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Office of Air Quality
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Research Triangle Park NC 27711

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National Emission Standards for Hazardous Air Pollutants for Source Categories: Aerospace Manufacturing and Rework-- Background Information for Proposed Standards

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National Emission Standards for Hazardous Air Pollutants for Source Categories: Aerospace Manufacturing and Rework -- Background Information for Proposed Standards

Emission Standards Division

U.S. Environmental Protection Agency
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

May 1994

ENVIRONMENTAL PROTECTION AGENCY

Hazardous Air Pollutants from the Aerospace Manufacturing and Rework Industry -- Background Information for Proposed Standards

Prepared by:

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5/11/94
(Date)

1. The proposed standards regulate emissions of hazardous air pollutants from cleaning operations; primer, topcoat, and chemical milling maskant application operations; depainting operations; and handling and storage of waste at aerospace manufacturing and rework facilities. Only those operations that are part of major sources under Section 112(d) of the Clean Air Act as amended in 1990 will be regulated.

2. Copies of this document have been sent to following Federal Departments: Labor, Health and Human Services, Defense, Transportation, Agriculture, Commerce, Interior, and Energy; the National Science Foundation; and the Council on Environmental Quality. Copies have also been sent to members of the State and Territorial Air Pollution Program Administrators; the Association of Local Air Pollution Control Officials; EPA Regional Administrators; and other interested parties.

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1.0 SUMMARY

The proposed rule would limit organic HAP emissions from the following sources at aerospace facilities: cleaning operations, primer application operations, topcoat application operations, depainting operations, chemical milling maskant application operations, and the handling and storage of waste. The proposed rule would also limit inorganic HAP emissions from primer, topcoat, and depainting operations.

Organic HAP emissions from chemical milling maskant, primer, and topcoat application operations occur from the evaporation of the solvent contained in the coatings. These emissions occur during the application of the coatings on aerospace vehicles or parts, which may take place in large open areas, such as hangars, or partially or fully enclosed spaces, such as within spray booths.

Organic HAP emissions from cleaning and depainting operations occur from evaporation of the volatile portion of the cleaning solvents or chemical strippers. Cleaning emissions are nearly always fugitive in nature and occur at essentially every processing step. Emissions from depainting are typically fugitive in nature since the operation is carried out within a large hangar or in open tanks.

Organic HAP emissions from waste occur from evaporation of the volatile portion of the waste while it is being handled or stored. These emissions are fugitive in nature, occurring from each waste container.

Inorganic HAP emissions from primer and topcoat application operations occur during the application of the primer or topcoat. These inorganic HAP emissions are paint particulates, commonly referred to as "overspray," that do not adhere to the surface being coated. Like the organic HAP emissions from the operations, the emission of the inorganic HAPs occur in large open areas, such as hangars, or in partially or fully enclosed spaces, such as within spray booths.

Inorganic HAP emissions from depainting operations occur from most non-chemical methods, such as plastic media blasting, used to strip an aerospace vehicle. (Chemical stripping techniques do not release inorganic HAPs.) These emissions occur as particulates generated during the blasting process. The operation is typically carried out within a large hangar equipped with a ventilation system and particulate filtration device (e.g., a baghouse). The inorganic HAPs that are released from the depainting operations are primarily found in the paint being stripped, although some stripping media may contain trace amounts of inorganic HAPs.

1.1 PROPOSED STANDARDS FOR AFFECTED SOURCES

The affected sources for the proposed standards are defined as follows: (1) the cleaning operation, which includes all hand-wipe, spray gun, and flush cleaning at the facility; (2) the primer application operation, which includes all primer applications at the facility; (3) the topcoat application operation, which includes all topcoat applications at the facility; (4) the depainting operation, which includes all depainting of the outer surface of aerospace vehicles at the facility; (5) the chemical milling maskant application operation, which includes all chemical milling maskant applications at the facility for use in Type II chemical milling solutions; and (6) handling and storage of waste. The following paragraphs summarize the proposed standards for each affected source.

1.1.1 Cleaning Operation

The proposed standards for the hand-wipe, spray gun, and flush cleaning operations would apply to all new and existing affected sources. The proposed standards would require that all fresh and used cleaning solvents be stored in closed containers and solvent-laden cloth, paper, or other material be placed in bags or other closed containers immediately after use. The bags or containers would be required to be of such design so as to contain the vapors of the cleaning solvent. In addition, the proposed standards would require the owner or operator to implement handling and transfer procedures to minimize spills during filling and transferring the cleaning solvent to or from enclosed systems, vats, waste containers, and other cleaning operation equipment that hold or store fresh or used cleaning solvents. The above requirements are known collectively as housekeeping measures.

The proposed standard for the hand-wipe cleaning operation would require the use of a cleaning solvent that conforms to the approved composition list detailed in Table 1-1 or a cleaning solvent that has a vapor pressure less than or equal to 45 millimeters of mercury (mm Hg) at 20°C.

The EPA is proposing a work practice standard for the cleaning of spray guns at all new and existing affected sources. The proposed rule would require all spray guns to be cleaned by one or more of the following methods: (1) use of an enclosed spray gun cleaning system that is kept closed when not in use; (2) unatomized discharge of solvent

TABLE 1-1

COMPOSITION REQUIREMENTS FOR APPROVED CLEANING SOLVENTS

Cleaning Solvent Type	Definition
Aqueous	Cleaning solvents in which water is the primary ingredient (≥80 percent of solvent as applied must be water). Aqueous solvents must be non-flammable, non-combustible, and 100 percent soluble in water. Detergents, surfactants, and bioenzyme mixtures and nutrients may be combined with the water along with a variety of additives such as organic solvents (e.g., high boiling point alcohols), builders, saponifiers, inhibitors, emulsifiers, pH buffers, and antifoaming agents.
Hydrocarbon-Based	Cleaners that are composed of a mixture of hydrocarbons and oxygenated hydrocarbons and have a maximum vapor pressure of 7 mm Hg at 20°C. These cleaners also contain no HAPs or ozone depleting compounds.

into a waste container that is kept closed when not in use; (3) disassembly of the spray gun and cleaning in a vat that is kept closed when not in use; and (4) atomized spray into a waste container that is fitted with a device designed to capture atomized solvent emissions. In addition, the EPA is proposing that leaks from enclosed spray gun cleaners be repaired within 14 days from when the leak is first discovered. The EPA is also proposing a work practice standard for the flush cleaning of parts, assemblies, and coating unit components. Under the proposed rule, each time a part, assembly, or coating unit component (with the exception of spray guns) is flush cleaned, the used cleaning solvent would be emptied into an enclosed container or collection system that is kept closed when not in use.

The following cleaning operations, which would still be required to comply with the proposed housekeeping requirements, would be exempt from the proposed cleaning solvent composition and vapor pressure requirements:

1. Cleaning during manufacturing, assembly, installation, or testing of components of breathing oxygen systems that are exposed to the breathing oxygen;
2. Cleaning during manufacturing, assembly, installation, or testing of parts, subassemblies, or assemblies that are exposed to strong oxidizers or reducers (e.g., nitrogen tetroxide, liquid oxygen, hydrazine);
3. Cleaning and surface activation prior to adhesive bonding;
4. Cleaning of electronics and assemblies containing electronics;

5. Cleaning of aircraft fluid systems that are exposed to the fluid. Aircraft fluid systems are defined as those systems that handle hydraulic fluids, fuel, cooling fluids, and oils;
6. Cleaning of fuel cells, fuel tanks, and limited access spaces;
7. Surface cleaning of solar cells, coated optics, and thermal control surfaces;
8. Cleaning during fabrication, assembly, installation, and maintenance of upholstery, curtains, carpet, and other textile materials used on the interior of the aircraft;
9. Cleaning of metallic and non-metallic materials used in honeycomb cores during the manufacture of these cores, and cleaning of the completed cores used in the manufacture of aerospace vehicles or components;
10. Cleaning of polycarbonate substrates; and
11. Cleaning and solvent usage associated with production, research, development, quality control, or laboratory testing.

1.1.2 Primer and Topcoat Application Operations

The proposed standards for primer and topcoat application operations would be the same for all new and existing affected sources. Standards are being proposed to limit organic and inorganic HAP emissions from these operations.

1.1.2.1 Organic HAP and VOC emissions. The standards being proposed would limit the organic HAP emissions from primer application operations to an equivalent organic HAP content level of 2.9 pounds of organic HAPs per gallon [350 grams per liter (g/l)] of primer (less water) as applied and from topcoat application operations to an equivalent organic HAP content level of 3.5 pounds of organic HAPs per gallon (420 g/l) of topcoat (less water) as applied. In addition to the organic HAP limits, the proposed standards would limit VOC emissions from primer application operations to an equivalent VOC content level of 2.9 pounds of VOCs per gallon of primer (less water and exempt solvents) as applied and from topcoat application operations to an equivalent VOC content level of 3.5 pounds of VOC per gallon of topcoat (less water and exempt solvents) as applied. Equivalent organic HAP and VOC content level means the emissions that would be generated by the use of coatings that are all equal to the applicable organic HAP or VOC content limits. Exempt solvents are those organic compounds that have been determined by the EPA to have negligible photochemical reactivity.

Sources would be allowed to comply with the proposed organic HAP and VOC content standards by the following means: (1) use coatings that individually comply with the organic HAP and VOC levels; (2) use any combination of coatings such that the daily volume-weighted average organic HAP and VOC contents of these coatings comply with the organic HAP and VOC levels for that category (averaging of primers and topcoats together is prohibited); (3) use a control device to reduce organic HAP and VOC emissions such that the overall emissions from each affected source are equivalent to or less than the emissions that would be achieved by using compliant coatings at the proposed content levels; or (4) any combination of the above.

Compliance with the proposed standard must be shown on a monthly basis when using all compliant coatings, or on a daily basis when using a weighted average or a control device other than a carbon adsorber. When a carbon adsorber is used to comply with the proposed organic HAP and VOC content limits, compliance must be shown by performing a solvent mass balance for each rolling material balance period. The length of the rolling period will vary from source to source and is determined by the procedure specified in proposed Method 310 in the proposed rule. The minimum rolling period is one day, and the maximum rolling period is 30 days.

Each control device used for the control of organic HAP or VOC emissions from primer or topcoat application operations must have an overall control efficiency, taking into account capture and removal efficiency, of greater than or equal to 81 percent. Except for incidental emissions that may escape from the capture system, a control device cannot be used to control only a portion of emissions from a coating operation.

In addition to the organic HAP and VOC content levels, the EPA is proposing an equipment standard for the application of primers and topcoats. The proposed standards would require the use of flow coat, roll coat, brush coat, dip coat, electrostatic attraction, or high volume low pressure (HVLP) spray guns other than for the exemptions listed below. All application equipment would be required to be operated and maintained according to manufacturer's specifications at all times.

The EPA is proposing to allow other application equipment that is demonstrated to achieve emission levels equivalent to HVLP or electrostatic spray guns. Two methods are being proposed to demonstrate this equivalence. The first method involves comparing the emissions generated by the alternative application method to the emissions generated by HVLP or electrostatic application methods in actual production. In this case, the alternative method must generate emissions less than or equal to that generated by HVLP or electrostatic spray methods. The second method, proposed as Method 309 in the proposed rule, involves determining the transfer efficiency of the alternative method and HVLP or electrostatic spray methods. In this case, the alternative application method must achieve a transfer efficiency greater than or equal to HVLP or electrostatic application methods.

The EPA is proposing to exempt the following list of situations and operations from the proposed equipment standard for the application of primers and topcoats:

1. Any situation that normally requires the use of an extension on the spray gun to properly reach limited access spaces;
2. The application of coatings that contain fillers that adversely affect atomization with HVLP spray guns and cannot be applied by any of the specified application techniques;
3. The application of coatings that normally have a dried film thickness of less than 0.0005 inch and cannot be applied by any of the specified application techniques;
4. The use of airbrush application methods for stenciling, lettering, and other identification markings; and
5. Touchup and repair operations.

1.1.2.2 Inorganic HAP emissions. The standards being proposed for inorganic HAP emissions from primer and topcoat application operations would apply to those operations that spray apply coatings that contain inorganic HAPs (usually chromium, cadmium, and selenium). Such operations would be required to be performed in a booth or hangar in which the airflow is directed across the part or assembly being coated and exhausted through one or more outlets. This air stream would be required to pass through either dry particulate filters or a waterwash system to remove the particulates before exhausting to the atmosphere. In addition, the pressure drop across the filter or waterwash would have to be maintained within the limits specified by the manufacturer. If the pressure drop moves outside of these limits, then the operation must immediately be shut down and corrective action taken. The process cannot resume until the pressure drop is within the limits specified by the manufacturer.

The EPA is proposing to exempt the following list of operations from the proposed standards for inorganic HAP emissions from primer and topcoat application operations:

1. Touch-up of scratched surfaces or damaged paint;
2. Hole daubing for fasteners;
3. Touch-up of trimmed edges;
4. Coating prior to joining dissimilar metal components;
5. Stencil operations performed by brush or air brush;
6. Section joining; and
7. Touch-up of bushings and other similar components.

1.1.3 <u>Depainting Operation</u>

Standards are being proposed for both organic HAP emissions and inorganic HAP emissions from depainting. With the exception of the proposed standard for spot stripping and decal removal, as discussed below, the standards being proposed for depainting would be the same for all new and existing affected sources. The proposed standards would apply only to the depainting of the outer surface of entire aerospace vehicles, including the fuselage, wings, and horizontal and vertical stabilizers of the aircraft, or the outer casing and stabilizers of missiles and rockets. Standards for the depainting of parts, subassemblies, radomes, and parts normally removed from the completed vehicle before depainting are not being proposed at this time. However, wings and stabilizers would always be required to comply.

1.1.3.1 Organic HAP emissions. The proposed standard would require that there be no organic HAP emissions from the depainting operation. This standard could be achieved through the use of (1) chemical strippers that contain no organic HAPs or (2) media blasting equipment, high intensity ultra-violet light blasting, or any other non-chemical depainting technique. However, the proposed rule would allow the use of organic HAP-containing chemical stripper for spot stripping and decal removal. The proposed rule would limit this use of organic HAP-containing chemical stripper to an average of 26 gallons per aircraft for commercial aircraft and 50 gallons per aircraft for military aircraft, calculated on an annual basis.

Non-chemical based depainting equipment would be required to be operated and maintained according to manufacturer's specifications. During any period of malfunction, the owner or operator would be allowed to use a substitute material to depaint the vehicles. Unless the substitute material does not contain any organic HAPs, the substitute material would not be allowed to be used for more than 14 consecutive days.

1.1.3.2 <u>Inorganic HAP emissions.</u> The proposed rule for inorganic HAP emissions would apply to those depainting methods (typically blasting methods) that generate airborne particulate emissions, such as dust and paint particles, that contain inorganic HAPs. The proposed standard would require that the depainting operation be carried out in an enclosed hangar and that any air stream removed from the depainting area be directed through a particulate filter (e.g., panel-type filter or baghouse) before exhausting to the atmosphere. This filtration system must have a removal efficiency greater than or equal to 99 percent, and the pressure drop across the filter must be maintained within the limits specified by the manufacturer. If the pressure drop moves outside of these limits, then the operation must immediately be shut down and corrective action taken. The process cannot resume until the pressure drop is within the limits specified by the manufacturer.

1.1.4 <u>Chemical Milling Maskant Operation</u>

The proposed standard for the chemical milling maskant operation would be the same for all new and existing affected sources and applies only to those operations utilizing a Type II chemical milling solution. The proposed standard would limit organic HAP emissions to an equivalent organic HAP content level of 1.3 pounds organic HAP per gallon of chemical milling maskant (less water) as applied, and limit the VOC emissions to an equivalent VOC content level of 1.3 pounds VOC per gallon of chemical milling maskant (less water and exempt solvents) as applied. Equivalent organic HAP and VOC content level means the emissions that would be generated by the use of chemical milling maskants that are all equal to the applicable organic HAP or VOC content limits. Exempt solvents are those organic compounds that have been determined by the EPA to have negligible photochemical reactivity.

Compliance with this standard could be met by the following means: (1) use only chemical milling maskants that individually comply with the organic HAP and VOC content levels; (2) use any combination of chemical milling maskants such that the daily volume-weighted average organic HAP and VOC content levels of these chemical milling maskants used in the chemical milling maskant operation complies with the organic HAP and VOC content levels; (3) reduce organic HAP and VOC emissions with a control device (e.g., a carbon adsorber) such that the overall emissions from the chemical milling maskant operation are equivalent to or less than the emissions that would be achieved by using compliant chemical milling maskants at the proposed organic HAP and VOC content levels; or (4) any combination of the above.

Compliance with the proposed standard must be shown on a monthly basis when using all compliant chemical milling maskants and on a daily basis when averaging across chemical milling maskants. When a carbon adsorber is used to comply with the proposed organic HAP and VOC content levels, compliance must be shown by performing a solvent mass balance for each rolling material balance period. The length of the rolling period will vary from source to source and is determined by the procedure specified in the proposed rule. The minimum rolling period is one day, and the maximum rolling period is 30 days.

Each control device used for the control of organic HAP or VOC emissions from primer or topcoat application operations must have an overall control efficiency, taking into account capture and removal efficiency, of greater than or equal to 81 percent. Except for incidental emissions that may escape from the capture system, a control device cannot be used to control only a portion of emissions from a coating operation.

1.1.5 Handling and Storage of Waste

The proposed standard for handling and storage of waste would be the same for all new and existing facilities. The proposed rule would require that the handling and transfer of HAP-containing waste to or from containers, tanks, vats, vessels, or piping systems be conducted in such a manner that minimizes spills. In addition, all HAP-containing waste would be stored in closed containers.

1.2 ENVIRONMENTAL IMPACT

1.2.1 Estimated Air Emission Reductions

1.2.1.1 Existing Facilities. For the existing aerospace OEM and rework facilities (approximately 2,869 facilities in the base year 1991), the nationwide baseline HAP emissions are estimated to be 189,000 Mg/yr (208,000 tpy). Implementation of the proposed regulation would reduce these emissions by approximately 112,600 Mg/yr (123,700 tpy), or 59 percent.

1.2.1.2 New Facilities. For the aerospace industry, no net growth is expected over the next five years; therefore, no new facilities are anticipated during this period.

1.2.2 Estimated Secondary Environmental Impacts

Secondary environmental impacts are considered to be any air, water, or solid waste impacts, positive or negative, associated with the implementation of the proposed standards. These impacts are exclusive of the direct air emission reductions discussed in the previous section. All of the impacts discussed below reflect the maximum increase or decrease, as appropriate, that would occur if all of the affected sources converted to the control option described.

Secondary air impacts are normally associated with the operation of certain control devices, primarily incineration systems, whose exhaust gases may contain air pollutants. However, none of the regulatory options considered in the environmental analysis includes incineration as a likely control measure. Some product reformulations that may be used to comply with the proposed standards for hand-wipe cleaning, primers, and topcoats may contain organic HAPs or VOCs not present in the original product. In these cases, different organic HAPs or VOCs may be emitted as a result of the proposed rule, but the overall level of these compounds that are emitted will decrease. Chemical strippers that do not contain organic HAPs used for depainting may result in increased VOC emissions when used to replace methylene chloride-based chemical strippers (methylene chloride is a HAP, but not a VOC).

There is a potential for an impact on water quality resulting from some of the prescribed control measures. Under baseline conditions for chemical milling maskant operations, no wastewater is generated; however, some of the sources may install a carbon adsorber to control solvent emissions. If all affected sources use carbon adsorbers, the amount of water needed to create regenerating steam for these systems, which will add to the wastewater burden from these sources, is estimated to be 447 million gallons per year nationwide. There are two options available for meeting the proposed rule for depainting operations, both of which will result in a decrease in the amount of wastewater generated compared to baseline, which is 251 million gallons per year. The decrease in wastewater nationwide is estimated to be 251 million gallons and 86 million gallons if all affected sources use dry media blasting or chemical strippers that do not contain organic HAPs, respectively.

Sources installing a carbon adsorption system on their chemical milling maskant operations would generate additional solid waste due to the necessity of periodically disposing of spent activated carbon. If all affected sources use carbon adsorbers, this added nationwide solid waste burden is estimated to be 4,500 tons per year, compared to the baseline of 21,200 tons per year. Rework facilities that presently use a methylene chloride-based paint stripper must dispose of 31,300 tons per year of paint/solvent sludge created by depainting. A total conversion to dry media paint removal would produce an increase in the amount of solid waste composed of dry paint chips and spent blasting media. This increase in solid waste is estimated to be 13,280 tons per year on a nationwide basis. The proposed standards for the control of inorganic HAP emissions from primer and topcoat application operations would result in the increase in solid waste generation from the disposal of used dry filter media. The increased solid waste burden is estimated to be 640 tons per year, compared to the baseline solid waste generation of 3,540 tons per year.

1.2.3 Estimated Energy Impacts

Some of the control measures proposed for aerospace manufacturing and rework operations would lead to increases in energy consumption. Both of the control options for chemical milling maskant operations, operation of a carbon adsorber or conversion to waterborne chemical milling maskant, would involve increased electricity usage (waterborne chemical milling maskants must be cured at elevated temperatures). The total additional energy needed if all affected sources operate new carbon adsorbers is estimated to be 1.7 billion kilowatt-hours (kWh) per year, and the energy increase for all affected sources to operate new curing ovens for waterborne chemical milling maskants is estimated at 324,700 kWh per year. Baseline energy consumption for chemical milling maskant operations is considered to be negligible since the use of solvent-based chemical milling maskants does not directly require the use of electricity.

The dry media paint removal systems that would be installed at rework facilities consume additional energy compared to the solvent stripping method. Baseline energy consumption for solvent stripping is considered to be negligible since the use of these strippers does not directly require the use of electricity. The increase in energy consumption involved in operating dry media blasting systems is estimated to be 51 million kWh per year. The use of chemical strippers that do not contain organic HAPs is essentially the same as the baseline solvent stripping operation; therefore, no energy impact will result from their use.

The proposed standards for the control of inorganic HAP emissions from primer and topcoat application operations would require some facilities to install additional spray booths. These spray booths, whether equipped with dry filters or waterwash, will increase the energy consumption of the affected sources. This increase in energy consumption is estimated to be 5.9 million kWh per year, compared to the baseline energy consumption of 117.4 million kWh per year.

1.3 ECONOMIC IMPACTS (ESTIMATED COST IMPACTS)

The total capital and annualized control costs (1992 dollars), including recovery credits, attributable to compliance with the proposed standards have been estimated for both existing and new facilities. The following two subsections summarize the results of this cost analysis.

1.3.1 Existing Facilities

1.3.1.1 Capital costs. Capital costs would be incurred with the implementation of control measures for chemical milling maskants (both solvent-based chemical milling maskants with a carbon adsorber and waterborne chemical milling maskants), dry media blasting for depainting, spray gun cleaning, and control of inorganic HAP emissions from primer, topcoat, and depainting operations. The nationwide capital costs listed below represent the maximum costs that would be incurred assuming that all affected sources implemented the specific control option.

For carbon adsorbers used in conjunction with solvent-based chemical milling maskants, the nationwide capital cost is estimated to be $500 million, and for waterborne chemical milling maskants it is estimated to be $289 million. The implementation of dry media blasting systems for depainting would require a nationwide capital cost of $2.8 billion. It should be noted that other control measures exist for depainting other than dry media blasting, such as chemical strippers that do not contain organic HAPs, that require no capital investment. Selection of chemical strippers that do not contain organic HAPs by all affected sources instead of dry media blasting would decrease the total nationwide capital investment by approximately 82 percent. The proposed rule would also require capital costs for high transfer efficiency application equipment and spray gun cleaning equipment totalling $130 million and $10 million, respectively. The control of inorganic HAP emissions from primer and topcoat application operations would require the installation of spray booths and filter systems at a capital cost of $13 million. The control of inorganic HAP emissions from blast depainting operations would require the installation of particulate filtration systems such as baghouses at a capital cost of $54.5 million. Total nationwide capital costs range from $3.3 billion to $3.5 billion, depending on which chemical milling maskant control option is used.

1.3.1.2 Annual costs. All of the control options will result in some costs being incurred by the affected sources. However, the annualized cost figures presented below reflect the net cost to implement the control options after taking into account the costs that would have been incurred for baseline. This net cost (MACT cost minus baseline cost) resulted in an overall cost savings for primers, topcoats, and high transfer efficiency application methods; spray gun cleaning; and the use of chemical strippers that do not contain organic HAPs. All other options resulted in net annual costs to the affected sources. The net cost (or savings) for all control options reflect the maximum cost (or savings) that would be incurred assuming all affected sources implemented the specific control option.

Only one cost analysis was completed for primers, topcoats, and high transfer efficiency application methods due to the inter-relationship between these operations. For example, high transfer efficiency application methods will result in a lower volume of primers and topcoats being applied. In addition, the organic HAP and VOC limits on primers and topcoats will, due to higher solids content, also result in a lower volume of the coatings being applied. The reduction in coating usage due to the lower organic HAP and VOC content had to be taken into account first, then the reduction in coating usage due to high transfer efficiency application methods was applied to this reduced coating volume to obtain the true overall reduction in coating usage. After factoring in the annualized cost of the coating equipment, the analysis showed a nationwide cost savings of $218 million for commercial sources and $10.6 million for military sources.

The cost savings for primers, topcoats, and high transfer efficiency application methods is due primarily to labor savings that would result from the reduced volume of coatings to be applied. For example, if it would have taken 15 gallons of primer under baseline conditions to coat an aircraft and only 12 gallons under MACT conditions, then the cost analysis assumes a labor savings for the 3 gallons of primer that were not applied. The EPA has received some evidence, however, that the labor stays the same or may even increase with the use of high transfer efficiency application methods (specifically HVLP spray guns). The EPA requests comments from facilities that have converted from conventional spray guns to HVLP spray guns regarding the labor hours per gallon of coating applied for each application method.

Nationwide annual costs are estimated to be $15.3 million for hand-wipe and flush cleaning, $164 million for solvent-based chemical milling maskants with a carbon adsorber, $146 million for waterborne chemical milling maskants, $622 million for depainting with dry media blasting (or a net savings of $38.8 million if all affected sources used chemical strippers that contain no organic HAPs), $2.3 million for inorganic HAP emissions from primer and topcoat application operations, and $7.8 million for inorganic HAP emissions from blast depainting operations.

Total nationwide annual costs, depending on which control options are chosen, range from a net savings of $49.2 million to a net cost of $660 million. The majority of this cost differential (97 percent) is a result of all affected sources using blast depainting methods rather than chemical strippers that contain no organic HAPs. Due to the high capital cost of blast depainting equipment, very few facilities are expected to use this option other than those that already have it.

1.3.2 New Facilities

For the aerospace industry, no net growth is expected over the next five years; therefore, no new facilities are anticipated during this period.

2.0 INTRODUCTION

2.1 BACKGROUND AND AUTHORITY FOR STANDARDS

According to industry estimates, more than 2.4 billion pounds of toxic pollutants were emitted to the atmosphere in 1988 ("Implementation Strategy for the Clean Air Act Amendments of 1990," EPA Office of Air and Radiation, January 15, 1991). These emissions may result in a variety of adverse health effects, including cancer, reproductive effects, birth defects, and respiratory illnesses. Title III of the Clean Air Act Amendments of 1990 provides the tools for controlling emissions of these pollutants. Emissions from both large and small facilities that contribute to air toxics problems in urban and other areas will be regulated. The primary consideration in establishing national industry standards must be demonstrated technology. Before national emission standards for hazardous air pollutants (NESHAP) are proposed as Federal regulations, air pollution prevention and control methods are examined in detail with respect to their feasibility, environmental impacts, and costs. Various control options based on different technologies and degrees of efficiency are examined, and a determination is made regarding whether the various control options apply to each emissions source or if dissimilarities exist between the sources. In most cases, regulatory alternatives are subsequently developed that are then studied by EPA as a prospective basis for a standard. The alternatives are investigated in terms of their impacts on the environment, the economics and well-being of the industry, the national economy, and energy and other impacts. This document summarizes the information obtained through these studies so that interested persons will be able to evaluate the information considered by EPA in developing the proposed standards.

National emission standards for hazardous air pollutants for new and existing sources are established under Section 112 of the Clean Air Act as amended in 1990 [42 U.S.C. 7401 et seq., as amended by PL 101-549, November 15, 1990], hereafter referred to as the Act. Section 112 directs the EPA Administrator to promulgate standards that "require the maximum degree of reduction in emissions of the hazardous air pollutants subject to this section (including a prohibition of such emissions, where achievable) that the Administrator, taking into consideration the cost of achieving such emission reductions, and any non-air quality health and environmental impacts and energy requirements, determines is achievable..." The Act allows the Administrator to set standards that "distinguish among classes, types, and sizes of sources within a category or subcategory."

A major source is defined as "any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit considering controls, in the aggregate, 10 tons per year or more of any hazardous air pollutant or 25 tons per year or more of any combination of hazardous air pollutants." The Administrator, however, may establish a lesser quantity cutoff. The level of the cutoff is based on the potency, persistence, or other characteristics or factors of the air pollutant. For new sources, the amendments state that the "maximum degree of reduction in emissions that is deemed achievable for new sources in a category or subcategory shall not be less stringent than the emission control that is achieved in practice by the best controlled similar source, as determined by the Administrator." Emission standards for existing sources "may be less stringent than the standards for new sources in the same category or subcategory but shall not be less stringent, and may be more stringent than--

(A) the average emission limitation achieved by the best performing 12 percent of the existing sources (for which the Administrator has emissions information), excluding those sources that have, within 18 months before the emission standard is proposed or within 30 months before such standard is promulgated, whichever is later, first achieved a level of emission rate or emission reduction which complies, or would comply if the source is not subject to such standard, with the lowest achievable emission rate (as defined by Section 171) applicable to the source category and prevailing at the time, in the category or subcategory for categories and subcategories with 30 or more sources, or

(B) the average emission limitation achieved by the best performing five source (for which the Administrator has or could reasonably obtain emissions information) in the category or subcategory for categories or subcategories with fewer than 30 sources."

The Federal standards are also known as "MACT" standards and are based on the maximum achievable control technology previously discussed. The MACT standards may apply to major sources, although the existing source standards may be less stringent than the new source standards, within the constraints presented above. The MACT is considered to be the basis for the standard, but the Administrator may promulgate more stringent standards, which have several advantages. First, they may help achieve long-term cost savings by avoiding the need for more expensive retrofitting to meet possible future residual risk standards, which may be more stringent (discussed in Section 2.7). Second, Congress was clearly interested in providing incentives for improving technology. Finally, in the Clean Air Act Amendments of 1990, Congress gave EPA a clear mandate to reduce the health and environmental risk of air toxics emissions as quickly as possible.

The standards for hazardous air pollutants (HAP's), like the new source performance standards (NSPS) for criteria pollutants required by Section 111 of the Act (42 U.S.C. 7411), differ from other regulatory programs required by the Act (such as the new source review program and the prevention of significant deterioration program) in that NESHAP and NSPS are national in scope (versus site-specific). Congress intended for the NESHAP and NSPS programs to provide a degree of uniformity to State regulations to avoid situations where some States may attract industries by relaxing standards relative to other States. States are free under Section 116 of the Act to establish standards more stringent than Section 111 or 112 standards.

Although NESHAP are normally structured in terms of numerical emissions limits, alternative approaches are sometimes necessary. In some cases, physically measuring emissions from a source may be impossible or at least impracticable due to technological and economic limitations. Section 112(h) of the Act allows the Administrator to promulgate a design, equipment, work practice, or operational standard, or combination thereof, in those cases where it is not feasible to prescribe or enforce an emissions standard. For example, emissions of volatile organic compounds (many of which may be HAP's, such as benzene) from storage vessels for volatile organic liquids are greatest during tank filling. The nature of the emissions (i.e., high concentrations for short periods during filling and low concentrations for longer periods during storage) and the configuration of storage tanks make direct emission measurement impractical. Therefore, the MACT standards may be based on equipment specifications.

Under Section 112(h)(3), the Act also allows the use of alternative equivalent technological systems: "If, after notice and opportunity for comment, the owner or operator of any source establishes to the satisfaction of the Administrator that an alternative means of emission limitation" will reduce emissions of any air pollutant at least as much as would be achieved under the design, equipment, work practice, or operational standard, the Administrator shall permit the use of the alternative means.

Efforts to achieve early environmental benefits are encouraged in Title III. For example, source owners and operators are encouraged to use the Section 112 (i)(5) provisions, which allow a 6-year compliance extension of the MACT standard in exchange for the implementation of an early emission reduction program. The owner or operator of an existing source must demonstrate a 90 percent emission reduction of HAP's (or 95 percent if the HAP's are particulates) and meet an alternative emission limitation, established by permit, in lieu of the otherwise applicable MACT standard. This alternative limitation must reflect the 90 (95) percent reduction and is in effect for a period of 6 years from the compliance date for the otherwise applicable standard. The 90 (95) percent early emission reduction must be achieved before the otherwise applicable standard is first proposed, although the reduction may be achieved after the standard's proposal (but before January 1, 1994) if the source owner or operator makes an enforceable commitment before the proposal of the standard to achieve the reduction. The source must meet several criteria to qualify for the early reduction standard, and Section 112(i)(5)(A) provides that the State may require additional reduction.

2.2 SELECTION OF POLLUTANTS AND SOURCE CATEGORIES

As amended in 1990, the Act includes a list of 189 HAP's. Petitions to add or delete pollutants from this list may be submitted to EPA. Using this list of pollutants, EPA will publish a list of source categories (major sources) for which emission standards will be developed. Within 2 years of enactment (November 1991), EPA will publish a schedule establishing dates for promulgating these standards. Petitions may also be submitted to EPA to remove source categories from the list. The schedule for standards for source categories will be determined according to the following criteria:

"(A) the known or anticipated adverse effects of such pollutants on public health and the environment;

(B) the quantity and location of emissions or reasonably anticipated emissions of hazardous air pollutants that each category or subcategory will emit; and

(C) the efficiency of grouping categories or subcategories according to the pollutants emitted, or the processes or technologies used."

After the source category has been chosen, the types of facilities within the source category to which the standard will apply must be determined. A source category may have several facilities that cause air pollution, and emissions from these facilities may vary in magnitude and control cost. Economic studies of the source category and applicable control technology may show that air pollution control is better served by applying standards to the more severe pollution sources. For this reason, and because there is no adequately demonstrated system for controlling emissions from certain facilities, standards often do not apply to all facilities at a source. For the same reasons, the standards may not apply to all air pollutants emitted. Thus, although a source category may be selected to be covered by standards, the standards may not cover all pollutants or facilities within that source category.

2.3 PROCEDURE FOR DEVELOPMENT OF NESHAP

Standards for major sources must (1) realistically reflect MACT; (2) adequately consider the cost, the non-air quality health and environmental impacts, and the energy requirements of such control; (3) apply to new and existing sources; and (4) meet these conditions for all variations of industry operating conditions anywhere in the country.

The objective of the NESHAP program is to develop standards to protect the public health by requiring facilities to control emissions to the level achievable according to the MACT guidelines. The standard-setting process involves three principal phases of activity: (1) gathering information, (2) analyzing the information, and (3) developing the standards.

During the information-gathering phase, industries are questioned through telephone surveys, letters of inquiry, and plant visits by EPA representatives. Information is also gathered from other sources, such as a literature search. Based on the information acquired about the industry, EPA selects certain plants at which emissions tests are conducted to provide reliable data that characterize the HAP emissions from well-controlled existing facilities.

In the second phase of a project, the information about the industry, the pollutants emitted, and the control options are used in analytical studies. Hypothetical "model plants" are defined to provide a common basis for analysis. The model plant definitions, national pollutant emissions data, and existing State regulations governing emissions from the source category are then used to establish "regulatory alternatives." These regulatory alternatives may be different levels of emissions control or different degrees of applicability or both.

From several alternatives, EPA selects the single most plausible regulatory alternative as the basis for the NESHAP for the source category under study. The EPA then conducts studies to determine the cost, economic, environmental, and energy impacts of this regulatory alternative.

In the third phase of a project, the selected regulatory alternative is translated into standards, which, in turn, are written in the form of a Federal regulation. The Federal regulation limits emissions to the levels indicated in the selected regulatory alternative.

As early as is practical in each standard-setting project, EPA representatives discuss the possibilities of a standard and the form it might take with representatives from industry, environmental groups, and State and local air pollution control agencies. Other interested parties also participate in these meetings.

The information acquired in the project is summarized in the background information document (BID). The BID is widely circulated to the industry being considered for control, environmental groups, other government agencies, and offices within EPA. Through this extensive review process, the points of view of expert reviewers are taken into consideration as changes are made to the documentation.

A "proposal package" is assembled and sent through the offices of EPA Assistant Administrators for concurrence before the proposed standards are officially enforced by the EPA Administrator. After being approved by the EPA Administrator, the preamble and the proposed regulation are published in the Federal Register.

The public is invited to participate in the standard-setting process as part of the Federal Register announcement of the proposed regulation. The EPA invites written comments on the proposal and also holds a public hearing to discuss the proposed standards with interested parties. All public comments are summarized and incorporated into a second volume of the BID. All information reviewed and generated in studies in support of the standards is available to the public in a "docket" on file in Washington, D.C. Comments from the public are evaluated, and the standards may be altered in response to the comments.

The significant comments and EPA's position on the issues raised are included in the preamble of a promulgation package, which also contains the draft of the final regulation. The regulation is then subjected to another round of internal EPA review and refinement until it is approved by the EPA Administrator. After the Administrator signs the regulation, it is published as a "final rule" in the Federal Register.

2.4 CONSIDERATION OF COSTS

The requirements and guidelines for the economic analysis of proposed NESHAP are prescribed by Presidential Executive Order 12291 (EO 12291) and the Regulatory Flexibility Act (RFA). The EO 12291 requires preparation of a Regulatory Impact Analysis (RIA) for all "major" economic impacts. An economic impact is considered to be major if it satisfies any of the following criteria:

1. An annual effect on the economy of $100 million or more;

2. A major increase in costs or prices for consumers; individual industries; Federal, State, or local government agencies; or geographic regions; or

3. Significant adverse effects on competition, employment, investment, productivity, innovation, or on the ability of United States-based enterprises to compete with foreign-based enterprises in domestic or export markets.

An RIA describes the potential benefits and costs of the proposed regulation and explores alternative regulatory and nonregulatory approaches to achieving the desired objectives. If the analysis identifies less costly alternatives, the RIA includes an explanation of the legal reasons why the less costly alternatives could not be adopted. In addition to requiring an analysis of the potential costs and benefits, EO 12291 specifies that EPA, to the extent allowed by the CAA and court orders, demonstrate that the benefits of the proposed standards outweigh the costs and that the net benefits are maximized.

The RFA requires Federal agencies to give special consideration to the impact of regulations on small businesses, small organizations, and small governmental units. If the proposed regulation is expected to have a significant impact on a substantial number of small entities, a regulatory flexibility analysis must be prepared. In preparing this analysis, EPA takes into consideration such factors as the availability of capital for small entities, possible closures among small entities, the increase in production costs due to compliance, and a comparison of the relative compliance costs as a percent of sales for small versus large entities.

The prime objective of the cost analysis is to identify the incremental economic impacts associated with compliance with the standards based on each regulatory alternative compared to baseline. Other environmental regulatory costs may be factored into the analysis wherever appropriate. Air pollutant emissions may cause water pollution problems, and captured potential air pollutants may pose a solid waste disposal problems. The total environmental impact of an emission source must, therefore, be analyzed and the costs determined whenever possible.

A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made for proposed standards. It is also essential to know the capital requirements for pollution control systems already placed on plants so that the additional capital requirements necessitated by these Federal standards can be placed in proper perspective. Finally, it is necessary to assess the availability of capital to provide the additional control equipment needed to meet the standards.

2.5 CONSIDERATION OF ENVIRONMENTAL IMPACTS

Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969 requires Federal agencies to prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The objective of NEPA is to build into the decision-making process of Federal agencies a careful consideration of all environmental aspects of proposed actions.

In a number of legal challenges to standards for various industries, the United States Court of Appeals for the District of Columbia Circuit has held that environmental impact statements need not be prepared by EPA for proposed actions under the Clean Air Act. Essentially, the Court of Appeals has determined that the best system of emissions reduction requires the Administrator to take into account counterproductive environmental effects of proposed standards as well as economic costs to the industry. On this basis, therefore, the Courts established a narrow exemption from NEPA for EPA determinations.

In addition to these judicial determinations, the Energy Supply and Environmental Coordination Act (ESECA) of 1974 (PL-92-319) specifically exempted proposed actions under the Clean Air Act from NEPA requirements. According to Section 7(c)(1), "No action taken under the Clean Air Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969" (15 U.S.C. 793(c)(1)).

Nevertheless, EPA has concluded that preparing environmental impact statements could have beneficial effects on certain regulatory actions. Consequently, although not legally required to do so by Section 102(2)(C) of NEPA, EPA has adopted a policy requiring that environmental impact statements be prepared for various regulatory actions, including NESHAP developed under Section 112 of the Act. This voluntary preparation of environmental impact statements, however, in no way legally subjects the EPA to NEPA requirements.

To implement this policy, a separate action is included in this document that is devoted solely to an analysis of the potential environmental impacts associated with the proposed standards. Both adverse and beneficial impacts in such areas as air and water pollution, increased solid waste disposal, and increased energy consumption are discussed.

2.6 RESIDUAL RISK STANDARDS

Section 112 of the Act provides that 8 years after MACT standards are established (except for those standards established 2 years after enactment, which have 9 years), standards to protect against the residual health and environmental risks remaining must be promulgated, if necessary. The standards would be triggered if more than one source in a category or subcategory exceeds a maximum individual risk of cancer of 1 in 1 million. These residual risk regulations would be based on the concept of providing an "ample margin of safety to protect public health." The Administrator may also consider whether a more stringent standard is necessary to prevent--considering costs, energy, safety, and other relevant factors--an adverse environmental effect.

3.0 AEROSPACE MANUFACTURING AND REWORK OPERATIONS

3.1 GENERAL

The aerospace industry being evaluated includes all manufacturing facilities that produce an aerospace vehicle or component and all facilities that rework or repair these aerospace products. Aerospace vehicle or component is defined as any fabricated part, processed part, assembly of parts, or completed unit of any aircraft including, but not limited to, airplanes, helicopters, missiles, rockets, and space vehicles. Facilities that also conduct non-aerospace work may be subject to the proposed rule, regardless of the relative proportion of aerospace and non-aerospace work at the facility. In addition to manufacturing and rework facilities, some shops may specialize in providing a service, such as chemical milling, rather than actually producing a component or assembly.

In general, aerospace manufacturing and rework facilities are covered by the SIC codes listed in Table 3-1. However, facilities classified under other SIC codes may be subject to the proposed rule if the facility meets the definition of a major source and the definition of an aerospace manufacturing or rework facility.

Aerospace facilities may be divided into four market segments: commercial original equipment manufacturers (OEM), commercial rework facilities, military OEMs, and military rework facilities. The commercial OEM segment of the market includes the manufacturing of commercial aircraft as well as the production of business and private aircraft. The military OEM

Table 3-1

Aerospace Manufacturing SIC Codes

SIC Code	Description
3720	Aircraft and Parts
3721	Aircraft
3724	Aircraft Engines and Engine Parts
3728	Aircraft Parts and Equipment
3760	Guided Missiles, Space Vehicles, and Parts
3761	Guided Missiles and Space Vehicles
3764	Space Propulsion Units and Parts
3769	Space Vehicle Equipment

Aerospace Rework SIC Code

SIC Code	Description
4581	Airports, Flying Fields, and Services

segment of the market includes military installations and defense contractors that manufacture aircraft, missiles, rockets, satellites, and spacecraft. Rework facilities, both commercial and military, may rework many of the above end products.

Based on information obtained through the Federal Aviation Administration and the U.S. Department of Commerce - Bureau of the Census,[1,2] there are an estimated 2,869 aerospace facilities that will be subject to the proposed standard. Of this number, 1,395 produce or rework commercial products, and 1,474 produce or rework military products. The combined hazardous air pollutant (HAP) emissions from these facilities are estimated to be over 280,000 Mg/yr (310,000 tons/yr).

In addition to these facilities, there are numerous subcontractors that manufacture or rework aerospace vehicles or components. The subcontractors may work directly for the OEM or rework facilities, or indirectly through first line subcontractors. As most of these subcontractors perform various types of work, they are often classified under non-aerospace SIC codes. Consequently, an estimate of the number of subcontractors cannot be made. One company alone, however, employs the services of over 5,000 subcontractors.

Aerospace manufacturing facilities and rework operations are typically located in or near industrial centers in areas of medium to high population density. Some states with large numbers of aerospace manufacturers are California, Texas, Connecticut, Florida, and Washington. Figure 3-1 presents the number of aerospace manufacturing facilities by state.

Aerospace manufacturing facilities range in size from small shops that produce a single aerospace component, such as propellers, to large corporations that produce the entire aircraft. Aerospace rework facilities,

ACTIVE U.S. AEROSPACE MANUFACTURING BASE

Total U.S. Manufacturing Facilities : 3504

Figure 3-1. Active U.S. Aerospace Manufacturing Base.
[References 1 and 2]

however, are usually large facilities that must be able to rework or repair every facet of several models of large commercial or military aircraft.

The hours of operation at aerospace manufacturing and rework facilities may vary greatly due to the production backlog at each facility. The hours of operation may range from 8 hours (or less) per day, 5 days per week, to 24 hours per day, 7 days per week.

3.2 PROCESS DESCRIPTION

Aerospace manufacturing and rework operations consists of the following basic operations: materials receiving, machining and mechanical processing, chemical milling maskant application, chemical milling, heat treating, sealing, adhesive bonding, hand-wipe cleaning, spray equipment cleaning, metal finishing, coating application, coating removal (depainting), electrodeposition (metal plating), composite processing, and testing. Many aerospace manufacturing and rework facilities may employ all of these processes in their operations, as with an OEM facility that produces the entire aircraft. However, an aerospace facility may only employ a subset of these operations, as with a facility that produces a single component or assembly, or a facility that provides a service such as chemical milling.

The following sections discuss thirteen general process categories. These categories are intended to cover all of the aerospace processes found at OEM and rework facilities.[3]

3.2.1 Materials Receiving

Materials used in aerospace manufacturing and rework fall into one of two general categories: materials to form parts, and coatings and chemicals. The most common materials are alloys of aluminum, which are used primarily for aircraft structural components and exterior skin sections. Other materials are titanium, stainless steel, magnesium, and non-metallics such as plastics, fabrics, and composite materials. Typical forms of materials are honeycomb, wire mesh, plate, sheet stock, bar cast, and forged material. Also received in this area are procured hardware (e.g., fasteners, rivets, and screws), fabricated parts, and assemblies. These materials are stored in a general storage area.

Minor processing of materials may occur in the receiving area. Examples of these operations are application of temporary protective coatings and oils to inhibit corrosion, and application of stenciled or stamped identification markings. Typically, no processing is done to coatings and chemicals in materials receiving.

3.2.2 Machining and Mechanical Processing

3.2.2.1 Machining. Materials may first require rough-cutting to a configuration approximating the size and shape of the final part. The raw or rough-cut materials are machined by milling, cutting, grinding, routing, or drilling to produce the final shape of the part. Sheet stock may be cut into the desired shapes using either a laser or knife-type cutter. Machined parts cover a wide variety of shapes and sizes, ranging from a small flat plate to a complex structural framework. Machining oils and coolants are used to lubricate and cool the parts and tools, and to carry away the machined chips. After machining, some parts are coated with an anti-rust oil, wrapped in a protective material, and put in storage to await further processing. Other parts are processed further as discussed below.

3.2.2.2 Deburring. Deburring involves removing metal shavings and burrs clinging to the cut edges of parts after machining has been completed. Deburring is typically one of two processes. Small parts can be deburred in a tumbler where the burrs are smoothed off the part by the constant friction with the tumbling media. This process, however, is not appropriate for long parts. Instead, long parts are scrubbed with an abrasive pad by hand or buffed with a power tool. The buffing operation can be performed either by hand or in an automatic operation.

3.2.2.3 Forming. Forming is the process in which machined component parts or bar and flat stock material are mechanically shaped to fit required specifications. Examples of forming processes are bending, flaring, stamping, forging, and fitting.

Machined components and flat stock are formed by placing the part between two halves of a mold, then pressing the mold together using high pressure. This shapes the part to the configuration of the mold. Release agents (either dry or liquid coatings) are typically applied to the part and the mold to prevent the part from sticking to the mold. Bar stock is formed by bending to the desired shape.

3.2.2.4 Welding. Welding is used to build permanent assemblies composed of a single metal or alloy. Some of these processes are tungsten-inert gas welding, metal-inert gas welding, heliarc, electron beam, and arc welding using manual or semi-automated equipment. Welding is performed before or after machining depending on the configuration requirements of the individual part. Each subassembly unit is ink stamped with a part number for identification.

3.2.3 Maskant Application and Chemical Milling

3.2.3.1 Maskant Application. Maskants are coatings that are applied to a part to protect the surface from chemical milling (see Section 3.2.3.2) and surface treatment processes subsequent to chemical milling such as anodizing, plating, etching, and bonding. Maskants are typically rubber- or polymeric-based substances (similar to common rubber cement) applied to an entire part or subassembly by brushing, dipping, spraying, or flow coating. Two major types of maskants are used: solvent-based and waterborne. Before the maskant can be applied to the part, the surface must be thoroughly cleaned and prepared, usually by the following three step process: (1) alkaline cleaning, the removal of dirt, oils, and grease with the use of an alkaline cleaner, (2) pickling, the removal of scale with inorganic acids, and (3) surface passivation, the chemical formation of an oxide layer. These three steps ensure a uniform removal of metal in the chemical milling process and provide adequate surface adhesion between the part and the masking agent.[4] After an adequate thickness of maskant has been applied to the part, the maskant is cured in a bake oven. The maskant is then cut following a specific pattern (called "scribing") and manually stripped away from selected areas of the part where metal is to be removed. The maskant remaining on the part protects those areas from the etching solution (etchant).

3.2.3.2 Chemical Milling. Chemical milling is used to reduce the thickness of selected areas of metal parts in order to reduce weight. The process is typically used when the size or shape of parts precludes mechanical milling or when chemical milling is advantageous due to shorter processing time or its batch capability.

Chemical milling is accomplished by submerging the component in an appropriate etchant. Commonly used etchants are sodium hydroxide for aluminum, nitric acid and hydrofluoric acid for titanium, dilute sulfuric acid for magnesium, and aqua regia (a mixture of nitric and hydrochloric acids) for stainless steel. Since the concentration of the solution affects the milling rate, it must be closely controlled to obtain the desired rate. The depth of the cut is controlled by the length of time the component is in the etchant and the concentration of the etchant. When the milling has been completed, the part is removed from the etchant and rinsed with water. Some metals may develop a smutty discoloration during the chemical milling process. A brightening solution, such as dilute nitric acid, is typically used as a final step in the process to remove the discoloration.[5] The process of removing discoloration is referred to as "desmutting." After desmutting, the part either goes back to chemical milling for further metal removal or to the stripping area to have the maskant removed. The maskant may be softened in a solvent solution and then stripped off by hand.

3.2.4 Heat Treating

Heat treating is the process of changing a material's or part's metallurgical properties prior to coating or assembly. For example, aluminum outer skin panels undergo a low temperature oven bake after forming to provide greater stress tolerance. Heat treating can be performed either before or after machining and includes carburizing (impregnating the surface with carbon), annealing (softening), stress relief, tempering, air furnace treating, and salt pot treating. Compounds, such as methanol, are often used in heat treating ovens to maintain a chemically reducing atmosphere in order to obtain the proper metallurgical properties on the surface of the part being treated. After heat treating, the parts can either be cooled in ambient air or placed in a liquid quenching bath. The quench bath is typically a glycol solution, a chromate solution, or an oil.

3.2.5 Sealing

Sealants, predominately composed of polysulfide, are applied throughout the aircraft structure primarily to seal out moisture and contaminants in order to prevent corrosion, such as on faying (i.e., closely or tightly fitting) surfaces, inside holes and slots, and around installed fasteners. They are also used to seal fuel tank cells. Sealants are applied using tubes, spatulas, brushes, rollers, or spray guns. Sealants are often stored frozen and thawed before use, and many are two-component mixtures that cure after mixing. Often a sealant is applied before assembly or fastener installation, and the excess is squeezed out or extruded from between the parts as assembly is completed. This ensures a moisture-tight seal between the parts. Solvents are often added to sealants to aid in achieving the proper application consistency.

3.2.6 Adhesive Bonding

Adhesive bonding involves the joining together of two or more metal or non-metal components, such as the splicing of two pieces of a honeycomb core or the joining of skins to a honeycomb core. This process is typically performed when the joints being formed are essential to the structural integrity of the aircraft. Bonding surfaces are typically roughened mechanically or etched chemically to provide increased surface area for bonding and then chemically treated to provide a stable corrosion resistant oxide layer. The surfaces are then coated with an adhesive bonding primer in a thin film (0.1 to 0.5 millimeter) to promote adhesion and protect from subsequent corrosion. Structural adhesives are applied as either a thin film or as a paste. The parts are joined together and cured either at ambient temperature or in an autoclave to activate the adhesive and provide a permanent bond between the components.[6]

3.2.7 Cleaning

3.2.7.1 Hand-wipe and flush cleaning. Aerospace components are cleaned frequently during manufacturing to remove contaminants such as dirt, grease, and oil, and to prepare the components for the next operation. Cleaning is typically performed by a hand wiping process using a wide variety of cleaning solvents. Assemblies and parts with concealed or inaccessible areas may be flush cleaned by pouring the cleaning agent over and into the part. The cleaning agent is then drained from the part and the procedure is repeated as many times as necessary to ensure the required cleanliness.

3.2.7.2 Spray gun and coating line cleaning. Spray guns and coating lines used to apply the various coatings used at aerospace facilities must be cleaned when switching from one coating to another and when they are not going to be immediately reused. The cleaning of spray guns can be performed either manually or with enclosed spray gun cleaners. Manual cleaning involves disassembling the gun and placing the parts in a vat containing an appropriate cleaning solvent. The residual paint is brushed or wiped off the parts. After reassembling, the cleaning solvent may be sprayed through the gun for a final cleaning. Coating lines are cleaned by passing the cleaning solvent through the lines until all coating residue is removed.

Enclosed spray gun cleaners are self-contained units that pump the cleaning solvent through the gun within a closed chamber. After the cleaning cycle is complete, the guns are removed from the chamber and typically undergo some manual cleaning to remove coating residue from areas not exposed to the cleaning solvent, such as the seals under the atomizing cap.

Cleaning agents for hand-wipe, flush, and spray equipment cleaning consist of solvents such as methyl ethyl ketone, methyl isobutyl ketone, toluene, or various solvent blends. Chlorinated hydrocarbons, such as 1,1,1-trichloroethane and trichloroethylene, are also often used. Some cleaners that contain little or no HAPs, particularly citrus-based cleaners or saponified aqueous (soapy water) solutions, are in use or under trial for hand-wipe cleaning at many facilities.

3.2.8 Metal Finishing

Metal finishing processes are used to prepare the surface of a part for better adhesion, improved surface hardness, and improved corrosion resistance.

Typical metal finishing operations include conversion coating, anodizing, passivation, pickling, alkaline cleaning, deoxidizing, desmutting, descaling, polishing, abrasive cleaning, shot-peening, or any operation that mechanically or chemically affects the surface layer of a part. Hydrochloric acid, nickel chloride, sodium cyanide, chromic conversion, and other solutions may be applied to a variety of metal substrates before other surface operations may proceed. After leaving the process lines, many parts are placed in a hot air dryer to remove residual moisture. Specific surface preparation processes are discussed below.

3.2.8.1 Conversion Coating. Conversion coating is the process of changing a metal's surface characteristics by applying a reactive chemical to the metal's surface or by reacting the metal in a chemical bath.[7] The desired result is improved coating adhesion, increased corrosion resistance, or both. The parts are typically prepared for these operations by alkaline cleaning, rinsing to neutralize and remove the alkaline cleaning solution, acid etching to prepare the surface, and rinsing to remove the etching solution. After these preparation steps, the conversion coating is applied by immersing, brushing, spraying, or wiping.[8]

3.2.8.2 Anodizing. Anodizing is the electrochemical treatment of aluminum, magnesium, and other select metals in order to form an oxide layer on the surface of the metal. This is used to protect a part from corrosion and increase the part's electrical insulation.[9] Anodizing involves immersing the part in a solution typically containing chromic acid or sulfuric acid. A direct electrical current is applied such that the part is the negative terminal, or anode. Afterwards, the part is rinsed and then immersed in hot water or a hot dilute solution of sodium dichromate to seal the anodized surface. The part may then be sent to an oven for drying.

3.2.8.3 Passivation. Passivation is a chemical process in which parts are immersed in a solution containing a strong oxidizing agent. This forms a thin oxide layer on the part surface, providing corrosion protection and increasing adhesion of subsequent coatings. It is often used before maskant application in the chemical milling process.

3.2.8.4 Pickling. Pickling is the chemical process of removing oxides from metal surfaces. Parts are immersed in an inorganic acid solution, generally hydrochloric, phosphoric, or sulfuric acid. The rate of removal is affected by concentration, temperature, and electrolysis. The usual solution has a concentration of 15 percent acid at or above 100°C (212°F).[10]

3.2.8.5 Alkaline Cleaning. Alkaline cleaning is typically a tank bath process in which parts are immersed in a solution containing a strong alkaline agent. Alkaline cleaning is used to remove dirt, oils, and grease.

3.2.8.6 Deoxidizing, Desmutting, and Descaling. Deoxidizing, desmutting, and descaling are acidic or alkaline metal cleaning processes. Deoxidizing and desmutting remove thin oxide layers from metal surfaces. A specific example of deoxidizing is brightening, an acidic process used after chemical milling to smooth and enhance the appearance of a metal surface. Descaling is the process of removing thick oxide layers or deposits from metal surfaces.[11] Example operations are chrome deoxidizing, chrome desmutting, acid etching, permanganate descaling, molten salt descaling, hydrofluoric acid/nitric acid descaling, hydrochloric acid descaling, and nitric acid descaling/passivation.

3.2.8.7 Polishing. Polishing is used at some facilities to clean and finish the outer skin of the aircraft. The polish is a lightly abrasive metal cleaner that is buffed on the metal surface, then wiped off. The polish gives a mirror-like surface finish and is usually applied instead of paint. Polishing can also be used on other metal parts as a cleaning step.

3.2.8.8 Abrasive Cleaning. Abrasive cleaning cleans surfaces with abrasive media such as rough fabric scrubbing pads or sandpaper. Abrasive cleaning is used instead of, or in addition to, deoxidation. This operation removes corrosion and slightly roughens the surface to prepare for painting.

3.2.8.9 Mechanical Surface Preparation. Mechanical surface preparation is the process of mechanically hardening the surface of a metal part. One example process often used by the industry is shot-peening. Shot-peening is a process where a metal part is blasted with small media (or shot).

3.2.9 Coating Application

A coating is a material that is applied to the surface of a part to form a decorative or functional solid film.[12] The most common coatings are the broad categories of non-specialized primers and topcoats. There are also numerous specialty coatings ranging from temporary protective coatings to radiation effect coatings designed to shield aircraft from radar detection.

Coatings are applied to aerospace vehicles or components using several methods of application. These are spraying, brushing, rolling, flow coating, and dipping. Spray application systems include conventional air spray, airless spray, air-assisted airless, electrostatic, and high-volume low-pressure (HVLP) spray. These latter two methods are generally accepted as having better transfer efficiency than the other spraying methods and are gaining increased use as a means of using less coating and, hence, reducing emissions.

Nearly all aerospace coatings contain a mixture of organic solvents, many of which are HAPs. The most common HAP solvents used in coatings are toluene, xylene, methyl ethyl ketone, trichloroethylene, and 1,1,1-

trichloroethane. The HAP content ranges differ for the various coating categories. High solids coatings and waterborne coatings, which generally contain less solvent than the solvent-based coatings, are slowly becoming accepted in the industry. Powder coatings, which do not contain solvents, are applied electrostatically as a dry powder and then cured. Powder coatings presently have limited use in the aerospace industry. A detailed discussion of coating substitutions is presented in Section 4.1.1.1.

3.2.10 Coating Removal (Depainting)

The depainting operation involves the removal of coatings from the outer surface of the aircraft. The two basic types are chemical depainting and blast depainting. Methylene chloride is the most common chemical stripper solvent. Chemical depainting agents are applied to the aircraft, allowed to degrade the coating, and then scraped or washed off with the coating residue. Blast depainting methods utilize a media such as plastic, wheat starch, carbon dioxide (dry ice), or high pressure water to remove coatings by physically abrading the coatings from the surface of the aircraft. Grit blasting and sand/glass blasting are also included in this category. High intensity ultraviolet light stripping has been developed for use in conjunction with carbon dioxide methods and is under development at several facilities.

3.2.11 Electrodeposition (Metal Plating)

Electrodeposition is an additive process for metal substrates in which another metal layer is added to the substrate in order to enhance corrosion and wear resistance necessary for the successful performance of a component. The two types of electrodeposition typically used are electroplating and plasma arc spraying.

Electroplating is a multi-step process where the part to be plated is first immersed in a series of chemical baths to clean and etch the surface of the part. The part is then immersed in the electroplating solution and a direct electrical current applied such that the part is the positive terminal, or cathode. The electroplating solution is an acidic solution containing a dissolved salt of the metal to be plated (e.g., copper sulfate for a copper plating solution). Soluble anodes of the metal being plated are immersed in the electroplating solution on either side of the part. The plating thickness is controlled primarily by the amount of current applied and the plating time.

The plasma arc spray process melts powdered metal materials using plasma (hot ionized gas) as a heat source. A gas or gas mixture is passed through an electric arc between a cathode and an orifice in an anode. The gas passing through the orifice is heated to temperatures much higher than those obtained with a combustion flame. During heating, the gas is partially ionized, producing a plasma. As the plasma exits the orifice, disassociated molecules of diatomic gases recombine and liberate heat. A metallic powder is then introduced into the plasma, melted, and propelled onto the work piece by the high velocity stream of gases. The resulting coating is very hard and wear resistant.[13]

The aerospace industry uses a wide variety of metals for electrodeposition including nickel, zinc, chromium, cadmium, copper, tin, and silver. Of these, nickel, chromium, and cadmium compounds are HAPs.

3.2.12 Composites Processing

The aerospace industry is increasingly substituting composites for metals in aircraft and space vehicles due to the superior strength-to-weight ratio, corrosion resistance, and fatigue life of composites. Composites are comprised of a resin matrix that bonds together layers of reinforcing material. The resultant structure has mechanical properties superior to each individual component.[14] The resin matrix is usually a polymeric material such as epoxy, polyester, nylon, or phenolic. The reinforcing material or fiber is usually carbon (graphite), fiberglass, or Kevlar®. The fibers are oriented at specific angles within the matrix to achieve desired strength characteristics.

Methods of forming composites include: injection molding, compression molding, and hand lay-up (or wet lay-up). Hand lay-up can involve applying resin on pre-woven fibers or can involve stacking thin sheets of pre-impregnated (prepreg) fiber material. Steps in hand lay-up are typically: lay-up, debulking, curing, and tear-down (break-out).

3.2.12.1 Injection Molding. Injection molding is the process of shaping a material by applying heat and utilizing the pressure created by injecting a resin into a closed mold.[15]

3.2.12.2 Compression Molding. Compression molding is the process of filling a mold with molding compound, closing the mold, and applying heat and pressure until the material has cured.[16]

3.2.12.3 Lay-up. Lay-up is the process of assembling composite parts by positioning reinforcing material in a mold and impregnating the material with resin.[17] With hand lay-up, reinforcing material with resin or prepreg (a composite fabric which is precoated with resin) can be added to an open mold until the design thickness and contours are achieved.[18]

3.2.12.4 Debulking. Debulking is the simultaneous application of low-level heat and pressure to composite materials to force out excess resin, trapped air, vapor, and volatiles from between the layers of the composite, thus removing voids within the composite.[19]

3.2.12.5 Curing. Curing is the process of changing the resin into a solid material so that the composite part holds its shape. This is accomplished by heating the lay-up assembly in order to initiate a polymerization reaction within the resin. Once the reaction is complete, the resin solidifies and bonds the layers of composite materials together.

The curing process is typically performed in an autoclave (a pressurized oven), with the composite lay-up enclosed in a bag so that a vacuum can be applied. The vacuum removes air and volatilized components of the resin from within the composite structure which may otherwise be trapped and create voids. Key parameters for curing are time, pressure, vacuum, temperature, and heating and cooling rates.[20]

3.2.12.6 Break-Out. Break-out is the removal of the composite materials from the molds or curing fixtures (includes the application of release agents prior to filling the mold).

3.2.13 Testing

A wide variety of tests are performed by the aerospace industry to verify that parts meet manufacturing specifications. Leak tests are performed on assemblies such as wing fuel tanks. These parts are filled with an aqueous solution or a gas to check seams and seals. Dye penetrant is used following chemical milling and other operations to check for cracks, flaws, and fractures. Many different kinds of penetrants, fluids, dyes, and etchants can be applied to the surface of metal parts to aid in the detection of defects. Hydraulic and fuel system checks are other typical testing operations. Weight checks are performed to verify the balance of certain structures, such as propeller blades and vertical tail rudders. Critical areas on the assembled components are checked for flaws, imperfections, and proper alignment of parts by X-ray.

3.3 UNCONTROLLED EMISSIONS

The thirteen processes presented in Section 3.2 are intended to encompass all HAP emitting processes involved in aerospace manufacturing and rework operations. Emissions data for each of these processes were obtained through Section 114 and site visit questionnaires. The total uncontrolled emissions of HAPs for each process, as reported in the questionnaires, are presented in Table 3-2. Sections 3.3.1 to 3.3.4 present the source of emissions and typical HAPs emitted from each process being considered in the rule.

Six non-coating related operations -- materials receiving; machining and mechanical processing; chemical milling, metal finishing, and electrodeposition; heat treating; composite processing; and testing -- and for four coating-related operations -- adhesives; adhesive bonding primers; sealants; and specialty coatings listed in Section 3.2 were found to contribute negligible amounts to the overall uncontrolled emissions. The six non-coating related operations were found to account for less than 1 percent of the total organic HAP emissions from aerospace facilities. The four coating-related operations will be covered under the aerospace CTG with VOC content limits. These processes will not be discussed in this section, and will not be considered further in the development of model plants or baseline emissions presented in Chapter 6.

All emission data presented in Sections 3.3.1 to 3.3.4 represent only the facilities surveyed through the Section 114 and site visit questionnaires (see Section 6.1 for a listing of these facilities). The emission values in this section, therefore, are not intended to represent nationwide values for the industry as a whole. Nationwide HAP emissions are presented in Section 6.2.

3.3.1 Maskant Application

HAP emissions are associated with solvent evaporation during maskant application and drying. Maskants generally contain high levels [greater than

TABLE 3-2

TOTAL ANNUAL HAP EMISSIONS BY PROCESS
AS REPORTED IN THE SECTION 114 AND
SITE VISIT QUESTIONNAIRES

Process	Emissions (Mg/year)	Emissions (tons/year)
Materials Receiving	4	5
Machining and Mechanical Processing	19	21
Maskant Application	594	654
Chemical Milling	6	7
Heat Treating	0.08	0.09
Sealants	689	758
Adhesive Bonding - Primers - Adhesives	256 423	282 465
Cleaning	4855	5341
Metal Finishing	20	22
Coating Application - Primers - Topcoats - Specialty	715 639 473	787 703 520
Coating Removal (Depainting)	1249	1374
Electrodeposition	0.4	0.4
Composites Processing	92	101
Testing	0.9	1

700 grams VOC/liter (5.8 pounds VOC/gallon)] of VOC or HAP solvents such as perchloroethylene or a toluene/xylene mixture.

The annual uncontrolled HAP emissions were 594 Mg (654 tons). Maskant applied by spray application methods are typically performed within a spray booth, allowing for collection of the emissions and subsequent routing to a control device. Maskant applied by dip tank methods typically result in fugitive emissions. However, one large military/OEM facility has demonstrated an enclosure for dip tank application in order to contain the HAP emissions.

3.3.2 Cleaning

HAP emissions from cleaning operations occur from the evaporation of cleaning solvents during the cleaning process, including evaporation of the solvent from open containers. Emissions also occur from the solvent-soaked rags. Cleaning solvent emissions occur from nearly every aerospace manufacturing and rework operation and typically account for the largest single portion of a facility's emissions.

HAPs typically used in cleaning processes are methyl ethyl ketone, methylene chloride, 1,1,1-trichloroethane, toluene, xylene, methyl isobutyl ketone, and glycol ethers. Total annual uncontrolled HAP emissions was 4,855 Mg (5,341 tons). Since cleaning solvents are used so extensively throughout the manufacturing and rework processes, emissions are typically fugitive and difficult to collect to any appreciable degree.

3.3.3 Coating Application

Most aerospace coatings used at the present time contain a mixture of organic solvents. HAP emissions from coating application occur from the evaporation of the organic solvents during mixing, application, and drying. Emissions of metal compounds (e.g., chromium and cadmium compounds) also occur from overspray which is exhausted from spray booths or paint spray hangars.

HAPs typically used in coating application operations are 1,1,1-trichloroethane, methyl ethyl ketone, toluene, methyl isobutyl ketone, and glycol ethers. Total annual uncontrolled coating emissions were 715 Mg (787 tons) for primers, 639 Mg (703 tons) for topcoats, and 473 Mg (520 tons) for specialty coatings. The majority of the coating application for parts and subassemblies occurs in spray booths, allowing for the collection of HAP emissions.

3.3.4 Coating Removal (Depainting)

Emissions from coating removal operations occur from evaporation of the solvent in the stripping solutions. The amount of emissions from the process is directly related to the surface area being stripped, the type and thickness of coating to be removed, and the effectiveness of the stripper.

HAPs typically used in the coating removal process are methylene chloride, toluene, xylene, and glycol ethers. Total annual uncontrolled HAP emissions were 1,249 Mg (1,374 tons). The majority of emissions occur from stripping the outer surface of aircraft in large hangars and are fugitive in nature.

3.4 EXISTING STATE REGULATIONS

The proposed rule represents the EPA's first comprehensive regulation of the aerospace manufacturing and rework industry. No Control Technology Guidelines (CTG) or new source performance standards (NSPS) have been promulgated specifically for this industry. However, the surface coating of miscellaneous metal parts and products CTG was intended to reduce emissions of VOCs from the coating of aerospace components under major group Standard Industrial Classification (SIC) Code 37.

The aerospace industry has been regulated primarily by State and local rules. California has the most comprehensive rules, such as South Coast Air

Quality Management District Rule 1124. This rule, which contains many technology-forcing provisions, is used as the model for many other districts in California, as well as other states. Several states have only minimal rules for the aerospace industry and several rely on the miscellaneous metal parts and products (MMP&P) CTG. The remaining states have no aerospace specific rules, due primarily to there being few aerospace facilities within the ozone nonattainment areas in these states.

Eight States have adopted regulations specifically for the control of emissions from aerospace manufacturing and rework operations. Eight other States apply the MMP&P CTG limits, with or without exemptions for specialty aerospace coatings. The regulations for these 16 States as well as the MMP&P CTG limits are discussed below. Additionally, five air toxics rules are presented as example regulations.

Table 3-3 presents the VOC limits extracted from the Miscellaneous Metal Parts and Products CTG.[21]

3.4.1 <u>California</u>

The State of California has been aggressive in developing and adopting regulations for the control of air emissions. Many local districts have written their own aerospace specific regulations. Three of these districts, South Coast Air Quality Management District (AQMD), San Diego County Air Pollution Control District (APCD), and Bay Area AQMD developed rules that were subsequently approved by the EPA as part of the State Implementation Plan (SIP). These districts have developed more current rules that are not yet EPA approved. SIP approved regulations for the Bay Area AQMD, the San Diego County APCD, and the South Coast AQMD are given in Section 3.4.1.1. The rules for these three districts are very similar. The other districts in California usually base their regulations on the existing, approved rules; therefore,

TABLE 3-3

MISCELLANEOUS METAL PARTS AND PRODUCTS CTG VOC LIMITS

Coating	VOC Limit (grams/liter) less water[a]
Clear Coating	520
Air or forced air dried items, parts too large or too heavy for practical size ovens and/or sensitive heat requirements, parts to which heat sensitive materials are attached, equipment assembled prior to top coating for specific performance or quality standards	420
Frequent color change and/or large number of colors applied, or first coat on untreated ferrous substrate	360
Outdoor or harsh exposure or extreme performance characteristics	420
No or infrequent color change, or small number of colors applied	
Powder coatings	50
Other	360

[a] Negligibly photochemically reactive compounds are to be treated as if they are water.

most regional rules will not differ significantly from the first three. A detailed account of the primary California regional regulations for aerospace industry emissions is presented in Sections 3.4.1.2 through 3.4.1.6. These are the current regulations for each district and have not been approved by the EPA. Other districts, such as Sacramento Metropolitan AQMD, are currently developing aerospace coating regulations.

3.4.1.1 SIP Approved Aerospace Coating Rule Requirements.[22] Table 3-4 presents the SIP approved regulations for the Bay Area AQMD, the San Diego County APCD, and the South Coast AQMD. Additionally, the Bay Area AQMD and the San Diego County APCD allow provisions for facilities to operate under alternative emission control plans (AECPs). The AECPs must be approved by the district's Air Pollution Control Officer. Also, the AECPs emissions, on a daily weighted average, must be no greater than would result if the processes were under compliance with the rules. Daily recordkeeping is required in the Bay Area AQMD and the San Diego County APCD if a facility is operating under an alternative emission control plan. In the South Coast AQMD, daily coating and solvent usage records are maintained at all facilities.

3.4.1.2 South Coast Air Quality Management District.[23] The South Coast Air Quality Management District's rule has been the basis for many other aerospace rules in the country. For facilities emitting 20 pounds of VOC per day or more, the VOC limits for coatings are presented in Table 3-5. These VOC limits may be achieved through the use of control equipment. This control equipment must reduce emissions from an emission collection system by at least 95 percent by weight, or the output of the air pollution control device must be less than 50 parts per million (ppm) calculated as carbon with no dilution. Additionally, the system must have a collection efficiency of at least 90 percent by weight of the emissions generated by the sources of emissions.

TABLE 3-4

VOC CONTENT REQUIREMENTS (grams/liter) IN SIP RULES

Coating Type	BAAQMD	SDAPCD	SCAQMD
Primers	350	350	350
Topcoats	600	600	600
Adhesive Bonding Primer	600	600	600
Electromagnetic Radiation Effect Coatings	600	600	600
Flight Test Coating	600	600	640
Fuel Tank Coating	600	600	600
Maskant	600[a]	600[a]	600[a]
Pretreatment Coatings	600	600	600
Temporary Protective Coating	250	250	250
All Other Coatings	600	600	600
Stripper	400[b]	400[b]	400[b]
EXEMPTIONS IN SIP RULES			
Low Usage Area	<20 lb/day [c]	<1 gal/day	<20 lb/day
Low Usage Facility		<50 gal/yr	
Low Usage Coating[d]	200 gal/yr	<20 gal/yr [e]	<20 gal/yr
SOLVENT CONTROL REQUIREMENTS IN SIP RULES			
Spray Equipment Cleanup	n/a	20 mmHg[f]	77.6 mmHg[f]
Surface Preparation and Clean-up	n/a	45 mmHg[g]	77.6 mmHg[g]
Closed Containers for:			
Fresh Solvent	yes[h]	no	no[i]
Spent Solvent	yes[h]	no	no[i]
Solvent Rags	yes	yes	yes

[a] Or 85 percent control.
[b] Or vapor pressure less than 10.0 mmHg at 20°C (68°F).
[c] Applies to each coating line.
[d] Applies to separate formulations.
[e] Provided that no more than 50 gallons total of low usage coatings are applied at the facility annually.
[f] And at 20°C (68°F) and 85 percent control.
[g] At 20°C (68°F).
[h] Required by Bay Area AQMD Rule 8-1.
[i] For cleanup of spray equipment, the facility must either collect VOC in a container and properly dispose of VOC, or disassemble and clean equipment in a vat that is closed when not in use, or use solvents with less than 200 g/l of VOC.

TABLE 3-5

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT VOC LIMITS[a]

Coating	VOC Limit (grams/liter) less water and exempt compounds				
	Limit[b]	7/1/91	1/1/92	1/1/93	1/1/94
Primer	350	350	350	350	350
Topcoat	600	420	420	420	420
Pretreatment Coating	780	780	780	780	780
Adhesion Promoter	850	850	850	850	850
Adhesive Bonding Primer					
Cured at 250°F or below	850	850	850	250[c]	250[c]
Cured above 250°F	1030	1030	1030	250[c]	250[c]
Flight-Test Coating					
Used on Missiles or Single Use Target Craft	420	420	420	420	420
All Other	840	840	840	840	840
Fuel-Tank Coating	720	720	720	420	420
Fuel-Tank Adhesive	620	630	620	620	620
Electric- or Radiation-Effect Coating	800	800	800	800	800
Touch-up, Line-Sealer Maskants	1200	750	750	750	750
Photolithographic Maskant	850	850	850	850	850
Temporary Protective Coating	250	250	250	250	250
Space-Vehicle Coatings					
Electrostatic Discharge Protection Coating	800	800	800	800	800
Other Space-Vehicle Coatings	1000	1000	1000	1000	1000
Adhesives	800	800	800	800	800
Wing Coating	750	750	750	750	420
Impact-Resistant Coating	600	600	600	600	420
High-Temperature Coating	850	850	850	850	850

TABLE 3-5 (Continued)

Coating	VOC Limit (grams/liter) less water and exempt compounds				
	Limit[b]	7/1/91	1/1/92	1/1/93	1/1/94
Antichafe Coating	600	600	600	600	600
Rain Erosion-Resistant Coating	800	800	800	800	420
Fire-Resistant Coating					
Civilian	650	650	650	650	650
Military	970	970	970	970	970
Conformal Coating	750	750	750	750	750
Sealant	850	850	600	600	600
Adhesives					
Non-Structural	850	850	250	250	250
Structural					
Autoclavable	850	50	50	50	50
Non-Autoclavable	850	850	850	850	850
Optical Anti-Reflective Coating	700	700	700	700	700
Wire Coatings					
Electronic Wire Coating	725	725	725	420	420
Anti-Wicking	825	825	825	420	420
Pre-Bonding Etchant	900	900	900	420	420
Phosphate Ester Resistant Ink	925	925	925	925	925
Metalized Epoxy Coating	700	700	700	700	700
Clear Topcoat	750	750	750	520	520
Scale Inhibitor	880	880	880	880	880
Primer Compatible with Rain Erosion-Resistant Coating	850	850	850	850	850
Self-Priming Topcoat	600	600	420	420	420

TABLE 3-5 (Concluded)

Coating	VOC Limit (grams/liter) less water and exempt compounds				
	Limit[b]	7/1/91	1/1/92	1/1/93	1/1/94
Maskant					
Chemical Processing	1200	1200	250	250	250
Chemical Milling	1200	1200	1200	250	250
Solid Film Lubricant					
Fastener Installation	880	880	880	880	880
Fastener Lubricative	880	880	880	250	250
Non-Fastener Lubricative	880	880	880	880	880
Fastener Sealant	675	675	675	675	675
Dry Lubricative Material					
Fastener Lubricative	880	880	250	250	250
Non-Fastener Lubricative	880	880	880	880	880
Barrier Coating	790	790	790	420	420

[a] Limits apply to facilities emitting more than 20 lbs VOC/day.

[b] Limits are established at the time of rule promulgation. Subsequent dates define effective dates for stricter limits.

[c] Effective dates for the lower limits have been delayed until 1/1/95.

Cleanup solvents must have a vapor pressure of 45 millimeters of mercury (mmHg) or less at 20°C (68°F) and must contain 200 grams VOC/liter (1.6 pounds VOC/gallon) or less. Closed containers must be used for the storage and disposal of cleanup materials. Application equipment must also be cleaned in an enclosed container. Strippers must contain less than 300 grams VOC/liter (2.5 pounds VOC/gallon) and have a vapor pressure of 9.5 mmHg or less at 20°C (68°F). Approved application methods are electrostatic application, flow coat, roll coat, dip coat, high volume low pressure (HVLP) spray, hand application methods, or approved alternatives. Coatings with separate formulations used at less than 20 gallons per year are exempt from the regulation limits. Additionally, 1,1,1-trichloroethane, methylene chloride, and trichlorotrifluoroethane are exempt.

3.4.1.3 <u>San Diego County Air Pollution Control District</u>.[24] The San Diego County Air Pollution Control District rule is similar to the South Coast AQMD rule. The VOC limits for coatings are presented in Table 3-6.

A company may reduce emissions from maskants by 85 percent or more in lieu of meeting the coating content limit. Surface preparation or cleanup solvents must have a vapor pressure of less than 40 mmHg at 20°C (68°F), and strippers must contain 400 grams VOC/liter (3.3 pounds VOC/gallon) or less and have a vapor pressure of 9.5 mmHg or less at 20°C (68°F). A facility must control at least 85 percent of VOC emissions from spray equipment cleanup operations and use closed containers for storage of solvent-laden materials.

Exemptions include low usage coatings with separate formulations used at less than 20 gallons per year per coating. The total of low usage coatings must be less than 50 gallons per year. Other exemptions are: stripper and methyl ethyl ketone (MEK) used solely to clean residue from components prior to painting; the use of 1,1,1-trichloroethane, trichlorotrifluoroethane, and

TABLE 3-6

SAN DIEGO COUNTY AIR POLLUTION CONTROL DISTRICT VOC LIMITS

Coating	VOC Limit (grams/liter) less water and exempt compounds
Primer (Except Adhesive Bonding)	350
Maskant for Chemical Processing	250
Temporary Protection Coating	250
Space Vehicle: Thermocontrol	600
Topcoat	420
Pretreatment Coating	780
Adhesive Bonding Primer	850
Flight Test Coating	840
Fuel Tank Coating	650
Electric-Effect Coating	800
All Other Coatings	600

methylene chloride; a defined area, spray paint booth, or room using less than 1 gallon per day; and a stationary source using 50 gallons or less per year.

3.4.1.4 Bay Area Air Quality Management District.[25] The Bay Area Air Quality Management District's rule provides a coating breakdown similar to the South Coast AQMD and the San Diego APCD rules. Facilities emitting 15 pounds or less of VOC per day are exempt from this rule. For facilities emitting greater than 15 pounds of VOC per day, the VOC limits for coatings are listed in Table 3-7. These VOC limits apply unless emissions are controlled to an equivalent level by air pollution abatement equipment with an abatement device efficiency of 85 percent or more. Strippers must contain less than 400 grams/liter (3.3 pounds/gallon) of precursor organic compounds or have a vapor pressure of less than 10 mmHg at actual usage temperature. Maskants must contain less than 600 grams VOC/liter (5.0 pounds VOC/gallon), or the emissions from maskant operations must be reduced by 85 percent.

A facility must also control at least 85 percent of VOC emissions from spray equipment cleanup operations and use closed containers for storage of solvent-laden materials.

Exemptions include the fabrication of electronic components including, but not limited to, microprocessors, circuit boards, control systems, and instrumentation; tank type strippers employing a sealing fluid of 4 inches or greater in depth and which consists of water or a fluid with a vapor pressure of less than 10 mmHg at actual usage temperature; and high temperature curing adhesive bonding primers which cure at temperatures greater than 325°F. Other exemptions are low usage coatings, which are coatings with separate formulations used in volumes of 20 gallons or less per year. The total of low usage coatings must be 250 gallons or less per year.

TABLE 3-7

BAY AREA AIR QUALITY MANAGEMENT DISTRICT VOC LIMITS[a]

Coating	VOC Limit (grams/liter) less water and exempt compounds
Primers (Except Adhesive Bonding)	350
Adhesive Bonding Primer	850
Interior Topcoat	340
Electric- or Radiation-Effect Coating	800
Extreme Performance Interior Topcoat	420
Fire Insulating Coating	600
Fuel Tank Coating	720
High Temperature Coating	720
Sealant	600
Self-Priming Topcoat	420
Topcoat	420
Pretreatment Wash Primer	420
Sealant Bonding Primer	720
Temporary Protective Coating	250

[a] Applies to facilities emitting >15 lbs VOC/day.

Coatings used in the aerospace industry that are subject to other non-aerospace rules are the following: paper-fabric film coatings (Bay Area Regulation 3, Rule 4), adhesives (Bay Area Regulation 8, Rule 4), aerosol can coatings (Bay Area Regulation 8, Rule 49), stencil coatings (Bay Area Regulation 8, Rule 4), solid film lubricants (Bay Area Regulation 8, Rule 4), test panel coatings (Bay Area Regulation 8, Rule 4), and satellite coatings (Bay Area Regulation 8, Rule 4).

3.4.1.5 Ventura County Air Pollution Control District.[26] The Ventura County Air Pollution Control District rule's reactive organic compound (ROC) limits are shown in Table 3-8. As with the South Coast rule, compliance with the ROC limits may be achieved through the use of control equipment. This control equipment must reduce emissions by at least 95 percent and must have a capture efficiency of at least 90 percent.

Cleanup solvents must have a vapor pressure of 45 mmHg or less at 20°C (68°F) and must contain 200 grams VOC/liter (1.7 pounds VOC/gallon) or less. Closed containers must be used for the storage and disposal of cleanup materials. Application equipment must also be cleaned in an enclosed container. Strippers must contain less than 300 grams VOC/liter (2.5 pounds VOC/gallon) and have a vapor pressure of 9.5 mmHg or less at 20°C (68°F).

Approved application methods are electrostatic application, flow coat, dip coat, HVLP spray, hand application methods, or approved alternatives with a transfer efficiency of 65 percent or greater.

Exemptions include stationary sources that release less than 3 pounds of ROC per day and 200 pounds or less per year from coatings, thinners, or any other solvent containing materials associated with coating operations. The Ventura rule exemptions also include low usage coatings. A low usage coating is any coating that is used less than 20 gallons per year or any adhesive that

TABLE 3-8

VENTURA COUNTY AIR QUALITY MANAGEMENT DISTRICT ROC[a] LIMITS

Coating	ROC Limit[b] (grams/liter) less water and exempt compounds				
	7/1/88	1/22/91	1/1/92	1/1/93	1/1/94
Adhesion Promoter		850	850	850	850
Adhesives					
Non-Structural		850	250	250	250
Structural					
Autoclavable		850	50	50	50
Nonautoclavable		850	850	850	850
Adhesive Bonding Primers	850	850	780	780	780
Antichafe Coatings		600	600	600	600
Barrier Coatings		790	790	420	420
Clear Topcoat		750	750	520	520
Conformal Coating		900	750	750	750
Dry Lubricative Materials					
Fastener Manufacturing		880	250	250	250
Nonfastener Manufacturing	880	880	880	880	880
Electric/Radiation Effect Coatings	800	880	880	880	880
Fastener Sealants			675	675	675
Fire Resistant Coatings					
Civilian (Interior)		650	650	650	650
Flight Test Coatings Used on Missiles or Single-Use Target Craft	600	600	420	420	420
All Others	600	600	600	600	600
Fuel Tank Coatings	720	720	650	650	420
Fuel Tanks Adhesives		620	620	620	620
High Temperature Coating		850	850	850	850

TABLE 3-8 (Continued)

Coating	ROC Limit (grams/liter) less water and exempt compounds				
	7/1/88	1/22/91	1/1/92	1/1/93	1/1/94
Impact Resistant Coating		600	600	600	420
Maskants - Chemical Milling		1200	1200	1200	250
Optical Anti-Reflective Coating		700	700	700	700
Pretreatment Coatings	780	780	780	780	780
Primers Not Resistant To Phosphate Esters	350	350	350	350	350
Phosphate Ester-Resistant Primers	650	650	350	350	350
Rain Erosion-Resistant Coating		800	800	800	420
Scale Inhibitor		880	880	880	880
Sealant		850	600	600	600
Solid Film Lubricants					
Fastener Manufacturing		880	880	250	250
Solid Film Lubricants					
Fastener Installation			880	880	800
Nonfastener Manufacturing	880	880	880	880	880
Space Vehicle Coatings					
Electrostatic Discharge Protection		800	880	800	800
Other Space Vehicle Coatings		1000	1000	1000	1000
Adhesives		800	800	800	800
Temporary Protective Coatings	250	250	250	250	250
Topcoats	600	600	420	420	420
Self-Priming Topcoats		600	420	420	420

TABLE 3-8 (Concluded)

Coating	ROC Limit (grams/liter) less water and exempt compounds				
	7/1/88	1/22/91	1/1/92	1/1/93	1/1/94
Wing Coating		750	750	750	420
Wire Coatings					
Electronic		725	725	420	420
Anti-Wicking		825	825	420	420
Pre-Bonding Etching		900	900	420	420
Phosphate Ester Resistant Ink		925	925	925	925

[a] ROC = reactive organic compounds

[b] Blank spaces indicate specific coatings are exempt until a subsequent date defines the effective limit.

is used less than 10 gallons per year. The total volume of low usage coatings for one year excluding adhesives must be less than 200 gallons. There is no stated total volume of low usage adhesives. Aerosol can coatings and coatings with a ROC content of less than 20 grams/liter (0.17 pounds/gallon) are also exempt.

3.4.1.6 Imperial County Air Pollution Control District.[27] The Imperial County Air Pollution Control District's rule is also similar to the South Coast rule. The VOC limits are listed in Table 3-9. Control devices may be used to achieve the VOC limits. These devices must have an abatement device efficiency of at least 90 percent and must control the emissions to an equivalent VOC level. The control systems must be designed, operated, and maintained to maximize the collection efficiency. Facilities must submit a petition for any specialty coating and low usage coating exemptions.

3.4.2 Alabama[28]

The Jefferson County, Alabama, aerospace regulation applies to facilities emitting 100 tons or greater of VOC per year and to coatings used in volumes of 20 gallons or greater per year. Facilities must use air-assisted airless application methods or those with an equivalent transfer efficiency. Primers must contain 350 grams VOC/liter (3.0 pounds VOC/gallon) or less. However, if the primer is used on an aircraft that is using phosphate ester as a hydraulic fluid, then the primer may contain up to 650 grams VOC/liter (5.4 pounds VOC/gallon) if the facility owner is in a compliance program to enable the 350 grams VOC/liter (3.0 pounds VOC/gallon) or less standard to be attained. The compliance program can consist of any of the following: add-on control equipment, replacement process equipment, low solvent content coating, or equipment modification. Surface preparation and cleanup materials must have a vapor pressure of less than 45 mmHg at 20°C

TABLE 3-9

IMPERIAL COUNTY AIR POLLUTION CONTROL DISTRICT VOC LIMITS

Coating	VOC Limits (grams/liter) less water and exempt compounds		Vapor Pressure Limits (mmHg)
	Limit[a]	1/92	
Primer	350	350	
Topcoat	420	420	
Pretreatment	780	420	
Adhesive Bonding	720	600	
Flight Test	600	420	
Fuel Tank	600	420	
Radiation or Electrical Effect	420	420	
Maskant	600	600	
Solid-Film Lubricant	800	600	
Temporary/Protective	250	250	
High Temperature	800	420	
Ablative	600	600	
Space-Vehicle			
Electrostatic	800	600	
Thermocontrol	600		
Other	1000	600	
Strippers	400	400	9.5[b]
Clean-Up Solvent			45[b]

[a] Limits established at the time of the rule promulgation.
[b] At 20°C (68°F).

(68°F) and contain 15 percent or less by weight of VOC or the facility must collect and dispose of 85 percent or more of the VOC. Chemical strippers must have a vapor pressure of 9.5 mmHg or less at 20°C (68°F) and contain 400 grams VOC/liter (3.3 pounds VOC/gallon) or less. Closed containers must be used for the disposal of VOC-containing materials. The MMP&P CTG limits apply to any aerospace facilities in the rest of the State.

3.4.3 Connecticut[29]

The State of Connecticut does not have a regulation specific to the aerospace industry. Instead, aerospace facilities are subject to rules for several sources of emissions. Connecticut has established reasonably available control technology (RACT) for flow coaters as a carbon adsorption/solvent recovery system. Further, all facilities are required to begin the conversion to low VOC coatings. The schedule of compliance is determined on a case-by-case basis. The use of low solvent coatings includes the alternative option of adsorption or the equivalent. These regulations only apply to facilities with actual VOC emissions of 100 tons or more per year and individual pieces of equipment with VOC emissions of 40 pounds or more per day.

3.4.4 Oklahoma[30]

The Oklahoma MMP&P regulation applies to facilities emitting 100 pounds or more per 24 hours. The VOC coating limits for general coatings are shown in Table 3-10.

The Oklahoma limits apply unless emissions that were uncontrolled prior to the rule promulgation are reduced by 90 percent by incineration, or reduced by 85 percent by adsorption, or the equivalent. Facilities are also limited to releasing a maximum of 3,000 pounds of organic material per day and 450 pounds or less per hour. Exemptions to these limits exist if the discharge is

TABLE 3-10

OKLAHOMA MMP&P VOC LIMITS

Coating	VOC Limit (grams/liter) less water and exempt compounds
Alkyd Primer	575
Vinyls	720
NC Lacquers	770
Acrylics	720
Epoxies	575
Maintenance Finishes	575
Custom Product Finishes	780

reduced by 85 percent or best available control technology (BACT) is attained by the facility. Owners or operators may develop a plant-wide emission plan which must be approved by the Commissioner. BACT is determined for specific sites by the Commissioner.

Cleanup solvents must be maintained in a closed container when not in use. Closed containers must also be used for the disposal of cloth or other materials containing cleanup solvents. Solvents used to clean application equipment must be collected. Exempt coatings are individual coating formulations that total less than 55 gallons per year per facility.

3.4.5 Texas[31]

The Texas MMP&P regulation is pending EPA approval. The daily weighted average VOC emissions of coating as applied are listed in Table 3-11. Interior coating operations fall under the MMP&P CTG.

TABLE 3-11

TEXAS MMP&P VOC LIMITS

Coating	VOC Limit (grams/liter) less water and exempt compounds
Exterior Primer	420
Clear Coat	515
Extreme Performance	420
Other Coatings	360

3.4.6 Missouri[32]

The Missouri regulation for aerospace facilities applies to the South St. Louis area and sets the VOC emission limits listed in Table 3-12.

TABLE 3-12

MISSOURI VOC LIMITS

Coating	VOC Limit (grams/liter) less water and exempt compounds
Primer	720
Topcoat	600
Maskant	120

Interior refinishing of airplanes is exempt as well as facilities that release less than 2.5 tons per year of VOC. Exempt coatings are adhesion promoters, adhesive bonding primers, flight test coatings, space vehicle coatings, fuel tank coatings, and dry film lubricants.

3.4.7 Washington[33]

The Puget Sound Air Pollution Control Agency (APCA) regulation, which covers King, Kitsa, Pierce, and Snohomism counties, regulates VOC emissions from aerospace facilities emitting 40 pounds or more of VOC per day on an annual average. Aerospace facilities in the rest of the State are subject to the MMP&P rule. The Puget Sound APCAs VOC limits for the regulated coatings are listed in Table 3-13.

TABLE 3-13

WASHINGTON AEROSPACE COATING VOC LIMITS

Coating	VOC Limit (grams/liter) less water and exempt compounds	
	Limit[a]	1994
Commercial Primer	650	350
Commercial Topcoat	600	420
Military Primer	350	350
Military Topcoat	420	420
Temporary Protective Covering	250	250

[a] Limits established at the time of rule promulgation.

Exempt coatings are maskants for chemical milling operations, adhesive bonding primers, flight test coatings, space vehicle coatings, fuel tank coatings, and any coating for which a reasonably available alternative does not exist. The VOC controls can also be achieved through vapor collection and a disposal system, or an approved equivalent. Approved application equipment are HVLP, electrostatic, flow coat, dip coat, brush coat, trowel coat, hand-held aerosol can, roll coat, electrodeposition, curtain coat, or other approved methods. This rule does not apply to the application of touch-up coatings, stencil coatings, wire markings, inks, and sheet mold compounds.

3.4.8 New York[34]

The New York regulation for aerospace facilities applies to the New York City metropolitan area and sets the VOC emission limits listed in Table 3-14.

TABLE 3-14

NEW YORK VOC LIMITS

Coating	VOC Limit (grams/liter) less water and exempt compounds
Primer	350
Topcoat	612
Maskant	612

Exempt coatings are those utilized for pretreatment, adhesive bonding primers, adhesion, sealing, flight testing, electric/radiation effects, space vehicles, fuel tanks, and temporary mechanical maskant/high temperature heat treatment. Also exempt are coatings that are applied manually with a brush or an aerosol spray can.

3.4.9 Other States

Table 3-15 presents the national areas that apply the MMP&P CTG limits.

TABLE 3-15
AREAS THAT APPLY THE MMP&P CTG LIMITS

AREAS	EXEMPTIONS
Washington	areas covered by specific aerospace rule
Pennsylvania	sources that emit $\leq$ 50 tons VOC/year
New Jersey	exterior coating of aircraft
Wisconsin	exterior coating of airplanes, specialized coatings required by State or Federal agencies
Oregon	sources that emit $\leq$ 15 lbs VOC/day
Delaware	no aerospace exemptions
Massachusetts	sources that emit $\leq$ 25 tons VOC/year
Colorado	coating of aircraft, division approved high performance coatings
Other States with no aerospace rules	no specific aerospace exemptions

3.4.10 Air Toxic Rules for Various States

The aerospace industry is also affected by State air toxics rules. Many States have regulations applicable to process emissions that are not covered by a specific State or Federal regulation. Five State air toxics regulations are discussed below as examples of typical regulations.

3.4.10.1 Michigan.[35] The Michigan Department of Natural Resources' Air Pollution Control General Rules state that anyone building or modifying any process or equipment that may emit a toxic air contaminant must apply for a permit. Additionally, any person applying for a permit shall not allow the emission of any toxic air contaminant in excess of each of the following:

(1) The maximum allowable emission rate based on the application of best available control technology for toxics (T-BACT). The maximum allowable emission rate is 0.1 pound per hour or less for a carcinogen or 1.0 pound per hour or less for any other toxic air contaminant.

(2) The maximum allowable emission rate that results in a predicted maximum ambient impact that is more than the initial threshold screening level (ITSL) (> 200 micrograms per cubic meter) or the initial risk screening level (IRSL) (> 0.1 micrograms per cubic meter), or both.

A commission will be established to determine, on a case-by-case basis, whether the maximum allowable emission rate provides adequate protection of human health or the environment. This commission may determine a more rigorous regulation limit.

This regulation is not applicable to processes that are covered by national emission standards. Other exemptions include processes that are in compliance with T-BACT or lowest achievable emission rate (LAER) requirements and processes with a predicted ambient impact for each toxic air contaminant that is less than the IRSL and the ITSL. The emissions of a carcinogen is exempt from being in compliance with the IRSL if the total allowable emissions of the carcinogen from the proposed new or modified process and all existing processes at the stationary source result in a predicted ambient impact less than or equal to the secondary risk screening level.

The initial and secondary risk screening levels for a carcinogen shall be determined by any of the following:

(1) the State cancer risk assessment methodology;

(2) the EPA guidelines;

(3) any alternative methodology proven to be more appropriate.

The predicted ambient impact of each toxic air contaminant shall be determined using the maximum hourly emission rate.

Permit system exemptions applicable to the aerospace industry are vacuum-cleaning systems used for housekeeping, water blast-cleaning equipment, furnaces, ovens, heaters, testing and inspection equipment, pilot processes, small storage containers, and maintenance or repairs. Other exempt processes are the following if the emissions are only released into the general in-plant environment: surface treatment, pickling, acid dipping, cleaning, etching, electropolishing, electrolytic stripping, or plating. Additionally, an adhesive coating line that has an application rate of less than 2 gallons per day and releases emissions only into the in-plant environment is exempt.

3.4.10.2 Ohio.[36] The Ohio EPA has developed a guidance policy for permitting new sources of air toxics emissions into the atmosphere.

Currently, the State of Ohio uses the following equation to determine maximum acceptable ground level concentration (MAGLC):

$$\text{MAGLC} = 4\,\frac{\text{TLV}}{\text{XY}}$$

where:

- X = operating hours per day of the source above 8 hr/day;
- Y = operating days per week above 5 days per week;
- TLV = Threshold Limit Values, published by the American Conference of Governmental Industrial Hygienists.

For 40 or less hours per week of plant operation, the MAGLC formula is the following:

$$\text{MAGLC} = 4\,\frac{\text{TLV}}{42}$$

The State is currently trying to pass a new policy document. This document includes a review of each specific compound to determine if it is toxic air contaminant.[37]

If the contaminant is carcinogenic, and emissions exceed the TLV, the State plans to perform a health impact/risk assessment study to determine the maximum individual risk. If this risk is greater than 1×10^{-5} per toxicant emitted (one incident of cancer per 100,000 persons exposed), the applicant must reduce the emissions by application of BACT. If the contaminant is not carcinogenic, MAGLC is used to determine acceptable concentrations. The MAGLC is to be modified and made more conservative as follows:

$$\text{MAGLC} = \frac{\text{TLV}}{70}$$

Sources covered by other Federal regulations are exempt.

3.4.10.3 Connecticut.[38] In the State of Connecticut, no stationary source may emit any hazardous air pollutant in excess of the maximum allowable stack concentration. The maximum allowable stack concentration (MASC) is determined as follows:

(1) If the discharge point is 20 meters or less measured vertically from the ground,

$$\mathrm{MASC} = \frac{0.885\ \mathrm{HLV}\ (X + 1.08V\ 0.64)^{1.56}}{V}$$

where:

HLV = hazard limiting value found in the regulation tables
V = average actual flow rate (cubic meters per second)
X = ten meters or the distance from the discharge point to the closest property line, whichever is greater

(2) If the discharge point is more than 20 meters:

$$\mathrm{MASC} = \frac{0.885\ \mathrm{HLV}\ (X + 1.08V^{0.69})^{1.58}\ \exp\left[10.33\ (H-20)^2\ (X + 1.08V^{0.64})^{-1.58}\right]}{V}$$

where:

H = height of discharge point (meters)
X = ten meters or the distance from the discharge point to the closest property line or $4.47\ (H-20)^{1.28}$, whichever is greater

If a source exceeds MASC, BACT must be installed and used for the applicable hazardous air pollutant.

3.4.10.4 Kansas.[39] The Kansas Air Toxics Strategy is a regulatory screening mechanism to control air toxics which are not controlled by State or Federal standards. The strategy gives the State the authority to promulgate air emission regulations and enforce those regulations through inspections, administrative orders, and injunctive orders.

The strategy applies a significant risk level to the emissions of air toxics from new or modified point sources during normal working operation. The significant risk level for carcinogens is 1×10^{-6} (one incident of cancer per million persons exposed). For non-carcinogens, the significant risk level is a fraction of the Threshold Limit Values (TLV) published by the American Conference of Governmental Industrial Hygienists. The significant risk level for long term (chronic) exposure is TLV/420 and the significant risk level for short term exposure is TLV/100.

All new or modified sources must apply for a State permit. At this time the source's emissions are identified and air toxic quantities are calculated. The significant risk levels are calculated and an air quality computer model is run to determine the ambient impact. If the significance level is exceeded, options for emission reductions are evaluated. If the air toxic is a carcinogen, BACT will be required. If not, a risk management decision will be made which reflects factors such as technical feasibility, costs, and social and economic benefits.

3.4.10.5 Washington.[40] The State of Washington's controls for new sources of toxic air pollutants affect all new sources in the aerospace industry. Exempt sources are containers, non-process fugitive emissions from stationary sources, solvent metal cleaners, spray coating operations, and abrasive blasting unless determined otherwise by the State.

The owner of a new source must notify the State prior to construction and file a notice of construction application for the proposed emission source(s). The facility must be in accord with Federal and State regulations. Additionally, the facility must use T-BACT for emissions control for any toxic air pollutants which are likely to increase and reasonably available control technology for toxics (T-RACT) for any toxic air pollutants which are likely to remain the same or decrease. A list of toxic air pollutants is given in the regulation as Class A or Class B toxics. Class A toxics are known and probable carcinogens. Class B toxics includes any substance that is not a simple asphyxiant or nuisance particulate. After review, the State will make a final determination and may require an operation and maintenance plan to assume continuous compliance.

Risk-based acceptable source impact levels for toxics can be calculated by:

$$\text{Risk-based} = \frac{\text{Risk}}{\text{URF}}$$

where:

Risk = Cancer risk level (1 in 1,000,000);
URF = Upper bound unit risk factor as published in the US EPA Integrated Risk Information System database or other appropriate sources.

T-BACT is described in the regulation for specific sources. The ones that affect the aerospace industry are solvent metal cleaners and abrasive blasting.

T-BACT for solvent metal cleaners requires the use of covers for tank lines, closed containers for solvents, and component drainage into the tank line. T-BACT for abrasive blasting requires blasting within an enclosed space to control particulates if possible and, if not, blasting outside with steel shot and with protective tarps.

An owner of a new source must also provide data to determine the expected ambient impact. Dispersion modeling is used to determine the affects on human health and safety from potential carcinogenic and/or other toxic effects. A detailed analysis may be involved including such factors as demographics, toxicological profiles of pollutants, and characterization of outlet pathways.

Finally, the State may approve the emissions even if the ambient concentrations are likely to result in an increased cancer risk only if: (1) the proposed controls represent all known and reasonably available technology; (2) prevention methods including recycling, chemical substitution, and efforts to redesign process; and (3) emission bubbles and offsets are put in place.

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4.0 EMISSION CAPTURE AND CONTROL TECHNIQUES

The principal techniques used by the aerospace industry to control HAP emissions are preventative measures and control devices. Preventative measures are any action, product modification, process modification, or equipment change designed to eliminate or reduce the generation of emissions. Control devices do not prevent the generation of emissions, but rather capture or destroy the emissions generated by a source.

The most common preventative measures are usually the most desirable method to reduce emissions since they eliminate or reduce the actual generation of pollutants. Typically, the emission reduction is obtained using less energy and producing less waste than using a control device to achieve the same emission reductions. Preventative measures used by the industry are: (1) product substitutions where products that contain high levels of HAPs and VOCs are replaced with products containing less HAPs and VOCs or that eliminate the HAP or VOC content completely, such as non-HAP chemical strippers for depainting; (2) product substitutions that reduce the amount of the HAP- and VOC-containing product used, such as higher solids content coatings; (3) equipment changes that result in emission reductions, such as replacing conventional spray guns with high-volume low-pressure (HVLP) spray guns; and (4) work practice standards, such as housekeeping.

Control devices are typically used where product substitution and equipment changes are not feasible or where the concentration of the exhaust stream is sufficiently high to warrant their use. Control devices may destroy the HAPs and VOCs, as with an incinerator, or capture the HAPs and VOCs, as with a carbon adsorber. Often, the compounds captured by a control device can be recovered for reuse. Control devices in predominant use by the industry to control organics are: (1) carbon adsorbers, (2) incinerators, and (3) ultraviolet oxidation. Activated carbon fiber absorbents to concentrate VOC emissions are frequently used in conjunction with incinerators, and catalyst-coated filter medias are being used in spray booths to control low VOC concentrations. Control devices used by industry to control dry particulates are: (1) baghouses, (2) mechanical centrifugal separators, and (3) dry filters; and control devices used to control wet particulates are: (1) dry filters and (2) waterwash spray booths.

4.1 PREVENTIVE MEASURES

4.1.1 Product Substitution

HAP and VOC emissions may be controlled by replacing products containing high concentrations of HAPs or VOCs with ones that have reduced or eliminated HAPs or VOCs entirely. Each individual facility must evaluate the ability of the new product to maintain standards of quality and performance. In addition, the potential overall environmental benefit of the reformulated products must be carefully evaluated.

4.1.1.1 Coating Substitutions. Product substitutions for coatings can be generally classified as waterborne, higher solids, powder, and self-priming topcoats. Resin seal anodizing can also be considered an alternative for coating application. Each category is discussed below.

4.1.1.1.1 Waterborne Coatings. Waterborne coatings utilize a resin system that is dispersible in water. A portion of the organic solvent is then replaced with water. The organic solvent may be 5 to 40 percent by weight of the waterborne coating as applied, compared to a conventional organic solvent-based coating containing as much as 70 to 80 percent by weight solvent, as applied. The use of solvent is to aid in coating application, wetting of substrate surface, viscosity control, and pigment dispersion.[1]

Waterborne coatings use water dispersible polymers or a suspension of water and polymers. In waterborne coatings, organic polymers (e.g., alkyds) are made dispersible by giving them ionic characteristics. Some of the base polymers for waterborne coatings are acrylics, polyesters, urethanes, and epoxies.[2]

In addition to the lower solvent content, waterborne coatings have other advantages over solvent-based coatings. Less overspray and improved spray transfer efficiency may be achieved with waterborne coatings than with conventional coatings that utilize solvents with a density less than that of water.[3] Additionally, because of the reduced solvent content, waterborne coatings may be less toxic and present a reduced fire hazard.[4]

Waterborne coatings have limitations such as requiring spray guns with specific materials of construction, protection from freezing, and better control of temperature and humidity during application.[5] In addition, waterborne coatings generally require longer drying times, are more sensitive to substrate cleanliness and composition, may have shorter shelf stability and pot-life, and have lower salt spray resistance.[6]

4.1.1.1.2 Higher Solids Coatings. Higher solids coatings are solvent-based coating formulations that have been modified to lower the solvent-to-solids ratio. The coatings usually contain 50 to 65 percent by volume solids, compared to conventional solvent-based coatings that may contain up to 40 percent by volume solids. The increased solids content gives greater surface area coverage per gallon of coating which reduces the total volume of coating required. Consequently, solvent emissions are also reduced when higher solids coatings are used to apply the same volume of solids as applied with a conventional solvent-based coating.[7]

Higher solids coatings generally have higher viscosities and longer drying times than conventional solvent-based coatings. Higher viscosity tends to make spray application more difficult because it is harder to control gloss and film thickness, and may require the coating to be heated before application. Higher solids coatings typically are not used as dip coatings due to the difficulty in maintaining a uniform dispersion of solids in the dip tank.[8]

4.1.1.1.3 Powder Coatings. Powder coatings are a class of coatings applied electrostatically in dry form and then baked to cure. The coatings consist of fine, dry particles of paint solids. During the curing step, the particles fuse to create a continuous film. Use of powder coatings requires that the substrate must be able to withstand the high temperatures [typically greater than 121°C (250°F) and often greater than 177°C (350°F)] necessary to cure the paint. Therefore, most powder coatings are developed for steel substrates which can accept the curing temperatures.[9]

These coatings require resins that are solid at room temperature and melt at higher temperatures. The most common resins used in powder coatings are epoxies and polyesters.[10]

The major advantage of using powder coatings is greatly reduced solvent emissions. The lack of a solvent base also reduces fire hazard, toxicity, and the make-up air requirements of the spray booth.[11]

Powder coatings must be applied electrostatically, so they cannot be used on non-conductive parts such as composites. Other reported disadvantages of powder coatings are the difficulty in obtaining a high quality appearance, production must be shut down for color changes, and the powder must remain dry at all times prior to application. Touch-up and rework is also difficult and coating resistance to soil is reduced. In addition, the high curing temperatures of powder coatings precludes its use on temperature sensitive substrates.[12]

4.1.1.1.4 Self-priming Topcoats. Self-priming topcoats eliminate the need to apply a primer coat between the substrate and the topcoat. The self-priming topcoat has the adhesion and corrosion characteristics of a conventional primer, and the environmental resistance and functional fluid resistance of a conventional topcoat. The required dried film thickness is generally the same as a conventional primer and topcoat; therefore, solvent emissions are reduced, particularly when the proper dried film thickness can be achieved by a single coat. These coatings also eliminate the need for chrome-containing primers.[13]

4.1.1.1.5 Resin Seal Anodizing. A resin seal anodize process has been developed by a large military/OEM facility that replaces the dichromate seal, priming, and topcoat operation for many parts and assemblies. In this process, an aerospace component is immersed in a resin seal anodize bath that contains 7 percent solids of a colloidal polyurethane resin. An anodize film develops on the surface of the part, and resin particles are deposited within the anodize film to form a resin-rich surface. The component has effectively been anodized and sealed, eliminating the need for primer and topcoat operations.[14]

Parts processed with resin seal anodizing are lighter in weight since primer and topcoat are not necessary. This process also provides better corrosion protection in some instances compared to conventional processes and greatly reduces the HAP emissions and waste streams associated with the conventional processes. According to the patent holding facility, the process reduces emissions 20 to 30 percent over the conventional process of anodizing, priming, and topcoating. However, a tank line to hold the process must be constructed, and the tanks must be large enough to hold the entire part.[15]

4.1.1.2 Hand-Wipe Cleaner Substitutions. Product substitutions for hand-wipe cleaning that are prevalent in the aerospace industry can be classified as aqueous, citrus-based, reduced HAP content, and non-chemical. Each category is discussed below:

4.1.1.2.1 Aqueous. Aqueous cleaners contain water as the base component rather than an organic solvent or mixture of solvents. Other components may include corrosion inhibitors, alkalinity builders, and organic surfactants depending on the desired soil removal properties.[16] Aqueous cleaners have been used in non-critical areas where strict cleanliness requirements do not have to be met, or where there are no confined spaces that may trap residues of the cleaner.

The advantages of using aqueous cleaning solvents include reducing HAP emissions and possibly reducing waste streams. Disadvantages are increased production time due to slower evaporation rates, possible decreased efficiency, and possible increase in wastewater treatment requirements. In addition, aqueous cleaners may not be applicable to all aerospace parts, especially those components that have small confined spaces where the cleaner residues cannot be adequately removed.[17]

4.1.1.2.2 Citrus-based. Citrus-based terpenes such as d-limonene are the primary components in many alternative cleaning solutions. While these solutions have high VOC contents, their vapor pressure is very low leading to reduced evaporation rates. These cleaners have been found to be effective in most cleaning operations except for cleaning prior to adhesive bonding.[18]

Some disadvantages include possible worker sensitivity, VOC emissions, and lack of rinseability in water.

4.1.1.2.3 Reduced HAP Content. Many cleaning solutions achieve a reduction and, in some cases, a complete elimination of the HAP content by substituting non-HAP components such as hydrocarbon or oxygenated hydrocarbon mixtures, or bioenzymes mixtures. These cleaning solutions differ from aqueous cleaners in that they are not water-based.[19]

4.1.1.2.4 Non-chemical. Several aerospace facilities have demonstrated the viability of using non-chemical methods such as dry media blasting for cleaning operations. These methods are typically used to remove dry, scale-like deposits such as carbon residue on engine components. Dry media blasting can usually be used only on components that can withstand the force of blasting without deformation.

4.1.1.3 Depainting Stripper Substitutions. Product substitutions for strippers generally contain no methylene chloride, no phenols, no chlorinated solvents, no heavy metals, and no chromates. The active components found in these strippers may include formic acid, phosphoric acid, benzyl alcohol, and ammonia. Therefore, they typically have a low toxicity level, low vapor pressure, and are not flammable.[20] These strippers can be used in existing facilities with no modifications.[21]

4.1.2 Equipment Changes

The aerospace industry has implemented several equipment changes that directly reduce the level of HAP emissions. While there are equipment changes that effect emissions from every process, the four changes predominantly used in the industry are high transfer efficiency spray guns, enclosed spray gun cleaners, proportional paint mixers, and non-chemical depainting methods. Each of these equipment changes are discussed below.

4.1.2.1 High Transfer Efficiency Spray Guns. Emissions from spray coating operations can be reduced through the use of spraying systems with higher transfer efficiency. Transfer efficiency, expressed as a percentage, can be defined as the ratio of coating solids actually applied to the surface of the component being coated to the amount of solids released from the spray gun.[22] Spraying systems with a higher transfer efficiency can coat the same surface area using less coating. Therefore, the HAP emissions resulting from the use of this equipment are reduced compared to applying the same coating with conventional spray equipment. The transfer efficiency values reported in this section depend on coating sprayed, part configuration, spray booth air velocity, and other variables.

This section discusses the coating application equipment generally used in the aerospace industry. Most aerospace components are coated using manual spray equipment. The discussion includes the conventional application methods as well as high efficiency application methods (e.g., electrostatic spray guns, high volume, low pressure spray guns, and conventional high efficiency methods).

4.1.2.1.1 Conventional Airspray. In conventional airspray systems, compressed air is applied to the paint reservoir and the coating is forced through a line and out the spray nozzle. The coating is released at high energy in a wide, flat spray pattern due to the high pressures involved. Typically, the transfer efficiency for this system is 20 to 40 percent.[23]

4.1.2.1.2 Airless Spraying. Airless spray systems use hydrostatic pressure (approximately 2,000 psi) to atomize the coating. The transfer efficiency for this system is typically 35 to 50 percent.[24]

An air-assisted airless spray system, which is a variation of this technique, uses lower pressures and lower air and fluid rates. It is also more manageable to operate than airless spray alone. The transfer efficiency for this system is in the 30 to 60 percent range.[25]

4.1.2.1.3 Conventional High Transfer Efficiency Application Methods. Conventional high transfer efficiency application methods include dip, roll, brush, and flow coating. These methods are discussed below.

4.1.2.1.3.1 Dip Coating. With dip coating application, parts are immersed into a tank of coating. The parts are then removed from the tank and held over it until the excess coating drips back into the tank. This method is simple and allows many different parts to be coated with high transfer efficiency.[26] However, dip coating is limited to parts that can fit into the dip tank. Other parts difficult to dip coat could include complex parts that would trap the coating, allowing unequal coating thicknesses.

4.1.2.1.3.2 Roll Coating. In roll coating application, a series of mechanical rollers are used to coat flat surfaces. This method achieves high efficiency with high rates of application and automation. However, roll coating is limited to flat parts.[27]

4.1.2.1.3.3 Brush Coating. In brush coating application, brushes and hand rollers are used to apply the coating manually. This method is used with operations (e.g., touch-up and detail painting) that cannot tolerate the overspray associated with spray gun application. For example, if a facility needs to paint only the tail section of an airplane, it may be easier to brush coat this area than to mask the entire plane to protect the rest of the shell from overspray. This application method typically involves high labor costs, increased production time, and poor coating thickness control.[28]

4.1.2.1.3.4 Flow Coating. In flow coating application, the part is conveyed over a closed sink, and a pumped stream of coating gently flows over the surface of the part. The excess coating is drained into the sink, filtered, and pumped to a holding tank for reuse.[29] Flow coating is typically limited to flat sheets and non-critical parts. Coating thickness is difficult to control using flow coating.

4.1.2.1.4 High Volume Low Pressure Spray Guns. High volume low pressure (HVLP) and electrostatic spraying systems are the primary high efficiency spray methods used by the industry. HVLP spray guns use high volumes [10 to 25 standard cubic feet per minute (scfm)] of low pressure [2 to 10 pounds per square inch gauge (psig)] air to deliver the paint. The lower air pressure creates a lower particle speed, resulting in a more controlled spray pattern with less overspray and bounce back from the substrate, thus improving transfer efficiency.[30]

HVLP systems have been in use in the United States for approximately 10 years. In early systems, turbines were used to supply a high volume of low pressure air to the spray guns through large hoses. The second generation used compressed air with an air regulator to maintain the required low pressure. The third and current generation of HVLP equipment uses restrictors within the gun to reduce the atomization pressure to a maximum of 10 psi at the air cap.[31]

One disadvantage of HVLP spray guns is that some very high solids coatings are difficult to atomize due to their higher viscosities. However, when a turbine is used, the temperature of the atomizing air increases which aids in reducing the viscosity of the coating.[32] A medium commercial/rework facility utilizes HVLP equipment with high solids paint and has had a reduction of 22-30 percent in coating usage for various aircraft types. Other disadvantages of HVLP spray guns are that they cannot be used with extension nozzles, and they may slow production rates because of the low fluid delivery rates.

It is estimated that HVLP can apply approximately 80 percent of the coating currently used in the aerospace industry, including primers, waterborne coatings, and both single and two-component topcoats. The HVLP technology has proven easy to use and maintain. It also provides high transfer efficiency and appears to be the preferred spray technology in the aerospace industry at this time.[33]

According to Section 114 questionnaire responses, application transfer efficiencies up to 82 percent may be achieved using HVLP spray equipment. A large military/rework facility and a military/OEM facility reported that HVLP increases transfer efficiency from 40 to 60 percent. A medium commercial/ and military/OEM facility stated that they are achieving a minimum transfer efficiency of 65 percent compared to 25 to 35 percent efficiency of conventional spray equipment, and a medium military/OEM facility estimated an increase in transfer efficiency from 25 to 65 percent. Finally, a medium commercial/OEM facility claimed that replacing all conventional spray equipment with HVLP equipment increased transfer efficiency from 25 to 82 percent.

Table 4-1 shows the reduction in emissions obtained from the Section 114 questionnaire responses from various facilities utilizing high transfer efficiency equipment such as HVLP or electrostatic equipment, either alone, in conjunction with each other, or, in one case, HVLP equipment with high solids coatings.

4.1.2.1.5 Electrostatic Spray Guns. With electrostatic spray systems, atomized particles of coating acquire an electric charge as they pass through a high voltage field at the end of the spray nozzle. This electric charge causes the particles to be attracted to the parts being painted, which are electrically grounded. Although other substrates can be pre-treated with

TABLE 4-1

Percent Reduction in Emissions with High Transfer Efficiency Equipment from Section 114 Data

Size	Commercial or Military	OEM or Rework	High Transfer Equipment	% Reduction in Emissions
Large	Military	OEM	HVLP	20%
Large	Military	OEM	HVLP	20%
Large	Military	OEM	HVLP	25%
Large	Commercial	OEM	Unspecified	30%
Large	Commercial	OEM	Unspecified	18%
Medium	Commercial Military Military	OEM OEM Rework	HVLP	25%
Medium	Commercial Military Military	OEM OEM Rework	HVLP	20-40%
Medium	Military	OEM	HVLP and Electrostatic	40%
Medium	Military	OEM	HVLP and Electrostatic	40%
Medium	Military	OEM	HVLP	40%
Medium	Military	OEM	HVLP	10%
Medium	Military Military	OEM Rework	Electrostatic	30-40%
Medium	Military	Rework	HVLP and Electrostatic	35-40%
Medium	Commercial	OEM	Unspecified	30%
Medium	Commercial	OEM	Unspecified	33%
Medium	Commercial	Rework	HVLP and Electrostatic	50%
Medium	Commercial	Rework	HVLP and High Solids	22% for large aircraft 25% for medium aircraft 30% for small aircraft
Small	Commercial	OEM	Unspecified	30%
Small	Commercial Military	OEM OEM	HVLP	28%

conductive coatings, this technology is primarily used for metal parts. The electrostatic effect can be utilized in conjunction with air spray, airless, and air-assisted airless systems to enhance the transfer efficiencies of these basic technologies. See Table 4-1 for examples of percent reduction obtained at various facilities using electrostatic spray guns or electrostatic spray guns in combination with HVLP spray guns. Application transfer efficiencies up to 90 or 95 percent may be achieved using electrostatically enhanced spraying.[34]

4.1.2.2 Enclosed spray gun cleaners. Spray guns are typically cleaned at the end of every job, as well as between color changes. Manual cleaning of spray guns involves disassembling the gun and placing the parts in a tray containing an appropriate cleaning solvent. The residual paint is brushed or wiped off the parts, then the cleaning solvent is sprayed through the gun after it is reassembled. Enclosed spray gun cleaners, however, are completely enclosed units that spray the cleaning solvent through and over the spray gun. The enclosed unit eliminates most of the exposure of the cleaning solvent to the air, thereby greatly reducing the HAP emissions from evaporation.[35] Additionally, Factory Mutual has approved at least one enclosed gun cleaner.[36]

4.1.2.3 Proportional Paint Mixers. The majority of coatings used in the aerospace industry are multi-component mixtures, consisting of a base component and one or more catalyst components. The components must be thoroughly mixed in the proper ratio immediately before application. When this mixing is performed manually, a greater volume of coating is mixed than will actually be used to ensure that there is enough coating available to complete the job. In contrast, proportional paint mixing equipment has been developed to mix two coating components prior to application. The two components then cure on the part through a chemical reaction. The paint used is a multi-component system in which a base pigment is mixed with a catalyst and then applied to the aircraft. Proportional paint mixers mix the base pigment and the catalyst within the spray gun or in a separate mixing chamber as the paint is applied. These systems generally consist of two positive displacement pumps, an air regulator, and a pressure relief safety valve. The pumps automatically dispense the components in a pre-determined ratio. Since the paint is mixed and supplied on demand, these systems greatly reduce the amount of coating wasted due to batch mixing. In batch mixing, a significant amount of paint is often left unused at the end of the job because the amount of the batch was determined by an estimate of the amount needed for the job. The unused paint became waste.[37] The use of proportional paint mixers result in reduced coating waste and, consequently, reduced emissions.

4.1.2.4 Non-chemical Depainting Processes. Methylene chloride is the primary solvent used in chemical strippers in the aerospace industry. However, several methods have been developed or are under development to replace methylene chloride. The alternatives presented in the Section 114 responses are discussed below.

4.1.2.4.1 Plastic Media Blasting (PMB). This process is an abrasive blasting process that uses plastic beads as the blasting media. Several different types of plastic beads, as defined by their chemical composition, exist. This process uses modified sandblasting equipment. The modifications are necessary to recycle the media and properly separate out contaminants. Plastic media blasting may require a dedicated facility to maintain low levels of media contamination. In addition, it produces large amounts of hazardous waste (i.e., spent media and paint chips).[38]

Plastic media blasting has been determined to be an acceptable process for paint removal from high strength steel and titanium parts. It can successfully produce strip rates of 5.6 m^2/hr (60 ft^2/hr) and above.[39] Additionally, at at least one facility, labor costs for plastic media blasting operations are about 40 percent less than those for chemical stripping operations.[40] However, in the case of aluminum and composite substrates, strict controls are necessary to obtain acceptable results. These controls include media contamination levels, process parameters, operator training, and quality assurance. There exists some disagreement on its effect on fatigue, crack growth, and crack detection. One study showed increases in the crack growth rates and reductions in the fatigue life of aluminum structures.[41] A follow-up study showed that the media contamination levels and aggressive blasting parameters were the main causes of these problems.[42]

4.1.2.4.2 Sodium Bicarbonate Blasting. This process uses sodium bicarbonate and water as the abrasive blasting media. The media is not recyclable and the sodium bicarbonate is partially soluble in water (up to 10 percent). The water and sodium bicarbonate are mixed at the nozzle of modified sandblasting equipment. As with plastic media blasting, the modifications are necessary to recycle the media and properly separate out contaminants. The water is used for dust control and to absorb some of the impact energy in order to minimize damage to the substrate.[43]

This process has the potential to be used on detailed composite parts. It can selectively remove the enamel layer without removing the primer layer. Therefore, the possibility of damaging the substrate is minimized. However, tests have not been performed to determine if the process damages the substrate (i.e., crack growth rates, fatigue, fiber damage, and crack detection).[44]

The surface obtained after stripping is much smoother than surfaces stripped with plastic media. However, damage to the clad layer of the outer skin of the aircraft may still occur. The strip rates, approximately 2.8 m^2/hr (30 ft^2/hr),[45] are almost half that of plastic media blasting. As with plastic media blasting, labor costs for at least one facility are about 40 percent less than those for chemical stripping operations.[46]

4.1.2.4.3 Carbon Dioxide Blasting Process. This process uses solid carbon dioxide pellets to abrasively and cryogenically remove paint from the substrate. The equipment uses liquid carbon dioxide generated from other industrial processes and converts it into the solid form. The solid pellets are then propelled with air at a pressure of 250 psi or greater to remove the paint. The pellets disintegrate upon impact and sublimate. The paint chips are the only waste generated.[47]

Studies have shown that this process has a large potential for damage, especially on thin gauge material. Warpage, dimpling, and blistering of the clad layer have been documented at pressures lower than the recommended 250 psi. The slow removal rates at which these systems currently operate increases the possibility of damage to the aircraft.[48] Also, the associated high noise level is a concern.

4.1.2.4.4 Ice Crystal Blasting. This process uses ice crystals as the blasting media. The mechanism for the process is a combination of fracturing, abrasion, and cryogenic effects. The process uses machinery that is self-contained in a trailer (includes the icemaker and compressors). The ice is propelled at the nozzle to minimize the loss of particle size.[49]

The results from lab tests show selective stripping of the enamel was possible on aluminum substrates. However, scale-up of the process has presented some difficulties in obtaining the same results as obtained with the lab set-up.[50]

The waste generated by this process consists of water and paint chips. The process has demonstrated slow removal rates and the effect on the substrate is currently unknown.[51]

4.1.2.4.5 Wheat Starch Blasting. This abrasive blasting process uses a recyclable polymerized wheat starch pellet as the blasting media. The equipment used for this process is modified plastic media or sand blast equipment with the media recycle and separation devices optimized for the wheat starch.[52] Preliminary results show this method to be very promising for both aluminum and composite structure.

The waste generated consists of a biodegradable wheat starch dust and paint chips. The hazardous constituents can be separated out after degrading the starch to a liquid form. However, the process may require a dedicated facility or a blast and vacuum unit (blasting equipment that simultaneously vacuums the created dust particles). In addition, the preliminary results show that the stripping rate of the process, approximately 2.8 m^2/hr (30 ft^2/hr), is approximately half of the rates obtained by plastic media.[53]

4.1.2.4.6 Water Jet Stripping. This process is a two step operation. The first step uses a paint softener to loosen the bond between the enamel and primer layer. The second step uses high pressure water to remove the loosened enamel layer, leaving the primer layer intact.[54]

Strip rates achieved by this process are relatively high and depend upon the softener used. The strip rates, 5.6 m^2/hr (60 ft^2/hr), are comparable to plastic media and the effect on the substrate is minimal. However, chemical waste is still generated. In addition, adequate prevention of water entrapment and the effects on composite structure need to be addressed.[55]

4.1.2.4.7 High Pressure Water Jet. This process uses water at ultra high pressure for paint removal. The process uses a unique nozzle configuration and must be robotically controlled. The strip rates obtained are comparable to those obtained with plastic media. It can also selectively remove the topcoat layer. No chemical waste is generated; however, the wastewater stream may contain hazardous constituents.[56]

Qualification tests are being performed for the high pressure water jet at some facilities. It has not been demonstrated on composite surfaces, and the effects on the substrate are unknown. Manual operation may not be possible and the possibility of water getting in the joints and around fastener heads and door frames is of major concern.[57]

4.1.2.4.8 Excimer Lasers. This process uses a pulsed laser to remove the coatings by ablative means with minimal heating of the substrate. The laser uses halogen gases (i.e., krypton fluoride [KrF] and xenon chloride [XeCl]) as the ultraviolet light source. The process is extremely precise and requires robotic controls.[58]

Based on laboratory studies, the strip rates are slower than some of the other paint removal processes. In addition, the laser is difficult to use on complex, contoured parts. Although some scale-up problems have been encountered, the process does show some promise for aluminum substrates. The full effects on all substrates has yet to be determined. Additionally, the process generates very little waste. Experiments are being performed to determine if HAPs are being released during the ablative process.[59]

4.1.2.4.9 Xenon Flash Lamp. This process consists of a pulsing lamp using a xenon light source. The high intensity light pulses supply the energy required to ablate the coating. Pigment and carbon residues are left on the surface after paint removal.[60]

Only preliminary studies have been conducted to date. The strip rates obtained by this process are relatively slow compared to other methods. However, the amount of paint removal is controllable. The residues that remain on the surface and the toxic by-products generated need to be studied in greater detail. The effects on aluminum and composite substrates also need to be determined. The use of this process on complex, contoured parts is difficult, as with the laser system. Also, the process is noisy and maintenance is high.[61]

4.1.2.4.10 Carbon Dioxide Pulsed Laser. This pulsed laser uses a carbon dioxide light source. The light pulses supply the energy necessary to ablate the coatings. This process also contains a vacuum filtration system to collect the toxic by-products generated during ablation.[62]

Studies show that it is a promising technique, and that the extent of paint removal is controllable. However, the strip rates achieved are very slow. No adverse structural effects to the aircraft have been detected. While subsequent paint adhesion tests are promising, toxic byproducts and effects on the substrate need to be studied in more detail. In addition, the use of this process on complex, contoured parts is difficult.[63]

4.1.3 Work Practice Standards

Work practice standards are changes in the method of operation that do not affect the products used in the process or the process itself, but result in a reduction in emissions. The aerospace industry has implemented work practice standards programs for housekeeping measures and managed chemical distribution systems.

Emissions of HAP compounds, particularly solvents, can be reduced by limiting both the amount of the material exposed to the atmosphere and the length of the exposure. The emission reductions can be achieved by implementing housekeeping measures whereby solvent soaked rags used for hand-wipe cleaning are placed into bags or containers that are kept closed. This eliminates the continual evaporation of the solvent from the rags when they are not in use. The bags or containers can then be collected and disposed in such a manner (e.g., by incineration) to eliminate any further solvent emissions.[64]

Managed chemical distribution systems centralize the distribution of solvents and coatings and controls the amount of these materials allowed to be used for a particular task. A control plan typically consists of centralized distribution to authorized employees who have taken a safety course and understand the pollution potential of the materials. In many cases, workers check out material for immediate use and then return any leftover chemical for storage or hazardous waste pickup. The control plan also limits the amount of solvent issued to each worker during a shift. This results in the reduction of total solvent consumption, but also requires each worker to carefully monitor solvent use so that the required cleaning is accomplished without impairing product quality. Additionally, the centralized distribution helps keep accurate usage records, assure full use of limited pot-life materials, manage inventory, and reduce waste. In this way, waste solvent and coatings are reduced, and emissions from these waste materials are eliminated.[65]

4.2 CONTROL DEVICES

The removal efficiency of each control device on the basis of the total volatile organic compound (VOC) concentration is included in each section. Since detailed data regarding HAPs are generally not available, HAP removal efficiency is assumed to equal VOC removal efficiency. Removal efficiency values are based on well maintained units with no emissions from leaks.[66]

4.2.1 Carbon Adsorbers

In carbon adsorption systems, activated carbon is used as the adsorbent for removing gaseous organic contaminants from an exhaust stream. The air stream containing HAPs is exhausted into the activated carbon bed and the contaminants are retained on the carbon due to chemical and physical forces.[67] Figure 4-1 is a schematic of a typical two-bed regenerative carbon adsorption system.[68]

Adsorption systems are used to remove VOCs from gas streams when strict limits on the outlet concentration must be met, or when recovery of the VOC is desired. Adsorption is effective on inlet concentrations ranging from a few part per billion to several thousand parts per million, and a flow rate of several hundred to several hundred thousand cubic feet per minute. Carbon adsorbers typically have a removal efficiency of 95 to 99 percent.[69]

Many factors affect the efficiency of the adsorption process. Four major ones are: (1) temperature, (2) humidity, (3) contaminants, and (4) velocity. The adsorptive power of the activated carbon decreases with increases in temperature. Secondly, at humidities greater than 50 or 60 percent, the solvent adsorption efficiency decreases, as water and solvent molecules compete for adsorption sites. In addition, contaminants such as high boiling point compounds may reduce the adsorption efficiency, and particulate matter will foul the surface of the activated carbon. Finally, the velocity of the air stream in the adsorber vessel determines the time the air stream remains in contact with the carbon beds (i.e., the residence time). The longer the residence time, the better chance the solvent molecule has in finding an available site on the activated carbon.[70]

Over time, the efficiency of the system is reduced due to the contaminants in the carbon. If a unit is allowed to become saturated,

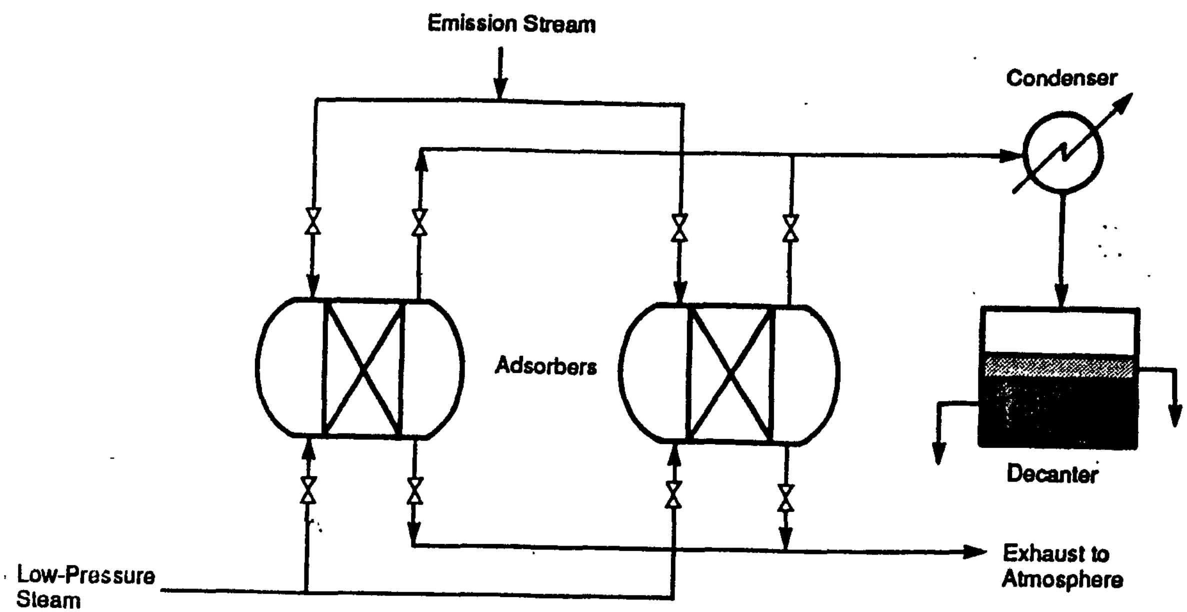

Figure 4-1. Typical two-bed regenerative carbon adsorption system.
[Reference 66, p. 4-31]

contaminants are able to vent out of the unit and the efficiency of the control device is zero. Additionally, if certain solvents are allowed to saturate the carbon substrate, there is a potential for carbon bed fires. At the first indication of breakthrough (an increase of organics in the exhaust stream), the bed must either be replaced or regenerated.[71]

In a typical large carbon bed system, the contaminated air stream passes through multiple adsorbers in parallel while another adsorber is in regeneration or standby mode. The clean air is discharged through a common stack. After a length of time, the adsorber that has been on-line the longest is taken off-line for regeneration and the standby adsorber is brought on line. The length of the adsorption cycle depends on the type and amount of contaminants and carbon present, but an 18 to 30 hour cycle is typical.

Several options for handling the spent carbon from carbon adsorption systems exist. One option is to send the spent carbon off-site for disposal. A second option is to strip the contaminants from the carbon with steam or hot gases. This procedure does not require removing the carbon from the adsorber and produces less waste than the non-regenerative options. This option does, however, produce a contaminated condensate that must be treated before discharge. A third option is to send the carbon off-site for reactivation. This process heats the carbon in the absence of air to the combustion temperature of the solvents adsorbed by the carbon. The carbon can then be reused.[72]

Steam is generally used to regenerate the carbon bed for vapor phase recovery processes because it is relatively cheap, usually already available at industrial sites, and easily condensed. Distillation or decanting techniques are used to remove the recovered solvent from the condensate. After the bed has been regenerated with steam, the bed should be cooled and dried. This step is done to reduce the moisture level in the bed so that solvent losses to the atmosphere may be minimized during the initial startup of the regenerated bed.[73]

4.2.2 Incinerators

Two basic types of incinerators, thermal and catalytic, are used in the aerospace industry to remove VOC contaminants. Each type is discussed below.

4.2.2.1 Thermal Incinerators. Thermal incinerators are generally used on air streams with dilute concentrations of VOCs. These control devices have minimal dependence on the characteristics of the VOC contaminants, so they can be used to control a wide variety of emission streams.[74] Thermal incinerators can achieve removal efficiencies of 98 percent and higher.[75]

A schematic diagram of a thermal incinerator is shown in Figure 4-2.[76] The basic operation of thermal incinerators involves raising the inlet air stream to the incineration temperature of the contaminants and maintaining that temperature for a specific residence time. The waste heat content of the incinerator exhaust stream is used to preheat the inlet air stream. An auxiliary fuel is then typically required to raise the air stream temperature to the incineration temperature. The preheated process exhaust stream enters the incineration combustion chamber that is maintained at a minimum of 760°C (1400°F) by fuel-fired burners and the thermal energy released by the VOCs. This incineration process converts the incoming VOCs primarily to carbon dioxide and water vapor. The airstream then leaves the combustion chamber and 95 percent of the thermal energy of the clean exhaust stream is recovered to be reused as preheat for the next inlet cycle. The clean airstream is then discharged by being drawn through an exhaust manifold by an exhaust fan and valve mechanism.[77]

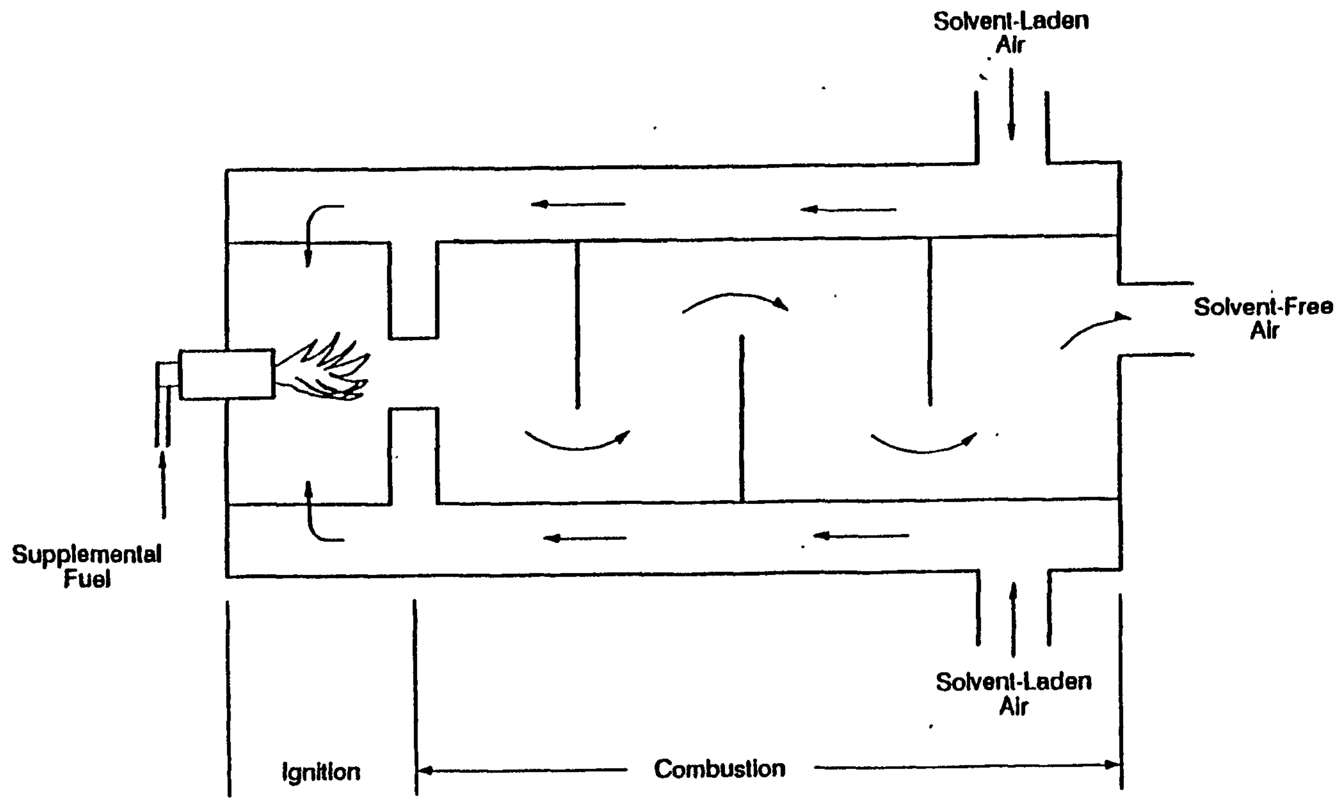

Figure 4-2. Schematic diagram of a thermal incinerator.
[Reference 1, p. 4-17]

Three important design considerations of the combustion chamber are residence time, temperature, and turbulence. The residence time, which must be sufficient to permit complete combustion of the VOC, is about 0.2 to 0.8 seconds. The necessary temperature range for thermal incineration is 760°C to 871°C (1400°F to 1600°F), and turbulence facilitates the mechanical mixing of oxygen, heat, and VOCs necessary for maximum removal efficiency. The specific design values depend on the design and manufacture of the incinerator.[78]

4.2.2.2 Catalytic Incinerators. Catalytic incinerators are similar to thermal incinerators except that they use a catalyst (a substance that accelerates the rate of oxidation without undergoing a chemical change itself) to assist in the oxidation of VOCs to carbon dioxide and water. Figure 4-3 shows a typical catalytic incinerator.[79] The solvent-laden air enters the device and is preheated to 260°C to 460°C (500°F to 860°F) by both a primary heat exchange and a preheater. The airstream is then blown across a catalyst site where oxidation occurs. The catalyst catalyzes the reaction with oxygen, causing it to take place at a lower temperature, thereby saving fuel. Typical catalyst materials used are noble metals, such as platinum or palladium dispersed on an alumina support. About 98 percent of the incoming VOC can be destroyed in this manner.[80]

A potential limitation of this system in some services is contamination of the catalyst surface. Materials in the emission stream such as bismuth, lead, arsenic, mercury, phosphorus, zinc, and sulfur can poison and decrease or destroy the catalyst's efficiency. Additionally, liquids or solids can deposit on catalysts, forming a coating which reduces the catalyst's performance. The life of the catalyst is also limited by erosion, attrition, vaporization, and thermal aging. However, with proper controls, catalysts can last two to five years.[81]

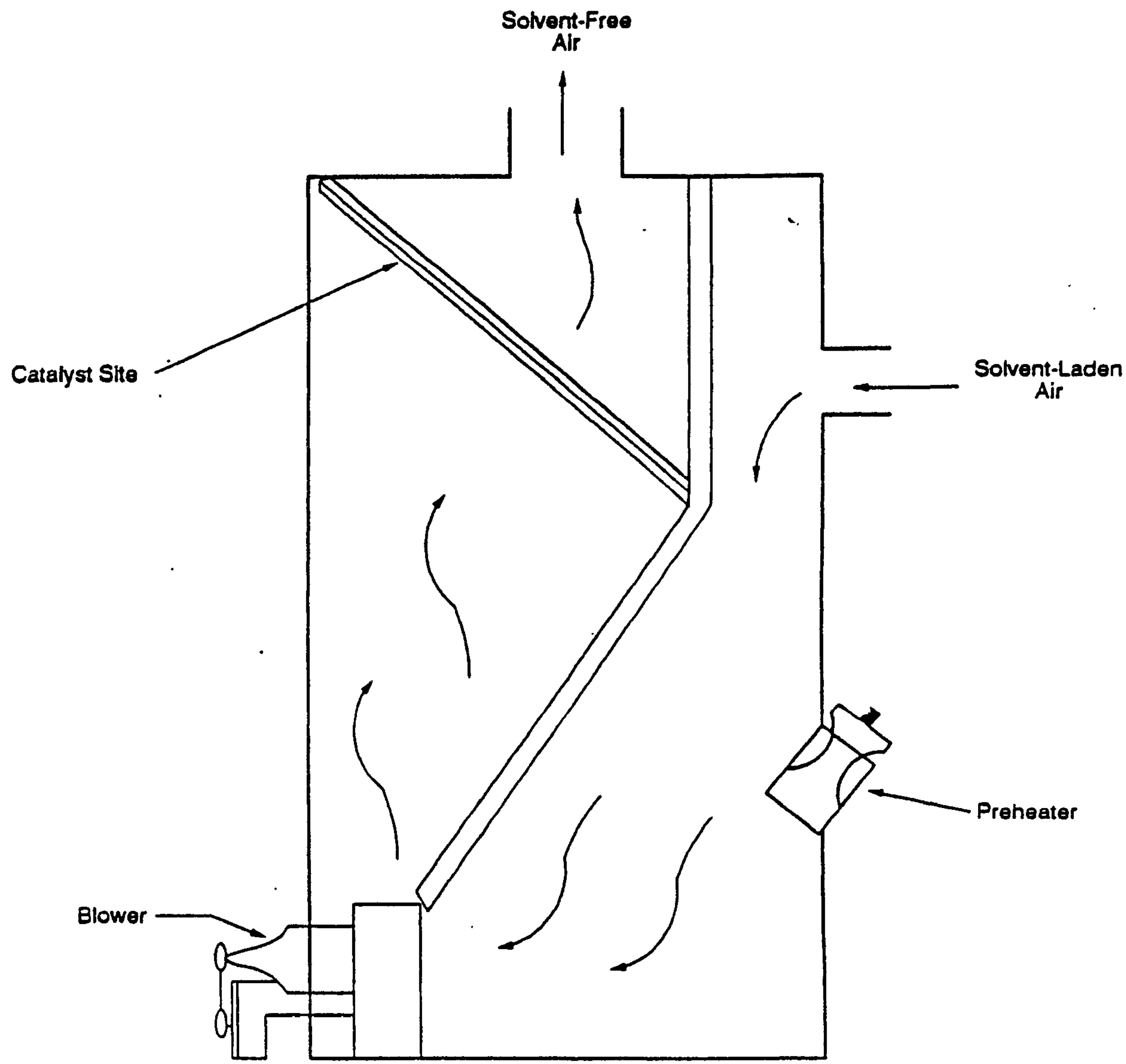

Figure 4-3. Schematic diagram of a catalytic incinerator system.
[Reference 1, p. 4-19]

4.2.3 Ultraviolet Oxidation

An ultraviolet light oxidation (UVOX) system has been developed as an abatement device for low VOC concentration air streams. Figure 4-4 gives a schematic of the ultraviolet oxidation system.[82] The air stream passes through particulate filters, then enters a reactor where it is exposed to ultraviolet light which initiates the oxidation of the VOCs. Ozone and other oxygen-based oxidants are injected into the reactor to react with the VOCs in the air stream to begin the oxidation of VOCs into carbon dioxide and water. The ozonated air enters the bottom of a packed column scrubber, and ozonated water enters the top. The air and water move countercurrently in the column, passing over mass transfer media, or packing media. This scrubbing process furthers the reaction of the oxidants with the VOCs. The airstream then travels through activated carbon beds. Although the airstream is considered clean after the packed column treatment, the carbon beds are final protection against any release of unreacted pollutants. Two carbon beds are used with the system. One bed can be placed off-line and cleaned with ozone while the other bed is in use. The water in the packed column is recycled, reozonated, and filtered so that there is little loss except for evaporation. The only regularly required disposal is for the particulate filters and occasional replacement of the carbon beds. A typical removal efficiency for UVOX is reported to be 95 percent.[83,84]

4.2.4 Activated Carbon Fiber Adsorbent

Another technology has been developed to control low concentration VOC emissions (e.g., paint spray booths). This technology utilizes an activated carbon fiber adsorbent to initially capture the VOC emissions. The adsorbent system consists of a honeycomb structure element made of activated carbon fiber paper in corrugated form. This structure adsorbs the VOCs in the

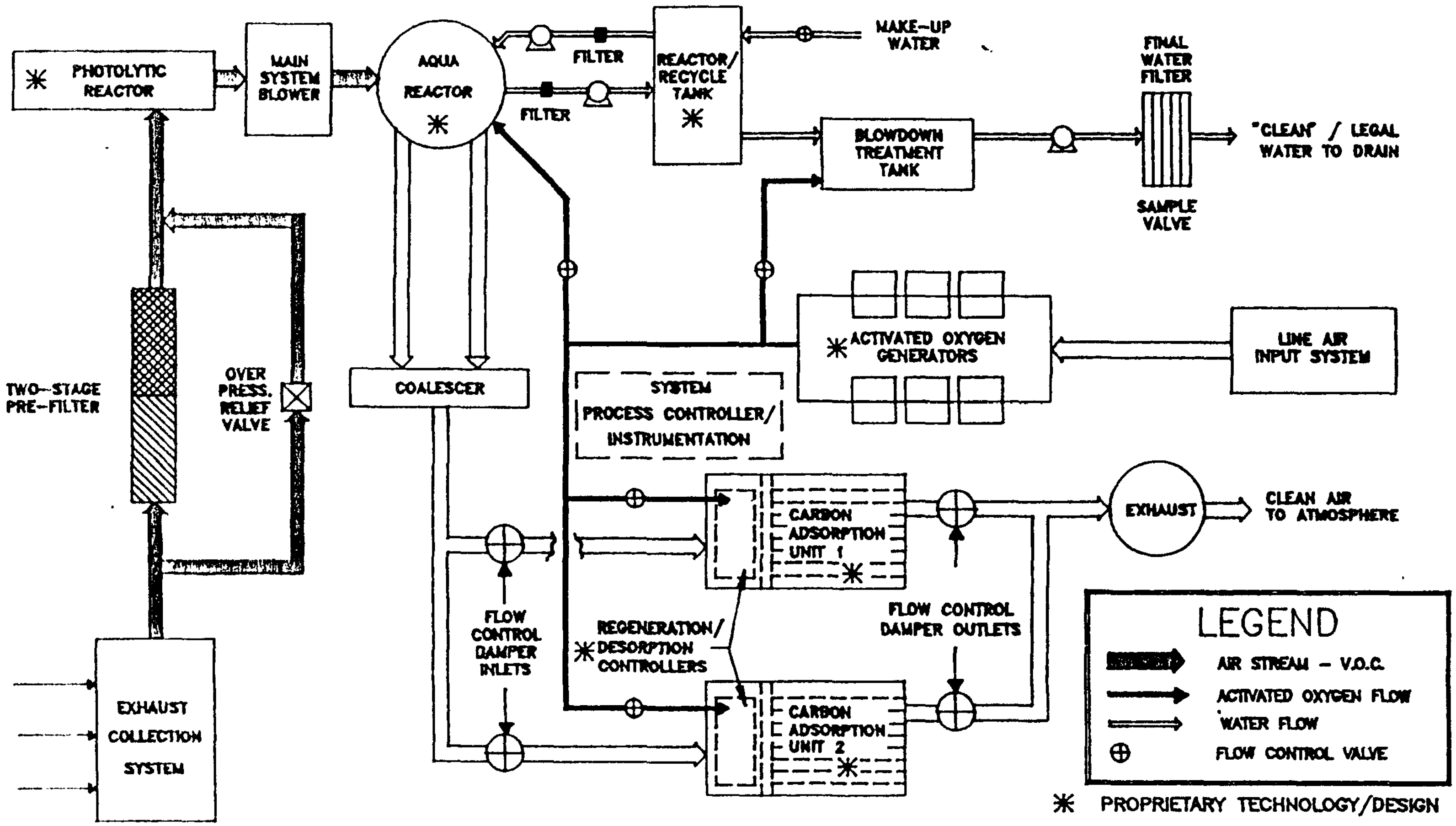

Figure 4-4. UVOX, packed tower, and adsorber system.
[Reference 82]

exhaust stream. As the activated carbon structure becomes saturated, the VOCs are desorbed using hot air. The portion of the activated carbon structure that was regenerated then begins the adsorption cycle again.[85]

4.2.5 Catalyst-coated Filter Media

Low concentration organic emissions (e.g., paint spray booths) can be controlled through the use of a catalyst-coated filter media. The catalyst material is impregnated onto the fibers of a dry filter which can then be used wherever conventional dry filters are used. The catalyst material, unlike activated carbon, permanently binds the organic material into its crystalline matrix so that it will not later desorb. In addition to the coated filters, the catalyst material can be used in a granular form to control emissions.[86]

4.2.6 Baghouses

Baghouses, one type of fabric filter system, operate by capturing particles on the surface of closely spaced fibers of the filter media. Woven and felt are the two general types of fabric used for bag filters. In the case of woven filters, the pores of the cloth are many times larger than the particles; however, within a few minutes of operation, a filter cake (layer of dust) will form on the filter that effectively reduces the pore size and increases collection efficiency. The pores in felt filters are small enough so that a coated layer not need form before a good collection efficiency can be achieved. Control efficiencies of 99 percent or greater can typically be achieved.[87] Typical cloth filters are shown in Figure 4-5.[88,89]

4.2.7 Mechanical Centrifugal Separator (Rotoclone)

Mechanical centrifugal separators, or rotoclones, operate by capturing particles with the use of centrifugal force. With this system, the fan and dust collector are combined in a single unit. The exhaust stream is directed into a centrifugal fan. The fan blades are shaped to direct particles by

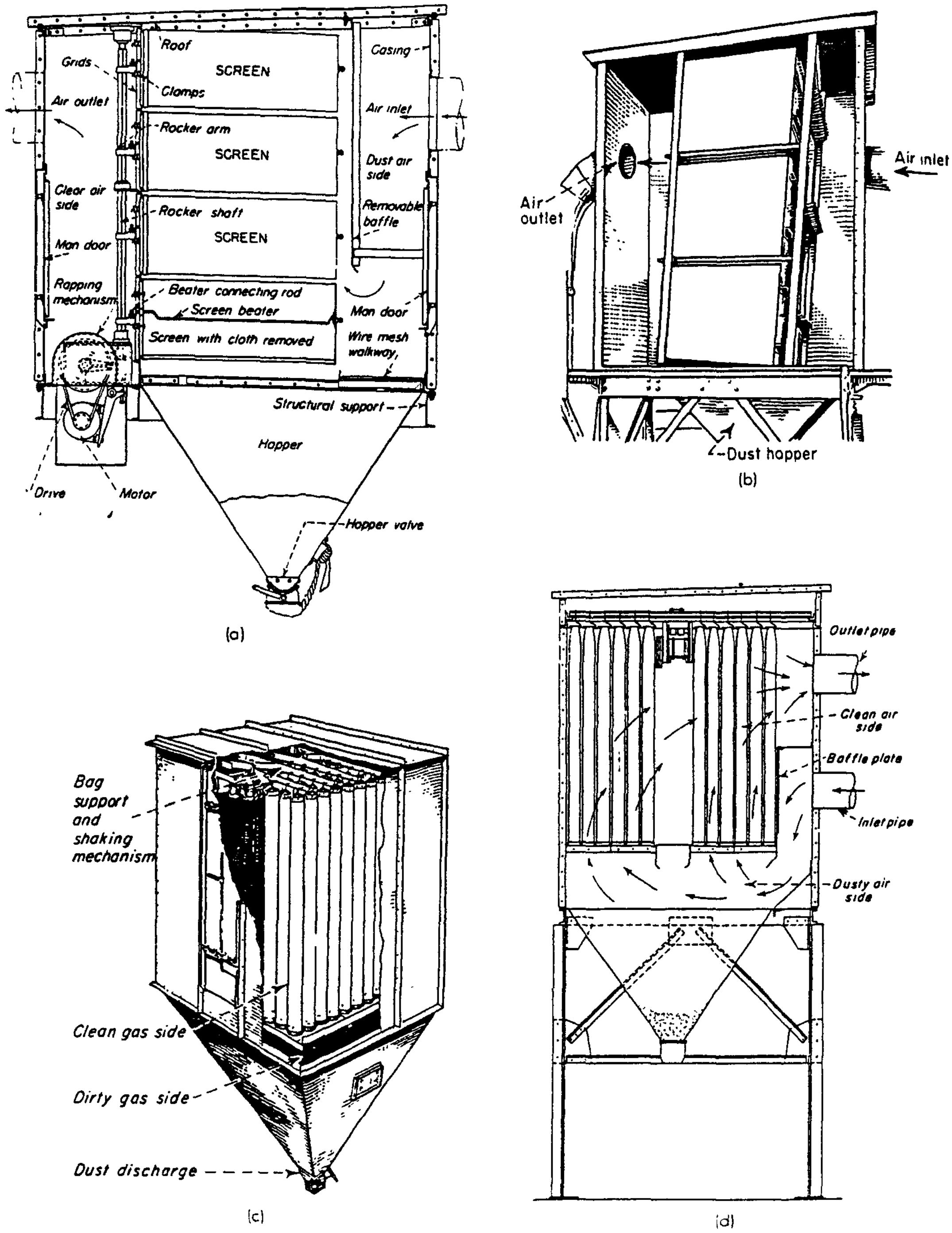

Figure 4-5. Typical cloth filters:

(a) Screen or envelope type (section view)
(b) Screen or envelope type (cutaway view)
(c) Bag type (cutaway view)
(d) Bag type (sectional view)

[Reference 89, p. 20-92]

using centrifugal force onto the unit's walls and then into a slot leading to a collection bin. The gas stream continues to an outlet.[90] Control efficiencies of 98 percent or greater have been reported.[91] A typical rotoclone dust collector is shown in Figure 4-6.[92]

4.2.8 Dry Filters for Spray Booths

During the coating application process, paint is sprayed from the spray gun onto the product being painted. Depending on the method of spraying, various amounts of coating overspray (e.g., paint particulates and solvent) are lost to the surrounding air, floor, and walls. When painting is done within a spray booth, exhaust air carries the overspray away from the worker and the product. This is done for several reasons. Removal of overspray prevents accumulation and concentration of hazardous components of the coating, preventing a buildup that could violate health, safety, or fire protection regulations. Additionally, air moving through the booth carries overspray away from the product, avoiding the detrimental consequences of particulates settling on freshly painted surfaces. Finally, the air flow can be directed to a capture device. Capturing and removing the particulates from the exhaust air stream eliminates the release of these particulates to the outside air.[93]

One way to remove overspray particulates from the exhaust air flow is to use a dry filter media. Air flow in a booth equipped with dry filter media generally passes from the painter, over the part, and through a filter bank. This air flow can be horizontal or vertical as in a downdraft spray booth. Examples of typical dry filter media includes: (1) paper filters formed into double accordion folds with staggered holes for air flow, (2) non-woven mesh type pads in series, and (3) non-woven cloth curtains that are roll fed across the face on the booth.[94] Dry filter media must replaced when the pressure

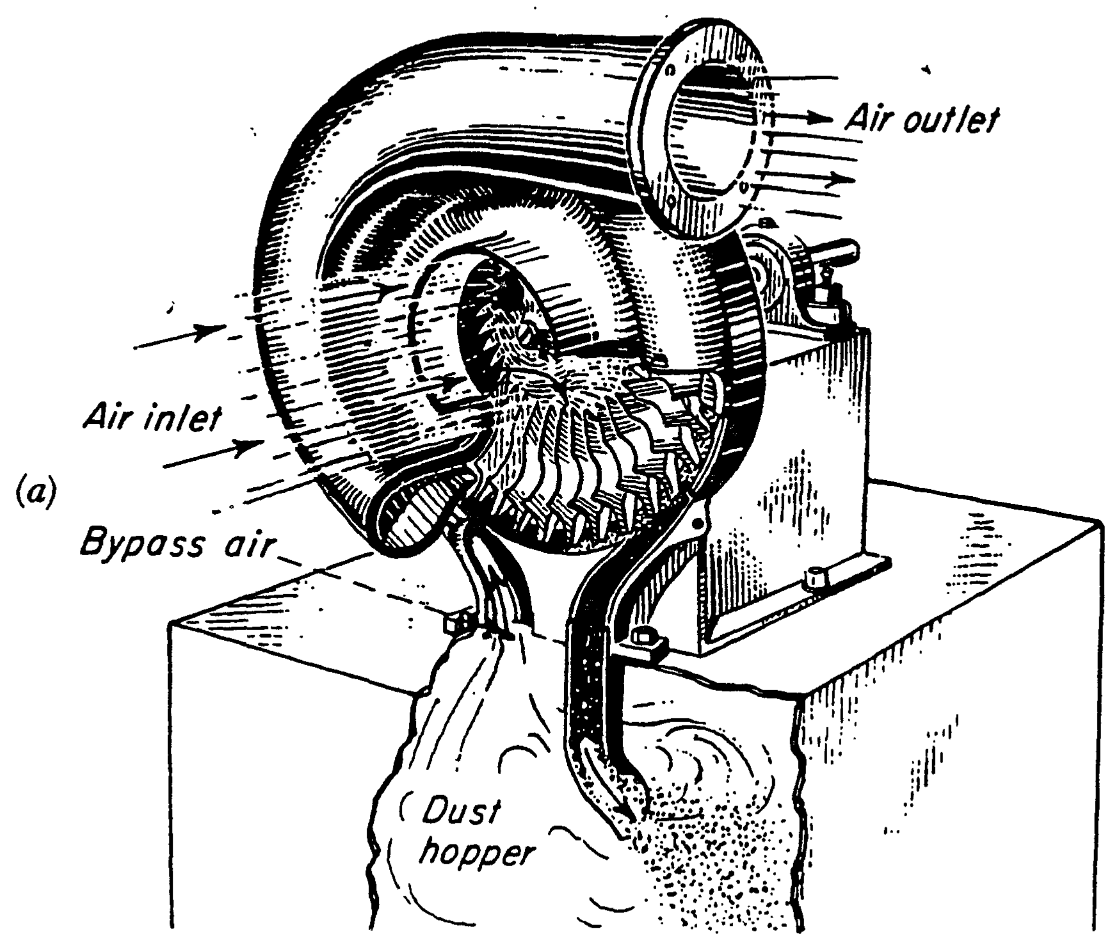

Figure 4-6. Typical mechanical centrifugal separator.
Rotoclone (cutaway view).
[Reference 89, p. 20-87]

drop across the filters exceeds the rated pressure drop for the filter, which is caused by accumulated overspray. The excessive pressure drop can either lower the air flow rate below acceptable levels, or cause one or more filters to tear or pull away from its mounting frame.

4.2.9 Waterwash Spray Booths

A second way to control overspray particulates is to use a waterwash spray booth. Similar to the dry filter spray booths, air flow can move horizontally or vertically into the face of the waterwash booth. The water removes the particulates by two methods. First, air is drawn through a continuous curtain of moving water and particulates are removed by contact with the water. Second, the air flow makes a sudden change in direction or velocity. As a result of inertial force, the particulates are impinged on the booth walls and are washed down by the water flow. Waterwash spray booths typically require very little maintenance. Periodically, the water is removed from the booth, leaving paint sludge in the water sump that must then be removed. Additionally, many companies recycle the water through the spray booth filter system indefinitely with water added only to account for evaporation. During the cycle, the water is typically treated to remove the residue paint particulates and the resulting paint sludge is disposed of as hazardous waste.[95]

4.7 REFERENCES

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53. Reference 21, p. 10.

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5.0 MODIFICATION AND RECONSTRUCTION

National emission standards for hazardous air pollutants (NESHAP) apply to both new and existing facilities that are major sources [as defined in Section 112(a)(1) of the Clean Air Act Amendments of 1990 (CAAA)] of hazardous air pollutant (HAP) emissions. The maximum degree of reduction in emissions for new sources (those sources for which construction commenced after the date of proposal of this standard) shall not be less than the maximum achievable control technology (MACT) demonstrated by the best controlled similar source. MACT standards for existing sources may be equally or less stringent than the MACT standards for new sources, but cannot be less stringent than the level of control achieved by the best performing 12 percent of existing sources.

After the effective date of a permit program under Title V of the CAAA, a major source which undergoes a modification that is not offset by reductions in emissions of a more hazardous pollutant at that source must meet the MACT emission limitation for existing sources. A major source which is constructed or undergoes a reconstruction, however, must meet the MACT emission limitation for new sources. Modification and reconstruction are further defined in Section 5.1, and their applicability to the aerospace manufacturing and rework industry is discussed in Section 5.2.

5.1 PROVISIONS FOR MODIFICATION AND RECONSTRUCTION

5.1.1 Modification

Section 112(a)(5) of the CAAA defines modification as "any physical change in, or change in the method of operation of, a major source which increases the actual emissions of any hazardous air pollutant emitted by such source by more than a de minimis amount or which results in the emissions of any hazardous air pollutant not previously emitted by more than a de minimis amount." Changes such as routine maintenance, repair, and replacement of worn parts or an increase in the hours of operation are not considered modifications.

Certain changes, even though they result in an increase in HAP emissions greater than a de minimis amount, are not considered modifications. Section 112(g)(1) of the CAAA establishes an offset provision such that a physical change in, or change in the method of operation of, a major source will not be considered a modification if the change also results in an equal or greater decrease in the quantity of emissions of another hazardous air pollutant (or pollutants) deemed by the EPA to be more hazardous. The owner or operator of the source shall submit a showing to the EPA (or the State) documenting the increase in emissions and the corresponding decrease of the more hazardous pollutant.

Modifications that are not subject to the offset provision must meet the MACT emission limitation for existing sources. After the effective date of a permit program under Title V of the CAAA, no modification may be made to a major source until such modification is approved by the EPA (or the State).

The key to determining if a change is considered a modification is whether actual emissions from the emission point or points, process, product line, or entire facility modified have increased on a mass per time basis (kg/hr) as a result of the modification. Changes in the emission rate may be determined by emission factors as specified in the latest issue of "Compilation of Air Pollution Emission Factors," EPA publication No. AP-42, or other emission factors determined by EPA to be superior to AP-42 emission factors. In cases where utilization of emission factors does not clearly demonstrate that emissions increase or decrease, material balances, continuous monitoring data, or manual emission tests may be used to determine changes in emission rates.

5.1.2 <u>Reconstruction</u>

Reconstruction is defined in 40 CFR 60.15 as "the replacement of components of an existing facility to such an extent that:

(1) The fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable new facility, and

(2) It is technologically and economically feasible to meet the applicable standards."

For this definition, "fixed capital costs" means the capital needed to provide all the depreciable components.

If the owner or operator of a major source is planning to replace components within that source, and the fixed capital cost of the new components exceed 50 percent of the fixed capital cost of a comparable entirely new source, then the owner or operator must notify the EPA of the proposed replacements. This notification must be made at least 60 days before construction of the replacement is commenced, and must include the information specified in 40 CFR 60.15(d). After the effective date of a permit program under Title V of the CAAA, no reconstruction of a major source may be made until such reconstruction is approved by the EPA (or the State).

There is no offset provision for reconstruction as there is for modification. Therefore, any reconstruction must meet the MACT emission limitation for new sources.

5.2 APPLICATION TO AEROSPACE MANUFACTURING AND REWORK FACILITIES

Aerospace manufacturing and rework encompasses numerous operations, and changes in any of these operations may result in a modification as defined in Section 112(a)(5) of the CAAA or a reconstruction as defined in 40 CFR 60.15. As such, a description of the modification and reconstruction that may occur for each process is beyond the scope of this section. However, several general changes that may occur at aerospace manufacturing and rework facilities are presented below.

5.2.1 Spray Booths

The addition of spray booths for coating application will generally increase emissions due to an increase in coating production capacity, even though the plant manufacturing capacity has not changed. For example, a facility that is near plant manufacturing capacity may be taxing the coating capacity of the existing spray booths. The facility then adds new spray booths to relieve this production bottleneck. The emissions will then increase on a mass per time basis (kg/hr), since more coating can be accomplished per hour with the additional spray booths than before the modification.

5.2.2 Addition of a New Operation

An aerospace facility may add an operation not previously performed at that facility, resulting in an increase in emissions. The addition of the operation may be due to the requirements of a new product line, or bringing in-house an operation previously performed by a subcontractor. Examples of these operations include chemical milling, coating removal, metal finishing, and composite processing.

The changes necessary to add one of these operations will typically be considered a modification. However, extensive changes necessary for adding a process such as coating removal for large aircraft (e.g., construction of a hanger and ventilation system, spray equipment, and waste treatment) may approach the criteria for classification as reconstruction.

5.2.3 Addition of a New Product Line

The addition of a new product line generally involves extensive changes throughout an existing facility. In addition to modifications described in Sections 5.2.1 and 5.2.2, the layout of all or part of the facility may change. This may involve the relocation or construction of raw material storage, process operations, offices, and utilities.

A new product line may be added at a facility under one of two scenarios. In the first scenario, the new product line is added to the existing product lines already being manufactured at the facility. This will usually involve the most extensive physical changes to the facility and will most likely increase emissions. Depending on the extent of the changes that are made to the existing product lines, this may qualify as reconstruction. The second scenario involves an old product line being replaced by the new product line. In this case, the physical changes to the facility may be minor since manufacturing floor space and process capacity will be available from the elimination of the old product line. This type of change may be considered a modification rather than a reconstruction.

6.0 MODEL PLANTS

This chapter describes the model plants for the aerospace manufacturing and rework industry. The model plants will be used to assess the environmental, energy, cost, and economic impacts of the proposed national emission standard for hazardous air pollutants (NESHAP).

6.1 MODEL PLANTS

Eleven model plants were developed to characterize facilities in the aerospace manufacturing and rework industry. The model plant parameters were developed primarily from responses to Section 114 questionnaires sent to aerospace manufacturing and rework facilities, and site visit questionnaires. Table 6-1 lists the aerospace manufacturing and rework facilities that received the initial Section 114 questionnaires and the facilities that provided voluntary responses. Table 6-2 lists the aerospace manufacturing and rework facilities that received the Section 114 questionnaire on emissions from waste and wastewater operations, storage tanks, and inorganic emissions from depainting and coating application operations. Site visits were conducted at the facilities listed in Table 6-3.

The model plants developed are presented in Table 6-4. The model plants were based primarily on three parameters: (1) market segment (commercial versus military), (2) type of work performed [original equipment manufacture (OEM) versus rework], and (3) the size of the

TABLE 6-1

AEROSPACE MANUFACTURING AND REWORK FACILITIES THAT RECEIVED SECTION 114 QUESTIONNAIRES

Company	Facility
American Airlines[a]	Tulsa Maintenance and Engineering Center - Tulsa, OK
	Alliance Maintenance Base - Ft. Worth, TX
	Line Maintenance Facilities - Chicago, IL - Dallas, TX - New York , NY (2 facilities) - Los Angeles, CA - San Francisco, CA
Boeing	Auburn, WA
	Development Center - Seattle, WA
	Everett, WA
	Kent Space Center - Kent, WA
	Macon, GA
	North Boeing Field - Seattle, WA
	Oakridge, TN
	Oxbow - Seattle, WA
	Philadelphia - Ridley Park, PA
	Plant 2 - Seattle, WA
	Portland - Gresham, OR
	Renton, WA
	Robbins - Kent, WA
	South Park - Seattle, WA
	Thompson Site - Seattle, WA
	Wichita, KS
Delta Air Lines[a]	Technical Operations Center - Atlanta, GA

TABLE 6-1 (Continued)

Company	Facility
General Dynamics	Air Defense - Pomona, CA
	Convair - San Diego, CA
	Fort Worth, TX
	Fort Worth/Abilene - Abilene, TX
	Space Systems - San Diego, CA
Grumman	Bethpage, NY
	Calverton, NY
	Glen Arm, MD
	Houston - Webster, TX
	Millidgeville, GA
	St. Augustine, FL
	Stuart, FL
Lockheed	Advanced Development - Palmdale, CA
	Aeromod Center - Greenville, SC
	Aeronautical Systems - Marietta, GA
	Aeromod Center - Tucson, AZ
	Aircraft Services - Ontario, CA
	Missiles and Space - Sunnyvale, CA
Martin Marietta	Space Launch Systems - Cape Canaveral, FL
	Aero and Naval Systems - Baltimore, MD
	Michoud Assembly - New Orleans, LA
	Sand Lake Facility - Orlando, FL
	Payload Fairing Processing Facility - Vandenburg Air Force Base, CA
	Waterton - Littleton, CO
McDonnell Douglas	Columbus, OH
	Helicopter Company - Culver City, CA
	Space Systems - Huntington Beach, CA
	C1 Facility - Long Beach, CA

TABLE 6-1 (Continued)

Company	Facility
McDonnell Douglas	Macon, GA
	Melbourne, FL
	Helicopter Company - Mesa, AZ
	Space Systems - Pueblo, CO
	St. Charles, MO
	MDC - St. Louis, MO
	Salt Lake City, UT
	Florida Missile Production - Titusville, FL
	Torrance, CA
	Tulsa, OK
Northrop	AG/AF - Hawthorne, CA
	Site 4 B-2 Division - Palmdale, CA
	B-2 Division - Pico Rivera, CA
	D-2 - Compton, CA
	East Complex - Hawthorne, CA
	Hawthorne-Aircraft/NAD - Hawthorne, CA
	K-1/K-3 - Torrance, CA
	K-4 - Torrance, CA
	K-6 - Torrance, CA
	K-8 - Torrance, CA
	West Complex - El Segundo, CA
	Y-12 - Anaheim, CA
Robins Air Force Base	Robins Air Force Base - Warner Robins, GA
Rohr	Arlington - Riverside, CA
	Moreno Valley, CA
	Riverside, CA

TABLE 6-1 (Concluded)

Company	Facility
Trans World Airlines[a]	Ground Operations Center - Kansas City, MO
TRW[a]	Space Park Facility - Redondo Beach, CA
United Airlines	San Francisco, CA
USAir	Winston Salem, NC

[a] Voluntary submittals

TABLE 6-2

AEROSPACE MANUFACTURING AND REWORK FACILITIES THAT RECEIVED SECTION 114 QUESTIONNAIRES ON WASTE, WASTEWATER, AND INORGANIC EMISSIONS

Company	Facility
Beech Aircraft Corp.	Andover, KS
	Salina, KS
	Wichita, KS
Boeing	Auburn, WA
	Development Center - Seattle, WA
	Everett, WA
	Kent Space Center - Kent, WA
	Macon, GA
	North Boeing Field - Seattle, WA
	Oakridge, TN
	Philadelphia - Ridley Park, PA
	Plant 2 - Seattle, WA
	Portland - Gresham, OR
	Renton, WA
	Robbins - Kent, WA
	Thompson Site - Seattle, WA
	Wichita, KS
Cherry Point Naval Aviation Depot	Cherry Point AFB, NC
Edward Air Force Base[a]	Edwards AFB, CA
Eglin Air Force Base[a]	Eglin AFB, NJ
Hill Air Force Base[a]	Hill AFB, UT
Kaman Aerospace Corp.	Bloomfield, CT
	Gilman, CT
	Moosup, CT

TABLE 6-2 (Concluded)

Company	Facility
Kaman Aerospace Corp. (Continued)	Jacksonville, FL
Kirtland Air Force Base[a]	Kirtland AFB, NM
Lockheed	Advanced Development - Palmdale, CA
	Aeromod Center - Tucson, AZ
	Aircraft Services - Ontario, CA
	Lockheed Fort Worth - Fort Worth, TX
	Missiles and Space - Sunnyvale, CA
Malmstrom Air Force Base[a]	Malmstrom AFB - Great Falls, MT
McDonnell Douglas	Helicopter Company - Culver City, CA
	Space Systems - Huntington Beach, CA
	Douglas - Long Beach, CA
	Melbourne, AR
	Helicopter Company - Mesa, AZ
	St. Charles, MO
	MDC - St. Louis, MO
	Salt Lake City, UT
	Florida Missile Production - Titusville, FL
	Tulsa, OK
McGuire Air Force Base[a]	McGuire AFB, NJ
PEMCO Aeroplex	Birmingham, AL
Tinker Air Force Base	Tinker Air Force Base, OK
United Airlines	San Francisco, CA
	Oakland, CA

[a] Voluntary submittals

TABLE 6-3

SITE VISIT FACILITIES

Beech Aircraft - Wichita, KS
Boeing - Seattle, WA
Caspian - San Diego, CA
Cessna - Wichita, KS
Delta Air Lines - Atlanta, GA
General Dynamics - Pomona, CA
Hughes - Fullerton & El Segundo, CA
Hunting Air - Peachtree City, GA
LearJet - Wichita, KS
Lockheed - Marietta, GA
Maxwell Laboratories - San Diego, CA
Naval Air Station Alameda - Alameda, CA
Northrop - Palmdale & El Segundo, CA
Robins Air Force Base - Warner Robins, GA
Trans World Airlines - Kansas City, MO
United Airlines - San Francisco, CA
USAir - Winston Salem, NC

TABLE 6-4

MODEL PLANT DESCRIPTIONS

Model Plant	Market Segment	Work Type	Size[a]
1	Commercial	OEM	Small
2	Commercial	OEM	Medium
3	Commercial	OEM	Large
4	Commercial	Rework	Small
5	Commercial	Rework	Medium
6	Military	OEM	Small
7	Military	OEM	Medium
8	Military	OEM	Large
9	Military	Rework	Small
10	Military	Rework	Medium
11	Military	Rework	Large

[a] Small = < 1,000 employees
Medium = 1,000 to 9,999 employees
Large = 10,000+ employees

facility (small, medium, or large) in terms of the number of employees. There are no large commercial/rework facilities based on the Section 114 questionnaire responses and information obtained during site visits. Secondary model plant parameters, as presented in Section 6.1.2, were then used to further refine the development of the model plants. Parameters specific to each process (e.g., tank size, number of spray guns) are detailed in the cost and environmental impact memos.

6.1.1 Primary Model Plant Parameters

6.1.1.1 Market Segment. Different model plants were developed for the commercial and military market segments because of differences in performance requirements or specifications. These differences result in the use of a different mix of processes and coatings in the commercial and military market segments.

6.1.1.2 Work Type. The type of work (OEM versus rework) performed at the facility was selected as a defining parameter for model plants because there are a few major HAP emitting processes that are nearly exclusive to each type of work. The principle of these are chemical milling and depainting.

The chemical milling process is used primarily at OEM facilities and consists of two steps: (1) the application and subsequent drying of a maskant to the surface of the parts to be milled and (2) the chemical milling. Rework facilities do not typically perform chemical milling to any large extent, other than in the manufacture of some replacement parts (e.g., outer skin panels).

Depainting is performed primarily at rework facilities where the entire outer surface of the aircraft is stripped. This operation presents air emission and waste disposal problems unique to rework facilities due to the large hangar in which the stripping is performed. While OEM facilities perform paint removal operations, (e.g., stripping of paint from small parts or assemblies) they are not typically of the scale seen at rework facilities.

6.1.1.3 Size. Three sizes (small, medium, and large) have been defined for the model plants. The sizes have been defined based on number of employees. Figure 6-1 shows the distribution of aerospace manufacturing and rework facilities by number of employees as reported in the Section 114 responses, and Figure 6-2 shows the nationwide distribution of facilities by number of employees as reported by the Bureau of the Census.

Small model plants have been defined as having less than 1,000 employees. Medium model plants have 1,000 to 9,999 employees. Large model plants have 10,000 or more employees. This reflects the makeup of the industry where there are a few large facilities and more numerous medium and small facilities.

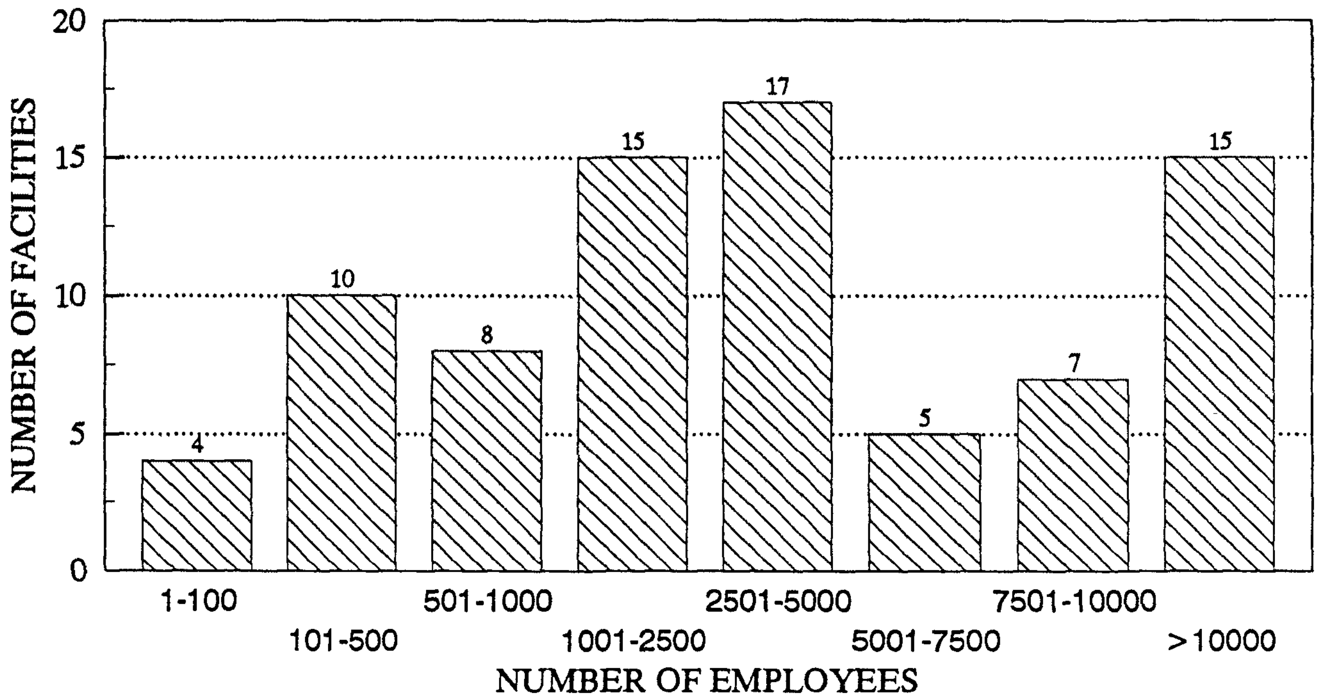
Although three model plant sizes have been defined, no data have been found that suggest there are commercial rework facilities in the large category. Therefore, only small and medium commercial rework model plants were developed.

6.1.2 Secondary Model Plant Parameters

The model plants were defined by three primary parameters (i.e., market segment, work type, and size) as presented in Section 6.1.1. In order to further define the model plants for the purpose of conducting the impact analyses and determining baseline emissions, secondary parameters were also developed.

FIGURE 6-1

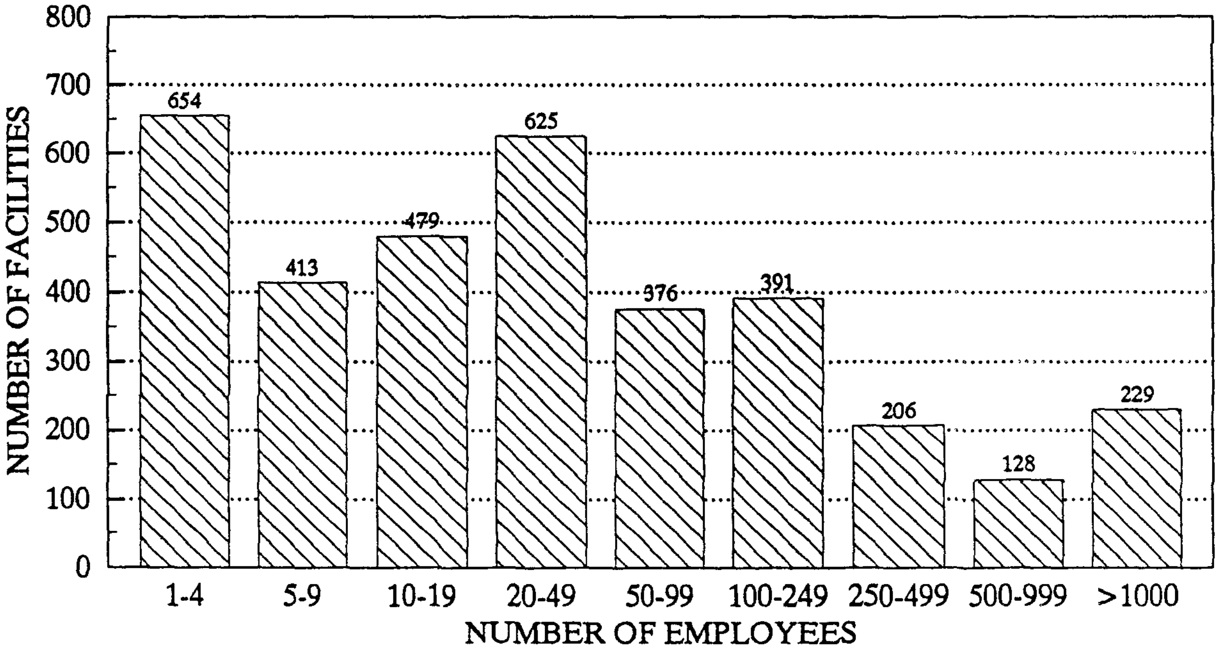
DISTRIBUTION OF AEROSPACE FACILITIES BY NUMBER OF EMPLOYEES



SOURCE: SECTION 114 QUESTIONNAIRE RESPONSES

FIGURE 6-2

DISTRIBUTION OF AEROSPACE MANUFACTURING FACILITIES BY NUMBER OF EMPLOYEES



SOURCE: U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS
COUNTY BUSINESS PATTERNS 1989

6.1.2.1 Process Profile. The responses to the Section 114 and site visit questionnaires were used to determine the similarities between each facility classification (i.e., commercial/OEM, commercial/rework, military/OEM, and military/rework) on the basis of processes used at the facility. Thirteen operations covering aerospace manufacturing and rework were developed as presented in Section 3.2. However, only the processes regulated under the proposed rule will be discussed in this chapter. Using the facility classification and number of employees as reported for each facility in the Section 114 responses, a "process profile" was developed for each model plant. These process profiles are presented in Table 6-5.

Medium and large commercial/OEM facilities tend to have all operations except depainting. Small commercial/OEM facilities, however, do not have maskant application, because these processes are typically beyond the scope of their operations. Small, medium, and large military/OEM facilities follow these same trends.

Based on survey data, maskant operations are generally not found at either commercial or military/rework facilities, regardless of size. Rework facilities typically perform all other operations.

TABLE 6-5

MODEL PLANT PROCESS PROFILES

Process	Model Plants										
	Commercial OEM			Commercial Rework		Military OEM			Military Rework		
	S	M	L	S	M	S	M	L	S	M	L
Depainting				X	X				X	X	X
Chemical Milling Maskant		X	X				X	X			
Spray Gun Cleaning	X	X	X	X	X	X	X	X	X	X	X
Hand-Wipe Cleaning	X	X	X	X	X	X	X	X	X	X	X
Primers and Topcoats	X	X	X	X	X	X	X	X	X	X	X

X = Process is performed at the model plant.

7.0 NATIONWIDE BASELINE HAP EMISSIONS AND ENVIRONMENTAL IMPACTS

7.1 INTRODUCTION

The purpose of this chapter is to present the nationwide baseline HAP emission estimates. Additionally, this chapter presents the air, water, energy, and solid waste impacts associated with compliance with the proposed standards.

7.2 NATIONWIDE BASELINE HAP EMISSIONS

The nationwide baseline HAP emissions presented in Table 7-1 were based on the baseline HAP emissions calculated in the environmental impact memos (see Appendix A). These HAP emissions were then multiplied by the number of model plant associated with each process to obtain the nationwide HAP emission estimates. As presented in Chapter 6, the number of model plants associated with each process differed. The HAP emissions from spray gun cleaning and hand-wipe cleaning are applicable to all model plants. The HAP emissions from primer and topcoat application also are applicable to all model plants, but differ between commercial and military market segments. In addition, the HAP emissions from chemical milling maskant application and depainting are only applicable to OEM and rework model plants, respectively.

7.3 ENVIRONMENTAL IMPACTS

Environmental impacts, defined as the air, water, energy, and solid waste effects of being in compliance with the proposed standard, were based on the model plants presented in Chapter 6. Tables 7-2 through 7-5 present the impacts on both a model plant and nationwide basis. The nationwide impacts are based on a combination of facility impacts for the model plants and the estimated number of operations nationwide of each size model plant.

The bases for the impact estimates for each of the processes are presented in environmental impact memos. Impact information was obtained from major vendors or from Section 114 questionnaire responses from aerospace manufacturing and rework facilities. Telephone calls were also used to clarify data and to obtain additional data. The model plant parameters presented in Chapter 6 were used to ensure a common basis for the estimates.

Some processes have multiple options to comply with the proposed standards. The environmental impacts used in the tables are those associated with the options that have the lowest cost impact. For depainting, the impacts associated with the use of non-HAP chemical strippers are used for both commercial and military rework model plants. For chemical milling maskant application, the impacts associated with the use of waterborne maskant application are used for medium model plants, and the impacts for solvent based maskant application in conjunction with a carbon adsorber are used for large model plants. There is only one option for both spray gun cleaning and hand-wipe cleaning, and the associated impacts are used for all model plants. The impacts used for primer and topcoat application are specific to military and commercial model plants.

The air, wastewater, energy, and solid waste impacts calculated for controlling inorganic HAP emissions from primer and topcoat application and depainting operations were calculated on a nationwide basis rather than on a model plant basis due to the data that was available. These values are presented in Tables 7-2B, 7-4B, and 7-5B. The total impacts are then presented in Tables 7-2C, 7-4C, and 7-5C. There is no wastewater generation associated with the inorganic controls and, therefore, there is only one table for wastewater (Table 7-3).

The data presented in this chapter is only for existing facilities. For the aerospace industry, no net growth is expected over the next five years; therefore, no new facilities are anticipated during this period.

TABLE 7-1
NATIONWIDE BASELINE HAP EMISSIONS (TONS/YEAR)

Process	Model Plant	Number of Facilities by Model Plant	Baseline Emissions by Model Plant	Baseline Emissions
Depainting	Small/Rework	27[a]	22.3	602
	Medium/Rework	73[b]	66.6	4,862
	Large/Rework	5	66.6	333
Chemical Milling Maskant	Medium/OEM	58	39	2,262
	Large/OEM	13	84.5	1,099
Spray Gun Cleaning	Small	1,318	0.3	395
	Medium	1,533	0.4	613
	Large	18	0.5	9
Hand-Wipe Cleaning	Small	1,318	4.4	5,799
	Medium	1,533	116	177,828
	Large	18	522	9,396
Primers and Topcoats	Commercial/Small	844	0.83	701
	Commercial/Medium	545	3.4	1,853
	Commercial/Large	6	29.6	178
	Military/Small	474	0.4	190
	Military/Medium	988	1.5	1,482
	Military/Large	12	13.4	161
Inorganic Emissions	Small	1,318	0.07	92
	Medium	1,533	0.2	307
	Large	18	0.02	0.4
Total Nationwide Baseline HAP Emissions				208,162

[a] Represents 5 percent of the 546 small rework facilities.
[b] Represents 5 percent of the 1,475 medium rework facilities.

TABLE 7-2A
ORGANIC HAP EMISSION REDUCTIONS (TONS/YEAR)

Process	Model Plant Size										
	Commercial/OEM			Commercial/Rework		Military/OEM			Military/Rework		
	Small	Medium	Large	Small	Medium	Small	Medium	Large	Small	Medium	Large
Depainting	N/A	N/A	N/A	21	63	N/A	N/A	N/A	21	63	63
Chemical Milling Maskant	N/A	35	68	N/A	N/A	N/A	35	68	N/A	N/A	N/A
Spray Gun Cleaning	0.2	0.3	0.4	0.2	0.3	0.2	0.3	0.4	0.2	0.3	0.4
Hand-Wipe Cleaning	2	63	282	2	63	2	63	282	2	63	282
Primers and Topcoats	0.6	2	18	0.6	2	0.3	1	10	0.3	1	10
TOTAL FOR ONE FACILITY	3	100	368	24	128	2	99	360	23	127	355
NUMBER OF FACILITIES	440	20	6	20	26	332	38	7	7	47	5
TOTAL FOR ALL FACILITIES	1,320	2,000	2,208	480	3,328	664	3,762	2,520	161	5,969	1,775
TOTAL NATIONWIDE (ORGANIC)	24,187										

TABLE 7-2B
INORGANIC HAP EMISSION REDUCTIONS (TONS/YEAR)

Process	Nationwide Model Plants		
	Small	Medium	Large
Depainting	63	233	87
Primers and Topcoats	0.04	0.02	0.005
TOTAL NATIONWIDE (INORGANIC)	383		

TABLE 7-2C
TOTAL HAP EMISSION REDUCTIONS (TONS/YEAR)

TOTAL NATIONWIDE	24,570

TABLE 7-3

WASTEWATER GENERATION (GALLONS/YEAR)[a]

Process	Model Plant Size										
	Commercial/OEM			Commercial/Rework		Military/OEM			Military/Rework		
	Small	Medium	Large	Small	Medium	Small	Medium	Large	Small	Medium	Large
Depainting	N/A	N/A	N/A	-19,470	-58,220	N/A	N/A	N/A	-19,470	-58,220	-58,220
Chemical Milling Maskant	N/A	0	435,290	N/A	N/A	N/A	0	435,290	N/A	N/A	N/A
Spray Gun Cleaning	0	0	0	0	0	0	0	0	0	0	0
Hand-Wipe Cleaning	0	0	0	0	0	0	0	0	0	0	0
Primers and Topcoats	0	0	0	0	0	0	0	0	0	0	0
TOTAL FOR ONE FACILITY	0	0	435,290	-19,470	-58,220	0	0	435,290	-19,470	-58,220	-58,220
NUMBER OF FACILITIES	440	20	6	20	26	332	38	7	7	47	5
TOTAL FOR ALL FACILITIES	0	0	2,611,740	-389,400	-1,513,720	0	0	3,047,030	-136,290	-2,736,340	-291,100
TOTAL NATIONWIDE	591,920										

[a] Negative values represent a wastewater reduction to the model plant.

TABLE 7-4A
ENERGY CONSUMPTION FOR CONTROLLING ORGANIC HAP EMISSIONS (KILOWATT-HOUR/YEAR)

Process	Model Plant Size										
	Commercial/OEM			Commercial/Rework		Military/OEM			Military/Rework		
	Small	Medium	Large	Small	Medium	Small	Medium	Large	Small	Medium	Large
Depainting	N/A	N/A	N/A	0	0	N/A	N/A	N/A	0	0	0
Chemical Milling Maskant	N/A	249,600	1,303,055	N/A	N/A	N/A	249,600	1,303,055	N/A	N/A	N/A
Spray Gun Cleaning	0	0	0	0	0	0	0	0	0	0	0
Hand-Wipe Cleaning	0	0	0	0	0	0	0	0	0	0	0
Primers and Topcoats	0	0	0	0	0	0	0	0	0	0	0
TOTAL FOR ONE FACILITY	0	249,600	1,303,055	0	0	0	249,600	1,303,055	0	0	0
NUMBER OF FACILITIES	440	20	6	20	26	332	38	7	7	47	5
TOTAL FOR ALL FACILITIES	0	4,992,000	7,818,330	0	0	0	9,484,800	9,121,385	0	0	0
TOTAL NATIONWIDE (ORGANIC)	31,416,515										

TABLE 7-4B
ENERGY CONSUMPTION FOR CONTROLLING INORGANIC HAP EMISSIONS (KILOWATT-HOURS/YEAR)

Process	Nationwide Model Plants		
	Small	Medium	Large
Depainting	N/A	N/A	N/A
Primers and Topcoats	5,940,000	N/A	N/A
TOTAL NATIONWIDE (INORGANIC)	5,940,000		

TABLE 7-4C
TOTAL ENERGY CONSUMPTION (KILOWATT-HOURS/YEAR)

TOTAL NATIONWIDE	37,356,520

TABLE 7-5A

SOLID WASTE GENERATION WHILE CONTROLLING ORGANIC HAP EMISSIONS (TONS/YEAR)[a]

Process	Model Plant Size										
	Commercial/OEM			Commercial/Rework		Military/OEM			Military/Rework		
	Small	Medium	Large	Small	Medium	Small	Medium	Large	Small	Medium	Large
Depainting[b]	N/A	N/A	N/A	11	33	N/A	N/A	N/A	11	33	33
Chemical Milling Maskant	N/A	4	4	N/A	N/A	N/A	4	4	N/A	N/A	N/A
Spray Gun Cleaning[c]	-15	-20	-26	-15	-20	-15	-20	-26	-15	-20	-26
Hand-Wipe Cleaning	0	0	0	0	0	0	0	0	0	0	0
Primers and Topcoats[d]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TOTAL FOR ONE FACILITY	-15	-16	-22	-4	13	-15	-16	-22	-4	13	7
NUMBER OF FACILITIES	440	20	6	20	26	332	38	7	7	47	5
TOTAL FOR ALL FACILITIES	-6,600	-320	-132	-80	338	-4,980	-608	-154	-28	611	35
TOTAL NATIONWIDE (ORGANIC)	-11,918										

[a] Negative values represent a solid waste reduction to the model plant.

[b] The sludge generation values calculated in the depainting impact memo were calculated in gallons per year. Actual model plant data are the following:

Small model plant: 2,220 gal/yr
Medium model plant: 6,610 gal/yr

The density used to convert these values was 10 pounds/gallon. There was no data available for large military rework model plants. It was assumed that the solid waste generation for this model plant is the same as for a medium military rework model plant.

[c] The sludge generation values calculated in the spray gun cleaning impact memo were calculated in gallons per year. Actual model plant data are the following:

Small model plant: -3,100 gal/yr
Medium model plant: -4,060 gal/yr
Large model plant: -5,110 gal/yr

The density used to convert these values was 10 pounds/gallon.

[c] The solid waste reduction values calculated in the primer and topcoat application impact memo were calculated in percent. Actual model plant data are the following:

Commercial small model plant: 47%
Commercial medium model plant: 25%
Commercial large model plant: 23%
Military small model plant: 46%
Military medium model plant: 24%
Military large model plant: 22%

No baseline data was available and, therefore, no solid waste reduction can be calculated in tons per year.

TABLE 7-5B
SOLID WASTE GENERATION WHILE CONTROLLING INORGANIC HAP EMISSIONS (TONS/YEAR)

Process	Nationwide Model Plants		
	Small	Medium	Large
Depainting	N/A	N/A	N/A
Primers and Topcoats	641	574	29
TOTAL NATIONWIDE (INORGANIC)	1,244		

TABLE 7-5C
TOTAL SOLID WASTE GENERATION (TONS/YEAR)

TOTAL NATIONWIDE	-10,670

8.0 COST ANALYSIS OF CONTROL OPTIONS

8.1 INTRODUCTION

This chapter presents the capital costs and annualized control costs, including recovery credits, attributable to compliance with the proposed standards that have been estimated for existing facilities.

8.2 ANNUAL COSTS

Annual costs were based on the application of the control options to the model plants presented in Chapter 6. Tables 8-1 through 8-4 present the annual costs by model plant. These tables also present the nationwide annual cost impact by model plant. Table 8-5 presents the total nationwide annual costs. The nationwide annual costs are based on a combination of facility costs for the model plants and the estimated number of operations nationwide of each size model plant.

The bases for the cost estimates for each of the processes are presented in cost impact memos (see Appendix B). Cost information was obtained from major vendors of the control option techniques or from Section 114 questionnaire responses from aerospace facilities. Telephone calls were also used to clarify data and to obtain additional data. The model plant parameters presented in Chapter 6 and in the impact memos helped to ensure a common basis for the cost estimates. All cost data presented in this chapter are in 1992 dollars.

Some processes have multiple options to comply with the proposed standards. The costs used in the tables are the lowest costs available for each process. For depainting, the costs associated with the use of non-HAP chemical strippers are used for both commercial and military rework model plants. For chemical milling maskant application, the costs associated with the use of waterborne maskant application are used for all medium model plants, and the costs associated with the use of solvent-based maskant application in conjunction with a carbon adsorber are used for large model plants. There is only one cost option for spray gun cleaning and hand-wipe cleaning, and this cost is used for all model plants. The costs used for primer and topcoat application are specific to military and commercial model plants.

Due to the available data, the costs calculated for controlling inorganic emissions from primer and topcoat application and depainting operations were calculated on a nationwide basis. Therefore, these values are presented only in the summary table, Table 8-5.

The data presented in this chapter are only for existing facilities. For the aerospace industry, no net growth is expected over the next five years; therefore, no new facilities are anticipated during this period.

8.3 CAPITAL COSTS

Capital costs would be incurred with the implementation of control measures for chemical milling maskants (both solvent-based chemical milling maskants with a carbon adsorber and waterborne chemical milling maskants), dry media blasting for depainting, spray gun cleaning, and control of inorganic HAP emissions from primer, topcoat, and depainting operations. The nationwide capital costs listed below represent the maximum costs that would be incurred assuming that all affected sources implemented the specific control option.

For carbon adsorbers used in conjunction with solvent-based chemical milling maskants, the nationwide capital cost is estimated to be $500 million, and for waterborne chemical milling maskants it is estimated to be $289 million. The implementation of dry media blasting systems for depainting would require a nationwide capital cost of $2.8 billion. It should be noted that other control measures exist for depainting other than dry media blasting, such as chemical strippers that do not contain organic HAPs, that require no capital investment. Selection of chemical strippers that do not contain organic HAPs by all affected sources instead of dry media blasting would decrease the total nationwide capital investment by approximately 82 percent. The control measures would also require capital costs for high transfer efficiency application equipment and spray gun cleaning equipment totalling $130 million and $10 million, respectively. The control of inorganic HAP emissions from primer and topcoat application operations would require the installation of spray booths and filter systems at a capital cost of $13 million. The control of inorganic HAP emissions from blast depainting operations would require the installation of particulate filtration systems such as baghouses at a capital cost of $54.5 million. Total nationwide capital costs range from $3.3 billion to $3.5 billion, depending on which chemical milling maskant control option is used.

TABLE 8-1

CONTROL COSTS FOR COMMERCIAL OEM[a]

Process	Total Annualized Costs		
	Small	Medium	Large
Depainting	N/A	N/A	N/A
Chemical Milling Maskant	N/A	106,680	135,540
Spray Gun Cleaning	-16,720	-22,100	-28,000
Hand-Wipe Cleaning	7,030	3,510	-9,260
Primers and Topcoats	-36,830	-67,350	-520,600
TOTAL FOR ONE FACILITY	-46,520	20,740	-422,320
NUMBER OF FACILITIES	440	20	6
TOTAL FOR ALL FACILITIES	-20,468,800	414,800	-2,533,920
TOTAL FOR COMMERCIAL REWORK	-22,587,920		

[a] Negative values represent a cost savings to the model plant.

TABLE 8-2

CONTROL COSTS FOR COMMERCIAL REWORK[a]

Process	Total Annualized Costs		
	Small	Medium	Large
Depainting	-7,200	-23,590	N/A
Chemical Milling Maskant	N/A	N/A	N/A
Spray Gun Cleaning	-16,720	-22,100	-28,000
Hand-Wipe Cleaning	7,030	3,510	-9,260
Primers and Topcoats	-36,830	-67,350	-520,600
TOTAL FOR ONE FACILITY	-53,720	-109,530	-557,860
NUMBER OF FACILITIES	404	525	0
TOTAL FOR ALL FACILITIES	-21,702,880	-57,503,250	0
TOTAL FOR COMMERCIAL REWORK	-79,206,130		

[a] Negative values represent a cost savings to the model plant.

TABLE 8-3

CONTROL COSTS FOR MILITARY OEM[a]

Process	Total Annualized Costs		
	Small	Medium	Large
Depainting	N/A	N/A	N/A
Chemical Milling Maskant	N/A	106,680	135,540
Spray Gun Cleaning	-16,720	-22,100	-28,000
Hand-Wipe Cleaning	7,030	3,510	-9,260
Primers and Topcoats	-8,680	-12,450	-90,830
TOTAL FOR ONE FACILITY	-18,370	75,640	7,450
NUMBER OF FACILITIES	332	38	7
TOTAL FOR ALL FACILITIES	-6,098,840	2,874,320	52,150
TOTAL FOR MILITARY OEM	-3,172,370		

[a] Negative values represent a cost savings to the model plant.

TABLE 8-4

CONTROL COSTS FOR MILITARY REWORK[a]

Process	Total Annualized Costs		
	Small	Medium	Large
Depainting	-7,200	-23,590	-23,590
Chemical Milling Maskant	N/A	106,680	135,540
Spray Gun Cleaning	-16,720	-22,100	-28,000
Hand-Wipe Cleaning	7,030	3,510	-9,260
Primers and Topcoats	-8,680	-12,450	-90,830
TOTAL FOR ONE FACILITY	-25,570	52,050	-16,1400
NUMBER OF FACILITIES	142	950	5
TOTAL FOR ALL FACILITIES	-3,630,940	49,447,500	-80,700
TOTAL FOR MILITARY REWORK	45,735,860		

[a] Negative values represent a cost savings to the model plant.

TABLE 8-5

SUMMARY OF CONTROL COSTS[a]

Model Plant Type	Control Costs
Commercial/OEM	-22,587,920
Commercial/Rework	-79,206,130
Military/OEM	-3,172,370
Military/Rework	45,735,860
Sub-Total	-59,230,560
Inorganics - Primers and Topcoats	2,287,380
Inorganics - Depainting	7,760,600
TOTAL	-49,182,580

[a] Negative values represent a cost savings.

9.0 ECONOMIC IMPACTS

9.1 INDUSTRY PROFILE

9.1.1 Introduction

The Clean Air Act Amendments of 1990 mandate the establishment of emission standards for major sources of hazardous air pollutants (HAPs) and the promulgation of regulations for the purpose of achieving these standards. By definition, any stationary source or group of sources that emits 10 tons or more of a hazardous air pollutant or 25 tons or more of a combination of hazardous air pollutants per year is deemed a "major source" and will be subject to regulation.

HAPs are emitted by coatings and solvents used in the aerospace industry and, as such, aerospace producers will be candidates for regulation as major sources. In an effort to evaluate the impact of the regulation on the industry, the current state of the aerospace industry must first be established. For this purpose, various market characteristics have been identified, the relevant ones being those that may exhibit some change after the regulation is promulgated.

Given the organization of aerospace production, the important supply-side variables that are likely to be affected by the potential regulation are output, employment, the number and size of establishments (economic unit),[1] profit rates, industry growth, plant and equipment expenditures, and net exports. Demand-side variables that will be affected by this potential regulation are revenue from the sale of domestically produced aerospace products and expenditures on imports of aerospace products. In the long run, the very organization of production could change.

In both the original equipment manufacture (OEM) and the repair and maintenance (rework) of aerospace products, coatings and solvents that emit HAPs are used. The associated processes include machining, cleaning, maskant application, chemical milling, assembling, bonding, surface preparation, coating application, and stripping, to name a few.[2] To the degree permitted by cost considerations and technological development, the industry will respond to regulation by adopting alternative materials (coatings and solvents), changing the methods of production, or using add-on controls.

The Standard Industrial Classification (SIC) codes that report data on original equipment manufacture in the aerospace industry are: SIC 3721, Aircraft; SIC 3724, Aircraft Engines and Engine Parts; SIC 3728, Aircraft Parts and Auxiliary Equipment, Not Elsewhere Classified (NEC); SIC 3761, Guided Missiles and Space Vehicles; SIC 3764, Guided Missiles and Space Vehicles/Propulsion Units and Propulsion Unit Parts; SIC 3769, Guided Missiles and Space Vehicle Parts and Auxiliary Equipment, NEC. SIC 4581, Airports, Flying Fields and Airport Terminal Services is also of interest in that it captures rework, but it will not be possible to separate aerospace output from the total output reported in this SIC code.

Independently owned rework establishments as well as hangars in which airlines perform rework on aircraft that they own or lease may be affected by the potential regulation.

Indirectly affected by the regulation will be establishments in SIC 2851, Paints, Varnishes, Lacquers, Enamels, and Allied Products; and in SIC 2891, Adhesives and Sealants.

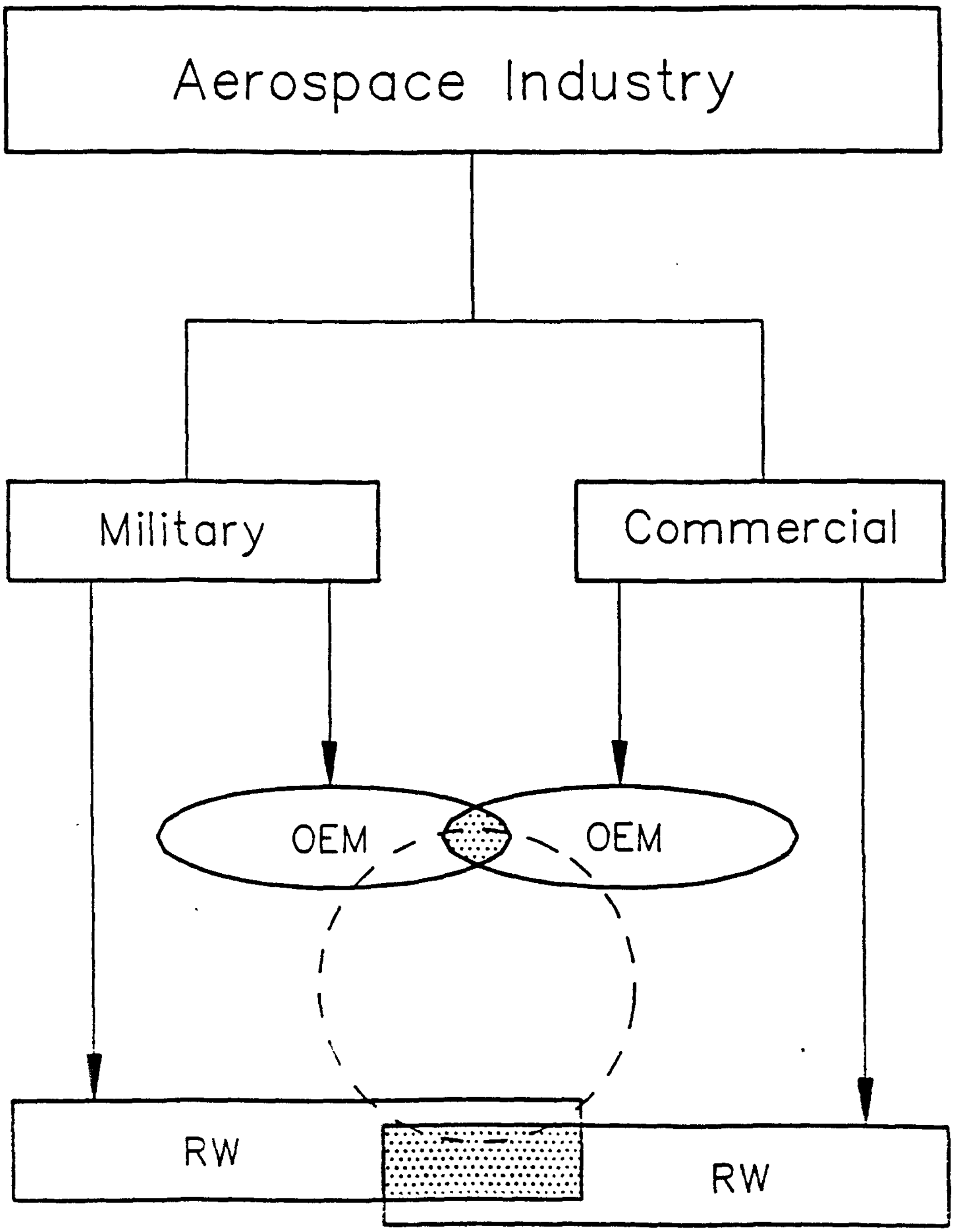
9.1.2 Industry Overview

The SIC codes that will be directly affected by the regulation are collectively referred to as the aerospace industry, represented schematically by Figure 9-1. The diagram depicts both the use of coatings and solvents and the specialization of establishments in the aerospace industry. Regarding the former, the quantities and combinations of coatings and solvents used in the industry differ according to the intended use of the product (military versus commercial) as well as the type of work being performed (original equipment manufacture versus rework). The shaded areas represent coatings and solvents common to both military and commercial products. Some coatings and solvents are common to original equipment production and to rework as indicated by the broken circle.

Establishments in the aerospace industry produce specialized output and perform specialized tasks. Broadly, some establishments produce original equipment exclusively for military purposes and others produce for commercial purposes. A few establishments serve both the commercial and the military segments of the market as indicated by the intersection of the ellipses in Figure 9-1. Similarly, there are establishments that engage exclusively in rework either on military or commercial equipment or both. Finally, a certain amount of "in factory" rework is done by OEMs on their own equipment.

The demand for aerospace products is derived from the demand for final goods such as air travel (business and leisure), defense,

Figure 9-1



OEM — Original Equipment Manufactures

RW — Rework

information, and national security. As such, the demand for any aerospace product is a function of its own price, the prices of substitutes, the prices of the final goods, and national income. The demand for rework on aerospace products is additionally a function of the age and intensity of usage of the existing products as well as the cost of rework. As the stock of durable original equipment increases, the demand for rework will increase, given the costliness and length of time required to produce aerospace products.

Table 9-1 gives an indication of the various products of the industry, their end uses, and major original equipment manufacturers. It makes clear both the variety of the products in the industry as well as the specialization of producers.

Manufacturing and assembling of complete units in the aerospace industry take place in a complex manner. This process involves prime contractors and several tiers of subcontractors:

- Prime Contractors — Design (develop) and assemble or manufacture complete units.
- 1st Tier Subcontractors — Do major assembly and/or manufacture of sections of air/space craft without designing or assembling complete units.
- 2nd Tier Subcontractors — Make various subassemblies and sections.
- 3rd Tier Subcontractors — Produce machined components and sub-assemblies.
- 4th Tier Subcontractors — Specialize in the production of particular components and in specific processes.

Corresponding to the designation "prime contractor" are the SIC codes 3721, 3724, 3761, and 3764. Both first and second tier

TABLE 9-1

PRODUCTS AND SELECTED MANUFACTURERS
IN THE U.S. AEROSPACE INDUSTRY

Product	Manufacturer/Developer
SIC 3721 Aircraft	
Military Aircraft	
Attack	McDonnell Douglas LTV Aircraft
Bombers	Boeing
Electronic Warfare	Grumman Aerospace
Fighters	McDonnell Douglas Northrop Grumman Aerospace
Reconnaissance	Lockheed
Observation	RI/NAA
Patrol ASW	Lockheed
Antisubmarine	Lockheed
Early Warning	Boeing
Cargo/Transport/ Refueling	Lockheed Aeronautical Systems Co. McDonnell Douglas
Training	RI/Colombus Beech Aircraft Corp.
Utility	Beech Aircraft Corp.
Research/Test Bed	Boeing
Helicopters	Bell Helicopter Textron Boeing Helicopter McDonnell Douglas Helicopter Co. Sikorsky Aircraft United Technologies Corp.
Commercial Passenger Aircraft	Beech Aircraft Corp. Boeing Fairchild Aircraft Corp. Lockheed Aeronautical Systems Co. McDonnell Douglas

TABLE 9-1 (CONTINUED)

Product	Manufacturer/Developer
SIC 3721 Aircraft (Cont.)	
Turbine Powered Business Aircraft	Beech Aircraft Corp. Cessna Aircraft Co. Learjet Inc.
General Aviation Aircraft	Beech Aircraft Corp. Maula Air, Inc. Piper Aircraft Corp. Taylor Aircraft Corp.
SIC 3724, Aircraft Engines Gas Turbine Engines	Allied-Signal Garrett Engine Div. General Electric Co. General Electric Aircraft Engines General Motors Allison Gas Turbine Div. Teledyne CAE Textron Lycoming Stratford Div. United Technologies Pratt & Whitney Williams Int. Corp.
Reciprocating Engines	Textron Lycoming Teledyne Continental Motors
SIC 3761 Guided Missiles and Space Craft	
Missiles	
Air-to-Air	Hughes/Raytheon Loral/Raytheon
Air-to-Surface	Hughes
Surface-to-Air	Ford Aerospace General Dynamics/Pomona
Surface-to-Surface	AFLC Hill Air Force Base Lockheed MSC

TABLE 9-1 (CONTINUED)

Product	Manufacturer/Developer
SIC 3761 Guided Missiles and Space Craft (Cont.)	
Spacecraft	Rockwell International Martin Marietta General Electric/Goddard S.F.C. Hughes General Electric TRW Lockheed
SIC 3764 Propulsion Units	
Basic Vehicles	Martin Marietta General Dynamics/Space Systems McDonnell Douglas
Upper Stages	General Dynamics/Space Systems Boeing Orbital Sciences

Source: Aviation Week and Space Technology, March 16, 1992 pp. 94-115.

subcontractors correspond to SICs 3728 and 3769. Third tier subcontractors are included in SIC 3599, as are fourth tier subcontractors who may be regarded as subcontractors to the third tier subcontractors.

With these different layers of subcontracting, the industry cannot be described as comprising vertically integrated firms. Even the production of components of complete units, though classified as distinct SIC codes, involves a sufficient degree of subcontracting to preclude the economies associated with vertical integration. Such subcontracting allows firms to specialize in order to meet the high precision requirements of the industry.

9.1.3 Original Equipment Manufacture

9.1.3.1 Market Structure. Table 9-2 shows that in 1988 there were 1,762 OEM establishments in the aerospace industry. Of these, 453 were engaged in the manufacture of aircraft engines and engine parts (SIC 3724), and 1013 were engaged in the manufacture of aircraft parts and auxiliary equipment (SIC 3728). Therefore, 83.2 percent of all the OEM establishments in the aerospace industry were engaged in production at these two SIC levels.

Additionally, Table 9-2 also shows the number of companies by SIC code. It indicates that, not only were establishments concentrated in SICs 3724 and 3728, as discussed in the preceding paragraph, but that production took place, to a large extent, in independently owned establishments (i.e., single-establishment companies). (This will prove to be an important consideration in the Economic Impact Analysis, Section 9.2.)

TABLE 9-2

DISTRIBUTION OF ESTABLISHMENTS IN THE U.S. AEROSPACE INDUSTRY
BY EMPLOYMENT SIZE, 1987

SIC	Industry	Total Number of Companies	Total Number of Establishments	Distribution of Establishments by Employment Size		
				1-999	1,000-9,999	10,000+
3721	Aircraft	137	155	130	15	10
3724	Aircraft Engines and Parts	372	453	431	20	2
3728	Aircraft Parts & Auxiliary Equipment, NEC	924	1,013	986	24	3
3761	Guided Missiles & Space Vehicles	19	40	11	26	3
3764	Guided Missiles, Space Vehicle Propulsion Units, & Propulsion Unit Parts	27	35	28	7	0
3769	Guided Missiles, Space Vehicle Parts, & Auxiliary Equipment, NEC	61	66	64	2	0
	TOTAL	1,540	1,762	1,650	94	18

Source: U.S. Dept. of Commerce, Bureau of the Census, Census of Manufactures, 1987, Table 4 pp. 13-14; Special Tabulation of Table 4.

Moreover, there is much less vertical integration in the production of aircraft than in the production of guided missiles and space vehicles: only 9.6 percent of all the establishments that engage in aircraft production (SIC 372) manufacture or assemble complete aircraft (SIC 3721), compared with 28.4 percent of the establishments in SIC 376 that manufacture complete guided missiles and space vehicles (SIC 3761). Differences in economies of scale may explain this observation.

In 1988, most of the establishments in the aerospace industry were small, employing less than 1,000 production workers. For this period, about 95.4 percent of all the establishments involved in aircraft production (SIC 372) and 73.0 percent of the establishments engaged in the production of missiles and space vehicles (SIC 376) were small. Thirteen percent of the large establishments, defined as those that employ 10,000 persons or more, manufactured aircraft engines and engine parts (SIC 3724), 20 percent specialized in aircraft parts and auxiliary equipment (SIC 3728), and 67 percent engaged in the manufacture or assembly of complete aircraft. In comparison, all of the large establishments in SIC 376 produced complete units (SIC 3761). It is reasonable to infer then, that there are greater economies (or less diseconomies) of scale associated with the manufacture of missiles and spacecraft than the manufacture of aircraft.

Table 9-3 presents, for each SIC Code, the distribution of revenue by employment-size class. While 93.6 percent of all establishments are small (as calculated from Table 9-2), it can be seen from Table 9-3 that, for each SIC code, revenue is concentrated in large facilities and

TABLE 9-3

DISTRIBUTION OF REVENUE GENERATED IN THE U.S. AEROSPACE INDUSTRY BY EMPLOYMENT SIZE CLASS OF ESTABLISHMENTS IN EACH SIC, 1987

SIC Code	Industry	Total Revenue 10^6 Dollars	Distribution of Revenue By Employment-Size Class (10^6 Dollars)			Percent of Total Revenue		
			1-999	1,000-9,999	10,000+	1-999	1,000-9,999	10,000+
3721	Aircraft	39,092.6	1,229.6	7,090.1	30,772.8	3.1	18.2	78.7
3724	Aircraft Engines and Engine Parts	20,262.1	4,836.2	15,425.9	(D)[1]	23.9	-	-
3728	Aircraft Parts and Equipment, NEC	17,923.4	5,855	6,151.6	5,916.7	32.7	34.3	33.0
3761	Guided Missiles and Space Vehicles	21,565.8	107.3	12,664.7	8,793.7	0.5	58.7	40.8
3764	Space Propulsion Units & Parts	3,537.1	637.4	2,899.7	0	18.0	82.0	0.0
3769	Space Vehicle Equipment, NEC	1,182.2	1,182.2	(D)[1]	0	100	-	-

[1] (D) indicates that data are included in the data of the previous employment-size class.

Source: U.S. Dept. of Commerce, Bureau of the Census, Census of Manufactures, 1987 Table 4, pp. 13-14.

medium facilities, the latter employing between 1,000 and 9,999 persons. This is especially the case for SICs 3721 and 3761 because small, medium, and large establishments belonging to the same SIC code engage in different activities, with the small establishments engaging in activities that contribute the least "value-added." In SIC 3721, for example, there are establishments of different sizes that manufacture or assemble complete aircraft; modify, convert, or overhaul previously accepted aircraft; engage in research and development; and provide aeronautical services on complete aircraft. These establishments will therefore contribute different amounts of value added to the product, with activities (such as research and development) that generate the least value added tending to employ less than 1000 production workers. Likewise, the preponderance of small establishments in SIC 3761 is associated with a concentration of revenue in the few large establishments because the small establishments engage in research and development while the large establishments also manufacture complete missiles and spacecraft.[3]

It can be seen from Table 9-3 that total aerospace revenue was $103.6 billion in 1987, the various product groups having the following shares:

SIC 3721 Aircraft - 37.7 percent

SIC 3724 Aircraft Engines and Engine Parts - 19.6 percent

SIC 3728 Aircraft Parts and Equipment, NEC - 17.3 percent

SIC 3761 Guided Missiles and Space Vehicles - 20.8 percent

SIC 3764 Space Propulsion Units and Parts - 3.4 percent

SIC 3769 Space Vehicle Equipment, NEC - 1.1 percent

Military production has historically been more significant than commercial production, accounting for an average of 60.6 percent of the output of the aerospace industry over the period 1986 to 1990.[4] With the U.S. Federal Government as the main customer in the military segment of the aerospace market, purchasing a typical 92.3 percent of the military output of the industry in 1990,[5] the health of the aerospace industry is very sensitive to changes in the Federal defense budget.

Table 9-4 indicates that real Federal spending on aerospace products and services began to decline in 1988. The increase in NASA's spending over the period 1978 to 1990 suggests that the military sector of the aerospace industry could look to the production of space vehicles as a potential source of growth, thereby attenuating the decline in the Department of Defense (DOD) budget.

In the commercial segment of the market, 9.2 percent of non-military output was purchased by the U.S. Federal Government while 90.8 percent was purchased by other customers such as airlines and businesses, both foreign and domestic.[6]

At the end-product stage (SICs 3721 and 3761), both the commercial and the military segments of the market are characterized by highly differentiated products each of which can be regarded as unique. Because other products in the "product group" are close substitutes, however, producers enjoy only limited monopoly power in these markets. Limited though the monopoly power may be, it allows each firm to behave as if other firms will not react to changes in its pricing (or other) behavior. This, together with the fact that any producer may affect

TABLE 9-4

FEDERAL OUTLAYS ON DEFENSE, NASA, AND AEROSPACE PRODUCTS AND SERVICES[a]

Fiscal Years 1978 to 1990

Year	Total National Defense (10^6 1987 Dollars)	Total NASA (10^6 1987 Dollars)	Federal Outlays for Aerospace Products & Services: Total (10^6 1987 Dollars)	Federal Outlays for Aerospace Products & Services: DOD (10^6 1987 Dollars)	Federal Outlays for Aerospace Products & Services: Total NASA (10^6 1987 Dollars)	Aerospace as a Percent of Total National Defense and NASA
1978	178,167	6,791	23,744	17,165	6,580	12.8%
1979	179,429	6,473	25,734	19,466	6,268	13.8
1980	186,052	6,737	28,144	21,602	6,541	14.6
1981	194,269	6,686	29,941	23,436	6,505	14.9
1982	206,611	6,729	32,892	26,285	6,607	15.4
1983	223,111	7,083	37,589	30,621	6,969	16.3
1984	223,222	6,918	38,931	32,119	6,812	16.9
1985	252,748	7,318	44,483	37,335	7,148	17.1
1986	272,150	7,371	49,550	42,367	7,183	17.7
1987	281,999	7,591	51,871	44,429	7,442	17.9
1988	285,507	8,940	48,031	39,255	8,777	16.3
1989	283,012	10,304	49,350	39,224	10,126	16.8
1990	268,290	11,140	47,685	36,741	10,944	17.1

[a] Deflated by the "Composite Price Deflator for the Aerospace Industry," Aerospace Industries Association (AIA) 1991-1992, Aerospace Facts and Figures.

Source: Aerospace Industries Association, Aerospace Facts and Figures 1991-1992.

NOTE: "National Defense" includes the military budget of the Department of Defense and other defense related activities. "Total NASA" includes all categories of the NASA budget; NASA construction is not included in "Aerospace Products and Services."

price — there being few producers — is sufficient to render price indeterminate in the market. Such is the consequence of oligopoly, the market structure characterized by few producers selling differentiated, though not distinct, products.

On the demand side, the commercial and military segments are significantly different. There are many customers in the commercial segment, including airlines and businesses, while there is for all practical purposes only one customer in the military segment, namely the Federal Government. One buyer or monopsony in the military segment suggests greater bargaining power, making it easier for the Federal Government to get favorable terms. During the 1980s, for example, the DOD had a marked preference for fixed price contracts with the consequence that military aircraft producers had to bear all cost increases, some suffering substantial losses.

The markets for other products (i.e., those in SICs 3724, 3728, 3764, 3769, 3599) are rather more difficult to characterize. At each stage there are many sellers and buyers, the latter being the producers of complete aircraft, guided missiles, and space vehicles (SICs 3721 and 3761). Producers in SICs 3721 and 3761 award contracts to parts producers in SICs 3728 and 3769 as well as to producers in SIC 3599 who perform tasks such as coating and machining, all of which are inputs in the production of complete units. Commercial airlines and the DOD purchase engines and propulsion units from producers in SICs 3724 and 3764.

9.1.3.2 Production. Table 9-5 presents data on the physical output of civilian and military aircraft. Though not shown in the

TABLE 9-5

SHIPMENTS OF COMPLETE U.S. AIRCRAFT 1978-1992
(VALUES IN 10^6 1987 DOLLARS)

Year	Total Aircraft		Civilian Aircraft		Military Aircraft	
	Units	Value	Units	Value	Units	Value
1978	19,958	10,177	18,962	6,458	996	3,719
1979	19,297	15,074	18,460	10,644	837	4,430
1980	14,681	18,950	13,634	13,058	1,047	5,892
1981	11,978	20,093	10,916	13,223	1,062	6,870
1982	6,244	19,257	5,085	8,610	1,159	10,647
1983	4,409	22,519	3,356	9,773	1,053	12,746
1984	3,935	21,933	2,999	7,717	936	14,216
1985	3,610	28,386	2,691	10,385	919	18,001
1986	3,258	34,809	2,151	11,857	1,107	22,952
1987	3,010	35,925	1,800	12,148	1,210	23,777
1988	3,254	34,875	1,949	15,858	1,305	19,020
1989	3,675	34,229	2,448	17,129	1,227	17,100
1990	3,418	41,920	2,268	24,476	1,150	17,444
1991	3,244	44,273	2,239	28,226	1,005	16,047
1992	3,132	43,989	2,262	28,928	870	15,063

Source: U.S. Dept. of Commerce, International Trade Administration, U.S. Industrial Outlook, 1992, Table 3, p. 21-6.

table, the number of units of general aviation aircraft and rotorcraft fell dramatically over the period 1978 to 1991 while the overall number of units of large transport aircraft increased over the same period. There was no obvious trend in the number of units of military aircraft produced. Since the size and performance of aircraft change with changes in specifications, very little can be concluded from these data about the state of the industry. The data do show that the industry is quite dynamic, with new products being constantly developed to increase technical efficiency and to meet changes in demand.[7]

The discussion of production will henceforth focus on the value of production because the heterogeneity of the output of the aerospace industry makes it difficult to analyze physical output. Annual production shall be taken to be the value of shipments or sales, measured in constant (1987) dollars.

Table 9-6 presents data on new orders, shipments, backlog, and inventories for the entire aerospace industry. (Depending on the product, the length of lag between the placement of orders and the production of complete units can range from 1 to 5 years.) After reaching an all time high of $151.8 billion in 1989, net new orders fell to $130.6 billion in 1990. This dramatic fall in net new orders led to a decrease in the rate of growth of the industry's backlog of orders, given a fairly constant rate of growth of shipments. When current dollars are used, the following identity holds by definition:

$$\text{Backlog}_t - \text{Backlog}_{t-1} = \text{Net New Orders}_t - \text{Net Sales}_t$$

The subscripts indicate different time periods. Industry backlog, that stood at $216.6 billion in 1990, continues to grow, suggesting that

TABLE 9-6

ORDERS, SHIPMENTS, BACKLOG, AND INVENTORIES OF AIRCRAFT, MISSILES, SPACE VEHICLES, AND PARTS, 1978 TO 1990[a]

Year	New Orders (10^6 1987 Dollars)	Shipments (10^6 1987 Dollars)	Backlog (10^6 1987 Dollars)	Inventories (10^6 1987 Dollars)
1978	93,095	63,855	93,761	19,090
1979	104,593	74,459	114,944	22,013
1980	100,686	81,204	122,967	27,359
1981	78,355	79,967	107,615	29,243
1982	81,798	74,061	105,022	31,333
1983	92,423	79,684	112,860	31,504
1984	89,929	77,675	116,474	32,446
1985	100,889	91,337	128,216	36,588
1986	107,509	101,376	133,775	38,277
1987	114,835	103,590	145,622	39,155
1988	134,610	105,945	171,853	42,945
1989	151,785	106,239	208,491	47,760
1990	130,678	114,517	216,598	50,562

[a] Deflated by the "Composite Price Deflator for the Aerospace Industry," Aerospace Industries Association, Aerospace Facts and Figures 1991-1992.

Source: U.S. Dept. of Commerce, Bureau of the Census, "Manufacturers Shipments, Inventories, and Orders" Series M3-1 (Monthly).

production levels can be maintained at least in the short run though the demand for aerospace products is declining.

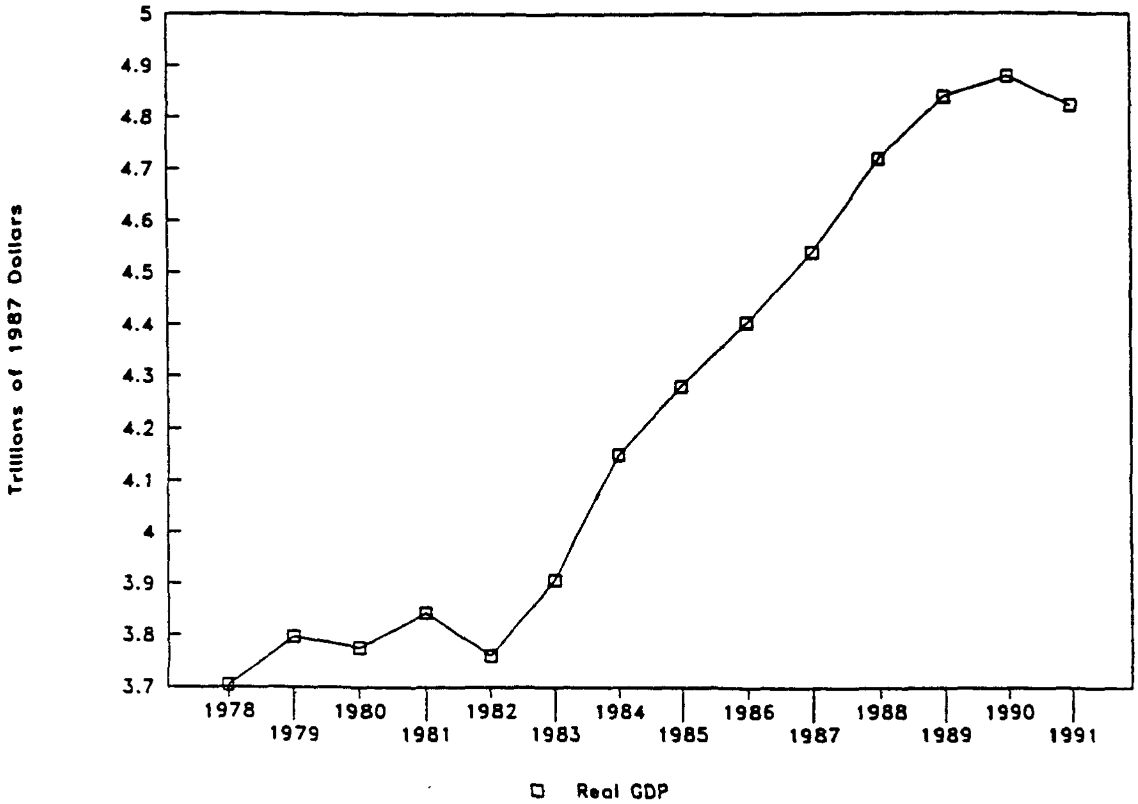
Since the industry produces to order, it does not keep inventories of complete aircraft, spacecraft, aircraft engines, or spacecraft propulsion units. Inventories may be interpreted as work, performed under a fixed price contract, that is yet "in progress."[8] (Work done on a cost plus contract is reported as a shipment and reflects the cost incurred plus a portion of the profits for the contract during the year.)

Figure 9-2 suggests a rough correlation between total aerospace production and real gross domestic product (GDP). Given the cost of aerospace products and the uncertainty about future real GDP, it is not surprising that the rate of increase in production exhibited more variation than did the rate of growth of real GDP.

Table 9-7, which gives production as the value of shipments in 1987 constant dollars, shows that aircraft production contributed an average of 37 percent of total aerospace output, ranging from 35.6 percent in 1984 to 37.4 percent in 1992, as calculated from Table 9-6. In 1990, the combined production of aircraft, engines, and parts set a record high.

In Figure 9-3, the annual percentage change in real shipments (i.e., production), measured in 1987 dollars, is presented for each SIC code. Particularly noticeable is that, while total shipments of aircraft grew over the period 1984 to 1990 as shown in Table 9-6, the rate of growth of aircraft production declined almost consistently since 1985, even becoming negative in 1989. Though the growth rate of

Figure 9-2. The Relationship Between RGDP and Aerospace Production



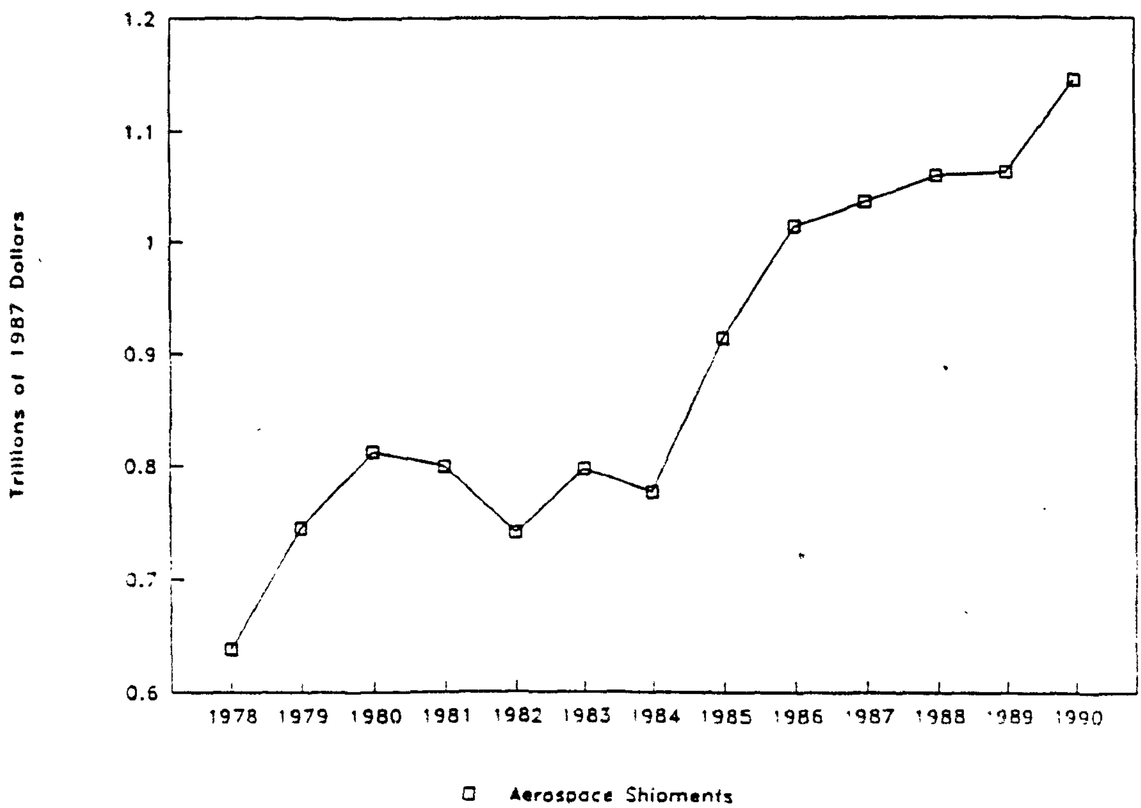


TABLE 9-7

TOTAL SHIPMENTS IN THE U.S. AEROSPACE INDUSTRY, 1984 - 1992[a]
(10^6 1987 DOLLARS)

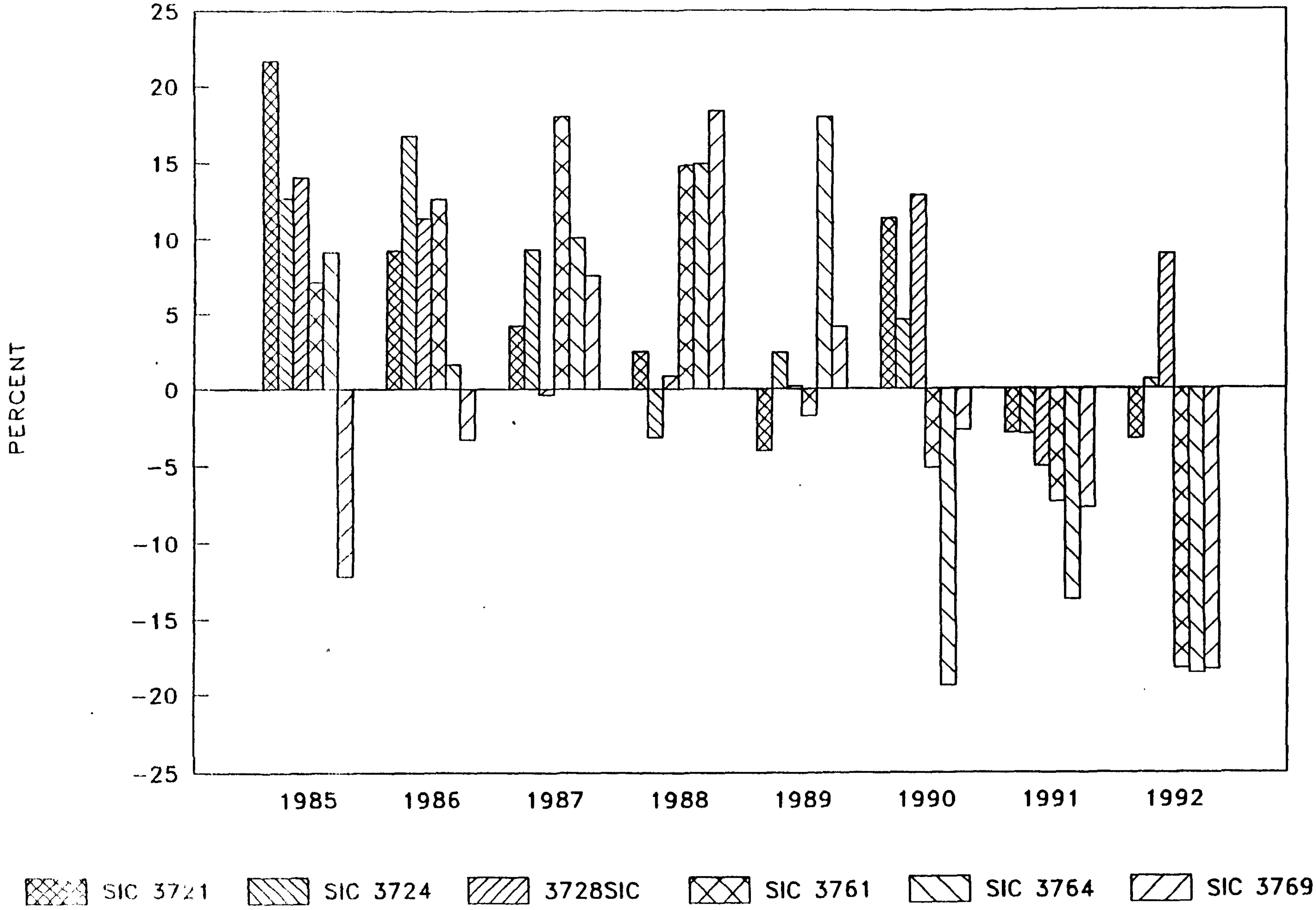
SIC	1984	1985	1986	1987	1988	1989	1990	1991[b]	1992[c]
3721	24,517	31,289	34,471	36,003	36,937	35,513	40,037	38,906	37,681
3724	12,408	14,209	17,074	18,822	18,245	18,704	19,607	19,047	19,162
3728	14,946	17,386	19,606	19,529	19,698	19,738	22,651	21,563	23,677
3761	10,654	14,470	13,130	16,012	18,786	18,465	17,562	16,363	13,835
3764	2,786	3,067	3,117	3,465	4,073	4,964	4,157	3,655	3,082
3769	3,594	3,204	3,101	3,354	4,110	4,287	4,175	3,876	3,275

[a] Product Data
[b] Estimate
[c] Forecast

Source: U.S. Department of Commerce, U.S. Industrial Outlook, 1992.

Figure 9-3. Production Growth Rates

U.S. Aerospace Industry, 1985-1992



production picked up in 1990, it is expected that this industry will experience negative growth rates in production in the ensuing years.

Capacity utilization rates are summarized in Table 9-8. In 1990, capacity utilization fell in all SIC codes except SIC 3724 and SIC 3769. The entire aerospace industry utilized an average of 70.8 percent of full capacity in 1990 with the aircraft industry using only 63 percent, a dramatic decline from the 80 percent capacity utilization rate of 1989. This decline may be partially accounted for by recessionary factors.

In conclusion, 1990 was an important year for the aircraft industry, both because it saw the industry outperforming any other in the aerospace industry and particularly because 1990 marked a watershed in the demand for military aircraft.

9.1.3.3 Employment. There are various measures of employment in the aerospace industry. Total employment includes administrative workers as well as production workers. A more accurate representation of employment is given by the number of labor hours devoted to administration and production but an analysis of the data showed a close relationship between the number of labor hours and the number of production workers. Table 9-9 presents data on the number of production workers in each SIC code for the period 1987 to 1992.

Figure 9-4 shows production workers employed in each SIC code as a percent of all the production workers in the aerospace industry. Over the period 1978 to 1992, SIC 372, Aircraft, Engines, and Parts employed approximately 80 percent of all the production workers in the industry.

TABLE 9-8

CAPACITY UTILIZATION RATES, U.S. AEROSPACE INDUSTRY, 1989, 1990

SIC	Industry	1989 (%)	1990 (%)
3721	Aircraft	80	63
3724	Aircraft Engines and Engine Parts	78	80
3728	Aircraft Parts and Equipment, NEC	86	82
3761	Guided Missiles and Space Vehicles	71	70
3764	Space Propulsion Units and Parts	74	71
3769	Space Vehicle Equipment, NEC	57	59

Source: U.S. Dept. of Commerce, Bureau of the Census Current Industrial Reports, "Survey of Plant Capacity, 1990," Table 1, p. 9.

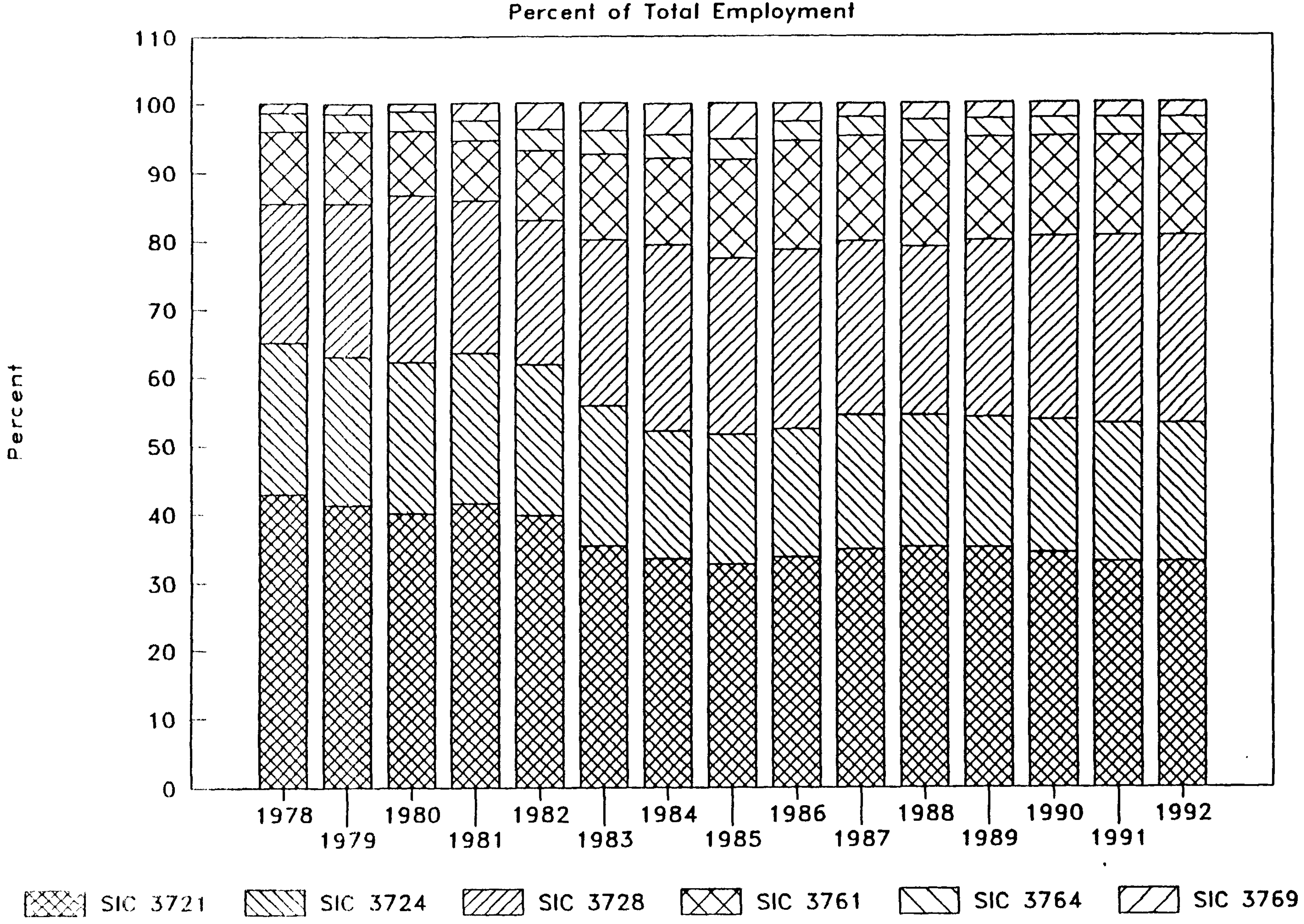
TABLE 9-9

EMPLOYMENT IN THE AEROSPACE INDUSTRY
(THOUSANDS OF EMPLOYEES)

SIC	1987	1988	1989	1990	1991	1992
3721						
Total Employment	268.0	274.0	278.0	273.0	244.0	242.0
Production Workers	142.0	140.0	140.0	136.0	120.0	119.0
3724						
Total Employment	140.0	141.0	132.0	130.0	123.0	122.0
Production Workers	79.8	76.8	76.2	76.4	73.1	72.4
3728						
Total Employment	188.0	181.0	193.0	196.0	182.0	180.0
Production Workers	104.0	98.3	103.0	106.0	99.7	98.7
3761						
Total Employment	167.0	169.0	173.0	168.0	156.0	154.0
Production Workers	62.7	61.3	60.1	57.8	53.0	52.5
3764						
Total Employment	31.8	35.3	30.0	29.1	27.1	26.8
Production Workers	11.2	12.6	10.6	10.2	9.4	9.3
3769						
Total Employment	15.1	19.4	18.4	17.8	16.6	16.4
Production Workers	7.9	9.5	9.1	8.7	8.0	7.9

Source: U.S. Department of Commerce, U.S. Industrial Outlook, various issues.

Figure 9-4. Production Workers By SIC



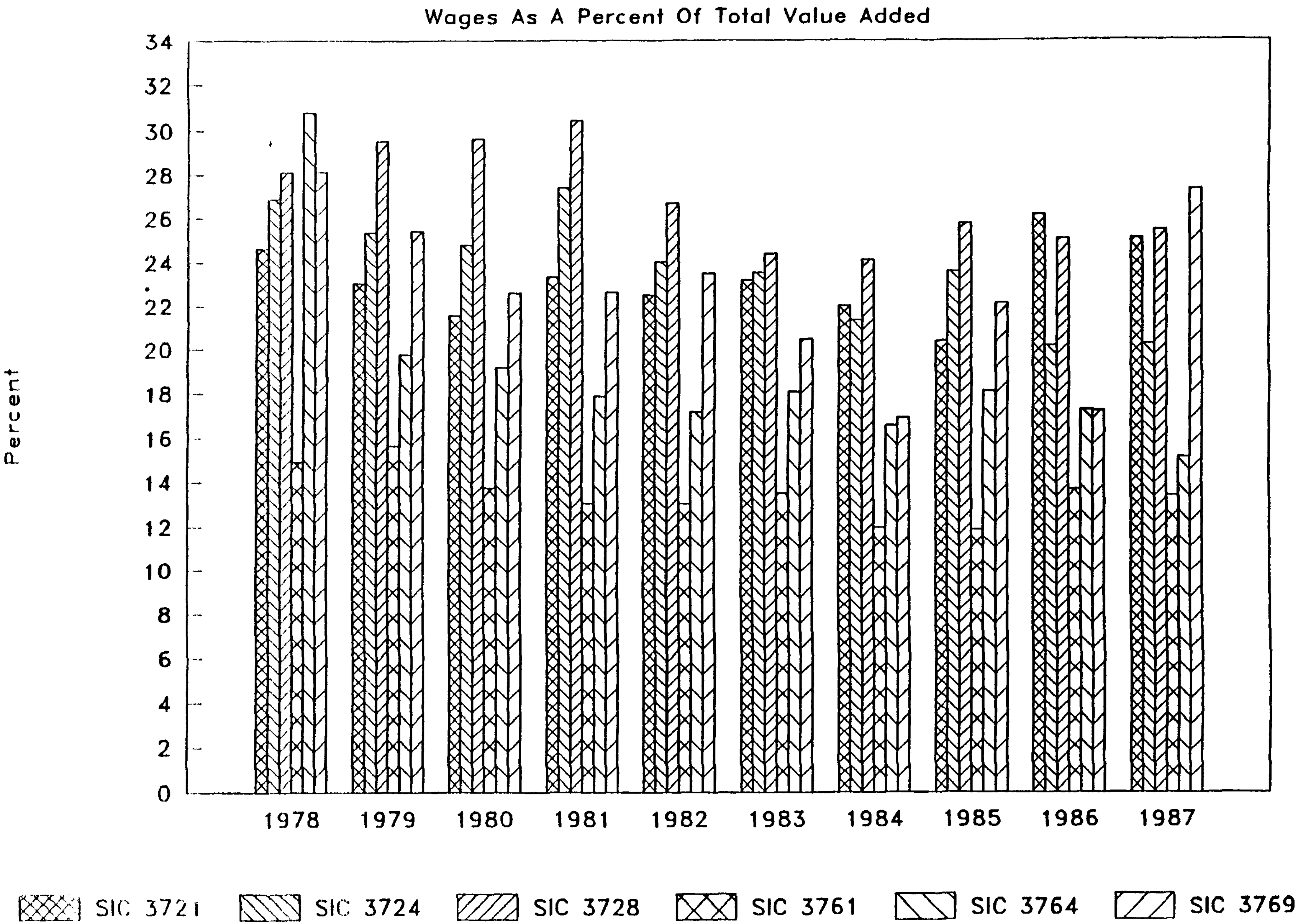
Production workers contributed 73.8 percent of the value added reported by facilities in SIC 372 and 53.8 percent of the value added reported by facilities in SIC 376, implying that labor is relatively more important in aircraft production compared with the production of guided missiles and space vehicles.

Figure 9-5[9] indicates that, over the period 1978 to 1987, production workers contributed more (as measured by their wages) to the value added of parts production than to the value added of either final assembly or engine/propulsion manufacture in both SIC 372 and SIC 376. This implies that SICs 3738 and 3769 are relatively labor intensive.

9.1.3.4 Demand/Consumption. In Section 9.1.3.2, production was taken to be shipments, measured in constant dollars. In the absence of inventories, annual consumption can likewise be taken to be annual shipments. Demand, the amount that domestic and foreign customers are willing and able to purchase at a given price, over a given period of time, is better given by net new orders that is the sum of shipments plus the change in the backlog of orders created by new orders and the cancellation of old orders.[10]

The demand for military aircraft derives, as noted earlier, from the demand for national defense, while the demand for commercial aircraft derives mainly from the demand for air travel, both business and leisure. While the commercial sector is increasing its use of space vehicles as technological advances enhance the applicability of these products and makes them more commercially viable, it can be reasonably though not accurately assumed that most of the demand for space vehicles derives from the demand for national security, a significant part of

Figure 9–5. Value Added By Labor



which is national defense. Naturally, the demand for missiles originates in the military sector.

In 1987, the military sector consumed approximately 60 percent of the output of the aircraft industry as measured by the value of shipments and 67 percent as measured by the number of units shipped. This reflected the significant shift in demand, over the period 1986 to 1990, from the military sector to the commercial sector. Net new orders increased from $110.3 billion (1987 dollars) in 1986 to $132.1 billion in 1990. This 19.8 percent increase in demand was made up of a 26.9 percent fall in demand in the military sector and a 100.2 percent increase in demand in the commercial sector.[11,12]

Apparent consumption in the aerospace industry is given by the following:

Consumption = Value of product shipments - Exports + Imports.

Table 9-10 reports apparent consumption data for the years 1987 to 1990. As can be seen, the U.S. imports only about 10 percent of the aircraft it uses while imports of missiles and spacecraft are negligible. Such a conclusion is easily challenged if it can be shown that, even though imports of complete aircraft, missiles, and space vehicles are insignificant, imports of components are significant.

Table 9-11 presents data on the value added by imports of engines and parts to aircraft and the value added by propulsion units and parts to guided missiles and space vehicles. It is apparent that imports constitute a relatively insignificant part of the complete units at SIC 3761, Guided Missiles and Space Vehicles. This is not surprising since very few military products are imported, given the need for a high level

TABLE 9-10

APPARENT CONSUMPTION OF AEROSPACE PRODUCTS, 1987-1990 (10^6 1987 DOLLARS)

SIC	Item	1987	1988	1989	1990
3721	Aircraft	27,082.06	27,550.6[b]	26,102	26,144.1
	(% Imported)[a]	(8.1)	(9.7)	(10.0)	(9.7)
3761	Guided Missiles & Space Vehicles	15,706.8	14,999.9	15,532.3	14,558.8
	(% Imported)[a]	(0.3)	(2.5)	(0.04)	(0.03)

[a] Import data are deflated by the "Composite Price Deflator for the Aerospace Industry," Aerospace Industries Association, Aerospace Facts and Figures, and expressed as a percent of "Apparent Consumption."

[b] Trade data are taken from the 1990 U.S. Industrial Outlook.

Source: U.S. Department of Commerce, U.S. Industrial Outlook, 1992, 1990.

TABLE 9-11

PERCENT VALUE ADDED BY IMPORTS TO INTERMEDIATE PRODUCTS AND COMPLETE UNITS OF THE U.S. AEROSPACE INDUSTRY, 1989-1991

Code	Industry	1989	1990	1991
3724	Aircraft Engines and Engine Parts	10.1	10.6	11.0
3728	Aircraft Parts and Equipment, NEC	7.4	7.7	8.5
% Value Added to Complete Aircraft by Imports of Engines and Parts		17.5	18.3	19.5
3761	Space Propulsion Units and Parts	0.02	0.03	0.06
3769	Space Vehicle Equipment, NEC	0.6	0.47	0.48
% Value Added to Complete Missiles and Space Vehicles by Imports of Propulsion Units and Parts		0.62	0.5	0.54

Source: Calculated from the U.S. Dept. of Commerce, U.S. Industrial Outlook, 1992.

of security in military production. (It is being assumed that most of the output classified under SIC 376 is produced for military purposes.)

In contrast, an average of 18.4 percent of the value of complete aircraft consisted of imported engines and parts. It is not implausible therefore, to envisage domestic producers purchasing more imported engines and parts after an increase in the cost of producing technologically comparable aerospace equipment.

9.1.3.5 Profitability. Compared with other manufacturing companies, the aerospace industry is characterized by relatively narrow profit margins (return on sales) and erratic profit fluctuations.[13] Table 9-12 shows that, for the past three decades, profit margins have been consistently below the average for all manufacturing companies.

In 1991, net profit margins fell to 3.3 percent, down from 3.4 percent in 1990. It is apparent from the table that the return on assets is also less than the average for manufacturing companies. The noteworthy difference is that the return on equity has generally been higher than the average for manufacturing companies.

In accounting for the relatively low net return on sales and assets as against the relatively high return on equity, it will be recalled that the aerospace industry has experienced low capacity utilization rates. Furthermore, in the realm of producing on an order basis, there is little scope for increasing sales through advertisement. The profitability of the industry is therefore quite sensitive to the profitability of customers' orders as well as budget decisions of the Office of Management and Budget.

TABLE 9-12

NET PROFIT AFTER TAXES, U.S. AEROSPACE INDUSTRY, 1976-1991

Year	Millions of Dollars	Aerospace Industry Profits As a Percent of:			All Manufacturing Corporations Profits As a Percent of:		
		Sales	Assets	Equity	Sales	Assets	Equity
1976	$1,091	3.4%	4.7%	12.8%	5.4%	7.5%	14.0%
1977	1,427	4.2	5.7	14.9	5.3	7.6	14.2
1978	1,816	4.4	5.5	15.7	5.4	7.8	15.0
1979	2,614	5.0	6.3	18.4	5.7	8.4	16.5
1980	2,588	4.3	5.2	16.0	4.8	6.9	13.9
1981	2,966	4.4	5.2	16.0	4.7	6.7	13.6
1982	2,193	3.3	3.7	12.0	3.5	4.5	9.2
1983	2,829	3.5	4.1	12.1	4.1	5.1	10.5
1984	3,639	4.1	4.7	14.1	4.6	6.0	12.5
1985	3,274	3.1	3.6	11.1	3.8	4.6	10.1
1986	3,093	2.8	3.1	9.4	3.7	4.2	9.5
1987	4,582	4.1	4.4	14.6	4.9	5.6	12.8
1988	4,883	4.3	4.4	14.9	6.0	6.9	16.2
1989	3,866	3.3	3.3	10.7	5.0	5.6	13.7
1990	4,487	3.4	3.4	11.5	4.0	4.3	10.7
1991	4,642	3.3	3.4	11.2	3.4	3.6	8.2

Source: Aerospace Industries Association.

Firms in the aerospace industry are now responding to the decline in profit rates and profit levels by diversifying. This is to be expected in an industry that employs highly skilled workers.

9.1.3.6 Foreign Trade and International Competitiveness. This section also focuses on the OEM segment of the market. The trade balance, calculated from Tables 9-13a and 9-13b, increased from $16.5 to $41.7 billion (1987 dollars) over the period 1988 to 1991. Moreover, 1990 was the sixth consecutive year of rising trade surpluses. Aerospace exports amounted to 9.9 percent of all U.S. merchandise exports in 1990, thereby offsetting trade deficits in other sectors of the economy and confirming the importance of the industry to the health of the economy.

An analysis of Table 9-13a reveals that aircraft exports constituted approximately 51 percent of all aerospace exports over the period 1988 to 1991, growing annually at an average rate of 17.5 percent. Not surprisingly, exports of civilian aircraft dominated exports of military aircraft.

While imports are relatively insignificant, it is apparent that the volume of imports has been growing at an increasing rate, especially in the products categorized in SIC 3724, Aircraft Engines and Engine Parts and SIC 3728, Aircraft Parts and Equipment, NEC. Imports of aircraft engines and parts constituted an average of 70.7 percent of total imports for the period 1988 to 1991 (calculated from Table 9-13b). It will be recalled from the discussion of domestic consumption that imports of complete aircraft, including the value added by imported parts was approximately 9.9 percent of total consumption for the period

TABLE 9-13a

U.S. EXPORTS OF AEROSPACE VEHICLES AND EQUIPMENT, 1988-91
(VALUES[a] IN 10^6 1987 DOLLARS)

Items	1988		1989		1990		1991	
	Units	Value	Units	Value	Units	Value	Units	Value
SIC 3721 Aircraft	2,784	12,242.87	4,786	14,123.62	3,891	17,502.91	3,786	19,814.14
civilian aircraft	2,784	10,121.93	3,940	13,292.00	3,446	16,231.96	3,288	18,220.77
military aircraft	-	2,120.94	846	831.62	445	1,327.42	498	1,593.37
SIC 3724 Aircraft Engines and Parts	-	5,329.40	-	6,180.81	-	6,157.57	-	6,158.81
SIC 3728 Aircraft Parts, NEC	-	7,107.18	-	7,643.11	-	8,050.55	-	7,886.56
SIC 376 Guided Missiles and Parts	-	426.75	-	971.47	-	1,170.57	-	1,224.26
Space Launch Equipment	-	611.60	-	358.01	-	591.56	-	468.59
TOTAL		27,960.67		43,400.64		51,032.54		55,366.50

[a] Deflated, using the Composite Price Index in the Aerospace Industries Association's Aerospace Facts and Figures.

Source: U.S. Dept. of Commerce, U.S. Industrial Outlook, 1992. p. 21-4.

TABLE 9-13b

U.S. IMPORTS OF AEROSPACE VEHICLES AND EQUIPMENT, 1988-91[a]
(VALUES[a] IN 10^6 1987 DOLLARS)

Items	1988		1989		1990		1991	
	Units	Value	Units	Value	Units	Value	Units	Value
SIC 3721 Aircraft	629	2,659.78	1,764	2,602.09	664	2,525.77	662	2,751.31
civilian aircraft	602	2,657.82	1,591	2,587.17	636	2,486.33	637	2,730.37
military aircraft	27	1.97	29	14.92	28	39.44	15	20.94
SIC 3724 Aircraft Engines and Parts	-	2,828.91	-	3,645.35	-	4,251.14	-	4,406.63
SIC 3728 Aircraft Parts, NEC	-	2,998.03	-	3,113.00	-	3,305.55	-	3,592.50
SIC 376 Guided Missiles and Parts	-	41.30	-	110.01	-	74.39	-	83.77
Space Launch Equipment	-	304.82	-	27.97	-	279.65	-	109.08
TOTAL		11,492.63		12,100.51		12,962.27		13,694.60

[a] Deflated, using the Composite Price Index in the Aerospace Industries Association's Aerospace Facts and Figures.

Source: U.S. Dept. of Commerce, U.S. Industrial Outlook, 1992. p. 21-4.

1987 to 1991. Imports of complete spacecraft and missiles constituted about 0.14 percent of total consumption for the same period.

Civilian products accounted for more than 80 percent of the total U.S. aerospace exports in 1990, increasing from $25.6 billion in 1989 to $31.5 billion in 1990. Commercial transport aircraft constituted about half of civilian exports.

Associated with the improving balance of trade position for the U.S. aerospace industry is a decline in the share of U.S. exports of aerospace products in the world market from about 80 percent in 1970 to 60 percent in 1990.[14]

Europe has provided the most formidable competition to the U.S. aerospace industry. The U.S. Industrial Outlook points out that the european aerospace industry grew twice as fast as its counterpart in the U.S. during the period 1978 to 1989.[15] This historical trend has been exacerbated by the creation of the Airbus Industrie consortium by France, Germany, Spain, and the U.K. Other countries seeking bigger shares in the global industry are Canada, Brazil, South Korea, China, Taiwan, Singapore, Sweden, Israel, and Australia.[16]

9.1.4 Outlook

In the short term, the growth in aerospace sales will continue to be slow. During 1990, aerospace manufacturers added 17 percent fewer new orders to their books than were added during 1989.[17] The U.S. Industrial Outlook points out that this decline in orders will be particularly severe in the military segment where 1990 orders fell by 29 percent over 1989. It will be recalled from Table 9-6, however, that the entire aerospace industry had a backlog of orders of $216.6 billion (1987 dollars) in 1990 so that production can continue for a limited time. There are indications that this backlog has begun to shrink,[18] implying that production rates will have to decline. In the short run therefore, employment is expected to fall for each SIC code.[19]

In the long term, the industry will begin to respond to demand shifts and cost changes. The commercial space business is expected to grow more than any other aspect of the industry. A recent example[20] of the growth in commercial space business is the worldwide mobile telephone system proposed by Motorola. The company will employ 66 satellites in 10 "necklaces" around the globe. Similar systems but with fewer satellites are operated by Loral (Globalstar) and TRW (Odyssey).

The role of technology cannot be overstated. New, high performance materials requiring less rework will be used in the industry.

There will be increased competition from abroad, leading to declines in the U.S. share of the world market. Firms will respond by restructuring and diversifying.

9.1.5 Rework in the Aerospace Industry

9.1.5.1 Overview. Original equipment can be classified into two categories: equipment such as missiles which once used cannot be retrieved, and equipment such as aircraft which have a longer useful life and therefore require repair and maintenance over the life cycle.

Rework may be understood to range from minor, routine maintenance to major overhaul, the degree of rework and the amount of coatings and solvents used being generally correlated. In the case of commercial passenger aircraft for example, routine "line maintenance" that takes place between flights requires small amounts of coatings and solvents compared with major overhaul on airframes. For the purposes of this profile, rework shall be taken to mean repair and maintenance that is undertaken to preserve and extend the useful life of the aerospace equipment rather than the continual repair and maintenance necessary for the regular operation of the equipment. This latter shall be referred to as routine repair and maintenance (R&M).

On the basis of the type of aerospace equipment on which rework is being performed, there can be said to be four categories of rework:

- Rework on large commercial transport aircraft.
- Rework on general aviation aircraft.
- Rework on military aircraft.
- Rework on military/government space vehicles and guided missiles.

There is no separate classification in the SIC system for any form of rework. Rework on aircraft, when done by OEMs (i.e., "factory rework"), is classified under SIC 3721, Aircraft, while non-factory rework is classified under SIC 4581, Airports, Flying Fields, and Aircraft Terminal Services. Furthermore, rework on guided missiles and space vehicles, if this does occur, is not recognized. All civilian aircraft repair stations must comply with Federal Aviation Regulation (FAR) Part 145. According to the FAA Advisory Circular No. 140-7F, there are 4,300 such repair stations engaged in the repair of airframes, power plants, propellers, radios, instruments, and accessories.[21]

In the case of commercial aircraft, the majority of rework is done on a non-factory basis, either by the air carriers or in independent repair stations engaged in "third party maintenance."

9.1.5.2 <u>Large Commercial Transport Aircraft</u>

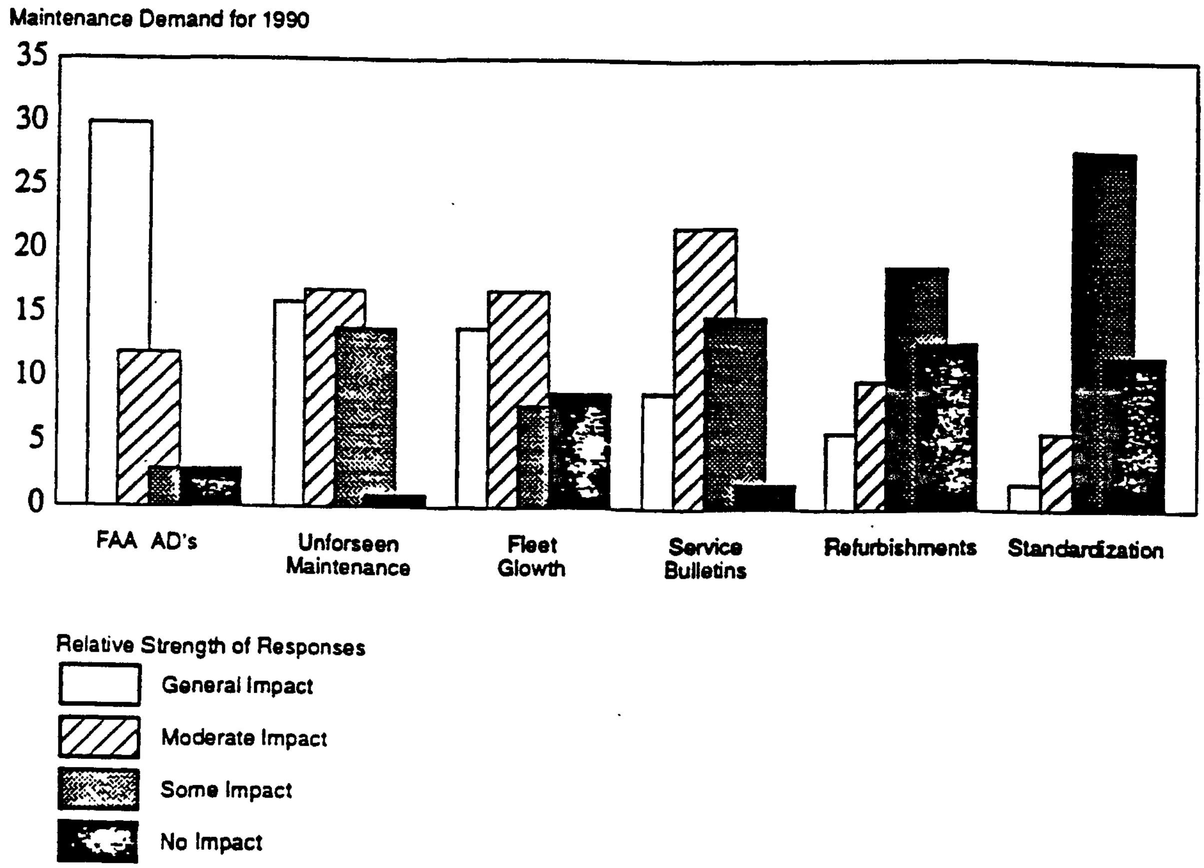
9.1.5.2.1 <u>The Demand Side</u>. Much of the information on rework of large commercial transport aircraft is drawn from a General Accounting Office (GAO) survey conducted in 1991.[22] Large commercial aircraft are defined as passenger or cargo aircraft that "carry more than 30 passengers or a payload greater than 7,500 pounds."[23] Such aircraft are covered by regulations in Part 121 of the FAR.

The demand for rework, an input used in the production of the final goods for air travel/transport, is affected by a number of factors other than the cost of rework or the price of the final goods. These include: (a) the FAA's aging aircraft airworthiness directives (ADs), (b) the age of aircraft, and (c) the demand for air carrier services:

(a) The FAA's airworthiness directives became more stringent after an accident on April 28, 1988, in which 18 feet of skin ripped from the fuselage of a 19-year old Aloha Airlines Boeing 737 while the aircraft was in flight.[24] Figure 9-6 shows that aging aircraft ADs have the greatest impact on the demand for heavy airframe maintenance. The diagram also shows the impact of other factors on the demand for rework. Apart from the label "service bulletins," the diagram is fairly self-explanatory. Aircraft manufacturers issue regular service bulletins suggesting improvements and modifications that may be undertaken by aircraft owners. Airlines also try to standardize the equipment in their fleet.

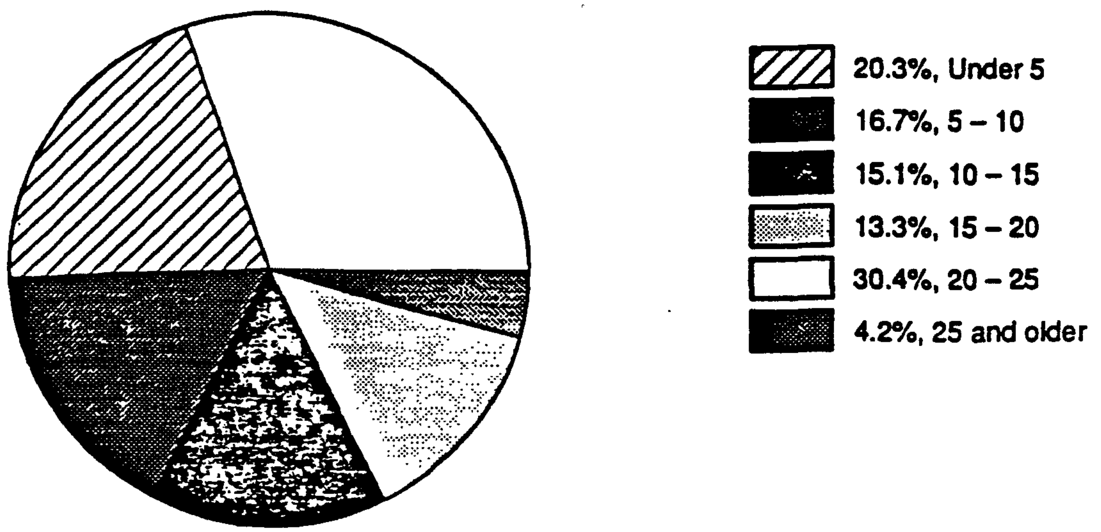
(b) In 1991, about 1,400 or 34.1 percent of the 4,100 large transports in the U.S. required major overhaul. The oldest aircraft were the Boeing 727s, 737s, 747s, and the Douglas DC-8s, -9s, -10s, and MD-80s.[25] Figure 9-7 shows the age profile of the March 1990 fleet of aircraft as it will be in the year 2000. It assumes that none of the aircraft will be

Figure 9–6. Relative Impact of Several Factors on Heavy Airframe Maintenance in 1990



Source: GAO/RCED-91-91A Aging Aircraft Repairs

Figure 9-7. Age Profile of U.S. Transport Fleet in the Year 2000 (as of March 1990)



Source: GAO/RCED-91-91A Aging Aircraft Repairs, Vol. I, p.13.

retired and excludes any purchases of new aircraft, both of which would lower the average age of the fleet. Given these qualifications, 63 percent of the fleet will be 20 years or older in the year 2000. Measured in years, the economic design life objective of these large transport aircraft is 20 years.[26] Naturally, the demand for rework will be greater if air carriers choose to continue using old aircraft rather than to replace them.

(c) Greater demand for air carrier services increases the demand for rework through two channels: the aircraft fleet may increase as new aircraft are purchased, and the existing fleet will be used more intensively, to the extent possible. In 1990, there were 8,302 aircraft in the world fleet, and Boeing predicts that this number will increase by 78 percent in the year 2005 to 14,772.[27] As aging aircraft require more rework than new aircraft, meeting increased demand for air carrier services by the more intensive use of existing aircraft will lead to a greater increase in the demand for rework than would the addition of new aircraft to the fleet.

Ultimately, the decision to continue using aircraft beyond their economic design lives is based on cost considerations, all factors being equal. Overall, costs are usually higher for old aircraft than for new aircraft, not only because of greater rework costs but also because of differences in fuel efficiency and general performance. Nonetheless, air carriers may forego purchasing new aircraft if expectations of future demand for air services are low or if interest rates are "too high." (Interest rates are too high if the sum of total interest payments on the new aircraft and the total operating and maintenance costs exceed the total operating and maintenance costs for the old and paid off aircraft, for the period beyond the economic design life of the old aircraft up to the time of its disposal.) In 1990, for their domestic operations, U.S. air carriers spent $6,924 x 10^6 on maintenance, or 11.7 percent of total operating expenses. In their international operations, maintenance expense was $2,050 x 10^6 or 10.9 percent of total operating expenses.[28]

The cost of heavy maintenance varies with the type of aircraft being serviced as well as the particular work that is to be performed. The total cost of rework equals the cost of the labor and material inputs used in the completion of the task, plus the lost income from having to take the aircraft out of service during maintenance. Depending on the type of aircraft and the usage, this lost income was estimated at between $25,000 and $100,000 a day.[29] The cost of rework on a Boeing 747 was estimated at $2.3 million before the FAA issued its aging aircraft directives.[30] Had the decision to perform rework on an aircraft been based on a purely economic calculation, the total cost of rework for the (marginal) oldest aircraft would have equalled the discounted present value of the stream of income associated with the extended life given to the aircraft by rework.

While FAA ADs in particular lead to an increase in the demand for rework, airlines are undertaking a number of initiatives to reduce their expenditure on rework. Moreover, when older aircraft are being serviced, rework done on them must satisfy regulations that did not exist at the time of original manufacture. Thus, new regulations governing noise, water, and air pollution may, for example, require the replacement of entire engines rather than routine repair and maintenance. These considerations can make it more cost effective to purchase new aircraft, thereby reducing the demand for rework.[31] On balance therefore, it is not clear whether the demand for rework will increase or decrease in the short-run.

9.1.5.2.2 Capacity and the Supply Side. In the GAO survey, 48 out of 54 air carriers responded, representing 99 percent of the large transport aircraft in the U.S. Of these, 24 had the capacity to perform heavy airframe maintenance. Also surveyed were 38 repair stations, not related to the air carriers, that had the capacity to perform heavy airframe maintenance. Thirty-five (35) of these independent repair stations responded.[32] Therefore, in 1991, there were at least 64 facilities that had the capacity to do heavy airframe maintenance, as determined by hangar space, the availability of spare parts, and skilled employees.

Whenever heavy maintenance is being performed, the FAA requires that the rework facility have the hangar space to fully enclose large transport aircraft.[33] This technical requirement has the economic consequence of precluding contract work to smaller repair stations and any kind of specialization that may follow. In this regard, rework facilities contrast to OEM facilities that are quite specialized (see Section 9.1.3.1).

In the past, air carriers with excess capacity in their rework facilities engaged in third party maintenance for other air carriers, but this practice ceased as carriers devoted this excess capacity to their own growing aircraft fleet.[34] The chief source of capacity constraints is hangar space, increasing the amount of hangar space being both costly and of a long term nature. The 24 air carriers with rework facilities now perform only about half of their own maintenance. As a result, an increasing number of independently owned rework facilities has been serving air carriers without their own rework facilities or whose rework facilities have become inadequate for their needs. Of the surveyed facilities, two thirds of the 24 air carriers that do heavy maintenance expected to be devoting their entire rework capacity to their own fleet in 1990, whereas only a third of the independent repair stations expected to be operating above 96 percent of full capacity.[35] This being the case, both the air carriers and independent repair stations plan to increase the hangar space available for rework.

Another determinant of the capacity of rework facilities is the size of the pool of available air mechanics. In their main repair facilities, the air carriers and independent repair stations reported that they employed 44,188 air mechanics in 1990. It is typical for the size of the facility and its employment of mechanics to be directly related. There are small independent repair facilities that employ less than 100 mechanics and cannot fully enclose one Boeing 737. One large national carrier operated a facility "capable of enclosing 20 aircraft at a time, including 747s, and employing several thousand mechanics."[36]

Rework facilities employ a relatively large fraction of the total number of air mechanics in the country. In 1988, air carriers employed more than 60 percent of the nation's 124,000 air mechanics.[37] Independent repair stations, aircraft assembly firms, the Federal Government, and owners of private aircraft employed the remaining 49,600 air mechanics. One may therefore argue that rework entails a relatively high air mechanic to total employment ratio and, therefore, discuss employment impacts at rework facilities in terms of air mechanics.

The capacity of rework facilities to meet demand is also influenced by the availability of spare parts. In order to perform rework, facilities must be able to purchase required spare parts when needed. Repair stations also maintain a stock of spare parts ranging from engines and airframe components to output classified under SIC 3728, Aircraft Parts and Equipment, NEC. The inability of OEMs to provide an adequate supply of spares has been a severe constraint on the capacity of rework facilities.[38] For facilities that usually keep a stock of spare parts, if there is urgent need for rework, a shortage of spare parts at a particular facility may compel air carriers to turn to repair stations located elsewhere, either within the country or abroad, to meet the demand.[39]

Regarding foreign repair stations, rework facilities owned by foreign airlines often have excess capacity that allows them to service U.S. aircraft. Further, there are also foreign repair stations, independent of the air carriers in those countries, that perform rework on U.S. aircraft. These foreign rework facilities may be regarded as offering competition to domestic facilities. In 1990, there were at least 34 foreign independent repair stations with the capacity to perform heavy maintenance on airframes, ranging from a facility that could contain one commuter aircraft to one that could enclose six wide-bodied aircraft.[40] These facilities were scattered across Europe, Canada, South East Asia, and Africa.

In looking abroad for repair and maintenance, airlines are especially cognizant of the differences in labor cost, quite apart from the limited capacity of domestic rework facilities. Such differences in labor cost may explain why some European facilities charge three times as much as their Asian competitors.[41]

9.1.5.3 General Aviation Aircraft. As of June 5, 1992, about 4,236 facilities were certified to perform wide ranging repair and maintenance on general aviation aircraft.[42] These facilities engage in repair and maintenance of small airframes, powerplants, propellers, radios, instruments, and accessories.

Table 9-14 presents employment and revenue information for 138 of these facilities. The table shows that for this sample of general aviation facilities, there are only small and medium facilities. The table includes facilities that repair the electronic gadgets on the aircraft even though such facilities will not be subject to the regulation.

9.1.5.4 Military Aircraft, Guided Missiles, and Space Vehicles. In the following discussion that draws heavily on a 1992 report[43] by the Office of Technology Assessment on the U.S. Defense Technology and Industrial Base (DTIB), the last two categories of rework facilities mentioned in Section 9.1.5.1 will be treated as one. Chapter 5 of the report addresses the maintenance base of the DTIB.

There are essentially three levels of defense maintenance: organizational, intermediate, and depot. Of these, depot level maintenance, where highly trained personnel rebuild, make complex repairs on, and overhaul equipment in specialized facilities,[44] will be likely candidates for the regulation.

The depot maintenance system is made up a service (i.e., service-owned and operated) and a private sector component, the former employing

TABLE 9-14

FEDERAL AVIATION REGULATION (FAR) PART 145
REWORK FACILITIES, NUMBER OF EMPLOYEES
AND REVENUE BY EMPLOYMENT-SIZE CLASS, 1992

Employment Size	Number of Facilities	Number of Employees	Revenue[a] (10^3)
0-9	43	283	29,807
10-24	40	686	48,350
25-49	19	704	49,000
50-99	16	986	57,000
100-299	11	1,842	145,500
300-499	1	400	15,000
500-999	3	2,297	120,000
1,000-3,999	4	4,511	1,070,000
4,000+	1	4,948	N/A

[a] Revenue is understated because, for many facilities, only employment data were available.

Source: National Aeronautical Repair Station Association.

about 150,000 persons, and the latter comprising thousands of firms, including both rework and OEM facilities.

In the past, each military service (i.e., the Army, Air Force, Marine Corps, and Navy) has maintained its own equipment except for a few select items (e.g., some aircraft engines), for which a single service has assumed overall maintenance responsibility.[45] While these services use various combinations of air-, land-, and sea-specific equipment, it is safe to assume that depot maintenance facilities in the Air Force and, to a lesser degree, the Navy, perform most of the in-service repair on military aerospace equipment.

The depot level maintenance of the Air Force is performed in five major facilities (Air Logistics Centers) and some smaller support centers. Very limited depot level rework is performed overseas (see Table 9-15). Approximately 60 to 70 percent of the depot maintenance of the Air Force is performed in the five major facilities, six percent by other services and the remainder by private firms under contract.[46]

In the fiscal year 1991, total depot level maintenance was about $4.7 million. This work was performed by both the service and the private sector components of the Air Force defense maintenance system. In fiscal year 1988, the Air Force Logistics Command repaired or modified 1,307 aircraft, 7,727 engines, and 817,000 exchangeable parts. In 1992, approximately 90 Air Force systems were being supported throughout their lives by the private sector.[47] Employment in these Air Force in-service facilities is expected to decline from 36,000 persons in 1992 to 31,000 in 1995.[48]

In the Naval Service, there are six naval aviation depots that, along with depots in other services and private sector companies,

TABLE 9-15

AIR FORCE SERVICE DEPOT MAINTENANCE FACILITIES

Facility	Location
Air Logistics Centers	
Ogden Air Logistics Center	Hill Air Force Base, Utah
Oklahoma City Air Logistics Center	Tinker Air Force Base, Oklahoma
Sacramento Air Logistics Center	McClellan Air Force Base, California
San Antonio Air Logistics Center	Kelly Air Force Base, Texas
Warner Robins Air Logistics Center	Robins Air Force Base, Georgia
Other Air Force Depot Maintenance Activities	
Aerospace Guidance and Metrology Center	Newark Air Force Station, Ohio
Support Group Europe[a]	RAF Kemble, United Kingdom
Detachment 35	Kadina Air Force Base, Japan
Aerospace Maintenance and Regeneration Center	Davis-Monthan Air Force Base, Arizona

[a] Scheduled to close.

Source: U.S. Congress Office of Technology Assessment, Building Future Security, OTA-ISC-530, p. 126.

perform depot level maintenance on this service's aerospace equipment. These Naval aviation depots employed 20,000 persons in 1992.[49]

9.1.6 Coatings Manufacturing

Aerospace coatings manufacturing is a subcategory of the more general classifications of paints and coatings manufacturing and adhesives and sealants manufacturing. These industries fall under SIC 2851, Paints, Varnishes, Lacquers, Enamels, and Allied Products (paints and coatings), and SIC 2891, Adhesives and Sealants.[50] While control costs stemming from the aerospace coatings NESHAP will directly impact aerospace original equipment manufacturers and rework facilities, coatings manufacturers will be indirectly affected as their products are inputs into OEM and rework facilities.

The top ten suppliers of coatings controlled 60 percent of the U.S. market share in 1990.[51] As of January 1991, there were 820 firms in the U.S. manufacturing coatings.

Table 9-16 presents value of shipments data for the paints and coatings and adhesives and sealants industries. Data are presented in millions of 1987 dollars. Value of shipments data for paints and coatings shows a decline from 1988 to 1991. This is due to the fact that demand for paints and coatings is closely related to the national business cycle, and this decline coincides with the downturn experienced by the national economy.[52] End users of this industry include construction, automotive, aerospace, and electronics, that also tend to be cyclical in nature.[53]

Shipments of adhesives and sealants have similar end uses to paints and coatings, and also tend to be cyclical in nature. Sales of these products were adversely affected by the notable declines in

TABLE 9-16

VALUE OF SHIPMENTS FOR PAINTS AND COATINGS AND ADHESIVES AND SEALANTS 1987 - 1991, (10^6 1987 DOLLARS)

Code	Industry	1987	1988	1989	1990	1991[a]
2851	Paints and Coatings	12,702	12,987	12,251	11,883	11,764
2891	Adhesives and Sealants	4,678	4,565	4,623	4,947	5,095

[a] Estimate

Source: U.S. Department of Commerce, Bureau of the Census of Manufactures, 1987. Annual Survey of Manufacturers, 1988-1990.

housing starts in 1991.[54] However, this deterioration was offset by significant growth in more specialized end uses such as packaging adhesives and bonding products for the electronic and wood working sectors.

Employment for paints and coatings and adhesives and sealants is presented in Table 9-17. As shown, employment for paints and coatings dropped from 1988 through 1991 due to the above-mentioned downturn in demand.

9.1.6.1 Aerospace Coatings. Aerospace coatings involve the use of coatings for both OEM and rework facilities. Within these market segments, coatings are specialized for use in commercial and military production.

No information is available on the share of production that aerospace coatings accounts for total coatings manufacturing. However, a 1990 study covering coatings production in Western Europe revealed that aircraft OEM coatings accounted for 2.6 percent of that market. Thus, it is assumed that aerospace coatings account for a relatively small share of the U.S. coatings market.

9.1.6.2 Future Prospects for Coatings Manufacturers. Since both paints and coatings production and adhesives and sealants production are cyclical in nature, future growth rates will be linked close to performance of the national economy.

Strong growth in demand for paints and coatings are expected for non-solvent-based materials, including waterborne and higher solids, due to their lower volatile organic compound (VOC) level.[55] Weaker performance is expected in the architectural coatings sector.[56] Overall performance should mirror growth in GNP.

TABLE 9-17

EMPLOYMENT FOR PAINTS AND COATINGS AND ADHESIVES AND SEALANTS, 1987 - 1991
(THOUSANDS OF EMPLOYEES)

SIC	Industry	1987	1988	1989	1990	1991[a]
2851	Paints and Coatings	55.2	56.9	55.0	54.7	54.5
2891	Adhesives and Sealants	20.9	21.2	21.9	22.5	22.3

[a] Estimate

Source: U.S. Department of Commerce, Bureau of the Census, 1987 Census of Manufactures, 1987. Annual Survey of Manufacturers, 1988-1990.

In the adhesive and sealant market, movement is expected away from solvent-based materials as well, in response to environmental concerns. Growth in the near term is expected to be 5 percent in real terms.[57] Long-term growth should mirror growth in GNP.

9.2 ECONOMIC IMPACT ANALYSIS (EIA)

9.2.1 Introduction

Compliance with the proposed NESHAP will result in total annual costs of approximately $21 million to the aerospace industry.[58] As will be explained further in this section, this cost is relatively small compared to total production costs in this industry. Therefore, the discussion of the economic impacts will be discussed in a qualitative manner due to the minimal costs associated with the proposed regulation.

Section 9.2.2 provides an analytical framework for discussing the impacts by identifying the aerospace market segments and the final goods and factor markets that will be affected by the proposed regulation and by discussing relevant market dynamics. The implications of having to comply with the emission standard and the costs and savings associated with compliance are discussed in Section 9.2.3. Section 9.2.5 presents a summary and the conclusion.

9.2.2 Analytical Framework

This section provides a framework for discussing the impacts associated with compliance with the regulation. In this framework, distinctions are made between primary impacts arising from price and output changes in the aerospace industry and secondary impacts arising from changes in the demand for inputs.

The aerospace industry engages in both original equipment manufacture and rework. Included are those firms producing aircraft, (SIC 3721); aircraft engines and engine parts, (SIC 3724); aircraft parts and auxiliary equipment, (SIC 3728); guided missiles and space vehicles, (SIC 3761); guided missile, space vehicle propulsion, and propulsion unit parts, (SIC 3764); and guided missile and space vehicle parts and auxiliary equipment, (SIC 3769). These products are produced and exchanged in the following markets (hereafter called market segments):

Commercial OEMs, SICs 3721, 3724, 3728
Military OEMs , SICs 3721, 3724, 3728, 3761, 3764, 3769
Commercial Rework
Military Rework.

One commercial rework facility categorized its operations as Airports, Flying Fields, and Services, SIC 4581.[59]

When broken down by size, it is possible to distinguish which facilities in these market segments perform similar activities among those that are considered to be emission sources under the potential NESHAP. This classification of facilities defines "model plants," the basis of the definition being the number of employees - small, medium, and large facilities having respectively 999 or fewer; 1,000 to 9,999; and 10,000 or more employees.

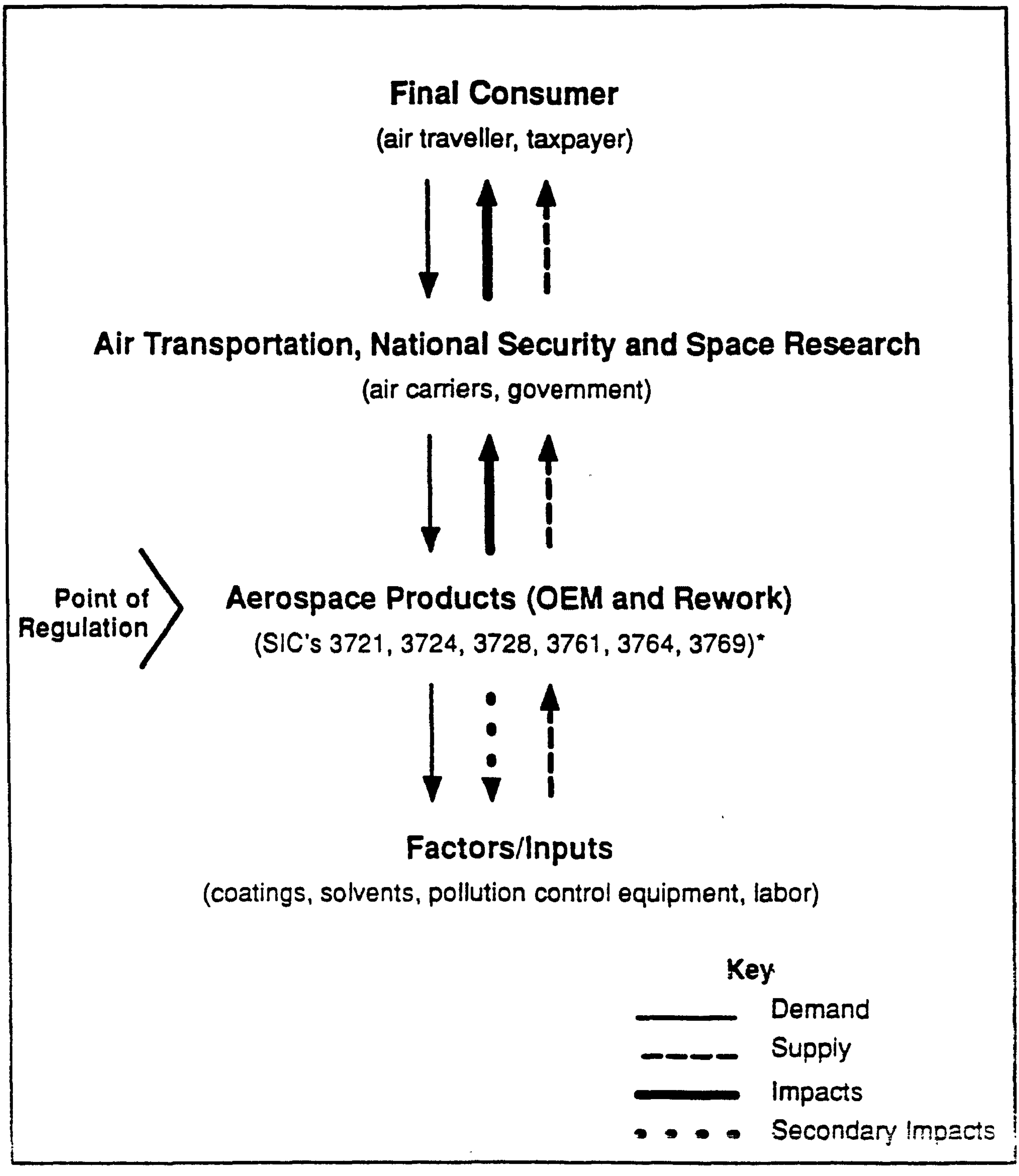
The producers of aerospace products purchase a variety of inputs or factors of production from "upstream" suppliers. The input markets that will be affected by the proposed NESHAP are the markets for aerospace coatings and solvents, pollution control equipment, and labor. Aerospace products are purchased by civilians, businesses, air carriers, and the government in response to the demand by air travellers and taxpayers for air travel, cargo transportation, space exploration, and national security.

Figure 9-8 summarizes how the regulation of activities in the aerospace industry will affect producers in this industry as well as producers in related industries through the indicated demand and supply channels. The diagram also shows the relationship between the users of aerospace products and the aerospace industry and factor markets. The market dynamics that lead to these effects will be discussed as primary and secondary impacts, respectively.

9.2.2.1 Primary Impacts. Cost estimates indicate that the requirements associated with the proposed regulation will cause industry-wide production costs to increase by approximately $21 million (1990 dollars) annually.[60] This cost includes the cost associated with additional control or substitution requirements as well as monitoring, recordkeeping, and reporting requirements. Though total production costs are unknown, an assumption of zero economic profits in the long run implies that industry production costs equal industry revenue which, according to the 1993 U.S. Industrial Outlook, equalled $118.1 billion in 1990 (original equipment manufacturing). Roughly, then, the costs associated with the standard are only 0.02 percent of total production costs for the industry.

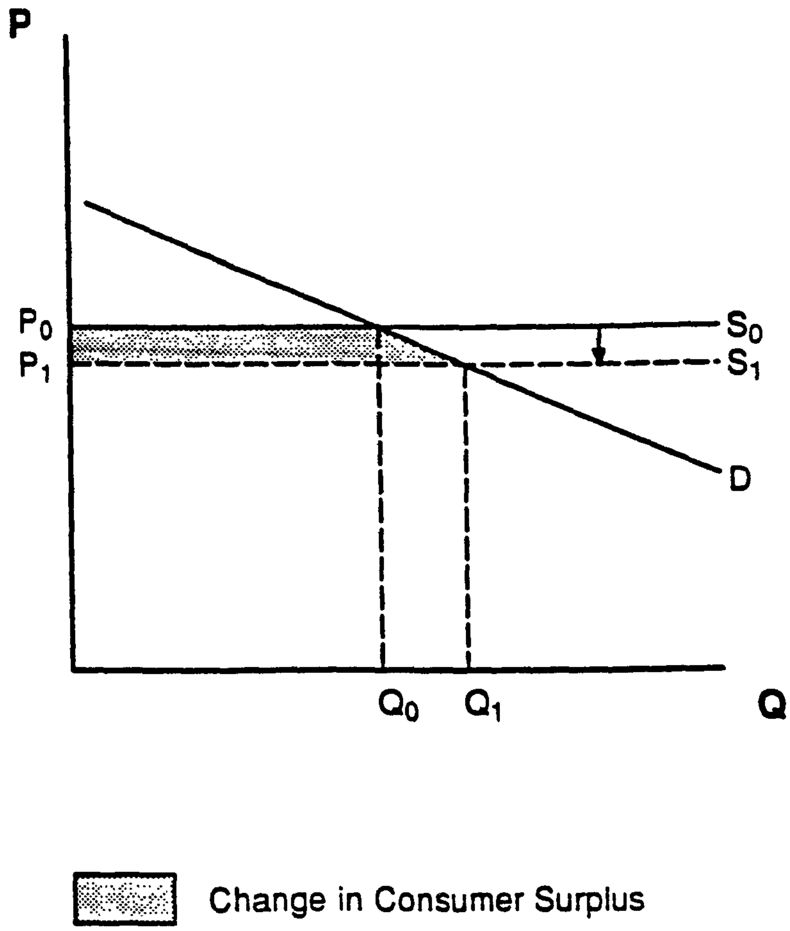
Economic profits will be zero if the supply of end products such as aircraft, guided missiles, and spacecraft to air carriers and the government is perfectly elastic, a reasonable long run assumption given that, for travel and cargo, air carriers usually operate in highly competitive markets. In the case of government provision of national security which is a public good, it is assumed that the government is not a profit (or revenue) maximizer and therefore will pass on all savings to the taxpayer. Figure 9-9 depicts the effect of these savings

Figure 9-8. Direction of demand and supply in the Aerospace Industry and of impacts of NESHAP proposed for the Aerospace Coatings Industry.



* These SICs are for original equipment. There is no separate SIC for rework.

FIGURE 9-9. EFFECTS OF PROPOSED NESHAP ON PRODUCERS OF FINAL GOODS IN THE AEROSPACE INDUSTRY*



* This industry includes goods in SICs 3721, 3724, 3728, 3761, 3764, 3769.

on air carriers and the government. The decrease in production costs causes the supply curve to shift from S_0 to S_1. Unit price declines from P_0 to P_1, and output increases from Q_0 to Q_1.

Because the supply curve is assumed to be horizontal, all the savings associated with the NESHAP will be passed on to the air carriers and the government by the aerospace producers. In turn, it is assumed that these savings are passed on entirely to the consumer or taxpayer as indicated by the increase in consumer surplus shown in Figure 9-9.

Table 9-18 shows the various emission sources, associated with various activities in the aerospace industry, that are subject to regulation under the potential NESHAP. The table also indicates the cost, for each model plant, of complying with the standard. The total costs for small, medium, and large model plants are also presented.

Although the total cost of the proposed regulation is positive, some model plants show negative costs (i.e., savings) and, moreover, these costs differ across model plant sizes. While such a pattern of positive and negative costs for different model plant sizes could, in theory, cause shifts in business among model plants of different sizes, when compared with total production costs, the absolute numbers are considered small enough to be inconsequential.

9.2.2.2 <u>Secondary Impacts</u>. The expression "secondary impacts" refers to changes in factor demand by all aerospace producers (regardless of where they are in the production process). For example, while the primary impact of the regulation on spray gun cleaning is a decrease in the cost of performing this task, the actual cause of the decrease in cost is a reduction in the use of methyl ethyl ketone (MEK)

TABLE 9-18

PER-PLANT CONTROL COSTS FOR REGULATED EMISSION SOURCES[a]
(1990 CONSTANT DOLLARS)

EMISSION SOURCE/ MODEL PLANT SIZE	MARKET SEGMENTS			
	COMMERCIAL OEM	MILITARY OEM	COMMERCIAL REWORK	MILITARY REWORK
Aircraft Depainting:				
small	N/A	N/A	(7,200)	(7,200)
medium	N/A	N/A	(23,590)	(23,590)
large	N/A	N/A	N/A	(23,590)
Chemical Milling Maskant:				
small	N/A	N/A	N/A	N/A
medium	106,680	106,680	N/A	106,680
large	135,540	135,540	N/A	135,540
Spray Gun Cleaning:				
small	(16,720)	(16,720)	(16,720)	(16,720)
medium	(22,100)	(22,100)	(22,100)	(22,100)
large	(28,000)	(28,000)	(28,000)	(28,000)
Hand-Wipe Cleaning:				
small	7,030	7,030	7,030	7,030
medium	3,510	3,510	3,510	3,510
large	(9,260)	(9,260)	(9,260)	(9,260)
Primers, Topcoats, and their Application:				
small	(36,830)	(8,680)	(36,830)	(8,680)
medium	(67,350)	(12,450)	(67,350)	(12,450)
large	(520,600)	(90,830)	(520,600)	(90,830)
Total:				
small	(46,520)	(18,370)	(53,720)	(25,570)
medium	20,740	75,640	(109,530)	52,050
large	(422,320)	7,450	(557,860)	(16,140)

[a] The emission source "Inorganics" is not included because the associated costs are not available on a model plant basis. These costs are positive but quite small.

Source: Facsimile, David Hendricks, PES, to Thomas Singh, JACA Corporation.

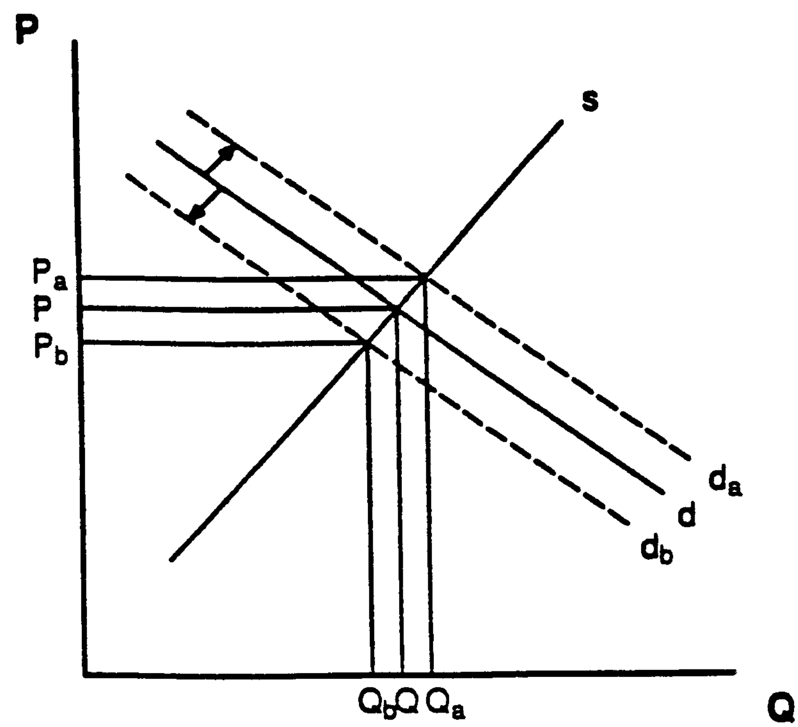
and other solvents, this reduction in solvent consumption being the secondary impact.

Figure 9-10 shows the direction of the change in price and quantity when the demand for the factor increases (from d to d_a) or decreases (from d to d_b). (Unlike in Figure 9-9, the supply curve is assumed to be upward sloping in order to demonstrate price and quantity effects of the changes in factor demand. Note that in this diagram, it is the demand curve that shifts along a given supply curve. In Figure 9-9, it was the supply curve that shifted and the magnitude of the shift, industry savings, was seen to be small, rendering the assumption of a perfectly elastic supply curve quite innocuous. Moreover, that assumption was defended as realistic.) When factor demand increases in response to the emission standard, quantity demanded increases to Q_a and price increases to P_a. Conversely, when factor demand decreases in response to the standard, quantity demanded and price decrease to Q_b and P_b, respectively. The process "spray gun cleaning" provides an illustration of how the standard, by requiring the increased use of one factor (enclosed spray gun cleaners), will lead to a reduction in the use of another (methyl ethyl ketone). While these two factors are produced and exchanged in two distinct markets, the analysis of Figure 9-10 suggests that the equilibrium price and quantity in the enclosed spray gun cleaner market will increase, and the equilibrium price and quantity in the methyl ethyl ketone market will decrease.

9.2.3 Discussion of Economic Impacts

In discussing the impacts, it is necessary to identify those markets that will be affected by the potential regulation. To this end, the effect of the standard on each emission source will be treated

FIGURE 9-10. EFFECTS OF PROPOSED NESHAP ON FACTOR MARKETS*



* Factors include Aerospace coatings and solvents, pollution control equipment and labor.

separately. As the primary impacts of the NESHAP are insignificant, only factor markets (i.e., secondary impacts) will be discussed. Moreover, while various control options may achieve the standard, only the least costly options will be used to calculate economic impacts.

In this analysis, both negative impacts such as a decrease in demand for coatings, solvents, or labor, and positive impacts such as an increase in demand for low-HAP content coatings, will be noted. When the potential standard leads to an increase in the demand for pollution control equipment (e.g., carbon adsorbers), the discussion will emphasize any associated changes in the demand for coatings and solvents.

Regulation of the emission source labelled "aircraft depainting" will affect primarily rework facilities. MACT specifies the elimination of organic HAP-containing chemical strippers (except for a 20 gallon per aircraft allowance for spot stripping and decal removal). Compliance can be achieved through the use of non-HAP chemical strippers or media blasting techniques such as wheat starch or plastic pellet blasting.

The least costly control option for aircraft depainting is the use of chemical strippers that contain no organic HAPs. No additional equipment is required under MACT and the number of hours required to perform the task of depainting is unchanged. Table 9-19 shows that the regulation will lead to a 1.6 million gallon decline in the annual consumption of methylene chloride-based chemical strippers and a 1.8 million gallon increase in the annual consumption of chemical strippers that contain no HAPs.

For the emission source "chemical milling maskant," performed in commercial/OEM, military/OEM, and military rework medium and large

TABLE 9-19

BASELINE AND MACT USE OF STRIPPERS FOR AIRCRAFT DEPAINTING

Model Facility Size	Number of Facilities	Consumption (gallons/year)			
		Per-plant[a]		Industry-wide	
		Baseline[b]	MACT[c]	Baseline[b]	MACT[c]
Small	27	6,060	6,880	163,620	185,760
Medium	73	18,120	20,560	1,322,760	1,500,880
Large[d]	5	18,120	20,560	90,600	102,800
Total	105	N/A	N/A	1,576,980	1,789,440

[a] Commercial and military rework facilities.
[b] Methylene Chloride-based chemical strippers.
[c] Non-HAP chemical strippers.
[d] Assume same value for large facilities as medium facilities.
N/A - Not Applicable

Source: Memorandum, February 8, 1994, "MACT Cost Analysis for Aircraft Depainting," D. Hendricks, PES Inc., to V. Boothe, EPA.

facilities, maskant consumption varies only with the size of facilities. Moreover, the least costly control technique is not identical across facility sizes.

As one control option, carbon adsorbers can be used with the baseline solvent-based maskants. Operation of carbon adsorbers requires more labor and utilities and also requires replacement carbon. (It is not possible to calculate this change in labor requirement from the available information.) The other control option specifies the substitution of waterborne maskant for the baseline solvent-based maskants. Use of waterborne maskants requires stainless steel tanks to replace the tanks used for solvent-based maskants. Additionally, waterborne maskants require ovens for drying. Waterborne and solvent-based maskants use the same amounts of labor.

Compliance will be least costly for the industry if medium facilities used waterborne rather than solvent-based maskants and if large facilities continued using solvent-based maskants but captured emissions with carbon adsorbers.

From Table 9-20, it may be concluded that all the relevant medium facilities will reduce their annual consumption of solvent-based maskants by a total of 696,000 gallons, and increase their annual consumption of waterborne maskants by 620,600 gallons. The total consumption of solvent-based maskants in the aerospace industry will decrease by 67 percent.

These influences on demand emanating from compliance at this emission source will place upward pressure on the price of waterborne maskants and downward pressure on the price of solvent-based maskants.

TABLE 9-20

BASELINE AND MACT USE OF CHEMICAL MILLING MASKANTS

Model Facility Size	Number of Facilities	Consumption of Maskants (gallons/year)			
		Per-plant[a]		Industry-wide	
		Baseline[b]	MACT[c]	Baseline[b]	MACT[c]
Medium	58	12,000	10,700	696,000	620,600
Large	13	26,000	26,000	338,000	338,000
Total	71	N/A	N/A	1,034,000	958,600

[a] Commercial/OEM and military/OEM and military rework facilities. Solvent usage is uniform across these types of facilities.
[b] Solvent-based maskants.
[c] Waterborne maskants for medium-sized facilities and baseline solvent-based maskants for large facilities.
N/A - Not Applicable

Source: Memorandum, August 25, 1993, "MACT Cost Analysis for Chemical Milling Maskant," D. Hendricks, PES Inc., to V. Boothe, EPA.

As large facilities can achieve the required emission reductions in the least costly manner by installing carbon adsorbers, they will not change their annual consumption of solvent-based maskants.

For "spray gun cleaning," MACT specifies the substitution of enclosed spray gun cleaners for "unlimited hand cleaning". Impacts differ only with the size of the model plants and not by work type (commercial/military, OEM/rework). The use of enclosed spray gun cleaners will lead to a decrease in solvent consumption, typically MEK. The labor requirement for spray gun cleaning is unaffected by the standard.

It can be concluded from Table 9-21 that the average annual consumption of solvents in the aerospace industry will decrease from 14,405,100 to 3,799,640 gallons, or 74 percent, as a direct consequence of the use of enclosed spray gun cleaners.

"Hand-wipe cleaning" is performed in all facilities and solvent consumption varies only with the size of facilities, not with the work type. MACT for hand-wipe cleaning specifies product substitution and the implementation of a housekeeping system. Product substitution refers particularly to the substitution of aqueous and low vapor pressure cleaners for MEK which is typically used in the baseline.

The housekeeping system under MACT involves the use of (a) sealable fiber drums and aluminized bags to capture fugitive emissions from solvent-laden rags and (b) compactors for compressing solid waste. This housekeeping system will lead to a reduction in the required amount of solvent. Thus, as may be seen from Table 9-22, instead of using 46,575,900 gallons of MEK each year for hand-wipe

TABLE 9-21

BASELINE AND MACT USE OF SOLVENTS FOR SPRAY GUN CLEANING

Model Facility Size	Number of Facilities	Consumption of Solvents (gallons/year)			
		Per-plant[a]		Industry-wide	
		Baseline[b]	MACT[c]	Baseline[b]	MACT[c]
Small	1,318	4,200	1,040	5,535,600	1,370,720
Medium	1,533	5,700	1,560	8,738,100	2,391,480
Large	18	7,300	2,080	131,400	37,440
Total	2,869	N/A	N/A	14,405,100	3,799,640

[a] Commercial/OEM, military/OEM, commercial rework, and military rework facilities. Solvent consumption is uniform across these types of facilities.
[b] MEK is the most commonly used solvent.
[c] Same as the baseline solvent. Solvent consumption differs from the baseline because MACT specifies the use of enclosed spray gun cleaners.
N/A - Not Applicable

Source: Memorandum, August 25, 1993, "MACT Cost Analysis for Spray Gun Cleaning," D. Hendricks, PES, Inc., to V. Boothe, EPA.

TABLE 9-22

BASELINE AND MACT USE OF SOLVENTS FOR HAND-WIPE CLEANING

Model Facility Size	Number of Facilities	Consumption of solvents (gallons/year)			
		Per-plant[a]		Industry-wide	
		Baseline[b]	MACT[c]	Baseline[b]	MACT[c]
Small	1,318	1,050	336	1,383,900	442,848
Medium	1,533	28,000	8,960	42,924,000	13,735,680
Large	18	126,000	40,320	2,268,000	725,760
Total	2,869	N/A	N/A	46,575,900	14,904,288

[a] Commercial/OEM, military/OEM, commercial rework and military rework facilities. Solvent consumption is uniform across these types of facilities.
[b] MEK is the most commonly used solvent.
[c] Aqueous and low vapor pressure solvents.
N/A - Not Applicable

Source: Memorandum, August 25, 1993, "MACT Cost Analysis for Hand-Wipe Cleaning," D. Hendricks, PES Inc., to V. Boothe, EPA.

cleaning, the aerospace industry will use 14,904,288 gallons of solvents with a lower vapor pressure.

While there may be a change in the labor requirement associated with the disposal of solvent-laden rags, it is only possible to say that this change should be proportional to the change in the actual number of solvent-laden rags which in turn should be proportional to the change in solvent consumption.

For "primers, topcoats, and application methods," MACT specifies (a) the substitution of low-HAP content primers and topcoats (coatings) for high-HAP content coatings and (b) the use of high transfer efficiency methods (namely high volume low pressure (HVLP) spray guns) for primer and topcoat application. The use of HVLP spray guns reduces the annual average consumption of coatings, and this in turn reduces the number of labor hours spent on the corresponding coating operations.

For both coatings substitutions and high transfer efficiency methods, the impacts differ in commercial and military facilities but are independent of whether the work being performed is original equipment manufacture or rework. For both MACT specifications, impacts vary with the size of the facility.

Tables 9-23a and 9-23b show the annual consumption of primers and topcoats in the baseline and after the regulation. Primer consumption will decline by 24 percent, from a baseline volume of 2,529,760 gallons per year to 1,927,600 gallons per year under MACT. Similarly, topcoat consumption will decline by 25 percent, from an annual baseline consumption of 2,132,100 gallons to 1,601,960 gallons. In both instances, the reduction in volume is the result of greater efficiency in application methods.

TABLE 9-23a

ANNUAL BASELINE AND MACT USAGE OF PRIMERS IN COMMERCIAL AND MILITARY FACILITIES

Model Facility Size	No. of facilities	Consumption of primers (gallons/year)					
		Per-plant			Industry-wide		
		Baseline	MACT	Change	Baseline	MACT	Change
		Commercial					
Small facilities	844	500	275	(225)	422,000	232,100	(189,900)
Medium facilities	545	2,100	1,640	(460)	1,144,500	893,800	(250,700)
Large facilities	6	18,000	14,490	(3,510)	108,000	86,940	(21,060)
Total	1,395	N/A	N/A	N/A	1,674,500	1,212,840	(461,660)
		Military					
Small facilities	474	170	100	(70)	80,580	47,400	(33,180)
Medium facilities	988	710	610	(100)	701,480	602,680	(98,800)
Large facilities	12	6,100	5,390	(710)	73,200	64,680	(8,520)
Total	1,474	N/A	N/A	N/A	855,260	714,760	(140,500)
		Total					
Small facilities	1,318	N/A	N/A	N/A	502,580	279,500	(223,080)
Medium facilities	1,533	N/A	N/A	N/A	1,845,980	1,496,480	(349,500)
Large facilities	18	N/A	N/A	N/A	181,200	151,620	(29,580)
Total	2,869	N/A	N/A	N/A	2,529,760	1,927,600	(602,160)

N/A - Not Applicable

Source: Memorandum, August 25, 1993, "MACT Cost Analysis for Primers and Topcoats," D. Hendricks, PES Inc., to V. Boothe, EPA.

TABLE 9-23b

ANNUAL BASELINE AND MACT USAGE OF TOPCOATS IN COMMERCIAL AND MILITARY FACILITIES

Model Facility Size	No. of facilities	Consumption of topcoats (gallons/year)					
		Per-plant			Industry-wide		
		Baseline	MACT	Change	Baseline	MACT	Change
		---------------Commercial---------------					
Small facilities	844	500	250	(250)	422,000	422,000	-
Medium facilities	545	2,000	1,420	(580)	1,090,000	773,900	(316,100)
Large facilities	6	17,900	13,100	(4,800)	107,400	78,600	(28,800)
Total	1,395	N/A	N/A	N/A	1,619,400	1,274,500	(344,900)
		---------------Military---------------					
Small facilities	474	110	50	(60)	52,140	52,140	-
Medium facilities	988	420	250	(170)	414,960	247,000	(167,960)
Large facilities	12	3,800	2,360	(1,440)	45,600	28,320	(17,280)
Total	1,474	N/A	N/A	N/A	512,700	327,460	(185,240)
		---------------Total---------------					
Small facilities	1,318	N/A	N/A	N/A	474,140	474,140	-
Medium facilities	1,533	N/A	N/A	N/A	1,504,960	1,020,900	(484,060)
Large facilities	18	N/A	N/A	N/A	153,000	106,920	(46,080)
Total	2,869	N/A	N/A	N/A	2,132,100	1,601,960	(530,140)

N/A - Not Applicable

Source: Memorandum, August 25, 1993, "MACT Cost Analysis for Primers and Topcoats," D. Hendricks, PES Inc., to V. Boothe, EPA.

As the amount of primers and topcoats will decrease following the regulation, so will the labor hours required to apply these coatings. The industry's annual labor requirement associated with this emission source will fall by approximately 1,771,160 hours or 852 persons per year, assuming 2080 hours per person-year.[61]

The final emission source is "inorganics," for which the incremental cost of compliance is the cost of implementing MACT.[62] MACT specifies the construction of booths or hangars in facilities that currently do not paint within such enclosures and the installation of dry filters or waterwash in all booths or hangars. As such, while there will be an increase in the demand for pollution control equipment, there is no product substitution nor is there a change in the consumption of coatings, solvents, or labor.

9.2.4 Small Business Impacts

The purpose of this section is to address the possibility that the proposed rule will significantly impact small entities in the aerospace industry. The Small Business Administration defines any establishment within SIC 3724, 3728, 3761, 3764, and 3769 as a small entity if it employs 1,000 employees or less. Establishments within SIC 3721 must employ less than 1,500 employees to qualify as a small entity. Although the possibility of the proposed rule affecting establishments classified as small entities exists, the EPA does not anticipate that the proposed rule will have a significant impact on a substantial number of small entities.

As discussed in Section 9.1.2, the manufacturing and assembling of complete products in the aerospace industry take place in a complex manner. This process involves prime contractors as well as several tiers of subcontractors. One SIC code may consist of a number of establishments of vastly varying sizes engaging in a number of different activities, with the small establishments engaging in activities that contribute the least value-added to the final product.

For example, SIC 3721 consists of establishments of different sizes that manufacture or assemble complete aircraft; modify, convert, or overhaul previously accepted aircraft; engage in research and development; and provide aeronautic services on complete aircraft. Each establishment contributes a different amount of value-added to the final product, with activities generating the least value-added typically employing less than 1,000 production workers. This situation is also expected to hold true for the rework segment of the industry.

The purpose of the proposed rule is to limit HAP emissions from aerospace facilities that are major sources (as defined in Section 112(a) of the Act) of these emissions. Establishments most likely to qualify as small entities are also least likely to qualify as major sources. As explained above, an establishment contributing a small amount of value-added to a final product will not likely generate enough HAP emissions to qualify as a major source.

Due to the above reasoning, the EPA has no information indicating that any small entities would meet the definition of a major source; therefore, the small entities would not be subject to the proposed rule and no impact would occur. Consequently, a Regulatory Flexibility Analysis is not required.

9.2.5 Summary and Conclusions

The primary impacts of this NESHAP occur in the markets for air transportation, space exploration, and national security. There will be an industry-wide cost associated with the regulatory requirements, but the primary impacts will be insignificant on account of the small magnitude of the costs compared to the industry-wide production costs.

The secondary impacts of this potential regulation occur in the factor markets for coatings and solvents, labor, and pollution control equipment. Consumption of methylene chloride is estimated to decline by approximately 1.6 million gallons per year, being replaced by 1.8 million gallons per year of non-HAP strippers. Consumption of solvent-based maskants is expected to decline by approximately 700,000 gallons per year or 67 percent annually, the substitute being waterborne maskants with a usage of approximately 600,000 gallons per year. The aerospace industry's consumption of methyl ethyl ketone is expected to decline by approximately 57 million gallons per year or 83 percent. The consumption of low vapor pressure solvents is expected to increase by approximately 15 million gallons annually. Finally, the average amount of primers and topcoats used annually in the industry will decrease by 6 million gallons or 24 percent and 5 million gallons or 25 percent, respectively.

These changes in the demand for coatings and solvents may be represented by shifts in the respective factor demand curves that will result in price and quantity changes as illustrated in Figure 9-10. As a result, the issue of demand elasticity does not enter and there will be unambiguous revenue changes associated with the changes in price and quantity. Thus, there will be a tendency for the price, quantity, and revenue to decline in the markets for methylene chloride, solvent-based maskants, MEK, primers, and topcoats. Associated with the product substitution that will take place in the industry, there will be a tendency for price, quantity, and revenue to increase in the markets for non-HAP strippers, waterborne maskants, and low vapor pressure solvents.

Regarding negative impacts, the effects of this NESHAP on producers of methylene chloride, solvent-based maskants, MEK, primers, and topcoats will be more severe on the larger producers. Likewise, when the NESHAP favors producers of non-HAP strippers, waterborne maskants, and low vapor pressure solvents, the impacts will be greater on producers who specialize in a single product.

It has been established that the use of high transfer efficiency application methods will lead to annual labor savings equivalent to 852 persons. The overall change in the demand for labor cannot be determined from the available information as the labor requirement increases with the use of carbon adsorbers in chemical milling maskant and decreases with the housekeeping system recommended for hand-wipe cleaning. Without knowing the direction of the change in demand, it will not be possible to predict the associated changes in price, quantity, and revenue in the market for labor.

For the various kinds of pollution control equipment required for MACT, the increase in demand will, as demonstrated in Figure 9-10, result in an increase in price, quantity, and revenue.

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APPENDIX A. DEVELOPMENT OF ENVIRONMENTAL IMPACTS FOR MODEL PLANTS

MEMORANDUM

TO:	Vickie Boothe US EPA:ESD
FROM:	David Hendricks Pacific Environmental Services, Inc. (PES)
DATE:	December 30, 1993 L:\N208
SUBJECT:	Environmental Impacts for Chemical Milling Maskants

The purpose of this memo is to compare baseline and MACT environmental impacts for chemical milling maskants. Baseline consists of a dip coating operation using a solvent based maskant. MACT floor specifies an emission rate of 1.3 pounds of HAP's per gallon less water of maskant as applied, which is based on either the use of solvent based maskant and a carbon adsorber to control emissions or the use of waterborne maskants.

Tables 1 and 2 summarize the environmental impacts. The use of solvent based maskants and a carbon adsorber (Table 1) is expected to result in an 80 percent reduction in HAP emissions. Additionally, increases in water, energy consumption, and solid waste generation of 435,290 gal/yr, 1,303,055 kW-hr/yr, and 8,700 lb/yr, respectively, are directly related to the operation of the carbon adsorber. The use of waterborne maskants (Table 2) is expected to result in an 90 percent reduction in air emissions because of the reduced solvent content of the waterborne maskants. Additionally, energy increases of 249,600 kW-hr/yr are directly related to the operation of the curing oven. Finally, solid waste increases of 7,590 to 16,520 lb/yr are related to the solids content difference between solvent based and waterborne maskants. The assumptions and calculations used in deriving these impacts are detailed below.

As defined in draft BID Chapter 6, chemical milling maskant operations occur only in commercial/OEM, military/OEM, and military/rework medium and large model plants. Since there is no difference in implementing MACT floor for commercial versus military or OEM versus rework facilities, the environmental analysis has been performed only for different size model plants.

TABLE 1
ENVIRONMENTAL IMPACTS TO IMPLEMENT
CHEMICAL MILLING MASKANT MACT - CARBON ADSORBER

Item		Model Plant	
		Medium	Large
1.	Baseline HAP Emissions (lb/yr)	78,000	169,000
2.	MACT HAP Emissions - Carbon Adsorber (lb/yr)	15,600	33,800
3.	MACT HAP Emission Reduction - Carbon Adsorber (lb/yr)	62,400	135,200
4.	Baseline Wastewater Generation (gal/yr)	0	0
5.	MACT Wastewater Generation - Carbon Adsorber (gal/yr)	435,290	435,290
6.	MACT Implementation Wastewater Generation - Carbon Adsorber (gal/yr)	435,290	435,290
7.	Baseline Energy Consumption (kWatt-hr/yr)	0	0
8.	MACT Energy Consumption - Carbon Adsorber (kWatt-hr/yr)	1,303,055	1,303,055
9.	MACT Implementation Energy Consumption - Carbon Adsorber (kWatt-hr/yr)	1,303,055	1,303,055
10.	Baseline Solid Waste Generation (lb/yr)	40,560	87,880
11.	MACT Solid Waste Generation - Carbon Adsorber (lb/yr)	49,260	96,580
12.	MACT Implementation Solid Waste Generation - Carbon Adsorber (lb/yr)	8,700	8,700

TABLE 2

ENVIRONMENTAL IMPACTS TO IMPLEMENT
CHEMICAL MILLING MASKANT MACT - WATERBORNE MASKANT

Item		Model Plant	
		Medium	Large
1.	Baseline HAP Emissions (lb/yr)	78,000	169,000
2.	MACT HAP Emissions - Waterborne Maskants (lb/yr)	7,640	16,590
3.	MACT HAP Emission Reduction - Waterborne Maskants (lb/yr)	70,360	152,410
4.	Baseline Energy Consumption (kWatt-hr/yr)	0	0
5.	MACT Energy Consumption - Waterborne Maskants (kWatt-hr/yr)	249,600	249,600
6.	MACT Implementation Energy Consumption - Waterborne Maskants (kWatt-hr/yr)	249,600	249,600
7.	Baseline Solid Waste Generation (lb/yr)	40,560	87,880
8.	MACT Solid Waste Generation - Waterborne Maskants (lb/yr)	48,150	104,400
9.	MACT Implementation Solid Waste Generation - Waterborne Maskants (lb/yr)	7,590	16,520

BASELINE

Primary Air Emissions

As stated previously, baseline chemical milling maskant application is a dip coating operation using a solvent based maskant. The baseline usage of solvent based maskant was obtained from the Section 114 questionnaire responses of a military/OEM/medium facility and a military/OEM/large facility. The baseline usage is 12,000 gal/yr for a medium facility[1], and 26,000 gal/yr for a large facility.[2] The maskant usage for each model plant multiplied by the baseline HAP content (6.5 lb/gal) as listed in draft BID Chapter 6 gives the baseline emission rate:

Medium model plant: 12,000 gal/yr x 6.5 lb/gal = 78,000 lb/yr

Large model plant: 26,000 gal/yr x 6.5 lb/gal = 169,000 lb/yr

Wastewater Generation and Energy Consumption

The use of solvent based maskants does not impact a facility's water or energy use.

Solid Waste Generation

According to two vendors,[3,4] solvent based maskant appears to have an indefinite life in a dip tank operation. Therefore, disposal of unused solvent based maskant will not be necessary.

The dried maskant film that is removed from components after scribing and chemical milling must be disposed of as waste. According to one vendor,[5] a typical solvent based maskant weighs 13 lb/gallon and is 26 percent solids by weight. Therefore, the waste generated from dried maskant is:

Medium model plant: 12,000 gal/yr x 13 lb/gal x 0.26 solids = 40,560 lb solids/yr

Large model plant: 26,000 gal/yr x 13 lb/gal x 0.26 solids = 87,880 lb solids/yr

MACT IMPACTS - CARBON ADSORBER

MACT for chemical milling maskant application can be based on the use of solvent based maskant and a carbon adsorber to control emissions. Since both the baseline and

MACT scenarios are based on the use of solvent based maskant, the type of maskant, usage, and dip application equipment remain the same and there are no incremental impacts from these factors. The only factor relevant in the impact analysis is the carbon adsorber. Therefore, the air impact is the reduction in solvent emissions caused by the carbon adsorber. Additionally, water, energy, and solid waste impacts are directly related to the operation of the carbon adsorber.

Primary Air Emissions

The primary air impact from using a carbon adsorber is a reduction in the HAP emissions equivalent to baseline emissions multiplied by the overall control efficiency of the carbon adsorber system. The control efficiency needed to achieve the MACT emission rate of 1.3 pounds of HAP's per gallon of maskant used less water is 80 percent. This is determined using the baseline emission rate of 6.5 lb HAP/gal (solvent-based) and the MACT emission rate of 1.3 lb HAP/gal less water in the following equation:

$$\frac{6.5 \text{ lb HAP/gal} - 1.3 \text{ lb HAP/gal}}{6.5 \text{ lb HAP/gal}} = 0.80$$

The reduction in emissions is:

Medium model plant: 78,000 lb/yr x 0.80 = 62,400 lb/yr

Large model plant: 169,000 lb/yr x 0.80 = 135,200 lb/yr

Therefore, the MACT emissions are:

Medium model plant: 78,000 lb/yr - 62,400 lb/yr = 15,600 lb/yr

Large model plant: 169,000 lb/yr - 135,200 lb/yr = 33,800 lb/yr

Secondary Air Emissions

Secondary air impacts are generated by the operation of certain control systems. For example, incineration may produce nitrogen oxides (NO_x) and carbon monoxide (CO) from the combustion of hydrocarbons. In contrast, carbon adsorbers do not cause any secondary impacts. The only emissions from a carbon adsorber are the original pollutants present in the air stream that are not removed by the carbon adsorber. These are taken into account in the control efficiency of the device. Additionally, secondary air impacts are generated by the use of products that contain different or additional HAP's from the baseline products. No product substitutions are necessary for MACT. Therefore, no secondary air impacts are expected.

Wastewater Generation

There are three possible sources of water effluent from carbon adsorbers: water used to cool the inlet gas stream, cooling water used to condense the regenerate steam, and the condensed regenerate steam. Cooling the inlet gas stream will not be necessary in this case since the process is typically operated at ambient temperatures. Therefore, this source is eliminated. Assuming that a regenerative carbon adsorption system is employed, the other two water sources will be present.

The quantity of cooling water has been calculated using the EPA OAQPS Control Cost Manual.[6] The cooling water needed for either the medium or the large model plant is approximately 12,447,000 gallons per year. However, the cooling water for the condenser does not come into contact with the contaminated steam; therefore, the water does not become contaminated. The cooling water can then be discharged directly from the facility, or used in other operations within the facility.

The quantity of regenerate steam, also calculated using the EPA OAQPS Control Cost Manual,[7] is 3,629,000 pounds per year for either the medium or the large model plant, which is equivalent to 435,290 gallons of water per year. The steam is used to strip the captured solvent from the carbon beds. The steam is then condensed, separated from the solvent, and disposed of as wastewater. The solvent is typically reused in the maskant process or sold back to the maskant manufacturer.

Energy Consumption

Electricity will be consumed by the blower used to dry and cool the carbon beds, as well as in the operation of the carbon adsorber fan and the water pump. The EPA OAQPS Control Cost Manual[8] has been used to calculate the electricity usage for each. The energy usage for the drying and cooling fan, the adsorber fan, and the water pump are 8,090, 161,775, and 6,190 kilowatt-hr/yr, respectively. Energy will also be consumed in the generation of the regenerate steam, which will most likely come from a gas fired boiler. The energy required to raise water from ambient temperature (60°F) to steam is the latent heat of evaporation, which is approximately 1059.9 Btu/pound of steam generated.[9] The quantity of steam need for the regeneration of the carbon is 3,629,000 pounds as detailed above in the water impacts section. Therefore, the energy required to produce the regenerate steam is:

1059.9 Btu/pound x 3,629,000 pounds/yr = 3.85×10^9 Btu/year

3.85×10^9 Btu/year x 0.000293 kW-hr/Btu = 1,127,000 kW-hr/yr

Table 3 summarizes the energy impact of the carbon adsorber.

TABLE 3
ENERGY IMPACTS OF A CARBON ADSORBER

	Item	Energy Impact All Model Plants (kW-hr/yr)
1.	Adsorber fan	161,775
2.	Drying and cooling fan	8,090
3.	Water pump	6,190
4.	Steam generation	1,127,000
	Total	1,303,055

Solid Waste Generation

The carbon beds must be replaced approximately every 5 years, resulting in the disposal of hazardous waste. The volume of carbon, calculated from the EPA OAQPS Control Cost Manual,[10] is 1,440 ft^3/5 years or 290 ft^3/yr. The density of carbon is 25 to 35 lb/ft^3.[11] Therefore, using the midpoint of 30 lb/ft^3, the solid waste is 8,700 lb/yr. This solid waste is typically incinerated.

As stated in the baseline section, solvent based maskant appears to have an indefinite life in a dip tank operation. Therefore, disposal of unused solvent based maskant will not be necessary.

The dried maskant film that is removed from components after scribing and chemical milling must be disposed of as waste. The pounds of dried maskant film will be the same as the pounds of baseline solid waste. Therefore, there is no net impact from the dried maskant. The total solid waste impact of implementing the MACT standard is equal to the total MACT solid waste generation minus the total baseline solid waste generation.

Medium model plant: 49,260 lb/yr - 40,560 lb/yr = 8,700 lb/yr

Large model plant: 96,580 lb/yr - 87,880 lb/yr = 8,700 lb/yr

MACT IMPACTS - WATERBORNE MASKANTS

MACT for chemical milling maskant application can be based on the use of waterborne maskants. Air impacts are related to a reduction in solvent in the waterborne maskants. Additionally, energy impacts are related to the use of curing ovens that are not used in the baseline process of solvent based maskant. Solid waste impacts are related to the thickness and solids content of waterborne maskants. There are no additional water impacts associated with the use of waterborne maskant compared to solvent based maskant.

Primary Air Emissions

There will be a reduction in HAP's emitted with the use of waterborne maskants due to the replacement of solvents by water. In order to accurately compare the reduction in emissions, the equivalent volume of waterborne maskant that will replace the baseline volume of solvent based maskant must be determined. The equivalent volume is calculated on a solids applied basis utilizing the percent by volume of solids and the required dry film thickness of each maskant.

One vendor of solvent based maskants reported that a typical solvent based maskant is 25 percent by volume solids and requires a 0.012 inch dry film thickness.[12] To calculate the surface area coverage per gallon of maskant:

1 square foot of surface area covered with a dry film thickness of 0.012 inches (0.001 feet) equates to a solids volume of 0.001 ft^3.

$$\frac{1\ ft^2\ \text{surface area}}{0.001\ ft^3\ \text{solids}} \times \frac{1\ \ ft^3\ \text{solids}}{7.48\ \text{gal solids}} \times \frac{0.25\ \text{gal solids}}{\text{gal maskant}} = \frac{33\ ft^2}{\text{gal maskant}}$$

One vendor of waterborne maskants reported that a typical waterborne maskant is 44 percent by volume solids[13] and requires a 0.019 inch dry film thickness.[14] To calculate the surface area coverage per gallon of maskant:

1 square foot of surface area covered with a dry film thickness of 0.019 inches (0.0016 feet) equates to a solids volume of 0.0016 ft^3.

$$\frac{1\ \text{ft}^2\ \text{surface area}}{0.0016\ \text{ft}^3\ \text{solids}} \times \frac{1\ \ \text{ft}^3\ \ \text{solids}}{7.48\ \text{gal solids}} \times \frac{0.44\ \text{gal solids}}{\text{gal maskant}} = \frac{37\ \text{ft}^2}{\text{gal maskant}}$$

Surface area coverage (baseline):

Medium model plant: 12,000 gal maskant x 33 ft^2/gal maskant= 396,000 ft^2

Large model plant: 26,000 gal maskant x 33 ft^2/gal maskant = 858,000 ft^2

Equivalent waterborne maskant volume:

Medium model plant: 396,000 ft^2/yr x 1 gal maskant/37 ft^2 = 10,700 gal/yr

Large model plant: 858,000 ft^2/yr x 1 gal maskant/37 ft^2 = 23,200 gal/yr

To calculate emissions, the waterborne maskant volumes need to be presented in gallons less water per year. One vendor stated that typical waterborne maskants contain 45 percent by volume water.[15] Therefore, the maskant usage less water is:

Medium model plant: 10,700 gal/yr - (10,700 gal/yr x 0.45) = 5,880 gal less water/yr

Large model plant: 23,200 gal/yr - (23,200 gal/yr x 0.45) = 12,760 gal less water/yr

With a HAP content of 1.3 lb/gal less water, waterborne maskant emissions are:

Medium model plant: 5,880 gal less water/yr x 1.3 lb/gal less water = 7,640 lb/yr

Large model plant: 12,760 gal less water/yr x 1.3 lb/gal less water = 16,590 lb/yr

MACT primary air emission reductions are baseline primary air emissions minus MACT primary air emissions:

Medium model plant: 78,000 lb/yr - 7,640 lb/yr = 70,360 lb/yr

Large model plant: 169,000 lb/yr - 16,590 lb/yr = 152,410 lb/yr

Secondary Air Emissions

Secondary air impacts are often generated by the operation of certain control systems. For example, incineration may produce nitrogen oxides (NO_x) and carbon monoxide (CO) from the combustion of hydrocarbons. The use of waterborne maskants does not require control equipment. Additionally, secondary air impacts are generated by the use of products that contain different or additional HAP's from the baseline products. Solvent based maskants typically contain perchloroethylene. In contrast, waterborne maskants typically contain toluene or styrene. Therefore, any solvent emissions will differ with the use of solvent based or waterborne maskants. However, all of these solvents are HAP's and are taken into account in the primary air impacts. Therefore, no additional secondary air impacts are expected.

Wastewater Generation

While waterborne maskants require water for dilution, one vendor stated that this water will have a negligible effect on the overall water consumption of the model plants.[16] Consequently, water impacts were assumed to be negligible.

Energy Consumption

Waterborne maskants require a final bake to cure the coating. Facilities would have to install ovens for this purpose, which will consume energy. According to one vendor, an oven (6' x 10' x 6' deep) that runs at 500°F consumes 60 kilowatts.[17] The ovens typically used in the chemical milling maskant curing process are larger and run at lower temperatures. However, this energy requirement will be used for this energy impact estimation. Two ovens are typically run 6 to 8 hours a day, 5 days a week, and 52 weeks a year.[18,19] Assuming the worst case where the ovens run 8 hours per day, or 2,080 hours per year, the energy requirement for the oven is:

60 kilowatts x 2,080 hr/yr x 2 ovens = 249,600 kilowatt-hr/yr

Solid Waste Generation

According to one vendor,[20] waterborne maskant appears to have an indefinite life in a dip tank operation with proper maintenance. According to another vendor,[21] waterborne maskant has a limited shelf life. However, as this second vendor noted, waterborne maskants have not been in service at any facility long enough to determine a probable shelf life. Therefore, it will be assumed that disposal of unused waterborne maskant from a dip tank operation will not be necessary.

The dried maskant film that is removed from components after drying and chemical milling must be disposed of as waste. According to one vendor,[22] a typical waterborne maskant has 4.0 to 4.8 pounds of solids per gallon of coating. A second vendor stated that their two coat system has an average of 4.7 pounds of solids per gallon of coating.[23] An average of 4.5 pounds of solids per gallon will be used in the calculations. Total solid waste disposal for MACT is:

Medium model plant: 10,700 gal/yr x 4.5 lb solids/gal = 48,150 lb solids/yr

Large model plant: 23,200 gal/yr x 4.5 lb solids/gal = 104,400 lb solids/yr

The MACT solid waste impact is then the amount of solid waste generated by MACT minus the baseline solid waste:

Medium model plant: 48,150 lb solids/yr - 40,560 lb solids/yr = 7,590 lb solids/yr

Large model plant: 104,400 lb solids/yr - 87,880 lb solids/yr = 16,520 lb solids/yr

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MEMORANDUM

TO: Vickie Boothe
US EPA:ESD

FROM: David Hendricks
Pacific Environmental Services, Inc. (PES)

DATE: August 25, 1993
L:\N019

SUBJECT: Environmental Impacts for Aircraft Depainting

The purpose of this memo is to calculate and compare baseline and MACT environmental impacts for aircraft depainting. Baseline consists of using methylene chloride based chemical strippers. The MACT floor specifies no HAP emissions from chemical depainting. Three basic methods have been identified for meeting the MACT floor. These methods are (1) media blasting such as plastic and wheat starch; (2) both acidic and alkaline non-HAP chemical strippers; and (3) reducing the amount of outer surface area of the aircraft that is coated. The data for the first option was derived mainly from military facilities. Since it is unknown whether the available data is applicable to commercial facilities, the environmental impacts for the first option were evaluated only for military model plants. Similarly, the available data for the second and third options was derived from commercial facilities. Since it is unknown whether the available data is applicable to military facilities, and the third option applies only to commercial aircraft, the environmental impacts for the second and third options were evaluated only for commercial model plants. All impact analyses also include an exemption of 20 gallons of chemical stripper per aircraft for spot stripping and decal removal.

Tables 1, 2, and 3 summarize the baseline and MACT environmental impacts for each of the options. The assumptions and calculations used in determining these impacts are detailed below.

The implementation of the first option is expected to result in a 98 percent reduction in air emissions and a 100 percent reduction in water emissions. Additionally, solid waste will be increased 4.8 times. Energy usage will increase by 300,000 to

TABLE 1

ENVIRONMENTAL IMPACTS OF IMPLEMENTING PLASTIC MEDIA BLASTING

Item	Model Plant		
	Small	Medium	Large
1. Baseline Emissions (lbs/yr)	425,700	588,070	3,185,780
2. MACT Emissions (lbs/yr)	13,230	14,700	22,050
3. MACT Emission Reduction (lbs/yr)	412,470	573,370	3,163,730
4. Baseline Wastewater Generation (gal/yr)	1,516,900	2,095,500	11,352,000
5. MACT Wastewater Generation (gal/yr)	0	0	0
6. MACT Implementation Wastewater Reductions (gal/yr)	1,516,900	2,095,500	11,352,000
7. Baseline Energy Consumption (kW-hr/yr)	0	0	0
8. MACT Energy Consumption (kW-hr/yr)	308,620	426,340	2,309,620
9. MACT Implementation Energy Consumption (kW-hr/yr)	308,620	426,340	2,309,620

TABLE 1 CONTINUED

Item	Model Plant		
	Small	Medium	Large
10. Baseline Solid Waste Generation (lbs/yr)	41,990	58,010	314,240
11. MACT Solid Waste Generation (lbs/yr)	248,980	340,020	1,778,650
12. MACT Implementation Solid Waste Generation (lbs/yr)	206,990	282,010	1,464,410

TABLE 2

ENVIRONMENTAL IMPACTS OF IMPLEMENTING NON-HAP STRIPPERS

Item	Model Plant	
	Small	Medium
1. Baseline HAP Emissions (lb/yr)	44,540	133,180
2. MACT HAP Emissions (lb/yr)	2,500	6,760
3. MACT HAP Emission Reduction (lb/yr)	42,040	126,420
4. Baseline Wastewater Generation (gal/yr)	19,670	58,750
5. MACT Wastewater Generation (gal/yr)	200	530
6. MACT Implementation Wastewater Reductions(gal/yr)	19,470	58,220
7. Baseline Solid Waste Generation (gal/yr)	4,670	13,950
8. MACT Solid Waste Generation (gal/yr)	6,890	20,560
9. MACT Implementation Solid Waste Generation (gal/yr)	2,220	6,610

TABLE 3

ENVIRONMENTAL IMPACTS OF REDUCING THE OUTER SURFACE AREA OF THE AIRCRAFT THAT IS COATED

Item	Model Plant	
	Small	Medium
1. Baseline HAP Emissions (lb/yr)	44,540	133,180
2. MACT HAP Emissions (lb/yr)	2,500	6,760
3. MACT HAP Emission Reduction (lb/yr)	42,040	126,420
4. Secondary Air Emissions - Baseline Repainting (lb/yr)	4,470	13,800
5. Secondary Air Emissions - MACT Repainting (lb/yr)	220	690
6. Secondary Air Emission Reduction - MACT Implementation (lb/yr)	4,250	13,110
7. Baseline Wastewater Generation (gal/yr)	19,670	58,750
8. MACT Wastewater Generation (gal/yr)	980	2,940
9. MACT Implementation Wastewater Reductions (gal/yr)	18,690	55,810
10. Baseline Solid Waste Generation (gal/yr)	4,670	13,950
11. MACT Solid Waste Generation (gal/yr)	230	700
12. MACT Implementation Solid Waste Reductions (gal/yr)	4,440	13,250

3,000,000 kilowatt-hours per year depending on the size of the model plant.

The implementation of the second option is expected to result in a 94 percent reduction in air emissions. Additionally, this option is expected to reduce wastewater by 99 percent and increase solid waste by 47 percent.

The implementation of the third option is expected to result in a 94 percent reduction in air emissions. Additionally, this option is expected to reduce secondary air emissions, wastewater, and solid waste by 95 percent.

OPTION 1 - PLASTIC MEDIA BLASTING

BASELINE

Baseline has been defined as depainting fully painted aircraft with methylene chloride based strippers with no emission controls in place. Many military facilities are currently using plastic media blasting. Therefore, for the purpose of this option, data from military facilities will be used for both baseline and MACT. The total outer surface area of aircraft reworked annually for each military model plant is:

Small model plant[1]: 137,900 ft^2/yr

Medium model plant[2,3]: 190,500 ft^2/yr

Large model plant[4]: 1,032,000 ft^2/yr

Primary Air Emissions

From data provided by Robins Air Force Base (AFB)[5], it takes 0.42 gal/ft^2 to depaint military aircraft using methylene chloride based strippers. The density of a typical methylene chloride stripper is 10.5 pounds per gallon and 70 percent of the stripper by weight is methylene chloride.[6] The other 30 percent is typically soaps, detergents, water, or non-HAP acids.[7] It is assumed from information in the Section 114 responses that 100 percent of the methylene chloride is lost as air emissions.[8] The baseline emissions of stripper by model plant are:

Small model plant: 137,900 ft^2/yr x 0.42 gal/ft^2 x 10.5 lb/gal x 0.7 = 425,700 lb/yr

Medium model plant: 190,500 ft^2/yr x 0.42 gal/ft^2 x 10.5 lb/gal x 0.7 = 588,070 lb/yr

Large model plant: 1,032,000 ft^2/yr x 0.42 gal/ft^2 x 10.5 lb/gal x 0.7 = 3,185,780 lb/yr

Wastewater Generation

The baseline method of depainting involves the use of methylene chloride based strippers followed by a water rinse. The volume of the rinse water has been quantified by both Lockheed Ontario and Robins AFB. Lockheed Ontario uses approximately 6 gallons of rinse water per square foot of aircraft stripped.[9] Robins AFB reports a range of 8 to 25 gallons per square foot,[10] the midpoint being 16 gal/ft^2. Therefore, an industry average of approximately 11 gallons of rinse water is used per square foot of aircraft stripped. The baseline gallons of rinse water by model plant are:

Small model plant: 137,900 ft^2/yr x 11 gal/ft^2 = 1,516,900 gal/yr

Medium model plant: 190,500 ft^2/yr x 11 gal/ft^2 = 2,095,500 gal/yr

Large model plant: 1,032,000 ft^2/yr x 11 gal/ft^2 = 11,352,000 gal/yr

Energy Consumption

Other than a ventilation system, the baseline method of depainting consumes very little energy. Therefore, the energy consumption of methylene chloride based depainting is assumed to be insignificant compared to the energy consumption of the facility as a whole.

Solid Waste Generation

The baseline methylene chloride based depainting process produces a spent stripper sludge that must be disposed. The sludge may be treated on-site or shipped off-site for disposal. No data on waste disposal is available from military facilities. Delta Air Lines specified that 0.029 gallons of waste stripper is disposed of per square foot of surface area stripped.[11,12] The density of a typical methylene chloride stripper is 10.5 pounds per gallon. Assuming that the density of the waste stripper is approximately equal to the density of the original stripper, the baseline pounds of solid waste disposed by model plant are:

Small model plant: 137,900 ft^2/yr x 0.029 gal/ft^2 x 10.5 lb/gal = 41,990 lb/yr

Medium model plant: 190,500 ft^2/yr x 0.029 gal/ft^2 x 10.5 lb/gal = 58,010 lb/yr

Large model plant: 1,032,000 ft^2/yr x 0.029 gal/ft^2 x 10.5 lb/gal = 314,240 lb/yr

MACT

As previously stated, the MACT floor specifies no HAP emissions from chemical depainting. This can be achieved through the use of dry media blasting techniques. Additionally, the regulation includes an exemption of 20 gallons of stripper per airplane stripped. As a result of MACT, HAP air emissions and wastewater generation will be virtually eliminated. Energy usage will increase due to electrical consumption by the blasting equipment. Solid waste generated will be in the form of paint chips and spent plastic media rather than spent stripper sludge.

Primary Air Emissions

The MACT standards are expected to virtually eliminate HAP emissions with the use of plastic media blasting. MACT air emissions will equal the approximate number of aircraft stripped per model plant[13,14,15] multiplied by the 20 gallon exemption. As stated in the baseline section, the density of a typical methylene chloride stripper is 10.5 pounds per gallon and 70 percent of the stripper by weight is methylene chloride. The other 30 percent is typically soaps, detergents, water, or non-HAP acids. Additionally, it is assumed from information in the Section 114 responses that 100 percent of the methylene chloride is lost as air emissions. The HAP emissions by model plant are:

Small model plant: 90 aircraft/yr x 20 gal x 10.5 lb/gal x 0.7 = 13,230 lb/yr

Medium model plant: 100 aircraft/yr x 20 gal x 10.5 lb/gal x 0.7 = 14,700 lb/yr

Large model plant: 150 aircraft/yr x 20 gal x 10.5 lb/gal x 0.7 = 22,050 lb/yr

The reduction in emissions will be equivalent to the baseline emissions minus the MACT air emissions:

Small model plant: 425,700 lb/yr - 13,230 lb/yr = 412,470 lb/yr

Medium model plant: 588,070 lb/yr - 14,700 lb/yr = 573,370 lb/yr

Large model plant: 3,185,780 lb/yr - 22,050 lb/yr = 3,163,730 lb/yr

Secondary Air Emissions

Secondary air emissions are generated by the operation of certain control systems. For example, incineration may produce nitrogen oxides (NO_x) and carbon monoxide (CO) from the combustion of hydrocarbons. Additionally, secondary air emissions are generated by the use of products that contain different or additional HAP's from the baseline products. The use of plastic media blasting does not require control equipment or product substitutions. However, a small amount of HAP emissions occur in the form of particulates from the blasting process. These particulates contain inorganic HAP components of the paint such as chromium and cadmium. The level of these emissions has not been quantified, but is believed to be very small compared to overall baseline emissions. Therefore, secondary air emissions are expected to be insignificant.

Wastewater Generation

Assuming a complete switch to plastic media blasting, the baseline rinse water usage would be eliminated. Water would be used only to rinse the areas stripped with the exempt 20 gallons of chemical stripper. As this 20 gallons can be used to strip any area on the aircraft, the square footage stripped is difficult to quantify, but is expected to be insignificant compared to the baseline wastewater generated. Therefore, the reduction in wastewater will be equivalent to the baseline wastewater disposal:

Small model plant: 1,516,900 gal/yr wastewater reduced

Medium model plant: 2,095,500 gal/yr wastewater reduced

Large model plant: 11,352,000 gal/yr wastewater reduced

Energy Consumption

The plastic media blasting systems consume electricity. According to Lockheed Ontario,[16] their plastic media blasting equipment requires a 100 horsepower air compressor system. Lockheed also stated that it takes approximately 0.03 hours to strip a square foot of aircraft.[17] Therefore, the energy used per model plant is:

Small model plant: 100 hp x 0.746 kW/hp x 0.03 hr/ft^2 x 137,900 ft^2/yr = 308,620 kW-hr/yr

Medium model plant: 100 hp x 0.746 kW/hp x 0.03 hr/ft^2 x 190,500 ft^2/yr = 426,340 kW-hr/yr

Large model plant: 100 hp x 0.746 kW/hp x 0.03 hr/ft^2 x 1,032,000 ft^2/yr = 2,309,620 kW-hr/yr

Solid Waste Generation

The blasting process produces paint chips mixed with some blasting media. Due to the metal content of the paint chips, this must be disposed of as a hazardous waste. The typical method of disposal is by landfill. According to Robins AFB,[18] an estimate of the amount of paint chips produced per square foot stripped is 0.15 to 0.25 pounds. Additionally, approximately 1.5 pounds per square foot is lost as waste.[19] Therefore, the solid waste generated by plastic media blasting is approximately 1.7 pounds/ft^2. The pounds of solid waste by model plant are:

Small model plant: 137,900 ft^2/yr x 1.7 lb/ft^2 = 234,430 lb/yr

Medium model plant: 190,500 ft^2/yr x 1.7 lb/ft^2 = 323,850 lb/yr

Large model plant: 1,032,000 ft^2/yr x 1.7 lb/ft^2 = 1,754,400 lb/yr

Additionally, solid waste is generated from the use of the 20 gallons of exempt stripper. Delta Air Lines specified that 0.77 gallons of stripper waste is disposed of per gallon of original stripper used.[20] Using the original chemical stripper density of 10.5 lb/gal, the pounds of solid waste by model plant are:

Small model plant: 90 aircraft/yr x 20 gal stripper/aircraft x 0.77 gal waste/gal stripper x 10.5 lb/gal = 14,550 lb/yr

Medium model plant: 100 aircraft/yr x 20 gal stripper/aircraft x 0.77 gal waste/gal stripper x 10.5 lb/gal = 16,170 lb/yr

Large model plant: 150 aircraft/yr x 20 gal stripper/aircraft x 0.77 gal waste/gal stripper x 10.5 lb/gal = 24,250 lb/yr

The total MACT solid waste generated is:

Small model plant: 234,430 lb/yr + 14,550 lb/yr = 248,980 lb/yr

Medium model plant: 323,850 lb/yr + 16,170 lb/yr = 340,020 lb/yr

Large model plant: 1,754,400 lb/yr + 24,250 lb/yr = 1,778,650 lb/yr

Therefore, the increase in solid waste with the implementation of MACT is the amount of solid waste generated by the MACT solid waste minus the baseline solid waste:

Small model plant: 248,980 lb/yr - 41,990 lb/yr = 206,990 lb/yr

Medium model plant: 340,020 lb/yr - 58,010 lb/yr = 282,010 lb/yr

Large model plant: 1,778,650 lb/yr - 314,240 lb/yr = 1,464,410 lb/yr

Noise Generation

Blasting equipment generates noise during the operation of the air compressor and the blasting nozzles. However, this noise impact is expected to be insignificant when compared to the model plant as a whole. Therefore, it is expected that the overall effect of increased noise volume is negligible.

OPTION 2 - NON-HAP STRIPPER AND
OPTION 3 - REDUCED PAINT SCHEME

BASELINE

The baseline for Options 2 and 3 has been defined as depainting fully-painted aircraft with methylene chloride based chemical strippers. Since Option 2 and 3 are demonstrated at commercial facilities, data for the baseline has been obtained from commercial facilities. The following parameters define baseline:

Total number of aircraft reworked annually

Small model plant	-	17 narrow body
Medium model plant[21,22]	-	35 narrow body 11 wide body

The number of aircraft reworked annually for the small model plant was extrapolated from the medium model plant data. Total outer surface area of aircraft reworked annually:

Small model plant[23]	-	163,900 ft^2
Medium model plant[24]	-	489,610 ft^2

Primary Air Emissions

From data provided by TWA and Delta, it takes 0.037 gal/ft^2 to depaint aircraft using methylene chloride based strippers.[25,26] Baseline stripper usage was calculated using these data and the baseline outer surface area per model plant. As stated in Option 1, the density of a typical methylene chloride stripper is 10.5 pounds per gallon, and 70 percent of the stripper by weight is methylene chloride. The other 30 percent is typically soaps, detergents, water, or non-HAP acids. Additionally, Delta Air Lines specified that 0.77 gallons of stripper waste is disposed of per gallon of original stripper used.

Stripper usage and disposal:

Small model plant: 163,900 ft^2/yr x 0.037 gal/ft^2 = 6,060 gal/yr

6,060 gal/yr x 0.77 = 4,670 gal for disposal

Medium model plant: 489,610 ft^2/yr x 0.037 gal/ft^2 = 18,120 gal/yr

18,120 gal/yr x 0.77 = 13,950 gal for disposal

Stripper Emissions (assuming 100 percent of the methylene chloride is emitted):

Small model plant: 6,060 gal/yr x 10.5 lb/gal x 0.7 = 44,540 lb/yr

Medium model plant: 18,120 gal/yr x 10.5 lb/gal x 0.7 = 133,180 lb/yr

Wastewater Generation

According to United Airlines in San Francisco, approximately 100,000 gallons of wastewater were generated from their depainting operations in 1990.[27] United Airlines depainted approximately 856,000 ft^2 of surface area during this year, resulting in the generation of 0.12 gallons of wastewater per square foot of outer surface area.[28] Applying this rate to the small and medium model plants:

Baseline Wastewater:

Small model plant: 163,900 ft^2/yr x 0.12 gal/ft^2 = 19,670 gal/yr

Medium model plant: 489,610 ft^2/yr x 0.12 gal/ft^2 = 58,750 gal/yr

OPTION 2 - NON-HAP STRIPPER

MACT IMPACTS

As stated previously, this option is based on using non-HAP strippers. At least one commercial facility uses non-HAP strippers to depaint aircraft. Data from this facility will be used for the purpose of this option. Additionally, 20 gallons of chemical stripper per aircraft stripped will be allowed as an exemption. As a result of MACT, air emissions, wastewater, and solid waste will be reduced.

Primary Air Emissions

The MACT standards are expected to virtually eliminate HAP emissions with the use of non-HAP strippers. Since the total number of aircraft reworked annually is 17 for a small model plant and 46 for a medium model plant, MACT air emissions will equal the approximate number of aircraft stripped per model plant multiplied by the 20 gallon exemption. As stated in the Option 1 baseline section, the density of a typical methylene chloride stripper is 10.5 pounds per gallon and 70 percent of the stripper by weight is methylene chloride. Additionally, it is assumed that 100 percent of the methylene chloride is lost as air emissions. The MACT emissions of stripper by model plant are:

Small model plant: 17 aircraft/yr x 20 gal x 10.5 lb/gal
x 0.7 = 2,500 lb/yr

Medium model plant: 46 aircraft/yr x 20 gal x 10.5 lb/gal
x 0.7 = 6,760 lb/yr

The reduction in emissions will be equivalent to the baseline emissions minus the MACT air emissions:

Small model plant: 44,540 lb/yr - 2,500 lb/yr = 42,040 lb/yr

Medium model plant: 133,180 lb/yr - 6,760 lb/yr = 126,420 lb/yr

Secondary Air Emissions

Secondary air emissions are often generated by the operation of certain control systems. For example, incineration may produce nitrogen oxides (NO_x) and carbon monoxide (CO) from the combustion of hydrocarbons. Additionally, secondary air emissions are generated by the use of products that contain different or additional HAP's from the baseline products. The MACT floor does not require control equipment and stripper substitutions must be non-HAP products. Some non-HAP strippers currently in use contain VOC. One non-HAP stripper has a VOC limit of 3.33 pounds per gallon of stripper.[29] However, the stripper has an evaporation limit less than one and a very low vapor pressure. It is expected that VOC emissions from this stripper are very low and associated secondary air emissions would be insignificant.

Wastewater Generation

The MACT method of depainting involves the use of non-HAP strippers followed by a water rinse. The volume of the rinse water has been quantified by Delta Airlines. Delta uses approximately 0.58 gallons of rinse water per gallon of non-HAP stripper used.[30] Assuming that each facility uses the allowed 20 gallons of stripper, the MACT gallons of rinse water by model plant are:

Small model plant: 17 aircraft/yr x 20 gal stripper/aircraft stripped x 0.58 gal water/gal stripper = 200 gal/yr

Medium model plant: 46 aircraft/yr x 20 gal stripper/aircraft stripped x 0.58 gal water/gal stripper = 530 gal/yr

The water impact is then calculated by subtracting the amount of wastewater generated by MACT from that generated by baseline:

Small model plant: 19,670 gal/yr - 200 gal/yr = 19,470 gal/yr

Medium model plant: 58,750 gal/yr - 530 gal/yr = 58,220 gal/yr

Energy Consumption

Other than a ventilation system, the non-HAP stripper method of depainting consumes very little energy. Therefore, the energy impact of non-HAP depainting is assumed to be insignificant compared to the energy consumption of the facility as a whole.

Solid Waste Generation

The non-HAP depainting process produces a spent stripper sludge that must be disposed. The sludge may be treated on-site in a standard wastewater treatment facility. A Delta Airlines representative stated that very little of the non-HAP stripper evaporates[31] and 0.042 gallons of stripper is used per square foot of aircraft stripped.[32] Assuming that all of the stripper is disposed as waste, the baseline pounds of solid waste disposed by model plant are:

Small model plant: 163,900 ft^2/yr x 0.042 gal/ft^2 = 6,890 gal/yr

Medium model plant: 489,610 ft^2/yr x 0.042 gal/ft^2 = 20,560 gal/yr

The solid waste impact is then calculated by subtracting the amount of solid waste generated by baseline from that generated by MACT:

Small model plant: 6,890 gal/yr - 4,670 gal/yr = 2,220 gal/yr

Medium model plant: 20,560 gal/yr - 13,950 gal/yr = 6,610 gal/yr

OPTION 3 - REDUCED PAINT SCHEME

MACT IMPACTS

As stated previously, this option is based on partially painting the aircraft and polishing the unpainted bare metal portion of the aircraft. As a result of MACT, air emissions, wastewater, and solid waste will be reduced. This option is demonstrated at commercial facilities and data from these facilities are used below.

Primary Air Emissions

The MACT standards are expected to virtually eliminate HAP emissions with the use of the reduced paint scheme. Facilities that currently use a reduced paint scheme are able to hand sand the tail and speed stripes, areas that are reworked during a typical maintenance stop. The wings, which are typically painted, are seldom stripped. Therefore, the 20 gallon exemption is adequate for decal and spot stripping. Since the total number of aircraft reworked annually is 17 for a small model plant and 46 for a medium model plant, MACT air emissions will equal the approximate number of aircraft stripped per model plant multiplied by the 20 gallon exemption. As stated in the baseline section, the density of a typical methylene chloride stripper is 10.5 pounds per gallon and 70 percent of the stripper by weight is methylene chloride. Additionally, it is assumed that 100 percent of the methylene chloride is lost as air emissions. The MACT emissions of stripper by model plant are:

Small model plant: 17 aircraft/yr x 20 gal x 10.5 lb/gal x 0.7 = 2,500 lb/yr

Medium model plant: 46 aircraft/yr x 20 gal x 10.5 lb/gal x 0.7 = 6,760 lb/yr

The reduction in emissions will be equivalent to the baseline emissions minus the MACT air emissions:

Small model plant: 44,540 lb/yr - 2,500 lb/yr = 42,040 lb/yr

Medium model plant: 133,180 lb/yr - 6,760 lb/yr = 126,420 lb/yr

Secondary Air Emissions

Secondary air emissions are often generated by the operation of certain control systems. For example, incineration may produce nitrogen oxides (NO_x) and carbon monoxide (CO) from the combustion of hydrocarbons. Additionally, secondary air emissions are generated by the use of products that contain different or additional HAP's from the baseline products. The MACT floor does not require control equipment. However, the regulations may result in the use of a polish on the unpainted portions of the aircraft. A polish is currently demonstrated in the industry that contains no HAP's.[33] A polish used by a second facility contains 35 percent kerosene.[34] Kerosene, a derivative of petroleum, typically contains a majority of aliphatic hydrocarbons. Any HAP's that may be in the kerosene (typically aromatic hydrocarbons) are in very small quantities and may be considered insignificant.

Another secondary impact affected by this option is the reduced emissions from repainting. Reworking an aircraft includes repainting as well as stripping and a reduced paint scheme reduces the amount of paint and, therefore, the amount of emissions from the paint. Based on information presented in the September 1991 issue of Industrial Finishing concerning Boeing's Seattle operations, 125 gallons of paint are required for a completely painted narrow body aircraft and 200 gallons for a completely painted wide body aircraft.[35]

Baseline Paint Usage:

Small model plant: 17 narrow body/yr x 125 gal/narrow body = 2,130 gal/yr

Medium model plant: 35 narrow body/yr x 125 gal/narrow body + 11 wide body/yr x 200 gal/wide body = 6,570 gal/yr

Using a weighted average HAP content of 2.1 lbs/gal for the primer and topcoat as determined from Section 114 questionnaire data, the annual emissions from repainting of fully-painted aircraft are:

Small model plant: 2,130 gal/yr x 2.1 lbs/gal = 4,470 lbs/yr

Medium model plant: 6,570 gal/yr x 2.1 lbs/gal = 13,800 lbs/yr

USAir, one of the principal airlines using aircraft with unpainted aluminum clad outer skins, leaves 95 percent of the total outer surface of the aircraft uncoated.[36] Assuming that 95 percent of the outer surface is unpainted and applying that percentage to the baseline repainting emissions gives the MACT emissions.

Small model plant: 4,470 lbs/yr x (1-0.95) = 220 lbs/yr

Medium model plant: 13,800 lbs/yr x (1-0.95) = 690 lbs/yr

The impact is then calculated by subtracting the emissions generated by MACT from that generated by baseline:

Small model plant: 4,470 lbs/yr - 220 lbs/yr = 4,250 lbs/yr

Medium model plant: 13,800 lbs/yr - 690 lbs/yr = 13,110 lbs/yr

Wastewater Generation

As stated above, USAir leaves 95 percent of the total outer surface of the aircraft uncoated. Assuming that 95 percent of the outer surface is unpainted and applying that percentage to the baseline wastewater disposal gives the MACT wastewater disposal.

Small model plant: 19,670 gal/yr x (1-0.95) = 980 gal/yr

Medium model plant: 58,750 gal/yr x (1-0.95) = 2,940 gal/yr

The water impact is then calculated by subtracting the amount of wastewater generated by MACT from that generated by baseline:

Small model plant: 19,670 gal/yr - 980 gal/yr = 18,690 gal/yr

Medium model plant: 58,750 gal/yr - 2,940 gal/yr = 55,810 gal/yr

Energy Consumption

Since the generation of wastewater and solid waste decreases under MACT, the energy consumed in the treatment and disposal of the waste will also decrease proportionally. However, no data were available to quantify this reduction in energy consumption.

Solid Waste Generation

Similar to water impacts, assuming that 95 percent of the outer surface is unpainted and applying that percentage to the baseline solid waste disposal gives the MACT solid waste disposal.

Small model plant: 4,670 gal/yr x (1-0.95) = 230 gal/yr

Medium model plant: 13,950 gal/yr x (1-0.95) = 700 gal/yr

Solid waste is also generated from the repainting process. However, the amount of solid waste cannot be quantified since it is directly related to the work practice standards of each facility. For the purpose of this analysis, the solid waste generated from repainting was assumed to be negligible.

The solid waste impact is then calculated by subtracting the amount of solid waste generated by MACT from that generated by baseline:

Small model plant: 4,670 gal/yr - 230 gal/yr = 4,440 gal/yr

Medium model plant: 13,950 gal/yr - 700 gal/yr = 13,250 gal/yr

References

1. Section 114 Questionnaire Response from Grumman Corporation St. Augustine Operations Facility in St. Augustine, Florida.

2. Section 114 Questionnaire Responses from Lockheed Aircraft Services Ontario Facility in Ontario, California.

3. Section 114 Questionnaire Responses from Naval Aviation Depot in Alameda, California.

4. Section 114 Questionnaire Response from Warner Robins Air Logistics Center, Robins Air Force Base, in Warner Robins, Georgia.

5. Reference 4.

6. Letter. J. Stafford, Ardrox Inc., to K. Feser, PES. February 2, 1993. Cost of and material safety data sheets for paint strippers.

7. Telephone Report. K. Feser, PES, and D. DeHaye, Turco, Inc., on December 16, 1992.

8. Section 114 Questionnaire Response from American Airlines Maintenance and Engineering Center in Tulsa, Oklahoma.

9. Reference 2.

10. Reference 4.

11. Paint Stripping, Processes developed and used by Delta Air Lines, Inc. Technical Operations Center, Atlanta, Georgia, May 19, 1993.

12. Letter. D. Collier, Air Transport Association, to V. Boothe, EPA:ESD. June 7, 1993. Information on commercial depainting.

13. Reference 1.

14. Reference 3.

15. Reference 4.

16. Telephone Report. K. Feser, PES, and K. Brady, Lockheed Aircraft Services Ontario Facility in Ontario, California, on February 27, 1993.

17. Reference 2.

18. Reference 4.

19. Reference 4.

20. Reference 11.

21. Section 114 Questionnaire Response from Trans World Airlines Ground Operations Center in Kansas City, Missouri.

22. Plant Visit Questionnaire Response from United Airlines Maintenance Operation Center in San Francisco, California.

23. References 21 and 22.

24. References 21 and 22.

25. Telephone Report. D. Hendricks, PES, and G. Mundy, Trans World Airlines, on February 11, 1993.

26. Reference 11.

27. Telephone Report. J. Hamilton, PES, and S. Peterson, United Airlines, on March 2, 1993.

28. Reference 22.

29. Material safety data sheet for Turco 6776LO.

30. Reference 11.

31. Telephone Report. K. Feser, PES, and S. Henley, Delta Air Lines, Inc., on August 11, 1993.

32. Reference 12.

33. Section 114 Questionnaire Response from USAir Heavy Maintenance Facility in Winston-Salem, North Carolina.

34. Reference 8.

35. "Painting Technology Soars at Boeing," Industrial Finishing, September 1991, pp. 18-21.

36. Letter. R. Warl, USAir, to David Hendricks, PES. June 4, 1992. Information on the percent of aircraft painted.

MEMORANDUM

TO: Vickie Boothe
US EPA:ESD

FROM: David Hendricks
Pacific Environmental Services, Inc. (PES)

DATE: August 25, 1993
L:\N019

SUBJECT: MACT Environmental Analysis for Hand Wipe Cleaning

The purpose of this memo is to calculate and compare baseline and MACT environmental impacts for hand wipe cleaning operations. Baseline consists of using a cleaning solvent such as methyl ethyl ketone (vapor pressure 71 mmHg at 20°C). In addition, it is assumed that no housekeeping system is utilized which is focused toward capturing fugitive emissions. The MACT floor specifies that hand wipe cleaning solvents are chosen from an approved list of solvents or comply with a vapor pressure limit of 45 mmHg at 20°C. Emission reductions are achieved through product substitutions such as aqueous and low vapor pressure cleaners and the implementation of a housekeeping system. The housekeeping system includes closed containers for solvent laden rags and for storage of solvent. No significant differences were identified for OEM versus rework or military versus commercial hand wipe cleaning operations; therefore, the environmental impacts are differentiated only by model plant size.

Table 1 summarizes the baseline and MACT impacts. With the implementation of MACT, primary air emissions will be reduced by 54 percent. The assumptions and calculations used in determining this impact is detailed below.

BASELINE

Primary Air Emissions

The baseline for hand wipe cleaning operations has been defined as using a cleaning solvent such as methyl ethyl ketone

TABLE 1

ENVIRONMENTAL IMPACTS FOR HAND WIPE CLEANING MACT

Item	Model Plants		
	Small	Medium	Large
1. Baseline HAP Emissions (lbs/yr)	8,700	232,000	1,044,000
2. MACT HAP Emissions (lbs/yr)	4,000	106,720	480,240
3. MACT HAP Emission Reduction (lbs/yr)	4,700	125,280	563,760

(vapor pressure 71 mmHg at 20°C). In addition, it is assumed that no housekeeping system is utilized which is focused toward capturing fugitive emissions. From Table 6-9 of draft BID Chapter 6, the average annual HAP emissions from hand wipe cleaning were calculated to be 58 lb/employee. The model plants are sized by number of employees with small, medium, and large facilities assigned 150, 4,000, and 18,000 employees, respectively. For the purposes of the environmental impacts, it is assumed that the following parameters define baseline:

Baseline HAP Emissions:

Small model plant: 150 emp x 58 lb/emp = 8,700 lb/yr

Medium model plant: 4,000 emp x 58 lb/emp = 232,000 lb/yr

Large model plant: 18,000 emp x 58 lb/emp = 1,044,000 lb/yr

MACT FLOOR

As stated previously, the MACT floor specifies using cleaning solvents from an approved list or with a vapor pressure limit of 45 mmHg at 20°C, and the implementation of a housekeeping system. As a result of MACT, air emissions will be reduced, and wastewater and solid waste generation will not be affected.

Primary Air Emissions

California regulations require cleanup solvent housekeeping measures and a limit on the maximum allowable vapor pressure of the solvent. Emissions are 54 percent less per employee than in other nonattainment areas.[1] There are not sufficient data to determine separate air emission impacts for low vapor pressure cleaning solvent substitution and housekeeping measures.

MACT Emissions:

Small model plant: 8,700 lb/yr x (1-0.54) = 4,000 lb/yr

Medium model plant: 232,000 lb/yr x (1-0.54) = 106,720 lb/yr

Large model plant: 1,044,000 lb/yr x (1-0.54) = 480,240 lb/yr

Primary air impact is equal to the baseline emissions minus MACT emissions:

Small model plant: 8,700 lb/yr - 4,000 lb/yr = 4,700 lb/yr

Medium model plant: 232,000 lb/yr - 106,720 lb/yr = 125,280 lb/yr

Large model plant: 1,044,000 lb/yr - 480,240 lb/yr = 563,760 lb/yr

Secondary Air Emissions

Secondary air impacts are generated by the operation of certain control systems. For example, incineration may produce nitrogen oxides (NO_x) and carbon monoxide (CO) from the combustion of hydrocarbons. The MACT floor, however, does not require control equipment. Additionally, secondary air impacts are generated by the use of products that contain different or additional HAP's from the baseline products. While the use of product substitution does not require control equipment, the substitution may introduce new VOC's or HAP's into the process. Since the number of different reformulations is virtually unlimited, it was impossible to determine what new HAP's or VOC's, if any, might be introduced.

Wastewater Generation

Aerospace representatives have mentioned that many d-limonene and aqueous cleaners require a water rinse in order to remove any residue. No data were readily available to quantify baseline and MACT wastewater consumption. However, the amount of wastewater generated from aerospace hand wipe cleaning operations is not expected to be significantly increased by these control measures.

Energy Consumption

The use of low vapor pressure cleaning solutions may lead some aerospace facilities to utilize heaters and ovens in order to increase evaporation rates and to ensure that no solvent remains in crevices and enclosed spaces. No data were readily available to quantify baseline and MACT energy consumption. However, the amount of energy consumption from aerospace hand wipe cleaning operations is not expected to be significantly increased by these control measures.

Solid Waste Generation

The solid waste generated during hand wipe cleaning consists of solvent-laden rags. Because of the California regulations requiring cleanup solvent housekeeping measures and a limit on the maximum allowable vapor pressure of the solvent, usage of cleanup solvent is 68 percent less per employee than in other nonattainment areas.[2] However, it is possible that the amount of solid waste generated from hand wipe cleaning operations may increase due to a need for more rag wiping. Under previous procedures, a worker might use a rag only briefly since the solvent evaporates very quickly. Under MACT control measures, the worker may use many more rags to wipe up the solvent since it does not evaporate quickly. Additionally, the worker would then place the rag in a closed container. At a later time, the worker would use a clean rag for another job rather than remove the dirty rag from the sealed container. Thus, the amount of dirty rags generated from the hand wipe cleaning process may increase. No data were readily available to quantify baseline and MACT rag waste impact. Additionally, it was assumed that most aerospace facilities were already disposing of large quantities of solvent-laden rags as solid waste. The amount of solid waste generated from aerospace hand wipe cleaning operations is not expected to be significantly increased by these control measures.

References

1. Section 114 Questionnaire Responses.

2. Reference 1.

MEMORANDUM

TO: Vickie Boothe
US EPA:ESD

FROM: David Hendricks
Pacific Environmental Services, Inc. (PES)

DATE: August 25, 1993
L:\N019

SUBJECT: Environmental Impacts for Spray Gun Cleaning

The purpose of this memo is to calculate and compare baseline and MACT environmental impacts for spray gun cleaning. Baseline consists of a combination of enclosed spray gun cleaners and hand cleaning. The MACT floor specifies enclosed spray gun cleaners, cabinet type gun cleaners, vat cleaning using unatomized spray, and atomized spray into a waste container fitted with a capture device designed to capture atomized solvent emissions. For the purpose of the impact analysis, it will be assumed that each facility uses enclosed spray gun cleaners. There is no difference in implementing MACT for commercial versus military or OEM versus rework facilities; therefore, the impact analysis was completed only for different size model plants.

Table 1 summarizes the environmental impacts. The implementation of MACT is expected to result in a 73 percent reduction in air emissions and in solid waste disposal. The assumptions and calculations used in deriving these impacts are detailed below.

BASELINE

Baseline consists of a combination of enclosed spray gun cleaners and hand cleaning. Table 2 presents the baseline values for the number of enclosed spray gun cleaners in use and the usage of spray gun cleaning solvent for each model plant size. Also included in the table are the values of these parameters that will be used for the MACT impact analysis.

The baseline and MACT solvent usages were derived from a facility that reported solvent consumption declined from 25

TABLE 1

ENVIRONMENTAL IMPACTS TO IMPLEMENT SPRAY GUN CLEANING MACT

Item	Model Plants		
	Small	Medium	Large
1. Baseline Primary Air Emissions (lbs/yr)	590	800	1,020
2. MACT Primary Air Emissions (lbs/yr)	150	220	290
3. MACT Implementation Emission Reduction (lbs/yr)	440	580	730
4. Baseline Solid Waste Generation (gal/yr)	4,120	5,590	7,150
5. MACT Solid Waste Generation (gal/yr)	1,020	1,530	2,040
6. MACT Implementation Solid Waste Reduction (gal/yr)	3,100	4,060	5,110

TABLE 2

NUMBER OF ENCLOSED GUN CLEANERS
AND SOLVENT USAGE REPRESENTED
BY BASELINE AND MACT

Model Plant Size	Number of Enclosed Gun Cleaners		Solvent Usage (gal/yr)	
	Baseline	MACT	Baseline	MACT
Small	1	4	4,200	1,040
Medium	2	6	5,700	1,560
Large	3	8	7,300	2,080

gallons per week to 5 gallons per week after the installation of an enclosed spray gun cleaner.[1]

Primary Air Emissions

Based on information provided by Lockheed Missiles and Space Company, Sunnyvale, California, approximately 98 percent of the original solvent usage must be disposed.[2] Therefore, approximately 2 percent is released as air emissions. Using an average solvent density of 7 pounds per gallon, baseline emissions are:

Small model plant: 4,200 gal/yr x 0.02 x 7 lb/gal = 590 lb/yr

Medium model plant: 5,700 gal/yr x 0.02 x 7 lb/gal = 800 lb/yr

Large model plant: 7,300 gal/yr x 0.02 x 7 lb/gal = 1,020 lb/yr

Solid Waste Generation

Based on the above information, approximately 98 percent of the original solvent usage must be disposed.

Small model plant: 4,200 gal/yr x 0.98 = 4,120 gal/yr

Medium model plant: 5,700 gal/yr x 0.98 = 5,590 gal/yr

Large model plant: 7,300 gal/yr x 0.98 = 7,150 gal/yr

MACT

As stated previously, the MACT floor specifies enclosed spray gun cleaners, cabinet type gun cleaners, vat cleaning using unatomized spray, and atomized spray into a waste container fitted with a capture device designed to capture atomized solvent emissions. For the purpose of the impact analysis, it will be assumed that each facility uses enclosed spray gun cleaners. As a result of implementing these control measures, air emissions will be reduced.

Primary Air Emissions

Based on information discussed in the baseline primary air impact section, approximately 2 percent of the cleaning solvent is released as air emissions. Using an average solvent density of 7 pounds per gallon, MACT emissions are:

Small model plant: 1,040 gal/yr x 0.02 x 7 lb/gal = 150 lb/yr

Medium model plant: 1,560 gal/yr x 0.02 x 7 lb/gal = 220 lb/yr

Large model plant: 2,080 gal/yr x 0.02 x 7 lb/gal = 290 lb/yr

The total primary air reduction impact of implementing the MACT standard is equal to the total baseline primary air impact emissions minus the total MACT primary air emissions.

Small model plant: 590 lb/yr - 150 lb/yr = 440 lb/yr

Medium model plant: 800 lb/yr - 220 lb/yr = 580 lb/yr

Large model plant: 1,020 lb/yr - 290 lb/yr = 730 lb/yr

Secondary Air Emissions

Secondary air impacts are generated by the operation of certain control systems. For example, incineration may produce amounts of nitrogen oxides (NO_x) and carbon monoxide (CO) from the combustion of hydrocarbons. Additionally, secondary air impacts are generated by the use of products that contain different or additional HAP's from the baseline products. The use of enclosed spray gun cleaners does not require additional control equipment or product substitutions. Therefore, no additional secondary air impacts are expected.

Wastewater Generation

No water impacts are expected since there is no water used in the spray gun cleaning process, either for baseline or MACT.

Energy Consumption

While the enclosed gun cleaners consume a small amount of compressed air to operate the diaphragm pump that sprays the cleaning solvent, it is assumed that they will have a negligible effect on the overall compressed air consumption of the model plants. Consequently, energy impacts will also be negligible.

Solid Waste Generation

Similar to the baseline solid waste impact, approximately 98 percent of the original solvent usage must be disposed.

Small model plant: 1,040 gal/yr x 0.98 = 1,020 gal/yr

Medium model plant: 1,560 gal/yr x 0.98 = 1,530 gal/yr

Large model plant: 2,080 gal/yr x 0.98 = 2,040 gal/yr

The total solid waste reduction impact of implementing the MACT standard is equal to the total baseline solid waste disposal minus the total MACT solid waste disposal.

Small model plant: 4,120 gal/yr - 1,020/yr = 3,100 gal/yr

Medium model plant: 5,590 gal/yr - 1,530/yr = 4,060 gal/yr

Large model plant: 7,150 gal/yr - 2,040/yr = 5,110 gal/yr

References

1. Trip Report - Naval Aviation Depot in Alameda, California, on February 28, 1992.

2. Letter. Kurucz, Kraig, Lockheed Missiles and Space Company, Inc., to David Hendricks, PES. May 17, 1993. Information on enclosed gun cleaner alternatives.

MEMORANDUM

TO: Vickie Boothe
US EPA:ESD

FROM: David Hendricks
Pacific Environmental Services, Inc. (PES)

DATE: December 30, 1993
L:\N208

SUBJECT: MACT Environmental Impact Analysis for Primers and Topcoats

The purpose of this memo is to calculate and compare baseline and MACT environmental impacts for low HAP primers and topcoats and for the coating application equipment for these primers and topcoats. Baseline coatings consist of military and commercial primers and topcoats as reported in the Section 114 questionnaire responses. Baseline application methods consist of a mix of conventional, HVLP, and electrostatic spray guns as reported in the Section 114 questionnaire responses. The MACT floor specifies product substitutions to reduce the HAP content of the coatings. For the purpose of the impact analysis, it will be assumed that each facility replaces all of their conventional primers and topcoats with reduced HAP content, higher solids primers and topcoats rather than controlling emissions through abatement. The MACT floor also specifies high transfer efficiency methods for primer and topcoat application (e.g., flow coat, roll coat, dip coat, electrostatic, or HVLP). For the purpose of the impact analysis, it will be assumed that all model plants replace their conventional spray guns used to apply primers and topcoats with HVLP spray guns. Due to the difference in coating usage between commercial and military model plants, the environmental impacts will also be different. Consequently, the impact analysis was completed for commercial and military model plants as well as for different size model plants. There is no difference, however, between OEM and rework facilities.

Table 1 summarizes the environmental impacts. The implementation of MACT is expected to result in approximately 66 percent reduction in HAP emissions for commercial model plants and 79 percent for military model plants. The implementation of MACT is expected to result in approximately 60 percent reduction in VOC emissions for commercial model plants and 52 percent for military model plants. There is a typical variation of less than 15 percent between the model plant sizes. In most cases, it is a variation of only 2 to 5 percent. Due to decreased usage and increase transfer efficiency, solid waste will decrease an average of 32 percent for commercial model plants and an average of 31 percent for military model plants. No wastewater or energy impacts are expected due to

TABLE 1
ENVIRONMENTAL IMPACTS TO IMPLEMENT SPRAY GUN MACT

Item	Model Plant Size					
	Commercial			Military		
	Small	Medium	Large	Small	Medium	Large
1. Baseline VOC Emissions (lbs/yr)	5,350	21,960	192,090	1,260	5,050	44,320
2. Baseline HAP Emissions (lbs/yr)	1,650	6,790	59,260	760	3,080	26,890
3. MACT VOC Emissions (lbs/yr)	1,660	9,730	87,840	500	2,650	23,930
4. MACT VOC Emission Reduction (lbs/yr)	3,690	12,230	104,250	760	2,400	20,390
5. MACT HAP Emissions (lbs/yr)	430	2,480	22,680	130	680	6,360
6. MACT HAP Emission Reduction (lbs/yr)	1,220	4,310	36,580	630	2,400	20,530
9. MACT Solid Waste Reduction (percent)	47	25	23	46	24	22

the implementation of MACT. The assumptions and calculations used in deriving these impacts are detailed below.

BASELINE

As stated above, baseline coatings consist of military and commercial primers and topcoats and baseline application methods consist of a mix of conventional, HVLP, and electrostatic spray guns as reported in the Section 114 questionnaire responses. Utilizing the usage (Table 2) and composition (Table 3) data, baseline coating emissions were calculated. The typical composition of aerospace primers and topcoats has been determined from material safety data sheets provided by aerospace coating manufacturers.[1,2,3,4] VOC and HAP composition is less water and exempt solvents. This does not affect the calculations since the baseline coatings used in these calculations do not contain water or exempt solvents. Sample VOC and HAP emission calculations for a small, commercial primer operation are presented below. The calculations for all other coating categories and model plants were done in a similar manner.

VOC Emissions = 5.6 lb VOC/gal x 500 gal/yr = 2,800 lb VOC/yr.
HAP Emissions = 2.6 lb HAP/gal x 500 gal/yr = 1,300 lb HAP/yr.

The baseline emissions are presented in Table 4.

The baseline usage is applied with the baseline coating application equipment breakdown that is defined as follows:

Small Model Plants		
Spray guns	-	30 conventional
		6 HVLP
		0 electrostatic
Medium Model Plants		
Spray guns	-	20 conventional
		50 HVLP
		10 electrostatic
Large Model Plants		
Spray guns	-	24 conventional
		80 HVLP
		20 electrostatic

TABLE 2

BASELINE AVERAGE ANNUAL COATING USAGE
BY MODEL PLANT SIZE[a]

Model Plant Size	Commercial Usage (gal)		Military Usage (gal)	
	Primers	Topcoats	Primers	Topcoats
Small	500	500	170	110
Medium	2,100	2,000	710	420
Large	18,000	17,900	6,100	3,800

[a] Source: Section 114 questionnaire responses.

TABLE 3

BASELINE PRIMER AND TOPCOAT COMPOSITION[a]

Coating Category	Commercial			Military		
	VOC Content (lb/gal less water and exempt solvents)	Solids Content (gal solids/ gal)	HAP Content (lb/gal less water)	VOC Content (lb/gal less water and exempt solvents)	Solids Content (gal solids/ gal)	HAP Content (lb/gal less water)
Primers	5.6	0.22	1.9	4.4	0.29	3.1
Topcoats	5.1	0.32	1.4	4.6	0.34	2.1

[a] Source: Section 114 questionnaire responses and vendor information.

TABLE 4

ANNUAL BASELINE EMISSIONS

Coating Category	Model Plant	Commercial		Military	
		VOC (lb)	HAP (lb)	VOC (lb)	HAP (lb)
Primers	Small	2,800	950	750	530
	Medium	11,760	3,990	3,120	2,200
	Large	100,800	34,200	26,840	18,910
Topcoats	Small	2,550	700	510	230
	Medium	10,200	2,800	1,930	880
	Large	91,290	25,060	17,480	7,980

MACT IMPACTS

As noted above, the implementation of MACT consists of replacing all conventional coatings with lower HAP content coatings and replacing all conventional spray guns used to apply primers and topcoats with HVLP spray guns. The result of these substitutions is reduced coating usage and increased transfer efficiency. Reduced coating usage results in reduced overall emissions. Additionally, increased transfer efficiency reduces overspray, which results in reduced solid waste.

<u>Primary Air Emissions</u>

In order to calculate the reduction in coating usage for each model plant through the use of HVLP spray guns, the volume of coating applied by conventional guns must first be calculated. It will be assumed that the volume of coatings applied with conventional spray guns is equal to the total volume of coating multiplied by the percent of the total number of spray guns that are conventional spray guns.

Percent conventional spray guns:

Small model plants: (30 conventional guns/36 total guns) = 83%

Medium model plants: (20 conventional guns/80 total guns) = 25%

Large model plants: (24 conventional guns/124 total guns) = 19%

The volume of coatings applied conventionally is then the value listed in Table 2 multiplied by the percentage of conventional guns listed for the model plant above. The volume applied with conventional guns is presented in Table 5.

One facility with extensive experience with HVLP spray guns has reported a 45 percent reduction in coating usage when they switched from conventional spray guns to HVLP spray guns.[5] Using the 45 percent reduction in coating usage achieved with the conversion to HVLP spray guns, the reduction in coating usage is then the volume applied conventionally (Table 5) multiplied by 0.45. These values are presented in Table 6. The annual coating usage that results after the implementation of HVLP spray guns is the baseline coating usage (Table 2) minus the usage reduction (Table 6). These values are presented in Table 7.

As mentioned previously, emission reductions are also achieved through product substitution. The composition of MACT floor coatings is typically lower in HAP and VOC content and higher in solids content than the baseline coatings. MACT floor VOC and HAP composition data are given in Table 8. VOC and HAP composition is less water and exempt solvents. This does not affect the calculations since the MACT coatings used in these calculations are higher solids coatings and do not contain water or exempt solvents. Additionally, since the solids content is higher for MACT floor coatings, the usage is slightly lower than baseline. Usage is determined on an equivalent solids basis with baseline usage or, in this case, the usage that takes into account the reduction for the high transfer efficiency application equipment. An example calculation is below:

Baseline commercial primer
Usage after MACT HVLP implementation: 310 gal coating
Solids content: 0.22 gal solids/gal coating

MACT commercial primer:
Equivalent usage = baseline usage x baseline solids/MACT solids:

$$\frac{\text{310 gal base coat x 0.22 gal base solids/gal coat}}{\text{0.25 gal MACT solids/gal coat}} = \text{270 gal coating}$$

The MACT annual coating usage achieved with the implementation of HVLP spray guns and product substitutions is presented in Table 9.

TABLE 5

AVERAGE ANNUAL COATING USAGE APPLIED WITH CONVENTIONAL SPRAY GUNS BY MODEL PLANT SIZE

Model Plant Size	Commercial Usage (gal)		Military Usage (gal)	
	Primers	Topcoats	Primers	Topcoats
Small	415	415	140	90
Medium	525	500	180	110
Large	3,420	3,400	1,160	720

TABLE 6

AVERAGE ANNUAL COATING USAGE REDUCTION ACHIEVED WITH HVLP SPRAY GUNS BY MODEL PLANT SIZE

Model Plant Size	Commercial Usage (gal)		Military Usage (gal)	
	Primers	Topcoats	Primers	Topcoats
Small	190	190	60	40
Medium	240	230	80	50
Large	1,540	1,530	520	320

TABLE 7

MACT AVERAGE ANNUAL COATING USAGE
(AFTER IMPLEMENTATION OF HVLP SPRAY GUNS)
BY MODEL PLANT SIZE

Model Plant Size	Commercial Usage (gal)		Military Usage (gal)	
	Primers	Topcoats	Primers	Topcoats
Small	310	310	110	70
Medium	1,860	1,770	630	370
Large	16,460	16,370	5,580	3,480

TABLE 8

WEIGHTED AVERAGE VOC AND HAP CONTENT FOR
PRIMERS AND TOPCOATS FOR MACT FLOORS[a]

Coating Category	Commercial			Military		
	VOC Content (lb/gal less water and exempt solvents)	Solids Content (gal solids/ gal)	HAP Content (lb/gal less water)	VOC Content (lb/gal less water and exempt solvents)	Solids Content (gal solids/ gal)	HAP Content (lb/gal less water)
Primers	2.9	0.25	0.3	2.9	0.3	0.3
Topcoats	3.5	0.4	1.4	3.5	0.5	2.0

[a]Source: Section 114 questionnaire responses and vendor information.

TABLE 9

MACT AVERAGE ANNUAL COATING USAGE
(AFTER IMPLEMENTATION OF HVLP SPRAY GUNS
AND PRODUCT SUBSTITUTIONS)
BY MODEL PLANT SIZE

Model Plant Size	Commercial Usage (gal)		Military Usage (gal)	
	Primers	Topcoats	Primers	Topcoats
Small	270	250	110	50
Medium	1,640	1,420	610	250
Large	14,480	13,100	5,390	2,370

The resulting MACT emissions were calculated by multiplying the MACT floor VOC and HAP content averages from Table 3 by the usage amounts in Table 9. The quantity of data for the HAP content of commercial primers was insufficient to ascertain a reasonable HAP content. Therefore, the HAP content for military primers was used for the emission calculations of commercial primers. MACT floor VOC and HAP emissions are given in Table 10. The emission reductions are determined by subtracting the emissions that would have occurred under the MACT floor from the emissions that will result from the baseline. The primary air impacts for MACT floor are shown in Table 11.

Secondary Air Emissions

Secondary air impacts are generated by the operation of certain control systems. For example, incineration may produce nitrogen oxides (NO_x) and carbon monoxide (CO) from the combustion of hydrocarbons. Additionally, secondary air impacts are generated by the use of products that contain different or additional HAP's from the baseline products. The use of HVLP spray guns does not require either control equipment or coating substitutions. While the use of low VOC and HAP coating substitutions does not require control equipment, the substitutions may introduce new VOC's or HAP's into the process. Since the number of different reformulations is virtually unlimited, it was impossible to determine what new HAP's or VOC's, if any, might be introduced. However, the quantity of HAP and VOC emission will not exceed the calculated impacts. Therefore, no secondary air impacts are expected.

Wastewater Generation

Some aerospace coatings that may be used to achieve MACT are waterborne or water-reducible. This may lead to a minor increase in water usage but should not affect wastewater quantities. Additionally, the use of high efficiency application methods does not require the use of water. Therefore, no water impacts are expected due to the replacement of conventional coatings.

Energy Consumption

Energy usage in the coating application process is generated by the spray gun and booth equipment; heating, ventilation, and air conditioning; and lighting. Product substitution is not expected to have any effect on these systems. Additionally, HVLP spray guns use approximately the same amount of energy to spray coatings as conventional spray guns. Therefore, no energy impacts are expected due to the replacement of conventional coatings.

Solid Waste Generation

The majority of solid waste from primer and topcoat coating application operations is generated by paint overspray collected in water wash or dry filter systems, and on the floor and walls of spray booths. Spray booth cleanup waste, water wash sludge, and spent dry filters are typical examples of solid waste from these operations. Replacing conventional coatings with reduced HAP and VOC content and higher solids content coatings should reduce the gallons of coating used and, therefore, the overspray. Additionally, using high transfer efficiency application methods also reduces overspray. Using the usage values from Tables 2 and 9, the percent reductions in usage are listed in Table 12. This reduction in coating usage is estimated to be equivalent to the reduction in solid waste generated.

TABLE 10

ANNUAL MACT EMISSIONS

Coating Category	Model Plant	Commercial		Military	
		VOC (lb)	HAP (lb)	VOC (lb)	HAP (lb)
Primers	Small	780	80	320	30
	Medium	4,760	490	1,770	180
	Large	41,990	4,340	15,630	1,620
Topcoats	Small	880	350	180	100
	Medium	4,970	1,990	880	500
	Large	45,850	18,340	8,300	4,740

TABLE 11

ANNUAL MACT EMISSION REDUCTION

Coating Category	Model Plant	Commercial		Military	
		VOC (lb)	HAP (lb)	VOC (lb)	HAP (lb)
Primers	Small	2,020	870	430	500
	Medium	7,000	3,500	1,350	2,020
	Large	58,810	29,860	11,210	17,290
Topcoats	Small	1,670	350	330	130
	Medium	5,230	810	1,050	380
	Large	45,440	6,720	9,180	3,240

TABLE 12

ANNUAL MACT FLOOR REDUCTIONS IN COATING USAGE (PERCENT)

Model Plant	Commercial	Military
Small	47	46
Medium	25	24
Large	23	22

References

1. Letter. K. McKown, Akzo, to D. Hendricks, PES. February 1993. Coating composition data and material safety data sheets.

2. Letter. F. Schuster, Crown Metro, to J. Hamilton, PES. March 17, 1993. Coating composition data and material safety data sheets.

3. Letter. S. Smith, DEFT, to J. Hamilton, PES. March 11, 1993. Coating composition data and material safety data sheets.

4. Letter. R. Martin, Courtaulds Aerospace, to K. Feser, PES. February 22, 1993. Coating composition data and material safety data sheets.

5. Section 114 Questionnaire Response from Naval Aviation Depot in Alameda, California.

MEMORANDUM

TO: Vickie Boothe
US EPA:ESD

FROM: David Hendricks
Pacific Environmental Services, Inc.

DATE: February 15, 1994
L:\N208

SUBJECT: Nationwide Environmental Impacts for the Control of Primer and Topcoat Inorganic Emissions, Depainting Inorganic Emissions, Wastewater Emissions, Storage Tank Emissions, and Waste Emissions

The purpose of this memo is to calculate and compare baseline and MACT environmental impacts for the control of primer and topcoat inorganic emissions, depainting inorganic emissions, wastewater emissions, storage tank emissions, and waste emissions. There is no difference in implementing MACT for commercial versus military or OEM versus rework facilities; therefore, the impact analyses were completed only for different size model plants. Additionally, due to the available data, the impacts were calculated on a nationwide basis.

For the purpose of the primer and topcoat inorganic emissions impact analysis, it was assumed that 5 percent of small facilities do not perform primer and topcoat operations within a booth or hangar, and that all medium and large facilities perform all of these operations within a booth or hangar. Additionally, 10 percent of small, 2 percent of medium, and 1 percent of large facilities perform primer and topcoat operations within a booth or hangar with no dry filters or waterwash. The MACT floor level of control specifies that all primer and topcoat operations must be performed within a spray booth or hangar with an active ventilation system. The exhaust air stream must pass through either dry filters or a waterwash system.

For the purpose of the depainting inorganic emissions impact analysis, it was assumed that only 5 percent of small and medium rework facilities and all large rework facilities depaint the outer surface of aerospace vehicles. The impact analysis is based on the conversion from low efficiency particulate filters to high efficiency particulate filters that meet the MACT floor level of control. The MACT floor level of control specifies that inorganic HAP emissions be controlled by 99 percent. This can be achieved by through the use of particulate filters or baghouses to control particulate emissions.

MACT floor is no control for wastewater and storage tanks; therefore, no impacts will be incurred. Additionally, 100 percent of the reporting facilities are performing housekeeping measures for waste; therefore, no impacts will be incurred.

Tables 1 and 2 summarize the environmental impacts for coating application and depainting inorganic emission controls. The implementation of MACT for coating application is expected to result in approximately 57 percent reduction in inorganic air emissions for small model plants, 16 percent for medium model plants, and 25 percent for large model plants. The energy impact is a 5 percent increase for small model plants only. The implementation is also expected to result in approximately 18 percent increase in solid waste for small model plants, 2 percent for medium model plants, and 6 percent for large model plants. The implementation of MACT for depainting is expected to result in a 80 percent reduction in air emissions. The assumptions and calculations used in deriving these impacts are detailed below.

A. PRIMER AND TOPCOAT INORGANIC HAP EMISSIONS

Baseline

For the purpose of the impact analysis, it was assumed that 5 percent of small facilities do not perform primer and topcoat operations within a booth or hangar, and that all medium and large facilities perform all of these operations within a booth or hangar. Additionally, 10 percent of small, 2 percent of medium, and 1 percent of large facilities perform primer and topcoat operations within a booth or hangar with no dry filters or waterwash. It is further assumed that these booths and hangars already have a ventilation system in place. Finally, it is assumed that 4 percent of the facilities using filters are using high efficiency dry filters and 2 percent are using high efficiency waterwash booths.

Table 3 presents the total number of facilities nationwide by size, number of each size of facility currently not painting within a booth or hangar, number of facilities currently painting within a booth or hangar with no dry filters or waterwash, and number of facilities using filters.

TABLE 1

NATIONWIDE ENVIRONMENTAL IMPACTS TO IMPLEMENT PRIMER AND TOPCOAT INORGANIC EMISSIONS MACT

Item	Nationwide Model Plants		
	Small	Medium	Large
1. Baseline Primary Air Emissions (lb/yr)	140	310	40
2. MACT Primary Air Emissions (lb/yr)	60	260	30
3. MACT Implementation Emission Reduction (lb/yr)	80	50	10
4. Baseline Energy Consumption (kWatt-hr/yr)	117,360,000	NA	NA
5. MACT Energy Consumption (kWatt-hr/yr)	123,300,000	NA	NA
6. MACT Implementation Energy Increase (kWatt-hr/yr)	5,940,000	NA	NA
7. Baseline Solid Waste Generation (lb/yr)	7,089,120	54,509,370	942,340
8. MACT Solid Waste Generation (lb/yr)	8,372,160	55,658,110	1,001,230
9. MACT Implementation Solid Waste Increase (lb/yr)	1,283,040	1,148,740	58,890

TABLE 2

NATIONWIDE ENVIRONMENTAL IMPACTS TO IMPLEMENT DEPAINTING INORGANIC EMISSIONS MACT

Item	Nationwide Model Plants		
	Small	Medium	Large
1. Baseline Primary Air Emissions (lbs/yr)	156,600	583,270	216,700
2. MACT Primary Air Emissions (lbs/yr)	31,320	116,800	43,350
3. MACT Implementation Emission Reduction (lbs/yr)	125,280	466,470	173,350

Table 3

Baseline Nationwide Distribution of Model Plants

Facility Size	Total Number of Facilities	Number of Facilities Without Booths or Hangars	Number of Facilities Without Dry Filters or Waterwash	Number of Facilities With Low Efficiency Dry Filters or Waterwash	Number of Facilities With High Efficiency Dry Filters	Number of Facilities With High Efficiency Waterwash
Small	1318	66 (5% of total)	132 (10% of total)	1,041 (79% of total)	53 (4% of total)	26 (2% of total)
Medium	1533	0	31 (2% of total)	1,410 (92% of total)	61 (4% of total)	31 (2% of total)
Large	18	0	1 (1% of total)	15 (93% of total)	1 (4% of total)	1 (2% of total)

Baseline Primary Air Emissions

Table 4 presents typical coating usage by model plant.

Table 4

Typical Coating Usage[a]

Model Plant Size	Primer	Topcoat	Total
Small	500	500	1,000
Medium	2,000	2,000	4,000
Large	18,000	18,000	36,000

[a]Source: Section 114 questionnaire responses.

Approximately 0.01 percent of the typical primer or topcoat is inorganic HAP.[1,2,3,4] Using an average coating density of 9 pounds per gallon[5], baseline inorganic emissions from primer and topcoat applications are:

Small model plant: 1,000 gal/yr x 0.0001 x 9 lb/gal = 0.9 lb/yr

Medium model plant: 4,000 gal/yr x 0.0001 x 9 lb/gal = 3.6 lb/yr

Large model plant: 36,000 gal/yr x 0.0001 x 9 lb/gal = 32.4 lb/yr

Assuming that, when a coating is sprayed, 40 percent of the paint particles are transferred to the substrate, 10 percent fall out of the airstream on to the booth walls or floor, and 50 percent of the particulates reach the filters, baseline emissions to the filters are:

Small model plant: 0.9 lb/yr x 0.50 = 0.45 lb/yr

Medium model plant: 3.6 lb/yr x 0.50 = 1.8 lb/yr

Large model plant: 32.4 lb/yr x 0.50 = 16.2 lb/yr

The control efficiency of a low efficiency filter is estimated at 90 percent. The control efficiency of a high efficiency dry filter is 99.89 percent as stated in the Section 114 data.[6,7,8] Also stated in the Section 114 data, the control efficiency of a high efficiency waterwash booth is 95.67 percent.[9,10,11] Using the appropriate control efficiency and the above emission rates by model plant, baseline emissions of inorganic HAPs from coating application are listed in Table 5. Nationwide baseline emissions of inorganic HAPs are listed in Table 6 and equal the numbers in Table 5 multiplied by the numbers in Table 3. Example calculations are:

Small model plant (with low efficiency dry filters): 0.45 lb/yr x (1-0.90) = 0.045 lb/yr

Nationwide small model plant (with low efficiency dry filters):
0.045 lb/yr per facility x 1041 facilities = 47 lb/yr

Baseline Energy Consumption

Based on vendor data, a 5 horsepower motor is used to run the ventilation system of all paint booths.[12] From this same vendor data, the pump used in a waterwash booth is approximately 10 horsepower.[13] Spray booths are used approximately 2 shifts or 16 hours per day, 250 days per year. Therefore, the nationwide energy usage by model plant is:

Small Facilities

(6 booths/facility x 5 hp/booth x 0.75 kWatt/hp x 16 hour/day x 250 days/yr x 1,252 facilities) + (6 booths/facility x 10 hp/booth x 0.75 kWatt/hp x 16 hour/day x 250 days/yr x 26 facilities) = 117,360,000 kWatt-hr/yr

The energy usage of ventilation systems and pumps for medium and large facilities will not be taken into account in this calculation since the energy usage will not change from the baseline to MACT.

Baseline Solid Waste Generation

For a worst case estimate, it is assumed that all the low efficiency filter systems are dry filter systems. The total number of model plants using dry filters equals the facilities using low efficiency filters and the facilities using high efficiency dry filters.

Small model plant: 1,041 facilities + 53 facilities = 1,094 facilities

Medium model plant: 1,410 facilities + 61 facilities = 1,471 facilities

Large model plant: 15 facilities + 1 facility = 16 facilities

Table 5

Baseline Inorganic Emissions from Coating Operations by Model Plant

Facility Size	Emissions from Facilities Without Booths or Hangars (lb/yr)	Emissions from Facilities Without Dry Filters or Waterwash (lb/yr)	Emissions from Facilities With Low Efficiency Dry Filters or Waterwash (lb/yr)	Emissions from Facilities With High Efficiency Dry Filters (lb/yr)	Emissions from Facilities With High Efficiency Waterwash (lb/yr)
Small	0.45	0.45	0.045	0.0005	0.019
Medium	1.8	1.8	0.18	0.002	0.078
Large	16.2	16.2	1.62	0.02	0.70

Table 6

Baseline Nationwide Inorganic Emissions from Coating Operations by Model Plant

Facility Size	Nationwide Emissions from Facilities Without Booths or Hangars (lb/yr)	Nationwide Emissions from Facilities Without Dry Filters or Waterwash (lb/yr)	Nationwide Emissions from Facilities With Low Efficiency Dry Filters or Waterwash (lb/yr)	Nationwide Emissions from Facilities With High Efficiency Dry Filters (lb/yr)	Nationwide Emissions from Facilities With High Efficiency Waterwash (lb/yr)	Total
Small	30	59	47	0.03	0.5	140
Medium		56	254	0.12	2.4	310
Large		16	24	0.02	0.7	40

From the cost impact memo[14], it is assumed that dry filters are changed 4 times a year. From vendor data[15], each dry filter weighs approximately 4 pounds. Baseline solid waste generation is calculated as shown below using the above assumptions and data from the cost memo.

Small Facilities

<u>10' x 10' Booth</u>
36 filters/booth x 5 booths/facility x 4 lb/filter x 4 changes/yr
x 1,094 facilities = 3,150,720 lb/yr

<u>25' x 25' Booth</u>
225 filters/booth x 1 booth/facility x 4 lb/filter x 4 changes/yr
x 1,094 facilities = 3,938,400 lb/yr

Total nationwide solid waste = 7,089,120 lb/yr

Medium Facilities

<u>10' x 10' Booth</u>
36 filters/booth x 7 booths/facility x 4 lb/filter x 4 changes/yr
x 1,471 facilities = 5,931,070 lb/yr

<u>25' x 25' Booth</u>
225 filters/booth x 2 booths/facility x 4 lb/filter x 4 changes/yr
x 1,471 facilities = 10,591,200 lb/yr

<u>150' x 200' x 75' Hangar</u>
807 filters/hangar x 2 hangars/facility x 4 lb/facility x 4 changes/yr
x 1,471 facilities = 37,987,100 lb/yr

Total nationwide solid waste = 54,509,370 lb/yr

Large Facilities

<u>10' x 10' Booth</u>
36 filters/booth x 10 booths/facility x 4 lb/filter x 4 changes/yr
x 16 facilities = 92,160 lb/yr

25' x 25' Booth
225 filters/booth x 4 booths/facility x 4 lb/filter x 4 changes/yr x 16 facilities = 230,400 lb/yr

150' x 200' x 75' Hangar
807 filters/hangar x 3 hangars/facility x 4 lb/filter x 4 changes/yr x 16 facilities = 619,780 lb/yr

Total nationwide solid waste = 942,340 lb/yr

MACT Floor

The MACT floor level of control specifies that all primer and topcoat operations must be performed within a spray booth or hangar with an active ventilation system. The exhaust air stream must pass through either dry filters or a waterwash system. The impact analysis assumes that facilities that do not currently paint within a booth or hangar and facilities that paint within a booth or hangar but have no dry filters or waterwash will begin filtering their exhaust air stream through a low efficiency dry filter system.

Table 7 presents the total number of facilities nationwide by size and the number of each size of facility currently painting within a booth or hangar with dry filters or waterwash.

Primary Air Emissions

As stated in the baseline section, the control efficiency of a low efficiency filter is estimated at 90 percent, the control efficiency of a high efficiency dry filter is 99.89 percent, and the control efficiency of a high efficiency waterwash booth is 95.67 percent. Using these control efficiencies and the emission estimates calculated in the baseline section, MACT emissions of inorganic HAPs from coating application are listed in Table 8 and equal the baseline emission estimates multiplied by the appropriate control efficiency. Table 9 contains the nationwide emissions and these values are the values in Table 7 multiplied by the values in Table 8. Example calculations are:

Small model plant (with low efficiency dry filters): 0.45 lb/yr x (1-0.90) = 0.045 lb/yr

Nationwide small model plant (with low efficiency dry filters):
0.045 lb/yr per facility x 1,239 facilities = 56 lb/yr

TABLE 7

MACT Nationwide Distribution of Model Plants

Facility Size	Total Number of Facilities	Number of Facilities with Low Efficiency Filters	Number of Facilities with High Efficiency Dry Filters	Number of Facilities with High Efficiency Waterwash Booths
Small	1,318	1,239	53	26
Medium	1,533	1,441	61	31
Large	18	16	1	1

TABLE 8

MACT Inorganic Emissions from Coating Operations by Model Plant

Facility Size	Emissions from Facilities with Low Efficiency Filters (lb/yr)	Emissions from Facilities with High Efficiency Dry Filters (lb/yr)	Emissions from Facilities with High Efficiency Waterwash Booths (lb/yr)
Small	0.045	0.0005	0.019
Medium	0.18	0.002	0.078
Large	1.62	0.02	0.78

TABLE 9

MACT Nationwide Inorganic Emissions from Coating Operations by Model Plant

Facility Size	Nationwide Emissions from Facilities with Low Efficiency Filters (lb/yr)	Nationwide Emissions from Facilities with High Efficiency Dry Filters (lb/yr)	Nationwide Emissions from Facilities with High Efficiency Waterwash Booths (lb/yr)	Total
Small	56	0.03	0.49	60
Medium	259	0.12	2.4	260
Large	26	0.02	0.78	30

The total primary air reduction impact of implementing the MACT standard is equal to the total baseline primary air impact emissions minus the total MACT primary air emissions.

Small model plant: 140 lb/yr - 60 lb/yr = 80 lb/yr

Medium model plant: 310 lb/yr - 260 lb/yr = 50 lb/yr

Large model plant: 40 lb/yr - 30 lb/yr = 10 lb/yr

Secondary Air Emissions

Secondary air impacts are generated by the operation of certain control systems. For example, incineration may produce amounts of nitrogen oxides (NO_x) and carbon monoxide (CO) from the combustion of hydrocarbons. Additionally, secondary air impacts are generated by the use of products that contain different or additional HAP's from the baseline products. The use of either particulate filters or waterwash booths does not require additional control equipment or product substitutions. Therefore, no additional secondary air impacts are expected.

Wastewater Generation

There is no water used with dry filters. Additionally, current practice with waterwash booths is to recycle the water in the booth replacing only the water lost through evaporation and sludge removal. This water usage is expected to be insignificant when compared to the model plant as a whole. Therefore, it is expected that the overall effect of increased water usage is negligible and no water impacts are expected.

Energy Consumption

Only 5 percent of small model plants and none of the medium or large plants will have to move their painting operations from outside into a spray booth. These facilities will need to install fans, motors, and pumps for their new booths. Similar to baseline calculations, it is assumed that a 5 horsepower fan and motor is used for the ventilation system of all paint booths. Additionally, the pump used in a waterwash booth is approximately 10 horsepower. Spray booths are used approximately 2 shifts or 16 hours per day, 250 days per year. Nationwide MACT energy usage by model plant is:

Small Facilities

(6 booths/facility x 5 hp/booth x 0.75 kWatt/hp x 16 hour/day x 250 days/yr x 1,318 facilities) + (6 booths/facility x 10 hp/booth x 0.75 kWatt/hp x 16 hour/day x 250 days/yr x 26 facilities) = 123,300,000 kWatt-hr/yr

The energy usage of the ventilation systems and pumps for medium and large facilities will not be taken into account in this calculation since the energy usage will not change from the baseline to MACT.

The total nationwide energy impact of implementing the MACT standard is equal to the total MACT energy consumption minus the total baseline energy consumption.

Small model plant: 123,300,000 kWatt-hr/yr - 117,360,000 kWatt-hr/yr
= 5,940,000 kWatt-hr/yr

Solid Waste Generation

For worst case estimates, it is assumed that all the low efficiency filter systems are dry filter systems. The total number of model plants using dry filters equals the facilities using low efficiency filters and the facilities using high efficiency dry filters.

Small model plant: 1,239 facilities + 53 facilities = 1,292 facilities

Medium model plant: 1,441 facilities + 61 facilities = 1,502 facilities

Large model plant: 16 facilities + 1 facility = 17 facilities

Similar to baseline calculations, it is assumed that dry filters are changed 4 times a year. No data is available on the weight of each dry filter. Therefore, from facility visits, it is assumed that each dry filter weighs approximately 4 pounds. Solid waste impacts are calculated using the above assumptions and data from the cost memo.

Small Facilities

10' x 10' Booth
36 filters/booth x 5 booths/facility x 4 lb/filter x 4 changes/yr
x 1,292 facilities = 3,720,960 lb/yr

<u>25' x 25' Booth</u>
225 filters/booth x 1 booth/facility x 4 lb/filter x 4 changes/yr
x 1,292 facilities = 4,651,200 lb/yr

Total nationwide solid waste = 8,372,160 lb/yr

Medium Facilities

<u>10' x 10' Booth</u>
36 filters/booth x 7 booths/facility x 4 lb/filter x 4 changes/yr
x 1,502 facilities = 6,056,060 lb/yr

<u>25' x 25' Booth</u>
225 filters/booth x 2 booths/facility x 4 lb/filter x 4 changes/yr
x 1,502 facilities = 10,814,400 lb/yr

<u>150' x 200' x 75' Hangar</u>
807 filters/hangar x 2 hangars/facility x 4 lb/facility x 4 changes/yr
x 1,502 facilities = 38,787,650 lb/yr

Total nationwide solid waste = 55,658,110 lb/yr

Large Facilities

<u>10' x 10' Booth</u>
36 filters/booth x 10 booths/facility x 4 lb/filter x 4 changes/yr
x 17 facilities = 97,920 lb/yr

<u>25' x 25' Booth</u>
225 filters/booth x 4 booths/facility x 4 lb/filter x 4 changes/yr
x 17 facilities = 244,800 lb/yr

<u>150' x 200' x 75' Hangar</u>
807 filters/hangar x 3 hangars/facility x 4 lb/filter x 4 changes/yr
x 17 facilities = 658,510 lb/yr

Total nationwide solid waste = 1,001,230 lb/yr

The total nationwide solid waste impact of implementing the MACT standard is equal to the total MACT solid waste minus the total baseline solid waste.

Small model plant: 8,372,160 lb/yr - 7,089,120 lb/yr = 1,283,040 lb/yr

Medium model plant: 55,658,110 lb/yr - 54,509,370 lb/yr = 1,148,740 lb/yr

Large model plant: 1,001,230 lb/yr - 942,340 lb/yr = 58,890 lb/yr

B. DEPAINTING INORGANIC HAP EMISSIONS

The MACT floor level of control specifies that inorganic HAP particulate emissions be controlled by 99 percent. This can be achieved through the use of particulate filters such as panel filters or baghouses. This analysis examines the conversion from low efficiency particulate filters to high efficiency particulate filters that meet the MACT floor level of control.

It is not reasonable to assume that all commercial and military rework facilities (a total of 2,026 facilities) depaint the outer surface of aerospace vehicles. Therefore, it was assumed that only 5 percent of the small and medium facilities and all of the large facilities perform outer surface depainting (see Table 10).

TABLE 10
NUMBER OF DEPAINTING FACILITIES BY MODEL PLANT SIZE

Model Plant Size	Number of Facilities
Small	27
Medium	73
Large	5

Baseline

Baseline has been defined as depainting fully painted aircraft with plastic media blasting and using particulate filters with a control efficiency of 95 percent. Many military facilities are currently using plastic media blasting. Therefore, for the purpose of this option, data from military facilities will be used for both baseline and MACT.

From vendor information, approximately 50 percent of the blasting particulates fall to the ground and 50 percent are airborne.[16] The emission factor for plastic media blasting is 0.021 pounds of emissions per pound of media used.[17] Based on data from a medium, military rework facility, a typical flow rate of media during blasting is 2,700 pounds per hour.[18] Using the above data, uncontrolled PM10 emissions are:

Average = 2,700 lb media/hr x 0.5 x 0.021 lb emissions/lb media = 28 lb emissions/hr

A medium, military rework facility also stated that it takes 0.03 hours to strip 1 square foot of aircraft outer surface area.[19] From the environmental impacts memo for depainting, the total outer surface area of aircraft reworked annually for each military model plant is[20]:

Small model plant: 137,900 ft^2/yr

Medium model plant: 190,500 ft^2/yr

Large model plant: 1,032,000 ft^2/yr

The time it takes to strip this area by model plant is calculated using the 0.03 hr/ft^2 stripping rate. The total time for depainting by model plant is:

Small model plant: 137,900 ft^2/yr x 0.03 hr/ft^2 = 4,140 hr/yr

Medium model plant: 190,500 ft^2/yr x 0.03 hr/ft^2 = 5,710 hr/yr

Large model plant: 1,032,000 ft^2/yr x 0.03 hr/ft^2 = 30,960 hr/yr

Using the emission rate of 28 lb/hr for each of the model plants, uncontrolled emissions are:

Small model plant: 4,140 hr/yr x 28 lb/hr = 115,920 lb/yr

Medium model plant: 5,710 hr/yr x 28 lb/hr = 159,880 lb/yr

Large model plant: 30,960 hr/yr x 28 lb/hr = 866,880 lb/yr

Baseline emissions per model plant, using a control efficiency of 95 percent, are:

Small model plant: (115,920 lb/yr x (1 - 0.95) = 5,800 lb/yr

Medium model plant: (159,880 lb/yr x (1 - 0.95) = 7,990 lb/yr

Large model plant: (866,880 lb/yr x (1 - 0.95) = 43,340 lb/yr

Using the number of facilities that perform depainting operations as listed in Table 10, nationwide baseline emission are:

Small model plant: 5,800 lb/yr x 27 rework facilities = 156,600 lb/yr

Medium model plant: 7,990 lb/yr x 73 rework facilities = 583,270 lb/yr

Large model plant: 43,340 lb/yr x 5 rework facilities = 216,700 lb/yr

MACT Floor

The MACT floor can be achieved by installing particulate filters with a minimum control efficiency of 99 percent. For the purpose of the impact analysis, it was assumed that each facility performs the blasting operation within a hangar and that a ventilation system is in place.

Primary Air Emissions

Assuming that MACT floor has a minimum control efficiency of 99 percent, MACT emissions by model plant are:

Small model plant: 115,920 lb/yr x (1 - 0.99) = 1,160 lb/yr

Medium model plant: 159,880 lb/yr x (1 - 0.99) = 1,600 lb/yr

Large model plant: 866,880 lb/yr x (1 - 0.99) = 8,670 lb/yr

Again using the number of depainting facilities from Table 10, nationwide MACT emission are:

Small model plant: 1,160 lb/yr x 27 rework facilities = 31,320 lb/yr

Medium model plant: 1,600 lb/yr x 73 rework facilities = 116,800 lb/yr

Large model plant: 8,670 lb/yr x 5 rework facilities = 43,350 lb/yr

The total nationwide primary air impact of implementing the MACT standard is equal to the total nationwide baseline primary air impact emissions minus the total nationwide MACT primary air emissions.

Small model plant: 156,600 lb/yr - 31,320 lb/yr = 125,280 lb/yr

Medium model plant: 583,270 lb/yr - 116,800 lb/yr = 466,470 lb/yr

Large model plant: 216,700 lb/yr - 43,350 lb/yr = 173,350 lb/yr

Secondary Air Emissions

Secondary air impacts are generated by the operation of certain control systems. For example, incineration may produce amounts of nitrogen oxides (NO_x) and carbon monoxide (CO) from the combustion of hydrocarbons. Additionally, secondary air impacts are generated by the use of products that contain different or additional HAP's from the baseline products. The use of particulate filters does not require incineration or product substitutions. Therefore, no additional secondary air impacts are expected.

Wastewater Generation

No water impacts are expected since there is no water used in conjunction with particulate filters, either for baseline or MACT.

Energy Consumption

While the fans and ventilation systems consume energy to operate, it is assumed that they will have a negligible effect on the overall energy consumption of the model plants. Additionally, ventilation systems will not have to change from baseline to MACT. Consequently, energy impacts will be negligible.

Solid Waste Generation

The only solid waste generated during this process is the spent particulate filters. It is not anticipated that the amount of spent filters generated under the MACT floor level of control will vary significantly with the baseline level of control.

C. WASTEWATER

MACT floor is no control; therefore, no impact incurred.

D. STORAGE TANKS

MACT floor is no control; therefore, no impact incurred.

E. WASTE

100 percent of the reporting facilities are performing housekeeping measures; therefore, no impacts will be incurred.

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21. Section 114 Questionnaire Response from Tinker Air Force Base, Oklahoma.

APPENDIX B. DEVELOPMENT OF MODEL PLANT COSTS

MEMORANDUM

TO: Vickie Boothe
US EPA:ESD

FROM: David Hendricks
Pacific Environmental Services, Inc. (PES)

DATE: August 25, 1993
L:\N019

SUBJECT: Cost Analysis for Chemical Milling Maskant

The purpose of this memo is to compare baseline and MACT costs for chemical milling maskants. Baseline consists of a dip coating operation using a solvent based maskant. The MACT floor specifies an emission rate of 1.3 pounds of HAP's per gallon less water of maskant as applied, which is based on the use of either solvent based maskant and a carbon adsorber to control emissions or the use of waterborne maskants.

Table 1 summarizes the costs. As presented on line 3 of Table 1, the use of a carbon adsorber is expected to result in a cost of $125,200 per year for medium model plants and $135,540 per year for large model plants. The use of waterborne maskants is expected to result in a cost of $106,680 per year for medium model plants and $199,090 for large model plants, as presented in line 7 of Table 1. The assumptions and calculations used in deriving these costs are detailed below.

As defined in draft BID Chapter 6, chemical milling maskant operations occur only in commercial/OEM, military/OEM, and military/rework medium and large model plants. Since there is no difference in implementing MACT floor for commercial versus military or OEM versus rework facilities, the cost analysis has been performed only for different size model plants.

BASELINE

The baseline usage of solvent based maskant was obtained from the Section 114 questionnaire responses of a

TABLE 1

ANNUAL COSTS TO IMPLEMENT CHEMICAL MILLING MASKANT MACT

Item	Model Plant	
	Medium	Large
1. Carbon Adsorber - Annualized Costs	$54,500	$58,540
2. Carbon Adsorber - Annual Operating Costs	70,700	77,000
3. Total MACT Implementation Costs - Carbon Adsorber (Line 1 + Line 2)	125,200	135,540
4. Tanks and Ovens - Annualized Capital Costs	31,380	35,590
5. Ovens - Annual Costs	2,700	5,900
6. Maskant Costs	72,600	157,600
7. Total MACT Implementation Costs - Waterborne Maskants (Line 4 + Line 5 + Line 6)	$106,680	$199,090

military/OEM/medium facility and a military/OEM/large facility. The baseline usage is 12,000 gal/yr for a medium facility,[1] and 26,000 gal/yr for a large facility.[2] The dip tank sizes used for the MACT cost analysis were determined from the tanks observed during several site visits.

MACT COSTS - CARBON ADSORBER

Both the baseline and MACT scenarios can be based on the use of solvent based maskant. Therefore, the type of maskant, usage, and dip application equipment remain the same and do not require costing. The only factor relevant in the cost analysis is the carbon adsorber.

Carbon Adsorber Costs

The exhaust flow rate and HAP concentration in the exhaust stream (inlet loading) were taken from the same Section 114 questionnaire responses referenced above for maskant usage. The values used for medium model plants were a flow rate of 10,000 acfm and an inlet loading of 120 lb/hr. For large model plants, a flow rate of 20,000 acfm and an inlet loading of 120 lb/hr were used. The OAQPS Control Cost Manual[3] was then used to develop the carbon adsorber capital costs and annual costs presented in Table 2.

Annualized Costs

The annualized costs were calculated by the following equation:

$$\text{Annualized Costs} = TCC \left[\frac{i\ (1+i)^n}{(1+i)^n - 1} \right]$$

where,

TCC = Total Capital Cost
i = Interest Rate
n = Equipment Life (years)

Using the total capital costs from line 4 of Table 2, an interest rate of 7 percent, and an equipment life of 10 years, the annualized costs by model plant are:

Medium model plant: $54,500/yr
Large model plant: $58,540/yr

TABLE 2

CAPITAL AND ANNUAL CARBON ADSORBER COSTS

FOR MEDIUM AND LARGE MODEL PLANTS

Item	Model Plant	
	Medium	Large
1. Purchased Equipment, including taxes and freight	$237,800	$255,400
2. Installation	71,300	76,600
3. Indirect	73,700	79,200
4. Total Capital Costs (Line 1 + Line 2 + Line 3)	382,800	411,200
5. Operating Labor	$12,400	$12,400
6. Maintenance	23,800	23,800
7. Replacement Carbon	47,100	47,100
8. Utilities	34,200	34,800
9. Indirect	94,200	99,900
10. Recovery Credit	(141,000)	(141,000)
11. Total Annual Costs (Line 5 + Line 6 + Line 7 + Line 8 + Line 9 - Line 10)	$ 70,700	$ 77,000

Net Annual Costs

Net annual costs represent the continual operating costs incurred to keep the carbon adsorber in service, including credit for the recovery of solvent from regeneration of the carbon bed. The operating costs, as presented in lines 5-9 of Table 2, are operating labor, maintenance, replacement carbon, utilities, and indirect costs (capital recovery, property taxes, insurance, overhead, and administrative). The operating costs are \$211,700/year for medium model plants and \$218,000/year for large model plants. The recovery credit for both medium and large model plants is \$141,000/year, resulting in net annual costs (line 11 of Table 2) of \$70,700/year for medium model plants and \$77,000/year for large model plants.

Total MACT Costs

Total MACT Cost = Annualized Costs + Net Annual Costs

Medium model plant: \$54,500/yr + \$70,700/yr = \$125,200/yr

Large model plant: \$58,540/yr + \$77,000/yr = \$135,540/yr

MACT COSTS - WATERBORNE MASKANTS

MACT floor can be based on the substitution of waterborne maskant for the solvent based maskant specified as baseline. The waterborne maskant requires a three tank system as opposed to the single tank required for solvent based maskant.[4] The waterborne maskant requires stainless steel tanks, so the baseline tanks cannot be used (tanks used for solvent based maskant are typically not constructed of stainless steel). Waterborne maskants also require a drying operation (ovens) to fully cure the coating. Solvent based maskants do not require this final cure.

Tank and Oven Costs

For medium model plants, a tank size of 20 feet x 10 feet x 10 feet deep was used, and 30 feet x 10 feet x 10 feet deep for large model plants. The cost of the 20 foot long tank was quoted as \$45,000, and the 30 foot long tank was quoted as \$50,000.[5] The quoted prices include delivery charges.

Waterborne maskant systems require two ovens.[6] For medium model plants, an oven size of 10 feet x 10 feet x 10 feet was used for both ovens. For large model plants, oven sizes of (10 feet x 10 feet x 10 feet) and (10 feet x 10 feet x 30 feet long) were used. Two vendors quoted costs for these ovens. The first vendor quoted \$37,500 for the small oven and \$45,000 for the large oven.[7] The second vendor quoted $48,000 for the small oven and $69,500 for the large oven.[8] For costing purposes, the average costs were used, or $42,700 for the small oven and $57,300 for the large oven.

Annualized Capital Costs

The total capital costs are equal to the cost of three tanks and two ovens as specified above for each model plant.

Medium model plants: ($45,000/tank x 3 tanks) + ($42,700/oven x 2 ovens) = $220,400

Large model plants: ($50,000/tank x 3 tanks) + $42,700 + $57,300 = $250,000

Using the annualized capital costs equation presented above, an interest rate of 7 percent, and an equipment life of 10 years, the annualized costs by model plant are:

Medium model plant: $31,380/yr

Large model plant: $35,590/yr

Annual Costs - Ovens

The annual operating costs for the ovens are comprised of energy and maintenance costs. One maskant manufacturer estimated the annual operating costs to be $\$0.004572/ft^2$ of surface area coverage.[9] A second maskant manufacturer estimated these same costs to be $\$0.00913/ft^2$ of surface area coverage.[10] Insufficient information was provided in these cost analyses to determine why the cost presented by the second manufacturer was almost exactly twice that of the first manufacturer. Consequently, an average of the two values, or $\$0.00685/ft^2$, will be used for the cost analysis. Neither of the two maskant manufacturers mentioned a difference in labor cost between solvent based and waterborne maskants, so it will be assumed that the labor requirements are the same for each type of maskant.

Using the surface area coverage calculated below for maskant cost, the annual costs are:

Medium model plant: $\$0.00685/ft^2 \times 396,000\ ft^2/yr = \$2,700/yr$

Large model plant: $\$0.00685/ft^2 \times 858,000\ ft^2/yr = \$5,900/yr$

Maskant Cost

In order to accurately compare cost, the equivalent volume of waterborne maskant that will replace the baseline volume of solvent based maskant must be determined. The equivalent volume is calculated using the percent by volume of solids and the dry film thickness.

One vendor of solvent based maskant reported that a typical solvent based maskant is 25 percent by volume solids, requires a 0.012 inch dry film thickness, and costs $10 per gallon.[11] To calculate the surface area coverage per gallon of maskant:

> 1 square foot of surface area covered with a dry film thickness of 0.012 inches (0.001 feet) equates to a solids volume of 0.001 ft^3.

$$\frac{1\ ft^2\ \text{surface area}}{0.001\ ft^3\ \text{solids}} \times \frac{1\ \ ft^3\ \ \text{solids}}{7.48\ \text{gal solids}} \times \frac{0.25\ \text{gal solids}}{\text{gal maskant}} = \frac{33\ ft^2}{\text{gal maskant}}$$

One vendor of waterborne maskant reported that a typical waterborne maskant is 44 percent by volume solids,[12] requires a 0.019 inch dry film thickness,[13] and costs $18 per gallon.[14] To calculate the surface area coverage per gallon of maskant:

> 1 square foot of surface area covered with a dry film thickness of 0.019 inches (0.0016 feet) equates to a solids volume of 0.0016 $ft.^3$

$$\frac{1\ ft^2\ \text{surface area}}{0.0016\ ft^3\ \text{solids}} \times \frac{1\ \ ft^3\ \ \text{solids}}{7.48\ \text{gal solids}} \times \frac{0.44\ \text{gal solids}}{\text{gal maskant}} = \frac{37\ ft^2}{\text{gal maskant}}$$

Surface area coverage (baseline):

Medium model plant: 12,000 gal maskant x 33 ft^2/gal maskant = 396,000 ft^2

Large model plant: 26,000 gal maskant x 33 ft^2/gal maskant = 858,000 ft^2

Equivalent waterborne maskant volume:

Medium model plant: 396,000 ft^2 x 1 gal maskant/37 ft^2 = 10,700 gal maskant

Large model plant: 858,000 ft^2 x 1 gal maskant/37 ft^2 = 23,200 gal maskant

Incremental maskant cost:

Medium model plant: (10,700 gal/yr x $18/gal) - (12,000 gal/yr x $10/gal) = $72,600/yr

Large model plant: (23,200 gal/yr x $18/gal) - (26,000 gal/yr x $10/gal) = $157,600/yr

Total MACT Cost

The total cost of implementing MACT is equal to the sum of the annualized capital costs, annual costs, and the incremental annual maskant cost.

Medium model plant: $31,380/yr + $2,700/yr + $72,600/yr = $106,680/yr

Large model plant: $35,590/yr + $5,900/yr + $157,600/yr = $199,090/yr

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4. Telephone Report. K. Feser, PES, and B. Werkema, McDonnell Douglas, on January 15, 1993.

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7. Telephone Report. K. Feser, PES, and D. Lauersdorf, Wisconsin Ovens, on February 1, 1993.

8. Telephone Report. K. Feser, PES, and P. Averett, Photo Chemical Systems, on February 11, 1993.

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11. Telephone Report. K. Feser, PES, and S. Weinstein, AC Products, on December 15, 1992.

12. Telephone Report. K. Feser, PES, and M. Jaffari, Malek, Inc., on November 11, 1992.

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MEMORANDUM

TO: Vickie Boothe
US EPA:ESD

FROM: David Hendricks
Pacific Environmental Services, Inc. (PES)

DATE: February 8, 1994
L:\N208

SUBJECT: MACT Cost Analysis for Aircraft Depainting

The purpose of this memo is to calculate and compare baseline and MACT costs for aircraft depainting. Baseline consists of using methylene chloride based chemical strippers. The MACT floor specifies no HAP emissions from chemical depainting. Three basic methods have been identified for meeting the MACT floor. These methods are (1) media blasting such as plastic media and wheat starch; (2) both acidic and alkaline non-HAP chemical strippers; and (3) reducing the amount of outer surface area of the aircraft that is coated. The data for the first option was derived mainly from military facilities. Since it is unknown whether the available data is applicable to commercial facilities, the cost impacts for the first option were evaluated only for military model plants. Similarly, the available data for the second and third options were derived from commercial facilities. Since it is unknown whether the available data is applicable to military facilities, and the third option applies only to commercial aircraft, the cost impacts for the second and third options were evaluated only for commercial model plants. All impact analyses also include an exemption of 20 gallons of chemical stripper per aircraft for spot stripping and decal removal.

Tables 1, 2, and 3 summarize the baseline and MACT cost impacts for each of the options. The assumptions and calculations used in determining these impacts are detailed below.

Table 1 summarizes the baseline and MACT costs for option 1. As shown in line 12 of Table 1, implementation of MACT is

TABLE 1

ANNUAL COSTS TO IMPLEMENT PLASTIC MEDIA BLASTING

Item	Model Plant		
	Small	Medium	Large
1. Baseline Labor Costs	$492,300	$680,080	$3,684,240
2. Baseline Material Costs	75,840	104,770	567,600
3. Baseline Utility Costs	8,270	11,430	61,920
4. Baseline Disposal Costs	23,440	32,380	175,440
5. Total Baseline Costs (Line 1 + Line 2 + Line 3 + Line 4)	599,850	828,660	4,489,200
6. MACT Labor Costs	386,120	533,400	2,889,600
7. MACT Material Costs	326,820	451,490	2,445,840
8. MACT Utility Costs	20,680	28,580	154,800
9. MACT Disposal Costs	11,030	15,240	82,560
10. MACT Annualized Costs	23,600	66,080	66,080
11. Total MACT Implementation Costs (Line 6 + Line 7 + Line 8 + Line 9 + Line 10)	768,250	1,094,790	5,638,880
12. Cost Impact (Line 11 - Line 5)	$168,400	$266,130	$1,149,680

TABLE 2

ANNUAL COSTS TO IMPLEMENT NON-HAP STRIPPERS

Item	Model Plant	
	Small	Medium
1. Baseline Stripper Costs	$86,960	$260,020
2. Baseline Disposal Costs	28,020	83,700
3. Baseline Labor Costs	170,000	614,000
4. Total Baseline Costs (Line 1 + Line 2 + Line 3)	284,980	957,720
5. MACT Non-HAP Stripper Costs	100,860	301,410
6. MACT HAP Stripper Costs	4,880	13,200
7. MACT HAP Stripper Disposal Costs	2,040	5,520
8. MACT Labor Costs	170,000	614,000
9. Total MACT Implementation Costs (Line 5 + Line 6 + Line 7 + Line 8)	277,780	934,130
10. Cost Impact (Line 9 - Line 4)	($7,200)	($23,590)

Note: Values in parentheses represent a cost savings to the model plant.

TABLE 3

ANNUAL COSTS OF REDUCING THE OUTER SURFACE AREA OF THE AIRCRAFT THAT IS COATED

Item	Model Plant	
	Small	Medium
1. Baseline Stripper Costs	$86,960	$260,020
2. Baseline Disposal Costs	28,020	83,700
3. Baseline Labor Costs	170,000	614,000
4. Total Baseline Costs (Line 1 + Line 2 + Line 3)	284,980	957,720
5. MACT Stripper Costs	4,350	13,000
6. MACT Stripper Disposal Costs	1,400	4,180
7. MACT Labor Costs	8,500	30,700
8. MACT Polishing Costs	236,430	1,284,180
9. Total MACT Implementation Costs (Line 5 + Line 6 + Line 7 + Line 8)	250,680	1,332,070
10. Cost Impact (Line 9 - Line 4)	($34,300)	$374,350

Note: Values in parentheses represent a cost savings to the model plant.

expected to result in an annual cost of $168,400 for small model plants, $266,130 for medium model plants, and $1,149,680 for large model plants.

Table 2 summarizes the baseline and MACT costs for option 2. As shown in line 10 of Table 2, implementation of MACT is expected to result in an annual savings of $7,200 for small model plants and $23,590 for medium model plants.

Table 3 summarizes the baseline and MACT costs for option 3. As shown in line 10 of Table 3, implementation of MACT is expected to result in an annual savings of $34,300 for small model plants and an annual cost of $374,350 for medium model plants.

OPTION 1 - PLASTIC MEDIA BLASTING

BASELINE

The baseline has been defined as depainting aircraft with methylene chloride based stripers with no emission controls in place. Many military facilities are currently using plastic media blasting. Therefore, for the purpose of this option, data from military facilities will be used for both baseline and MACT. The total outer surface area of aircraft reworked annually for each model plant is:

Small model plants[1] - 137,900 ft^2

Medium model plant[2,3] - 190,500 ft^2

Large model plant[4] - 1,032,000 ft^2

Baseline Costs

A medium size military rework facility provided labor, materials, and utility costs for methylene chloride depainting on a cost per square foot of outer surface area basis.[5] These costs are:

Labor:	$3.57/$ft^2$
Materials:	$0.55/$ft^2$
Utilities:	$0.06/$ft^2$

It will be assumed that these costs remain constant for all model plant sizes.

Since there is no difference between the disposal of spent stripper from military facilities and that from commercial facilities, the disposal cost should also be the same. Delta Air Lines stated that depainting produces 0.029 gallons of waste stripper for every square foot of surface area stripped, and waste disposal costs are \$6.00/gallon.[6,7] Therefore, it costs \$0.17/ft^2 for spent stripper disposal.

Based on site visits and general knowledge of the industry, virtually all aerospace facilities have a wastewater treatment facility on-site to treat waste generated by a variety of operations. Consequently, the capital costs associated with wastewater treatment from the depainting operation will not be included in the cost analysis since these facilities are already in place.

Labor cost for chemical depainting:

Small model plant: 137,900 ft^2/yr x \$3.57/ft^2 = \$492,300/yr

Medium model plant: 190,500 ft^2/yr x \$3.57/ft^2 = \$680,080/yr

Large model plant: 1,032,000 ft^2/yr x \$3.57/ft^2 = \$3,684,240/yr

Material Costs:

Small model plant: 137,900 ft^2/yr x \$0.55/ft^2 = \$75,840/yr

Medium model plant: 190,500 ft^2/yr x \$0.55/ft^2 = \$104,770/yr

Large model plant: 1,032,000 ft^2/yr x \$0.55/ft^2 = \$567,600/yr

Utility costs:

Small model plant: 137,900 ft^2/yr x \$0.06/ft^2 = \$8,270/yr

Medium model plant: 190,500 ft^2/yr x \$0.06/ft^2 = \$11,430/yr

Large model plant: 1,032,000 ft^2/yr x \$0.06/ft^2 = \$61,920/yr

Spent stripper disposal costs:

Small model plant: 137,900 ft^2/yr x $\$0.17/ft^2$ = \$23,440/yr

Medium model plant: 190,500 ft^2/yr x $\$0.17/ft^2$ = \$32,380/yr

Large model plant: 1,032,000 ft^2/yr x $\$0.17/ft^2$ = \$175,440/yr

Total Baseline Costs

The total baseline costs equal the sum of the labor, material, utility, and disposal costs for each model plant.

	Model Plant		
	Small	Medium	Large
Labor costs	\$492,300/yr	\$680,080/yr	\$3,684,240/yr
Material costs	75,840/yr	104,770/yr	567,600/yr
Utility costs	8,270/yr	11,430/yr	61,920/yr
Disposal costs	23,440/yr	32,380/yr	175,440/yr
Total Costs	\$599,850/yr	\$828,660/yr	\$4,489,200/yr

MACT COSTS

As previously stated, the MACT floor specifies no HAP emissions from chemical depainting. This can be achieved through the use of media blasting techniques. Plastic media blasting will be used for the purpose of evaluating cost impacts since it is already in use at several military facilities.

Annual Costs

The costs associated with implementing plastic media blasting are for capital equipment, labor, materials, utility, and waste disposal. The same facility that provided cost per square foot of surface area data for methylene chloride based stripping also provided the same data for plastic media blasting.[8] These costs are:

Labor: $\$2.80/ft^2$
Materials: $\$2.37/ft^2$
Utilities: $\$0.15/ft^2$

As with methylene chloride based stripping, it will be assumed that these values remain constant for all model plant sizes.

One facility estimated the disposal cost of the paint chips and spent blasting media to be $900 per aircraft.[9] This facility strips only one type of aircraft, which has an outer surface area of 11,000 square feet.[10] The disposal cost then equates to $0.08 per square foot.

Facilities that have implemented plastic media blasting systems typically use an existing building for the operation rather than constructing a new building. Consequently, no building costs will be included in the total capital cost calculations.

Labor costs:

Small model plant: 137,900 ft^2/yr x $2.80/$ft^2$ = $386,120/yr

Medium model plant: 190,500 ft^2/yr x $2.80/$ft^2$ = $533,400/yr

Large model plant: 1,032,000 ft^2/yr x $2.80/$ft^2$ = $2,889,600/yr

Material costs:

Small model plant: 137,900 ft^2/yr x $2.37/$ft^2$ = $326,820/yr

Medium model plant: 190,500 ft^2/yr x $2.37/$ft^2$ = $451,490/yr

Large model plant: 1,032,000 ft^2/yr x $2.37/$ft^2$ = $2,445,840/yr

Utility costs:

Small model plant: 137,900 ft^2/yr x $0.15/$ft^2$ = $20,680/yr

Medium model plant: 190,500 ft^2/yr x $0.15/$ft^2$ = $28,580/yr

Large model plant: 1,032,000 ft^2/yr x $0.15/$ft^2$ = $154,800/yr

Disposal costs:

Small model plant: 137,900 ft^2/yr x \$0.08/ft^2 = \$11,030/yr

Medium model plant: 190,500 ft^2/yr x \$0.08/ft^2 = \$15,240/yr

Large model plant: 1,032,000 ft^2/yr x \$0.08/ft^2 = \$82,560/yr

Capital Costs

Capital costs for plastic media blasting systems can vary greatly depending on the capabilities of the system, sophistication of controls, and number of blasting guns. One facility reported a capital cost of \$250,000 for a small plane facility.[11] Another facility reported a capital cost of \$700,000 for a large plane facility.[12] This cost was also used for medium facilities.

Total capital costs:

Small model plants: \$250,000

Medium model plants: \$700,000

Large model plants: \$700,000

<u>Annualized Capital Costs</u>

The annualized capital costs were calculated from the following equation:

$$\text{Annualized Costs} = TCC \left[\frac{i\,(1+i)^n}{(1+i)^n - 1} \right]$$

where,

TCC = Total Capital Cost
i = Interest Rate
n = Equipment Life (years)

No information on the life of the blasting equipment could be obtained other than it is indefinite with proper maintenance. Therefore, 20 years will be used for the equipment life. Using an interest rate of 7 percent and the total capital costs presented above, the annualized costs by model plant are:

Small model plant: $23,600/yr

Medium model plant: $66,080/yr

Large model plant: $66,080/yr

Total MACT Cost

The total MACT cost is the sum of the labor, material, utility, disposal, and annualized costs for the plastic media blasting systems.

	Model Plant		
	Small	Medium	Large
Labor costs	$386,120/yr	$533,400/yr	$2,889,600/yr
Material costs	326,820/yr	451,490/yr	2,445,840/yr
Utility costs	20,680/yr	28,580/yr	154,800/yr
Disposal costs	11,030/yr	15,240/yr	82,560/yr
Annualized costs	23,600/yr	66,080/yr	66,080/yr
Total Costs	$768,250/yr	$1,094,790/yr	$5,638,880/yr

Cost Impact

The total cost impact of implementing the MACT standard is equal to the total MACT costs minus the total baseline costs.

Small model plants: $768,250/yr - $599,850/yr = $168,400/yr

Medium model plants: $1,094,790/yr - $828,660/yr = $266,130/yr

Large model plants: $5,638,880/yr - $4,489,200/yr = $1,149,680/yr

OPTION 2 - NON-HAP STRIPPER AND
OPTION 3 - REDUCED PAINT SCHEME

BASELINE

The baseline for Options 2 and 3 has been defined as depainting fully-painted aircraft with methylene chloride based chemical strippers. Since Option 2 and 3 are demonstrated at commercial facilities, data for the baseline has been obtained from commercial facilities. The following parameters define baseline:

Total number of aircraft reworked annually

Small model plant	-	17 narrow body
Medium model plant[13,14]	-	35 narrow body 11 wide body

The number of aircraft reworked annually for the small model plant was extrapolated from the medium model plant data. Total outer surface area of aircraft reworked annually:

Small model plant[15]	-	163,900 ft^2
Medium model plant[16]	-	489,610 ft^2

From data provided by TWA and Delta, it takes 0.037 gal/ft^2 to depaint aircraft using methylene chloride based strippers.[17,18] Baseline stripper usage was calculated using these data and the baseline outer surface area per model plant. Additionally, Delta Air Lines specified that 0.77 gallons of stripper waste is disposed of per gallon of original stripper used.[19] Delta Air Lines also provided the cost of stripper and disposal at $14.35/gal and $6.00/gal, respectively.[20] TWA stated that approximately 250 man-hours are used to depaint a narrow body aircraft and 600 man-hours for a wide body aircraft.[21] TWA's labor costs were listed as $40 per hour.[22]

Stripper usage and disposal:

Small model plant: 163,900 ft^2/yr x 0.037 gal/ft^2 = 6,060 gal/yr

6,060 gal/yr x 0.77 gal waste/gal = 4,670 gal waste/yr

Medium model plant: 489,610 ft^2/yr x 0.037 gal/ft^2 = 18,120 gal/yr

18,120 gal/yr x 0.77 gal waste/gal = 13,950 gal waste/yr

Stripper Cost:

Small model plant: 6,060 gal/yr x $14.35/gal = $86,960/yr

Medium model plant: 18,120 gal/yr x $14.35/gal = $260,020/yr

Waste Stripper Disposal Cost:

Small model plant: 4,670 gal/yr x $6.00/gal = $28,020/yr

Medium model plant: 13,950 gal/yr x $6.00/gal = $83,700/yr

Labor cost for chemical depainting:

Narrow body aircraft: 250 man-hours/aircraft x $40/man-hours = $10,000/aircraft

Wide body aircraft: 600 man-hours/aircraft x $40/man-hours = $24,000/aircraft

Small model plant: 17 aircraft/yr x $10,000/aircraft = $170,000/yr

Medium model plant: (35 aircraft/yr x $10,000/aircraft) + (11 aircraft/yr x $24,000/aircraft) = $614,000/yr

Based on site visits and general knowledge of the industry, virtually all aerospace facilities have a wastewater treatment facility on-site to treat waste generated by a variety of operations. Consequently, the capital costs associated with wastewater treatment from the depainting operation will not be included in the cost analysis since these facilities are already in place.

Total depainting costs:

	Small Model Plants	Medium Model Plants
Cost of stripper	$86,960/yr	$260,020/yr
Cost of spent stripper disposal	28,020/yr	83,700/yr
Labor costs for depainting	170,000/yr	614,000/yr
Total Costs	$284,980/yr	$957,720/yr

OPTION 2 - NON-HAP STRIPPER

MACT COSTS

As stated previously, this option is based on using non-HAP strippers. At least one commercial facility uses non-HAP strippers to depaint aircraft. Data from this facility will be used for the purpose of this option wherever possible. Additionally, 20 gallons of chemical stripper that contains HAP's per aircraft stripped will be allowed as an exemption.

Delta Air Lines stated that 0.042 gallons of non-HAP stripper is used per square foot of aircraft stripped.[23] MACT stripper usage was calculated using these data and the outer surface area per model plant. The stripper is disposed as waste into on-site wastewater treatment facilities. As stated previously, virtually all aerospace facilities have a wastewater treatment facility on-site to treat waste generated by a variety of operations. Consequently, the capital costs associated with wastewater treatment will not be included in the cost analysis since these facilities are already in place. Delta Air Lines also stated that the cost of stripper is $14.66/gal.[24] TWA stated that approximately 250 man-hours are used to depaint a narrow body aircraft and 600 man-hours for a wide body aircraft. TWA's labor costs were listed as $40 per hour.

Non-HAP Stripper Usage:

Small model plant: 163,900 ft^2/yr x 0.042 gal/ft^2 = 6,880 gal/yr

Medium model plant: 489,610 ft^2/yr x 0.042 gal/ft^2 = 20,560 gal/yr

Stripper Cost:

Small model plant: 6,880 gal/yr x $14.66/gal = $100,860/yr

Medium model plant: 20,560 gal/yr x $14.66/gal = $301,410/yr

Labor cost for chemical depainting:

Narrow body aircraft: 250 man-hours/aircraft x $40/man-hours = $10,000/aircraft

Wide body aircraft: 600 man-hours/aircraft x $40/man-hours = $24,000/aircraft

Small model plant: 17 aircraft/yr x $10,000/aircraft = $170,000/yr

Medium model plant: (35 aircraft/yr x $10,000/aircraft) + (11 aircraft/yr x $24,000/aircraft) = $614,000/yr

Since the total number of aircraft reworked annually is 17 for a small model plant and 46 for a medium model plant, The exempted use of methylene chloride based stripper will equal the number of aircraft stripped per model plant multiplied by the 20 gallons. As stated in the baseline section, Delta Air Lines generates 0.77 gallons of waste per gallon of stripper used. Delta Air Lines also stated that it costs $6.00/gallon to dispose of waste stripper. The MACT methylene chloride based stripper usage and disposal by model plant are:

HAP Stripper Usage and Disposal:

Small model plant: 17 aircraft/yr x 20 gal/aircraft = 340 gal/yr

340 gal/yr x 0.77 gal waste/gal = 260 gal waste/yr

Medium model plant: 46 aircraft/yr x 20 gal/aircraft = 920 gal/yr

920 gal/yr x 0.77 gal waste/gal = 710 gal waste/yr

HAP Stripper Cost:

Small model plant: 340 gal/yr x $14.35/gal = $4,880/yr

Medium model plant: 920 gal/yr x $14.35/gal = $13,200/yr

HAP Stripper Disposal Cost:

Small model plant: 340 gal/yr x $6.00/gal = $2,040/yr

Medium model plant: 920 gal/yr x $6.00/gal = $5,520/yr

Total MACT Cost

The total MACT cost is the sum of the material, disposal, and labor costs.

	Small Model Plants	Medium Model Plants
Cost of non-HAP stripper	$100,860/yr	$301,410/yr
Cost of methylene chloride based stripper	4,880/yr	13,200/yr
Cost of spent methylene chloride based stripper disposal	2,040/yr	5,520/yr
Labor costs for depainting	170,000/yr	614,000/yr
Total Costs	$277,780/yr	$934,130/yr

Cost Impact

Actual cost of implementing the MACT standard is equal to the total MACT cost minus the baseline cost.

Small model plant: $277,780/yr - $284,980/yr = ($7,200/yr)

Medium model plant: $934,130/yr - $957,720/yr = ($23,590/yr)

The negative values indicate an overall net savings for the model plants to implement the MACT standard.

OPTION 3 - REDUCED PAINT SCHEME

MACT COSTS

As stated previously, this option is based on partially painting the aircraft and polishing the unpainted bare metal portion of the aircraft. This option is demonstrated at commercial facilities and data from these facilities is used below. Although the cost impact of a reduction in paint usage is not taken into account in this analysis, polishing cost must be included since polishing unpainted bare metal is necessary. Additionally, polishing is performed more frequently than repainting and, therefore, the number of aircraft reworked annually increases. The following parameters define MACT:

Total number of aircraft reworked annually:

Small model plant[25]	-	56 narrow body
Medium model plant[26]	-	107 narrow body 74 wide body

Total outer surface area of aircraft reworked annually

Small model plant[27]	-	379,048 ft^2
Medium model plant[28]	-	2,258,118 ft^2

Polishing Costs

Based on information provided by American Airlines, 150 labor hours are required to polish a narrow body aircraft, and 400 labor hours are required to polish a wide body aircraft. American also reported the cost of the polish to be $27.50 per pound.[29] USAir reported costs of $6.09 and $25.50 per gallon of two polishes they use.[30] American uses 2 pounds of polish for a narrow body aircraft and 5 pounds for a wide body aircraft.[31] USAir, which only services narrow body aircraft, reported using 0.5 gallon of each polish per narrow body aircraft.[32] Extrapolating USAir's narrow body usage to wide body usage on the basis that American Airlines uses 2.5 times the amount of polish on a wide body than on a narrow body aircraft, USAir would use 1.25 gallons of each polish on a wide body aircraft. Since the cost and usage of the polish is an average of data provided by USAir and American, the same polish cost will be used whether 5 percent or 40 percent of the outer surface area is painted.

Cost of Polish:

American - narrow body: 2 lb/aircraft x $27.50/lb = $55/aircraft

- wide body: 5 lb/aircraft x $27.50/lb = $140/aircraft

USAir - narrow body: (0.5 gal/aircraft x $6.09/gal) +
(0.5 gal x $25.50/gal) = $18/aircraft

- wide body: (1.25 gal/aircraft x $6.09/gal) +
(1.25 gal x $25.50/gal) = $39/aircraft

Average narrow body: ($55 + $18)/2 = $37/aircraft

Average wide body: ($140 + $39)/2 = $89/aircraft

Small model plant: 56 aircraft/yr x $37/aircraft = $2,070/yr

Medium model plant: (107 aircraft/yr x $37/aircraft) + (74 aircraft/yr x $89/aircraft) = $10,550/yr

Labor cost to polish:

The cost and labor hours per aircraft are from data provided by American Airlines.[33] This facility paints up to 60 percent of their planes.

Narrow body: 150 hours/aircraft x $18/hour = $2,700/aircraft

Wide body: 400 hours/aircraft x $18/hour = $7,200/aircraft

Small model plant: 56 aircraft/yr x $2,700/aircraft = $151,200/yr

Medium model plant: (107 aircraft/yr x $2,700/aircraft) + (74 aircraft/yr x $7,200/aircraft) = $821,700/yr

Since 55 percent more of the surface area of the aircraft must be polished when only 5 percent of the surface area is painted, it will be assumed that the labor requirements are 55 percent greater than that calculated above.

Small model plant: $151,200/yr x 1.55 = $234,360/yr

Medium model plant: $821,700/yr x 1.55 = $1,273,630/yr

Total polishing costs:

Small model plant: $2,070/yr + $234,360/yr = $236,430/yr

Medium model plant: $10,550/yr + $1,273,630/yr = $1,284,180/yr

Depainting Costs

The portion of the aircraft that is painted must also be stripped. For aircraft with 5 percent of the surface area painted, stripping costs are assumed to be 5 percent of the cost to strip a fully painted aircraft.

Small model plant: $284,980/yr x 0.05 = $14,250/yr

Medium model plant: $957,720/yr x 0.05 = $47,890/yr

Total MACT Cost

Total MACT cost is equal to the sum of the polishing costs and depainting costs.

Small model plant: $236,430/yr + $14,250/yr = $250,680/yr

Medium model plant: $1,284,180/yr + $47,890/yr = $1,332,070/yr

Cost Impact

Actual cost of implementing the MACT standard is equal to the total MACT cost minus the baseline cost.

Small model plant: $250,680/yr - $284,980/yr = ($34,300/yr)

Medium model plant: $1,332,070/yr - $957,720/yr = $374,350/yr

The negative values indicate an overall net savings for the model plants to implement the MACT standard.

References

1. Section 114 Questionnaire Response from Grumman Corporation St. Augustine Operations Facility in St. Augustine, Florida.

2. Section 114 Questionnaire Responses from Lockheed Aircraft Services Ontario Facility in Ontario, California.

3. Section 114 Questionnaire Responses from Naval Aviation Depot in Alameda, California.

4. Section 114 Questionnaire Response from Warner Robins Air Logistics Center, Robins Air Force Base, in Warner Robins, Georgia.

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8. Reference 5.

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17. Telephone Report. D. Hendricks, PES, and G. Mundy, Trans World Airlines, on February 11, 1993.

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27. Reference 25.

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29. Telephone Report. K. Feser, PES, and B. Curtis, American Airlines, on February 1, 1993.

30. Telephone Report. K. Feser, PES, and A. Wipfield, USAir, on February 4, 1993.

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33. Reference 26.

MEMORANDUM

TO: Vickie Boothe
US EPA:ESD

FROM: David Hendricks
Pacific Environmental Services, Inc. (PES)

DATE: August 25, 1993
L:\N019

SUBJECT: MACT Cost Analysis for Hand Wipe Cleaning

The purpose of this memo is to calculate and compare baseline and MACT cost impacts for hand wipe cleaning operations. Baseline consists of using a cleaning solvent such as methyl ethyl ketone (vapor pressure 71 mmHg at 20°C). In addition, it is assumed that no housekeeping system is utilized which is focused toward capturing fugitive emissions. The MACT floor specifies that hand wipe cleaning solvents are chosen from an approved list of solvents or comply with a vapor pressure limit of 45 mmHg at 20°C. Emission reductions are achieved through product substitutions such as aqueous and low vapor pressure cleaners and the implementation of a housekeeping system. The housekeeping system includes closed containers for solvent laden rags and for storage of solvent. No significant differences were identified for OEM versus rework or military versus commercial hand wipe cleaning operations; therefore, the cost impacts are differentiated only by model plant size.

Table 1 summarizes the baseline and MACT cost impacts. As presented on line 11 of Table 1, implementation of MACT is expected to result in a cost of $7,030/yr for small model plants and $3,510/yr for medium model plants, and an annual savings of $9,260/yr for large model plants. The assumptions and calculations used in determining these impacts are detailed below.

BASELINE

The baseline for hand wipe cleaning operations has been defined as using a cleaning solvent such as methyl ethyl ketone

TABLE 1

ANNUAL COSTS TO IMPLEMENT HAND WIPE CLEANING MACT

Item	Model Plant		
	Small	Medium	Large
1. Baseline Solvent Cost	$7,350	$196,000	$882,000
2. Baseline Waste Disposal Cost	1,330	35,560	160,000
3. Total Baseline Cost (Line 1 + Line 2)	8,680	231,560	1,042,000
4. MACT Solvent Cost	5,380	143,360	645,120
5. MACT Solvent Testing Cost	900	900	900
6. MACT Waste Disposal Cost	1,080	28,890	130,000
7. MACT Other Material Cost	6,890	22,930	81,260
8. MACT Implementation Cost	630	16,770	75,460
9. MACT Recurring Education Cost	830	22,220	100,000
10. Total MACT Cost (Line 4 + Line 5 + Line 6 + Line 7 + Line 8 + Line 9)	15,710	235,070	1,032,740
11. Cost Impact (Line 10 - Line 3)	$7,030	$3,510	($9,260)

Note: Values in parentheses represent a cost savings to the model plant.

(vapor pressure 71 mmHg at 20°C). In addition, it is assumed that no housekeeping system is utilized which is focused toward capturing fugitive emissions. From Table 6-9 of the draft BID Chapter 6, the average annual hand wipe cleaning emissions was calculated to be 58 lb/employee. Assuming an average solvent density of 8 lb/gal, the average solvent usage was calculated to be 7 gal/employee. Conventional, higher vapor pressure solvents vary in cost depending on type of solvent and amount of solvent purchased. Typical solvent costs range from \$5/gal to \$9/gal.[1] For the purposes of determining cost impacts, a value of \$7/gal was assumed. The model plants are sized by number of employees with small, medium, and large facilities assigned 150, 4,000, and 18,000 employees, respectively.

For the purposes of the cost impacts, it was assumed that the following parameters define baseline:

Annual Solvent Purchase Cost by Model Plant:

Small model plant: 150 emp x 7 gal/emp-yr x \$7/gal = \$7,350/yr

Medium model plant: 4,000 emp x 7 gal/emp-yr x \$7/gal = \$196,000/yr

Large model plant: 18,000 emp x 7 gal/emp-yr x \$7/gal = \$882,000/yr

The annual cost to dispose of solvent-laden rags was estimated at \$160,000/yr by one facility classified as a large aerospace model plant.[2] This cost includes labor, transportation of waste, and off-site disposal fees. The costs have been scaled to the small and medium model plants based on number of employees.

Annual Solid Waste Disposal Cost by Model Plant:

Small model plant: (150 emp/18,000 emp) x \$160,000 = \$1,330/yr

Medium model plant: (4,000 emp/18,000 emp) x \$160,000 = \$35,560/yr

Large model plant: \$160,000/yr

Total Baseline Costs by Model Plant:

Total Baseline Cost = solvent cost + disposal cost

Small model plant: \$7,350/yr + \$1,330/yr = \$8,680/yr

Medium model plant: \$196,000/yr + \$35,560/yr = \$231,560/yr

Large model plant: \$882,000/yr + \$160,000/yr = \$1,042,000/yr

MACT COSTS

As stated previously, the MACT floor specifies using cleaning solvents from an approved list or with a vapor pressure limit of 45 mmHg at 20°C. In addition, a housekeeping system must be implemented which focuses on capturing fugitive emissions as demonstrated by one aerospace facility.[3] The costs of implementing the MACT floor control measures are derived primarily from data provided by one aerospace facility.

Several companies have developed and marketed low vapor pressure solvents to the aerospace industry. The cost for replacement solvents varies by type of solvent and amount of solvent purchased. Based on data provided by a vendor, the estimated cost of a substitute solvent is \$16/gal.[4] Total annual solvent usage is reduced by 68 percent.[5]

Annual Solvent Purchase Cost by Model Plant:

Small model plant: 150 emp x 7 gal/emp x (1-0.68) x \$16/gal = \$5,380/yr

Medium model plant: 4,000 emp x 7 gal/emp x (1-0.68) x \$16/gal = \$143,360/yr

Large model plant: 18,000 emp x 7 gal/emp x (1-0.68) x \$16/gal = \$645,120/yr

In addition to purchase costs, facilities must test every solvent that is not on the approved list for vapor pressure. Some facilities are currently using low vapor pressure solvents that may be included on the list. In addition to these substitutes, each facility uses approximately three other solvents that must be tested for vapor pressure.[6] This testing may occur once a year or less, depending on how often a facility implements new solvents. Typical vapor pressure tests for solvent mixtures range between \$150 to \$400.[7] Since many low vapor pressure solvents are complex mixtures, the cost of \$300 per test will be used in this memo. The testing costs are not scaled to model plant size since it is assumed model plants would utilize the same breakdown of solvents.

Annual Solvent Testing Cost by Model Plant: 3 x \$300 = \$900/yr

A large aerospace model plant reported the implementation of a disposal system that improved the capture of fugitive emissions. This system involves using sealable drums and bags to capture fugitive emissions from solvent-laden rags. The rags are then disposed of by off-site incineration. The cost includes labor, transportation of waste, and off-site disposal fees. This facility had already implemented these MACT control measures and reported disposal costs of $130,000. For the purposes of calculating cost impacts, a cost of $130,000/yr was used for the disposal of solvent-laden rags for a large model plant.[8] The costs have been scaled to the small and medium model plants based on number of employees.

Annual Solid Waste Disposal Cost by Model Plant:

Small model plant: (150 emp/18,000 emp) x $130,000 = $1,080/yr

Medium model plant: (4,000 emp/18,000 emp) x $130,000 = $28,890/yr

Large model plant: $130,000/yr

Additionally, sealable drums and bags must be purchased in order to provide a capture mechanism for the solvent-laden rags and other materials. The annual cost to purchase drums and aluminized bags was estimated at approximately $75,000/yr by the above facility classified as a large model plant.[9] The costs have been scaled to the small and medium model plants based on number of employees.

Annual Purchase Cost for Fiber Drums and Aluminized Bags:

Small model plant: (150 emp/18,000 emp) x $75,000 = $630/yr

Medium model plant: (4,000 emp/18,000 emp) x $75,000 = $16,670/yr

Large model plant: $75,000/yr

When dealing with large volumes of compressible solid waste, some aerospace facilities utilize compactors to reduce the volume of this waste. A facility classified as a large model plant purchased one compactor to handle solid waste. A capital cost of $44,000 was determined for the purchase and installation a compactor for a large aerospace model plant.[10]

The annualized costs were calculated by the following equation:

$$\text{Annualized Costs} = TCC \left[\frac{i\,(1+i)^n}{(1+i)^n - 1} \right]$$

where,

TCC = Total Capital Cost
i = Interest Rate
n = Equipment Life (years)

An interest rate of 7 percent and an equipment life of 10 years was assumed. The annualized costs for a large model plant are:

Annualized Compactor Cost = $6,260/yr.

The annualized compactor costs are not scaled to small and medium model plants since it is assumed the model plants would utilize the same size and type of compactor. Total material costs (excluding solvent) equal the costs of drums and bags plus the annualized compactor cost.

Annual Other Material Costs by Model Plant:

Small model plant: $630/yr + $6,260/yr = $6,890/yr

Medium model plant: $16,670/yr + $6,260/yr = $22,930/yr

Large model plant: $75,000/yr + $6,260/yr = $81,260/yr

Finally, implementing new solvents in production involves implementation and education costs. Implementation costs include engineering specification revisions, production planning document changes, process control standard revisions, and internal research and development to test and qualify low vapor pressure solvents. Training costs to educate workers on the new solvent cleaning procedures and the hazardous waste management and collection system must also be included. Education costs include instructor labor, lost labor in class, creation of training materials, and creation of awareness posters and signs. Table 2 summarizes the one time implementation costs for a large model plant. Table 3 summarizes the annual recurring education costs. The costs were obtained from a large model plant[11] and have been scaled to the small and medium model plants based on number of employees.

TABLE 2

IMPLEMENTATION COST SUMMARY

Item	Model Plant		
	Small	Medium	Large
1. Engineering Specification Revision	$1,130	$30,000	$135,000
2. Production Planning Documents Changes	210	5,560	25,000
3. Process Control Standard Revisions	40	1,110	5,000
4. Education			
Instructor Labor	380	10,000	45,000
Lost Labor in Class	2,000	53,330	240,000
Creation of Training Materials	330	8,890	40,000
5. Internal Research and Development to Test and Quantify Solvents	330	8,890	40,000
6. Total Cost (Line 1 + Line 2 + Line 3 + Line 4 + Line 5)	$4,420	$117,780	$530,000

TABLE 3

ANNUAL RECURRING EDUCATION COSTS

Item	Model Plant		
	Small	Medium	Large
1. Education			
Instructor Labor	$90	$2,440	$11,000
Lost Labor in Class	660	17,560	79,000
Training Materials	80	2,220	10,000
2. Total Cost	$830	$22,220	$100,000

The annualized implementation costs were calculated by the above annualized cost equation. An interest rate of 7 percent and a life of 10 years was assumed.

Annualized Implementation Cost:

Small model plant: $630

Medium model plant: $16,770

Large model plant: $75,460

Total MACT Costs

Total MACT Floor Costs by Model Plant:

Total MACT Cost = solvent cost + solvent testing cost + disposal cost + other material cost + implementation cost + annual education cost

Small model plant: $5,380/yr + $900/yr + $1,080/yr + $6,890/yr + $630/yr + $830/yr = $15,710/yr

Medium model plant: $143,360/yr + $900/yr + $28,890/yr + $22,930/yr + $16,770/yr + $22,220/yr = $235,070/yr

Large model plant: $645,120/yr + $900/yr + $130,000/yr + $81,260/yr + $75,460/yr + $100,000/yr = $1,032,740/yr

Cost Impacts

The cost impact is calculated by subtracting the baseline costs from the MACT costs:

Small model plant: $15,710/yr - $8,680/yr = $7,030/yr

Medium model plant: $235,070/yr - $231,560/yr = $3,510/yr

Large model plant: $1,032,740/yr - $1,042,000/yr = ($9,260/yr)

References

1. Letter. T. Phillips, Lockheed, to D. Hendricks, PES. June 4, 1993. Comments and questions about the MACT cost analysis for hand wipe cleaning.

2. Reference 1.

3. Letter. T. Phillips, General Dynamics, to V. Boothe, EPA:ESD. January 20, 1993. Alternative Cleanup Solvent Strategy for Aerospace CTG-Recently Implemented General Dynamics Fort Worth Division Program.

4. Telephone Report. K. Feser, PES, and a Dynamold representative on August 17, 1993. Cost of low vapor pressure solvent.

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6. Section 114 Questionnaire Responses.

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8. Letter. T. Phillips, Lockheed, to D. Hendricks, PES. March 19, 1993. Response to inquiry from D. Hendricks dated 2/4/93 concerning cost information on product substitution of low vapor pressure solvents at Lockheed. Non-proprietary version.

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10. Telephone Report. G. Pagett, PES, and S. Knowak, Compaction Technology, Inc., on May 18, 1993. Cost information on compactors.

11. Reference 1.

MEMORANDUM

TO: Vickie Boothe
US EPA:ESD

FROM: David Hendricks
Pacific Environmental Services, Inc. (PES)

DATE: August 25, 1993
L:\N019

SUBJECT: MACT Cost Analysis for Spray Gun Cleaning

The purpose of this memo is to calculate and compare baseline and MACT costs for spray gun cleaning. Baseline consists of a combination of enclosed spray gun cleaners and unlimited hand cleaning. The MACT floor specifies enclosed spray gun cleaners, cabinet type gun cleaners, vat cleaning using unatomized spray, and atomized spray into a waste container fitted with a capture device designed to capture atomized solvent emissions. For the purpose of the impact analysis, it will be assumed that each facility uses enclosed spray gun cleaners. There is no difference in implementing MACT for commercial versus military or OEM versus rework facilities; therefore, the impact analysis was completed only for different size model plants.

Table 1 summarizes the baseline and MACT costs. As presented in line 9 of Table 1, the implementation of MACT is expected to result in an annual savings of $16,720 for small model plants, $22,100 for medium model plants, and $28,000 for large model plants. The assumptions and calculations used in deriving these costs are detailed below.

BASELINE

Baseline consists of a combination of enclosed spray gun cleaners and unlimited hand cleaning. Table 2 presents the baseline values for the number of enclosed spray gun cleaners in use and the usage of spray gun cleaning solvent for each model plant size. Also included in the table are the values of these parameters that will be used for the MACT cost analysis.

TABLE 1

ANNUAL COST TO IMPLEMENT SPRAY GUN CLEANING MACT

Item	Model Plant		
	Small	Medium	Large
1. Baseline Annualized Costs	$270	$550	$830
2. Baseline Solvent Costs	16,800	22,800	29,200
3. Baseline Solvent Disposal Costs	6,170	8,380	10,730
4. Total Baseline Costs (Line 1 + Line 2 + Line 3)	23,240	31,730	40,760
5. MACT Annualized Costs	830	1,100	1,380
6. MACT Solvent Costs	4,160	6,240	8,320
7. MACT Solvent Disposal Costs	1,530	2,290	3,060
8. Total MACT Cost (Line 5 + Line 6 + Line 7)	6,520	9,630	12,760
9. Cost Impact (Line 8 - Line 4)	(16,720)	(22,100)	(28,000)

Note: Values in parentheses represent a cost savings to the model plant.

TABLE 2

NUMBER OF ENCLOSED GUN CLEANERS
AND SOLVENT USAGE REPRESENTED
BY BASELINE AND MACT

Model Plant Size	Number of Enclosed Gun Cleaners		Solvent Usage (gal/yr)	
	Baseline	MACT	Baseline	MACT
Small	1	4	4,200	1,040
Medium	2	6	5,700	1,560
Large	3	8	7,300	2,080

The baseline and MACT solvent usages were derived from a facility that reported solvent consumption declined from 25 gallons per week to 5 gallons per week after the installation of an enclosed spray gun cleaner.[1]

Cost information for enclosed spray gun cleaners with a capacity of 4 spray guns and equipped to handle both waterborne and solvent-based coatings was obtained from two vendors. The average cost of the three models quoted was $2,300.[2,3]

Maintenance and utility costs for all quoted models are very small. The primary maintenance item is an air-actuated diaphragm pump. However, the pump is expected to last over 100,000 3-minute cycles before replacement.[4] Assuming 10 cleaning cycles per shift, 3 shifts per day, and 250 days per year, this corresponds to a life expectancy of 13 years.

Methyl ethyl ketone (MEK) was the most frequently reported spray gun cleaning solvent in the Section 114 questionnaire responses and was used as the baseline solvent for the cost impacts. The cost of MEK was reported as $4.00 per gallon.[5]

Baseline Costs

Capital cost of equipment:

Small model plant:	1 enclosed gun cleaner x $2,300	= $2,300
Medium model plant:	2 enclosed gun cleaners x $2,300	= $4,600
Large model plant:	3 enclosed gun cleaners x $2,300	= $6,900

Annualized cost:

The annualized costs were calculated by the following equation:

$$\text{Annualized Costs} = TCC \left[\frac{i\,(1+i)^n}{(1+i)^n - 1} \right]$$

where,

TCC = Total Capital Cost
i = Interest Rate
n = Equipment Life (years)

Using the total capital cost of the enclosed spray gun cleaners presented above, an interest rate of 7 percent, and an equipment life of 13 years, the annualized costs by model plant are:

Small model plant:	\$270/yr
Medium model plant:	\$550/yr
Large model plant:	\$830/yr

Solvent cost:

Small model plant: 4,200 gal/yr x \$4.00/gal = \$16,800/yr

Medium model plant: 5,700 gal/yr x \$4.00/gal = \$22,800/yr

Large model plant: 7,300 gal/yr x \$4.00/gal = \$29,200/yr

Solvent Disposal Costs

Based on information provided by Lockheed Missiles and Space Company, Inc., Sunnyvale, California, approximately 98 percent of the original solvent usage must be disposed.[6] Disposal costs were quoted as \$1.50/gallon.[7]

Small model plant: 4,200 gal/yr x 0.98 x \$1.50/gal = \$6,170/yr

Medium model plant: 5,700 gal/yr x 0.98 x \$1.50/gal = \$8,380/yr

Large model plant: 7,300 gal/yr x 0.98 x \$1.50/gal = \$10,730/yr

Total Baseline Costs

Total baseline costs = Solvent costs + Annualized costs + Solvent disposal costs

Small model plant: \$16,800/yr + \$270/yr + \$6,170/yr = \$23,240/yr

Medium model plant: \$22,800/yr + \$550/yr + \$8,380/yr = \$31,730/yr

Large model plant: \$29,200/yr + \$830/yr + \$10,730/yr = \$40,760/yr

MACT COSTS

As stated previously, MACT floor specifies enclosed spray gun cleaners, cabinet type gun cleaners, vat cleaning using unatomized spray, and atomized spray into a waste container fitted with a capture device designed to capture atomized solvent emissions. For the purpose of the impact analysis, it will be assumed that each facility uses enclosed spray gun cleaners.

Capital cost of equipment:

Small model plant: 3 enclosed gun cleaners x $2,300 = $ 6,900

Medium model plant: 4 enclosed gun cleaners x $2,300 = $ 9,200

Large model plant: 5 enclosed gun cleaners x $2,300 = $11,500

Annualized cost (see annualized cost for baseline):

Small model plant:	$830/yr
Medium model plant:	$1,100/yr
Large model plant:	$1,380/yr

Solvent cost:

Small model plant: 1,040 gal/yr x $4.00/gal = $4,160/yr

Medium model plant: 1,560 gal/yr x $4.00/gal = $6,240/yr

Large model plant: 2,080 gal/yr x $4.00/gal = $8,320/yr

Spent Solvent Disposal Costs

As explained in the baseline spent solvent disposal section, approximately 98 percent of the original solvent usage must be disposed of at the same disposal cost.

Small model plant: 1,040 gal/yr x 0.98 x $1.50/gal = $1,530/yr

Medium model plant: 1,560 gal/yr x 0.98 x $1.50/gal = $2,290/yr

Large model plant: 2,080 gal/yr x 0.98 x $1.50/gal = $3,060/yr

Total MACT Costs

Total MACT costs = Solvent cost + Annualized costs + Solvent Disposal costs

Small model plant: \$4,160/yr + \$830/yr + \$1,530/yr = \$6,520/yr

Medium model plant: \$6,240/yr + \$1,100/yr + \$2,290/yr = \$9,630/yr

Large model plant: \$8,320/yr + \$1,380/yr + \$3,060/yr = \$12,760/yr

Cost Impact

The total cost impact of implementing the MACT standard is equal to the total MACT costs minus the total baseline cost.

Small model plant: \$6,520/yr - \$23,240/yr = (\$16,720/yr)

Medium model plant: \$9,630/yr - \$31,730/yr = (\$22,100/yr)

Large model plant: \$12,760/yr - \$40,760/yr = (\$28,000/yr)

References

1. Trip Report - Naval Aviation Depot in Alameda, California, on February 28, 1992.

2. Letter. Sabol, Mick, James McGraw, Inc., to Kathy Feser, PES. January 26, 1993. Pricing and specifications of enclosed spray gun cleaners.

3. Letter. Lowe, Ronnie, Air Power, Inc., to Kathy Feser, PES. January 26, 1993. Pricing and specifications of enclosed spray gun cleaners.

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6. Letter. Kurucz, Kraig, Lockheed Missiles and Space Company, Inc., to David Hendricks, PES. May 17, 1993. Information on enclosed gun cleaner alternatives.

7. Letter. Taylor, Carole, Northrop Corp., Aircraft Division, to David Hendricks, PES. February 22, 1993. Usage and cost of gun cleaning solvent.

MEMORANDUM

TO: Vickie Boothe
US EPA:ESD

FROM: David Hendricks
Pacific Environmental Services, Inc. (PES)

DATE: August 25, 1993
L:\N019

SUBJECT: MACT Cost Impact Analysis for Primers and Topcoats

The purpose of this memo is to calculate and compare baseline and MACT cost impacts for low HAP primers and topcoats and for the coating application equipment for these primers and topcoats. Baseline coatings consist of military and commercial primers and topcoats as reported in the Section 114 questionnaire responses. Baseline application methods consist of a mix of conventional, HVLP, and electrostatic spray guns as reported in the Section 114 questionnaire responses. The MACT floor specifies product substitutions to reduce the HAP content of the coatings. For the purpose of the impact analysis, it will be assumed that each facility replaces all of their conventional primers and topcoats with reduced HAP content primers and topcoats rather than controlling emissions through abatement. The MACT floor also specifies high transfer efficiency methods for primer and topcoat application (e.g., flow coat, roll coat, dip coat, electrostatic, or HVLP). For the purpose of the impact analysis, it will be assumed that all model plants replace their conventional spray guns used to apply primers and topcoats with HVLP spray guns. Due to the difference in coating usage between commercial and military model plants, the coating substitution cost impacts will also be different. Consequently, the impact analysis was completed for commercial and military model plants as well as for different size model plants. There is no difference in coating application methods for commercial and military model plants and the calculations will be assumed the same for either model plant. There is no difference between OEM and rework facilities.

Table 1 summarizes the costs. As presented in Table 1, implementation of MACT coating substitutions is expected to result in annual savings of $36,830 for small commercial model plants, $67,350 for medium commercial model plants, and $520,600 for large commercial model plants. Additionally, the implementation of MACT application methods is expected to result in annual savings of $8,680 for small military model plants, $12,450 for medium military model plants, and $90,830 for large military model plants. The assumptions and calculations used in deriving these costs are detailed below. Baseline and MACT for coating substitutions and application methods are analyzed separately. The total cost impacts are then calculated.

BASELINE FOR COATING SUBSTITUTIONS

Coating Usage

Baseline coatings consist of military and commercial primers and topcoats as reported in the Section 114 questionnaire responses. The average annual baseline usage of commercial and military primers and topcoats is presented in Table 2.

The cost of primers and topcoats was provided by three coating manufacturers.[1,2,3] Average costs per gallon are presented in Table 3 for baseline and MACT coatings.

Baseline costs are calculated by multiplying annual baseline coating usage by cost per gallon. The result is cost per year. Sample cost calculations for a large, commercial primer operation are presented below. The calculations for all other coating categories and model plants were done in a similar manner. Baseline costs are presented in Table 4.

Baseline Primer Cost = 18,000 gal/yr x $23/gal = $414,000/yr

Coating Labor

Based on an article in Industrial Finishing, one aerospace manufacturer uses 200 gallons of paint and 1,250 labor hours to paint a wide body aircraft, and 125 gallons of paint and 500 labor hours for a narrow body aircraft.[4] A large portion of the labor hours, however, are for masking and drying operations that will occur regardless of the spray guns used. According to the same article, 67 percent of the labor hours are spent during drying, and 8 percent for masking. These two operations account

TABLE 1

COST IMPACTS TO IMPLEMENT PRODUCT SUBSTITUTION
FOR PRIMERS AND TOPCOATS

Item	Commercial			Military		
	Model Plant			Model Plant		
	Small	Medium	Large	Small	Medium	Large
1. Baseline Costs	$89,270	$367,920	$3,158,340	$26,570	$110,330	$897,640
2. MACT Costs	52,440	300,570	2,637,740	17,890	97,880	806,810
3. MACT Implementation Costs (Line 2 - Line 1)	($36,830)	($67,350)	($520,600)	($8,680)	($12,450)	($90,830)

Note: Values in parentheses represent a cost savings to the model plant.

TABLE 2
BASELINE AVERAGE ANNUAL COATING USAGE
BY MODEL PLANT SIZE[a]

Model Plant Size	Commercial Usage (gal)		Military Usage (gal)	
	Primers	Topcoats	Primers	Topcoats
Small	500	500	170	110
Medium	2,100	2,000	710	420
Large	18,000	17,900	6,100	3,800

[a] Source: Section 114 questionnaire responses.

TABLE 3
BASELINE AND MACT PRIMER AND TOPCOAT COATING COSTS[a]

Coating Category	Baseline		MACT	
	Commercial	Military	Commercial	Military
	($/Gallon)	($/Gallon)	($/Gallon)	($/Gallon)
Primers	23	23	32	39
Topcoats	48	59	55	74

[a] Source: Section 114 questionnaire responses and vendor information.

TABLE 4
ANNUAL BASELINE COSTS FOR AEROSPACE COATINGS

Model Plant Size	Commercial Costs ($)		Military Costs ($)	
	Primers	Topcoats	Primers	Topcoats
Small	11,500	24,000	3,910	6,490
Medium	48,300	96,000	16,330	24,780
Large	414,000	859,200	140,300	224,200

for 75 percent of the labor hours, leaving 25 percent for the actual application of the paint. Thus, 313 hours are used to apply 200 gallons on the wide body aircraft, and 125 hours to apply 125 gallons on the narrow body aircraft. This equates to 1.6 hours/gallon and 1.0 hours/gallon for applying paint on wide body and narrow body aircraft, respectively. An average of 1.3 hours/gallon will be used for the cost analysis. The baseline labor hours are presented in Table 5 and are the values in Table 2 multiplied by 1.3 hours/gallon. Using $40/labor hour as developed in the MACT cost analysis for aircraft depainting,[5] the baseline labor costs by model plant are presented in Table 6 and are the values in Table 5 multiplied by $40/hour.

The total baseline costs for coating substitutions are presented in Table 7. These values were calculated by adding the costs in Table 4 and Table 6 and then adding the primer and topcoat values for each size model plant.

MACT COSTS FOR COATING SUBSTITUTIONS

Coating Usage Savings

The MACT floor specifies product substitutions to reduce the HAP content of the coatings. The cost per gallon of MACT floor primers and topcoats was calculated from data provided by three coating manufacturers as referenced in the baseline coating substitution section. The costs for the coatings that would be allowed under the MACT floor were averaged for primers and topcoats. The MACT floor cost per gallon is presented in Table 3. MACT floor coating usage values were calculated in the environmental impact analysis for primers and topcoats[6] and are presented in Table 8. The MACT floor costs were calculated by multiplying the cost per gallon from Table 3 by the annual usage from Table 8. These values are shown in Table 9.

Labor Savings

The implementation of MACT will reduce labor required to paint due to the reduced number of gallons to be applied. Because HVLP spray guns transfer coatings more efficiently than conventional spray guns, fewer gallons of coating need to be applied to achieve the same coating thickness. As a result, there is an equivalent reduction in the labor hours needed to apply the coatings. MACT labor hour data are presented in Table 10 and are the values in Table 8 multiplied by 1.3 hours/gallon (see baseline labor calculations).

TABLE 5
ANNUAL BASELINE LABOR HOURS
BY MODEL PLANT SIZE

Model Plant Size	Labor Hours (hours)			
	Commercial		Military	
	Primers	Topcoats	Primers	Topcoats
Small	650	650	220	140
Medium	2,730	2,600	920	550
Large	23,400	23,270	7,930	4,940

TABLE 6
ANNUAL BASELINE LABOR HOUR COSTS
BY MODEL PLANT SIZE

Model Plant Size	Labor Hour Costs ($)			
	Commercial		Military	
	Primers	Topcoats	Primers	Topcoats
Small	26,000	26,000	8,800	5,600
Medium	109,200	104,000	36,800	22,000
Large	936,000	930,800	317,200	197,600

TABLE 7
ANNUAL BASELINE TOTAL COST FOR COATING SUBSTITUTIONS AND LABOR

Model Plant Size	Total Cost ($)	
	Commercial	Military
Small	87,500	24,800
Medium	357,500	99,910
Large	3,140,000	879,300

TABLE 8
ANNUAL MACT AVERAGE COATING USAGE
(AFTER IMPLEMENTATION OF HVLP SPRAY GUNS
AND PRODUCT SUBSTITUTIONS)
BY MODEL PLANT SIZE

Model Plant Size	Commercial Usage (gal)		Military Usage (gal)	
	Primers	Topcoats	Primers	Topcoats
Small	275	250	100	50
Medium	1,640	1,420	610	250
Large	14,490	13,100	5,390	2,360

TABLE 9
ANNUAL MACT COSTS FOR AEROSPACE COATINGS

Model Plant Size	Commercial Costs ($)		Military Costs ($)	
	Primers	Topcoats	Primers	Topcoats
Small	8,800	13,750	3,900	3,700
Medium	52,480	78,100	23,790	18,500
Large	463,680	720,500	210,210	174,640

TABLE 10
ANNUAL MACT LABOR HOURS
BY MODEL PLANT SIZE

Model Plant Size	Labor Hours (hours)			
	Commercial		Military	
	Primers	Topcoats	Primers	Topcoats
Small	360	330	130	70
Medium	2,130	1,850	790	330
Large	18,840	17,030	7,010	3,070

Using $40/labor hour rate as used for baseline, the labor costs by model plant are presented in Table 11 and are the values in Table 10 multiplied by $40/hour.

The total MACT floor costs for coating substitutions and labor are presented in Table 12. The cost impacts were calculated by adding the costs in Table 9 and Table 11 and then adding the primer and topcoat values for each size model plant.

BASELINE FOR APPLICATION METHODS

Baseline application methods consist of a mix of conventional, HVLP, and electrostatic spray guns as reported in the Section 114 questionnaire responses. The capital costs of conventional, HVLP, and electrostatic spray guns including spare parts are $285, $650, and $3,500, respectively.[7,8] Maintenance cost are higher for HVLP and electrostatic spray guns than conventional, but this could not be quantified. Utility costs are higher for electrostatic spray guns, but this could not be quantified also. There are no known installation costs for any of the guns. The baseline coating application equipment has been defined as follows:

Small Model Plants
Spray guns - 30 conventional
6 HVLP
0 electrostatic

Medium Model Plants
Spray guns - 20 conventional
50 HVLP
10 electrostatic

Large Model Plants
Spray guns - 24 conventional
80 HVLP
20 electrostatic

TABLE 11
ANNUAL MACT LABOR HOUR COSTS
BY MODEL PLANT SIZE

Model Plant Size	Labor Hour Costs ($)			
	Commercial		Military	
	Primers	Topcoats	Primers	Topcoats
Small	14,400	13,200	5,200	2,800
Medium	85,200	74,000	31,600	13,200
Large	753,600	681,200	280,400	122,800

TABLE 12
ANNUAL TOTAL MACT COST FOR COATING SUBSTITUTION AND LABOR
BY MODEL PLANT SIZE

Model Plant Size	Total Cost ($)	
	Commercial	Military
Small	50,150	15,600
Medium	289,780	87,090
Large	2,618,980	788,050

Baseline Spray Gun Cost

Small Model Plants:	30 spray guns x \$285/spray gun =	\$ 8,550
	6 spray guns x \$650/spray gun =	3,900
	Total	12,450
Medium Model Plants:	20 spray guns x \$285/spray gun =	\$ 5,700
	50 spray guns x \$650/spray gun =	32,500
	10 spray guns x \$3,500/spray gun=	35,000
	Total	73,200
Large Model Plants:	24 spray guns x \$285/spray gun =	\$ 6,840
	80 spray guns x \$650/spray gun =	52,000
	20 spray guns x \$3,500/spray gun=	70,000
	Total	128,840

Annualized costs were calculated by the following equation:

$$Annualized\ Costs = TCC \left[\frac{i\ (1+i)^n}{(1+i)^n - 1}\right]$$

where,

TCC = Total Capital Cost
i = Interest Rate
n = Equipment Life (years)

Using the total capital cost presented above, an interest rate of 7 percent, and an equipment life of 10 years,[9] the annualized costs by model plant for baseline are:

Small model plant: \$1,770
Medium model plant: \$10,420
Large model plant: \$18,340

MACT COSTS FOR APPLICATION METHODS

As noted above, MACT consists of replacing all conventional spray guns used to apply primers and topcoats with HVLP spray guns. Costs need to be developed, therefore, for the replacement HVLP spray guns. The capital cost imposed by the MACT floor is the cost of replacing the percentage of conventional spray guns used to apply primers and topcoats with HVLP spray guns. The percentage of conventional spray guns used to apply primers and topcoats is assumed to be equivalent to the percentage of the total overall coating usage represented by the usage of primers and topcoats by model plant. Based on the coating usage reported in the Section 114 questionnaire responses, primers accounted for approximately 16 percent of the total coating usage and topcoats accounted for approximately 17 percent of the total coating usage.

Small Model Plants:	30 spray guns x (16% + 17%) =	10
Medium Model Plants:	20 spray guns x (16% + 17%) =	7
Large Model Plants:	24 spray guns x (16% + 17%) =	8

Therefore, the MACT coating application equipment is defined as follows:

Small Model Plants
Spray guns - 20 conventional
16 HVLP
0 electrostatic

Medium Model Plants
Spray guns - 13 conventional
57 HVLP
10 electrostatic

Large Model Plants
Spray guns - 16 conventional
88 HVLP
20 electrostatic

<u>MACT Spray Gun Cost</u>

Small Model Plants:	20 spray guns x $285/spray gun =	$ 5,700
	16 spray guns x $650/spray gun =	10,400
	Total	16,100
Medium Model Plants:	13 spray guns x $285/spray gun =	$ 3,710
	57 spray guns x $650/spray gun =	37,050
	10 spray guns x $3,500/spray gun =	35,000
	Total	75,760
Large Model Plants:	16 spray guns x $285/spray gun =	$ 4,560
	88 spray guns x $650/spray gun =	57,200
	20 spray guns x $3,500/spray gun =	70,000
	Total	131,760

Annualized costs for MACT were calculated using the equation from the baseline section.

Small model plant: $2,290
Medium model plant: $10,790
Large model plant: $18,760

Total Baseline Costs

The total baseline costs are calculated by adding the costs in Table 7 with the baseline annualized equipment costs. These values are presented in Table 13.

TABLE 13
TOTAL BASELINE COSTS
BY MODEL PLANT SIZE

Model Plant Size	Total Cost ($)	
	Commercial	Military
Small	89,270	26,570
Medium	367,920	110,330
Large	3,158,340	897,640

Total MACT Costs

The total MACT costs are calculated by adding the costs in Table 12 with the MACT annualized equipment costs. These values are presented in Table 14.

TABLE 14
TOTAL MACT COSTS
BY MODEL PLANT SIZE

Model Plant Size	Total Cost ($)	
	Commercial	Military
Small	52,480	17,890
Medium	300,570	97,880
Large	2,637,740	806,810

Cost Impact

The MACT cost impacts were calculated by subtracting the costs that would have occurred under baseline (Table 13) from the costs that will result from implementation of MACT (Table 14). These values are presented in Table 15.

TABLE 15
TOTAL COST IMPACT
BY MODEL PLANT SIZE[a]

Model Plant Size	Total Cost ($)	
	Commercial	Military
Small	(36,830)	(8,680)
Medium	(67,350)	(12,450)
Large	(520,600)	(90,830)

[a] Values in parentheses represent a cost savings to the model plant.

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5. Memorandum. D. Hendricks, PES, to V. Boothe, EPA:ESD. August 25, 1993. MACT cost analysis for aircraft depainting.

6. Memorandum. D. Hendricks, PES, to V. Boothe, EPA:ESD. August 25, 1993. MACT environmental impact analysis for primers and topcoats.

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9. Industrial Surface Coating: Appliances - Background Information for Proposed Standards, EPA-450/3-80-037a, November 1980, p. 3-31.

MEMORANDUM

TO: VICKIE BOOTHE
US EPA:ESD

FROM: DAVID HENDRICKS
PACIFIC ENVIRONMENTAL SERVICES, INC.

DATE: February 15, 1994

SUBJECT: NATIONWIDE MACT COST ANALYSIS FOR THE CONTROL OF PRIMER AND TOPCOAT INORGANIC EMISSIONS, DEPAINTING INORGANIC EMISSIONS, WASTEWATER EMISSIONS, STORAGE TANK EMISSIONS, AND WASTE EMISSIONS

A. PRIMER AND TOPCOAT INORGANIC HAP EMISSIONS

The MACT floor level of control specifies that all primer and topcoat operations must be performed within a spray booth or hangar with an active ventilation system. The exhaust air stream must pass through either dry filters or a waterwash system. The cost analysis examines the following two situations: (1) facilities that do not currently paint within a booth or hangar and must construct these facilities, and (2) facilities that paint within a booth or hangar but have no dry filters or waterwash.

Table 1 summarizes the MACT cost impacts. The total annual MACT implementation costs are $2,287,310, which includes annualized costs for adding new spray booths and modifying existing spray booths and hangars, and annual operating costs for dry filter replacement.

TABLE 1
ANNUAL COSTS TO IMPLEMENT PRIMER AND TOPCOAT INORGANIC HAP EMISSION CONTROLS

Item	Cost (1993 Dollars)
1. Annualized Costs for Spray Booths	$978,230
2. Annualized costs for Modifying Existing Spray Booths	452,990
3. Annual Operating Costs	856,160
4. Total MACT Implementation Cost	2,287,380

Baseline

For the purpose of the cost analysis, it was assumed that 5 percent of small facilities do not perform primer and topcoat operations within a booth or hangar, and that all medium and large facilities perform all of these operations within a booth or hangar. Additionally, it was assumed that 10 percent of small, 2 percent of medium, and 1 percent of large facilities perform primer and topcoat operations within a booth or hangar with no dry filters or waterwash. It is further assumed that these booths and hangars already have a ventilation system in place.

No baseline costs are incurred in either situation. Those facilities not painting within a booth or hangar have no baseline capital costs for booths or hangars, nor do they have baseline operating costs associated with dry filters. Those facilities that have booths or hangars without dry filters or waterwash have already incurred the capital cost of these structures; therefore, the capital costs will not be included in the baseline. Additionally, since there are no filtering systems being used in these existing booths and hangars, no operating costs are incurred.

MACT Floor

Table 2 presents the total number of facilities nationwide by size, number of each size of facility currently not painting within a booth or hangar, and number of facilities currently painting within a booth or hangar with no dry filters or waterwash.

Facility Size	Total Number of Facilities	Number of Facilities Without Booths or Hangars	Number of Facilities Without Dry Filters or Waterwash
Small	1318	66 (5% of total)	132 (10% of total)
Medium	1533	0	31 (2% of total)
Large	18	0	1 (1% of total)

Based on Section 114 questionnaire responses and observations made during site visits, Table 3 presents the number and size of spray booths and hangars for each facility size. For the small facilities with no spray booths, all five 10′ x 10′ booths would have to be added, as well as one 25′ x 25′ booth. For the facilities that already have the booths or hangars in place, dry filters and the associated framework needed for mounting the filters would have to be added.

TABLE 3

DISTRIBUTION AND SIZE OF SPRAY BOOTHS/HANGARS BY FACILITY SIZE

Facility Size	Number of Booths/Hangars		
	10′ x 10′ Booth	25′ x 25′ Booth	150′x 200′x 75′ Hangar
Small	5	1	0
Medium	7	2	2
Large	10	4	3

For the purpose of the cost analysis, the worst case was used where all of the new spray booths (for the small facilities that currently have no booths) are equipped with waterwash systems rather than dry filters. The waterwash booths are approximately 50-100 percent more expensive than the dry filter booths. One vendor quoted the cost of a waterwash booth measuring 10′ x 10′ x 7′ deep to be $15,000, and the cost of a waterwash booth measuring 18′ x 16′ x 64′ deep to be $60,000.[1] These cost were assumed to approximate the cost of the 10′ x 10′ and 25′ x 25′ booths presented in Table 3. The capital cost associated with the 66 small facilities that currently have no spray booths is then:

[($15,000/booth x 5 booths) + ($60,000/booth x 1 booth)]
x 66 facilities = $8,910,000

Amortizing this cost over 15 years at an interest rate of 7 percent, the annualized cost is $978,230.

The operating costs associated with waterwash booths is assumed to be negligible since these booths require no replacement filters or continuous labor requirements.

The facilities that must upgrade existing booths or hangars were assumed to add dry filters rather than waterwash. For the number of filters per spray booth or hangar, it was assumed that the entire rear wall of both the small and large booths was comprised of filters. For the hangar, it was assumed that 20 percent of the area of the rear wall was comprised of filters. The size of all filters was taken to be 20" x 20", as this is a standard size for the industry. Table 4 present the number of filters per booth or hangar.

TABLE 4

NUMBER OF 20" X 20" FILTERS PER SPRAY BOOTH OR HANGAR

Booth/Hangar Size	Number of Filters
10' x 10'	36
25' x 25'	225
150' x 200' x 75'	807

In order to modify existing booths and hangars for the dry filters, a one time cost for a framework assembly to hold the filters in place will be incurred. One vendor quoted a cost of $32 per filter (20" x 20") for the framework.[2] The total capital cost for this framework by facility size is then:

Small Facilities

10' x 10' Booth
36 filters/booth x 5 booths/facility x $32/filter x 132 facilities = $760,320

25' x 25' Booth
225 filters/booth x 1 booth/facility x $32/filter x 132 facilities = $950,400

Total capital costs = $760,320 + $950,400 = $1,710,720

Medium Facilities

10' x 10' Booth
36 filters/booth x 7 booths/facility x $32/filter x 31 facilities = $249,980

25' x 25' Booth
225 filters/booth x 2 booths/facility x $32/filter x 31 facilities = $446,400

150' x 200' x 75' Hangar
807 filters/hangar x 2 hangars/facility x $32/facility x 31 facilities = $1,601,090

Total capital costs = \$249,980 + \$446,400 + \$1,601,090
= \$2,297,470

Large Facilities

<u>10' x 10' Booth</u>
36 filters/booth x 10 booths/facility x \$32/filter
x 1 facility = \$11,520

<u>25' x 25' Booth</u>
225 filters/booth x 4 booths/facility x \$32/filter
x 1 facility = \$28,800

<u>150' x 200' x 75' Hangar</u>
807 filters/hangar x 3 hangars/facility x \$32/filter
x 1 facility = \$77,470

Total capital costs = \$11,520 + \$28,800 + \$77,470 = \$117,790

Amortizing this cost over 15 years at an interest rate of 7 percent, the annual cost by model plant size is:

Small - \$187,820
Medium - \$252,240
Large - \$12,930

Total annualized capital costs are then the sum of the individual annualized capital costs for each size model plant, or \$452,990.

Annual operating costs are associated with replacing the dry filters. It was assumed that all filters would be changed four times per year. One vendor quoted a price of \$1.66 for a typical 20" x 20" filter.[3] Annual operating costs are then:

Small Facility

<u>10' x 10' Booth</u>
36 filters/booth x 5 booths/filter x \$1.66/filter
x 132 facilities x 4 = \$157,770

<u>25' x 25' Booth</u>
225 filters/booth x 1 booth/facility x \$1.66/filter
x 132 facilities x 4 = \$197,210

Total operating costs = \$354,980

Medium Facility

<u>10' x 10' Booth</u>
36 filters/booth x 7 booths/facility x $1.66/filter
x 31 facilities x 4 = $51,870

<u>25' x 25' Booth</u>
225 filters/booth x 2 booths/facility x $1.66/filter
x 31 facilities x 4 = $92,630

<u>150' x 200' x 75' Hangar</u>
807 filters/hangar x 2 hangars/facility x $1.66/filter
x 31 facilities x 4 = $332,230

Total operating costs = $476,730

Large Facility

<u>10' x 10' Booth</u>
36 filters/booth x 10 booths/facility x $1.66/filter
x 1 facility x 4 = $2,390

<u>25' x 25' Booth</u>
225 filters/booth x 4 booths/facility x $1.66/filter
x 1 facility x 4 = $5,980

<u>150' x 200' x 75' Hangar</u>
807 filters/hangar x 3 hangars/facility x $1.66/filter
x 1 facility x 4 = $16,080

Total operating costs = $24,450

Total operating costs are then the sum of the costs for each size model plant, or $856,160.

Total MACT implementation costs are the sum of the annualized capital costs plus the annual operating costs:

MACT implementation costs = $978,230 + $452,990 + $856,160
= $2,287,380

B. DEPAINTING INORGANIC HAP EMISSIONS

The MACT floor level of control specifies that inorganic HAP emissions be controlled by 99 percent. This can be achieved through the use of a baghouse or particulate filters. This cost analysis examines the conversion from low efficiency particulate filters to high efficiency particulate filters that meet the MACT floor level of control. Table 5 summarizes the baseline and MACT costs. The total annual MACT implementation costs are $116,580.

TABLE 5
ANNUAL COSTS TO IMPLEMENT DEPAINTING
INORGANIC HAP EMISSION CONTROLS

Item	Model Plant		
	Small	Medium	Large
1. Baseline Annual Operating Costs	$3,590	$13,400	$13,400
2. MACT Annual Operating Costs	3,950	14,770	14,770
3. Cost Impact (line 2 - line 1)	360	1,370	1,370

It is not reasonable to assume that all commercial and military rework facilities (a total of 2,026 facilities) depaint the outer surface of aerospace vehicles. Therefore, it was assumed that only 5 percent of the small and medium facilities and all of the large facilities perform outer surface depainting (see Table 6).

TABLE 6
NUMBER OF DEPAINTING FACILITIES BY MODEL PLANT SIZE

Model Plant Size	Number of Facilities
Small	27
Medium	73
Large	5

Baseline

Baseline has been defined as depainting fully painted aircraft with plastic media and using particulate filters with a control efficiency of 95 percent. Based on Section 114 questionnaire responses and observations made during site visits, it was assumed that small facilities would perform the blasting operation in a 100′ x 100′ x 30′ high hangar, and medium and large facilities would use a 150′ x 200′ x 75′ high hangar. It was also assumed that the small size hangar has 216 filters (20" x 20"), the large size hangar has 807 filters (20" x 20"), and that these filters are changed 10 times per year.

One vendor quoted a price of $1.66 for a typical low efficiency 20" x 20" filter.[4] Based on the number of filters for each size hangar and the number of filter changes per year presented above, the baseline annual operating costs per model plant are:

Small rework facility: 216 filters x $1.66/filter x 10 = $3,590/yr
Medium rework facility: 807 filters x $1.66/filter x 10 = $13,400/yr
Large rework facility: 807 filters x $1.66/filter x 10 = $13,400/yr

MACT Floor

The MACT floor can be achieved through the use of high efficiency particulate filters. One vendor quoted a price of $1.83 for a typical high efficiency 20" x 20" filter.[5] Annual operating costs for the MACT floor level of control are then:

Small rework facility: 216 filters x $1.83/filter x 10 = $3,950/yr
Medium rework facility: 807 filters x $1.83/filter x 10 = $14,770/yr
Large rework facility: 807 filters x $1.83/filter x 10 = $14,770/yr

The MACT implementation costs are then the MACT costs minus the baseline costs:

Small rework facility: $3,950/yr - $3,590/yr = $360/yr
Medium rework facility: $14,770/yr - $13,400/yr = $1,370/yr
Large rework facility: $14,770/yr - $13,400/yr = $1,370/yr

Nationwide costs are then the MACT implementation costs multiplied by the total number of facilities:

Small rework facility: $360/yr x 27 = $9,720/yr
Medium rework facility: $1,370/yr x 73 = $100,010/yr
Large rework facility: $1,370/yr x 5 = $6,850/yr

Total nationwide costs = $9,720/yr + $100,010/yr + $6,850/yr = $116,580

C. WASTEWATER

MACT floor is no control; therefore, no cost incurred.

D. STORAGE TANKS

MACT floor is no control; therefore, no cost incurred.

E. WASTE

100 percent of the reporting facilities are already performing housekeeping measure; therefore, no additional costs will be incurred.

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1. Telephone Report. K. Feser, PES, and Sales Representative, JBI, on November 5, 1993.

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3. Reference 2.

4. Reference 2.

5. Reference 2.

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

A rule is being proposed for the regulation of emissions of hazardous air pollutants (HAP) from aerospace manufacturing and rework processes under the authority of sections 112, 114, 116 and 301 of the Clean Air Act, as amended in 1990. This document presents the background data and information that supports the proposed regulation.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air pollution Pollution control Aerospace Hazardous air pollutant National impacts	Air pollution control	

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