DEPARTMENT OF
ECOLOGY
State of Washington

DRAFT TECHNICAL SUPPORT DOCUMENT FOR THE BOEING COMPANY BOEING EVERETT 777X PROJECT

Prepared by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. EXECUTIVE SUMMARY

1.1 Original Permit

Boeing Commercial Airplane's Everett facility (Boeing Everett) produces wide-body airplanes. Boeing Everett currently manufactures the plane models 747, 767, 777, and 787. Boeing proposes to produce new models of the Boeing 777. These new models are referred to as the Boeing 777X models. Production of the 777X is scheduled to begin in 2017, and make the first 777X delivery in 2020. As production of the 777X ramps up, the production of the current 777 models will be phased out.

The 777X will differ from the 777 models in that the 777X wings will be primarily made of composite material rather than aluminum. The 777X will have a greater wing span that will require folding wing tips so the 777X will fit at the airport's gates. The 777-9X will have a slightly longer fuselage than the longest 777 model currently in production.

The components for the 777X wing will be made at Boeing Everett in a new building. Final assembly of the 777X will occur in the same building where the current models of the 777 are assembled.

The 777X project involves two phases. The first phase is a transition from production of the traditional 777 models to 777X models. The second phase will be an increase in the maximum production capacity and thereafter, production rate from the current rate of about 8.3 777X per month (or about 100 planes per year) to as many as 10.4 777Xs per month (about 125 777Xs per year).

Phase 1 of the project consists of two components. The first component will make the changes to the facility necessary to begin production of the 777X. This will occur while maintaining production of legacy 777 models at levels up to about 8.3 airplanes per month, which is consistent with the Prevention of Significant Deterioration (PSD) permit number 11-01. The changes include constructing a new building in which to manufacture the components for the new composite wing, but also creating additional wing and airplane assembly capacity for the 777X within the existing buildings.

The second component of Phase 1 will be an increase in 777X production capacity and rate to about 8.3 airplanes per month while correspondingly decreasing production of the 777s to the point of eventually transitioning to producing only the 777X. During Phase 1, Boeing does not plan to exceed a combined production rate (i.e., rate for legacy 777s plus 777Xs) of about 8.3 airplanes per month. Phase 1 will include the following changes at Boeing Everett to achieve a production capacity of 8.3 777Xs per month:

- Construct a new building to fabricate 777X wing components. The new building will include new emission units such as autoclaves to cure the wing components and spray and sealing booths.
- Install a new 777X wing spar build-up line in an existing factory building.

- Install a new 777X wing assembly line in an existing factory building.
- Install a new 777X final assembly line in an existing factory building.
- Reconfigure the existing 777 final assembly line to accommodate final assembly of the 777X.
- Constructing new 777X vertical fin spray booths and prep booths in an existing factory building.
- Change existing tooling and equipment throughout the 777 factory to accommodate the larger 777X body sections and wings.

Phase 2 is a second independent phase of the Boeing 777X project. Phase 2 will make further changes to Boeing Everett to increase overall 777X production capacity to up to about 10.4 airplanes per month. Phase 2 is tentatively scheduled to begin in 2021, and will involve additional tooling and equipment to increase the 777X production capacity. For example, additional tape layup machines for fabricating wing panels might be installed in the wing component fabrication building, and additional spray booths and a composite press might be installed in the interiors manufacturing building.

Currently, it is anticipated that construction of Phase 1 will begin on or before November 1, 2014, and construction of Phase 2 will begin on or before December 1, 2021.

The Washington State Department of Ecology (Ecology) received the PSD application and fee for the project on February 20, 2014. Ecology determined the application to be complete on March 20, 2014. Boeing submitted a revised PSD permit application on May 23, 2014, and that application was determined to be complete on June 23, 2014.

The proposed project emissions for volatile organic compounds (VOCs) are above the PSD threshold. Therefore, a full technical review of the project for VOCs, including a Best Available Control Technology (BACT) analysis, and the project’s effect on National Ambient Air Quality Standards (NAAQS), PSD increments, visibility, soils and vegetation, is required and included in this Technical Support Document (TSD).

The emissions of other air pollutants not subjected to PSD review will be covered in the Puget Sound Clean Air Agency’s (PSCAA) Notice of Construction (NOC) approval for this project.

Ecology has issued several PSD permits to Boeing Everett in past years that established VOC emission limits for 777 production. These permits are:

- Permit number PSD-91-06 established a VOC emission limit of 238.8 tons per year (tpy) for all 777 assembly operations.
- Permit number PSD-05-02 established a VOC emission limit of 205 tpy for interiors manufacturing operations associated with all Boeing airplane models and a VOC

emission limit of 412 tpy for paint hangar final exterior coating operations for all Boeing airplane models.

- Permit number PSD-11-01 established a VOC emission limit of 34 tpy for three existing 777 wing spray booths in Building 40-37.

Of the existing VOC emission limits noted above, the 777X project will require an increase in all but the paint hangar final exterior coating limit.

1.2 Amendment 1

Ecology received a PSD application and fee for Amendment 1 on September 3, 2015. Ecology determined the application to be complete on September 24, 2015. Amendment 1 will allow Boeing to install the following additional units but requires the emissions limits in the original permit to remain unchanged:

- A second wing spar spray booth.
- Three additional small quantity paint mix booths.
- Two additional coating equipment cleaning booths.
- One additional emergency diesel generator.

2. INTRODUCTION

2.1. The Permitting Process

2.1.1. The PSD Process

PSD permitting requirements in Washington State are established in Title 40, Code of Federal Regulations (CFR) §52.21; Washington Administrative Code (WAC) 173-400-700 through 750. Washington State implements its PSD program as a State Implementation Plan (SIP)-approved program. This SIP-approved program became effective May 29, 2015[1]

Federal and state rules require PSD review of all new or modified air pollution sources that meet certain criteria in an attainment or unclassifiable area with the NAAQS. The objective of the PSD program is to prevent significant adverse environmental impact from emissions into the atmosphere by a proposed new major source, or major modification to an existing major source. The program limits degradation of air quality to that which is not considered "significant." PSD rules require the utilization of BACT for certain new or modified emission units, which is the most effective air pollution control equipment and procedures that are determined to be available after considering environmental, economic, and energy factors.

[1] 80 FR 23721, April 29, 2015.

The PSD rules must be addressed when a company is adding a new emission unit or modifying an existing emission unit in attainment or unclassifiable area. PSD rules apply to pollutants for which the area is classified as attainment or unclassifiable with the NAAQS. PSD rules are designed to keep an area with "good" air in compliance with the NAAQS. The distinctive requirements of PSD are BACT, air quality analysis (allowable increments and comparison with the NAAQS), and analysis of impacts of the project on visibility, vegetation, and soils.

2.1.2. The NOC Process

Boeing Everett's 777X project is subject to NOC permitting requirements under state of Washington regulations Chapters 173-400 and 173-460. PSCAA is the permitting authority for all air emission regulatory requirements not included in PSD permitting. This includes the New Source Review (NSR) permitting of criteria pollutants that are not PSD-applicable, air toxics issues under federal maximum achievable control technology (MACT) and state 173-460 WAC, and Title V permitting requirements. The procedure for issuing an NOC permit was established in Chapter 70.94 RCW.

WAC 173-400-110 outlines the NSR procedures for permitting criteria pollutants. These procedures are further refined in WAC 173-400-113 (requirements for new sources located in attainment or unclassifiable areas).

WAC 173-460-040 NSR supplements the requirements contained in Chapter 173-400 WAC by adding additional requirements for sources of toxic air pollutants (TAPs).

2.2. Site and Project Description

2.2.1. Site Description

The Boeing Everett facility is located in the city of Everett in Snohomish County, Washington. Boeing Everett is situated in the south half of Section 10 and the north half of Section 15, Township 28N, Range 4E Willamette Meridian, and consists of the North and South Complexes located north and south, respectively, of State Route 526. A building number starting with 40 identifies North Complex buildings, and buildings on the South Complex are identified with a number starting with 45 (see Figure 1). The proposed project will not increase the current footprint acreage of the site.

The Boeing Everett facility is located in a Class II area that is designated as "attainment or unclassifiable" for the purpose of PSD permitting for all pollutants.

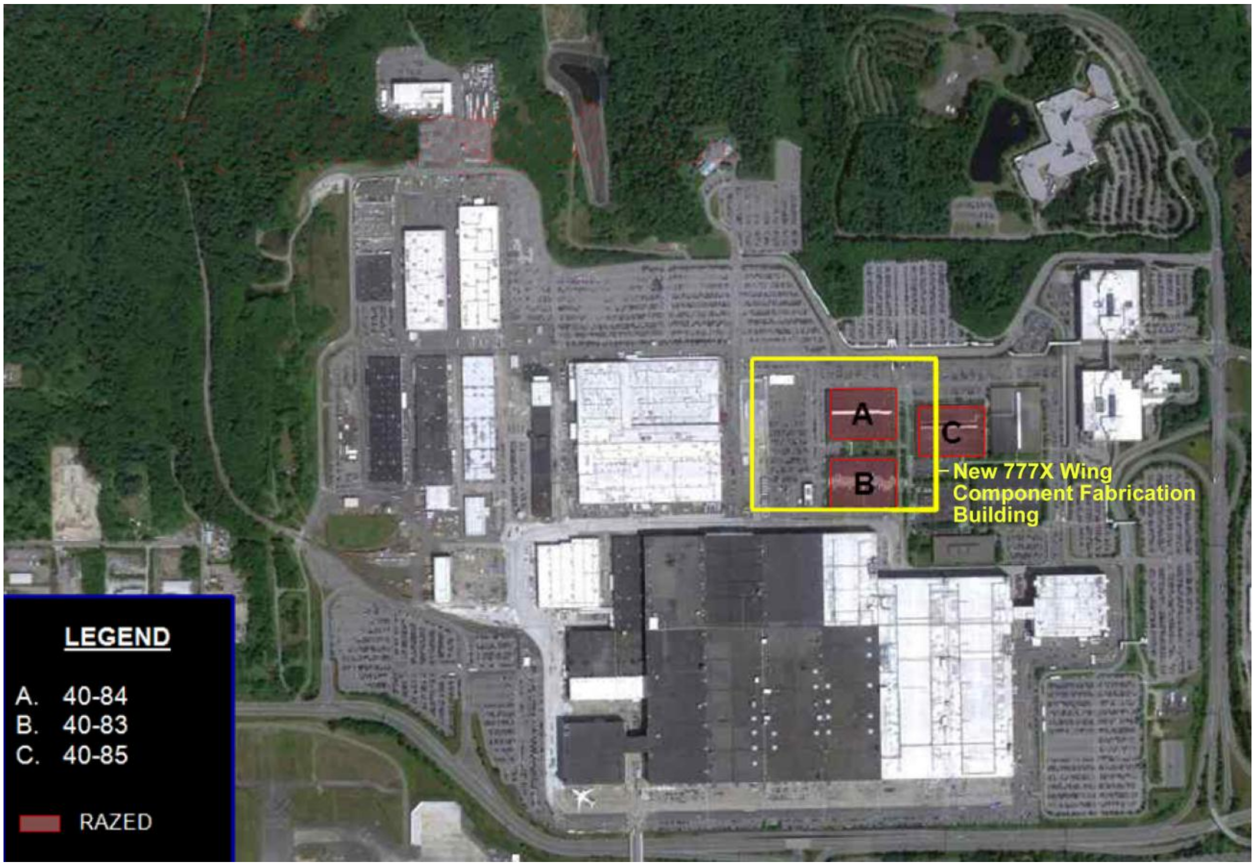

Figure 1. The Boeing Everett facility aerial photograph with new 777X Wing Component Fabrication Building identified

(Source: Boeing's application 2nd revision, received May 23, 2014)

2.2.2. Project Description

The Boeing Company owns and operates the Boeing Everett facility. The existing Boeing Everett facility consists of:

- 777 Assembly Operations: Model 777 assembly operations currently occur primarily in Buildings 40-04, 40-25, 40-34, 40-35, 40-36, 40-37, and 40-53.

The primary 777 assembly operations are:

- Wing component fabrication
- Wing assembly
- Body (fuselage) section assembly
- Wing and body structures seal and paint
- Airplane assembly

The 777X project will add a new building to fabricate composite wing components for the new 777X wing. The project will also add new operations such as a new vertical fin coating operation. The vertical fin on the current 777 models is painted in the existing airplane paint hangars after the fin is installed on the airplane. The new vertical fin coating operation requires that the fin be coated in a dedicated spray booth before it is installed on the airplane. In addition, some existing equipment such as body section spray booths may have to be modified to accommodate the larger 777X body sections.

2.2.2.1. Wing Component Fabrication

The wings of the 777X will be primarily made of composite material. The main wing components that will be made of composite material include upper and lower panels, front and rear spars, and upper and lower panel stringers. The manufacturing process of each of these parts is similar and involves the following steps:

- Wing component layup
- Curing in an autoclave
- Trimming and drilling
- Washing
- Non-destructive inspection
- Preparation for priming (e.g., abrading, solvent cleaning)
- Priming
- Wing component build-up

Composite material is in the form of resin pre-impregnated tape or sheets. Part layup involves the manual or automated layup of composite material onto a mandrel (i.e., mold) which is preformed into the shape of the part being fabricated. Emissions associated with the part layup primarily occur from preparing the mandrel between each layup/cure cycle. Preparing the mandrel includes cleaning the surface with solvent, applying a mold release compound, and applying a tackifier solution.

Once the part is laid up on the mandrel, a vacuum bag is sealed around the part and the assembly is then sent to an autoclave for curing. In the autoclave, vacuum from a vacuum pump is used to hold the bagged part under negative pressure while the autoclave is pressurized with nitrogen and heated to the curing temperature of up to about 350 degrees Fahrenheit (°F). The part is then held under negative pressure for the entire curing cycle, which is about 12 to 14 hours.

Emissions during the curing cycle are gases from the composite material and combustion emissions from the indirect gas-fired heater that is used to heat the autoclave. The gases travel through the vacuum system and are exhausted by the vacuum pump. Boeing is planning for as many as three autoclaves, each equipped with a gas-fired heater with a rated heat input of approximately 40 million British thermal units per hour (MMBtu/hr). The curing cycle will begin with the autoclave initially being brought up to the curing temperature with the natural gas-fired heater for about one to two hours. After this initial heating stage, an electric heater will be used to maintain the curing temperature for the rest of the cure cycle.

Once the part is cured, it is taken out of the autoclave, removed from the bag, and undergoes various machining operation such as trimming and drilling. After machining is complete, the part is placed in a wash stall and washed using an aqueous solution and water rinse. After washing, the parts are inspected for defects. Following inspection, the parts are placed in a prep booth where the part surface is abraded and cleaned with solvent prior to being moved to either be cleaned within the spray booth or at specially designed equipment cleaning booths. After priming, the part might be moved to a heated cure booth to allow the primer to cure. VOC emissions will result from the solvent cleaning, spray coating, and curing of the parts as well as form cleaning of spray equipment. The trimming, drilling, abrading, and spray coating operations result in particulate emissions and will be controlled using a dust collection system and spray booth exhaust filters.

Once priming is completed, “build-up” work will be performed on the parts. For example, the spars will have stiffeners, bracket, and other components attached, including a portion of the leading and trailing edges. The wing panels will similarly undergo some build-up work. This type of work consists of open floor mechanical assembly processes (e.g., vacuum pumps, prep booths, and spray booths) and will involve the application of VOC containing products such as hand wipe cleaning solvents, sealants, and touch-coatings. At this time, it is planned that all the wing component fabrication work will take place in a new building with the exception of some wing spar build-up work, and possibly wing panel build-up work that will occur in an existing building, and the emission units (e.g., vacuum pumps, prep booths, and spray booths) associated with the fabrication work will be new. The new emission units and activities and related VOC emissions for wing component fabrication are shown in Table 1. Table 1 also lists open floor activities that will take place as part of wing component fabrication. Boeing believes that such activities should not be treated as new emission units since similar open floor activities occur throughout the Boeing Everett facility, and can be easily moved about.

Table 1. Wing Component Fabrication VOC Emissions from New Emission Units

Unit ID	Emission Unit or Activity	New or Modified	Combustion Emissions (lb/plane)	Open Floor Emissions (lb/plane)	Stack Non-Combustion Emissions (lb/plane)
WCF-1	Open floor activities which include prep of layup mandrels (e.g., hand wipe cleaning and application of mold release and tackifier) and wing panel and wing spar build-up (e.g., hand wipe cleaning and sealant application)	New	0.00	1,895	0
WCF-2	Gas-fired heater for liquid nitrogen vaporization unit	New	1.45	0	0
WCF-3	Gas-fired process heater for autoclave #1	New	1.45	0	0
WCF-3b	Gas-fired process heater for autoclave #2	New	1.45	0	0
WCF-3c	Gas-fired process heater for autoclave #3	New	0.00	0	0
WCF-4	Vacuum pump(s) servicing autoclaves	New	0.00	0	114

Table 1. Wing Component Fabrication VOC Emissions from New Emission Units					
Unit ID	**Emission Unit or Activity**	**New or Modified**	**Combustion Emissions (lb/plane)**	**Open Floor Emissions (lb/plane)**	**Stack Non-Combustion Emissions (lb/plane)**
WCF-5	Dust collector(s) used to collect particulates from trimming, drilling, and other machining operations on cured components	New	0.00	0	0
WCF-6a	Wing panel wash stall #1	New	0.12	0	0
WCF-6b	Wing panel wash stall #2	New	0.12	0	0
WCF-6c	Wing spar and stringer wash stall #1	New	0.03	0	0
WCF-6d	Wing spar and stringer wash stall #2	New	0.03	0	0
WCF-7	Gas-fired plasma unit for treatment of wing panel stringers	New	0.17	0	0
WCF-8a	Wing panel prep booth(s) (abrasive blast/sanding, solvent hand wipe, edge seal) (see Note 1)	New	0.46	0	504
WCF-8b	Wing spar prep booth (abrasive blast/sanding, solvent hand wipe, edge seal)	New	0.00	0	70
WCF-9a	Wing panel spray booth #1	New	1.39	0	273
WCF-9b	Wing panel spray booth #2	New	1.39	0	273
WCF-9d	Wing panel spray booth #3	New	1.39	0	273
WCF-9c	Wing spar spray booth #1	New	0.165	0	59
WCF-9e	Wing spar spray booth #2	New	0.165	0	59
WCF-10a	Wing panel primer curing booth #1	New	0.70	0	See Note 2
WCF-10b	Wing panel primer curing booth #2	New	0.70	0	See Note 2
WCF-10c	Wing spar primer curing booth	New	0.17	0	See Note 2
WCF-11a	Small quantity paint mix booth #1	New	0.00	0	Less than 1
WCF-11b	Small quantity paint mix booth #2	New	0.00	0	Less than 1
WCF-11c	Small quantity paint mix booth #3	New	0.00	0	Less than 1
WCF-11d	Small quantity paint mix booth #4	New	0.00	0	Less than 1
WCF-12a	Coating equipment cleaning booth #1	New	0.00	0	8
WCF-12b	Coating equipment cleaning booth #2	New	0.00	0	8
WCF-12c	Coating equipment cleaning booth #3	New	0.00	0	8
WCF-12d	Coating equipment cleaning booth #4	New	0.00	0	8
WCF-14	Wing spar seal booth(s) #1 (see Note 3)	New	0.18	0	152

Notes:

- Currently, Boeing is considering building one or two wing panel prep booths. If Boeing decides to build two wing panel prep booths, the 504 pounds of VOC emissions will be divided between the two booths.
- Curing emissions are minimal and included in the spray booth emissions.
- Currently, Boeing is considering building as many as four wing spar seal booths. If Boeing decides to build more than one wing spar seal booth, the 152 pounds of VOC emissions per plane will be divided between the multiple booths.

All the emission units shown in Table 1 will be installed in Phase 1 of the project. Additional tooling and equipment such as tape-laying machines and additional work positions might be installed in Phase 2, but no additional emission units associated with wing component fabrication are planned for Phase 2.

2.2.2.2. Wing Assembly

After the wing panel and wing spar build-up work is complete, the 777X wings will be assembled from the completed panels, spars, and ribs which will have been manufactured elsewhere. This assembly work primarily consists of open floor mechanical assembly processes and will involve the application of VOC-containing products such as hand wipes with cleaning solvents, sealants, and touch-up coatings.

Boeing plans to locate the 777X wing assembly line in the main factory building with the existing 777 wing assembly line, but at a new location within that building. Neither Phase 1 nor Phase 2 require the installation or establishment of any new emission units or modification of any existing emission units associated with wing assembly.

2.2.2.3. Body Section Assembly

Body section assembly involves the assembly of individual body section panels into forward, aft, and mid body sections. This work consists of open floor mechanical assembly processes and the application of VOC products such as hand wipe cleaning solvents, sealants, and touch-up coatings.

Boeing plans to locate the 777X body section assembly work in the main factory building with the existing 777 body section assembly work, but all 777 body section assembly work will transition to a new location within that building. Neither Phase 1 nor Phase 2 will require the installation or establishment of any new VOC emission units or modification of any existing emission units associated with body section assembly.

2.2.2.4. Wing and Body Structures Seal/Paint and Vertical Fin Paint

Once the 777X wings and individual body sections are assembled, they will be moved to the existing 777 wing and body section spray booths in Building 40-37 for cleaning, sealing, and coating. The 777X wings will be cleaned, primed, and top coated in the same booths where the existing 777 model wings are cleaned, primed, and top coated. Similarly, 777X body sections will have their interior structures and a small portion of their exterior structures (e.g., the area under the wing fairing) cleaned, sealed, primed, and sprayed with a corrosion-inhibiting compound (CIC) in the same booths that the existing 777 model body structures use.

In Phase 1 of the project, some of the existing 777 body section booths may be lengthened to accommodate the slightly longer forward and aft fuselage sections of the 777-9X.

Also, as part of Phase 1, Boeing will add a new prep booth and three new spray booths to coat the 777X vertical fins. As noted above, the 777 vertical fin painting is currently completed in the existing Boeing Everett airplane paint hangars after the fin is installed on the airplane. The new coating operation will result in less aerodynamic drag and requires that the fin be coated in a dedicated spray booth before it is installed on the airplane.

In Phase 2 of the 777X project, two additional robotic cleaning and coating machines might be added to the existing wing booths to achieve a production capacity of up to 10.4 airplanes per month.

The new or modified emission units and related VOC emissions for the wing and body structures seal/paint and vertical fin paint are listed in Table 2.

Table 2. Wing and Body Structures Seal/Paint and Vertical Fin Paint VOC Emissions from New and Modified Emission Units

Unit ID	Emission Unit or Activity	New or Modified	Combustion Emissions (lb/plane)	Open Floor Emissions (lb/plane)	Stack Non-Combustion Emissions (lb/plane)
WBSP-1a	Robotic wing spray booth for LH wing	Modified	0.00	0	472
WBSP-1b	Robotic wing spray booth for RH wing	Modified	0.00	0	472
WBSP-2	Forward body section spray booth	Modified	0.00	0	209
WBSP-3	Mid body section spray booth	Modified	0.00	0	217
WBSP-4	Aft body section spray booth	Modified	0.00	0	209
WBSP-6	Forward body section CIC spray booth	Modified	0.00	0	194
WBSP-7	Mid body section CIC spray booth	Modified	0.00	0	98
WBSP-8	Aft body section CIC spray booth	Modified	0.00	0	194
WBSP-10	Vertical fin HLFC prep booth	New	0.39	0	20
WBSP-11a	Vertical fin HLFC spray booth #1	New	1.14	0	70
WBSP-11b	Vertical fin HLFC spray booth #2	New	1.14	0	70
WBSP-11c	Vertical fin HLFC spray booth #3	New	1.14	0	70

WBSP = wing and body structure paint
LH = left hand
RH = right hand
HLFC = hybrid laminar flow control

2.2.2.5. Airplane Assembly

Airplane assembly operations include the installation of various airplane systems (e.g., hydraulic, fuel, electrical) in the wing and body sections; the installation of the empennage (i.e., vertical fin and horizontal stabilizers) onto the aft body section; assembly of the body sections and wings into a completed structure; integration of the airplane systems; installation of landing gear, engines, and interior components (e.g., seats, sidewalls, partitions); and functional testing. Most of these activities occur on the open floor and involve the application of VOC containing products such as hand wipe cleaning solvents, sealants, and touch-up coatings.

As discussed earlier, a new 777X airplane assembly line will be located in the main factory building as is the existing 777 airplane assembly line, but at a new location within that building. This new assembly line might only be used for the low-rate initial production of the airplane. After a period of time, this new line might be phased out and all 777X final assembly moved to the existing 777 final assembly line reconfigured for the 777X.

The only new or modified emission units associated with 777X airplane assembly that will be installed as part of Phase 1 of the project are two wing stub ventilated spray coating enclosures. These enclosures will be used to capture emissions from coating certain portions of the wing stub and wing stub join areas. The enclosures will be filtered as required by the Aerospace National Emission Standards for Hazardous Air Pollutants (ANESHAP). One new enclosure will be installed in the new 777X airplane assembly line, and the existing wing stub spray booth that is part of the existing 777 assembly line will be modified or replaced.

Other than these two ventilation systems, neither Phase 1 nor Phase 2 should require the installation or establishment of any new emission units or the modification of any existing emission units associated with airplane assembly. VOC emissions from the wing stub ventilated spray coating enclosures are shown in Table 3.

Table 3. Airplane Assembly VOC Emissions from New and Modified Emission Units

Unit ID	Emission Unit or Activity	New or Modified	Combustion Emissions (lb/plane)	Open Floor Emissions (lb/plane)	Stack Non-Combustion Emissions (lb/plane)
AA-2a	Wing stub spray coating enclosure #1	New	0.00	0	22
AA-2b	Wing stub spray coating enclosure #2	Modified	0.00	0	22

2.2.2.6. 777 Assembly Existing PSD VOC Emission Limits

PSD permit PSD-91-06 established a VOC emission limit of 238.8 tpy for all 777 assembly operations. The 777X project will require that this emission limit be increased to 513 tpy to account for new wing component fabrication emissions, the higher production rate anticipated in Phase 2 of the 777X project, and the new vertical fin prep and spray booths. A background PSD applicability and production rate increase analysis is provided in Appendix A of this TSD.

PSD permit PSD-11-01 established a VOC emission limit of 34 tpy for the robotic wing spray booths and a per wing average emission limit of 0.17 ton. The 777X project will require that these emission limits be increased to 59 tpy and 0.25 ton per wing to account for the higher production rate anticipated in Phase 2 of the 777X project, the larger size of the composite wing, and the different materials used to clean and coat the composite wing.

2.2.2.7. Airplane Manufacturing Support Operations Facilities

In addition to the new heating equipment associated with specific production emissions units listed in Table 1 and 2, there will be additional open space heating and general process heating requirements in the new wing component fabrication building that total approximately 111 MMBtu/hr. Table 4 lists the expected emissions from these heating processes.

Table 4. Comfort and Process Heating VOC Emissions from New 777X Wing Component Fabrication Building

Unit ID	Emission Unit or Activity	New or Modified	Combustion Emissions (lb/plane)	Open Floor Emissions (lb/plane)	Stack Non-Combustion Emissions (lb/plane)
F-1	Combustion equipment for comfort or process heating	New	16.88	0	0

The 777X project is expected to require as many as nine new 2,750-kilowatt (kW) backup emergency diesel generators for the autoclaves and up to two 750-kW backup diesel generator for other wing manufacturing activities. Table 5 lists the expected VOC emissions from these engines.

Table 5. Emergency Diesel Generators VOC Emissions

Unit ID	Emission Unit or Activity	New or Modified	Combustion Emissions (tpy)
F-2a	Nine 2,750-kW diesel generators	New	0.94
F-2b	Up to two 750-kW diesel generators	New	0.06

2.2.2.8. Airplane Manufacturing Support Operations—Interiors Production Operations

Interiors production operations primarily occur in the Interiors Responsibility Center's (IRC's) Building 40-56 and support all airplane models produced at Boeing Everett, as well as the 737 model produced at Boeing Renton. Interiors production involves the manufacture of stowbins, sidewalls, ceilings, partitions, closets, and other cabin interior components. Air emissions occur from activities such as spray coating, hand wipe cleaning, screen printing, composite material curing, and the use of adhesives, resins, and other VOC containing products.

No changes to the IRC emission units are planned for Phase 1 of the 777X project. For Phase 2 of the project, it is anticipated that three adhesive spray booths, a paint booth, and a crushed core press will need to be added to the IRC to reach the 777X interiors production rate capacity of up to 10.4 shipsets per month. Table 6 lists these new emission units and their estimated VOC emissions.

Table 6. IRC VOC Emissions from New Emission Units

Unit ID	Emission Unit or Activity	New or Modified	Combustion Emissions (lb/plane)	Open Floor Emissions (lb/plane)	Stack Non-Combustion Emissions (lb/year)
IRC-1a	Adhesive spray booth #1	New	0	0	17,700
IRC-1b	Adhesive spray booth #2	New	0	0	17,700
IRC-1c	Adhesive spray booth #3	New	0	0	17,700
IRC-2	Paint spray booth	New	0	0	10,000
IRC-3	Crushed core press	New	0	0	4,500

PSD permit PSD-05-02 established a VOC emission limit of 205 tpy for all interiors production operations at Boeing Everett. This limit covers emissions from 777 interiors production as well as interiors production for other Boeing airplane models. The 777X project will require that this emission limit be increased to 239 tpy to account for the additional emissions from the new emission units anticipated to achieve the higher production rate of up to 10.4 shipsets per month.

The estimated VOC emissions from interiors production for each 777X are 0.53 ton per airplane.

2.2.2.9. Everett Delivery Center Operations

Everett Delivery Center (EDC) paint hangar and preflight/delivery operations occur in Buildings 45-01, 45-03, and 45-04 paint hangars; in Building 45-02; in Building 45-334 at the Everett Modification Center (EMC) plus the paint hangar in Bay 4 Building 45-334, and on the flight line; and support all airplane models produced at Boeing Everett. Air emissions primarily occur from activities such as exterior prep and spray coating activities in the paint hangars, and the use of hand wipe cleaning solvents and adhesives, resins, and other VOC containing products on the flight line. PSD permit PSD-05-02 establishes a VOC emission limit of 412 tpy for all airplane manufacturing operations that occur at the EDC, including 777 paint hangar and preflight and delivery operations. The project will not require any increase in this VOC emission limit.

Boeing Everett paint hangars, which are all part of EDC, are operating at or near capacity. The current paint hangar capacity is less than that necessary to serve the combined production of all airplane models at Boeing Everett today, requiring many airplanes to be flown offsite for final decorative coating. There are currently no plans to increase onsite paint hangar capacity to support the increased 777X production rate enabled by Phase 2 of the project. Therefore, the project will not result in an emission increase at the paint hangars. However, other EDC work such as coating and cleaning of 777 rudders and elevator and the preflight/delivery work that occurs on each airplane on the flight line before it is delivered, will increase as a result of the project. The estimated emissions from these activities are 0.15 ton of VOCs per 777X produced.

Neither Phase 1 nor Phase 2 will require the installation or establishment of any new emission units or the modification of any existing emission units associated with the EDC operations.

2.2.2.10. Propulsion Systems Operations

Propulsion systems operations primarily occur in Building 40-54 and involve receiving airplane engines and engine struts for 747, 767, and 777 models from offsite and preparing them for installation on the airplane. Air emissions are relatively minor and primarily occur from the open floor use of hand wipe cleaning solvents, touch-up coatings, and adhesives, resins, and other VOC containing products. The VOC emissions from this operation are not subject to a PSD or PSCAA established VOC annual emission limit. The estimated emissions from propulsion systems are 0.005 ton of VOCs per engine. The 777X has two engines, and the estimated emissions are 0.01 of VOCs per 777X produced.

Neither Phase 1 nor Phase 2 should require the installation or establishment of any new emission units or the modification of any existing emission units associated with propulsion systems operations.

2.2.2.11. Emergent Operations

Emergent operations involve the emergent, non-routine fabrication and repair of aerospace components. Emergent operations support all airplane models produced at Boeing Everett. Air emissions from emergent operations are relatively minor and primarily occur from spray coating and the use of hand wipe cleaning solvents and adhesives, resins, and other VOC containing products. The VOC emissions from this operation are not subject to a PSD VOC emission limit. The estimated emissions from these activities are 0.06 ton of VOC per 777X produced.

Neither Phase 1 nor Phase 2 should require the installation or establishment of any new emission units or the modification of any existing emission units associated with emergent operations.

2.2.2.12. Electrical Systems Production Operations

Electrical systems production operations occur in the space that the Electrical Systems Responsibility Center (ESRC) shares with the IRC in Building 40-56, and in Building 40-02, and primarily support the 747, 767, and 777 airplane models produced at Boeing Everett, as well as the 737 model produced at Boeing Renton. Electrical systems production operations involve the assembly of wiring harnesses, power panels, and other electrical components. Air emissions are relatively insignificant and occur from the use of hand wipe cleaning solvents and adhesives, resins, and other VOC containing products. The VOC emissions from this operation are not subject to a PSD VOC emission limit. The estimated emissions from these activities are 0.013 ton of VOC per 777X produced.

Neither Phase 1 nor Phase 2 should require the installation or establishment of any new emission units or the modification of any existing emission units associated with electrical systems production operations.

2.2.2.13. Summary of Proposed PSD Permit Changes

Boeing proposed to limit annual natural gas usage from new combustion units related to the 777X project to 1,000,000 MMBtu/yr. Ecology will include this annual limit of natural gas usage as a permit limit.

Table 7 lists the proposed changes to the VOC emission limits in the current PSD permits.

Table 7. Proposed PSD VOC Emission Limit Changes				
PSD Permit	**Emission Unit or Activity**	**Current Limit**	**Proposed Limit**	**Increase (tpy)**
91-06	777 Assembly	238.8 tpy	513 tpy	274.2
05-02	Interiors	205 tpy	239 tpy	34
11-01	Wing Painting	34 tpy	59 tpy	Note 1
11-01	Wing Painting	0.17 tons/wing	0.24 tons/wing	Note 1
11-01	Wing Painting	36.3 tpy	61.3 tpy	Note 1
Total Proposed Increase		**308.2**		
Note 1: These emissions are included in 777 assembly current and proposed emission limits.				

3. PSD APPLICABILITY REVIEW

3.1. Overview and Permitting History

The existing facility is a major PSD stationary source per 40 CFR 52.21(b)(1)(i). Under WAC 173-400-720 through 750, a project proposed at an existing major stationary source is subject to PSD review if the project either is a “major modification” to an existing “major stationary source,” or is a major stationary source unto itself.

Unless otherwise exempted by applicable regulation, a change to an existing major stationary source is a major modification if the change results in both a significant emissions increase and a significant net emissions increase at the source. “Significant emissions increase” means that the emissions increase for any regulated PSD pollutant is greater than the PSD significant emission rate (SER) threshold for that regulated pollutant.

The proposed 777X project will require a PSD permit if both the project’s emissions increase and the net contemporaneous emissions increase caused by the project exceed any PSD SERs of any NSR pollutant, including greenhouse gases (GHGs). The proposed new building and modifications to the existing buildings at Boeing Everett require a PSD review. In accordance with the requirements of 40 CFR 52.21(a)(2), these emission increases associated with the new units is based on their potential to emit (PTE). Also, as addressed in the regulation, their baseline actual emissions are zero.

The significant emissions increase analysis looks only at the emissions from the proposed project and is called Step 1. The significant net emissions increase analysis looks at additional increases and decreases from “contemporaneous” projects at the source and is called Step 2.

For the significant emissions increase analysis, the 777X project will involve both constructing new emissions units and modifying existing units. The PSD regulations require use of the hybrid test for projects that involve both the addition of new emissions units and the modification of existing emissions units. The PSD regulations require use of the hybrid test for projects that involve both the addition of new emissions units and the modification of existing emissions units (40 CFR 52.21(a)(2)(iv)(f)). Under the hybrid test, a significant emissions increase of a regulated NSR pollutant is projected to occur if the sum of the emissions increases for each emissions unit, using the actual-to-projected-actual applicability test (40 CFR 52.21(a)(2)(iv)(c) for modified units and the actual-to-potential applicability test (40 CFR 52.21(a)(2)(iv)(d)) for new units, equals or exceeds the significance threshold for that pollutant as defined in paragraph 40 CFR 52.21(b)(23). The actual-to-projected-actual applicability test involves adding the projected actual emissions from existing emissions units that are modified as part of the project or that are otherwise expected to experience an emission increase as a result of the project, and then subtracting the past actual emissions (called the “baseline actual emissions”) from those units.

However, in lieu of projecting future actual emissions for a particular existing emissions unit, an applicant can choose instead to use the unit’s PTE as the unit’s post project emissions (40 CFR 52.21(b)(41)(ii)(d)). The actual-to-potential test, which is required for all new units being constructed as part of the project, involves totaling the potential emissions of the proposed new emissions units, then subtracting past actual emissions of those units. A new unit that is being constructed as part of the project has a baseline of zero (40 CFR 52.21(b)(48)(iii)).

If the project would result in a significant emissions increase, then a significant net emissions increase analysis is often conducted. However, EPA has clearly stated that calculating a net emissions increase is at the source’s option (see, for example, 67, Federal Register 80186, at 80197 [December 31, 2002]). Therefore, a source may seek a PSD permit based on a calculated significant emission increase alone. For the 777X project, Boeing requested that option, and is foregoing the Step 2 significant net emission increase analysis.

Essentially, this means that the 777X project will trigger PSD review because the Boeing Everett facility currently has the PTE more than 250 tpy of VOC which is a regulated NSR pollutant. Therefore, Boeing Everett is considered a “major stationary source” for PSD purposes, as defined by 40 CFR 52.21(b)(1)(i).

As a result of the possible increased 777X production rate enabled by Phase 2 of the project, emissions from the existing 777 assembly operations are expected to increase as well as emissions from other operations where Boeing Everett produces or processes 777 components (including interiors production, some EDC operations, and propulsion systems operations). Further, the amount of steam and heat produced at the Boeing Everett facility will increase to support the increased production.

3.2. Emissions Calculation

3.2.1. Significant Emissions Increases

The 777X project will involve both modifying existing emission units and constructing new emission units. There a hybrid test is required under 40 CFR 52.21(a)(2)(iv)(f). The hybrid test involves using the actual-to-projected-actual applicability test (40 CFR 52.21(a)(2)(iv)(c)) for modified and debottlenecked units, and the actual-to-potential applicability test (40 CFR 52.21(a)(2)(iv)(d)) for new units to be constructed as part of the project. In addition, EPA's aggregation policy is to deter sources from attempting to expedite construction by permitting several changes separately as minor modifications. In the case of a new project that is undergoing PSD permitting, the aggregation analysis is used to determine all of the pollutants and emission units that are subject to PSD review. In the situation of the 777X project, all projects involving the future production of 777X models has been included in the 777X project.

3.2.1.1. Actual-to-Projected-Actual Applicability Test for Modified and Debottlenecked Emissions Units

Debottlenecking is the term used for situations when emission units upstream or downstream from the unit(s) undergoing a physical change or change in the method of operation will experience an emission increase a result of the project. Emissions increases from debottlenecked units are calculated using an actual-to-projected-actual applicability test.

For existing emission units that are being modified or debottlenecked as part of the 777X project, the PSD baseline emissions are emissions averaged over any 24 consecutive month period in the 10 years before Ecology receives a complete application for the project. For a regulated NSR pollutant, when a project involves more than one emission unit, only one 24 consecutive month period may be used to determine the baseline actual emissions for all emission units being changed. However, a different 24 consecutive month period can be used for each regulated NSR pollutant (40 CFR 52.21(b)(48)(ii)(d)). For the 777X project, the 10-year period from which the baseline period may be selected for all NSR regulated pollutants begins in 2004 and includes the full calendar years 2005 through 2013. For "new" units constructed prior to the 777X project (i.e., units that have been in operation for less than two years), baseline actual emissions are the units' PTE (40 CFR 52.21(b)(48)(iii)).

Table 8 presents the VOC emissions from 777 assembly operations and the number of 777s produced for the nine years 2005 through 2013. Boeing selected 2012 and 2013 calendar years as the baseline period for VOC emissions.

Table 8. Estimated VOC Emissions from 777 Assembly Operations for 2005 through 2013

Year	# of 777s Produced	Estimated VOC Emissions Before Subtracting	Estimated VOCs in Waste (tons)	Estimated VOC Emissions After Subtracting Waste (tons)	Estimated VOC Emissions per Airplane (tons)
2005	44	107.8	4.2	103.6	2.35
2006	62	117.9	5.9	112.0	1.81
2007	83	179.3	8.7	170.6	2.05
2008	68	152.7	8.2	144.5	2.13
2009	83	164.5	10.1	154.4	1.86
2010	71	133.3	8.0	125.3	1.77
2011	75	146.8	8.6	138.2	1.84
2012	83	167.7	11.2	156.5	1.89
2013	99	181.1	17.1	164	1.66
Note: A 2-month work stoppage occurred in 2008.					

Increased 777X production enabled by Phase 2 of the project would be expected to result in increased emissions from the existing 777 assembly operations and related combustion from boilers and heaters. Table 9 lists the projected actual emissions (at the maximum production rate of 10.4 airplanes per month, or 125 airplanes per year) from the 777X assembly operations and from the related operations that would experience increased emissions as a result of increased production at the assembly operations. Details of the emission estimates are shown in Appendices A and B.

Table 9. Projected Actual Emissions of Regulated NSR Pollutants for Existing 777 Assembly Operations and Related 777 Operations (tpy)

Operation	CO	NO_X	PM	SO_X	Lead	VOC	CO_2e
777 Assembly			*			265.5	
Interiors			*			66.3	
EDC			*			18.8	
Propulsion			*			1.3	
Emergent			*			7.5	
ESRC			*			1.6	
Boilers†	55	67	5.1	1.5	0.0004	3.6	79,500
Total	**55**	**67**	**6.35**	**1.5**	**0.0004**	**364.6**	**79,500**
*Non-combustion PM emissions will primarily be generated from spray coating operations. Total combined PM emissions from spray coating operations from							

Table 9. Projected Actual Emissions of Regulated NSR Pollutants for Existing 777 Assembly Operations and Related 777 Operations (tpy)

Operation	CO	NO_X	PM	SO_X	Lead	VOC	CO_2e

all 777 operations are estimated to be less than or equal to approximately 0.01 ton per airplane. Therefore, total combined PM projected actual emissions from all 777 spray coating operations are estimated to be less than or equal to 0.01 ton/airplane x 125 airplanes/yr = 1.25 tpy.

†All combustion-related emissions are accounted for in Boilers.

CO = carbon monoxide

NO_X = nitrogen oxides

PM = particulate matter

SO_X = sulfur oxides

CO_2e = carbon dioxide equivalent

EDC = Everett Delivery Center

ESRC = Electrical Systems Responsibility Center

The existing boilers and heaters provide heat and energy to all operations at the Boeing Everett facility, including operations such as office buildings and other airplane model manufacturing that are not directly related to 777 production. Therefore, emissions from boilers and heaters are treated differently than those from the other operations. The projected actual emissions rate for combustion operations is the baseline rate for the entire Boeing Everett facility plus the expected additional heat that would be required to support 777X production at the maximum potential production rate, based on an average heat usage of 3,206 MMBtu per airplane. Details of the emission estimates are shown in Appendices A and B.

VOC emissions from the EDC operations do not include final painting of the airplane exterior, which is performed in paint hangars. Currently, the paint hangars at the Boeing Everett facility are operating at or near capacity, with many airplanes being flown offsite for final coating. Because there are currently no plans to increase paint hangar capacity to support the 777X, the 777X project will not result in an increase emissions at Boeing Everett facility from paint hangars.

Table 10 shows the baseline actual emissions for calendar years 2012 and 2013 from the 777 assembly operations and related operations that are expected to experience an emission increase as a result of the increased 777X production enabled by Phase 2 of the project, except that carbon dioxide equivalent (CO_2e) is based on 2006 and 2007, which was the 2-year period with the greatest CO_2e production rate.

Table 10. Baseline Actual Emissions of Regulated NSR Pollutants for Existing 777 Assembly Operations and Related 777 Operations (tpy)

Operation	CO	NO_X	PM	SO_X	Lead	VOC	CO_2e
777 Assembly			*			160	
Interiors			*			48	
EDC			*			14	
Propulsion			*			1	
Emergent			*			5	
ESRC			*			1	
Boilers†	50	60	4.5	1.1	0.0003	3	72,000
Total	**50**	**60**	**4.5**	**1.1**	**0.0003**	**233**	**72,000**

*Non-combustion PM emissions will primarily be generated from spray coating operations. Total combined PM emissions from spray coating operations from all 777 operations are estimated to be less than or equal to approximately 0.01 ton per airplane. Therefore, total combined PM baseline actual emissions from all 777 spray coating operations for calendar years 2012 and 2013 are estimated to be less than or equal to 1 tpy.

†All combustion-related emissions are accounted for in boilers.

During the baseline period, Boeing Everett did not operate above any legally enforceable emission limitation, and there are no new emission standards that affect these units or activities that have come into effect between the baseline period and the date of the application. Therefore, no adjustments are required under 40 CFR 52.21(b)(48)(ii)(b) or (c).

3.2.1.2. Actual-to-Projected Test for Newly Constructed Emissions Units

For emissions units that will be newly constructed as part of the 777X project, baseline emissions are zero and post-project emissions are the units' PTE. Therefore, the emission increase from these new units resulting from the project is their PTE. The proposed new emissions units and their associated PTE are identified in Table 11. The PTE for the new non-combustion emission units is based on a maximum production rate of 125 airplanes per year. The potential emissions from new combustion emissions units are based on a voluntary total combined heat input limit of 1,000,000 MMBtu per year for all new combustion units associated with this project. Detailed calculations are included in Appendices A and B.

Table 11. Emissions Increases of Regulated NSR Pollutants for New Units (tpy)

Emission Unit	CO	NO_X	PM	SO_X	Lead	VOC	CO_2e
Wing component fabrication emission units (non-combustion)			<0.5			235	
Vertical fin prep and spray booths			<0.1			14	
Wing stub spray coating enclosure			<0.1			1	

Table 11. Emissions Increases of Regulated NSR Pollutants for New Units (tpy)							
Emission Unit	**CO**	**NO_X**	**PM**	**SO_X**	**Lead**	**VOC**	**CO_2e**
Interiors emission units			<0.1			34	
Emergency engines	11	18	0.6	0.74	0	1	2,100
Combustion emission units	20	6	4	0.50	0	3	59,400
Total for new units	**31**	**24**	**5.4**	**1.24**	**0**	**288**	**61,500**

3.2.1.3. Hybrid Total Emissions Increase

The total emission increase relating to the 777X project is the sum of the increases from the existing units (projected actual minus baseline actual emissions) and the PTE from the newly constructed units and is presented in Table 12.

Table 12. Emissions Increases of Regulated NSR Pollutants for Existing and New Emissions Units (tpy)							
Emissions	**CO**	**NO_X**	**PM**	**SO_X**	**Lead**	**VOC**	**CO_2e**
Baseline actual emissions	50	60	5.5	1.10	0.0003	233	72,000
Projected actual emissions from existing units	55	67	6.4	1.51	0.0004	365	79,500
Potential emissions from new units	31	24	5.4	1.24	0	288	61,500
Emissions increase	36	31	6.3	1.66	0.0001	420	69,000
PSD Significant Emission Rate (SER)	100	40	10	40	0.6	40	75,000
Significant?	**No**	**No**	**No**	**No**	**No**	**Yes**	**No**

The federal rule defines a significant increase to be equal to or exceeding any of the rates listed in Table 13 (40 CFR 52.21(b) (23)). The 777X project is not expected to emit measurable quantities of fluorides, hydrogen sulfide (H_2S), or reduced sulfur compounds (TRS). The expected increase in ozone depleting substances is about 2.25 tpy (see Appendix B of this TSD). As noted in Table 12, the emissions increases from the 777X project will exceed the SER for only VOCs. Therefore, the project will only have a significant emissions increase for VOCs.

Table 13. Pollutant and PSD SERs	
Pollutant	**SER**
CO	100
NO_X	40
SO_2	40
PM	25
PM_{10}	15
$PM_{2.5}$	10
Ozone	40 (VOCs or NO_X)*

Table 13. Pollutant and PSD SERs	
Pollutant	**SER**
Lead	0.6
Fluorides	3
Sulfuric acid mist	7
H_2S	10
Total Reduced Sulfur	10
Reduced sulfur compounds	10
Ozone-depleting substances	100†
Greenhouse gases	75,000 CO_2e

Note: There are additional rates for municipal waste combustors and landfills; however, Boeing does not combust or landfill municipal waste at the Boeing Everett facility.

*VOC and NO_X are precursors of ozone.

†WAC 173-400-720(4) (b) (iii) (B).

SO_2: sulfur dioxide

PM_{10}: particulate matter less than 10 microns in diameter

$PM_{2.5}$: particulate matter less than 2.5 microns in diameter

H_2S: hydrogen sulfide

3.2.1.4. Significant Emissions Increase Analysis

If the project causes a significant emissions increase, then the project is a major modification only if it also results in a significant net emissions increase (40 CFR 52.21(a)(2)(iv)(a)). The 777X project will result in a significant emissions increase only for VOCs, and will be considered a major modification only if it also results in a significant net emissions increase of VOCs. The steps necessary to calculate the net emission increase are outlined in 40 CFR 52.21(b) (3) (i). As noted earlier in this section, EPA has stated that calculating a net emission increase is at the source's option. So a source may seek a PSD permit based on a calculated significant emission increase alone. For the 777X project, Boeing is taking that option and foregoing the Step 2 significant net emission increase analysis.

The 777X project will not exceed the SER of any regulated NSR pollutant except for VOCs. Therefore, Boeing submitted an application for PSD review only for VOCs.

Ecology has discussed the emissions from painting previously in this section. As noted above, the emissions from painting completed airplanes in the paint hangars were not included in the 777X project PSD application because Boeing is operating those activities at near capacity and will not be adding additional paint hangars as part of this project. The paint hangars will not experience an increase in utilization as a result of this project. Even if those activities were included, the 777X project would not be a major modification for any non-VOC NSR-regulated pollutant.

In addition to regulated NSR pollutants, GHGs are subject to regulation as of January 2, 2011. EPA's PSD rule under 40 CFR 52.21(b) (49) states the following:

> Beginning January 2, 2011, the pollutant GHGs is subject to regulation if:
> The stationary source is a new major stationary source for a regulated NSR pollutant that is not GHGs, and also will emit or will have the potential to emit 75,000 tpy CO_{2e} or more; or
>
> The stationary source is an existing major stationary source for a regulated NSR pollutant that is not GHGs, and also will have an emissions increase of a regulated NSR pollutant, and an emissions increase of 75,000 tpy CO_{2e} or more.

Boeing Everett is an existing major stationary source for a regulated NSR pollutant that is not GHGs, and the proposed 777X project is expected to result in a significant increase of VOCs. However, the project will not result in an emissions increase of 75,000 tpy of CO_2e.

Therefore, the GHGs emissions from the project are not subject to PSD review.

4. BACT

4.1. Definitions and Policy Concerning BACT

All new major sources or major modifications are required to utilize BACT for those new and modified emission units that will experience an increase in emissions as a result of the project. BACT is defined as an emissions limitation based on the maximum degree of reduction for each pollutant subject to regulation, emitted from any proposed major stationary source or major modification, on a case-by-case basis, taking into account cost-effectiveness, economic, energy, environmental, and other impacts (40 CFR § 52.21(b)(12)).

Federal guidance requires each PSD permit applicant to implement a "top-down" BACT analysis process for each new or physically or operationally changed emissions unit. Ecology has adopted the top-down BACT process for its BACT determinations. This top-down BACT analysis process consists of five basic steps described below:[2]

Step 1. Identify all available control technologies with practical potential for application to the specific emission unit for the regulated pollutant under evaluation.

Step 2. Eliminate all technically infeasible control technologies.

[2] See EPA's *Draft New Source Review Workshop Manual*, 1990; and PSD and Title V Permitting Guidance for Greenhouse Gases <http://www.epa.gov/nsr/ghgdocs/ghgpermittingguidance.pdf>.

Step 3. Rank remaining control technologies by control effectiveness and tabulate a control hierarchy.

Step 4. Evaluate most effective controls and document results.

Step 5. Select BACT, which will be the most effective practical option not rejected, based on economic, environmental, and/or energy impacts.

If the applicant proposes to implement the most effective or “top” available control strategy, Step 4 is not necessary.

As shown above, the "top-down" BACT process starts by considering all available emission control technologies, and ranks them for further evaluation from most effective to least effective technically available control technology. The most effective emission reduction technology is then evaluated for economic feasibility. If the technology is proven infeasible based on economics, energy, or other environmental considerations, then the next most stringent level of reduction is considered. The most stringent level of emissions control that is not determined to be technically and economically infeasible is selected as BACT. While the permitting agency makes the final BACT decision, the burden is on the applicant to prove why the most stringent level of control should not be used.

Boeing provided a 5-step top-down VOCs BACT analysis for the 777X project, which was fully evaluated by Ecology.

For the 777X project, the only regulated NSR pollutant for which the project results in a plantwide significant emission increase is VOCs. This section will discuss the BACT analysis focusing on VOCs for the new and modified prep booths, spray booths, combustion sources, and fugitive (open floor) sources using the EPA top-down approach.

4.2. BACT Analysis

4.2.1. Prep and Spray Paint Booths BACT Analysis

There are several proposed new or modified prep and spray paint booths anticipated for the 777X project. These booths are listed in Table 14. The table presents the total potential VOC emissions based on the anticipated annual hours of operation for each of the new or modified emissions units.

Table 14. New and Modified Booths

Emission Unit	Booth Type	Qty.	New/ Modified	Annual Hr of Operation (per booth)	VOC Emissions (tpy/booth)	Exhaust Rate (acfm)
WCF-8a	Wing panel prep booth(s)(abrasive blast/sanding	2	New	2000	31.6 (See Note 1)	32,500

Table 14. New and Modified Booths						
Emission Unit	Booth Type	Qty.	New/ Modified	Annual Hr of Operation (per booth)	VOC Emissions (tpy/booth)	Exhaust Rate (acfm)
	solvent hand wipe, edge seal)					
WCF-8b	Wing spar prep booth (abrasive blast/sanding solvent hand wipe, edge seal)	1	New	1,000	4.4	7,800
WCF-9a,b,d	Wing panel spray booths	3	New	500	25.6 (See Note 2)	195,000
WCF-9c,e	Wing spar spray booths	2	New	500	7.4 (See Note 3)	46,800
WCF-10a, b	Wing panel primer curing booths	2	New	500	1.6	97,500
WCF-10c	Wing spar primer curing booths	1	New	500	0.4	23,400
WCF-11a,b,c,d	Wing spar primer curing booths	4	New	250	0.1 (See Note 4)	3,635
WCF-12a,b,c,d	Coating equipment cleaning booths	4	New	250	1.0 (See Note 5)	3,635
WCF-14	Wing spar seal booths	4	New	1000	9.5 (See Note 6)	25,000
WBSP-1a,1b	Robotic wing spray booths	2	Might be modified to add new robot	2,275	31.3	120,000
WBSP-2	Forward body section spray booth	1	Might need to be modified to accommodate larger sections	1,000	12.5	54,900
WBSP-3	Mid body section spray booth	1	Might need to be modified to accommodate larger section	1,000	12.5	65,750
WBSP-4	Aft body section spray booth	1	Might need to be modified to accommodate larger sections	1,000	12.5	64,000
WBSP-6	Forward body section CIC spray booth	1	Might need to be modified to accommodate larger sections	625	12.1	33,500
WBSP-7	Mid body section CIC spray booth	1	Might need to be modified to accommodate larger sections	625	6.1	44,800
WBSP-8	Aft body section CIC spray booth	1	Might need to be modified to accommodate larger sections	625	12.1	33,500
WBSP-10	Vertical fin HLFC prep booth	1	NEW (Currently this work is done on the 777 vertical fin with final coat in the airplane paint hangars.)	500	1.3	50,000
WBSP-11a,b,c	Vertical fin HLFC spray booths	3	NEW (Currently this work is done with final coat in the airplane paint hangars.)	500	4.4	150,000
AA-2	Wing stub spray booths	2	One new, one modified	1,000	1.4	4,000
IRC-1a,b,c	Adhesive spray booths	3	NEW	2,000	8.9	20,000
IRC-2	Paint spray booth	1	NEW	2,000	5	20,000

Acfm: Actual cubic feet per minute

Notes:
1. Emissions are based on the assumption that only one Wing Panel Prep Booth is installed; however, Boeing may decide to install two Wing Panel Prep Booths. In that case the total combined emissions from both booths will be 31.6 tons per year, and the emissions per booth will average 15.8 tons per year.

Table 14. New and Modified Booths

Emission Unit	Booth Type	Qty.	New/ Modified	Annual Hr of Operation (per booth)	VOC Emissions (tpy/booth)	Exhaust Rate (acfm)

2. Emissions are based on the assumption that only two Wing Panel Spray Booths are installed; however, Boeing may decide to install three Wing Panel Booths. In that case the total combined emissions from all three booths will be 51.2 tons per year, and the emissions per booth will average 17.0 tons per year.

3. Emissions are based on the assumption that only one Wing Spar Spray Booth is installed; however, Boeing may decide to install two Wing Spar Booths. In that case the total combined emissions from the two booths will be 7.4 tons per year, and the emissions per booth will average 3.7 tons per year.

4. Emissions are based on the assumption that only one paint mix booth is installed; however, Boeing may decide to install up to four paint mix booths. In that case the total combined emissions from the four booths will be 0.1 tons per year, and the emissions per booth will average 0.025 tons per year.

5. Emissions are based on the assumption that only two equipment cleaning booths are installed; however, Boeing may decide to install up to four equipment cleaning booths. In that case the total combined emissions from the four booths will be 2 tons per year, and the emissions per booth will average 0.5 tons per year.

6. Emissions are based on the assumption that only one Wing Spar Seal Booth is installed; however, Boeing may decide to install up to four Wing Spar Seal Booths. In that case the total combined emissions from the four booths will be 9.5 tons per year, and the emissions per booth will average 2.4 tons per year.

VOC emission estimates for paint spray booths include gun and line cleaning operations because the paint containers and the spray guns are connected by long lines that need to be cleaned. Although the cleaning solution is collected in containers, for the purposes of the emission estimates and the BACT analysis, a portion of the gun and line cleaning solvent is assumed to be emitted through the booth.

BACT analysis was performed for each emission unit operating at the emission rates and exhaust flow rates listed in Table 14. Boeing currently uses a combination of low-VOC coatings, high transfer efficiency application techniques, and good work practices (i.e., keeping containers of coating closed when not in use) to minimize VOC emissions. The Aerospace National Emission Standard for Hazardous Air Pollutants (ANESHAP) regulation requires low-VOC coatings, high transfer efficiency coating techniques, and these work practices. Therefore, these coatings, application techniques, and work practices are considered the base case for BACT.

The cleaning and coating operations planned for the new and modified spray paint booths are as follows:

- Aircraft parts cleaning: Before the parts of the airplane can be sealed and/or coated, they first must be cleaned and prepped.
- Aircraft parts sealing: Areas on certain parts of the airplane (e.g., parts that will become part of a fuel tank or the pressurized fuselage) must be sealed prior to coating.
- Aircraft parts priming: Priming provides corrosion protection and ensures the necessary bond between the surface of the airplane components and the topcoat.

- Aircraft parts topcoat: The topcoat is the final coating of the normally visible surfaces of the airplane. The topcoat not only provides the final protection of the airplane surface, but on the exterior of the fuselage and empennage (the tail assembly of an aircraft, including the horizontal and vertical stabilizers, elevators, and rudder) also provides the decorative color to the airplane.
- Aircraft parts corrosion inhibiting compound (CIC): Portions of the airplane that are not normally visible often need a special coating to further protect them from corrosion.
- Adhesive spray booths: Interior composite panels (e.g., aircraft cabin sidewalls and ceilings) are sprayed with adhesive to apply a decorative laminate.
- Spray equipment cleaning: The spray equipment used to perform the operations above is cleaned after each use. A small amount of solvent evaporates while cleaning the spray equipment.

4.2.2. Available Control Technologies

BACT databases from EPA (EPA, RACT/BACT/LAER Clearinghouse [RBLC]), California Air Resources Board (CARB), and South Coast Air Quality Management District (SCAQMD) were reviewed for possible control technologies that are both available on the market and proven practice in the aerospace or other industries with similar requirements for coating very large objects. The technologies reviewed are summarized in Table 15.

4.2.3. BACT Feasibility Review

The control technologies in Table 15 have been demonstrated and achieved in practice and therefore could be feasible technologies for implementation for the 777X project.

Table 15. BACT Review

Control Technology	Equipment Description	Company	Date Implemented	Pollutant Controlled	Control Efficiency (%)	Emission Limit	Database Reference
Thermal oxidizer	Spray booth	Watkins Manufacturing Corporation	10/28/2002	VOC	98.9	95% control	CARB, BACT Clearinghouse
RTO	Spray booth	Arcadia, Inc.	2/6/2001	VOC	99.3	.89 lb/hr	CARB, BACT Clearinghouse, SCAQMD Clearinghouse
RTO	Spray booth	Huck International – Deutsch Operations	N/A	VOC	90.6	59 lb/day	CARB, BACT Clearinghouse, SCAQMD Clearinghouse
RTO w/ concentrator	Spray booth	Kal-Gard Coating & Mfg, E/M Corp.	8/14/2008	VOC	Not Available	2 tpy	CARB, BACT Clearinghouse
RTO w/ concentrator	Spray booth	Douglas Production Division	3/30/94	VOC	93.2	341 gal/day	CARB, BACT Clearinghouse, SCAQMD Clearinghouse

Table 15. BACT Review							
Control Technology	**Equipment Description**	**Company**	**Date Implemented**	**Pollutant Controlled**	**Control Efficiency (%)**	**Emission Limit**	**Database Reference**
Carbon adsorption	Spray booth	Lippert Components, Inc.	5/8/2002	VOC	99.3	85.5% control	CARB, BACT Clearinghouse
Carbon adsorption	Spray booth	Northrop-Grumman	2/25/91	VOC	90	414 lb/day	CARB, BACT Clearinghouse
Low-VOC coatings, HVLP coating gun, best management practices	Spray booth	Dean Baldwin Painting LP	09/21/2011	VOC	N/A	4.5 lb VOC/gal coating	EPA, RBLC Clearinghouse
Low-VOC coatings, HVLP coating gun, best management practices	Spray booth	Time Aviation Services, Inc.	6/18/99	VOC	N/A	3 gal/day	CARB, BACT Clearinghouse
Low-VOC coatings, HVLP coating gun, best management practices	Spray booth	California Air National Guard, Fresno	1/22/97	VOC	N/A	5.23 lb VOC / gal coating	CARB, BACT Clearinghouse
Low-VOC coatings, HVLP coating gun, enclosed gun cleaner	Spray booth	Toter	12/16/99	VOC	N/A	1.09 lb VOC / gal	CARB, BACT Clearinghouse
RTO = regenerative thermal oxidizer N/A = not applicable HVLP = high-volume low-pressure							

4.2.4. Ranking of BACT by Control

The potential control options listed in Table 15 are ranked in Table 16 based on the control efficiencies documented as being achieved in practice.

Table 16. Ranking of Control Technologies		
Type of Control Technology	**Control Efficiency**	**Ranking**
RTO	99.3%	1
Carbon adsorption	99.3%	2
Thermal oxidizer	98.9%	3
RTO w/concentrator	93.2%	4
Low-VOC coatings, HVLP coating gun, best management practices	N/A	5

4.2.5. Cost-Effectiveness Evaluation

Vendors of paint operation control technologies were contacted by Boeing to assess implementation of the different controls available in the marketplace listed in Table 16. Vendor quotes were collected and are summarized in the cost-effectiveness evaluation spreadsheets. Cost-effectiveness evaluations were made following EPA's guidance for VOC Control by Incinerator and by Carbon Adsorption (EPA, 2002). These evaluations are discussed below.

Before discussing the evaluations' results, note the cost-effectiveness analyses use the standard default values for construction as provided by EPA unless otherwise noted. Boeing Everett expects the installation of any add-on control technology at an existing part of the facility would require complicated retrofit construction and expenses. The existing facility has limited space available for the footprint of additional equipment, which might require that any add-on controls be placed on the roof. The need for additional structural support would have to be evaluated, and the existing natural gas lines might need to be upgraded to supply sufficient follow and pressure to operate the control equipment as designed. Retrofits and new equipment installation add costs to the cost-effectiveness analysis. Providing utilities such as natural gas is expected, but not currently available at every location. For these reasons, Boeing projected construction costs for both retrofits and for new equipment installed at Boeing Everett's existing facility are expected to be above standard EPA default values for construction for a new facility.

4.2.6. Thermal Oxidizer

A thermal oxidizer uses a burner to destroy VOC emissions prior to release to the atmosphere through a stack. This control technology includes preheating the incoming air stream to obtain additional fuel efficiencies. In prior BACT reviews for Boeing (PSD application for 737 MAX production and capacity increase, February 2013), the thermal oxidizer technologies have been demonstrated to be the most expensive technology to implement for this application. It was implemented only once in the industry over 10 years ago (see Table 15 above). Since that implementation, other control technologies for coating applications have been implemented.

4.2.7. Carbon Adsorption

Carbon adsorption uses a filter bank of canisters that contain activated carbon which adsorbs the VOC emissions as the emissions pass through before being released to the atmosphere. Vendor information for the carbon adsorption technology was obtained from Thermal Recover Systems (TRS). The carbon adsorption control technology overall cost-effectiveness in dollars per ton removed is discussed below.

4.2.8. Regenerative Thermal Oxidizer

A regenerative thermal oxidizer (RTO) was ranked as one of the top control technologies available based on control efficiency. VOC emissions created from cleaning and coating activities are burned inside an enclosed chamber. Heat from the exhaust gas is recovered in a heat exchanger, which allows for fuel efficiencies in sustaining the high burn temperature. Vendor information for the RTO technology was obtained from Epcon. The RTO with control technology overall cost-effectiveness in dollars per ton removed is discussed in the summary section below.

4.2.9. RTO with Concentrator

This control technology augments the RTO methodology with the addition of a concentrator wheel. The wheel provides for a more concentrated VOC content in a smaller air stream for burning. The concentration of VOCs allows greater fuel efficiencies to be obtained during operation. Vendor information for the RTO with concentrator control technology was obtained from Anguil. The RTO with concentrator control technology overall cost-effectiveness in dollars per ton removed is discussed below in the summary section below.

4.2.10. Low VOC Coatings, High Transfer Efficiency Coating Techniques, and Good Work Practices

Boeing Everett currently uses low VOC coatings that meet specifications for airplane coating operations. Boeing also uses high transfer efficiency coating techniques, such as high volume low pressure (HVLP) spray guns, which provide high transfer efficiency and reduce the overall amount of paint required to perform a job. In addition, Boeing uses good work practices to minimize VOC emissions, including storing coatings and solvents in closed container, bagging solvent hand wipe cleaning rags when not in use, and capturing and containing solvent used for cleaning spray equipment. The VOC emissions standards for uncontrolled use will be applied in this operation. No cost analysis was performed because Boeing considers this to be the base case for BACT.

4.2.11. Summary of Cost-Effectiveness Analysis

The costs of control technologies identified as being available and technologically feasible for the new and modified prep booths and spray booths are summarized in Tables 17 through 20. These cost estimates are conservative (potentially underestimating the costs) and include an additional construction expense estimated at 15 percent of the Total Purchased Equipment Cost. In some cases, that additional expense was included in the vendor’s quote, and in others the expense was added.

Vendor information was not collected for every booth configuration and VOC loading rate expected for the 777X project. Vendor cost basis information is summarized in Table 17. Costs were scaled from the parameters quoted from vendors in Table 17 to match those emission units listed in Table 14. The carbon adsorption quote from Thermal Recovery Systems was obtained in 2011 for a previous Boeing PSD application using a 25,000 cubic feet per minute (CFM) air flow rate. The same quote was used in this analysis using a conservative cost approach to not include inflation costs. The RTO quote from Epcon was for a 33,500 cfm, and a 100,000 cfm booth. Quotes for RTO with concentrator from Anguil were provided for 46,800 cfm, 120,000 cfm, 195,000 cfm, and 400,000 cfm capacity booths. RTO with concentrator equipment operating costs were only obtained for the 400,000 cfm unit as operating costs are minimal compared to the equipment costs.

For control equipment that would be installed in existing buildings, a 15 percent contingency factor was applied. This is a very conservative estimate considering that the thermal oxidizers would likely be outside the building, and require considerable duct work and foundation supports.

Table 17. Vendor Quote Basis Summary

Type of Control Technology	Vendor	Air Flow Rates (cfm)	Operating Costs Inc. in Quote?	Equipment Cost Contingency Inc. in Quote
Regenerative canister thermal oxidize	Epcon	33,500	Yes	15%
Regenerative canister thermal oxidizer	Epcon	100,000	Yes	0%
Carbon adsorption	TRS	25,000	Yes	0%
RTO w/Zeolite concentrator	Anguil	46,800 120,000 195,000	No*	15%
RTO w/Zeolite concentrator	Anguil	400,000	Yes	15%
*Operating costs were scaled from four 100,000-cfm units.				

The standard method of evaluating the cost-effectiveness of various air pollution control options is to calculate the annualized cost of each option and divide that by the amount of emissions that would be removed by that option. Using this approach, the annualized cost of removing one ton of VOC emissions was calculated for each applicable control option and is summarized in Tables 18, 19, and 20.

Table 18. Summary of Costs for Wing Component Fabrication (WCF) Control Technologies by Emission Unit

Emission Unit	Unit Description	TRS Carbon Adsorption Control Costs ($/ton of VOC controlled)	Anguil RTO w/Zeolite Concentrator Control Costs ($/ton of VOC controlled)	Epcon Canister RTO Control Costs ($/ton of VOC controlled)
WCF-8a	Wing panel prep booth(s) (abrasive blast/sanding, solvent hand wipe, edge seal) (see note 1 – costs assume only one booth is installed)	$177,294	$9,177	$11,638
WCF-8b	Wing spar prep booth (abrasive blast/sanding, solvent hand wipe, edge seal)	$181,961	$19,135	$21,459
WCF-9a, b, and d	Wing panel spray booths (see note 1 – costs assume only two booths are installed)	$179,228	$34,789	$47,347
WCF-9c,e	Wing spar spray booth(s) (see note 1 – costs assume only one booth is installed)	$180,074	$42,914	$48,706
WCF-10a and 10b	Wing panel primer curing booth	$217,873	$275,799	$377,238

Table 18. Summary of Costs for Wing Component Fabrication (WCF) Control Technologies by Emission Unit

Emission Unit	Unit Description	TRS Carbon Adsorption Control Costs ($/ton of VOC controlled)	Anguil RTO w/Zeolite Concentrator Control Costs ($/ton of VOC controlled)	Epcon Canister RTO Control Costs ($/ton of VOC controlled)
WCF-10c	Wing spar primer curing booth	$245,353	$403,271	$454,442
WCF-11a,b,c,d	Small quantity paint mix booth(s) (see note 1 – costs assume only one booth is installed)	$333,083	$498,125	$533,096
WCF-12a, b,c,d	Coating equipment cleaning booths (see note 1 – costs assume only two booths are installed)	$184,137	$31,133	$33,318
WCF-14	Wing spar seal booth(s) (see note 1 – costs assume only one booth is installed)	$179,439	$20,722	$24,382

Note:

1. In some cases, the final number of booths to be installed has not yet been determined. In such cases, it is conservatively assumed for purposes of calculating the control technology costs that the least anticipated number of booths will be installed. If the control technology costs were instead based on the total potential number of booths to be installed, the costs would be higher than those shown in the above table.

Table 19. Summary of Costs for Wing and Body Structure Paint (WBSP) Control Technologies by Emission Unit

Emission Unit	Unit Description	TRS Carbon Adsorption Control Costs ($/ton of VOC controlled)	Anguil RTO w/Zeolite Concentrator Control Costs ($/ton of VOC controlled)	Epcon Canister RTO Control Costs ($/ton of VOC controlled)
WBSP-1a and 1b	Robotic wing spray booth – 120,000 acfm	$180,958	$22,944	$40,850
WBSP-1a and 1b	Robotic wing spray booth – 90,000 acfm	$179,209	$18,050	$24,331
WBSP-1a and 1b	Robotic wing spray booth – 60,000 acfm	$178,248	$14,126	$13,357
WBSP-2	Forward body section spray booth	$179,654	$32,206	$38,495
WBSP-3	Mid body section spray booth	$180,185	$36,908	$43,945
WBSP-4	Aft body section spray booth	$180,313	$37,366	$44,477
WBSP-6	Forward body section CIC spray booth	$177,730	$21,008	$23,958
WBSP-7	Mid body section CIC spray booth	$182,221	$54,501	$63,344
WBSP-8	Aft body section CIC spray booth	$177,730	$21,008	$23,958
WBSP-10	Vertical fin HLFC prep booth	$211,205	$291,315	$329,290
WBSP-11a, 11b, and 11c	Vertical fin HLFC spray booth	$190,538	$118,905	$153,698

Table 20. Summary of Costs for Airplane Assembly (AA) and Interior Fabrication (IRC) Control Technologies by Emission Unit

Emission Unit	Unit Description	TRS Carbon Adsorption Control Costs ($/ton of VOC controlled)	Anguil RTO w/Zeolite Concentrator Control Costs ($/ton of VOC controlled)	Epcon Canister RTO Control Costs ($/ton of VOC controlled)
AA-2a and 2b	Wing stub spray booth	$199,978	$44,284	$47,829
IRC-1a, 1b, And 1c	Adhesive spray booth	$183,800	$24,144	$29,528
IRC-2	Paint spray booth	$191,095	$42,735	$52,265

The robotic wing spray booths (WPSB-1a and 1b) are designed to operate in three operating modes, with ventilation rates of 120,000 cfm, 90,000 cfm, and 60,000 cfm. In that supplement, three options were evaluated:

1. Option A is to use a VOC control system for each booth designed to handle all 120,000 cfm. This option would ensure that all VOC emissions are treated by the control system. It would operate all the time that coating or cleaning occurred. About 29.5 tons of VOCs per year would be treated by each system and no VOC would be untreated.

2. Option B is to use a VOC control system for each booth designed only to handle up to 60,000 cfm, the most common operating mode of the robotic booth. Any exhaust above 60,000 cfm would be vented directly to the atmosphere without going through the VOC control system. Because the 60,000 cfm mode represents most of the operation and potential emissions, most emissions would be controlled. About 26 tons of VOC would be treated per year and about three tons per year would be untreated.

3. Option C is similar to Option B except that the VOC control system for each booth would be designed to handle up to 90,000 cfm, and any exhaust greater than 90,000 cfm would be vented directly to the atmosphere. About 29.1 tons of VOCs would be treated per year, and 0.4 tpy would be untreated.

Each of these options was evaluated and the results are presented in Table 19. Note that under the current Boeing plan, a decision to modify the robotic wing spray booth by installing a second robotic spray system in each booth will not be made until Phase 2 of the project and, at that time, BACT will likely be reevaluated. Phase 2 is tentatively scheduled to begin in 2021.

4.2.12. Comparison with Other Aerospace BACT Determinations

Boeing is currently the only manufacturer of large commercial airplanes in the United States. Even though Boeing has some smaller facilities elsewhere in the country and Airbus is developing a new airplane assembly plant in Alabama, there are few airplane facilities to compare to Boeing Everett due to the size of the planes made at Everett, and the size of the facilities at Everett.

A review of RBLC entries of the last 10 years for aerospace surface coatings (Process Type 41.001) shows entries for Boeing commercial airplane operations in the Puget Sound area and one entry for a Dean Baldwin aircraft refinishing operation in Indiana (Table 21). None of these entries indicates that add-on controls were considered BACT. Also, no BACT determinations for the Alabama Airbus facility are listed in the RBLC, even though the plant is under construction. A further review of the RBLC entries for permits between 1990 and 2003 (Table 22) indicates some BACT decisions for aerospace coating operations that required add-on controls. However, evaluation of the location of each of these operations indicates that each was in an ozone nonattainment area at the time of permitting. For example, Huck International is located in Los Angeles, an ozone nonattainment area; CA-0889, CA-1045, and CA-0977. For each of these RBLC entries, we believe that the control determinations were intended to implement LAER for those operations under nonattainment area NSR rather than BACT under the PSD program.

Table 21. RBLC Aerospace Coating Entries Since 2000 (Process Type 41.001)

ID	Co.	State	Permit Date	Process	Control Method Description	BACT
WA-0326	Boeing Commercial Airplanes Group	WA	10/12/2005	Exterior coating operations		N/A
WA-0326	Boeing Commercial Airplanes Group	WA	10/12/2005	Final assembly		N/A
WA-0326	Boeing Commercial Airplanes Group	WA	10/12/2005	Interiors manufacturing		N/A
WA-0330	Boeing Commercial Airplanes Group	WA	10/12/2005	Paint hangar final exterior coating	A BACT review was not required because Ecology determined that there was no physical change, or change in the method of operation, that causes or results in an emissions increase.	BACT-PSD
WA-0330	Boeing Commercial Airplanes Group	WA	10/12/2005	787 final assembly	A BACT review was not required because Ecology determined that there was no physical change, or change in the method of operation, that causes or results in an emissions increase.	BACT-PSD
WA-0330	Boeing Commercial Airplanes Group	WA	10/12/2005	Interiors manufacturing	A BACT review was not required because Ecology determined that there was no physical change, or change in the method of operation, that causes or results in an emissions increase.	BACT-PSD
WA-0340	The Boeing Company	WA	07/27/2007	Paint hangar/final		Other case-by-

Table 21. RBLC Aerospace Coating Entries Since 2000 (Process Type 41.001)

ID	Co.	State	Permit Date	Process	Control Method Description	BACT
				exterior coating		case
WA-0344	Boeing Commercial Airplanes Group	WA	10/07/2008	Paint booth/hangar	Compliance with 40 CFR Part 63, Subpart GG and low-VOC vapor pressure cleaning solvents and strippers with low pressure applicators or manual application for depainting	BACT-PSD
IN-0126	Dean Baldwin Painting LP	IN	09/21/2011	Aircraft refinishing		Other case-by-case
WA-0347	The Boeing Company Boeing Renton	WA	02/19/2013	Paint booths/hangars/floor Activities	Compliance with 40 CFR Part 63, Subpart GG and low-VOC vapor pressure cleaning solvents and strippers with low pressure applicators or manual application for depainting.	BACT-PSD
WA-0348	The Boeing Company Boeing Renton	WA	02/19/2013	Paint booth/final exterior coating	Compliance with 40 CFR Part 63, Subpart GG and low-VOC vapor pressure cleaning solvents and strippers with low pressure applicators or manual application for depainting.	BACT-PSD

Table 22. RBLC Aerospace Coating Entries Between 1990 and 2000

ID	Co.	State	Permit Date	Process	Control Method Description	BACT
WA-0326	Boeing Commercial Airplanes Group	WA	10/12/2005	Exterior coating operations		N/A
WA-0326	Boeing Commercial Airplanes Group	WA	10/12/2005	Final assembly		N/A
WA-0326	Boeing Commercial Airplanes Group	WA	10/12/2005	Interiors manufacturing		N/A
WA-0330	Boeing Commercial Airplanes Group	WA	10/12/2005	Paint hangar final exterior coating	A BACT review was not required because Ecology determined that there was no physical change, or change in the method of operation, that causes or results in an emissions increase.	BACT-PSD

Table 22. RBLC Aerospace Coating Entries Between 1990 and 2000						
ID	Co.	State	Permit Date	Process	Control Method Description	BACT
WA-0330	Boeing Commercial Airplanes Group	WA	10/12/2005	787 final assembly	A BACT review was not required because Ecology determined that there was no physical change, or change in the method of operation, that causes or results in an emissions increase.	BACT-PSD
WA-0330	Boeing Commercial Airplanes Group	WA	10/12/2005	Interiors manufacturing	A BACT review was not required because Ecology determined that there was no physical change, or change in the method of operation, that causes or results in an emissions increase.	BACT-PSD
WA-0340	The Boeing Company	WA	07/27/2007	Paint hangar/final exterior coating		Other case-by-case
WA-0344	Boeing Commercial Airplanes Group	WA	10/07/2008	Paint booth/hangar	Compliance with 40 CFR Part 63, Subpart GG and low-VOC vapor pressure cleaning solvents and strippers with low pressure applicators or manual application for depainting.	BACT-PSD
IN-0126	Dean Baldwin Painting LP	IN	09/21/2011	Aircraft refinishing		Other case-by-case
WA-0347	The Boeing Company Boeing Renton	WA	02/19/2013	Paint booths/ hangars/floor activities	Compliance with 40 CFR Part 63, Subpart GG and low-VOC vapor pressure cleaning solvents and strippers with low pressure applicators or manual application for depainting.	BACT-PSD

Table 22. RBLC Aerospace Coating Entries Between 1990 and 2000						
ID	**Co.**	**State**	**Permit Date**	**Process**	**Control Method Description**	**BACT**
WA-0348	The Boeing Company Boeing Renton	WA	02/19/2013	Paint booth/final exterior coating	Compliance with 40 CFR Part 63, Subpart GG and low-VOC vapor pressure cleaning solvents and strippers with low pressure applicators or manual application for depainting.	BACT-PSD
WA-0287	Boeing Commercial Airplanes - Everett Facility	WA	12/23/1991	Surface coating, corrosion inhibitor	Best management practices. Electrostatic, air assisted, or airless spray equipment. Baseline emission rate: 11.5 tpy. Control efficiency: 15%-35%.	BACT-PSD
CA-0771	California Air National Guard, Fresno	CA	01/22/1997	HVLP applicator used to coat parts	Lowest available VOC content which meets military specifications.	LAER
CA-0977	Kal-Gard Coatings & Manufacturing	CA	05/28/1997	Metal parts coating operation	Zeolite concentrator and thermal oxidizer	LAER
CA-0979	Douglas Products Division	CA	03/30/1994	Metal parts coating operation	Concentrator and thermal oxidizer	LAER
CA-0980	Huck International - Deutsch Operations	CA	03/09/1995	Metal parts coating operation	Thermal oxidizer	LAER
CA-0549	Edwards Air Force Base	CA	05/07/1993	Hangar-sized spray booth for aircraft up to EC-18	Carbon adsorption filter bank w/ flame ionization detector to detect breakthrough	Other case-by-case
CA-0685	T.B.M. Inc.	CA	11/06/1995	Aircraft refinishing operation	Low-VOC coatings and Hercules GW/R enclosed gun	Other case-by-case
UT-0058	Hill Air Force Base	UT	12/15/1997	Surface coating, military operations	Zeolite adsorption system - M&W condesorb fob – 26 Zeolite adsorption cells - 100,000 acfm @ 80°F - max loading 122 lb VOC/hr	Other case-by-case
WA-0045	Heath Tecna Aerospace Co.	WA	03/27/1992	Spray booth	Carbon adsorber (methylene chloride)	Other case-by-case

Table 22. RBLC Aerospace Coating Entries Between 1990 and 2000						
ID	**Co.**	**State**	**Permit Date**	**Process**	**Control Method Description**	**BACT**
WA-0287	Boeing Commercial Airplanes - Everett Facility	WA	12/23/1991	Surface coating, corrosion inhibitor	Best management practices. Electrostatic, air assisted, or airless spray equipment. Baseline emission rate: 11.5 tpy. Control efficiency: 15%-35%.	BACT-PSD
NAA = Nonattainment area						

The RBLC also indicates that add-on controls have been installed at both Edwards Air Force Base (AFB) in California and Hill AFB in Utah. Edwards AFB is in an ozone nonattainment area. Neither of these entries purports to reflect a BACT decision under PSD. Each of these decisions is discussed further below. Boeing was provided information on these facilities by CH2M Hill and Air Force personnel familiar with those operations.

Edwards AFB has two booths used to paint airplanes and parts, and the booths have carbon adsorption systems installed. The first booth has an air flow of 111,000 cfm with 2.25 tpy of uncontrolled VOC emissions. The second booth is much larger (493,000 cfm) with 1.65 tpy of uncontrolled VOC emissions. Both of the carbon systems were installed because the AFB believed a cost savings, compared to other control technologies would be achieved while meeting nonattainment area requirements applying LAER and obtaining offsets.

These systems were supposed to be regenerative carbon systems, but soon after installation the regenerative portion failed and was never repaired. Today, carbon is swapped out manually at great expense. Albeit infrequently because of decreased VOC emissions over the years. The use of good work practices to reduce VOC emissions by using low VOC paints and application methods has proved more cost-effective than maintaining the carbon VOC control system and running it. This VOC control system's efficiency is not achieved in practice as designed and listed in the EPA RBLC.

Hill AFB was in an ozone nonattainment or maintenance area at the time of permitting and installed a Zeolite adsorption system. The initial installation of the unit appears to have been associated with technology demonstration and funded under a pollution prevention program. This unit has not been operational at Hill AFB for an extended period of time. Boeing was unable to determine how long the unit operated or the reason it was taken out of operation. Because of this lack of information, Boeing believes that no judgment can be made as to the feasibility of such a system for Boeing Everett. Ecology agrees with this assessment.

In summary, Boeing was unable to identify similar aerospace coating operations operated by other companies in the United States and could not find a recent BACT determination in EPA's

RBLC that requires add-on controls for similar aerospace coating operations. The few older determinations that are listed as BACT were intended to implement LAER for those operations under nonattainment area NSR rather than BACT under the PSD program.

4.2.13. BACT Selection

In determining BACT, energy, environmental, and economic impacts are taken into account. For PSD analysis, VOC is regulated as an ozone precursor. However, ozone formation in the Puget Sound area is limited by NO_X emissions and not VOC emissions. Therefore, the 777X project is not expected to have any measurable effect on ambient ozone levels. In addition, control technologies that involve combusting the VOCs will require some additional energy.

As noted above in Tables 18 through 20, the identified add-on control technologies are not economically feasible for the Boeing Everett facility. After taking into account energy, environmental, and economic impacts, add-on control technologies are not considered BACT. The Boeing Everett facility will be required to continue to implement the use of low VOC coatings, used high transfer efficiency coating equipment, and follow good work practices to minimize VOC emissions in compliance with the Aerospace NESHAP VOC emission standards in 40 CFR 63 Subpart GG. These requirements are listed in Table 23.

Ecology reviewed the State of South Carolina's Air Operating Permits number 0560-0372 (issued on July 23, 2007) , number 0560-0415 (issued on August 2, 2012), and Air Quality State Construction Permit for the Boeing IRC and Propulsion South Carolina number 0560-0415-CB (issued on January 22, 2014). These permits are Air Operating and Notice of Construction permits, and were found to not be applicable to Ecology's PSD permitting effort for the Boeing 777X project.

Ecology also contacted Alabama in regards to the proposed Airbus facility. Ecology discovered that Airbus' facility will be three separate facilities with different owners. One facility will be for utilities and owned by Honeywell, Inc. This facility will be permitted for natural gas-fired boilers. The second facility is the airplane manufacturing plant, and will be owned by Airbus. The third facility will be for painting the completed airplanes. As of March 2014, the application had not been submitted. A foreign company will own the painting facility. The Alabama plant's producing a final airplane for Airbus will not require a PSD permit.

Based on all this information, Ecology believes the proposed limits meet BACT requirements.

Table 23. Summary of Aerospace NESHAP VOC Emission Standards Applicable to the New and Modified Emission Units of the 777X Project

Production Activity	Control Technology
Low-VOC primers	Large commercial aircraft component exteriors: 5.4 lb VOC/gal All other applications: 2.9 lb VOC/gal
Low-VOC topcoats	3.5 lb VOC/gal
Low-VOC cleaning solvents	Hand wipe cleaning solvent: vapor pressure less than 45 millimeters mercury (mm Hg) at 20°C or solvent meets

Table 23. Summary of Aerospace NESHAP VOC Emission Standards Applicable to the New and Modified Emission Units of the 777X Project	
Production Activity	**Control Technology**
	composition requirements in Table 1 in 40 CFR 63.744. Flush cleaning: use collection system to capture flushed solvent.
High-transfer-efficiency spray coating equipment	HVLP, electrostatic, or other equivalent spray coating equipment
Paint gun cleaning, waste solvents, and rags	Capture and closed containment

4.3. BACT for Natural Gas Combustion

Manufacturing of the new Boeing Model 777X will require Boeing Everett to install new natural gas combustion units. These units include process heaters, space heaters, and a gas-fired plasma unit for surface treatment of the wing panel stringers. These new natural gas combustion emission units are listed in Table 24. With the exception of the natural gas combustion units associated with the vertical fin hybrid laminar flow control (HLFC) prep (WBSP 10) and HLFC spray booths (WBSP 11 a, b, and c), all the units identified in Table 24 will be located in the new wing component fabrication building.

These natural gas-fired combustion units will emit NO_X, PM_{10}, $PM_{2.5}$, CO, SO_2, and VOCs. Natural gas-fired boilers and heaters less than 50 MMBtu/hr generally fall into the category of generic BACT and not case-by-case BACT. The following section presents the generic BACT analysis for VOC from natural gas combustion units.

10–50 MMBtu/hr

Table 24. Proposed Natural Gas Combustion Units		
Unit ID	**Description**	**Rated Capacity (MMBtu/hr)**
WCF-3a	Gas-fired process heater for autoclave #1	40
WCF-3b	Gas-fired process heater for autoclave #2	40
WCF-3c	Gas-fired process heater for autoclave #3	40
WCF-9a	Space heating - wing panel spray booth #1	13.34
WCF-9b	Space heating - wing panel spray booth #2	13.34
WCF-9d	Space heating – wing panel spray booth #3	13.34
WBSP-11a	Space heating - vertical fin HLFC spray booth #1	10.94
WBSP-11b	Space heating - vertical fin HLFC spray booth #2	10.94
WBSP-11c	Space heating - vertical fin HLFC spray booth #3	10.94

5– 10 MMBtu/hr

Unit ID	Description	Rated Capacity (MMBtu/hr)
F-1	Combustion equipment for comfort or process heating not otherwise identified elsewhere in this table; multiple units, most of which will be less than 5 MMBtu/hr, and all of which will be less than 10 MMBtu/hr	Range: < 10 MMBtu/hr to < 5 MMBtu/hr
WCF-2	Gas-fired heater for liquid nitrogen vaporization unit (if this option is chosen to supply autoclaves with nitrogen	8
WCF-10a	Space heating - wing panel primer curing booth #1	6.67
WCF-10b	Space heating - wing panel primer curing booth #2	6.67

2–5 MMBtu/hr

Unit ID	Description	Rated Capacity (MMBtu/hr)
WBSP-10	Space heating - vertical fin HLFC prep booth	3.69
WCF-9c	Space heating - wing spar spray booth	3.2
WCF-9e	Space heating - wing spar spray booth	3.2
WCF-8a	Space heating - wing panel prep booth	2.22
WCF-14	Space heating - wing spar seal booth	2.9

<2 MMBtu/hr

Unit ID	Description	Rated Capacity (MMBtu/hr)
WCF-7	Gas-fired plasma unit for treatment of wing panel stringer	1.6
WCF-10c	Space heating - wing spar primer curing booth	1.6
WCF-6a	Space heating - wing panel wash stall #1	1.11
WCF-6b	Space heating - wing panel wash stall #2	1.11
WCF-8b	Space heating - wing spar prep booth	0.534
WCF-6c	Space heating - wing spar and stringer wash stall #1	0.267
WCF-6d	Space heating - wing spar and stringer wash stall #2	0.267

4.3.1. Available Control Technologies

BACT databases from EPA (EPA, RBLC), CARB, and SCAQMD were reviewed for possible VOC control technologies that are both available on the market and proven in practice for similar sized natural gas boilers and heaters. The review determined that no add-on controls were listed as BACT for similar-sized natural gas process heaters, space heaters, or plasma surface treatment units.

Acceptable control technologies included good combustion practices. Good combustion practices require operating the combustion unit in a manner to reduce incomplete combustion. Through the reduction of incomplete combustion, VOC emissions can be reduced. Good combustion practices are technically feasible to control VOC emissions from the natural gas combustion units.

Boeing will be required to implement the technically feasible control technologies of good combustion practices. In addition, Boeing may choose to limit fuel usage on some or all of the new combustion devices, but that will be due to establishing emission limits for the process and not due to BACT considerations. Thus, further discussion of economic, environmental, and energy impacts are not necessary.

4.3.2. BACT Selection

Review of BACT databases and industry standards determined that the only technically feasible VOC control methods identified for natural gas combustion units less than 50 MMBtu/hr are good combustion practices. Boeing will implement the identified technically feasible control option of good combustion practices as BACT for VOC emissions from combustion units less than 50 MMBtu/hr.

4.4. BACT for Emergency Generators

The 777X project will need as many as nine 2,750-kW diesel emergency generators, and up to two 750-kW diesel emergency generator for the wing component fabrication building. These diesel- fired emergency generators will emit NO_X, PM_{10}, $PM_{2.5}$, CO, SO_2, and VOCs.

4.4.1. Available Control Technologies

The emission standards and operating limits of the emergency generators in the size range that Boeing will use for the wing component fabrication building are contained in 40 CFR 60 New Source Performance Standards, Subpart IIII, Standards of Performance for Stationary Compression Ignition Internal Combustion Engines and are considered to be BACT. The emission standards are provided in Sections 60.4202 and 60.4205. These standards require emergency diesel engines of the size for the 777X project to comply with the Tier 2 emission standards in 40 CFR 89.112, which are 6.4 g/kWh for VOC and NO_X combined, 3.5 g/kWh for CO, and 0.20 g/kWh for particulate. The operating requirements for emergency stationary internal combustion engines are provided in 40 CFR 60.4205, which generally limit non-emergency use to 100 hours per year (hr/yr). Boeing assumed in their permit application that each engine will operate 100 hr/yr. Boeing's engines will each be limited in the permit to 100 hr/yr of operation in non-emergency situations.

BACT for emergency generators is the emission standards and operating conditions established in 40 CFR 60 Subpart IIII.

4.4.2. BACT Selection

Boeing will implement the emission standards and operating conditions established in 40 CFR 60 Subpart IIII. Therefore, further review of economic, environmental, and energy impacts are unnecessary.

4.5. BACT for Wing Composite Layup and Curing

The wings of the 777X will be primarily made of composite material. The composite material is in the form of resin pre-impregnated tape or sheets. The main wing components include front and rear spars, upper and lower panel stringers, and upper and lower panels. Part layup involves the layup of composite material onto a mandrel which is preformed into the shape of the part being fabricated. Once the part is laid up on the mandrel, a vacuum bag is sealed around the part and the assembly is then sent to an autoclave for curing. In the autoclave, vacuum from a vacuum pump is used to hold the bagged part under negative pressure while the autoclave is pressurized with nitrogen and heated to the curing temperature of up to about 350°F. The part is then held under negative pressure for the entire curing cycle, approximately 12 to 14 hours. Emissions during the curing cycle are offgases from the composite material and combustion emissions from the indirect gas-fired heater that is used to heat the nitrogen in the autoclave. The offgases travel through the vacuum system and are exhausted by the vacuum pump (emission unit WCF-4). Boeing is planning for as many as three autoclaves and six vacuum pumps.

VOC emissions from the vacuum pumps are estimated at 1.2 tpy per pump (7.2 tpy total), and were calculated based on the volatile content of the uncured composite material. This VOC emission estimate is conservative because a portion of the volatiles in the uncured material may be water that is released from the material during curing. The estimated air flow from each of the vacuum pumps is 100 dry standard cubic feet per minute (dscfm). This estimated air flow is consistent with the measured flow rate taken during a source test conducted on a similar vacuum pump used in a similar process at Boeing's Frederickson facility in 2013 for an EPA Section 114 Emission Data Request.

The air flow from the vacuum pumps is not constant, and the emission concentrations are not consistent. At any time, one vacuum pump or six vacuum pumps may be operating depending on the number of parts being laid up and cured. Emission estimates are based on VOCs (and potentially non-VOCs like water) lost from the material during the entire layup and curing process, but emissions may be higher at certain times during the process than others. The estimated emission concentrations are low (approximately 7.5 x 10^{-5} lb VOC/dscf, or less than 0.05 percent, on average) with the balance of the emissions being ambient air.

4.5.1. Available Control Technologies

Composite processing, except for some cleaning, coating, and composite tooling operations, is not covered under 40 CFR 63, Subpart GG. BACT databases from EPA (EPA, RBLC), CARB, and SCAQMD were reviewed for possible control technologies that are both available on the market and proven in practice in the aerospace or other industries that manufacture items from composite molds. The search provided one determination for the production of structural honeycomb for aerospace and other industrial applications by Hexcel Corporation (Hexcel). The search also provided two determinations since the year 2000 for polyester resin operations, Lasco Bathware and Jacuzzi Whirlpool Bath. The database provided very little information about the Hexcel operation or the type of composite material used in the process. The bathtub manufacturing facilities use a liquid polyester thermosetting resin that contains styrene monomer.

The wing components will be made of a material containing an epoxy resin rather than a polyester resin, and the resin is pre-impregnated into a woven fabric (prepreg). The composition and emission characteristics of the prepreg woven fabric emissions are significantly different than polyester resin emissions. Boeing also looked at carbon adsorption, which is a typical control technology for VOC emissions from a process with a stack. The potential control technologies are presented in Table 25.

Table 25. Potential Control Technologies for VOCs for Composite Layup and Curing

Control Technology	Database Reference	Date Implemented	Control Efficiency	Emission Limit
Thermal oxidizer or RTO	EPA, BACT Clearinghouse – Hexcel	11/25/2009	95%	
Regenerative thermal oxidizer w/concentrator	EPA, BACT Clearinghouse – Lasco Bathware	3/13/2007	95%	14.84 lb/hr
RTO w/concentrator	CARB, BACT Clearinghouse – Jacuzzi Whirlpool Bath	10/15/2002	90%	
Carbon adsorption	Often used for control of VOC emissions	NA	>95%	

4.5.2. BACT Feasibility Review

Currently, there is no control technology demonstrated in practice for the composite processing vacuum pumps. The only information provided for the Hexcel process were the emissions from an oven used for the curing of honeycomb blocks and the main hazardous air pollutant (HAP) of concern was acetaldehyde. Acetaldehyde may be present in the prepreg material Boeing uses, but it is not a significant component of the material. There was no information provided in the BACT determination about the type of materials used in the Hexcel process, the airflow rate, or the emission rates from the operation. Based on this information, it could not be determined whether the Hexcel process was similar to Boeing's process.

4.5.3. RTO with Concentrator

The bathtub manufacturing facilities use a polyester thermosetting resin that contains styrene monomer to manufacture bathtubs. The Lasco Bathware process has an average throughput of raw materials of 0.645 ton per hour, which includes gelcoat, laminate, and barrier coat, all of which contain styrene monomer in a liquid state. The raw materials are sprayed into open molds in a spray booth. There was no emission rate information provided for Jacuzzi Whirlpool Bath.

The VOCs released from the process are drawn into a concentrator, which captures the VOCs by adsorption. Hot gas desorbs the VOCs, which are then fed to the thermal oxidizer for incineration. The overall efficiency for capture and control is estimated to be 90 to 95 percent.

Boeing's composite process will use a prepreg containing an epoxy resin rather than a coating containing a polyester resin. The resin comes pre-impregnated into a woven material and is not in a liquid state. The vacuum pump flow rate and concentration of VOCs in the air stream are significantly lower than for the spray booths at Lasco Bathware. This assumption is based on the emission limit of 14.8 lb/hr with a control of 95 percent listed in the determination. This should be compared to the maximum expected uncontrolled emission rate of less than one pound per hour for each vacuum pump. In addition, combination concentrators or carbon adsorbers and thermal oxidizers are intended for sources with high air flow and a high enough VOC emission rate to make thermal oxidation viable. The autoclave process does not meet either of these criteria. Individually, combustion of the VOC emissions and carbon adsorption has additional issues which are discussed below.

4.5.4. Thermal Incineration

Hexcel uses a thermal oxidizer or regenerative thermal oxidizer to combust the VOC emissions from the process. When using combustion units for VOC control, the VOC emissions in an air stream are injected into a burner or chamber that destroys those emissions prior to release to the atmosphere through a stack.

The air flows from the vacuum pumps are not constant and the emission concentrations are not consistent. At any time, one vacuum pump or six vacuum pumps may be operating, depending on the number of parts to be laid up and cured. Emission estimates are based on VOCs lost from the material during the entire layup and curing process, but emissions may be higher at certain times during the process than others. The VOC concentrations in the air stream exhausted by the vacuum pump are also very low, about 7.5 x 10^{-5} lb VOC/dscf on average, with the balance of the emissions being ambient air. Even without knowing the exact heat content of the VOCs, it is evident that the concentration of the VOCs in the offgas is low, less than 0.05 percent. Therefore, the heat content of the offgas will be low. The combination of variable operation, variable flow rates and low heat content for the offgases make destruction of the offgases in a combustion device infeasible.

4.5.5. Carbon Adsorption

Carbon adsorption uses a filter bank of canisters that contain activated carbon, which adsorbs the VOC emissions from the air stream as it passes through the carbon before being released to the atmosphere. Carbon adsorption has not been used in practice on any aerospace composite layup and curing operation. However, carbon adsorption has been used on other low flow, low-VOC sources, and is a feasible option for offgases with the characteristics described above.

4.5.6. Ranking of BACT by Control

Carbon adsorption is the only add-on option that is feasible. A well designed and operated carbon adsorption system can consistently demonstrate VOC removal efficiencies over 95 percent.

4.5.7. Cost-Effectiveness Evaluation

Vendor information for the carbon adsorption technology was obtained from Thermal Recovery Systems. Based on Boeing’s situation, potential contaminants and their concentration, the temperature of the emission, and the high humidity (3 percent by volume), Thermal Recovery Systems thought that between 5 and 10 percent weight capacity for the activated carbon would be required. If 8 percent was used as the target, it was believed it would take 90 tons of carbon to control 7.2 tpy of emissions. The cost in carbon alone would be over $225,000 per year, or over $31,000 per ton operating costs. Based on this cost, Ecology agrees with Boeing that carbon adsorption is not cost-effective.

4.6. BACT for Crush Core Press

In a crush core press, a composite “sandwich” layup consisting of a lightweight honeycomb core material sandwiched between sheets of resin pre-impregnated woven fabric (prepreg) is placed between heated matched dies and then the press is used to apply pressure to the dies until the resin in the prepreg sheets cures and hardens (emission unit IRC-3). At the Boeing Everett IRC, crushed core presses are used to fabricate all Boeing airplane models’ cabin interior panels, which are ceilings and sidewalls. Most of the emissions from the crushed core press come from the mold release agent that is applied to the surface of the matched dies. Some VOCs are also released by the curing prepreg.

Emissions from the crush core press were calculated based on the VOC content of the mold release and prepreg, and the estimated volume of those materials to be used over a year. The estimated volume of materials to be used in the new crush core press was based on the volume of materials used in the existing crush core presses at Boeing Everett, and includes a safety factor of three to ensure that the potential VOC emissions from the press were not under estimated. For the prepreg, the estimated VOC emissions are conservative since it is assumed all the volatiles released from the curing prepreg are VOCs, whereas a significant portion of the volatiles may be water. The estimated air flow from the crush core press operation is 7,500 cfm. The total VOC emission from the unit is 4,500 lb/yr or 2.25 tpy.

4.6.1. Available Control Technologies

Composite processing, except for some cleaning, coating, and composite tooling operations, is not covered under the Aerospace NESHAP (40 CFR 63, Subpart GG). BACT databases from EPA (EPA, RBLC), CARB, and SCAQMD were reviewed for possible control technologies that are both available on the market and proven in practice in the aerospace or other industries that manufacture items from composite molds. There were no determinations found for a crush core press operation. The search provided one determination for the production of structural honeycomb for aerospace and other industrial applications by Hexcel. The database provided very little information about the Hexcel operation or the type of composite material used in the process.

The crush core press process is similar to the composite layup and curing operation in that it uses resin pre-impregnated fabric, but the prepreg used in the crush core process contains a phenolic resin rather than an epoxy resin. However, an estimated 90 percent of the emissions come from the use of the mold release compounds. Since there were no control technologies for aerospace crush core press emissions in the databases, Boeing also looked at typical control technologies for VOC emissions from a process with a stack. The potential control technologies are presented in Table 26.

Table 26. Potential Control Technologies for VOCs for Crush Core Press

Control Technology	Database Reference	Date Implemented	Control Efficiency
Thermal oxidizer or regenerative thermal oxidizer	EPA, BACT Clearinghouse – Hexcel	11/25/2009	95%
Regenerative thermal oxidizer w/concentrator	Often used for control of VOC emissions	N/A	>90%
Carbon adsorption	Often used for control of VOC emissions	N/A	>95%

4.6.2. BACT Feasibility Review

Currently, no control technologies have been found in practice for the crush core press operation. It could not be determined if the Hexcel process was applicable because the only information provided for the Hexcel process was that the emissions were from an oven used for the curing of honeycomb blocks and the main HAP of concern was acetaldehyde. Acetaldehyde may be present in the emissions from the press, but is not a significant component of the prepreg material and should not be present in the mold release agent. There was no information provided in the BACT determination about the type of materials used in the Hexcel process, the airflow rate, or the emissions from the operation. Based on this information, it could not be determined whether the Hexcel process was similar to Boeing's process.

4.6.3. RTO with Concentrator

The VOCs released from the process are drawn into a concentrator, which captures VOCs by adsorption. Hot gas desorbs the VOCs, which are then fed to the thermal oxidizer for incineration. The overall efficiency for capture and control is estimated to be 90 to 95 percent.

Combination concentrators or carbon adsorbers and thermal oxidizers are intended for sources with high air flow and a high enough VOC emission rate (lb/hr) to make thermal oxidation viable. The emission rate needs to be high enough to produce a moderately concentrated emission from the outlet of the concentrator. The crush core press flow rate and emission rate do not meet either of these criteria. Individually, combustion of the VOC emissions and carbon adsorption has additional issues which are discussed below.

4.6.4. Thermal Incineration

Hexcel uses a thermal oxidizer or regenerative thermal oxidizer to combust the VOC emissions from the process. When using combustion units for VOC control, the VOC emissions in an air stream are injected into a burner or chamber that destroys those emissions prior to release to the atmosphere through a stack.

The emission concentrations in the exhaust from the crush core press are low, approximately 8×10^{-8} lb VOC/dscf on average, with the balance of the emissions being ambient air. Even without knowing the exact heat content of the VOCs, it is evident that the concentration of VOCs in the offgas are low, and therefore the heat content of the offgas will be low. In addition, the concentration of the VOCs in the offgas is very low, conservatively as much as 15 parts per million (ppm), but more likely near 7 ppm. Thermal oxidizers have demonstrated poor destruction efficiencies when the inlet concentrations are very low. The Bay Area BACT guidelines for an oxidizer or adsorber are typically:

- Less than 10 ppm at outlet; or
- Greater than 98.5 percent destruction/recovery efficiency if inlet VOCs are greater than 200 to less than 2,000 ppm; or

- Greater than 97 percent efficiency if inlet VOCs are greater than 200 to less than 2,000 ppm; or
- Greater than 90 percent efficiency if inlet VOCs are less than 200 ppm.

Some EPA standards allow up to 20 ppm at the outlet. The uncontrolled emission concentration for the crush core press is actually lower than the Bay Area BACT guidelines typical emission limit.

The low heat content for the offgases and low concentration of VOCs make destruction of the offgases in a combustion device not a feasible option.

4.6.5. Carbon Adsorption

Carbon adsorption uses a filter bank of canisters that contain activated carbon, which adsorbs the VOC emissions from the air stream as it passes through the carbon before being released to the atmosphere. Carbon adsorption has not been used in practice on any aerospace crush core press operation. However, carbon adsorption has been used on other low-flow, low-VOC sources.

4.6.6. Ranking of BACT by Control

Carbon adsorption is the only option that is feasible. A well designed and operated carbon adsorption system can consistently demonstrate VOC removal efficiencies over 95 percent.

4.6.7. Cost-Effectiveness Evaluation

Vendor information for carbon adsorption technology on the vacuum pumps for the composite layup and curing process was obtained from Thermal Recovery Systems. Thermal Recovery Systems informed Boeing that based on the potential contaminants listed and their concentrations, the temperature of the emission, and the high humidity (3 percent by volume), they would expect between 5 and 10 percent weight capacity for the activated carbon. If they used 8 percent as their target, they believe it would take 90 tons of carbon to control 7.2 tpy of emissions. The cost in carbon would be over $225,000 per year, or over $31,000 per ton operating costs. This does not include capital cost or labor cost.

The crush core press emission concentration of 8×10^{-8} lb VOC/dscf is significantly lower, and the air flow is significantly higher at 7,500 cfm than the emissions from the autoclave vacuum pumps (7.5×10^{-5} lb VOC/dscf and air flow of 100 to 600 cfm). Because one of the mechanisms in the adsorption of compounds on carbon is the concentration gradient, or the difference between the concentration of the VOCs in the offgas and the concentration of the compound in the carbon, lower concentrations tend to have a negative effect on the weight capacity of the carbon. Increases in air flow may also lead to a decrease in the weight capacity of the carbon. Based on the $31,000 per ton operating cost for carbon on the composite layup and curing vacuum pumps, and the expected even lower weight capacity and potential increase in operating cost for the crush core process, Boeing concluded that carbon adsorption is not cost-effective.

Ecology agrees with this assessment. In addition, the inlet concentration is less than the Bay Area BACT typical emission limit of 10 ppm VOC.

4.6.8. BACT Selection

Because no control technologies have been demonstrated to be effective in practice on a crush core press, and a cost estimate for just the carbon needed for a carbon adsorption system exceeds $31,000 per ton of VOC removed, Boeing does not consider any of the identified add-on control technologies in Table 26 to be technically or economically feasible for Boeing Everett. Ecology agrees with this conclusion. Boeing will continue to implement the use of low-VOC emitting prepreg materials to minimize VOC emissions from the process.

4.7. BACT for Open Floor Emissions

Open floor emissions are also known as fugitive emissions, and are typically emissions that result from hand application of cleaners, sealants, and coatings that are not done in a confined area such as a paint booth. These activities occur throughout the manufacturing process and in very large buildings. The emissions exit the buildings via various openings (e.g., hangar doors, roll-up doors, vents, and general building air handling systems). The VOC emissions result from the VOCs in the various solvents or coatings. This BACT analysis considers those technologies that reduce fugitive VOC emissions from the open floor activities that will take place in the new wing component fabrication process. Open floor activities that will take place as part of wing assembly, body section assembly, airplane assembly, and other related operations are not addressed here because these operations will take place in existing buildings where these open floor activities already occur.

4.7.1. Wing Component Fabrication

The wings of the 777X will be primarily made of composite material. The main wing components include front and rear spars, upper and lower panel stringers, and upper and lower panels. The manufacturing process of each of these parts is similar and involves the following major steps:

- Wing component part layup
- Curing in an autoclave
- Trimming and drilling
- Washing
- Non-destructive inspection
- Preparation for priming (e.g., abrading, solvent cleaning)
- Priming
- Wing component part build-up

Fugitive VOC emissions can be generated by the following activities.

Part layup: Part layup involves the manual or automated layup of composite material (in the form of resin pre-impregnated tape or sheets) onto a mandrel which is preformed into the shape of the part being fabricated. Emissions associated with the part layup primarily occur from preparing the mandrel prior to the actual part layup process. Preparing the mandrel involves cleaning the surface with solvent, applying a mold release compound, and applying a tackifier solution.

Wing component cleaning: Open floor emissions from wipe cleaning primarily occur during the part buildup process, but can occur throughout the manufacturing process.

Sealing and touch up coating: Open floor emissions from the application of sealant and miscellaneous coatings will primarily occur during the part buildup process, but can occur throughout the manufacturing process. Most of the coating of the wing components will take place in the spray booths and will not result in open floor emissions.

Open floor VOC emissions from the wing component fabrication building are estimated to be 128 tpy.

4.7.2. Available Control Technologies

The open floor activities listed above are addressed and regulated under 40 CFR 63, Subpart GG, Aerospace NESHAP. In addition, the VOC emission standards for uncontrolled use of cleaning solvents and coatings are defined in 40 CFR 63, Subpart GG, Aerospace NESHAP. These requirements will be applied to these activities. Because of the nature of these open floor activities and the fugitive emissions generated by the activities (e.g., numerous locations, low VOC concentrations, and low emission rates), and the fact that they may occur anywhere in the manufacturing process, capture and control of the fugitive emissions is not feasible. This conclusion is supported by the fact that in developing the Aerospace NESHAP, EPA has determined that work practices rather than emission standards are the only practical way to regulate these open floor emissions.

Boeing uses good work practices (Table 27) to minimize VOC emissions, including storing coatings and solvents in closed containers and bagging solvent hand wipe cleaning rags when not in use. The Aerospace NESHAP regulation requires low-VOC cleaners and coatings, and these work practices. Therefore, these techniques are considered the base case for BACT.

Table 27. Summary of Aerospace NESHAP VOC Emission Standards Applicable to the New and Modified Emission Units of the 777X Project

Production Activity	Control Technology
Low-VOC primers	Large commercial aircraft component exteriors: 5.4 lb VOC/gal. All other applications: 2.9 lb VOC/gal
Low-VOC topcoats	3.5 lb VOC/gal
Low-VOC cleaning solvents	Hand wipe cleaning solvent: vapor pressure less than 45 mm Hg at 20°C or solvent meets composition requirements in Table 1 in 40 CFR 63.744.

Table 27. Summary of Aerospace NESHAP VOC Emission Standards Applicable to the New and Modified Emission Units of the 777X Project	
Production Activity	**Control Technology**
	Flush cleaning: use collection system to capture flushed solvent.
High-transfer-efficiency spray coating equipment	HVLP, electrostatic, or other equivalent spray coating equipment
Paint gun cleaning, waste solvents, and rags	Capture and closed containment

4.7.3. BACT Feasibility Review

The use of low-VOC cleaners and coatings, and good work practices in compliance with the 40 CFR 63, Subpart GG, Aerospace NESHAP requirements have been demonstrated and achieved in practice and are therefore considered feasible technologies to implement for the open floor activities in the new wing component fabrication building. Boeing believes this is the base case for BACT, and uses these techniques for its current operations.

Boeing will implement all of the base case BACT techniques. Thus, further review of economic environmental and energy impacts is unnecessary.

4.7.4. BACT Selection

Boeing will continue to implement the use of low-VOC coatings and cleaners, and good work practices to minimize fugitive VOC emissions in compliance with the 40 CFR 63, Subpart GG, Aerospace NESHAP.

Based on this information, Ecology believes the proposed limits meet BACT requirements.

4.8. Toxic Air Pollutants

PSD rules require the applicant to consider emissions of TAPs during the course of a BACT analysis, but specifically exempt all pollutants subject to regulation under Section 112 of the federal Clean Air Act from regulation under the PSD program.

The emissions of TAPs will be covered in the PSCAA NOC approval for this project.

5. AMBIENT AIR QUALITY IMPACTS ANALYSIS

5.1. Regulatory Requirements

For PSD, an ambient Air Quality Impacts Analysis (AQIA) is required for all pollutants that are emitted in significant quantities to determine the ambient impacts associated with the construction and operation of the proposed modifications. The main purpose of the air quality analysis is to demonstrate that new emissions emitted from the proposed major stationary source or major modification will not cause or contribute to a violation of any applicable NAAQS or PSD increment.

The AQIA starts with preliminary modeling for each pollutant to determine whether an applicant can forego detailed analysis and preconstruction monitoring. If the projected ambient concentration increase for a given pollutant is below the PSD Significant Impact Levels (SILs) and Significant Monitoring Concentration (SMCs) for each averaging period, no further analysis of the ambient impact is required for that pollutant.

For those pollutants with averaging periods that have impacts greater than the SIL, a full impact analysis is used to demonstrate compliance with NAAQS and PSD increments.

Typically, the AQIA includes an analysis of impacts to local areas that are within 50 kilometers (km) of the project, and a regional air quality impact assessment for impacts beyond 50 km. For projects in Washington State, this latter analysis usually includes impacts on Class I areas.

5.2. Impacts on Class I Areas

Because the proposed emission increase in VOCs from the Boeing Everett 777X project would exceed 100 tpy, there must be a demonstration that the project would not cause or significantly contribute to a violation of the ozone NAAQS. Furthermore, PSD rules require an analysis of air quality related values (AQRVs) on federally designated Class I areas. Federally mandated Class I areas are defined in the Clean Air Act as having special national or regional value from a natural, scenic, recreational, or historic perspective. Class I areas include national parks over 6,000 acres and wilderness areas and memorial parks over 5,000 acres as of 1977. The impacts to these areas are stringently regulated because they have remained relatively untouched by development. Therefore, in addition to tighter PSD increment standards for criteria air pollutants, additional analyses of air quality impacts on Class I areas are required. Class I areas within 200 km of the Boeing Everett facility are listed in Table 28.

Table 28. Class I Areas within 200 KM of the Boeing Everett Facility

Area	Distance from Boeing Everett to Class 1 Area (km)	VOC Emissions Increase (Qty.) Divided by Distance (Q/D) (tons VOC/km)	Allowable VOC Emissions Increase (Qty.) Divided by Distance (Q/D) (tons VOC/km)
Alpine Lakes Wilderness Area	60	6.9	5.7
Glacier Peak Wilderness Area	70	5.9	4.9
Mount Baker Recreation Area	90	4.6	3.8
Olympic National Park	91	4.6	3.7
North Cascades National Park	108	3.9	3.2
Mount Rainier National Park	123	3.4	2.8
Goat Rocks Wilderness Area	205	2.0	1.7

AQRVs include impacts on visibility, soil, flora, fauna, and aquatic resources within the Class I area. The Federal Land Managers' (FLMs) guidance on evaluating impacts of major projects on Class I areas is the *Federal Land Managers' Air Quality Related Values Work Group (FLAG) Phase I Report – revised* (2010) (National Park Service, 2010). In FLAG, the FLMs have developed a tool to screen out projects that would not have a significant impact on AQRVs based on annual emissions and distance from a Class I area. This screening tool is called the Q/D Method, which is to divide the amount of emission increases in tons per year (Q) by the distance to a federal Class I area in km (D). FLAG states that "The FLM role within the regulatory context consists of considering whether emissions from a new source, or emission increases from a modified source, may have an adverse impact on AQRVs and providing comments to permitting authorities (States or EPA). Therefore, the agencies will consider a source locating greater than 50 km from a Class I area to have negligible impacts with respect to Class I AQRVs if its total SO_2, NO_X, PM_{10}, and H_2SO_4 (sulfuric acid) annual emissions (in tons per year, based on 24-hour maximum allowable emissions), divided by the distance (in km) from the Class I area (Q/D) is 10 or less. The agencies would not request any further Class I AQRV impact analyses from such sources." For the 777X project, the only pollutant that would have a significant increase is VOC. VOC is not among the pollutants that the FLMs recommend including in the calculation of Q. While VOCs and NO_X are recognized as precursors to the formation of ground level ozone, which is regulated as a criteria pollutant, the FLAG guidance states that "current information indicates most FLM areas are NO_X limited" with respect to the formation of ground level ozone. A NO_X limited region is one where the concentration of ozone depends on the amount of NO_X in the atmosphere. This occurs when there is a lack of Nitrogen Dioxides, thus inhibiting ozone titration when oxygen mixes with VOCs. In these regions, controlling NO_X would reduce ozone concentrations. A VOCs limited region is one where concentration of ozone depends on the amount of VOCs in the atmosphere. In these regions, controlling VOCs would reduce ozone concentrations. The FLAG guidance further states that "until there is enough information available for FLAG to determine whether ozone formation in each FLM area is primarily limited by NO_X or VOC emissions, we will assume all FLM areas are NO_X limited and will focus on control of NO_X emissions" (FLAG Executive Summary and Section 3.4.5). Because there has not been a demonstration that ozone formation in the Puget Sound region's Class I areas is not NO_X-limited and VOC is the only pollutant that is expected to have a significant increase as a result of the 777X project, there is no need to perform the Q/D analysis and it is presumed that the 777X project will have no significant adverse impacts on Class I areas.[3]

[3] Nonetheless, for informational purposes the 777X project's Q/D for all Class I areas within 200 km are shown in column 3 of Table 28 where Q is that annual emission rate of VOC. As shown in column 3 of Table 28, the ratio of Q/D would be less than 10 for all the Class I areas and, according to the FLAG guidance, it could be presumed that the project would have no significant adverse impacts on Class I areas. Table 28 also shows that the combined proposed increases in the annual VOC emissions limits in the existing PSD permits 91-06, 05-02, and 11-01, would also result in Q/D being less than 10.

5.3. Ozone Impacts

VOCs are a precursor to ozone. Boeing's proposed increase in VOC emissions is greater than 100 tpy and therefore requires an analysis of the effect that the proposed increase in emissions of VOCs would have on the area's ozone levels. The analysis of the 777X project is discussed below.

EPA has set primary and secondary ozone standards to protect human health and welfare. On March 12, 2008, EPA revised the primary and secondary ozone standards to 0.075 ppm for an 8-hour average.

Ozone is formed in the troposphere when sunlight causes complex photochemical reactions involving oxides of nitrogen (NO_X), VOCs, and carbon monoxide (CO) that originate chiefly form gasoline engines and burning of other fossil fuels. Woody vegetation is another major source of VOC emissions to NO_X emissions within the surrounding airshed, and the relative reactivities of the VOC species. NO_X and VOCs can be transported long distances by regional weather patterns before they react to create ozone in the atmosphere, where it can persist for several weeks. Because ozone is a regional pollutant, precursor sources both near and far can contribute to ozone formation.

Breathing ozone can trigger a variety of health problems for humans, including chest pain, coughing, throat irritation, and congestion. It can worsen bronchitis, emphysema, and asthma. Elevated levels of ozone can also reduce lung function by inflaming the linings of the lungs. Repeated exposure to elevated concentrations of ozone may permanently scar lung tissue. Ozone is also phytotoxic, causing damage to a variety of vegetation (Ashmore et al., 2004). Ozone pollution has been shown to reduce plant growth, alter species composition, and predispose trees to insect and disease attack. Ozone also causes direct foliar injury to some plant species. Ozone affected leaves are marked with discoloration and lesions, and they age more rapidly than normal leaves (EPA, 2007).

Ozone enters plants through leaf stomata, causing changes in biochemical and physiological process. The mesophyll cells under the upper epidermis of leaves are the most sensitive to ozone, and those are the first cells to die. The adjacent epidermal cells then die, forming a small black or brown interveinal necrotic lesion that becomes visible on the upper surface of the leaf. These lesions, termed oxidant stipple, are quite specific indicators that the plant has been exposed to ozone. There are other plant symptoms that can result from exposure to ozone. However, these symptoms are non-specific for ozone since other stressors can also cause them to occur. In general, the most reliable indicator that ozone has impacted vegetation is oxidant stipple.

In addition to effecting individual plants, ozone can also affect entire ecosystems. Plants growing in areas with high exposure to ambient ozone may undergo natural selection for ozone tolerance (EPA, 2007). The final result could be the elimination of the most ozone sensitive genotypes from the area (National Park Service, 2010).

In the Class I areas closest to Boeing Everett, several species are known to be sensitive to ozone, including quaking aspen (*Populus tremuloides*), spreading dogbane (*Apocynum androsaemifolium*), subalpine fir (*Abies lasiocarpa*), black cottonwood (*Populus trichocarpa*), and ponderosa pine (*Pinus ponderosa*) (Brace et al., 1998). These sensitive species have been systematically evaluated and no ozone injury has been documented in the parks.

In a previous PSD permit application for the 787 project (PSD 05-02), Boeing reported that 297 tpy of VOC emissions would not cause or significantly contribute to an exceedance of any NAAQS or PSD increment. The study reported a projected maximum increase in ozone concentration of about 0.1 parts per billion (ppb) from a 297 tpy increase in VOC emissions. This is a small fraction of the national ambient air quality standard for ozone of 75 ppb for an 8-hour average. Similarly, for the 737 MAX project in Renton (PSD 12-01), Boeing noted that a 384 tpy increase from Boeing's Renton facility would not cause or significantly contribute to an exceedance of any NAAQS or PSD increment and in the worst case would only increase the maximum ozone concentration by less than 0.35 ppb. As shown in Table 7, Boeing is proposing to increase Boeing Everett's allowed VOC emissions by 308.2 tpy. This is within the range that Ecology previously reviewed and determined will not have a significant adverse impact on air quality. Therefore, an additional air quality impact analysis addressing the impact of VOC emissions from the 777X project is not required.

6. ADDITIONAL IMPACTS ANALYSIS

6.1. Air Quality Related Values (AQRV)

PSD regulations and guidance require an evaluation of the effects of the 777X project's emissions on visibility, local soils, and vegetation in Class I and II areas, the effect of increased air pollutant concentrations on flora and fauna in the Class I areas, and the effect of the project on construction and population growth in the area surrounding the project. The analyses assess increment consumption and impacts on AQRVs in Class I areas. AQRVs include regional visibility or haze, the effects of primary and secondary pollutants on sensitive plants, the effects of pollutant deposition on soils and receiving water bodies, and other effects associated with secondary aerosol formation. The FLMs for the National Park Service, U.S. Fish and Wildlife Service, and U.S. Forest Service have the responsibility of ensuring AQRVs in the Class I areas are not adversely affected.

PSD regulations and guidance require additional impact analyses to evaluate the effects of the project's emissions on visibility, local soils, and vegetation in Class I and II areas, and the effect of increased air pollutant concentrations on flora and fauna in the Class I areas. The additional impact analyses are also used to evaluate the effect of the project on growth in the area surrounding the project.

6.2. Growth Analysis

6.2.1. Construction and Growth Impacts

Employment at Boeing Everett is expected to increase by no more than 3,000 employees as a result of the 777X project. This growth is less than 10 percent of the potential 45,000 employees at the Boeing Everett facility that were added in the Southwest Everett EIS and Planned Action (City of Everett, 1997). Additionally, there will not be a significant increase in congestion on Washington's roads and highways as a result of the project. The details of the congestion discussion may be found in SEPA Addendum #1 (Revised) Southwest Everett Planned Action EIS SEPA #13-019 in Appendix E of that document. Therefore, the proposed 777X project is not expected to cause adverse construction and growth related impacts.

6.3. Soils and Vegetation Analysis

EPA guidance[4] for most types of soils and vegetation, ambient concentrations of criteria pollutants below the secondary NAAQS will not result in harmful effects. Only the VOC emissions from the 777X project are subject to PSD review. VOC is regulated as a precursor to ozone. However, ozone has no secondary NAAQS. In addition, the expected VOC emissions from the 777X project do not trigger a detailed AQIA for Class I area. The incremental increase in ozone concentrations directly attributable to the 777X project would be less than about 0.4 ppb on an hourly average. Consequently, the impacts on local soils, vegetation, and animals attributable to the 777X project will be negligible.

FLAG guidance does not indicate a specific BOC impact on vegetation in the Pacific Northwest. The National Park Service has established monitors for ozone in three Class I areas in the state of Washington. The three sites are Mount Rainer National Park, Olympic National Park, and North Cascades National Park. As previously discussed in the TSD, in the past Boeing demonstrated that similar incremental concentrations less than about 0.4 ppb on an hourly average which is a very small fraction of the NAAQS of 75 ppb on an 8-hour average. Therefore, the increase in ozone from the 777X project is not likely to harm vegetation or animals.

Project emissions that have the most potential to affect soils and vegetation are those that contain either sulfur or nitrogen. SO_2 and NO_X are not subjected to PSD review for this project because their emissions are less than their respective SERs. As a result, no deposition analysis was required, but this analysis was conducted and is included in the application.

7. ENDANGERED SPECIES ACT

Pursuant to Section V.A. of the Agreement for the Delegation of the Federal Prevention of Significant Deterioration Program from the United States Environmental Protection Agency to

[4] Draft EPA New Source Review Workshop Manual, Chapter D, § IIC (EPA, 1990).

the Washington State Department of Ecology, dated December 10, 2013, Ecology shall not issue a PSD permit until EPA has notified Ecology in writing that EPA has satisfied its obligations, if any, under Section 7 of the Endangered Species Act (ESA), 16 U.S.C. § 1531 et seq., and 50 CFR Part 402, Subpart B (Consultation Procedures), and with Section 305(b)(2) of the Magnuson-Stevens Fishery and Conservation Act (Magnuson-Stevens Act, MSA), 16 U.S.C. § 1801 et seq., 50 CFR Part 600, Subpart K (EFH Coordination, Consultation, and Recommendations), for federal PSD permits, regarding essential fish habitat. Therefore, the final PSD permit will not be issued for this project until EPA has notified Ecology that this consultation has been completed.

On August 19, 2014, EPA notified Ecology that they have satisfied their obligations under the ESA and the MSA relative to this permitting action. No further ESA or MSA consultation was undertaken relative to this action.

8. STATE ENVIRONMENTAL POLICY ACT (SEPA)

Under Washington State rules, a final PSD permit shall not be issued for a project until the applicant has demonstrated that SEPA review has been completed for the project. The City of Everett is the lead agency for SEPA.

On December 10, 2013, the City of Everett Approved SEPA Addendum #1 (Revised) Southwest Everett Planned Action EIS, SEPA #13-019. Ecology concludes that the applicant has adequately demonstrated compliance with SEPA requirements.

9. PUBLIC INVOLVEMENT

9.1. Original Permit PSD 14-01

This PSD permitting action was subject to a minimum 30-day public comment period under WAC 173-400-740. A newspaper public notice announcing the public comment period was published in the Daily Herald on August 1, 2014. In accordance with WAC 173-400-740(2)(a), application materials and other related information were made available for public inspection at:

City of Everett
Main Library
2702 Hoyt Avenue
Everett, WA 98201

Washington State Department of Ecology
Air Quality Program
300 Desmond Drive SE
Lacey, WA 98503

A public meeting and hearing on the proposed PSD permit was held at 6:30 PM PDT on September 2, 2014, at the Future of Flight Aviation Center in the Forward Cabin Conference Room, 8415 Paine Field Boulevard, Mukilteo, Washington 98275. No comments were submitted at the hearing.

The public comment period closed on September 3, 2014, at 5 PM PDT. No comments were submitted.

9.2. PSD 14-01, Amendment 1

The permitting action was subject to a minimum 30-day public comment period under WAC 173-400-740(1)(c). A newspaper public notice announcing the public comment period was published in The Daily Herald on November 4, 2015. In accordance with WAC 173-400-740(2)(a), application materials and other related information were made available for public inspection at:

City of Everett
Main Library
2702 Hoyt Avenue
Everett, WA 98201

Washington State Department of Ecology
Air Quality Program
300 Desmond Drive SE
Lacey, WA 98503

The public comment period closed on December 4, 2015, at 5 PM PDT. No comments were submitted.

10. AGENCY CONTACT

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ACRONYMS AND ABBREVIATIONS

˚F	degrees Fahrenheit
$\mu g/m^3$	micrograms per cubic meter
ALW	Alpine Wilderness
AQIA	Air Quality Impacts Analysis
AQRV	Air Quality Related Values
BACT	Best Available Control Technology
CARB	California Air Resources Board
CFR	Code of Federal Regulations
CO	carbon monoxide
CO_2e	carbon dioxide equivalent
Ecology	Washington State Department of Ecology
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
FLAG	Federal Land Managers' Air Quality Relative Values Workgroup
FLM	Federal Land Manager
FR	Federal Register
GHG	greenhouse gas
H_2SO_4	sulfuric acid mist
HAPs	hazardous air pollutants
hr/yr	hours per year
kW	kilowatt
MACT	maximum achievable control technology
MSA	Magnuson-Stevens Act
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOC	Notice of Construction
NO_X	nitrogen oxides
NPS	National Park Service

NSR	New Source Review
PM	particulate matter
PM_{10}	particulate matter less than 10 micrometers in diameter
$PM_{2.5}$	particulate matter less than 2.5 micrometers in diameter
ppb	parts per billion
ppm	parts per million
PSD	Prevention of Significant Deterioration
PSCAA	Puget Sound Clean Air Agency
PTE	potential to emit
Q/d	emissions to distance
RBLC	RACT/BACT/LAER Clearinghouse
SCR	selective catalytic reduction
SEPA	State Environmental Policy Act
SER	significant emission rate
SIL	significant impact level
SO_2	sulfur dioxide
SO_X	sulfur oxides
TAP	toxic air pollutant
tpy	tons per year
VOC	volatile organic compound
WAC	Washington Administrative Code

APPENDIX A. BACKGROUND PSD APPLICABILITY ANALYSIS FOR THE 777X AND PRODUCTION RATE INCREASE
FOR TECHNICAL SUPPORT DOCUMENT OF PSD-14-01, AMENDMENT 1

APPENDIX A

Background PSD Applicability Analysis for the 777X and Production Rate Increase[1]

The 777 airplane model has been manufactured at the Boeing Everett plant since the 777 program first began in the mid-1990s. In the past 10 years, the 777 production rate has varied between approximately 3 airplanes a month and 8.3 airplanes a month in response to market demand and delivery schedules. Boeing was able to reach the 8.3 airplanes per month rate in part because in August 2011, the Washington Department of Ecology issued PSD-11-01 to allow Boeing Everett to make changes to the facility which increased the 777 production capacity from approximately 7 airplanes per month to approximately 8.3 airplanes per month. For this project Boeing proposes to produce new models of the Boeing 777, hereafter referred to as the 777X models. Production of the 777X models will require several new emission units, mostly to produce a new larger wing that will be primarily made of composite material. Boeing may also further increase the production rate of the 777 to approximately 10.4 planes per month, or 125 planes per year, depending on future Boeing management directives.

The changes being made to produce the 777X and to possibly increase the production rate (hereafter referred to as the "Project") will require a Prevention of Significant Deterioration (PSD) permit if both the emission increase and the net emissions increase of volatile organic compounds (VOCs) caused by the Project exceed the PSD significance level of 40 tons per year for VOCs. This PSD applicability analysis examines only the emissions increase caused by the Project and not the net emissions increase. If the emissions increase of VOCs is less than 40 tons per year, then the Project is not subject to PSD for VOCs. If the emissions increase of VOCs is greater than 40 tons per year, Boeing may elect to seek a PSD permit for this Project without performing a net emission increase analysis.

The main 777-related production operations at Boeing Everett can be categorized as follows:

- 777 assembly operations, which include:
  - Wing component fabrication
  - Wing assembly
  - Body section assembly
  - Wing and body structures seal/paint and vertical fin paint
  - Airplane assembly
- Interiors Responsibility Center (IRC) operations
- Everett Delivery Center (EDC) operations
- Propulsion systems operations
- Emergent operations
- Electrical Systems Responsibility Center (ESRC) operations

[1] This analysis only evaluates VOC emissions. For an analysis of all other New Source Review regulated pollutants, see the document "Estimate of Non-Significant PSD Pollutant Emissions Increases from the 777X Project" in Appendix B.

For the significant emissions increase analysis, the proposed project will involve both constructing new emissions units and modifying existing units. Other units or activities will not be new or modified, but will be debottlenecked as a result of this project. The PSD regulations require use of the hybrid test for projects that involve both the addition of new emission units and the modification of existing emission units (40 Code of Federal Regulations [CFR] 52.21(a)(2)(iv)(f)). Under the hybrid test, a significant emissions increase of a regulated NSR pollutant is projected to occur if the sum of the emissions increases for each emissions unit, using the actual-to-projected-actual applicability test (40 CFR 52.21(a)(2)(iv)(c)) for modified and debottlenecked units and the actual-to-potential applicability test (40 CFR 52.21(a)(2)(iv)(d)) for new units, equals or exceeds the significant amount for that pollutant (as defined in 40 CFR 52.21 (b)(23)).

The actual-to-projected-actual applicability test involves adding the projected (future) actual emissions from existing emission units that are modified as part of the project or that are expected to experience an emission increase as a result of the project, and then subtracting the past actual emissions (referred to as "baseline actual emissions") from those units. In lieu of projecting future actual emissions for a particular existing emission unit, an applicant can choose instead to use the unit's potential to emit as the unit's post-project emissions (40 CFR 52.21(b)(41)(ii)(d)). The actual-to-potential test, which is required for all new units being constructed as part of the project, involves totaling the potential emissions of the proposed new emission units, then subtracting past actual emissions of those units. A new unit that is being constructed as part of the project has a baseline of zero (40 CFR 52.21(b)(48)(iii)).

777 Assembly Emissions Increase from Existing Emission Units

Using material transaction data from Boeing's Haztrax database and VOC content estimates provided by Sunhealth and material safety data sheets (MSDSs), estimated actual VOC emissions from 777 assembly operations for the last 9 years are provided in Table A-1.

Baseline actual emissions, using 2012 and 2013 as the baseline years, is calculated below.

Baseline actual emissions:

= (156.5 + 164.0) / 2 = 160.3 tons/yr

In this analysis, projected actual emissions are based on a maximum anticipated production rate of 125 777s per year. The emission factor used to calculate projected actual emissions is based on the emission factor from the second highest recent annual VOC emissions per plane (2008) as shown in Table A-1.

Projected actual emissions are:

= (125 planes/yr x 2.125 tons/plane)
= 265.6 tons/yr

Projected actual emission – baseline actual emissions

= 265.6 – 160.3 = 105.3 tons/yr

TABLE A-1. ESTIMATED VOC EMISSIONS FROM 777 ASSEMBLY OPERATIONS FOR 2005 THROUGH 2013

Year	# of 777s Produced	Estimated VOC Emissions Before Subtracting Waste (tons)	Estimated VOCs in Waste (tons)	Estimated VOC Emissions After Subtracting Waste (tons)	Estimated VOC Emissions per Airplane (tons)
2005	44	107.8	4.2	103.6	2.35
2006	62	117.9	5.9	112.0	1.82
2007	83	179.3	8.7	170.6	2.06
2008[a]	68	152.7	8.2	144.5	2.12
2009	83	164.5	10.1	154.4	1.86
2010	71	133.3	8.0	125.3	1.77
2011	75	146.8	8.6	138.2	1.84
2012	83	167.7	11.2	156.5	1.89
2013	99	181.1	17.1	164.0	1.66

[a] A 2-month work stoppage occurred in 2008.

Wing Component Fabrication Emissions Increase from New Emission Units

Wing component fabrication will involve about 25 new emissions units, and as discussed above, all new units being constructed as part of the Project are required to undergo the actual-to-potential test. A new unit that is being constructed as part of the Project has a baseline of zero (40 CFR 52.21(b)(48)(iii)). Potential emissions for the wing component fabrication include open floor and point sources. Some of the emissions units also have associated combustion emissions from process heating; however, these emissions are accounted for in the combustion section of this appendix. The potential emissions for wing component fabrication are based on the projected maximum production rate of 125 airplanes per year and a combined emission rate for all the new wing component fabrication emissions units. The individual emission rates for each new wing component fabrication emission units and their combined emission rate are shown in Table A-2.

Potential emissions are:

= (3,763 lb VOC/airplane x 125 airplanes/yr) / 2,000 lb/ton
= 235 tons VOC/yr

Wing Assembly Emissions Increase from New Emission Units

No new VOC emission units will be installed for wing assembly operations as part of the 777X Project. (The emissions increase from the existing wing assembly operation has been accounted for in the 105.3 tpy emissions increase calculated above for the existing 777 assembly operation.)

TABLE A-2. WING COMPONENT FABRICATION: NEW SOURCES

Emission Unit or Activity Identifier	Emission Unit or Activity Description	Exhaust CFM	Non-Combustion Related VOC Emission Estimate Per Shipset	Estimate of Quantity of Each Coating, Solvent, Sealant and Other Products Used Per Shipset and Boeing MSDS #s[a]
WCF-1	Prep of layup mandrels (cleaning and application of mold release, tackifier (if req'd), and tooling filler (if req'd)) Wing panel buildup (shop floor emissions from hand-wipe cleaning, sealing, touchup coating, and other miscellaneous activities) Wing spar buildup (shop floor emissions from hand-wipe cleaning, sealing, touchup coating, and other miscellaneous activities)	NA	Total: 1,895 lb/shipset (subtotals listed below) Prep: 1,552 lb per shipset Wing panel buildup: 190 lb/shipset Wing spar buildup: 153 lb/shipset	Prep estimate: 97 gal per shipset of IPA to clean mandrels, caul plates, and other tooling (MSDS #s 64334 or 133755) 86 gal per shipset of mold release compound (Frekote 710 NC, MSDS # 59753) 43 gal per shipset tackifier solution (Toray E-09 tackifier / MEK thinner, assume 1:3 mix ratio, MSDS #s 38669 and 64337 or 133755, respectively) 12 gal per shipset mandrel repair coating (Chemlease MPP 117, MSDS # 115060) 14 gal per shipset mandrel repair coating (Zyvax Sealer GP, MSDS # 69607) Wing panel buildup: Wing panel assembly, wing panel buildup, and wing assembly for the aluminum 777 wing currently occur within Building 40-34. Based on Haztrax data for 12/1/2012 to 11/30/2013, VOC emissions from Building 40-34 were 759 lb/shipset. The wing panel buildup is assumed to account for approximately 20% of the VOC emissions that occur in Building 40-34. Therefore, the 777X wing panel buildup emissions are estimated at 0.2 x 759 lb/shipset x 1.25 = 190 lb/shipset (using a 1.25 safety factor). Wing spar buildup: Wing spar assembly and wing spar buildup for the aluminum 777 wing currently occur within Building 40-04. VOC emissions from wing spar buildup in Bldg. 40-04 occur from both shop floor activities and from four existing wing spar seal booths. Based on Haztrax data for 12/1/2012 to 11/30/2013, VOC emissions from Building 40-04 were 244 lb/shipset. The wing spar buildup is assumed to account for all the VOC emissions that occur in Building 40-04 (conservative estimate since some of the emissions are attributable to the wing spar assembly operations), so for the 777X wing spar buildup, emissions are estimated at 244 lb/shipset x 1.25 = 305 lb/shipset (using a 1.25 safety factor). Of this 305 lb VOC/shipset, approximately 152 lb/shipset is estimated to be emitted from the wing spar seal booth(s) (see entry for the WCF-14 at the bottom of this table). Therefore, shop floor VOC

TABLE A-2. WING COMPONENT FABRICATION: NEW SOURCES

Emission Unit or Activity Identifier	Emission Unit or Activity Description	Exhaust CFM	Non-Combustion Related VOC Emission Estimate Per Shipset	Estimate of Quantity of Each Coating, Solvent, Sealant and Other Products Used Per Shipset and Boeing MSDS #s[a]
				emissions from 777X wing spar buildup are estimated as follows: 305 lb/shipset – 152 lb/shipset = 153 lb/shipset.
WCF-4	Vacuum pump(s) servicing autoclaves (2 per autoclave, or 6 vacuum pumps total)	65	Total of 114 lb VOC emitted from all vacuum pumps combined per shipset.	38,152 lb of BMS 8-276 prepreg per shipset. Boeing MSDS #s of products qualified under BMS 8-276 are 123335, 133438, and 131737. BMS allows for a maximum of 1.5% by wt volatiles in prepreg, but test results from prepreg vendor (Toray) indicate average volatile content is less than 0.3% by weight.
WCF-5	Dust collector used to collect particulates from trimming, drilling, and other machining operations on cured components	5,000	0	NA
WCF-6a	Wing panel wash stall #1	16,250	0 lb	Ardrox JC-5 aqueous cleaner used to wash parts. Boeing MSDS # 18100. MSDS states that the VOC content is zero. Quantity used per shipset not estimated since VOC content is zero.
WCF-6b	Wing panel wash stall #2	16,250	0 lb	Ardrox JC-5 aqueous cleaner used to wash parts. Boeing MSDS # 18100. MSDS states that the VOC content is zero. Quantity used per shipset not estimated since VOC content is zero.
WCF-6c	Wing spar and stringer wash stall #1	3,900	0 lb	Ardrox JC-5 aqueous cleaner used to wash parts. Boeing MSDS # 18100. MSDS states that the VOC content is zero. Quantity used per shipset not estimated since VOC content is zero.
WCF-6d	Wing spar and stringer wash stall #2	3,900	0 lb	Ardrox JC-5 aqueous cleaner used to wash parts. Boeing MSDS # 18100. MSDS states that the VOC content is zero. Quantity used per shipset not estimated since VOC content is zero.

TABLE A-2. WING COMPONENT FABRICATION: NEW SOURCES

Emission Unit or Activity Identifier	Emission Unit or Activity Description	Exhaust CFM	Non-Combustion Related VOC Emission Estimate Per Shipset	Estimate of Quantity of Each Coating, Solvent, Sealant and Other Products Used Per Shipset and Boeing MSDS #s[a]
WCF-7	Gas-fired plasma unit for treatment of wing panel stringer	23,400	NA	NA
WCF-8a	Wing panel prep booth(s) (abrasive blast/sanding, solvent handwipe, edge seal)	32,500	504 lb per shipset. Currently Boeing is considering building one or two wing panel prep booths. If Boeing decides to build two wing panel prep booths, the 504 pounds of VOC emission will be divided between the two booths.	Various hand-wipe cleaning solvents might be used, including MPK, MEK, 70/30 blend of MPK and MEK, IPA, Turco 4460-BK (MSDS #s 88325, 64337, 140751, 64334, and 85374, respectively.) Assume 18 gal of solvent per wing panel (i.e., 36 gal per wing, 72 gal per shipset). Edge seal: Two-part adhesive. Will use either 3M EC2216 or Henkel Hysol EA9330. For EC2216, mix ratio is 3 parts accelerator (part A) / 2 parts base (part B). Per 3M's online MSDS dated 8/5/2008, VOC content of mixed EC2216 is 12 g/liter. For EA9330, mix ratio is 100 parts by wt Part A (MSDS # 32991) / 33 parts by wt Part B (MSDS 32992). Per MSDSs, VOC content of both parts is less than 10 g/liter. Total usage of edge seal per shipset is anticipated to be just a few gallons at the most, so VOC emissions are negligible.
WCF-8b	Wing spar prep booth (abrasive blast/sanding, solvent handwipe, edge seal)	7,800	70 lb per shipset.	Various hand-wipe cleaning solvents might be used, including MPK, MEK, 70/30 blend of MPK and MEK, IPA, Turco 4460-BK (MSDS #s 88325, 64337, 140751, 64334, 85374, respectively.) Assume 2.5 gal of solvent per wing spar (i.e., 5 gal per wing, 10 gal per shipset). Edge seal: Two-part adhesive. Will use either 3M EC2216 or Henkel Hysol EA9330. For EC2216, mix ratio is 3 parts accelerator (part A) / 2 parts base (part B). Per 3M's online MSDS dated 8/5/2008, VOC content of mixed EC2216 is 12 g/liter. For EA9330, mix ratio is 100 parts by wt Part A (MSDS # 32991) / 33 parts by wt Part B (MSDS 32992). Per MSDSs, VOC content of both parts is less than 10 g/liter. Total usage of edge seal per shipset is anticipated to be just a few gallons at the most, so VOC emissions are negligible.

TABLE A-2. WING COMPONENT FABRICATION: NEW SOURCES

Emission Unit or Activity Identifier	Emission Unit or Activity Description	Exhaust CFM	Non-Combustion Related VOC Emission Estimate Per Shipset	Estimate of Quantity of Each Coating, Solvent, Sealant and Other Products Used Per Shipset and Boeing MSDS #s[a]
WCF-9a	Wing panel spray booth #1	195,000	818 lb per shipset, but note there are three wing panel booths, so assuming each booth is used for one third of all wing panels, each booth would actually only emit 273 lb per shipset on average.	36.5 gal of BMS 10-103 Grade A primer per shipset (512X310 base / 910X533 catalyst, 1/1 mix ratio, MSDS #s 82874 and 81600, respectively). 108 gal of BMS 10-20 per shipset (454-4-1 base / CA-109 cat / TL-52 (optional), assume 3/1/0.5 mix ratio, MSDS #s 85408, 85406, and 84472, respectively). 12 gal 70/30 MPK/MEK blend for spray equipment cleaning per shipset. Assume 20% of this amount is emitted to the air during the cleaning process, the rest is collected for disposal. MSDS # 140751.
WCF-9b	Wing panel spray booth #2	195,000	818 lb per shipset, but note there are three wing panel booths, so assuming each booth is used for one third of all wing panels, each booth would actually only emit 273 lb per shipset on average.	36.5 gal of BMS 10-103 Grade A primer per shipset (512X310 base / 910X533 catalyst, 1/1 mix ratio, MSDS #s 82874 and 81600, respectively). 108 gal of BMS 10-20 per shipset (454-4-1 base / CA-109 cat / TL-52 (optional), assume 3/1/0.5 mix ratio, MSDS #s 85408, 85406, and 84472, respectively). 12 gal 70/30 MPK/MEK blend for spray equipment cleaning per shipset. Assume 20% of this amount is emitted to the air during the cleaning process, the rest is collected for disposal. MSDS # 140751.
WCF-9d	Wing panel spray booth #3	195,000	818 lb per shipset, but note there are three wing panel booths, so assuming each booth is used for one third of all wing panels, each booth would actually only emit 273 lb per shipset on average.	36.5 gal of BMS 10-103 Grade A primer per shipset (512X310 base / 910X533 catalyst, 1/1 mix ratio, MSDS #s 82874 and 81600, respectively). 108 gal of BMS 10-20 per shipset (454-4-1 base / CA-109 cat / TL-52 [optional], assume 3/1/0.5 mix ratio, MSDS #s 85408, 85406, and 84472, respectively). 12 gal 70/30 MPK/MEK blend for spray equipment cleaning per shipset. Assume 20% of this amount is emitted to the air during the cleaning process, the rest is collected for disposal. MSDS # 140751.

TABLE A-2. WING COMPONENT FABRICATION: NEW SOURCES

Emission Unit or Activity Identifier	Emission Unit or Activity Description	Exhaust CFM	Non-Combustion Related VOC Emission Estimate Per Shipset	Estimate of Quantity of Each Coating, Solvent, Sealant and Other Products Used Per Shipset and Boeing MSDS #s[a]
WCF-9c	Wing spar spray booth	46,800	118 lb per shipset if one booth used. Or, an average of 59 lb per shipset if two booths used.	5.4 gal of BMS 10-103 Grade A primer per wing spar shipset (512X310 base / 910X533 catalyst, 1/1 mix ratio, MSDS #s 82874 and 81600, respectively). 12.9 gal of BMS 10-20 per wing spar shipset (454-4-1 base / CA-109 cat / TL-52 (optional), assume 3/1/0.5 mix ratio, MSDS #s 85408, 85406, and 84472, respectively). 12 gal 70/30 MPK/MEK blend for spray equipment cleaning per shipset. Assume 20% of this amount is emitted to the air during the cleaning process, the rest is collected for disposal. MSDS # 140751.
WCF-9e	Wing spar spray booth	46,800	118 lb per shipset if one booth used. Or, an average of 59 lb per shipset if two booths used.	5.4 gal of BMS 10-103 Grade A primer per wing spar shipset (512X310 base / 910X533 catalyst, 1/1 mix ratio, MSDS #s 82874 and 81600, respectively). 12.9 gal of BMS 10-20 per wing spar shipset (454-4-1 base / CA-109 cat / TL-52 (optional), assume 3/1/0.5 mix ratio, MSDS #s 85408, 85406, and 84472, respectively). 12 gal 70/30 MPK/MEK blend for spray equipment cleaning per shipset. Assume 20% of this amount is emitted to the air during the cleaning process, the rest is collected for disposal. MSDS # 140751.
WCF-10a	Wing panel primer curing booth #1	97,500	53 lb per shipset, but note there are two wing panel booths, so assuming each booth is used for only half the panels of a shipset, each booth would actually only emit 26.6 lb per shipset on average.	NA
WCF-10b	Wing panel primer curing booth #2	97,500	53 lb per shipset, but note there are two wing panel booths, so assuming each booth is used for only half the panels of a shipset, each booth would actually only emit 26.6 lb per shipset on average.	NA
WCF-10c	Wing spar primer curing booth	23,400	7.7 lb per shipset.	NA

TABLE A-2. WING COMPONENT FABRICATION: NEW SOURCES

Emission Unit or Activity Identifier	Emission Unit or Activity Description	Exhaust CFM	Non-Combustion Related VOC Emission Estimate Per Shipset	Estimate of Quantity of Each Coating, Solvent, Sealant and Other Products Used Per Shipset and Boeing MSDS #s[a]
WCF-11a, b, c, d	Small quantity paint mix booth	3,635 each	On the order of 1 lb or less. Note: There might be up to four paint mix booths.	NA
WCF-12a	Coating equipment cleaning booth #1	3,635	32 lb per shipset, but note there might be only two or as many as four equipment cleaning booths for the wing component spray booths, so assuming only two booths are built and each booth is used for only one-half of the cleaning, each booth would actually only emit 16 lb per shipset on average. Similarly, if four booths are built, the emissions per booth would be 8 lb per shipset on average.	24 gal 70/30 MPK/MEK blend for spray equipment cleaning per shipset. Assume 20% of this amount is emitted to the air during the cleaning process, the rest is collected for disposal. MSDS # 140751.
WCF-12b	Coating equipment cleaning booth #2	3,635	32 lb per shipset, but note there might be only two or as many as four equipment cleaning booths for the wing component spray booths, so assuming only two booths are built and each booth is used for only one-half of the cleaning, each booth would actually only emit 16 lb per shipset on average. Similarly, if four booths are built, the emissions per booth would be 8 lb per shipset on average.	24 gal 70/30 MPK/MEK blend for spray equipment cleaning per shipset. Assume 20% of this amount is emitted to the air during the cleaning process, the rest is collected for disposal. MSDS # 140751.
WCF-12c	Coating equipment cleaning booth #3	3,635	32 lb per shipset, but note there might be only two or as many as four equipment cleaning booths for the wing component spray booths, so assuming only two booths are built and each booth is used for only one-half of the cleaning, each booth would actually only emit 16 lb per shipset on average. Similarly, if four booths are built, the emissions per booth would be 8 lb per shipset on average.	24 gal 70/30 MPK/MEK blend for spray equipment cleaning per shipset. Assume 20% of this amount is emitted to the air during the cleaning process, the rest is collected for disposal. MSDS # 140751.

TABLE A-2. WING COMPONENT FABRICATION: NEW SOURCES

Emission Unit or Activity Identifier	Emission Unit or Activity Description	Exhaust CFM	Non-Combustion Related VOC Emission Estimate Per Shipset	Estimate of Quantity of Each Coating, Solvent, Sealant and Other Products Used Per Shipset and Boeing MSDS #s[a]
WCF-12d	Coating equipment cleaning booth #4	3,635	32 lb per shipset, but note there might be only two or as many as four equipment cleaning booths for the wing component spray booths, so assuming only two booths are built and each booth is used for only one-half of the cleaning, each booth would actually only emit 16 lb per shipset on average. Similarly, if four booths are built, the emissions per booth would be 8 lb per shipset on average.	24 gal 70/30 MPK/MEK blend for spray equipment cleaning per shipset. Assume 20% of this amount is emitted to the air during the cleaning process, the rest is collected for disposal. MSDS # 140751.
WCF-14	Wing spar seal booth(s)	Variable: 10,000 CFM for sealing; 25,000 CFM for solvent wipe cleaning; 53,000 CFM for spray coating[b]	152 lb per shipset (the majority of these emissions come from hand-wipe cleaning). Currently Boeing is considering building up to four wing spar seal booths. If Boeing decides to build multiple booths, the 152 lb of VOC emission will be divided between the multiple booths.	Various hand-wipe cleaning solvents might be used, including MPK, MEK, or IPA (MSDS #s 88325, 64337, 64334, respectively.) Assume 3.75 gal of solvent per wing spar or 15 gal per shipset. 135 lb BMS 5-45 Class B sealant per spar, or 540 lb per shipset. Assume sealant is PR-1776M B-2 (MSDS # 121363). 15 lb BMS 5-45 Class A sealant per spar, or 60 lb per shipset. Assume sealant is Pro Seal 890M A-2 (MSDS # 126361). 0.2 gal of BMS 10-20 per spar, or 0.8 gal per shipset (454-4-1 base / CA-109 cat / TL-52 [optional], assume 3/1/0.5 mix ratio, MSDS #s 85408, 85406, and 84472, respectively). FRONT SPAR ONLY: 0.1 gal of BMS 10-103 Grade A primer per spar, or 0.2 gal per shipset (512X310 base / 910X533 catalyst, 1/1 mix ratio, MSDS #s 82874 and 81600, respectively) FRONT SPAR ONLY: 0.05 gal of BMS 10-60 topcoat per spar, or 0.1 gal per shipset (ECL-G-101 / PC-233 / TR-112, 2/1/1 mix ratio, MSDS #s 97699, 92002, and 95733, respectively).
TOTAL	**--**	**--**	**3,763 lb per shipset.**	**--**

[a] Mix ratios are by volume unless otherwise specified.

[b] Because the majority of emissions from the seal booths will occur during the solvent cleaning step, BACT costs are based on an exhaust flow rate of 25,000 CFM.IPA = Isopropyl Alcohol
MEK = methyl ethyl ketone
MPK = methyl propyl ketone

Body Section Assembly Emissions Increase from New Emission Units

No new VOC emission units will be installed for body section assembly operations as part of the Project. (The emissions increase from the existing body section assembly operation has been accounted for in the 105.3 tpy emissions increase calculated above for the existing 777 assembly operation.)

Wing and Body Structures Seal/Paint Building Emissions Increase from New Emission Units

Wing and body structures seal/paint operations will involve four new emissions units, which are subject to the actual-to-potential test. Potential emissions for these new units are based on the projected maximum production rate of 125 airplanes per year and a combined emission rate for all four new emissions units in this category. The individual emission rates for each new emission unit and their combined emission rate are shown in Table A-3. (The emissions increase from the existing seal/paint building operation has been accounted for in the 105.3 tpy emissions increase calculated above for the existing 777 assembly operation.)

Potential emissions:

= (230 lb VOC/airplane x 125 airplanes/yr) / 2,000 lb/ton
= 14.4 tons VOC/yr

Airplane Assembly Emissions Increase from New Emission Units

Airplane assembly operations will involve two new emission units and are subject to the actual-to-potential test. Potential emissions for airplane assembly from these new emission units are based on the projected maximum production rate of 125 airplanes per year and a combined emission rate for the two new emissions units in this category. The individual emission rates for each new emission unit and their combined emission rate are shown in Table A-4. (The emissions increase from the airplane assembly operation has been accounted for in the 105.3 tpy emissions increase calculated above for the existing 777 assembly operation.)

Potential emissions are:

= (22 lb VOC/airplane x 125 airplanes/yr) / 2,000 lb/ton
= 1.38 tons VOC/yr

TABLE A-3. WING AND BODY STRUCTURES SEAL/PAINT BUILDING: NEW SOURCES

Emission Unit or Activity Identifier	Emission Unit or Activity Description	Exhaust (cfm)	Non-Combustion Related VOC Emission Estimate Per Shipset	Estimate of Quantity of Each Coating, Solvent, Sealant and Other Products Used Per Shipset and Boeing MSDS #s[a]
WBSP-10	Vertical fin HLFC prep booth	50,000	20 lb per shipset.	3 gal MPK (MSDS # 88325) or CDG-110 (MSDS # 86849). 4.5 gal Pace B-82 cleaner (MSDS # 6172).
WBSP-11a	Vertical fin HLFC spray booth #1b	3 stacks @ 50,000 each	209 lb per shipset, but note there are three vertical fin booths, so assuming each booth is used for only one-third the fins, each booth would actually only emit 70 lb per shipset on average.	9 gal of BMS 10-103 Grade A primer per shipset (512X310 base / 910X533 catalyst, 1/1 mix ratio, MSDS #s 82874 and 81600, respectively). 15 gal BMS 10-125 topcoat per shipset (3001GXXXXX base / CS6000 curing solution / A9004 activator, 6/1/0.5 mix ratio; MSDS #s 143664, 139555, and 146375, respectively). Note that MSDS for base component will vary depending on color. A white base is most common. MSDS # 143664 is for one of the most common white bases used. 6 gal Sur-Prep AP-1 Adhesion Promoter per shipset (Part A / Part B, 1 / 8.33 mix ratio, MSDS #s 140722 and 140723, respectively.) 15 gal BMS 10-125 clearcoat per shipset (3001G00002 base / CS6003 curing solution / A9052 activator, 2/2/1 mix ratio; MSDS #s 144406, 141227, and 145945, respectively). 9 gal MPK (MSDS # 88325) for spray equipment cleaning. Assume 20% of this amount is emitted to the air during the cleaning process, the rest is collected for disposal.
WBSP-11b	Vertical fin HLFC spray booth #2b	3 stacks @ 50,000 each	209 lb per shipset, but note there are three vertical fin booths, so assuming each booth is used for only one-third the fins, each booth would actually only emit 70 lb per shipset on average.	9 gal of BMS 10-103 Grade A primer per shipset (512X310 base / 910X533 catalyst, 1/1 mix ratio, MSDS #s 82874 and 81600, respectively). 15 gal BMS 10-125 topcoat per shipset (3001GXXXXX base / CS6000 curing solution / A9004 activator, 6/1/0.5 mix ratio; MSDS #s 143664, 139555, and 146375, respectively). Note that MSDS for base component will vary depending on color. A white base is most common. MSDS # 143664 is for one of the most common white bases used. 6 gal Sur-Prep AP-1 Adhesion Promoter per shipset (Part A / Part B, 1 / 8.33 mix ratio, MSDS #s 140722 and 140723, respectively.)

TABLE A-3. WING AND BODY STRUCTURES SEAL/PAINT BUILDING: NEW SOURCES

Emission Unit or Activity Identifier	Emission Unit or Activity Description	Exhaust (cfm)	Non-Combustion Related VOC Emission Estimate Per Shipset	Estimate of Quantity of Each Coating, Solvent, Sealant and Other Products Used Per Shipset and Boeing MSDS #s[a]
				15 gal BMS 10-125 clearcoat per shipset (3001G00002 base / CS6003 curing solution / A9052 activator, 2/2/1 mix ratio; MSDS #s 144406, 141227, and 145945, respectively). 9 gal MPK (MSDS # 88325) for spray equipment cleaning. Assume 20% of this amount is emitted to the air during the cleaning process, the rest is collected for disposal.
WBSP-11c	Vertical fin HLFC spray booth #3b	3 stacks @ 50,000 each	209 lb per shipset, but note there are three vertical fin booths, so assuming each booth is used for only one-third of the fins, each booth would actually only emit 70 lb per shipset on average.	9 gal of BMS 10-103 Grade A primer per shipset (512X310 base / 910X533 catalyst, 1/1 mix ratio, MSDS #s 82874 and 81600, respectively). 15 gal BMS 10-125 topcoat per shipset (3001GXXXXX base / CS6000 curing solution / A9004 activator, 6/1/0.5 mix ratio; MSDS #s 143664, 139555, and 146375, respectively). Note that MSDS for base component will vary depending on color. A white base is most common. MSDS # 143664 is for one of the most common white bases used. 6 gal Sur-Prep AP-1 Adhesion Promoter per shipset (Part A / Part B, 1 / 8.33 mix ratio, MSDS #s 140722 and 140723, respectively.) 15 gal BMS 10-125 clearcoat per shipset (3001G00002 base / CS6003 curing solution / A9052 activator, 2/2/1 mix ratio; MSDS #s 144406, 141227, and 145945, respectively). 9 gal MPK (MSDS # 88325) for spray equipment cleaning. Assume 20% of this amount is emitted to the air during the cleaning process, the rest is collected for disposal.
Total			**230 lb per shipset**	

[a] Mix ratios are by volume unless otherwise specified.

TABLE A-4. AIRPLANE ASSEMBLY: NEW SOURCES

Emission Unit or Activity Identifier	Emission Unit or Activity Description	Exhaust CFM	Non-Combustion VOC Related Emission Estimate Per Shipset	Estimate of Quantity of Each Coating, Solvent, Sealant and Other Products Used Per Shipset and Boeing MSDS #s[a]
AA-2a	Wing stub spray-coating ventilation system	4,000	22 lb per shipset. Note that although there are two wing stub spray coating ventilations systems, one of them will be associated with the "low rate initial production" airplane assembly line, which may be deactivated after a period of time. Therefore, for the BACT analysis, assume all 22 lb of VOC emissions from each airplane produced will be emitted from just one wing stub spray coating ventilation system (i.e., assume annual emissions from one wing stub spray coating ventilation system is 22 lb x 125 airplanes per year = 2,750 lb per year).	1.875 gal of BMS 10-11 Type I primer per shipset (44-Y-022 base / 44-Y-022 cat / water, assume 2/1/4.5 mix ratio, MSDS #s 81045 and 81046, respectively). 0.15 gal of BMS 10-20 per wing primer shipset (454-4-1 base / CA-109 cat / TL-52 (optional), assume 3/1/0.5 mix ratio, MSDS #s 85408, 85406, and 84472, respectively). 0.3 gal of BMS 10-11 Type II topcoat per shipset (446-22-2000 base / X-530 catalyst, assume 3/1 mix ratio, MSDS #s 90168 and 82649, respectively). 1.25 gal of BMS 5-81 Type II fuel barrier coating per shipset (PR-1197 Part A / PR-1197 Part B / MEK thinner, mix ratio is 90 parts by weight Part A, 100 parts by weight Part B, then thin with MEK at a ratio of 10 parts by weight mixed coating to 4 parts by weight MEK, MSDS #s 84584, 84585, and 64337, respectively). 0.375 gal Cor-Ban 35 aerosol per shipset (MSDS # 106501). 0.25 gal AV-8 aerosol per shipset (MSDS # 78343).

TABLE A-4. AIRPLANE ASSEMBLY: NEW SOURCES

Emission Unit or Activity Identifier	Emission Unit or Activity Description	Exhaust CFM	Non-Combustion VOC Related Emission Estimate Per Shipset	Estimate of Quantity of Each Coating, Solvent, Sealant and Other Products Used Per Shipset and Boeing MSDS #s[a]
AA-2b	Wing stub spray coating ventilation system	4,000	22 lb per shipset. Note that although there are two wing stub spray coating ventilations systems, one of them will be associated with the "low rate initial production" airplane assembly line, which may be deactivated after a period of time. Therefore, for the BACT analysis, assume all 22 lb of VOC emissions from each airplane produced will be emitted from just one wing stub spray coating ventilation system (i.e., assume annual emissions from one wing stub spray coating ventilation system is 22 lb x 125 airplanes per year = 2,750 lb per year).	1.875 gal of BMS 10-11 Type I primer per shipset (44-Y-022 base / 44-Y-022 cat / water, assume 2/1/4.5 mix ratio, MSDS #s 81045 and 81046, respectively). 0.15 gal of BMS 10-20 per wing primer shipset (454-4-1 base / CA-109 cat / TL-52 [optional], assume 3/1/0.5 mix ratio, MSDS #s 85408, 85406, and 84472, respectively). 0.3 gal of BMS 10-11 Type II topcoat per shipset (446-22-2000 base / X-530 catalyst, assume 3/1 mix ratio, MSDS #s 90168 and 82649, respectively). 1.25 gal of BMS 5-81 Type II fuel barrier coating per shipset (PR-1197 Part A / PR-1197 Part B / MEK thinner, mix ratio is 90 parts by weight Part A, 100 parts by weight Part B, then thin with MEK at a ratio of 10 parts by weight mixed coating to 4 parts by weight MEK, MSDS #s 84584, 84585, and 64337, respectively). 0.375 gal Cor-Ban 35 aerosol per shipset (MSDS # 106501). 0.25 gal AV-8 aerosol per shipset (MSDS # 78343).
Total			**22 lb per shipset**	

[a] Mix ratios are by volume unless otherwise specified.

Interiors Emissions Increase

No changes to the IRC emission units are anticipated for Phase 1 of the Project. However, for Phase 2, five new IRC VOC sources are proposed as part of this Project. These include three adhesive spray booths, a paint spray booth, and a crushed core press. The actual-to-potential test, which is required for all new units being constructed or installed as part of the Project, involves totaling the potential emissions of the proposed new emissions units, then subtracting past actual emissions of those units. Unlike other new emissions units in this Project, the new IRC emissions units' potential emissions are not calculated on a shipset basis. The potential emissions for the new units are based on the maximum VOC emissions per year from each unit. The new IRC units are shown in Table A-5.

Existing cleaning, coating, and other activities (including open floor activities and activities conducted at existing spray booths, presses, etc.) that generate emissions during the production of 777 interiors will be debottlenecked by the Project since once the Project is complete, more 777 interior shipsets are expected to be produced to support the higher 777X production rate. Because the same equipment is also used to produce interiors for other airplane models, for the purposes of this estimate, the existing emission units being debottlenecked are taken to be the cleaning, coating, and other activities associated with the production of 777 interiors only. The emission increase from these existing emission units is estimated here by determining the difference between projected actual emissions and baseline actual emissions.

Although overall VOC emissions from IRC operations are tracked to demonstrate compliance with the PSD-05-02 annual VOC emission cap, VOC emissions from 777 interiors production are not tracked separately from VOC emissions from interiors production for other airplane programs. However, it is estimated that approximately 0.53 ton of VOCs are generated per 777 interiors shipset produced.[2]

Using this emission factor and an average annual 777 interiors shipset production during the 2012/2013 baseline years of (99 + 83)/2 = 91, baseline actual emissions for IRC are:

= (91 shipsets/yr) x (0.53 ton VOC/shipset)
= 48.2 tons VOC/yr

Projected actual emissions based on 125 shipsets per year for IRC are:

= (125 shipsets/yr) x (0.53 ton VOC/shipset)
= 66.3 tons VOC/yr

Potential new emissions are:

= [IRC-1a, -1b, and -1c adhesive spray booths (17,700 lb VOC /booth x 3 booths) + IRC-2 paint spray booth (10,000 lb VOC) + IRC-3 crushed core press (4,500 lb VOC)] /year / 2,000 lb/ton
= 33.8 tons VOC/yr

2 See Appendix B of the Prevention of Significant Deterioration Application for the 787 Project, March 2005.

TABLE A-5. IRC NEW EMISSIONS UNITS

Emission Unit or Activity Identifier	Emission Unit or Activity Description	Exhaust CFM	Non-Combustion-Related VOC Emission Estimate Per Shipset	Estimate of Quantity of Each Coating, Solvent, Sealant and Other Products Used Per Shipset and Boeing MSDS #'s[a]
IRC-1a	Adhesive spray booth #1	20,000	17,700 lb/year **Note**: This is not a per shipset estimate. It is an annual estimate based on a production rate of 125 airplanes per year.	2,860 gal per year of BMS 5-127 adhesive (Bostik 7132 base / Boscodur 24T activator / MEK thinner, assume 16/1/17 mix ratio, MSDS #'s 45308, 31392, and 80402, respectively).
IRC-1b	Adhesive spray booth #2	20,000	17,700 lb/year **Note**: This is not a per shipset estimate. It is an annual estimate based on a production rate of 125 airplanes per year.	2,860 gal per year of BMS 5-127 adhesive (Bostik 7132 base / Boscodur 24T activator / MEK thinner, assume 16/1/17 mix ratio, MSDS #'s 45308, 31392, and 80402, respectively).
IRC-1c	Adhesive spray booth #3	20,000	17,700 lb/year **Note**: This is not a per shipset estimate. It is an annual estimate based on a production rate of 125 airplanes per year.	2,860 gal per year of BMS 5-127 adhesive (Bostik 7132 base / Boscodur 24T activator / MEK thinner, assume 16/1/17 mix ratio, MSDS #'s 45308, 31392, and 80402, respectively).
IRC-2	Paint spray booth	20,000	10,000 lb/year **Note**: This is not a per shipset estimate. It is an annual estimate based on a production rate of 125 airplanes per year.	690 gal per year BMS 10-83 Type 4 primer (Polane primer E61WC40 base / V66VC227 catalyst / R99KY29 thinner, assume 7/1/8 mix ratio, MSDS #'s 39195, 105392, and 80657, respectively). 1030 gal per year BMS 10-83 Type 2, 3, or 5 topcoat (Polane F63WY30 base / V66VC229 catalyst / R99KY29 thinner, assume 7/1/8 mix ratio, MSDS #'s 20442, 105387, and 80657, respectively). Note that the MSDS for base component will vary depending on color. A white base is most common. MSDS # 20442 is for one of the most common white bases used.
IRC-3	Crushed core press	7,500	4,500 lb/yr **Note**: This is not a per shipset estimate. It is an annual estimate based on a production rate of 125 airplanes per year.	75 gal per year mold release agent (1894-EX-S, MSDS # 15462). 585 gal per year mold release agent thinner (Shellsol OMS, MSDS # 123245). 162,000 lb pre-impregnated material (prepreg) (BMS 8-222, Cytec MXB 6070, MSDS # 31457) MXB 6070 is the most common type of prepreg used in the crushed core presses. Per lab tests, the VOC content of MXB is estimated at 0.17% by weight. Other types of prepreg used in the crushed core presses have not be tested but are believed to have a similar VOC content.

[a] Mix ratios are by volume unless otherwise specified.

The Project's hybrid emission increase from IRC operations is:

= (Projected actual emissions – baseline actual emissions) + potential new emissions

= (66.3 tons VOC/yr – 48.2 tons VOC/yr) + 33.8 tons VOC/yr
= 51.9 tons VOC/yr

This is a very conservative approach because the project actual emissions is based on 125 airplanes per year and includes some of the 33.8 tons per year (tpy) VOC emissions from the new emission units. Hence, some of the 33.8 tpy is double counted.

Everett Delivery Center Emissions Increase

The EDC does not anticipate any new or modified emission units in support of the Project. EDC work can be divided into paint hangar work and everything else. The EDC paint hangars are by far the largest source of emissions at the EDC, and they are already operated at their capacity. Because there are currently no plans to increase paint hangar capacity to support this Project, the Project will not result in increased emissions at Everett from paint hangars.

Work performed by the EDC that arguably will be debottlenecked and thereby experience an emission increase as a result of the Project is the coating and cleaning of 777 rudders and elevators (the moving surfaces on the vertical fin and horizontal stabilizer, respectively) performed in one of three existing EDC rudder and elevator spray booths, and the preflight/delivery work that occurs in Building 45-02 and on the flightline. Because work in support of other airplane models is also performed in these same spray booths, Building 45-02, and on the flightline, for the purposes of this estimate, the emission units being debottlenecked are taken to be the cleaning and coating of 777 rudders and elevators, and the preflight/delivery work performed on 777 airplanes. The emission increases from these emission units are estimated here by determining the difference between projected actual emissions and baseline actual emissions.

Although overall VOC emissions from EDC operations are tracked to demonstrate compliance with the PSD-05-02 annual VOC emission cap, VOC emissions from EDC work related to 777 production are not tracked separately from VOC emissions related to other airplane programs. However, based on estimates of the quantity of materials used to clean and coat 777 rudders and elevators, it is estimated that VOC emissions per rudder/elevator shipset are approximately 0.1 ton. Similarly, based on material transaction data for the flightline, it is estimated that the preflight/delivery VOC emissions per 777 are approximately 0.05 ton. For EDC then, total VOC emissions per 777 from these presumed debottlenecked emissions units are estimated at approximately 0.15 ton.

Using this emission factor and an average annual 777 production rate during the 2012/2013 baseline period of 91 [(83 + 99) /2], baseline actual emissions are:

= (91 airplanes/yr) x (0.15 ton VOC/airplane)
= 13.7 tons VOC/yr

Projected actual emissions based on 125 shipsets per year are:

= (125 airplanes/yr) x (0.15 ton VOC/airplane)
= 18.8 tons VOC/yr

Projected actual emission – baseline actual emissions

= 18.8 tons VOC/yr – 13.7 tons VOC/yr
= 5.1 tons VOC/yr

Propulsion Systems Emissions Increase

Propulsion Systems does not anticipate any new or modified emission units in support of the Project. However, the cleaning, coating, and other activities that generate emissions during the work performed on 777 engines and engine struts are arguably debottlenecked by the Project, since once the Project is complete, more 777 engines and engine struts are expected to be processed to support the higher production rate. Because the Propulsion Systems also supports other airplane models, for the purposes of this estimate, the emission units being debottlenecked are taken to be the cleaning, coating, and other activities associated with preparing 777 engines and engine struts. The emissions increases from these emission units are estimated here by determining the difference between projected actual emissions and baseline actual emissions.

Based on material transaction data from the Haztrax database and VOC content estimates provided by Sunhealth and MSDSs, Propulsion Systems' 2009 emissions are estimated at 0.276 ton. In 2009, 83 777s, 13 767s, and 10 747s were produced at Boeing Everett, meaning a total of [(83 + 13) x 2] + (10 x 4) = 232 engines were processed by Propulsion Systems. Propulsion Systems' VOC emissions per engine are then:

= 0.276 ton/232 engines = 0.00119 ton/engine or 2.38 lb/engine

Prior to Propulsion Systems moving to the Boeing Everett site in 2008, VOC emissions per engine were estimated at up to 0.003 ton/engine. Therefore, for purposes of this exercise, a conservative estimate of 0.005 ton/engine will be used.

Using this emission factor and an average annual 777 production rate during the 2012/2013 baseline period of 91 [(83 + 99) /2], baseline actual emissions are:

= (91 airplanes/yr) x (0.005 ton VOC/engine) x (2 engines/airplane)
= 0.91 ton VOC/yr

Projected actual emissions based on 125 shipsets per year are:

= (125 airplanes/yr) x (0.005 ton VOC/engine) x (2 engines/airplane)
= 1.25 tons VOC/yr

Projected actual emissions – baseline actual emissions

= 1.25 tons VOC/yr – 0.91 ton VOC/yr
= 0.34 ton VOC/yr

Emergent Operations Emissions Increase

No new or modified emission units are anticipated for Emergent Operations. However, the cleaning, coating, and other activities that generate emissions during emergent operations related to 777 production are presumed to be debottlenecked by the Project since once the Project is complete, more emergent operations related to 777 production are expected to occur to support the higher 777 production rate. Because Emergent Operations also supports other airplane models as well as the 777, for the purposes of this estimate, the emission units being debottlenecked are assumed to be the cleaning, coating, and other activities associated with emergent operations related to 777 production. The emissions increase from these emission units is estimated here by determining the difference between projected actual emissions and baseline actual emissions.

VOC emissions from emergent operations are not tracked separately for each airplane program. However, based on material transaction data from the Haztrax database from 2007 through 2010 and VOC content estimates provided by Sunhealth and MSDSs, it is estimated that VOC emissions from emergent operations related to 777 production is approximately 0.06 ton/airplane.

Using this emission factor and an average annual 777 production during the 2012/2013 baseline years of (83 + 99)/2 = 91, baseline actual emissions are:

= (91 777s/yr) x (0.06 ton VOC/777)
= 5.46 tons VOC/yr

Projected actual emissions based on 125 shipsets per year are:

= (125 airplanes/yr) x (0.06 ton VOC/airplane)
= 7.5 tons VOC/yr

Projected actual emission – baseline actual emissions

= 7.5 tons VOC/yr – 5.46 tons VOC/yr
= 2.04 tons VOC/yr

Electrical Systems Emissions Increase

The ESRC does not anticipate any new or modified emission units in support of the Project. However, the cleaning, coating, and other activities that generate emissions during the production of electrical systems for the 777 are likely to be debottlenecked by the Project since once the Project is complete, more 777 electrical system components are expected to be produced to support the higher 777 production rate. Because the ESRC also supports other airplane models, for the purposes of this estimate, the emission units being debottlenecked are taken to be the cleaning, coating, and other activities associated with 777 electrical systems production. The emissions increase from these emission units is estimated here by determining the difference between projected actual emissions and baseline actual emissions.

VOC emissions from electrical systems production are not tracked separately for each airplane program. However, based on material transaction data from the Haztrax database from 2005 through 2010 and VOC content estimates provided by Sunhealth and MSDSs, it is estimated that VOC emissions from 777 electrical systems production are approximately 25 lb/airplane or 0.0125 ton/airplane.

Using this emission factor, and an average annual 777 production during the 2012/2013 baseline years of (83 + 99)/2 = 91, baseline actual emissions are:

= (91 shipsets/yr) x (0.0125 ton VOC/shipset)

= 1.14 tons VOC/yr

Projected actual emissions based on 125 shipsets per year are:

= (125 airplanes/yr) x (0.0125 ton VOC/airplane)
= 1.56 tons VOC/yr

Net increase = Projected actual emission – baseline actual emissions

= 1.56 tons VOC/yr – 1.14 tons VOC/yr
= 0.42 ton VOC/yr

Boilers and Other Combustion Equipment Emissions Increase from Existing Emission Units

Six existing 150-million-British-thermal-units-per-hour (MMBtu/hr) natural-gas-fired industrial steam boilers provide steam for process and space heating in support of all twin-aisle airplane programs (i.e., 747, 767, 777, and 787 models) and IRC manufacturing operations (including twin-aisle airplanes and 737 interiors manufacturing) at Boeing Everett. Boilers #1 through #4 are located in the Building 40-12 boiler plant on the north side of the Everett site, and Boilers #5 and #6 are located in the Building 45-07 boiler plant on the south side of the Everett site. The six boilers consume approximately 90 percent of the total amount of natural gas delivered to Boeing Everett. The remainder of the natural gas delivered to Boeing Everett is consumed in small (less than 10-MMBtu/yr) boilers, furnaces, process equipment, HVAC equipment, and hot water heaters. To simplify the emissions estimates from the boilers and other stationary fuel-burning equipment, it is assumed that all the natural gas burned onsite is burned only in the 150-MMBtu/hr boilers. All six boilers burn distillate #2 fuel oil when the natural gas provider curtails delivery due to regionally high demand for natural gas during winter cold spells. In addition, the boilers burn distillate oil for test purposes. Other than the six boilers, the only other existing stationary equipment onsite that burns distillate oil is the emergency generators and fire pump engines, which are not included in this emission estimate since the 777X Project is not expected to result in an increase in emissions from those units.

The emission increase that will occur as a result of the Project from the existing boilers and other stationary fuel-burning equipment is the difference between projected actual emissions and baseline actual emissions. For purposes of this emission estimate, the 24-month period is taken to be 2012 and 2013. Baseline actual emissions, using 2012 and 2013 as the baseline years as shown in Table A-6, are calculated below.

Baseline actual emissions are:

= (3.26 + 3.32) / 2 = 3.29 tons/yr

In this analysis, projected actual emissions are based on a maximum anticipated production rate of 125 777X's per year and the 2012/2013 average production rate, (83 + 99)/2 = 91, for a projected increase of 34 airplanes a year over the baseline (125 – 91 = 34). A natural gas usage factor of 3,206 MMBtu/airplane is used to estimate projected actual emissions resulting from the increased production rate. A detailed analysis of this natural gas usage factor is found in Appendix B, Estimate of Non-Significant PSD Pollutant Emissions Increases from the 777X Project, and its associated Attachment A.

TABLE A-6. ESTIMATED VOC EMISSIONS BOILERS #1-6 FOR 2005 THROUGH 2012

Year	# of 777s Produced	Boilers #1-6 VOC Emissions (tons)
2005	44	2.59
2006	62	2.68
2007	83	2.92
2008[a]	68	3.00
2009	83	3.07
2010	71	2.94
2011	75	3.24
2012	83	3.26
2013	99	3.32

[a] A 2-month work stoppage occurred in 2008.

Distillate oil #2 is only burned in the boilers when the natural gas supply is curtailed or for test purposes. Therefore, the amount of fuel oil burned in the boilers annually is primarily dependent on the length of the curtailment (if any), not on the airplane production rate. In the baseline years of 2012 and 2013, natural gas was never curtailed, so very little fuel oil was burned in the boilers. In order to provide a conservative estimate of the projected actual VOC emissions increase from the boilers and other stationary fuel-burning equipment as a result of the Project, it is assumed that a curtailment period lasting nine manufacturing days (the highest number of days that natural gas was curtailed to the Everett site in any of the past 15 years) will occur. The same consumption factor derived for natural gas (3,206 MMBtu/airplane) is used for fuel oil. The estimate assumes distillate #2 fuel oil contains 140 MMBtu/1,000 gal (Figure 27.3 on page 27-10 of *Perry's Chemical Engineers' Handbook*[3]). The airplane manufacturing rate was derived from 125 airplanes produced in 250 work days per year for a daily rate of 0.5 airplane produced per day.

Projected natural gas emissions increase from Boilers #1-6 are:

= (34 planes/yr x 3,206 MMBtu/airplane x 5.4E-3 lb VOC/MMBtu) / 2,000 lb/ton
= 0.294 ton/yr

Projected fuel oil emissions increase from Boilers #1-6 are:

= (9 days/yr x 0.5 plane/day x 3,206 MMBtu/airplane x 0.200 lb VOC/1,000 gal) / (140 MMBtu/1,000 gal) / 2,000 lb/ton
= 0.010 ton/yr

Projected total emissions increase from Boilers #1-6 are:

= 0.294 ton VOC/yr + 0.010 ton VOC/yr
= 0.304 ton VOC/yr

[3] 8th Edition, October 2007.

Combustion Equipment Emissions Increases from New Emission Units

In addition to the increased emissions from the existing boilers and other existing natural gas combustion units, this Project is also proposing to add new combustion equipment for additional process heating. The actual-to-potential test, which is required for all new units being constructed as part of the Project, involves totaling the potential emissions of the proposed new emissions units, then subtracting past actual emissions of those units. A new unit that is being constructed as part of the Project has a baseline of zero (40 CFR 52.21(b)(48)(iii)). The estimated heat input for all new combustion emissions units for the Project are shown in Table A-7.

The potential total heat input per airplane for all process heaters is approximately 750,000 MMBtu per 12-month rolling total. Adding a safety factor of 1.33 to the potential total heat input yields a 12-month rolling total of approximately 1,000,000 MMBtu. Using this conservative total heat input and using standard EPA AP-42 emission factors, the potential emissions from new process heaters are:

= 750,000 MMBtu/year x 1.33 safety factor ≈ 1,000,000 MMBtu/year
= (1,000,000 MMBtu/year x 5.4E-3 lb VOC/MMBtu) / 2,000 lb/ton
= 2.7 tons VOC/year

Standby diesel generators are also proposed new emissions units as a part of this Project. Nine 2,750-kW generators and one or two 750-kW rated generator are proposed to provide standby power for the wing component fabrication process. The engines necessary to power the generators have a net power rating of 2,957 kW and 816 kW. As stated previously, the actual-to-potential test is required for these new emissions units. Estimated VOC emissions are based on Tier 2 EPA non-road engine emissions standards, the engine rating, and the maximum annual operating schedule of 100 hours per year as these engines qualify as emergency engines. They are:

= [(2,957 kW/engine x 9 engines) + (816 kW/engine x 2 engine)] x 100 hours/yr x 0.32 gram (g) VOC/kW-hr* / 1,000 g/kg / (1,000 kg/metric ton x 1.1 US tons/metric ton)
= 0.994 ton VOC/year

*Note: The EPA's Tier 2 NOx + non-methane hydrocarbons (NMHC) emission factor was apportioned to NOx and VOC by a ratio of 0.95 and 0.05, respectively, according to "The Carl Moyer Program Guidelines - Approved Revisions 2011", released March 27, 2013, California Environmental Protection Agency - Air Resources Board, Table D-25: Pollutant Fractions NOx + NMHC Standards.

Adding the total projected actual emissions increase from existing boilers to the potential emissions from the new process heaters and diesel generators yields the total VOC emissions increase from the Project from the existing and new combustion sources.

Total Project emissions increase from combustion sources is:

= 0.304 ton VOC/yr + 2.7 tons VOC/year + 0.994 ton VOC/year
= 4.00 tons VOC/year

TABLE A-7. COMBUSTION: NEW SOURCES

Emission Unit or Activity Identifier	Emission Unit or Activity Description	Estimated MMBtu of Fuel Consumed at 125 Planes per Year
WCF-2	Gas-fired heater for liquid nitrogen vaporization unit (if this option is chosen to supply autoclaves with nitrogen)	7,500
WCF-3a	Gas-fired process heater for autoclave #1	33,333
WCF-3b	Gas-fired process heater for autoclave #2	33,333
WCF-3c	Gas-fired process heater for autoclave #3	33,333
WCF-6a	Wing panel wash stall #1	2,668
WCF-6b	Wing panel wash stall #2	2,668
WCF-6c	Wing spar and stringer wash stall #1	640
WCF-6d	Wing spar and stringer wash stall #2	640
WCF-7	Gas-fired plasma unit for treatment of wing panel stringer	3,841
WCF-8a	Wing panel abrasive blast/sanding booth(s)	10,670
WCF-8b	Wing spar abrasive blast/sanding booth	1,280
WCF-9a	Wing panel spray booth #1	32,011
WCF-9b	Wing panel spray booth #2	32,011
WCF-9c	Wing spar spray booth #1	3,842
WCF-9d	Wing panel spray booth #3	32,011
WCF-9e	Wing panel spray booth #2	3,842
WCF-10a	Wing panel primer curing booth #1	16,006
WCF-10b	Wing panel primer curing booth #2	16,006
WCF-10c	Wing spar primer curing booth	3,841
WCF-14	Wing spar seal booth(s)	4,104
WBSP-10	Vertical fin HLFC prep booth	8,865
WBSP-11a	Vertical fin HLFC spray booth #1b	26,266
WBSP-11b	Vertical fin HLFC spray booth #2b	26,266
WBSP-11c	Vertical fin HLFC spray booth #3b	26,266
F-1	Combustion equipment for comfort or process heating not already identified above. This combustion equipment consists of multiple small units located throughout the wing component fabrication building.	388,271
Total	**All new process heaters**	**749,514 (~750,000)**

HLFC = hybrid laminar flow control

Total VOC Emissions Increase for the Project

Based on the above analysis, the total emissions increase for existing emissions units is estimated to be approximately 132 tons per year:

= 777 Assembly (105 tons/yr) + Interiors (18.0 tons/yr) + EDC (5.1 tons/yr) + Propulsion (0.34 ton/yr) + Emergent Operations (2.04 tons/yr) + ESRC (0.43 ton/yr) + Boilers (0.30 ton per year)
= 132 tons/yr

Based on the above analysis, the potential VOC emissions increase for new units is estimated to be approximately 288 tons per year:

= Wing Component Fabrication (235 tons/yr) + Interiors (33.8 tons/yr) + Wing Assembly (0.0 tons/yr) + Wing and Body Structures Seal/Paint (14.4 tons/yr) + Airplane Assembly (1.38 tons/ yr) + Process Heaters (2.72 tons/yr) + Generators (0.99 ton per year)
= 288 tons/yr

APPENDIX B. ESTIMATE OF NON-SIGNIFICANT PSD POLLUTANT EMISSIONS INCREASES FROM THE 777X PROJECT FOR TECHNICAL SUPPORT DOCUMENT OF PSD-14-01, AMENDMENT 1

APPENDIX B

Estimate of Non-Significant PSD Pollutant Emissions Increases from the 777X Project

The purpose of this appendix is to demonstrate that, other than for volatile organic compounds (VOCs), the 777X Project will not result in a significant emission increase of any pollutant regulated by the Prevention of Significant Deterioration (PSD) program.[4]

Table B-1 below lists the non-VOC PSD pollutants and identifies the operations, if any, at Boeing Everett that are expected to have emissions of those pollutants related to 777 production.

TABLE B-1. POLLUTANTS REGULATED BY PSD (OTHER THAN VOCS) AND THE OPERATIONS WITH EMISSIONS OF THOSE POLLUTANTS RELATED TO 777 PRODUCTION

Pollutants Regulated by PSD (Significant Emission Rate)	Operations Whose Emissions Might Increase as a Result of the 777 Project
Nitrogen Oxides (NOx) (40 tpy) Carbon Monoxide (CO) (100 tpy) Sulfur Oxides (SOx) (40 tpy) Particulate Matter (PM) (25 tpy) Particulate Matter Less Than 10 microns in Diameter (PM10) (15 tpy) Lead (0.6 tpy)	Boilers and other stationary fuel-burning equipment.
Ozone Depleting Substances (100 tpy)	Cleaning operations and other miscellaneous uses of ozone depleting substances
Fluorides (3 tpy) Sulfuric Acid Mist (7 tpy) Hydrogen Sulfide (H_2S) (10 tpy) Total Reduced Sulfur (including H_2S) (10 tpy) Reduced Sulfur Compounds (including H_2S) (10 tpy) Municipal Waste Combustor Organics (3.5×10^{-6} tpy) Municipal Waste Combustor Metals (15 tpy) Municipal Waste Combustor Acid Gases (40 tpy) Municipal Solid Waste Landfills Emissions (50 tpy)	There are no operations at Boeing Everett whose emissions of the listed pollutants might increase as a result of the 777 project.
Greenhouse Gases (75,000 tpy)	Boilers and other stationary fuel-burning equipment.

tpy = tons per year

4 In addition, at the request of Boeing, in order to assure PSD non-applicability for NOx, CO, CO2e, and PM2.5, the emission increases for NOx, CO, CO2e, and PM 2.5 from all new, modified and debottlenecked emission units and activities collectively are limited in Section V.2 of the permit to levels below the PSD significance thresholds.

Boilers and Other Fuel Burning Equipment

As discussed in Appendix A, the six natural-gas-fired industrial steam boilers provide steam for process and space heating in support of all twin-aisle airplane programs and interiors manufacturing operations at Boeing Everett. See Appendix A for a more detailed discussion on the boilers' operation and the assumptions used in the PSD determination calculations.

Table B-2 and Table B-3 show the applicable boiler emission factors on natural gas and distillate oil, respectively, taken from Section 1.3 and 1.4 in EPA's *AP-42: Compilation of Air Pollutant Emission Factors* (Fifth Edition) for each PSD pollutant, with the exception of the NOx emission factors shown for Boilers #4, 5, and 6 and the SO_2 emission factor for natural gas. Boilers #4, 5, and 6 were installed in the 1990s, are subject to 40 Code of Federal Regulations (CFR) Part 60 Subpart Db, and are equipped with low-NOx burners and flue gas recirculation. In addition, Boilers #4, 5, and 6 are subject to a PSD permit condition that limits the NOx emission rate to 0.05 lb/million British thermal units (MMBtu) on gas and 0.10 lb/MMBtu on distillate oil. Therefore, the NOx emission factors for Boilers #4, 5, and 6 are estimated at 0.05 lb/MMBtu on gas and 0.10 lb/MMBtu (or 14 lb/1,000 gal) on oil. Actual NOx emissions from Boilers #4, 5, and 6 as measured by their continuous emission monitor systems are consistently well below these limits. The SO_2 emission factor is based on 100 percent conversion of fuel sulfur to SO_2 and derived by multiplying the AP-42 SO_2 emission factor of 0.60 lb/million standard cubic feet (MMscf) by the ratio of site-specific sulfur content to sulfur content of 2,000 grains (gr)/MMscf assumed in AP-42. The site-specific sulfur content is based on the 2012 annual average sulfur content in natural gas of 0.61 gr per 100 scf as reported at the Williams Northwest Pipeline Sumas Compressor Station.

TABLE B-2. BOILER EMISSION FACTORS FOR NATURAL GAS

NOx (lb/MMBtu)	CO (lb/MMBtu)	PM, Total (lb/MMBtu)	SO_2 (lb/MMBtu)	Lead (lb/MMBtu)
0.137 (Boilers #1, 2, and 3) 0.05 (Boilers #4, 5, and 6)	0.08	0.0075	0.00654	4.9×10^{-7}

Note: With the exception of the NOx emission factor for Boilers #4, 5, and 6 and the SO_2 emission factor, all emission factors are taken from Table 1.4-1 and 1.4-2 of AP-42 and converted to units of lb/MMBtu.
SO_2 = sulfur dioxide

TABLE B-3. BOILER EMISSION FACTORS FOR DISTILLATE #2 FUEL OIL

NOx (lb/1,000 gal)	CO (lb/1,000 gal)	PM, Total (lb/1,000 gal)	$SO_2 + SO_3$ (lb/1,000 gal)	Lead (lb/1,000 gal)
19 (Boilers #1, 2, and 3) 14 (Boilers #4, 5, and 6)	5	3.3	147.7S, where S is wt. % sulfur in oil [a]	0.00126

Note: With the exception of the NOx emission factor for Boilers #4, 5, and 6, all emission factors are taken from Table 1.3-1, 1.3-2, and 1.3-10 of AP-42. The emission factor for lead in Table 1.3-10 has been converted to units of lb/1,000 gal.
[a] A PSD permit condition limits the sulfur content of the distillate oil burned in Boilers #4, 5, and 6 to 0.05% by weight. Since Boilers #1, 2, and 3 draw their oil from the same tank used by Boiler #4, they too burn oil with a sulfur content of 0.05% by weight or less. At 0.05% by weight sulfur, the SOx emission factor from fuel oil combustion is 147.7 x 0.05 = 7.39 lb/1,000 gal.

SO_3 = sulfur trioxide

Boilers #1, 2, and 3 are equipped with low-NOx burners. Therefore, the NOx emission factor of 140 lb/10^6 standard cubic feet (0.137 lb/MMBtu) is the applicable emission factor from Table 1.4-1 in AP-42 when these boilers are combusting gas. Consistent with Table 1.3-14 of AP-42, the NOx emission factor of 24 lb/1,000 gal shown in Table 1.3-1 of AP-42 for No. 2 oil-fired boilers greater than 100 MMBtu/hr is reduced by 20 percent to account for the fact that Boilers #1, 2, and 3 are equipped with low-NOx burners.

The emission increase that will occur as a result of the 777X Project from the existing boilers and other stationary fuel-burning equipment is the difference between projected actual emissions and baseline actual emissions. For all new combustion emissions units, the emission increase will be estimated by calculating their potential emissions, with a baseline of zero.

As defined in 40 CFR 52.21(b)(48), baseline actual emission is the rate of emission in tons per year at which an emission unit actually emitted the pollutant during any consecutive 24-month period within the 10-year period immediately preceding actual construction of the project. Table B-4 shows the past 10 years of actual emissions from Boilers #1-6. For purposes of this emission estimate, the 24-month period is taken to be 2012 and 2013.

TABLE B-4. ACTUAL EMISSIONS BOILERS #1-6 FOR 2004 THROUGH 2012 (tons)

Year	CO	NOx	PM	SOx	Lead	CO_2e
2004	41.3	50.8	4.01	1.58	3.7E-04	60,556
2005	39.7	59.3	3.66	1.04	2.7E-04	57,163
2006	41.1	52.9	3.83	1.15	2.9E-04	59,442
2007	44.7	53.8	4.04	0.98	2.7E-04	63,950
2008	45.8	54.0	4.14	1.00	2.7E-04	65,543
2009	46.9	59.1	4.25	1.03	2.8E-04	67,176
2010	44.9	58.3	4.06	0.98	2.7E-04	64,241
2011	49.4	61.8	4.47	1.08	2.9E-04	70,784
2012	49.9	57.4	4.51	1.09	3.0E-04	71,367
2013	50.7	61.9	4.59	1.10	3.0E-04	72,553

CO_2e = carbon dioxide equivalent

Baseline emissions were highest in 2012/2013 for CO, PM, and CO_2e; however, SO_2, lead, and NOx had higher baseline emissions in years other than 2012/2013. For this analysis 2012/2013 was chosen as the baseline years for all pollutants. The 2012/2013 actual emissions from Boilers #1-6 were averaged to calculate the baseline actual emissions, as shown in Table B-5.

TABLE B-5. BASELINE ACTUAL EMISSIONS FROM BOILERS AND OTHER STATIONARY FUEL BURNING EQUIPMENT (tpy)

Year	CO	NOx	PM	SOx	Lead	CO_2e
2012/2013	50.3	59.6	4.55	1.10	3.0E-04	71,960

As defined in 40 CFR 52.21(b)(41), projected actual emissions means the maximum annual rate, in tons per year, at which the emission unit is projected to emit in any one of the 5 years following the date the emission unit resumes regular operations after the project (10 years if the project involves increasing the emission unit's design capacity or potential to emit and full utilization of the unit would result in a significant emission increase). Projected actual emissions exclude that portion of the emission unit's emissions following the project that the existing unit could have accommodated during the consecutive 24-month period used to establish the baseline actual emissions and that are unrelated to the project.

For the 777X Project, projected actual emissions from the boilers and other stationary fuel-burning equipment are taken to be the baseline actual emissions plus the emissions increase that results from producing additional 777s above the number produced in the baseline years of 2012 and 2013, once the Project is complete. Excluded from projected actual emissions from the boilers and other stationary fuel-burning equipment are emission increases that may result from any increased production (relative to the baseline years) associated with the other airplane models at Boeing Everett since those emissions are unrelated to the Project, and the boilers and other stationary fuel-burning equipment could have accommodated those emissions during the baseline years.

Attachment A contains a chart showing Boeing Everett's natural gas consumption, measured in MMBtu, and the number of airplane deliveries for the years 1998 through 2004. The chart displays two sets of data points with a "best fit" line drawn through each set. The upper set of data points is the natural gas consumption versus airplanes delivered when both the Building 40-12 (i.e., Boilers #1-4) and Building 45-07 (i.e., Boilers #5 and 6) boiler plants were operating. The lower set of data points is natural gas consumption versus airplanes delivered when only the Building 40-12 boiler plant was operating. (The data were split into two sets since, as the chart shows, the baseline natural gas consumption for the site [i.e., the natural gas consumption for the site regardless of the number of airplanes delivered] is lower when only the Building 40-12 boiler plant is operating.) The "best fit" line through each set of data points was determined using linear regression. The slopes of these lines (3,206 MMBtu/airplane for the upper line, 3,101 MMBtu/airplane for the lower curve) provide an estimate of the natural gas consumed per additional airplane delivered.

During the baseline years of 2012 and 2013, 182 777s were produced at Boeing Everett, or an average of 91 per year. A total of 125 777s per year is projected to be produced once the 777X Project is complete. Using the highest natural gas usage factor (3,206 MMBtu/airplane) shown in the chart in order to maintain conservatism, the additional natural gas that is estimated to be consumed annually at Boeing Everett as a result of the 777 Project is:

= (125 – 91) x 3,206 MMBtu/airplane
= 109,004 MMBtu/yr

Assuming this natural gas is distributed between Boilers #1-3 and Boilers #4-6 in the same approximate percentages as occurred in years past (i.e., 70 percent to Boilers #1-3 and 30 percent to Boilers #4-6), then the projected actual NOx emissions from natural gas combustion in the boilers and other stationary fuel-burning equipment as a result of the 777X Project are:

= (109,004 MMBtu/yr) x [(0.7) x (0.137 lb NOx/MMBtu) + (0.3) x (0.05 lb NOx/MMBtu)]/2,000 lb/ton

= 6.04 tons NOx/yr

As mentioned above, distillate oil #2 is only burned in the boilers when natural gas is curtailed or for test purposes. Therefore, the amount of fuel oil burned in the boilers annually is primarily dependent on the length of the curtailment (if any), not on airplane production rate. In order to provide a conservative estimate of the projected actual NOx emissions increase from the boilers and other stationary fuel-burning equipment as a result of the 777X Project, it is assumed that a curtailment period lasting 9 manufacturing days (the highest number of days that natural gas was curtailed to the Everett site in any of the past 15 years) will occur. The same consumption factor derived for natural gas (3,206 MMBtu/airplane) is used for fuel oil. The estimate assumes distillate #2 fuel oil contains 140 MMBtu/1,000 gal (Figure 27.3 on page 27-10 of *Perry's Chemical Engineers' Handbook*[5]).

Distillate fuel used during curtailment period is:

= (9 days curtail) x (0.5 777s /day) x (3,206 MMBtu/airplane) / (140 MMBtu/1,000 gal)
= 103,000 gal/yr

Again assuming this distillate fuel is distributed between Boilers #1, 2, and 3 and Boilers #4 and 6 in the same approximate percentages as occurred in past years for natural gas, then the projected actual NOx emissions from distillate fuel combustion in the boilers as a result of the 777X Project are:

= (103,000 gal/yr) x [(0.7) x (19 lb NOx/1,000 gal) + (0.3) x (14 lb NOx/1,000 gal)] / 2,000 lb/ton
= 0.902 ton NOx/yr

Total projected actual NOx emissions from the boilers and other stationary fuel-burning equipment related to the 777X Project is therefore 59.6 + (6.04 + 0.902) = 66.5 tpy. Projected actual emission estimates for the other pollutants identified in Tables B-4 and B-5 from the boilers and other stationary fuel-burning equipment were calculated in a similar manner and are shown in Table B-6. Table B-7 shows the emissions increase of each pollutant (i.e., the difference between projected actual emissions in Table B-6 and baseline actual emissions in Table B-5). The emission increases for all the pollutants are below their respective PSD significance rates.

TABLE B-6. PROJECTED ACTUAL EMISSIONS FROM BOILERS AND OTHER STATIONARY FUEL-BURNING EQUIPMENT RELATED TO THE 777X PROJECT (tpy)

CO	NOx	PM	SOx	Lead	CO_2e
54.9	66.6	5.1	1.8	0.0004	79,500

TABLE B-7. EMISSION INCREASES FROM BOILERS AND OTHER STATIONARY FUEL-BURNING EQUIPMENT AS A RESULT OF THE 777X PROJECT (tpy)

CO	NOx	PM	SOx	Lead	CO_2e
4.62	6.95	0.58	0.70	0.00009	7,500

5 8th Edition, October 2007.

Details of these calculations are shown in Table B-8. The emissions from the new natural gas fired combustion units were based on the emission factors in Table B-9 and a proposed limit of 1,000,000 MMBtu/yr. Detailed calculations of the emissions from the proposed emergency generators are shown in Table B-10.

Ozone Depleting Substances (ODS)

ODS are found in a handful of chemical products onsite, but by far the greatest use of ODS is 1,1,2-trichloro-1,2,2-trifluoroethane as a cleaning solvent. Based on 2004 hazardous materials use records, 0.09 ton of ODS per airplane was used. It is assumed that all the ODS used are emitted to the atmosphere.

The emission increase that will occur as a result of the 777X Project is the difference between projected actual emissions and baseline actual emissions. During the baseline years of 2012 and 2013, a total of 182 777s were produced at Boeing Everett, or an average of 91 per year. The estimated emission increase of ODS that will occur as a result of the 777X Project is:

= (125 – 91) x 0.09 ton ODS/airplane
= 3.06 tons ODS/yr

This is less than the 100 tons/yr significant emission rate for ODS.

Table B-8

Combustion Emission Calculations for VOC PSD Determination

	Factors											
		Total Gas Used in Baseline Period:	2.44E+06	MMBtu/ 2-yr		1.22E+06	MMBtu/yr					
		Gas Used in Boilers 1-3 in Baseline Period:	1.70E+06	MMBtu/ 2-yr		8.50E+05	MMBtu/yr					
		Gas Used in Boilers 4-6 in Baseline Period:	7.40E+05	MMBtu/ 2-yr		3.70E+05	MMBtu/yr					
		Total Oil Used in Baseline Period:	1544	Gal/2-yr		0.772	1000 Gal/y	140	MMBtu/1000 gal		108.08	MMBtu/yr
	Baseline Years:	2012 - 2013	ıonth Avg Production:		91	airplanes/yr						
	Pollutant of Concern:	VOC										
Baseline												
			CO	NOx 1-3	NOx 4-6	NOx Total	PM	SO2	Lead	VOC	CO2e	
Gas	Emission Factor	lb/MMBtu	0.08	0.137	0.05		0.0075	0.00059	4.90E-07	0.00539	117.004	
	Emissions	Ton/yr	48.80	58.23	3.80	62.03	4.58	0.36	0.0003	3.29	71,372	
Oil	Emission Factor	lb/1000 gal (lb/MMBtu of GHG)	5	19	14		3.3	7.385	0.00126	0.2	163.5916	
	Emissions	Ton/yr	0.00	0.01	0.01	0.01	0.00	0.00	0.0000	0.00	8.84	
	Total Baseline	Tons/yr	50.27			59.64	4.55	1.10	0.0003	3.29	71,960	
			Gas increase:			Oil increase:				Fraction of fuel burned in Boilers 1-3:	Fraction of fuel burned in Boilers 4-6:	
			3,206	MMBtu/plane		9	day/yr on oil			0.7	0.3	
			34	plane/yr		0.5	plane/day					
			109,004	MMBtu/yr		14,427	MMBtu/yr		Gas:	76,302.80	32,701	
						103.05	1000 gal/yr		Oil:	72.14	30.92	
			CO	NOx 1-3	NOx 4-6	NOx Total	PM	SO2	Lead	VOC	CO2e	
Gas	Emission Factor	lb/MMBtu	0.08	0.137	0.05		0.0075	0.00059	4.90E-07	0.00539	117.004	
	Emissions	Ton/yr	4.36	5.23	0.82	6.04	0.41	0.03	0.00003	0.294	6,377	
Oil	Emission Factor	lb/1000 gal (lb/MMBtu of GHG)	5	19	14		3.3	7.385	0.00126	0.2	163.5916	
	Emissions	Ton/yr	0.26	0.69	0.22	0.902	0.17	0.38	0.00006	0.010	1,180.07	
	Total Increase	Tons/yr	4.62	5.91	1.03	6.95	0.58	0.41	0.00009	0.304	7,557	

Table B-9. NSR Pollutants and Combustion Emissions from Natural Gas Combustion

Pollutant	Emission Factor (lb/MMBtu)	Annual Emissions-1,000,000 MMBtu/yr (tpy)
CO @ 50 ppm	0.04	20
NO_x (low NOx)	0.012	6
SO_2	0.001	0.5
PM	0.008	4
PM_{10}	0.008	4
$PM_{2.5}$	0.008	4
VOC	0.0054	2.7
Ozone	NA	-
Lead	NA	-
Fluorides	NA	-
Sulfuric Acid Mist	NA	-
H_2S	NA	-
Total Reduced Sulfur	NA	-
Reduced Sulfur Compounds	NA	-
Ozone-Depleting Substances	NA	-
Greenhouse Gases	118.8	59,411

Table B-10. Diesel Engine Emissions

					CO	NOx[a]	VOC[a]	PM	SO2[b, c]	CO2e[b]
EPA Tier 2 Standards				g/kW-hr	3.5	6.08	0.32	0.2		
				lb/hp-hr					0.0004045	1.16
kW	**BHP**	**Eng. kW**	**No. Eng.**	**Hr/eng.**	**Annual Emissions (tpy)**					
2,750	3,965	2,957	9	100	10.24	17.80	0.94	0.59	0.74	2,119
750	1,094	816	2	100	0.63	0.1.09	0.057	0.04	0.05	133
				Total	**10.87**	**18.89**	**0.99**	**0.62**	**0.79**	**2,252**

[a] The EPA's Tier 2 NOx + NMHC emission factor was apportioned to NOx and VOC by a ratio of 0.95 and 0.05, respectively, according to "The Carl Moyer Program Guidelines - Approved Revisions 2011", released March 27, 2013, California Environmental Protection Agency - Air Resources Board, Table D-25: Pollutant Fractions NOx+NMHC Standards.
[b] AP-42 Table 3-4.1.
[c] Assume 500 ppm sulfur.

ATTACHMENT A