3	yes	0%	0
325211	NAICS	847	70	43%	25,363	unknown	100%	25,363	unknown	100%	25,363
325991	NAICS	340	48	43%	6,981	unknown	100%	6,981	unknown	100%	6,981
326199	NAICS	4,857	66	45%	145,381	unknown	100%	145,381	unknown	100%	145,381
336211	NAICS	609	71	58%	24,988	unknown	100%	24,988	yes	0%	0
336310	NAICS	656	85	61%	33,936	unknown	100%	33,936	yes	0%	0
336320	NAICS	528	102	61%	32,777	unknown	100%	32,777	yes	0%	0

Table F-1: Number of Workers Incurring PPE Costs Worker Protection Cost Calculations Primary Option by NAICS (2022$)											
NAICS	Employee Number Basis	Firms	Average Employees Per Establishment in NAICS	Percent of Employees who May be Affected	Workers Affected	Standard Industry Respiratory PPE Identified	Respirator Baseline Percent Non-compliant	Workers Needing Respira-tory PPE	Standard Industry Dermal PPE Identified	Dermal Baseline Percent Non-compliant	Workers Needing Dermal PPE
336390	NAICS	1,090	119	61%	78,942	unknown	100%	78,942	yes	0%	0
336991	NAICS	378	24	32%	2,943	unknown	100%	2,943	yes	100%	2,943
336999	NAICS	389	37	32%	4,670	unknown	100%	4,670	yes	0%	0
325520	NAICS	383	47	43%	7,700	unknown	100%	7,700	unknown	100%	7,700
336412	NAICS	321	168	24%	12,976	yes	25%	3,244	yes	0%	0
336413	NAICS	738	122	24%	21,664	yes	0%	0	yes	0%	0
336415	NAICS	17	636	24%	2,601	yes	100%	2,601	yes	100%	2,601
336419	NAICS	31	156	24%	1,164	yes	100%	1,164	yes	100%	1,164
334412	NAICS	406	56	34%	7,738	yes	100%	7,738	yes	100%	7,738
334418	NAICS	722	66	34%	16,219	yes	0%	0	yes	0%	0
335931	NAICS	355	65	41%	9,407	unknown	100%	9,407	yes	100%	9,407
325510	NAICS	958	35	43%	14,343	yes	17%	2,473	yes	0%	0
333242	NAICS	153	115	39%	6,782	yes	0%	0	yes	0%	0
334413	NAICS	715	120	34%	29,203	yes	50%	14,601	yes	0%	0
Total PIP (3:1):		***14,508***			***486,415***			***405,495***			***209,332***
Total:		**14,509**			**486,416**			**405,495**			**209,332**

Table F-2: Number of Workers Incurring PPE Costs Worker Protection Cost Calculations Alternative Option by NAICS (2022$)

NAICS	Employee Number Basis	Firms	Average Employees Per Establishment in NAICS	Percent of Employees who May be Affected	Workers Affected	Standard Industry Respiratory PPE Identified	Respirator Baseline Percent Non-compliant	Workers Needing Respira-tory PPE	Standard Industry Dermal PPE Identified	Dermal Baseline Percent Non-compliant	Workers Needing Dermal PPE
DecaBDE											
3261	NAICS	7550	66	45%	225,989	yes	100%	225,989	yes	3%	6,908
325991	NAICS	340	48	43%	6,981	unknown	100%	6,981	unknown	100%	6,981
562920	NAICS	985	16	9%	1,356	yes	100%	1,356	yes	6%	85
Total DecaBDE:		***8,875***			***234,326***			***234,326***			***13,974***
PIP (3:1)											
324110	Identified Companies	2	394	37%	289	unknown	100%	289	yes	11%	32
324191	Identified Companies	5	48	37%	88	unknown	100%	88	yes	0%	0
325180	Identified Companies	1	63	43%	27	yes	17%	4	yes	0%	0
325199	Identified Companies	1	82	43%	35	yes	17%	6	yes	0%	0
424690	Identified Companies	1	14	21%	3	unknown	100%	3	yes	8%	0
333415	Identified Companies	1	115	39%	44	unknown	100%	44	yes	9%	4
423120	Identified Companies	1	18	16%	3	unknown	100%	3	yes	0%	0
423840	Identified Companies	1	12	11%	1	unknown	100%	1	yes	0%	0
325211	NAICS	847	70	43%	25,363	unknown	100%	25,363	unknown	100%	25,363
325991	NAICS	340	48	43%	6,981	unknown	100%	6,981	unknown	100%	6,981
334412	NAICS	406	56	34%	7,738	yes	100%	7,738	yes	100%	7,738
334418	NAICS	722	66	34%	16,219	yes	0%	0	yes	0%	0
335931	NAICS	355	65	41%	9,407	unknown	100%	9,407	yes	100%	9,407

Table F-2: Number of Workers Incurring PPE Costs Worker Protection Cost Calculations Alternative Option by NAICS (2022$)

NAICS	Employee Number Basis	Firms	Average Employees Per Establishment in NAICS	Percent of Employees who May be Affected	Workers Affected	Standard Industry Respiratory PPE Identified	Respirator Baseline Percent Non-compliant	Workers Needing Respira-tory PPE	Standard Industry Dermal PPE Identified	Dermal Baseline Percent Non-compliant	Workers Needing Dermal PPE
333242	NAICS	153	115	39%	6,782	yes	0%	0	yes	0%	0
334413	NAICS	715	120	34%	29,203	yes	50%	14,601	yes	0%	0
Total PIP (3:1):		***3,551***			***102,184***			***64,530***			***49,525***
Total:		**12,426**			**336,510**			**298,855**			**63,499**

Table F-3: Worker Protection Total Annualized Cost Calculations Primary Option by NAICS (2022$)												
NAICS	Employee Number Basis	Years	Workers Needing Respiratory PPE	Workers Needing Dermal PPE	Respira-tory PPE Cost per Employee (3%)	Total Respira-tory PPE Cost (3%)	Respira-tory PPE Cost per Employee (7%)	Total Respira-tory PPE Cost (7%)	Dermal PPE Cost per Employe e (3%)	Total Dermal PPE Cost (3%)	Dermal PPE Cost per Employee (7%)	Total Dermal PPE Cost (7%)
DecaBDE												
532490	Identified Companies	30	0	0	$811	$0	$811	$0	$238	$0	$238	$0
Total DecaBDE:			**0**	**0**		**$0**		**$0**		**$0**		**$0**
PIP (3:1) - New Parts												
324110	Identified Companies	30	434	48	$2,780	$1,205,921	$2,780	$1,205,921	$238	$11,485	$238	$11,485
325199	Identified Companies	30	6	0	$2,780	$16,253	$2,780	$16,253	$238	$0	$238	$0
325180	Identified Companies	30	4	0	$2,780	$12,487	$2,780	$12,487	$238	$0	$238	$0
424690	Identified Companies	30	3	0	$2,780	$8,331	$2,780	$8,331	$238	$55	$238	$55
324191	Identified Companies	30	88	0	$2,780	$244,857	$2,780	$244,857	$238	$0	$238	$0
333415	Identified Companies	15	44	4	$1,659	$73,558	$2,020	$89,567	$54	$220	$78	$314
423120	Identified Companies	15	3	0	$1,659	$4,661	$2,020	$5,676	$54	$0	$78	$0
423840	Identified Companies	30	3	0	$2,780	$7,273	$2,780	$7,273	$238	$0	$238	$0
325211	NAICS	30	25,363	25,363	$2,780	$70,508,154	$2,780	$70,508,154	$238	$6,043,362	$238	$6,043,362
325991	NAICS	30	6,981	6,981	$2,780	$19,407,878	$2,780	$19,407,878	$238	$1,663,479	$238	$1,663,479
326199	NAICS	15	130,843	130,843	$484	$63,337,557	$589	$77,121,660	$142	$18,587,347	$173	$19,168,384
336211	NAICS	15	22,489	0	$484	$10,886,244	$589	$13,255,409	$142	$0	$173	$0
336310	NAICS	15	30,542	0	$484	$14,784,669	$589	$18,002,245	$142	$0	$173	$0

Table F-3: Worker Protection Total Annualized Cost Calculations Primary Option by NAICS (2022$)												
NAICS	Employee Number Basis	Years	Workers Needing Respiratory PPE	Workers Needing Dermal PPE	Respira-tory PPE Cost per Employee (3%)	Total Respira-tory PPE Cost (3%)	Respira-tory PPE Cost per Employee (7%)	Total Respira-tory PPE Cost (7%)	Dermal PPE Cost per Employe e (3%)	Total Dermal PPE Cost (3%)	Dermal PPE Cost per Employee (7%)	Total Dermal PPE Cost (7%)
336320	NAICS	15	29,499	0	$484	$14,279,827	$589	$17,387,534	$142	$0	$173	$0
336390	NAICS	15	71,048	0	$484	$34,392,386	$589	$41,877,174	$142	$0	$173	$0
336991	NAICS	15	2,649	2,649	$484	$1,282,370	$589	$1,561,451	$142	$376,331	$173	$458,231
336999	NAICS	15	4,203	0	$484	$2,034,518	$589	$2,477,289	$142	$0	$173	$0
325520	NAICS	30	7,700	7,700	$0	$0	$0	$0	$238	$1,834,821	$238	$1,834,821
336412	NAICS	30	3,244	0	$811	$2,630,826	$811	$2,630,826	$238	$0	$238	$0
336413	NAICS	30	0	0	$811	$0	$811	$0	$238	$0	$238	$0
336415	NAICS	30	2,601	2,601	$811	$2,109,812	$811	$2,109,812	$238	$619,879	$238	$619,879
336419	NAICS	30	1,164	1,164	$811	$943,679	$811	$943,679	$238	$277,260	$238	$277,260
334412	NAICS	30	7,738	7,738	$2,780	$21,512,789	$2,780	$21,512,789	$238	$1,843,894	$238	$1,843,894
334418	NAICS	30	0	0	$2,780	$0	$2,780	$0	$238	$0	$238	$0
335931	NAICS	30	9,407	9,407	$2,780	$26,150,774	$2,780	$26,150,774	$238	$2,241,423	$238	$2,241,423
325510	NAICS	5	2,473	0	$637	$1,574,207	$910	$2,249,336	$142	$0	$173	$0
333242	NAICS	15	0	0	$1,659	$0	$2,020	$0	$142	$0	$173	$0
334413	NAICS	15	13,141	0	$1,659	$21,805,818	$2,020	$26,551,401	$142	$0	$173	$0
PIP (3:1) - Replacement Parts												
326199	NAICS	30	14,538	14,538	$811	$11,790,409	$811	$11,790,409	$238	$3,464,114	$238	$3,464,114

Table F-3: Worker Protection Total Annualized Cost Calculations Primary Option by NAICS (2022$)												
NAICS	Employee Number Basis	Years	Workers Needing Respiratory PPE	Workers Needing Dermal PPE	Respira-tory PPE Cost per Employee (3%)	Total Respira-tory PPE Cost (3%)	Respira-tory PPE Cost per Employee (7%)	Total Respira-tory PPE Cost (7%)	Dermal PPE Cost per Employee (3%)	Total Dermal PPE Cost (3%)	Dermal PPE Cost per Employee (7%)	Total Dermal PPE Cost (7%)
336211	NAICS	30	2,499	0	$811	$2,026,495	$811	$2,026,495	$238	$0	$238	$0
336310	NAICS	30	3,394	0	$811	$2,752,195	$811	$2,752,195	$238	$0	$238	$0
336320	NAICS	30	3,278	0	$811	$2,658,218	$811	$2,658,218	$238	$0	$238	$0
336390	NAICS	30	7,894	0	$811	$6,402,209	$811	$6,402,209	$238	$0	$238	$0
336991	NAICS	30	294	294	$811	$238,716	$811	$238,716	$238	$70,137	$238	$70,137
336999	NAICS	30	467	0	$811	$378,730	$811	$378,730	$238	$0	$238	$0
333242	NAICS	30	0	0	$2,780	$0	$2,780	$0	$238	$0	$238	$0
334413	NAICS	30	1,460	0	$2,780	$0	$2,780	$0	$238	$0	$238	$0
Total PIP (3:1):			**405,495**	**209,332**		**$335,461,819**		**$371,584,745**		**$37,033,806**		**$37,696,837**
Total:			**405,495**	**209,332**		**$335,461,819**		**$371,584,745**		**$37,033,806**		**$37,696,837**

Table F-4: Worker Protection Total Annualized Cost Calculations Alternative Option by NAICS (2022$)												
NAICS	Employee Number Basis	Years	Workers Needing Respiratory PPE	Workers Needing Dermal PPE	Respira-tory PPE Cost per Employee (3%)	Total Respira-tory PPE Cost (3%)	Respira-tory PPE Cost per Employee (7%)	Total Respira-tory PPE Cost (7%)	Dermal PPE Cost per Employee (3%)	Total Dermal PPE Cost (3%)	Dermal PPE Cost per Employee (7%)	Total Dermal PPE Cost (7%)
DecaBDE												
3261	NAICS	30	225,989	6,908	$2,780	$628,248,813	$2,780	$628,248,813	$238	$1,646,014	$238	$1,646,014
325991	NAICS	30	6,981	6,981	$2,780	$19,407,878	$2,780	$19,407,878	$238	$1,663,479	$238	$1,663,479
562920	NAICS	30	1,356	85	$2,780	$3,769,021	$2,780	$3,769,021	$238	$20,191	$238	$20,191
Total DecaBDE:			**234,326**	**13,974**		**$651,425,712**		**$651,425,712**		**$3,329,684**		**$3,329,684**
PIP (3:1) - New Parts												
324110	Identified Companies	30	289	32	$2,780	$803,947	$2,780	$803,947	$238	$7,656	$238	$7,656
324191	Identified Companies	30	88	0	$2,780	$244,857	$2,780	$244,857	$238	$0	$238	$0
325180	Identified Companies	30	4	0	$2,780	$12,487	$2,780	$12,487	$238	$0	$238	$0
325199	Identified Companies	30	6	0	$2,780	$16,253	$2,780	$16,253	$238	$0	$238	$0
424690	Identified Companies	30	3	0	$2,780	$8,331	$2,780	$8,331	$238	$55	$238	$55
333415	Identified Companies	5	44	4	$637	$28,219	$910	$40,321	$54	$220	$78	$314
423120	Identified Companies	5	3	0	$637	$1,788	$910	$2,555	$54	$0	$78	$0
423840	Identified Companies	5	1	0	$637	$833	$910	$1,190	$54	$0	$78	$0
325211	NAICS	30	25,363	25,363	$2,780	$70,508,154	$2,780	$70,508,154	$238	$6,043,362	$238	$6,043,362
325991	NAICS	30	6,981	6,981	$2,780	$19,407,878	$2,780	$19,407,878	$238	$1,663,479	$238	$1,663,479

Table F-4: Worker Protection Total Annualized Cost Calculations Alternative Option by NAICS (2022$)												
NAICS	Employee Number Basis	Years	Workers Needing Respiratory PPE	Workers Needing Dermal PPE	Respira-tory PPE Cost per Employee (3%)	Total Respira-tory PPE Cost (3%)	Respira-tory PPE Cost per Employee (7%)	Total Respira-tory PPE Cost (7%)	Dermal PPE Cost per Employee (3%)	Total Dermal PPE Cost (3%)	Dermal PPE Cost per Employee (7%)	Total Dermal PPE Cost (7%)
334412	NAICS	30	7,738	7,738	$2,780	$21,512,789	$2,780	$21,512,789	$238	$1,843,894	$238	$1,843,894
334418	NAICS	30	0	0	$2,780	$0	$2,780	$0	$238	$0	$238	$0
335931	NAICS	30	9,407	9,407	$2,780	$26,150,774	$2,780	$26,150,774	$238	$2,241,423	$238	$2,241,423
333242	NAICS	20	0	0	$2,068	$0	$2,350	$0	$177	$0	$201	$0
334413	NAICS	20	13,141	0	$2,068	$31,234,373	$2,350	$34,942,877	$177	$0	$201	$0
PIP (3:1) - Replacement Parts												
333242	NAICS	30	0	0	$2,780	$0	$2,780	$0	$238	$0	$238	$0
334413	NAICS	30	1,460	0	$2,780	$4,059,195	$2,780	$4,059,195	$238	$0	$238	$0
Total PIP (3:1):			**64,530**	**49,525**		**$169,930,681**		**$173,652,412**		**$11,800,090**		**$11,800,184**
Total:						**$821,356,393**		**$825,078,124**		**$15,129,773**		**$15,129,867**