Prevention of Significant Deterioration Application for Changes Related to 737 Production Capacity Increase

Prepared for

Boeing Commercial Airplanes - Renton

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Washington Department of Ecology

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1. Project Description

Boeing Commercial Airplanes' Renton facility (Boeing Renton) produces single-aisle airplanes and is located in Renton, King County, Washington (Figure 1-1). Boeing manufactures the 737 model airplane in Renton and proposes to make changes to the facility that will enable it to increase the production capacity from the current rate of about 376 737 airplanes per year to a maximum of about 504 737 airplanes per year.

The Washington Department of Ecology (Ecology) has issued several Prevention of Significant Deterioration (PSD) permits for Boeing Renton. These include the following:

- PSD-08-01 for the Boeing Renton Site, 5-50 Paint Hangar and Buildings 4-20, 4-21, 4-81, and 4-82. PSD-08-01 limits the VOC emissions from Buildings 4-20, 4-21, 4-81, and 4-82 to 118 tons per year (tpy). Boeing is not seeking to change that limit with this application; however, the project will result in physical and operational changes in Building 4-20.
- PSD-88-4 for the Boeing Renton Site, 4-41 Paint Hangar. PSD-88-4 Condition 1 of that permit limits volatile organic compound (VOC) emissions from Building 4-41 to 124 tpy. There will be no physical or operational changes to Building 4-41 because of this project and Boeing is not seeking any changes to the limits.
- PSD-97-2 for the Boeing Renton Site, Building 4-86. PSD-97-2 Condition 2 limits VOC emissions from Building 4-86 to 242 tpy. Boeing is not seeking to change that limit with this application; however, the project will result in physical and operational changes in Building 4-86.

Model 737 assembly operations primarily occur in Buildings 4-20, 4-21, 4-42, 4-81, 4-82, and 4-86 and can be grouped as follows.

- Wing Assembly Operations include assembling the upper and lower wing panels. These operations primarily occur in Buildings 4-20 and 4-21.
- Wing Clean, Seal, Test, and Paint Operations include cleaning the complete wing assemblies, sealing them including the interior surfaces of the fuel tank, applying corrosion inhibiting compounds, testing the fuel tank for leaks, correcting any leaks, and painting the exterior surfaces. These activities only occur in Building 4-86.
- Final Assembly Operations include joining the wings and tail assemblies to the fuselage, adding the necessary electrical systems, hydraulic systems, and interiors. These operations occur in Buildings 4-81 and 4-82.
- Delivery Operations include final painting, any necessary depainting, and preparing the airplane for delivery. These operations occur in Building 4-42 and the paint hangars. Some airplanes receive their final exterior coating in Building 4-41 Paint Hangar and some in the 5-50 Paint Hangar. Others are flown offsite because Renton does not have the capacity to apply the final exterior coating to all the airplanes produced in Renton.

- Combustion Operations include the boilers and heaters and backup diesel generators. The boilers are located in Building 4-89 and 5-50.

These operations include the assembly of various sub-assemblies (e.g., wing spars and wings) from their component parts; the installation of various airplane systems (e.g., hydraulic, fuel, electrical) in the sub-assemblies; final assembly of a complete airplane structure and integration of the airplane systems; the installation of landing gear, engines, and interior components (e.g., seats, sidewalls, partitions); and functional testing. The main body sections (fuselages) are assembled in Kansas and are delivered to Boeing Renton by rail. Air emissions primarily occur from activities such as spray coating, sealing, hand-wipe and flush cleaning, and the use of miscellaneous adhesives, resins, and other products that contain volatile organic compounds.

As part of this project, Boeing intends to replace four existing wing panel spray booths (covered under the existing PSD 08-01) in Building 4-20 (Figures 1-2 and 1-3) with four new booths at another location in Building 4-20 to allow replacement of the vertical wing build line with a new horizontal wing build line (HBL). No other new or modified spray booths are planned, and no other emission units would be added or modified in Building 4-20 as part of this project.

Model 737 wings have two major wing panels, the upper and lower surfaces of the wing. Before assembling the two panels together, the wing panels are cleaned, sealed, and coated with protective coatings. These cleaning, sealing, and coating operations are the source of VOC emissions.

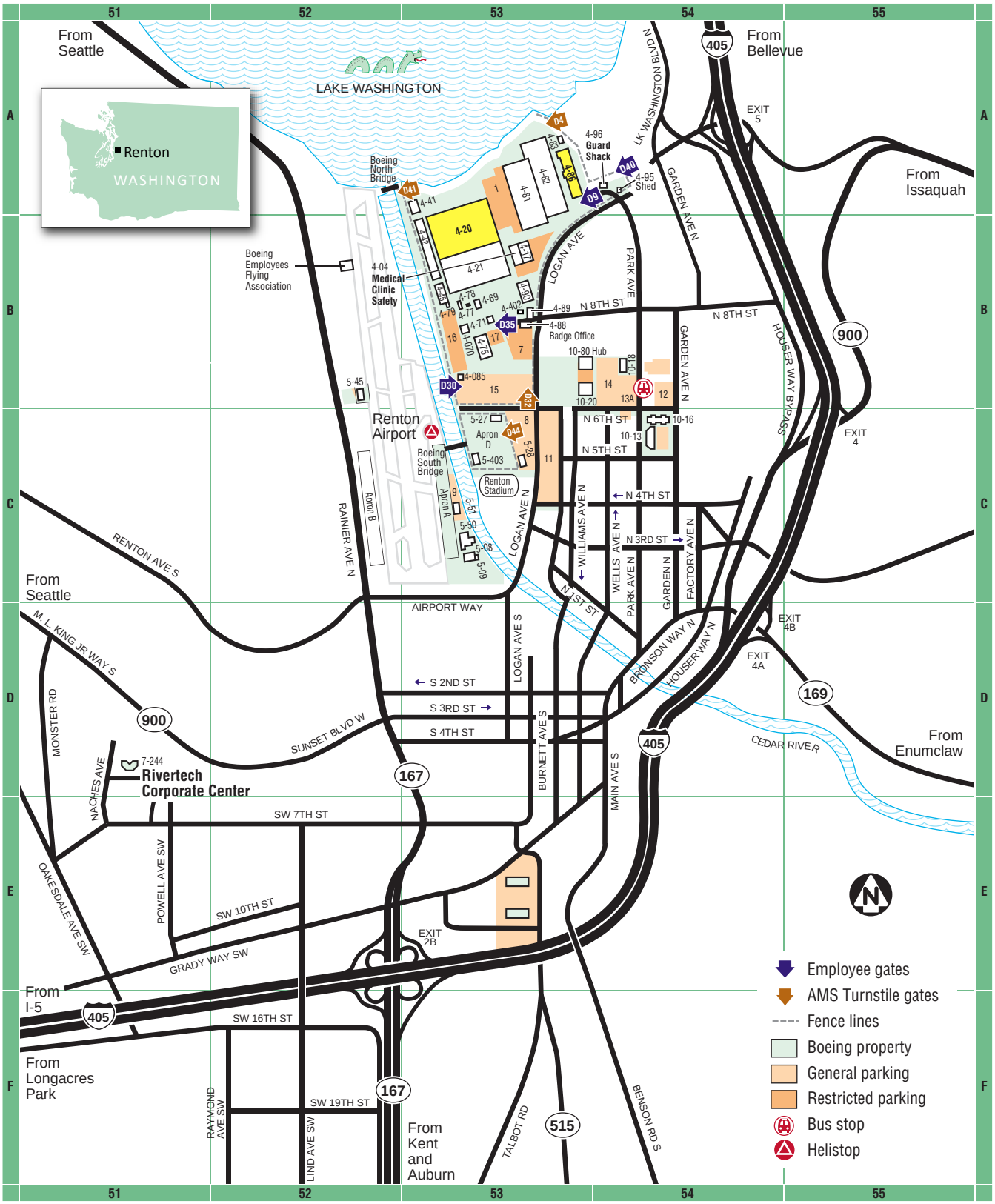
In Building 4-86 (Figures 1-4 and 1-5), Boeing paints wings that are mostly assembled. Boeing intends to add one new booth (PB-4) that will paint the upper and lower sections of the wing with the wing in a vertical position. To improve the quality of the paint finish, the exhaust rate on one existing inspar (vertical) wing booth (PP-8) would be increased. Because, PP-8 will undergo a physical change that will allow more wings to be painted that meet the current quality requirements, the changes to PP-8 are considered a modification for PSD purposes.

In addition to the changes described above, Boeing intends to make other changes to 737 assembly operations that are not expected to involve changes to spray booths or other emission units. These changes include, but are not necessarily limited to, installing a new wing-riveter, a second Wing Horizontal Build Line and other miscellaneous assembly tooling. Table 1-1 summarizes the proposed actions for each building.

TABLE 1-1
Summary of Proposed Project

Building	Changes
4-20	4 replacement wing panel booths New Wing Horizontal Build Line New Wing-riveter Miscellaneous assembly tooling
4-86	1 new inspar (vertical) wing booth Install new fan(s) in an existing inspar wing booth

VOC emissions from all 737 assembly operations at Boeing Renton, excluding painting of completed aircraft, average about 0.46 ton per airplane. Of the 0.46 ton per airplane, the projected potential VOC emissions from each of the wing panel booths in Building 4-20 are about 22 pounds per airplane, or about 2.08 tpy per booth. The new and modified booths in Building 4-86 would each emit 130 pounds of VOCs per airplane for a potential VOC emission rate of 11.86 tpy per booth.



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North

0 0.5 1

Approximate scale in feet

FIGURE 1-1
Site Map
Boeing

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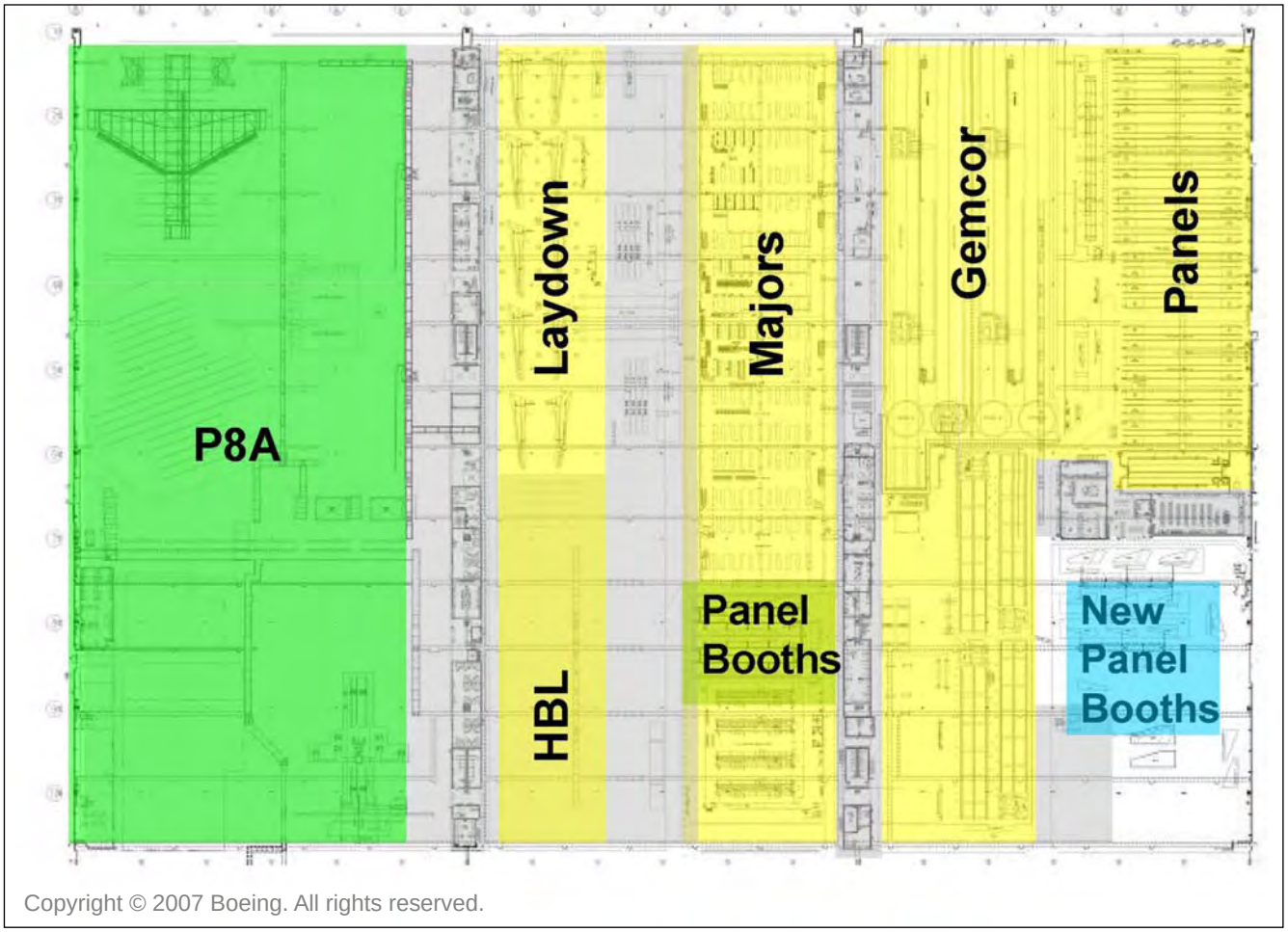

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North

FIGURE 1-2
Current Building 420 Layout
Boeing

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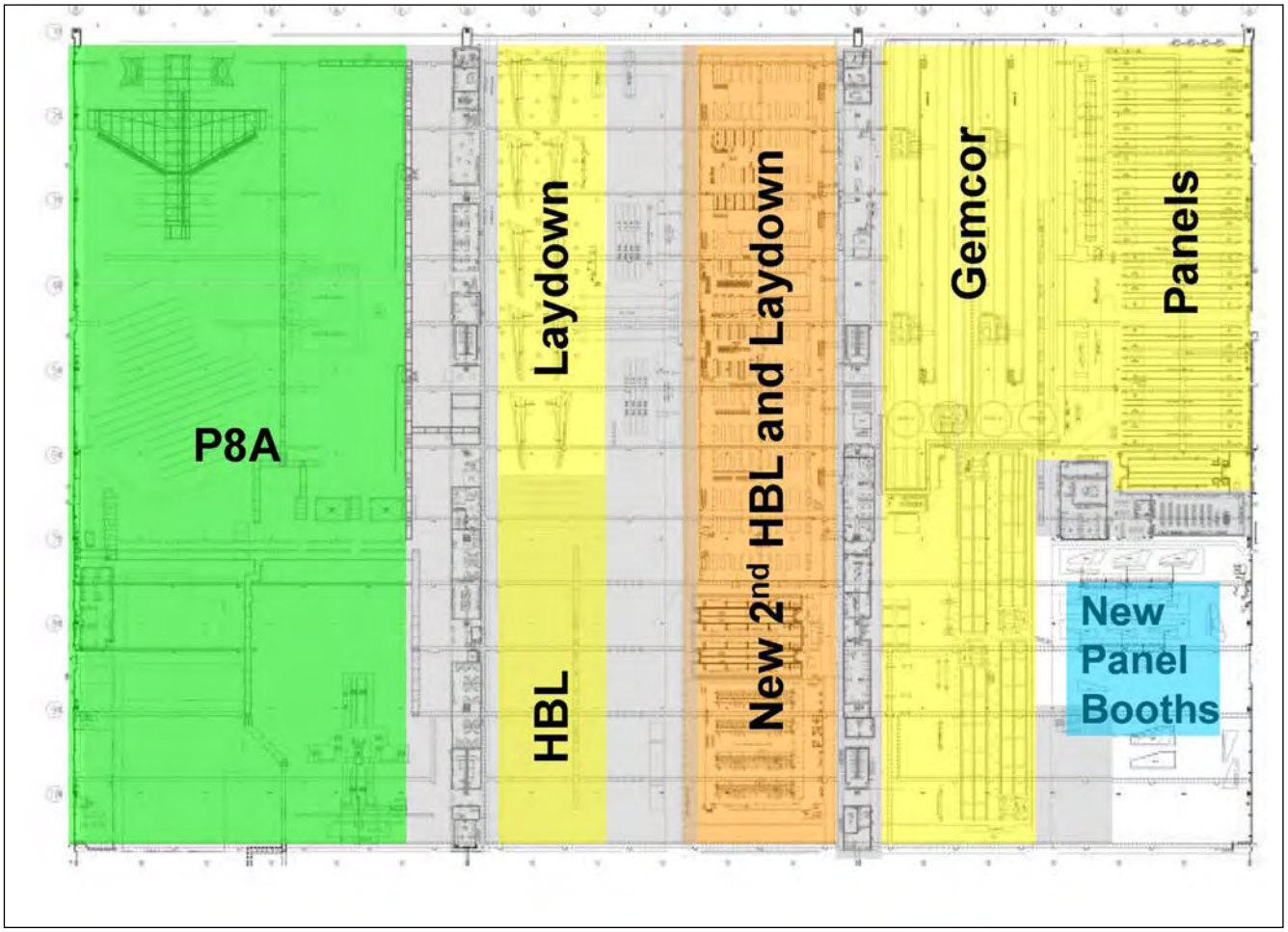

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North

FIGURE 1-3
Future Building 420 Layout
Boeing

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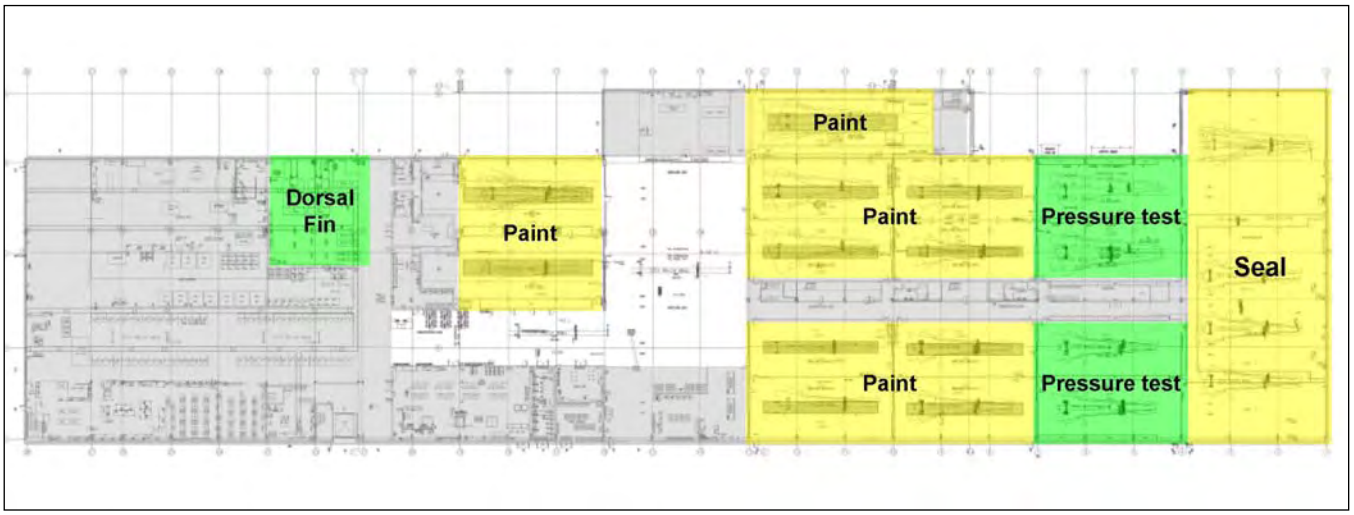

North

FIGURE 1-4
Current Building 4-86 Layout
Boeing

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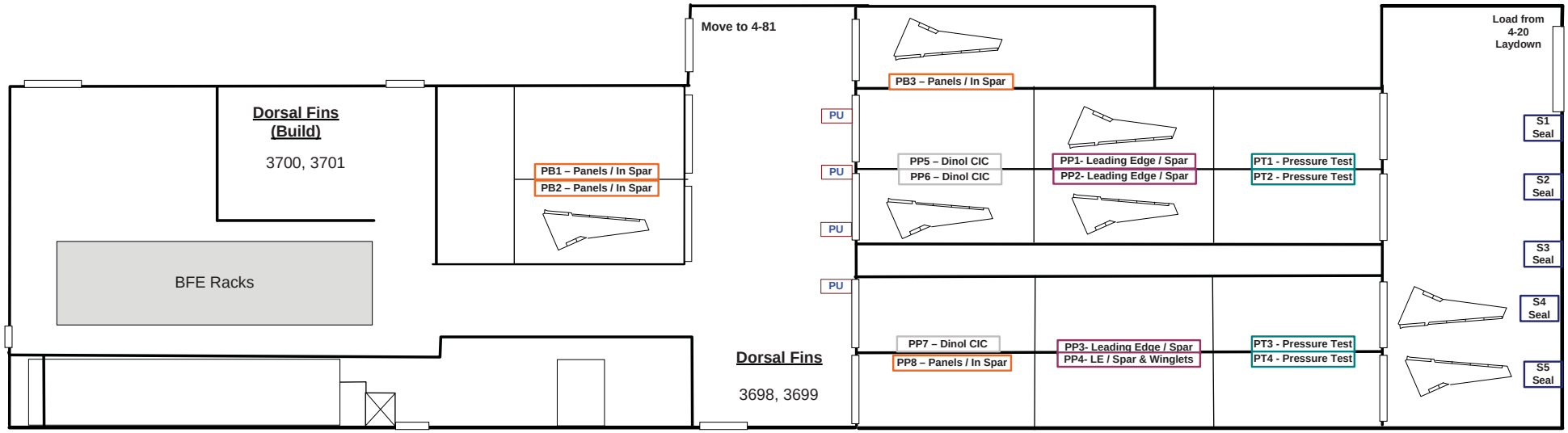

FIGURE 1-5
Building 4-86 Layout Detail
Boeing

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2. Prevention of Significant Deterioration

The Prevention of Significant Deterioration (PSD) program is intended to protect current levels of air quality and to ensure that the air quality does not significantly deteriorate in areas that meet the National Ambient Air Quality Standards (NAAQS). The program requires certain major emissions sources and major modifications to undergo a specific review procedure. The federal PSD requirements are contained in 40 Code of Federal Regulations (CFR) 52.21; however, in Washington State the U.S. Environmental Protection Agency (EPA) has delegated much of the implementation of the program to the Washington Department of Ecology (Ecology). Ecology implements the PSD program under Washington Administrative Code (WAC) 173-400-720. Under 40 CFR 52.21(a)(2)(iv)(a), "a project is a major modification for a regulated NSR pollutant if it causes two types of emissions increases—a significant emissions increase (as defined in paragraph (b)(40) of this section), and a significant net emissions increase (as defined in paragraphs (b)(3) and (b)(23) of this section)." The significant emissions increase analysis (often called Step 1) looks only at the emissions from the proposed project and the significant net emissions increase (often called Step 2) looks at additional increases from related projects.

For the significant emissions increase analysis, the proposed project will involve both constructing new emissions units and modifying existing units. PSD requires use of the Hybrid Test for projects that involve both the addition of new emission units and the modification of existing emission units (40 CFR 52.21(a)(2)(iv)(f)). Under the Hybrid Test, a significant emissions increase of a regulated New Source Review (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 significant amount for that pollutant (as defined in paragraph 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 from those units. The Actual-to-Potential test involves totaling the potential emissions of the proposed new emission units.

If the project would result in a significant emissions increase, then a significant net emissions increase analysis is often conducted. Although EPA has clearly stated that calculating a net emissions increase is at the source's option (see, for example, 67 Fed. Reg. 80186, at 80197 [December 31, 2002]) and therefore a source may seek a PSD permit based on a calculated significant emission increase alone.

Because the Boeing Renton facility currently has the potential to emit more than 250 tpy of a regulated NSR pollutant, Boeing Renton is considered a "major stationary source" for PSD purposes, as defined by 40 CFR 52.21 (b)(1)(i).

The purpose of this project is to increase Boeing's ability to produce Model 737 airplanes from current production of about 376 airplanes per year to a maximum of about 504 airplanes per year. One of the main bottlenecks in the current 737 assembly operation is assembling and

painting the wings. To remove this bottleneck, Boeing proposes to replace four existing wing panel spray booths in Building 4-20 with four new booths at another location in Building 4-20, and in Building 4-86 add a new wing booth and increase the exhaust rate on one existing inspar (vertical) wing booth (PP-8) (see Table 1-1) to improve the quality of the paint finish. Other debottlenecking activities related to this project include adding a new wing horizontal build line in Building 4-20 (some of which will occupy the space that the four current Wing Panel Booths occupy), installing a new wing riveter, and installing other miscellaneous assembly tooling in Building 4-20. None of these other debottlenecking activities are VOC emission units. There no other physical changes or changes in method of operation anticipated at the Renton facility as a result of this project.

As a result of the increased 737 production capacity enabled by this project, the emissions from the 737 assembly operations are expected to increase. Boeing intends to begin operating Paint Hanger 5-50 at the same time as the proposed project, but it was subject to Ecology-issued PSD permit 08-01 and is not included in this analysis.

2.1 Significant Emissions Increase Analysis

As stated above, this project will involve both modifying existing emission units and constructing new emission units, therefore a hybrid test is required under 40 CFR 52.21(a)(2)(iv)(f). The hybrid test involves both 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.

2.1.1 Actual-to-Projected-Actual Applicability Test

For existing emission units, the PSD baseline emissions are the 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 (see 40 CFR 52.21(b)(48)(ii)(d)). For this project, the 10-year period from which the baseline period may be selected for all NSR regulated pollutants begins in 2001 and includes the full calendar years 2002 through 2010.

Table 2-1 presents the VOC emissions from 737 assembly operations and the number of 737s produced for the 6 years 2005 through 2010. (The table does not include data from 2001 through 2004 because the maximum number of 737s produced during any 24-consecutive-month period from 2001 through 2004 that is part of the 10-year period is fewer than the number of 737s produced during any 24 consecutive months from 2005 through 2010.) Boeing has selected 2009 and 2010 calendar years as the baseline period for VOC emissions. During the baseline period that average production rate was 374 airplanes per year.

TABLE 2-1
Estimated VOC Emissions from 737 Assembly Operations for 2005 through 2010

Year	Number of 737s Produced	Estimated VOC Emissions (tons)	Estimated VOC Emissions per Airplane (tons)
2005	214	84	0.33
2006	302	133	0.38
2007	330	154	0.41
2008[a]	290	124	0.36
2009	372	163	0.36
2010	376	174	0.46

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

Increased 737 production enabled by the project is expected to result in increased emissions from the 737 assembly operations and related combustion from boilers and heaters. Note that while Building 5-50 paint hangar will become operational before the project is completed, its operation and emissions are unrelated to this project and its operation was permitted under a recent PSD permit issued by Ecology.

Table 2-2 lists the projected actual emissions from the 737 assembly operations and related operations that are expected to increase emissions as a result of the increased 737 production enabled by the project. The increased emissions is primarily achieved by debottlenecking the assembly operations as via the increased capacity of the wing assembly operations in Building 4-20 and Building 4-86. Details of the emission estimates are shown in Appendix A. The project actual VOC emissions were based on the baseline emission multiplied by the ratio of the future estimated maximum production rate of 504 airplanes per year and the baseline production rate of 374 airplanes per year. Note that with the exception of combustion-related emissions, the emissions listed in Table 2-2 are specific to 737 production only. Because the combustion operations provide heat and energy to all operations at the Boeing Renton facility, including operations such as office buildings that are not directly related to production, emissions from combustion are treated differently than from the other operations. The projected actual emission rate for combustion operations is the baseline rate for the entire Boeing Renton facility plus the expected additional heat required for the production capacity increase based on an average heat usage of 1,209 million British thermal units (MMBtu) of natural gas per airplane and 31,550 gallons of oil. For natural gas, the maximum usage rate per airplane in the last 5 years was used. The maximum oil firing rate was estimated based on double the maximum amount of oil burned in any of the last 5 years. The emissions of greenhouse gases were estimated based on the maximum emission rate per airplane in the last 5 years for Scope 1 Stationary Sources combustion sources, of 71 tons of carbon dioxide equivalent (CO_2e) per airplane in 2008. Similarly, the manufacturing process results in emissions of 7.6 tons of CO_2e per airplane in 2008 in the form of hydrofluorocarbons (HFC).

TABLE 2-2
Projected Actual Emissions of Regulated NSR Pollutants for Existing 737 Assembly Operations and Related Operations (tpy)

Operation	CO	NOx	PM [a]	SOx	Lead	VOC	CO_2e
Wing Assembly						79.0	
Wing Coating						102.5	
Final Assembly						19.3	
Paint Hangar/ Flightline						48.7	
737 Assembly [b]							3,855
Combustion [c]	24.4	62.9	2.3	0.3	0.0002	1.6	35,553
Total	**24.4**	**62.9**	**≤3.3**	**0.3**	**0.0002**	**251.1**	**39,408**

CO = carbon monoxide
NOx = nitrogen oxides
PM = particulate matter
SOx = sulfur oxides

[a] PM, NOx, SOx, and Lead emission from non-combustion sources will be less than 1 tpy
[b] All CO2e emissions are accounted for in 737 Assembly
[c] All combustion-related emissions are accounted for in Combustion.

VOC emissions from the 4-41 Hangar/Flightline operations include final exterior painting of 12 additional airplanes per year. While Boeing has not decided if the 12 additional airplanes per year would be painted in the 4-41 Paint Hangar, it is physically possible to do so, although currently the paint hangars at Boeing's Renton facility are being operated at or near capacity, with many airplanes being flown offsite for final coating. The 5-50 paint hangar is currently being modified, but that project is unrelated to this project.

Table 2-3 lists the baseline actual emissions for calendar years 2009 and 2010 from the 737 assembly operations and related operations that are expected to experience an emission increase as a result of the increased 737 production enabled by the project, except that CO_2e is based on 2006 and 2007. Emissions for the Building 4-20 paint booths that will be shutdown are not included, nor are the emissions from the proposed new booths.

TABLE 2-3
Baseline Actual Emissions of Regulated NSR Pollutants for Existing 737 Assembly Operations and Related Operations (tpy in 2009-2010 except for CO_2e, which was in 2006-2007)

Operation	CO	NOx	PM[a]	SOx	Lead	VOC	CO_2e
Wing Assembly						58.6	
Wing Coating						76.0	
Final Assembly						14.3	
Paint Hangar/ Flightline						36.2	
737 Assembly[b]							2,714
Combustion[c]	13.3	34.2	1.3	0.1	0.0	0.9	22,039
Total	**13.3**	**34.2**	**≤2.3**	**0.1**	**0.0**	**186.0**	**24,753**

[a] PM emission from non-combustion sources were less than 1 tpy
[b] All CO2e emissions are accounted for in 737 Assembly
[c] All combustion-related emissions are accounted for in Combustion

During the baseline period, Boeing Renton 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 this application. Therefore, no adjustments are required under 40 CFR 52.21(b)(48)(ii)(b) or (c). Table 2-4 shows the difference between the actual emissions from existing emission units and the projected actual emissions from the existing emission units.

TABLE 2-4
Emissions Increases of Regulated NSR Pollutants for Existing 737 Assembly Operations and Related 737 Operations (tpy)

	CO	NOx	PM	SOx	Lead	VOC	CO_2e
Projected	24.4	62.9	3.3	0.3	0.00017	251.1	39,408
Baseline	13.3	34.2	2.3	0.1	0.00008	186.0	24,753
Total Increase from Existing Sources	**11.2**	**28.7**	**1.0**	**0.2**	**0.00009**	**65.1**	**14,655**

2.1.2 Actual-to-Potential Applicability Test

Under the Hybrid Test, the potential emissions of the new or modified emission units must be added. The only new emission units would be four new wing panel booths in Building 4-20 and a new booth in Building 4-86. One booth in Building 4-86 would be modified. Boeing Renton normally operates two production shifts per day and the projected production rate of 504 airplanes per year is based on two shifts per day. However, the new and modified booths will be physically capable of operating three shifts per day; therefore, the potential to emit for the new booths is based on three shifts per day operation. The potential emissions from all the new booths in Building 4-20 would be 8.3 tons per year, and the VOC potential for the new and modified 4-86 booth would be 23.7 tons per year. These totals are shown in Table 2-5.

TABLE 2-5
Emissions Increases of Regulated NSR Pollutants for New and Modified Emission Units (tpy)

	CO	NOx	PM	SOx	Lead	VOC	CO_2e
4-20 Wing Panel Booths						8.3	
4-86 Wing Booths						23.7	
Total for New and Modified Emission Units						**32.1**	

2.1.3 Hybrid Total Emissions Increase

The total emission increase relating to the production capacity increase project is the sum of the increases from the existing units and the potential to emit from the new units and is presented in Table 2-6.

TABLE 2-6
Emissions Increases of Regulated NSR Pollutants for Existing and New Emission Units (tpy)

	CO	NOx	PM	SOx	Lead	VOC	CO_2e
Total for Existing Units	11.2	28.7	1.2	0.2	0.00009	65.1	14,655
Total for New and Modified Units						32.1	
Hybrid Total	11.2	28.7	1.2	0.2	0.00009	97.1	14,655
PSD Significant Rate	100	40	10	40	0.6	40	75,000
Significant	**No**	**No**	**No**	**No**	**No**	**Yes**	**No**

As shown in Table 2-6, only the VOC emissions increase from this project is above the PSD significant emission increase rate.

The PSD rule (40 CFR 52.21(b)) defines "major modification" as follows:

> (2)(i) Major modification means any physical change in or change in the method of operation of a major stationary source that would result in: a significant emissions increase (as defined in paragraph (b)(40) of this section) of a regulated NSR pollutant (as defined in paragraph (b)(50) of this section); and a significant net emissions increase of that pollutant from the major stationary source.

The federal rule in 40 CFR 52.21 (b)(23) defines a significant increase to be equal to or exceeding any of the rates listed in Table 2-7.

The project is not expected to emit measurable quantities of fluorides, hydrogen sulfide (H_2S), total reduced sulfur, reduced sulfur compounds, or ozone depleting substances. As shown in Table 2-6, the emissions increases from the project will not exceed the significant emission rate of any regulated NSR pollutant except for VOCs; therefore, the project will only have a significant emissions increase for VOC.

TABLE 2-7

Pollutant and PSD Significant Emission Rates

Pollutant	Significant Emission Rate (tpy)
CO	100
NO_x	40
SO_2	40
PM	25
PM_{10}	15
$PM_{2.5}$	10
Ozone	40 (VOCs or NOx)[a]
Lead	0.6
CO_2e	75,000
Fluorides	3
Sulfuric Acid Mist	7
H_2S	10
Total Reduced Sulfur	10
Reduced Sulfur Compounds	10
Ozone-Depleting Substances	100[b]

Note: There are additional rates for municipal waste combustors and landfills; however, Boeing does not combust or landfill municipal waste at the Boeing Renton facility.
[a] VOC and NO_x are precursors of ozone.
[b] WAC 173-400-720(4)(b)(e)(B).

In addition, greenhouse gases (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:
>
> > (a) 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 CO2e or more; or
> >
> > (b) 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 CO2e or more;

Boeing Renton is an existing major stationary source for a regulated NSR pollutant that is not GHGs, and the proposed project is expected to result in a significant increase of VOC; however, the project will not result in an emissions increase of 75,000 tpy of CO2e.

40 CFR 52.21(b)(49) continues:

> Beginning July 1, 2011, in addition to the provisions in paragraph (b)(49)(iv) of this section, the pollutant GHGs shall also be subject to regulation
>
> > (a) At a new stationary source that will emit or have the potential to emit 100,000 tpy CO2e; or
> >
> > (b) At an existing stationary source that emits or has the potential to emit 100,000 tpy CO2e, when such stationary source undertakes a physical change or change

in the method of operation that will result in an emissions increase of 75,000 tpy CO2e or more.

Boeing Renton is an existing stationary source with the potential to emit 100,000 tpy CO2e; however, the project will not result in an emissions increase of 75,000 tpy of CO2e.

2.2 Significant Net Emissions Increase Analysis

As stated in 40 CFR 52.21(a)(2)(iv)(a) "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." The proposed project will result in a significant emissions increase only for VOC; therefore, the project will be subject to PSD for VOC and will be considered a major modification only if it also results in a significant net emissions increase of VOC. 40 CFR 52.21(b)(3)(i) outlines the steps necessary to calculate the net emissions increase. Although EPA has clearly stated that calculating a net emission increase is at the source's option (see, for example, 67 Fed. Reg. 80186, at 80197 [December 31, 2002]) and therefore a source may seek a PSD permit based on a calculated significant emission increase alone, this section addresses the net emission increase associated with the project.

The first step is to calculate the emissions increase from the project; this is shown in Table 2-6. Next, all creditable increases and decreases in actual emissions that are contemporaneous with the proposed change (i.e., occurring during the period beginning on the date 5 years before construction commences on the proposed project and ending on the date that the emission increase from the proposed project occurs) must be considered. See 40 CFR 52.21(b)(2)(ii). Creditable increases do not include any increases that Ecology or EPA have relied on in issuing a PSD permit. See 40 CFR 52.21(b)(3)(iii)(*a*). In the past 5 years, the following projects have or may have caused VOC emission increases or VOC emission increases as a result of debottlenecking operations:

- Reconfigure and refurbish existing Paint Hangar 1 (P1) in Building 5-50.
- Install additional automated spar assembly tools and metal shim wet milling machine in Building 4-21.
- Install an additional automatic wing fastener insertion.
- Install additional assembly tooling and support equipment in Buildings 4-20, 4-21, 4-81, and 4-82.

Ecology has relied on the VOC emission increases from those changes listed above when Ecology approved PSD-08-01 Amendment 1, and Boeing Renton has complied with the emission requirements of that permit. Other increase in emissions over the past five years have been due to demand growth and were able to be accommodated by existing capacity and changes that Ecology has approved under PSD-97-2 for Building 4-86 or PSD-88-4 for Building 4-41 Paint Hangar.

In addition, Boeing is not seeking changes to any of the PSD permit conditions; therefore, there have not been any other increases in actual emissions at Boeing Renton that are contemporaneous with this particular change and are otherwise creditable.

2.3 PSD Requirements

A PSD permit application must demonstrate that:

- Best available control technology (BACT) will be used for each new emission unit that will emit the pollutant for which PSD is triggered, and for each modified emission unit that will experience an increase in emissions of the pollutant for which PSD is triggered as a result of the modification to that unit.
- Allowable emissions increases from the project will not cause or contribute to a violation of any ambient air quality standard or increment.
- The project will not significantly adversely impact air quality related values such as soils, vegetation, and visibility in Class I areas.

Sections 3, 4, and 5 address these requirements.

3. Best Available Control Technology Analysis

As required by 40 CFR 52.21(j)(3), a major modification shall apply best available control technology for each regulated NSR pollutant for which it would result in a significant net emissions increase at the source. This requirement applies to each proposed new emission unit, and each emissions unit at which a net emissions increase in the pollutant would occur as a result of a physical change or change in the method of operation in the unit. Thus, emission units that are not new units or modified units are not subject to BACT, regardless of whether such units will experience an increase in emissions of that pollutant as a result of the project. Further, new or modified units that are associated with a project but will not emit that pollutant (for new units) or will not experience an increase in emissions of that pollutant "as a result of" the project (for modified units) will not be subject to BACT.

40 CFR 52.21(b)(12) defines BACT as follows:

> Best available control technology means an emissions limitation (including a visible emission standard) based on the maximum degree of reduction for each pollutant subject to regulation under Act *[sic]* which would be emitted from any proposed major stationary source or major modification which the Administrator, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of such pollutant. In no event shall application of best available control technology result in emissions of any pollutant that would exceed the emissions allowed by any applicable standard under 40 CFR parts 60 and 61. If the Administrator determines that technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard, or combination thereof, may be prescribed instead to satisfy the requirement for the application of best available control technology. Such standard shall, to the degree possible, set forth the emissions reduction achievable by implementation of such design, equipment, work practice or operation, and shall provide for compliance by means which achieve equivalent results.

As discussed in Section 2 of this application, the only regulated NSR pollutant for which the project results in a plant-wide significant emission increase is VOCs. There are four new VOC emission units anticipated for the project in Building 4-20. In Building 4-86 there will be one new unit and one modified unit, as shown in Table 3-1. The table also shows the potential VOC emissions, based on three shifts per day of operation, for each of the new or modified booths. This significantly over-estimates the emissions because Boeing Renton normally operates two shifts per day. For the Wing Panel Booths in Building 4-20, spraying is conducted with small high-volume low-pressure (HVLP) spray guns that are equipped with disposable paint cups, so there are no paint lines to be cleaned and the spray guns are disassembled and cleaned outside the booth. Hence, there are little or no emissions from gun cleaning from the Wing Panel

Booths. Gun and line cleaning operations are included in the emissions for the 4-86 Wing Booths 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 emissions estimates and this BACT analysis all the gun and line cleaning solvent is assumed to be emitted through the booth.

TABLE 3-1
New and Modified Emission Units

Building	Booth Type	Quantity	New/Modified	VOC Emissions (tpy/– booth)	Exhaust Rate (acfm)
Building 4-20	Wing Panel Booth	4	New	2.08	50,600
Building 4-86	Wing Booth	1	New	12.29	140,000
	Wing Booth	1	Modified	12.29	140,000

acfm = actual cubic feet per minute

Therefore, this section presents a BACT analysis for these new and modified spray booths using the EPA top-down approach. This top-down approach includes the following steps:

- Identify pollution control technology options available in the market.
- Evaluate the options and remove technically infeasible options.
- Rank remaining control technologies by control effectiveness.
- Evaluate effective controls considering energy, environmental, and economic impacts.
- Select BACT based on analysis.

This BACT analysis considers those technologies that reduce VOC emissions from the cleaning and coating operations that will take place in the new or modified units. BACT analysis was performed for each booth operating at the emission rates and exhaust flow rates listed in Table 3-1. Boeing currently uses a combination of low-VOC coatings, high-transfer-efficiency application techniques, and good work practices (such as keeping containers of coating closed when not in use) to minimize VOC emissions. The Aerospace National Emission Standard for Hazardous Air Pollutants (NESHAP) and/or PSCAA regulations require 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 that are planned for the new and modified wing booths are as follows:

- **Wing cleaning and conversion coating –** Before the exterior of the wing can be coated, it first must be cleaned and prepped for priming.
- **Wing priming –** Priming provides corrosion protection and ensures the necessary bond between the surface of the wing and the topcoat.
- **Wing topcoat –** The topcoat is the final coating of the normally visible surfaces of the wing, top and bottom. The topcoat not only provides the final protection of the wing surface but also provides the decorative color to the top and bottom of the wing.

- **Wing corrosion-inhibiting compound –** Portions of the wing that are not normally visible often need a special coating to further protect them from corrosion. This corrosion- inhibiting compound is applied to the wing assembly before the wing is transported to the main assembly line for attaching to the fuselage of the airplane.
- **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.

3.1 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 3-2.

3.2 BACT Feasibility Review

The control technologies in Table 3-2 have been demonstrated and achieved in practice and therefore could be feasible technologies for implementation at Boeing Renton paint booth operations. Note that Boeing considers the use of low-VOC coating, high-transfer-efficiency spray equipment, and good work practices to minimize VOC emissions to be the base case for BACT.

3.3 Ranking of BACT by Control

The potential control options provided in Table 3-2 have been ranked in Table 3-3 based on the control efficiencies documented as being achieved in practice.

3.4 Cost-effectiveness Evaluation

Reputable vendors of paint operation and control technologies were identified based on contacts within the aerospace industry and contacted to assess implementation of the different controls available in the marketplace (listed in Table 3-3). Vendor quotes were collected and are summarized in the cost-effectiveness evaluation spreadsheets located in Appendices B and C. Cost evaluations followed published EPA guidance for VOC Control by Incinerators and by Carbon Adsorption (EPA, 2002). Sections 3.4.1 through 3.4.6 discuss those results.

The cost-effectiveness analyses use the standard default values for construction as provided by EPA. Boeing Renton expects that the installation of any add-on control technology would require complicated retrofit construction and expenses. The existing facility has limited space available for the footprint of additional equipment, which may 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 flow and pressure to operate the control equipment as designed. Complicated retrofits can increase installation costs by a factor of 50 percent.

TABLE 3-2
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
Regenerative thermal oxidizer	Spray Booth	Arcadia, Inc.	2/6/2001	VOC	99.3%	.89 lb/hr	CARB, BACT Clearinghouse SCAQMD Clearinghouse
Regenerative thermal oxidizer	Spray Booth	Huck International – Deutsch Operations	NA	VOC	90.6%	59 lb/day	CARB, BACT Clearinghouse SCAQMD Clearinghouse
Regenerative thermal oxidizer with concentrator	Spray Booth	Kal-Gard Coating & Mfg, E/M Corp.	8/14/2008	VOC	NA	2 tpy	CARB, BACT Clearinghouse
Regenerative thermal oxidizer with concentrator	Spray Booth	Douglas Production Division	3/30/94	VOC	93.2%	341 gallons/ day	CARB, BACT Clearinghouse SCAQMD Clearinghouse
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	Time Aviation Services Inc.	6/18/99	VOC	NA	3 gallons/ day	CARB, BACT Clearinghouse
Low-VOC coatings, HVLP coating gun, best management practices	Spray Booth	California Air National Guard, Fresno	1/22/97	VOC	NA	5.23 lb VOC/ gallon coating	CARB, BACT Clearinghouse
Low-VOC coatings, HVLP coating gun, enclosed gun cleaner	Spray Booth	Toter	12/16/99	VOC	NA	1.09 lb VOC/ gallon	CARB, BACT Clearinghouse

NA = not applicable
HVLP = high-volume low-pressure

TABLE 3-3
Ranking of Control Technologies

Type of Control Technology	Control Efficiency	Ranking
Regenerative thermal oxidizer	99.3%	1
Carbon adsorption	99.3%	2
Thermal oxidizer	98.9%	3
Regenerative thermal oxidizer with concentrator	93.2%	4
Low-VOC coatings, HVLP coating gun, best management practices	NA	5

3.4.1 Thermal Oxidizer

A thermal oxidizer introduces the VOC emissions in an air stream to a burner that destroys those emissions prior to release to the atmosphere through a stack. This control technology has been improved upon over the years to also include preheating the incoming air stream to obtain additional fuel efficiencies. Vendor information for thermal oxidizers with and without preheaters was considered from Callidus and John Zink. Those equipment cost and operating parameters are provided in Appendices B and C. The thermal oxidizer control technology overall cost-effectiveness in dollars per ton removed is listed in Tables 3-4 and 3-5 in Section 3.4.6.

3.4.2 Carbon Adsorption

Carbon adsorption uses a filter bank of canisters that contain activated carbon, which adsorbs the VOC emissions as the air stream passes through before being released to the atmosphere. Vendor information for the carbon adsorption technology was obtained from Thermal Recovery Systems. Those equipment cost and operating parameters are provided in Appendices B and C. The carbon adsorption control technology overall cost-effectiveness in dollars per ton removed is listed in Table Tables 3-4 and 3-5.

3.4.3 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 Anguil for the booths in Building 4-86. Anguil advised that a system of this size would not be appropriate for the use of a RTO with concentrator for the flow rates and concentration found in the Building 4-20 wing panel booths; therefore no cost analysis was done. The equipment cost and operating parameters are provided in Appendices B and C. The RTO control technology overall cost-effectiveness in dollars per ton removed is listed in Tables 3-4 and 3-5 in Section 3.4.6.

3.4.4 Regenerative Thermal Oxidizer 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. Greater fuel efficiencies are obtained during operation. Vendor information for the RTO with concentrator control technology was obtained from Anguil. Anguil advised not to use a regenerative thermal oxidizer with a concentrator on the wing panel booths for Building 4-20. Those equipment cost and operating parameters are provided in Appendices B and C. The RTO with concentrator control technology overall cost-effectiveness in dollars per ton removed is listed in Tables 3-4 and 3-5 in Section 3.4.6.

3.4.5 Low-VOC Coatings, High-Transfer-Efficiency Coating Techniques, and Good Work Practices

Boeing Renton already uses low-VOC coatings that meet specifications required for airplane coating operations. Boeing also uses high-transfer-efficiency coating techniques, such as HVLP spray guns, which provide a 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 containers, 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 of cleaning solvents and coatings as defined in 40 CFR 63 Subpart GG, Aerospace NESHAP and PSCAA Regulation II, 3.09, will be applied in this operation. No cost analysis was performed because Boeing considers this to be the base case for BACT.

3.4.6 Summary of Cost-effectiveness Analysis

The costs of control technologies identified as being available and technologically feasible for the new and modified spray booths are summarized in Tables 3-4 and 3-5. These cost estimates are conservative (potentially underestimating the costs) and do not include the complicated retrofit installation expenses that Boeing Renton might incur. For the Building 4-20 wing panel booth an exhaust flow rate of 25,000 cubic feet per minute (cfm) was assumed for initial design and cost of BACT controls. The final design exhaust rate is 50,600 cfm. The greater exhaust rate would add significantly to the capital and operating cost of the controls; therefore, the estimates listed in Table 3-4 are very conservative. In addition, the emission estimate for the Building 4-86 wing booths assumed an emission rate of 12.29 tons per year from each of the new or modified booths. The current emission estimate is that the maximum potential emissions from those booths would be 11.86 tons per year.

TABLE 3-4
Summary of Costs for Control Technologies for Building 4-20

Type of Control Technology	Vendor Name	Total Cost per Ton of VOC Reduced
Thermal oxidizer	Callidus	$622,394
Thermal oxidizer with preheater	John Zink	$342,475
Thermal oxidizer with preheater	Callidus	$426,192
Carbon adsorption	Thermal Recovery Systems	$142,721
Regenerative thermal oxidizer	Anguil	$150,662
Regenerative thermal oxidizer with concentrator	Anguil	$449,780

Notes: Costs are based on preliminary design exhaust flow of 25,000 cfm. The current design requires an exhaust rate of 50,600 cfm; therefore, the costs would be greater.

Anguil advised not to use a regenerative thermal oxidizer with a concentrator on the wing panel booths

TABLE 3-5
Summary of Costs for Control Technologies for Building 4-86

Type of Control Technology	Vendor Name	Total Cost per Ton of VOC Reduced
Thermal oxidizer	Callidus	$420,745
Thermal oxidizer with preheater	John Zink	$390,572
Thermal oxidizer with preheater	Callidus	$225,408
Carbon adsorption	Thermal Recovery Systems	$54,062
Regenerative thermal oxidizer	Anguil	$81,643
Regenerative thermal oxidizer with concentrator	Anguil	$67,597

3.5 Comparison with other Aerospace BACT Determinations

Because of the unique nature of Boeing's operations at this facility, comparison with other aerospace facilities is of limited usefulness. For example, Boeing is currently the only

manufacturer of large commercial airplanes in the United States. A review of RBLC entries of the last 10 years for aerospace surface coatings (Process Type 41.001) shows only entries for Boeing commercial airplane operations in the Puget Sound area (Table 3-6). None of those entries indicates that add-on controls were considered BACT.

A further review of the RBLC entries for permits between 1990 and 2000 (Table 3-7) indicates some BACT decisions for aerospace coating operations that required add-on controls. However, evaluation of the location of each of those operations indicates that each was in an ozone non-attainment area at the time of permitting. For example, Huck International is located in Los Angeles, an ozone non-attainment area; CA-0881 issued in 1996 indicates "BACT-PSD," yet CA-0980 issued to the same company a year earlier indicates that lowest achievable emissions rate (LAER) was required. Similar issues can be found with Kal-Gard Coating, also located in Los Angeles, permit ID numbers 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 New Source Review rather than BACT under the PSD program.

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

TABLE 3-6
RBLC Aerospace Coating Entries Since 2000 (Process Type 41.001)

ID	Company	Permit Date	Process	Control Method Description	BACT
WA-0326	Boeing Commercial Airplanes Group	10/12/2005	Exterior Coating Operations		N/A
WA-0326	Boeing Commercial Airplanes Group	10/12/2005	Final Assembly		N/A
WA-0326	Boeing Commercial Airplanes Group	10/12/2005	Interiors Manufacturing		N/A
WA-0330	Boeing Commercial Airplanes Group	10/12/2005	Paint Hangar Final Exterior Coating	10. 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	10/12/2005	787 Final Assembly	10. 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	10/12/2005	Interiors Manufacturing	10. 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	07/27/2007	Paint Hangar/Final Exterior Coating		Other Case-by-Case
WA-0344	Boeing Commercial Airplanes Group	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

TABLE 3-7
RBLC Aerospace Coating Entries between 1990 and 2000

ID	Company	State	Permit Date	Process	Control Method Description	BACT
CA-0410	Northrop 3-2 Division	CA	05/03/1990	Paint Spray Facility In Hanger	Filter-type carbon adsorption panel over exhaust air vent.	BACT-PSD (Note Ozone NAA)
CA-0451	Tracor Flight Systems, Inc.	CA	10/23/1991	Coating Operation	Diagonal fan and filter cells w/ arrestor pads.	BACT-PSD
CA-0881	Huck International - Deutsch Operations	CA	02/29/1996	Four Spray Booths	BACT determination is Tellkamp Systems regenerative thermal oxidizer with a 1.6-MMBtu/hr natural gas burner and 3-MMBtu/hr stand-by burner. Permit limit is lb VOC/day limit.	BACT-PSD (Note Ozone NAA)
CA-0889	Kal-Gard Coating & Mfg., E/M Corp.	CA	01/06/1999	Spray Booths, Nine Brinks, Devilbiss; Blekker	BACT determination is use of Zeolite concentrator and thermal oxidizer. Permit limit is lb VOC/day facility limit.	BACT-PSD (Note Ozone NAA)
CA-0901	Time Aviation Services, Inc.	CA	06/18/1999	Spray Booths, Two Dry Filters	Permit limit is usage limit and use of SCAQMD Regulation XI compliant materials. Listings of VOC limits for individual aerospace coating types can be found at: www.aqmd.gov/rules/html/r1124.html.	BACT-PSD
CA-1045	Kal-Gard Coating & Mfg. E/M	CA	01/06/1999	Spray Booth	A Zeolite concentrator and thermal oxidizer	BACT-PSD (Note Ozone NAA)
WA-0283	Boeing Commercial Airplanes Group, Everett Div. Plant	WA	07/10/1991	Surface Coating	Solvent substitution and best management practices. HVLP, electrostatic airless, and modified high-efficiency air-assisted airless spray equipment. Baseline emission rate; 278 tpy.	BACT-PSD
WA-0284	Boeing Commercial Airplanes Group, Everett Div. Plant	WA	10/08/1992	Surface Coating	Best management practices, electrostatic air-assisted airless spray equipment. Baseline emissions: 237 tpy.	BACT-PSD
WA-0285	Boeing Commercial Airplanes Group	WA	11/26/1991	Surface Coating, Parts	Solvent substitute and best management practices. HVLP spray equipment. Baseline emission rate: 167 tpy.	BACT-PSD
WA-0286	Boeing Commercial Airplanes Group	WA	12/31/1990	Surface Coating	Baseline emissions: 182 tpy. Control methods: low-VOC coatings and best management practices; electrostatic air-assisted spray equipment.	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 eff. 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

TABLE 3-7
RBLC Aerospace Coating Entries between 1990 and 2000

ID	Company	State	Permit Date	Process	Control Method Description	BACT
CA-0977	Kal-Gard Coatings & Manufacturing	CA	05/28/1997	Metal Part 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/ fid 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 degrees Fahrenheit - 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 chl.).	Other Case-by-Case

Edwards AFB has two booths used to paint airplanes and parts; the booths have carbon adsorption systems installed. The first booth has an air flow of 111,000 cubic feet per minute (cfm) with 2.25 tpy of uncontrolled VOC emissions. The second booth is much larger (493,000 cfm) and has only 1.65 tpy of uncontrolled VOC emissions. The emissions from these Edwards AFB booths are much lower than those expected at the Boeing Renton booths. Both of the carbon systems were installed because the AFB believed a cost savings would be achieved while meeting nonattainment area requirements. 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 non-attainment or maintenance area at the time of permitting and installed a Zeolite adsorption system. This unit has not been operational at Hill AFB for an extended period of time. We have been unable to determine how long the unit operated or the reason it was taken out of operation. Because of this lack of information, we believe that no judgment can be made as to the feasibility of such a system for Boeing Renton.

In summary, we do not think that there are 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 aerospace coating operations. The few older determinations that are listed as BACT were intended to implement LAER for those operations under nonattainment area New Source Review rather than BACT under the PSD program.

3.6 BACT Selection

With costs exceeding $150,000 per ton of VOC removed, as documented above, Boeing does not consider any of the identified add-on control technologies in Tables 3-4 and 3-5 to be economically feasible for the Boeing Renton facility. Boeing will continue to implement the use of low-VOC coatings, high-transfer-efficiency coating equipment, and good work practices to minimize VOC emissions in compliance with the Aerospace NESHAP VOC emission standards in 40 CFR 63 Subpart GG and the PSCAA standards in Regulation II, Section 3.09; these requirements are listed in Table 3-8. This conclusion is consistent with other recent BACT determinations made by Ecology, PSCAA, and others for coating large aerospace parts and components.

TABLE 3-8
BACT Work Practice Limitations

Production Activity	Control Technology
Low-VOC primers	General aviation rework: 4.5 pounds per gallon (lb/gal). Large commercial aircraft: 5.4 lb/gal. All other applications: 2.9 lb/gal as required by 40 CFR 63.745(c).
Low-VOC topcoats	General aviation rework: 4.5 lb/gal. All other applications: 3.5 lb/gal as required by 40 CFR 63.745(c).
Low-VOC vapor-pressure cleaning solvents	Less than 45 millimeters mercury (mm Hg) at 20°C or Table 1 in 40 CFR 63.744.
High-transfer-efficiency coating equipment	65% or greater rated transfer efficiency as required by 40 CFR 63.745(f).
Bulk solvent application	Low-pressure applicators or manual application as required by 40 CFR 63.745(f).
Paint gun cleaning, waste solvents and rags	Capture and closed containment as required by 40 CFR 63.744.
Low-VOC vapor-pressure cleaning solvents and strippers	Less than 45 mm Hg at 20°C or as specified in Table 1 of 40 CFR 63 Subpart GG.
Solvents and strippers application	Low-pressure applicators or manual application.

4. Air Quality Impact Analysis

A project subject to PSD review must demonstrate that the allowable emissions will not cause or contribute to a violation of any ambient air quality standard. As shown in Section 2, the total net increase in VOC emissions from this project is not expected to exceed approximately 97.1 tpy. Note that VOC is a precursor to ozone. EPA's and Ecology's guidelines do not require modeling for increases in VOCs of less than 100 tpy (see EPA 1990 PSD Workshop Manual at C.30 and Table C-4).

In addition, for this project, Boeing is not requesting a change in PSD 08-01 Amendment 1, which limits VOC emissions from Building 5-50 to 40.8 tons per year (Condition 3.1) and VOC emissions from the Wing Buildup and Final Assembly operation in Buildings 4-20, 4-21, 4-81, and 4-82 to 118 tons per year or PSD-97-2 Condition 2 which limits VOC emissions from Building 4-86 to 242 tpy.

5. Air Quality-Related Values

PSD rules require an analysis of impacts on federal Class I areas. Federal Class I areas are areas of special national or regional value from a natural, scenic, recreational, or historic perspective. By PSD rules, they are afforded the highest level of air quality protection. Class I areas within 200 kilometers (km) of the Boeing Renton facility include the national parks and national wilderness areas listed in Table 5-1.

TABLE 5-1
Class I Areas within 200 km of the Boeing Renton Facility

Area	Distance from Boeing Renton to Class I Area (km)	Emissions Quantity Divided by Distance (Q/D) (tons/km)
Alpine Lakes Wilderness Area	45.5	1.5
Mt. Rainier National Park	58.9	1.2
Olympic National Park	72.1	1.0
Glacier Peak Wilderness Area	94.5	0.7
Goat Rocks Wilderness Area	104	0.7
North Cascades National Park	139	0.5
Mt. Adams Wilderness Area	140	0.5

Air quality-related values include impacts on visibility from a federal Class I area and impacts on soil, flora, fauna, and aquatic resources within the Class I area. One screening tool that has been used by Ecology, EPA, and the federal lands managers to screen out projects that will likely not have a significant impact on air quality related values, is to divide that amount of emission increase in tons (Q) by the distance to a federal Class I area in kilometers (D). If the result is less than 10, a project is normally considered to not have a significant impact on air quality-related values in a Class I area. As shown in Table 5-1, the Q/D is much less than 10 for all nearby Class I areas.

Boeing Renton's 4-86 Building Upgrade Project (PSD 97-02) evaluated the facility-wide emission increases that would result from increasing production from 32 to 41 airplanes per month (i.e., a potential facility-wide increase in VOC emissions of up to 366 tpy). Because Boeing is not requesting changes to that limit, the projected VOC emissions associated with this project are within the levels evaluated in PSD 97-02 and, therefore, have already been accounted for in that permitting action, which concluded that the project would have no significant adverse additional impacts.

6. References

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APPENDIX A

Detailed Emission Estimates

TABLE A-1
Annual VOC Emission Rates

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Renton: VOC Tons	140	83	66	74	84	133	154	124	166	212
Aircraft produced 737 + 757	346	250	182	213	214	302	330	290	372	376
PSD-88-4 for the Boeing Renton Site, 4-41 Paint Hangar	18	12	1	3	14	18	20	19	30	42
Renton less paint hangar	122	71	65	71	70	115	134	105	136	170
2 yr ave, Tons VOC/yr		96.5	68.3	68.0	70.3	92.3	124.5	119.6	120.3	152.9
tons/plane	0.351	0.286	0.358	0.333	0.326	0.380	0.407	0.362	0.365	0.453
tpy at 42 planes/month		143.9	180.3	167.6	164.4	191.5	205.1	182.4	183.8	228.1

TABLE A-2
Combustion-Related Fuel Consumption

Fuel	Oil #6	Oil #2	Natural Gas - 10-100 MMBtu/Hr	Natural Gas - < 10 MMBtu/Hr	Natural Gas - > 100 MMBtu/Hr	Total Oil	Total Gas	Planes	Gas
	gal	gal	1000 Therms	1000 Therms	1000 Therms	MMBtu	MMBtu	Planes/yr	MMBtu/pl
2002		-	594	32	4,358	-	498,400	250	1,994
2003	800	60	452	22	3,318	120	379,200	182	2,084
2004	31,548	200	431	20	3,159	4,445	361,000	213	1,695
2005	16,000	500	403		2,743	2,310	314,600	214	1,470
2006	12,000	500	1,373		2,277	1,750	365,000	302	1,209
2007	16,312		1,361		2,082	2,284	344,300	330	1,043
2008	4,743	57	820		2,561	672	338,100	290	1,166
2009	5,154		1,055		2,194	722	324,900	372	873
						Two year total			
Fuel			Natural Gas - 10-100 MMBtu/Hr	Natural Gas - < 10 MMBtu/Hr	Natural Gas - > 100 MMBtu/Hr	NG <100 MMBtu/hr	NG> 100 MMBtu/hr		
			MMBtu	MMBtu	MMBtu				
2002			59,400	3,200	435,800				
2003			45,200	2,200	331,800	110,000	767,600		
2004			43,100	2,000	315,900	92,500	647,700		
2005			40,300	-	274,300	85,400	590,200		
2006			137,300	-	227,700	177,600	502,000		
2007			136,100	-	208,200	273,400	435,900		
2008			82,000	-	256,100	218,100	464,300		
2009			105,500	-	219,400	187,500	475,500		
Factors	140	MMBtu/1000 gal							
	100	MMBtu/ 1000 Therms							

TABLE A-3
Combustion Related Emissions

Combustion Emission Calculations

	Factors									
	Total Gas Used in Baseline Period:		6.63E+05	MMBtu/ 2-yr	3.32E+05	MMBtu/yr				
	Gas Used in <100 MMBtu Boilers Baseline		1.88E+05	MMBtu/ 2-yr	9.38E+04	MMBtu/yr	28%			
	Gas Used in >100 MMBtu Boilers Baseline		4.76E+05	MMBtu/ 2-yr	2.38E+05	MMBtu/yr	72%			
	Total Oil Used in Baseline Period:		9954	Gal/2-yr	4.977	1000 Gal/yr	140	MMBtu/1000 gal		696.78
Baseline										
			CO	NOx <100 MMBtu	NOx > 100 MMBtu	NOx Total	PM	SO2	Lead	VOC
Gas	Emission Factor	lb/MMBtu (AP-42)	0.08	0.031	0.275		0.0075	0.00059	4.90E-07	0.00539
	Emissions	Ton/yr	13.26	1.47	32.63	34.10	1.24	0.10	0.0001	0.89
Oil	Emission Factor	lb/1000 gal	5	19	14		3.3	7.385	0.00126	0.2
	Emissions	Ton/yr	0.01	0.05	0.03	0.08	0.01	0.02	0.0000	0.00
	Total Baseline	Tons/yr	13.27	1.52	32.67	34.19	1.25	0.12	0.0001	0.89
	Gas			Oil increase:			Fraction of fuel burned in Boilers <100 MMBtu	Fraction of fuel burned in Boilers > MMBtu:		
	1,209	MMBtu/plane					28%	72%		
	504	plane/yr								
	609,139	MMBtu/yr				Gas:	172,268	436,871		
				32.62	1000 gal/yr	Oil:	9.23	23.40	4,567.36	MMBtu
			CO	NOx <100 MMBtu	NOx > 100 MMBtu	NOx Total	PM	SO2	Lead	VOC
Gas	Emission Factor	lb/MMBtu	0.08	0.031	0.275		0.0075	0.00059	4.90E-07	0.00539
	Emissions	Ton/yr	24.37	2.70	59.96	62.66	2.28	0.18	0.00015	1.64
Oil	Emission Factor	lb/1000 gal	5	19	14		3.3	7.385	0.00126	0.2
	Emissions	Ton/yr	0.08	0.09	0.16	0.25	0.05	0.12	0.00002	0.00
	Projected	Tons/yr	24.45	2.79	60.13	62.92	2.34	0.30	0.00017	1.64

TABLE A-4
Combustion-Related GHG Emissions

Utilities	2010	2009	2008	2007	2006	2005	2004	2003
	CO2e Metric ton	CO2e Metric ton	CO2e Metric ton	CO2e Metric ton	CO2e Metric ton	CO2e Metric ton	CO2e Metric ton	CO2e Metric ton
Electricity	32,327	34,139	32,266	34,867	36,879	36,210	39,758	42,081
Natural Gas	15,631	17,453	17,668	18,149	19,372	17,939	19,253	20,352
#6 Residual Fuel Oil	29	60	54	184	136	0	0	0
Purchased Steam	0	0	0	0	0	0	0	0
Total	47,988	51,652	49,988	53,201	56,387	54,149	59,011	62,432
Other Fuels	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**
#1, #2 Petroleum Diesel (on-road - taxed)	1,552	1,400	1,315	1,064	1,490	1,448	0	0
#2 Petroleum Diesel (untaxed)	115	84	79	288	98	100	0	0
#1 Petroleum Diesel (untaxed)	0	0	0	0	0	0	0	0
#4 Petroleum Diesel (untaxed)	0	0	0	0	0	0	0	0
#5 Petroleum Residual Fuel Oil (untaxed)	0	0	0	0	0	0	0	0
Bio-diesel (on-road - taxed)	145	135	135	0	0	0	0	0
Bio-diesel (untaxed)	6	5	8	0	0	0	0	0
Motor Gasoline (on-road - taxed)	367	374	362	365	749	707	0	0
Motor Gasoline (untaxed)	308	363	337	377	0	0	0	0
Jet A / Jet Fuel (used in aircraft)	13,956	14,825	11,516	32,286	29,519	18,846	0	0
Jet A / Jet Fuel (used in stationary source)	0	0	0	0	0	0	0	0
Aviation Gasoline (mobile)	0	0	0	0	0	0	0	0
Propane (used in stationary source)	37	39	45	45	0	0	0	0
Propane (used in mobile source)	329	336	299	390	6	0	0	0
LPG	0	0	0	0	0	0	0	0
CNG	0	0	0	0	0	0	0	0
Total Scope 1	34,368	37,614	34,084	55,319	54,628	39,040	19,253	20,352
Total Scope 2	32,327	34,139	32,266	34,867	36,879	36,210	39,758	42,081
Total Stationary (scope 1)	18,096	20,544	20,457	21,214	22,864	18,039	19,253	20,352
Planes/yr	376	372	290	330	302	214	213	182
Tons/plane	48	55	71	64	76	84	90	112
2 Yr Ave	19,320	20,501	20,835	**22,039**	20,451	18,646	19,802	23,514
Total Mobile (scope 1)	16,349	17,069	13,627	34,105	31,764	21,001	0	0
Total by year	66,772	71,753	66,350	90,186	91,507	75,250	59,011	62,432

Other Direct / Fugitive Emissions	2010	2009	2008	2007	2006	2005	2004	2003
	CO2e Metric ton	CO2e Metric ton	CO2e Metric ton	CO2e Metric ton	CO2e Metric ton	CO2e Metric ton	CO2e Metric ton	CO2e Metric ton
CO_2	0	0	0	0	0	0	0	0
CH_4	0	2	1	0	2	0	0	0
N_2O	0	0	0	0	0	0	0	0
SF_6	0	0	0	0	0	0	0	0
NF_3	0	0	0	0	0	0	0	0
HFC-23	0	0	111	106	231	0	0	0
HFC-32	7	0	0	0	0	0	0	0
HFC-41	0	0	0	0	0	0	0	0
HFC-43-10mee	16	35	6	0	0	0	0	0
HFC-125	85	14	0	13	31	0	0	0
HFC-134	0	0	0	0	0	0	0	0
HFC-134a	1,697	2,464	2,148	2,029	2,904	0	0	0
HFC-143	0	0	0	0	0	0	0	0
HFC-143a	86	21	0	22	50	0	0	0
HFC-152	0	0	0	0	0	0	0	0
HFC-152a	0	0	0	0	0	0	0	0
HFC-161	0	0	0	0	0	0	0	0
HFC-227ea	0	0	0	0	0	0	0	0
HFC-236cb	0	0	0	0	0	0	0	0
HFC-236ea	0	0	0	0	0	0	0	0
HFC-236fa	0	0	0	0	0	0	0	0
HFC-245ca	0	0	0	0	0	0	0	0
HFC-245fa	1	0	0	0	41	0	0	0
HFC-365mfc	0	4	0	0	0	0	0	0
Total	1,970	2,540	2,266	2,170	3,258	0	0	0
2 Yr Ave	2,255	2,403	2,218	2,714	1,629	0		
Tons/plane	6.0	6.5	7.6	8.2	5.4	0.0		
Total Stationary	21,575	22,904	23,054	24,753	22,081	18,646	19,802	23,514
Total Stationary Tons/plane	57.4	61.6	79.5	75.0	73.1	87.1	93.0	129.2
504 Tons/yr	28,919	31,031	40,066	37,805	36,850	43,914	46,856	65,116
Increase	7,345	8,127	17,012	13,052	14,769	25,268	27,054	41,602

TABLE A-5
Building 4-20 Wing Panel Booths Emissions

Number of Booths	4				Number of Booths	4			
Number of panels/yr	3024				Number of Planes/yr	213		17.75	
		Gallons/Airplar	Lbs VOC/gallon	lbs VOC/plane			Gallons/Ai	Lbs VOC/g	lbs VOC/plane
	MPK	0.75	7	5.25		MPK	0.75	7	5.25
	BMS 5-45 Sealant	7	0.7	4.9		BMS 5-45 Sealant	7	0.7	4.9
	BMS 10-20 Primer	1.36	5.5	7.48		BMS 10-20 Primer	1.36	5.5	7.48
	Total VOC (lbs/airplane)			17.63		Total VOC (lbs/airplane)			17.63
	Total VOC (lbs/airplane)			17.6		**Total VOC (lbs/airplane)**			17.6
	Total VOC (tons per airplane)			0.01		**Total VOC (tons per airplane)**			0.01
	Total VOC (lbs/booth-yr)			3,332		**Total VOC (lbs/booth-yr)**			939
	Total VOC (tons/booth-yr)			1.67		**Total VOC (tons/booth-yr)**			0.47
	Total VOC (tons/yr)			6.66		**Total VOC (tons/yr)**			1.88
	Adjustment for changes in paints and wings, 25% (lbs/airplan)			22.04					
	Adjustment for changes in paints and wings, 25% (tons/booth-yr)			2.08					
	Adjustment for changes in paints and wings, 25% (tons/yr)			8.33					

TABLE A-6
Building 4-86: Adding 1 booth, modifying 1 booth.

Building 4-86: Adding 1 booth; and modify 1 existing					
New Inspar (top and bottom of wing)					
Number of Planes/yr	756				
Wings/Booth-yr	378				
	Gallons/Airplane	lbs VOC/gallon	lbs VOC/plane		
BMS 10-79 GD (10P20-44) Primer	2	2.3	4.6		
BMS 5-95 spray seal	6	4.4	26.4		
BMS 10-60 Enamel	8	3.5	28		
Total			59		
	lbs VOC	planes	lbs VOC/plane		
Gun and Line Cleaning	13,050	290	45.0		
Note: 1572 is for toluene and it's a 50/50 mix					
		Painting	**Cleaning**	**Total**	
	Total VOC (lbs/airplane)	59	45	104	
	Total VOC (tons per airplane)	0.03	0.02	0.052	
	Total VOC (lbs/booth-yr)	11,151	8,505	19,656	
	Total VOC (tons per booth-yr)	5.58	4.25	9.83	
Adjustment for changes in paints and wings, 25% (tons/booth-yr)		6.97	5.32	12.29	
Adjustment for changes in paints and wings, 25% (pounds per wing)				65	
Adjustment for changes in paints and wings, 25% (pounds per plane)				130	

TABLE A-7
Emissions Increase

Wing Assembly						79.0	
Wing Coating						102.5	
Final Assembly						19.3	
Paint Hangars/ Flightline						48.7	
737 Assembly							3,855
Combustion	24.4	62.9	2.3	0.3	0.0	1.6	35,553
Total	24.4	62.9	2.3	0.3	0.0002	251.1	39,408
Note: Does not include new or booths							
Baseline Actual Emissions of Regulated NSR Pollutants for existing 737 Assembly Operations							
Tons per year							
Unit or Activity	**CO**	**NOx**	**PM**	**SOx**	**Lead**	**VOC**	**CO2e**
Wing Assembly						58.6	
Wing Coating						76.0	
Final Assembly						14.3	
Paint Hangars/ Flightline						36.2	
737 Assembly							2,714
Combustion	13.3	34.2	1.3	0.1	0.0	0.9	22,039
Total	13.3	34.2	1.3	0.1	0.0	186.0	24,753
Note: Does not include booths that will be shutdown							

Adjusted Projected Actual Emissions of Regulated NSR Pollutants for 737 Assembly Operations

Tons per year

Unit or Activity	CO	NOx	PM	SOx	Lead	VOC	CO_2e
Wing Assembly						79.0	
Wing Coating						102.5	
Final Assembly						19.3	
Paint Hangars/ Flightline						48.7	
737 Assembly							3,855
Combustion	24.4	62.9	2.3	0.3	0.0	1.6	35,553
Total	24.4	62.9	2.3	0.3	0.0	251.1	39,408

Emission Increase of Regulated NSR Pollutants for 737 Assembly Operations from Existing Units and Related Activities

Tons per year

Net	CO	NOx	PM	SOx	Lead	VOC	CO_2e
Adj. Proj. Actual	24.4	62.9	2.3	0.3	0.00017	251.1	39,408
Baseline Actual	13.3	34.2	1.3	0.1	0.00008	186.0	24,753
Difference	11.2	28.7	1.1	0.2	0.00009	65.1	14,655

Potential Emissions from New Units

Unit or Activity	CO	NOx	PM	SOx	Lead	VOC	CO_2e
4-86 Inspar						23.7	
4-20 Panel						8.3	
Total	0.0	0.0	0.0	0.0	0.0	32.1	-
Total Hybrid	11.2	28.7	1.1	0.2	0.0	97.1	14,655

APPENDIX B

Building 4-20 BACT Costs

Control Technology: Regenerative Thermal Oxidizer - Anguil

Given Parameters

			Reference
Annual operating hours	3024	hrs	Boeing
Exhaust flow rate, Q	25,000	acfm	Boeing
Estimated uncontrolled emissions	1.11	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month	1.665	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month + 25% safety factor	2.08125	tons/year	Boeing
Interest rate	10.5%		Boeing
Equipment lifetime	15	years	Anguil
Fuel requirement	3.3	MMBtu/hr	Anguil
Electricty requirement	112	kw	Anguil

Table 1. Capital Cost Estimate

			Cost	Reference
Purchased Equipment				
Basic equipment and auxillaries	A		$430,000	Anguil
Freight	.05A		$21,500	EPA
Sales Tax		0.092	$41,538	
Total Purchased Equipment Cost	B		$493,038	
Direct Installation Cost				
Foundation and supports	.08B		$39,443	EPA
Erection and handling	.14B		$69,025	EPA
Electrical	.04B		$19,722	EPA
Piping	.02B		$9,861	EPA
Painting	.01B		$4,930	EPA
Insulation	.01B		$4,930	EPA
Building and site preparation not included				
Total Direct Installation Cost			$147,911	
Total Direct Cost			$640,949	
Indirect Cost				
Engineering and supervision	0.10B		$49,304	EPA
Construction and field expenses	0.05B		$24,652	EPA
Construction fee	0.10B		$49,304	EPA
Start-up	0.02B		$9,861	EPA
Performance test	0.01B		$4,930	EPA
Contingency	0.03B		$14,791	EPA
Total Indirect Cost			$152,842	
Total Capital Cost			**$793,791**	

Assumptions

Fuel Requirement

Fuel usage is based on 1.1 lb of VOC/hour of operation.

(17.6 lb VOC/plane) /(2016 hours/yr/126 planes/yr) = 1.1 lb VOC/hr.

Electricity Requirement

Motor size is 150 hp *.746 = 111.9 kw

Control Technology: **Regenerative Thermal Oxidizer - Angui**

Table 2. Annual Cos

				Annual Cost		Reference
Direct Costs						
2-1	Operating labor		0.5 hrs/shift @ $102.63/hr	$19,397		Boeing/EPA
2-2	Supervisory labor		included in labor rate	$0		Boeing
2-3	Maintenance labor		0.5 hr/shift@$102.63/hr	$19,397		Boeing/EPA
2-4	Maintenance materials		100% of maintenance lbr	$19,397		EPA
Utilities						
	Electricty	$0.06	per kwh	$20,321		Boeing
	Fuel	$9	per MMBtu	$92,807		Boeing
Total Direct Cost				$171,319		
Indirect Costs						
	Administrative charges	0.02	of total capital cost	$15,876		EPA
	property tax	0.01	of total capital cost	$7,938		EPA
	Insurance	0.01	of total capital cost	$7,938		EPA
Total Annual Costs Excluding Capital Recovery				$203,071		
	Capital recovery			$107,359		
	Interest		10.5%			Boeing
	Lifetime		15 years			Anguil
Total Annual Cost				$310,429		
Estimated uncontrolled emissions at 63 planes/month				1.10	lb/hr	
Estimated uncontrolled emissions at 63 planes/month + 25% safety				1.38	lb/hr	
Control Efficiency				99%		Anguil
Emission Reduction at 63 planes/month				1.65	tons/year	
Emission Reduction at 63 planes/month + 25% safety factor				2.06	tons/year	
Cost Effectiveness at 63 planes/montl				$188,327	$/ton	
Cost Effectiveness at 63 planes/month + 25% safety factoı				$150,662	$/ton	

References

EPA — EPA Capital Cost Factors for Thermal and Catalytic Incinerators
EPA Air Pollution Control Cost Manual - Sixth Edition (EPA 452/B-02-001)
Section 3 - VOC Controls
Section 3.2 - VOC Destruction Controls
Chapter 2 - Incinerators

Anguil — E-mail from Scott Bayon, Anguil, 04/25/2011

Boeing — Boeing capital project opportunity cost = 10.5%
Boeing operating and maintenance labor cost = $102.63/hr
Boeing projected natural gas = $9.30 per million Btu
Boeing electricty cost = $0.06 per kwh

BACT Cost Estimation Spreadsheet

Control Technology: Thermal Oxidizer - Callidus w/o preheater

Given Parameters

			Reference
Annual operating hours	3024	hrs	Boeing
Exhaust flow rate, Q	25,000	acfm	Boeing
Estimated uncontrolled emissions	1.11	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month	1.665	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month + 25% safety factor	2.08125	tons/year	Boeing
Interest rate	10.5%		Boeing
Equipment lifetime	15	years	Callidus
Fuel requirement	36.0	MMBtu/hr	Callidus
Electricty requirement	26	kw	Callidus

Table 1. Capital Cost Estimate

			Cost	Reference
Purchased Equipment				
Basic equipment and auxillaries	A		$600,000	Callidus
Freight	.05A		$30,000	EPA
Sales Tax		0.092	$57,960	
Total Purchased Equipment Cost	B		$687,960	
Direct Installation Cost				
Foundation and supports	.08B		$55,037	EPA
Erection and handling	.14B		$96,314	EPA
Electrical	.04B		$27,518	EPA
Piping	.02B		$13,759	EPA
Painting	.01B		$6,880	EPA
Insulation	.01B		$6,880	EPA
Building and site preparation not included				
Total Direct Installation Cost			$206,388	
Total Direct Cost			$894,348	
Indirect Cost				
Engineering and supervision	0.10B		$68,796	EPA
Construction and field expenses	0.05B		$34,398	EPA
Construction fee	0.10B		$68,796	EPA
Start-up	0.02B		$13,759	EPA
Performance test	0.01B		$6,880	EPA
Contingency	0.03B		$20,639	EPA
Total Indirect Cost			$213,268	
Total Capital Cost			**$1,107,616**	

Assumptions

Electricty requirement

35 bhp * .746 = 26.11 KW

Control Technology: **Thermal Oxidizer - Callidus w/o preheater**

Table 2. Annual Cost

				Annual Cost	Reference
Direct Costs					
2-1	Operating labor		0.5 hrs/shift @ $102.63/hr	$19,397	Boeing/EP/
2-2	Supervisory labor		included in labor rate	$0	Boeing
2-3	Maintenance labor		0.5 hr/shift@$102.63/hr	$19,397	Boeing/EP/
2-4	Maintenance materials		100% of maintenance lbr	$19,397	EPA
Utilities					
	Electricty	$0.06	per kwh	$4,717	Boeing
	Fuel	$9	per MMBtu	$1,012,435	Boeing
Total Direct Cost				$1,075,344	
Indirect Costs					
	Administrative charges	0.02	of total capital cost	$22,152	EPA
	property tax	0.01	of total capital cost	$11,076	EPA
	Insurance	0.01	of total capital cost	$11,076	EPA
Total Annual Costs Excluding Capital Recovery				$1,119,648	
	Capital recovery			$149,803	
	Interest		10.5%		Boeing
	Lifetime		15 years		Callidus
Total Annual Cost				$1,269,451	
Estimated uncontrolled emissions at 63 planes/month				1.10 lb/hr	
Estimated uncontrolled emissions at 63 planes/month + 25% safety				1.38 lb/hr	
Control Efficiency				98%	Callidus
Emission Reduction at 63 planes/month				1.63 tons/year	
Emission Reduction at 63 planes/month + 25% safety factor				2.04 tons/year	
Cost Effectiveness at 63 planes/month				$777,993 $/ton	
Cost Effectiveness at 63 planes/month + 25% safety factor				$622,394 $/ton	

References

EPA — EPA Capital Cost Factors for Thermal and Catalytic Incinerators
EPA Air Pollution Control Cost Manual - Sixth Edition (EPA 452/B-02-001)
Section 3 - VOC Controls
Section 3.2 - VOC Destruction Controls
Chapter 2 - Incinerators

Callidus — E-mail from Ania Guy, Callidus Technologies by Honeywell, 04/27/2011.

Boeing — Boeing capital project opportunity cost = 10.5%
Boeing operating and maintenance labor cost = $102.63/hr
Boeing projected natural gas = $9.30 per million Btu
Boeing electricty cost = $0.06 per kwh

BACT Cost Estimation Spreadsheet

Control Technology: Thermal Oxidizer - Callidus w preheater

Given Parameters

			Reference
Annual operating hours	3024	hrs	Boeing
Exhaust flow rate, Q	25,000	acfm	Boeing
Estimated uncontrolled emissions	1.11	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month	1.665	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month + 25% safety factor	2.08125	tons/year	Boeing
Interest rate	10.5%		Boeing
Equipment lifetime	15	years	Callidus
Fuel requirement	17.0	MMBtu/hr	Callidus
Electricty requirement	52	kw	Callidus

Table 1. Capital Cost Estimate

			Cost	Reference
Purchased Equipment				
Basic equipment and auxillaries	A		$1,000,000	Callidus
Freight	.05A		$50,000	EPA
Sales Tax		0.092	$96,600	
Total Purchased Equipment Cost	B		$1,146,600	
Direct Installation Cost				
Foundation and supports	.08B		$91,728	EPA
Erection and handling	.14B		$160,524	EPA
Electrical	.04B		$45,864	EPA
Piping	.02B		$22,932	EPA
Painting	.01B		$11,466	EPA
Insulation	.01B		$11,466	EPA
Building and site preparation not included				
Total Direct Installation Cost			$343,980	
Total Direct Cost			$1,490,580	
Indirect Cost				
Engineering and supervision	0.10B		$114,660	EPA
Construction and field expenses	0.05B		$57,330	EPA
Construction fee	0.10B		$114,660	EPA
Start-up	0.02B		$22,932	EPA
Performance test	0.01B		$11,466	EPA
Contingency	0.03B		$34,398	EPA
Total Indirect Cost			$355,446	
Total Capital Cost			**$1,846,026**	

Control Technology: **Thermal Oxidizer - Callidus w preheater**

Table 2. Annual Cost

				Annual Cost	Reference
Direct Costs					
2-1	Operating labor		0.5 hrs/shift @ $102.63/hr	$19,397	Boeing/EP/
2-2	Supervisory labor		included in labor rate	$0	Boeing
2-3	Maintenance labor		0.5 hr/shift@$102.63/hr	$19,397	Boeing/EP/
2-4	Maintenance materials		100% of maintenance lbr	$19,397	EPA
Utilities					
	Electricty	$0.06	per kwh	$9,475	Boeing
	Fuel	$9	per MMBtu	$478,094	Boeing
Total Direct Cost				$545,760	
Indirect Costs					
	Administrative charges	0.02	of total capital cost	$36,921	EPA
	property tax	0.01	of total capital cost	$18,460	EPA
	Insurance	0.01	of total capital cost	$18,460	EPA
Total Annual Costs Excluding Capital Recovery				$619,601	
	Capital recovery			$249,671	
	Interest		10.5%		Boeing
	Lifetime		15 years		Callidus
Total Annual Cost				$869,273	
Estimated uncontrolled emissions at 63 planes/month				1.10 lb/hr	
Estimated uncontrolled emissions at 63 planes/month + 25% safety				1.38 lb/hr	
Control Efficiency				98%	Callidus
Emission Reduction at 63 planes/month				1.63 tons/year	
Emission Reduction at 63 planes/month + 25% safety factor				2.04 tons/year	
Cost Effectiveness at 63 planes/month				$532,741 $/ton	
Cost Effectiveness at 63 planes/month + 25% safety factor				$426,192 $/ton	

References

EPA	EPA Capital Cost Factors for Thermal and Catalytic Incinerators
	EPA Air Pollution Control Cost Manual - Sixth Edition (EPA 452/B-02-001)
	Section 3 - VOC Controls
	Section 3.2 - VOC Destruction Controls
	Chapter 2 - Incinerators
Callidus	E-mail from Ania Guy, Callidus Technologies by Honeywell, 04/27/2011.
Boeing	Boeing capital project opportunity cost = 10.5%
	Boeing operating and maintenance labor cost = $102.63/hr
	Boeing projected natural gas = $9.30 per million Btu
	Boeing electricty cost = $0.06 per kwh

Control Technology: Thermal Oxidizer w Preheater - John Zink

Given Parameters

			Reference
Annual operating hours	3024	hrs	Boeing
Exhaust flow rate, Q	25,000	acfm	Boeing
Estimated uncontrolled emissions	1.11	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month	1.665	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month + 25% safety factor	2.08125	tons/year	Boeing
Interest rate	10.5%		Boeing
Equipment lifetime	20	years	John Zink
Fuel requirement	11.8	MMBtu/hr	John Zink
Electricty requirement	93	kw	John Zink

Table 1. Capital Cost Estimate

			Cost	Reference
Purchased Equipment				
Basic equipment and auxillaries	A		$1,000,000	John Zink
Freight	.05A		$50,000	EPA
Sales Tax		0.092	$96,600	
Total Purchased Equipment Cost	B		$1,146,600	
Direct Installation Cost				
Foundation and supports	.08B		$91,728	EPA
Erection and handling	.14B		$160,524	EPA
Electrical	.04B		$45,864	EPA
Piping	.02B		$22,932	EPA
Painting	.01B		$11,466	EPA
Insulation	.01B		$11,466	EPA
Building and site preparation not included				
Total Direct Installation Cost			$343,980	
Total Direct Cost			$1,490,580	
Indirect Cost				
Engineering and supervision	0.10B		$114,660	EPA
Construction and field expenses	0.05B		$57,330	EPA
Construction fee	0.10B		$114,660	EPA
Start-up	0.02B		$22,932	EPA
Performance test	0.01B		$11,466	EPA
Contingency	0.03B		$34,398	EPA
Total Indirect Cost			$355,446	
Total Capital Cost			**$1,846,026**	

Assumptions

Electricity Requirements

125 hp motor * .746 = 93.25 KW

Control Technology: **Thermal Oxidizer w Preheater - John Zink**

Table 2. Annual Cost

				Annual Cost	Reference
Direct Costs					
2-1	Operating labor		0.5 hrs/shift @ $102.63/hr	$19,397	Boeing/EP/
2-2	Supervisory labor		included in labor rate	$0	Boeing
2-3	Maintenance labor		0.5 hr/shift@$102.63/hr	$19,397	Boeing/EP/
2-4	Maintenance materials		100% of maintenance lbr	$19,397	EPA
Utilities					
	Electricty	$0.06	per kwh	$16,919	Boeing
	Fuel	$9.30	per MMBtu	$332,416	Boeing
Total Direct Cost				$407,527	
Indirect Costs					
	Administrative charges	0.02	of total capital cost	$36,921	EPA
	property tax	0.01	of total capital cost	$18,460	EPA
	Insurance	0.01	of total capital cost	$18,460	EPA
Total Annual Costs Excluding Capital Recovery				$481,368	
	Capital recovery			$224,280	
	Interest		10.5%		Boeing
	Lifetime		20 years		John Zink
Total Annual Cost				$705,647	
Estimated uncontrolled emissions at 63 planes/month				1.10 lb/hr	
Estimated uncontrolled emissions at 63 planes/month + 25% safety				1.38 lb/hr	
Control Efficiency				99%	John Zink
Emission Reduction at 63 planes/month				1.65 tons/year	
Emission Reduction at 63 planes/month + 25% safety factor				2.06 tons/year	
Cost Effectiveness at 63 planes/month				$428,093 $/ton	
Cost Effectiveness at 63 planes/month + 25% safety factor				$342,475 $/ton	

References

EPA	EPA Capital Cost Factors for Thermal and Catalytic Incinerators
	EPA Air Pollution Control Cost Manual - Sixth Edition (EPA 452/B-02-001)
	Section 3 - VOC Controls
	Section 3.2 - VOC Destruction Controls
	Chapter 2 - Incinerators
John Zink	E-mail from Carl Connally, John Zink, 04/26/2011.
Boeing	Boeing capital project opportunity cost = 10.5%
	Boeing operating and maintenance labor cost = $102.63/hr
	Boeing projected natural gas = $9.30 per million Btu
	Boeing electricty cost = $0.06 per kwh

BACT Cost Estimation Spreadsheet

Control Technology: Thermal Oxidizer - Callidus w preheater

Given Parameters

			Reference
Annual operating hours	3024	hrs	Boeing
Exhaust flow rate, Q	25,000	acfm	Boeing
Estimated uncontrolled emissions	1.11	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month	1.665	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month + 25% safety factor	2.08125	tons/year	Boeing
Interest rate	10.5%		Boeing
Equipment lifetime	15	years	Callidus
Fuel requirement	17.0	MMBtu/hr	Callidus
Electricty requirement	52	kw	Callidus

Table 1. Capital Cost Estimate

			Cost	Reference
Purchased Equipment				
Basic equipment and auxillaries	A		$1,000,000	Callidus
Freight	.05A		$50,000	EPA
Sales Tax		0.092	$96,600	
Total Purchased Equipment Cost	B		$1,146,600	
Direct Installation Cost				
Foundation and supports	.08B		$91,728	EPA
Erection and handling	.14B		$160,524	EPA
Electrical	.04B		$45,864	EPA
Piping	.02B		$22,932	EPA
Painting	.01B		$11,466	EPA
Insulation	.01B		$11,466	EPA
Building and site preparation not included				
Total Direct Installation Cost			$343,980	
Total Direct Cost			$1,490,580	
Indirect Cost				
Engineering and supervision	0.10B		$114,660	EPA
Construction and field expenses	0.05B		$57,330	EPA
Construction fee	0.10B		$114,660	EPA
Start-up	0.02B		$22,932	EPA
Performance test	0.01B		$11,466	EPA
Contingency	0.03B		$34,398	EPA
Total Indirect Cost			$355,446	
Total Capital Cost			**$1,846,026**	

BACT Cost Estimation Spreadsheet

Control Technology: **Thermal Recovery Systems - Carbon Adsorption**

Table 2. Annual Cost

				Annual Cost		Reference
Direct Costs						
2-1	Operating labor		0.5 hrs/shift @ $102.63/hr	$19,397		Boeing/EPA
2-2	Supervisory labor		included in labor rate	$0		Boeing
2-3	Maintenance labor		0.5 hr/shift@$102.63/hr	$19,397		Boeing/EPA
2-4	Maintenance materials		100% Maintenance Labor	$19,397		TRS
	Replacement Parts, Carbon		12 carbon swaps/yr			TRS
	Carbon Replacement Labor		3.75hr@$102.63/hr	$4,618		TRS/Boeing
	Carbon Replacement Costs		$14,520 per carbon swap	$174,240		TRS
Utilities						
	Electricty	$0.06	per kwh	$16,919		Boeing
	Fuel	$9.30	per MMBtu	$0		Boeing
Total Direct Cost				$253,969		
Indirect Costs						
	Administrative charges	0.02	of total capital cost	$3,220		EPA
	property tax	0.01	of total capital cost	$1,610		EPA
	Insurance	0.01	of total capital cost	$1,610		EPA
Total Annual Costs Excluding Capital Recovery				$260,409		
	Capital recovery			$21,776		
	Interest		10.5%			Boeing
	Lifetime		5 years			EPA
Total Annual Cost				$282,186		
Estimated uncontrolled emissions at 63 planes/month				1.10	lb/hr	
Estimated uncontrolled emissions at 63 planes/month + 25% safety f				1.38		
Control Efficiency				95%		TRS
Emission Reduction at 63 planes/month				1.58	tons/year	
Emission Reduction at 63 planes/month + 25% safety factor				1.98	tons/year	
Cost Effectiveness at 63 planes/month				$178,401	$/ton	
Cost Effectiveness at 63 planes/month + 25% safety factor				$142,721	$/ton	

Assumptions

Carbon Replacement Labor Time Calculation:

1 units * 15 Filter Banks * 15 minutes swap time per filter bank = 3.75 hours of labor time per carbon swap

15 minutes swap time per filter bank from Phil Chapman

References

EPA	EPA Capital Cost Factors for Thermal and Catalytic Incinerators
	EPA Air Pollution Control Cost Manual - Sixth Edition (EPA 452/B-02-001)
	Section 3 - VOC Controls
	Section 3.1 - VOC Recapture Controls
	Section 3.1 Carbon Adsorbers
TRS	E-mail from Phil Chapman, Thermal Recovery Systems, Inc. 04/20/11
Boeing	Boeing capital project opportunity cost = 10.5%
	Boeing operating and maintenance labor cost = $102.63/hr
	Boeing projected natural gas = $9.30 per million Btu
	Boeing electricty cost = $0.06 per kwh

APPENDIX C

Building 4-86 BACT Costs

Control Technology: Regenerative Thermal Oxidizer - Anguil

Given Parameters

			Reference
Annual operating hours	3024	hrs	Boeing
Exhaust flow rate, Q	140,000	acfm	Boeing
Estimated uncontrolled emissions	6.55	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month	9.825	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month + 25% safety factor	11.4625	tons/year	Boeing
Interest rate	10.5%		Boeing
Equipment lifetime	15	years	Anguil
Fuel requirement	11.4	MMBtu/hr	Anguil
Electricty requirement	344	kw	Anguil

Table 1. Capital Cost Estimate

			Cost	Reference
Purchased Equipment				
Basic equipment and auxillaries	A		$1,500,000	Anguil
Freight	.05A		$75,000	EPA
Sales Tax		0.092	$144,900	
Total Purchased Equipment Cost	B		$1,719,900	
Direct Installation Cost				
Foundation and supports	.08B		$137,592	EPA
Erection and handling	.14B		$240,786	EPA
Electrical	.04B		$68,796	EPA
Piping	.02B		$34,398	EPA
Painting	.01B		$17,199	EPA
Insulation	.01B		$17,199	EPA
Building and site preparation not included				
Total Direct Installation Cost			$515,970	
Total Direct Cost			$2,235,870	
Indirect Cost				
Engineering and supervision	0.10B		$171,990	EPA
Construction and field expenses	0.05B		$85,995	EPA
Construction fee	0.10B		$171,990	EPA
Start-up	0.02B		$34,398	EPA
Performance test	0.01B		$17,199	EPA
Contingency	0.03B		$51,597	EPA
Total Indirect Cost			$533,169	
Total Capital Cost			**$2,769,039**	

Assumptions

Exhaust Flow Rates

Vendor quote is for a 120,000 cfm unit. It is assummed that a 140,000 cfm unit will be more expensive and using the qoute for the 120,000 cfm unit is a conservative estimate for cost.

Estimated uncontrolled emissions

Emissions are from painting activities only. Assumed that gun and line cleaning solvent activities are recovered and not emitted.

Control Technology: **Regenerative Thermal Oxidizer - Anguil**

Table 2. Annual Cost

				Annual Cost	Reference
Direct Costs					
2-1	Operating labor		0.5 hrs/shift @ $102.63/hr	$19,397	Boeing/EP/
2-2	Supervisory labor		included in labor rate	$0	Boeing
2-3	Maintenance labor		0.5 hr/shift@$102.63/hr	$19,397	Boeing/EP/
2-4	Maintenance materials		100% of maintenance lbr	$19,397	EPA
Utilities					
	Electricty	$0.06	per kwh	$62,415	Boeing
	Fuel	$9	per MMBtu	$320,604	Boeing
Total Direct Cost				$441,211	
Indirect Costs					
	Administrative charges	0.02	of total capital cost	$55,381	EPA
	property tax	0.01	of total capital cost	$27,690	EPA
	Insurance	0.01	of total capital cost	$27,690	EPA
Total Annual Costs Excluding Capital Recovery				$551,973	
	Capital recovery			$374,507	
	Interest		10.5%		Boeing
	Lifetime		15 years		Anguil
Total Annual Cost				$926,480	
Estimated uncontrolled emissions at 63 planes/month				6.50 lb/hr	
Estimated uncontrolled emissions at 63 planes/month + 25% safety factor				7.58 lb/hr	
Control Efficiency				99%	Anguil
Emission Reduction at 63 planes/month				9.73 tons/year	
Emission Reduction at 63 planes/month + 25% safety factor				11.35 tons/year	
Cost Effectiveness at 63 planes/month				$95,251 $/ton	
Cost Effectiveness at 63 planes/month + 25% safety factor				$81,643 $/ton	

References

EPA — EPA Capital Cost Factors for Thermal and Catalytic Incinerators
EPA Air Pollution Control Cost Manual - Sixth Edition (EPA 452/B-02-001)
Section 3 - VOC Controls
Section 3.2 - VOC Destruction Controls
Chapter 2 - Incinerators

Anguil — E-mail from Scott Bayon, Anguil, 03/10/11 and 03/14/11

Boeing — Boeing capital project opportunity cost = 10.5%
Boeing operating and maintenance labor cost = $102.63/hr
Boeing projected natural gas = $9.30 per million Btu
Boeing electricty cost = $0.06 per kwh

Control Technology: Thermal Recovery Systems - Carbon Adsorption

Given Parameters

			Reference
Annual operating hours	3024	hrs	Boeing
Exhaust flow rate, Q	140,000	acfm	Boeing
Estimated uncontrolled emissions	6.55	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month	9.825	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month + 25% safety factor	11.4625	tons/year	Boeing
Interest rate	10.5%		Boeing
Equipment lifetime	5	years	EPA
Fuel requirement	0.0	MMBtu/hr	TRS
Electricty requirement	187	kw	EPA

Table 1. Capital Cost Estimate

			Cost	Reference
Purchased Equipment				
Basic equipment and auxillaries	A		$286,944	TRS
Freight	.05A		$14,347	EPA
Sales Tax		0.092	$27,719	
Total Purchased Equipment Cost	B		$329,010	
Direct Installation Cost				
Foundation and supports	.08B		$26,321	EPA
Erection and handling	.14B		$46,061	EPA
Electrical	.04B		$13,160	EPA
Piping	.02B		$6,580	EPA
Painting	.01B		$3,290	EPA
Insulation	.01B		$3,290	EPA
Building and site preparation not included				
Total Direct Installation Cost			$98,703	
Total Direct Cost			$427,713	
Indirect Cost				
Engineering	0.10B		$32,901	EPA
Construction and field expenses	0.05B		$16,450	EPA
Construction fee	0.10B		$32,901	EPA
Start-up	0.02B		$6,580	EPA
Performance test	0.01B		$3,290	EPA
Contingency	0.03B		$9,870	EPA
Total Indirect Cost			$101,993	
Total Capital Cost			**$529,706**	

Assumptions

Exhaust Flow Rates

Vendor quote is for a 120,000 cfm unit. It is assummed that a 140,000 cfm unit will be more expensive and using the qoute for the 120,000 cfm unit is a conservative estimate for cost.

Estimated uncontrolled emissions

Emissions are from painting activities only.

Assumed that gun and line cleaning solvent activities are recovered and not emitted.

Electricity calculations

2 units * 125 hp motors * .746 = 187 kW

Basic Equipment and Auxillaries calculation

$146,944 filters and frames+$100,000 modify plenums+$40,000 motor replacement=$286,944

Control Technology: **Thermal Recovery Systems - Carbon Adsorption**

Table 2. Annual Cost

				Annual Cost	Reference
Direct Costs					
2-1	Operating labor		0.5 hrs/shift @ $102.63/hr	$19,397	Boeing/EP/
2-2	Supervisory labor		included in labor rate	$0	Boeing
2-3	Maintenance labor		0.5 hr/shift@$102.63/hr	$19,397	Boeing/EP/
2-4	Maintenance materials		100% Maintenance Labor	$19,397	TRS
	Replacement Parts, Carbon		5.25 carbon swaps/yr		TRS
	Carbon Replacement Labor		16hr@$102.63/hr	$8,621	TRS/Boein
	Carbon Replacement Costs		$61,952 per carbon swap	$325,248	TRS
Utilities					
	Electricty	$0.06	per kwh	$33,929	Boeing
	Fuel	$9.30	per MMBtu	$0	Boeing
Total Direct Cost				$425,989	
Indirect Costs					
	Administrative charges	0.02	of total capital cost	$10,594	EPA
	property tax	0.01	of total capital cost	$5,297	EPA
	Insurance	0.01	of total capital cost	$5,297	EPA
Total Annual Costs Excluding Capital Recovery				$447,178	
	Capital recovery			$141,524	
	Interest		10.5%		Boeing
	Lifetime		5 years		EPA
Total Annual Cost				$588,702	
Estimated uncontrolled emissions at 63 planes/month				6.50 lb/hr	
Estimated uncontrolled emissions at 63 planes/month + 25% safety				7.58 lb/hr	
Control Efficiency				95%	TRS
Emission Reduction at 63 planes/month				9.33 tons/year	
Emission Reduction at 63 planes/month + 25% safety factor				10.89 tons/year	
Cost Effectiveness at 63 planes/month				$63,072 $/ton	
Cost Effectiveness at 63 planes/month + 25% safety factor				$54,062 $/ton	

Assumptions

Carbon Replacement Labor Time Calculation:
2 units * 32 Filter Banks * 15 minutes swap time per filter bank = 16 hours of labor time per carbon swap
15 mjinutes swap time per filter bank from Phil Chapman

Number of Carbon Swaps
24 carbon swaps/year adsorbed 17tpy of VOC emissions. Each set of carbon adsorbed 1.41tpy of VOC.
3.72tpy at 1.41tpy of VOC adsorbed per set of carbon = 5.25 carbon swaps per year

References

EPA	EPA Capital Cost Factors for Thermal and Catalytic Incinerators
	EPA Air Pollution Control Cost Manual - Sixth Edition (EPA 452/B-02-001)
	Section 3 - VOC Controls
	Section 3.1 - VOC Recapture Controls
	Section 3.1 Carbon Adsorbers
TRS	E-mail from Phil Chapman, Thermal Recovery Systems, Inc. 03/14/11 and 03/15/11
Boeing	Boeing capital project opportunity cost = 10.5%
	Boeing operating and maintenance labor cost = $102.63/hr
	Boeing projected natural gas = $9.30 per million Btu
	Boeing electricty cost = $0.06 per kwh

Control Technology: Thermal Oxidizer w Preheater - John Zink

Given Parameters

			Reference
Annual operating hours	3024	hrs	Boeing
Exhaust flow rate, Q	140,000	acfm	Boeing
Estimated uncontrolled emissions	6.55	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month	9.825	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month + 25% safety factor	12.28	tons/year	Boeing
Interest rate	10.5%		Boeing
Equipment lifetime	20	years	John Zink
Fuel requirement	128.0	MMBtu/hr	John Zink
Electricty requirement	261	kw	John Zink

Table 1. Capital Cost Estimate

			Cost	Reference
Purchased Equipment				
Basic equipment and auxillaries	A		$3,500,000	John Zink
Freight	.05A		$175,000	EPA
Sales Tax		0.092	$338,100	
Total Purchased Equipment Cost	B		$4,013,100	
Direct Installation Cost				
Foundation and supports	.08B		$321,048	EPA
Erection and handling	.14B		$561,834	EPA
Electrical	.04B		$160,524	EPA
Piping	.02B		$80,262	EPA
Painting	.01B		$40,131	EPA
Insulation	.01B		$40,131	EPA
Building and site preparation not included				
Total Direct Installation Cost			$1,203,930	
Total Direct Cost			$5,217,030	
Indirect Cost				
Engineering and supervision	0.10B		$401,310	EPA
Construction and field expenses	0.05B		$200,655	EPA
Construction fee	0.10B		$401,310	EPA
Start-up	0.02B		$80,262	EPA
Performance test	0.01B		$40,131	EPA
Contingency	0.03B		$120,393	EPA
Total Indirect Cost			$1,244,061	
Total Capital Cost			**$6,461,091**	

Assumptions

Exhaust Flow Rates

2 units each at 70,000 cfm was qouted by vendor.

Estimated uncontrolled emissions

Emissions are from painting activities only.

Assumed that gun and line cleaning solvent activities are recovered and not emitted.

Control Technology: **Thermal Oxidizer w Preheater - John Zink**

Table 2. Annual Cost

				Annual Cost	Reference
Direct Costs					
2-1	Operating labor		0.5 hrs/shift @ $102.63/hr	$19,397	Boeing/EPA
2-2	Supervisory labor		included in labor rate	$0	Boeing
2-3	Maintenance labor		0.5 hr/shift@$102.63/hr	$19,397	Boeing/EPA
2-4	Maintenance materials		100% of maintenance lbr	$19,397	EPA
Utilities					
	Electricty	$0.06	per kwh	$47,356	Boeing
	Fuel	$9.30	per MMBtu	$3,599,770	Boeing
Total Direct Cost				$3,705,317	
Indirect Costs					
	Administrative charges	0.02	of total capital cost	$129,222	EPA
	property tax	0.01	of total capital cost	$64,611	EPA
	Insurance	0.01	of total capital cost	$64,611	EPA
Total Annual Costs Excluding Capital Recovery				$3,963,760	
	Capital recovery			$784,979	
	Interest		10.5%		Boeing
	Lifetime		20 years		John Zink
Total Annual Cost				$4,748,739	
Estimated uncontrolled emissions at 63 planes/month				6.50 lb/hr	
Estimated uncontrolled emissions at 63 planes/month + 25% safety				8.12 lb/hr	
Control Efficiency				99%	John Zink
Emission Reduction at 63 planes/month				9.73 tons/year	
Emission Reduction at 63 planes/month + 25% safety factor				12.16 tons/year	
Cost Effectiveness at 63 planes/month				$488,214 $/ton	
Cost Effectiveness at 63 planes/month + 25% safety factor				$390,572 $/ton	

References

EPA	EPA Capital Cost Factors for Thermal and Catalytic Incinerators
	EPA Air Pollution Control Cost Manual - Sixth Edition (EPA 452/B-02-001)
	Section 3 - VOC Controls
	Section 3.2 - VOC Destruction Controls
	Chapter 2 - Incinerators
John Zink	E-mail from Carl Connally, John Zink, 04/26/2011.
Boeing	Boeing capital project opportunity cost = 10.5%
	Boeing operating and maintenance labor cost = $102.63/hr
	Boeing projected natural gas = $9.30 per million Btu
	Boeing electricty cost = $0.06 per kwh

Control Technology: Thermal Oxidizer - Callidus w preheater

Given Parameters

			Reference
Annual operating hours	3024	hrs	Boeing
Exhaust flow rate, Q	140,000	acfm	Boeing
Estimated uncontrolled emissions	6.55	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month	9.825	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month + 25% safety factor	12.28	tons/year	Boeing
Interest rate	10.5%		Boeing
Equipment lifetime	15	years	Callidus
Fuel requirement	77.0	MMBtu/hr	Callidus
Electricty requirement	22	kw	Callidus

Table 1. Capital Cost Estimate

			Cost	Reference
Purchased Equipment				
Basic equipment and auxillaries	A		$1,500,000	Callidus
Freight	.05A		$75,000	EPA
Sales Tax		0.092	$144,900	
Total Purchased Equipment Cost	B		$1,719,900	
Direct Installation Cost				
Foundation and supports	.08B		$137,592	EPA
Erection and handling	.14B		$240,786	EPA
Electrical	.04B		$68,796	EPA
Piping	.02B		$34,398	EPA
Painting	.01B		$17,199	EPA
Insulation	.01B		$17,199	EPA
Building and site preparation not included				
Total Direct Installation Cost			$515,970	
Total Direct Cost			$2,235,870	
Indirect Cost				
Engineering and supervision	0.10B		$171,990	EPA
Construction and field expenses	0.05B		$85,995	EPA
Construction fee	0.10B		$171,990	EPA
Start-up	0.02B		$34,398	EPA
Performance test	0.01B		$17,199	EPA
Contingency	0.03B		$51,597	EPA
Total Indirect Cost			$533,169	
Total Capital Cost			**$2,769,039**	

Assumptions

Exhaust Flow Rates

Vendor quote is for a 120,000 cfm unit. Vendor confirmed that cost for a 140,000 cfm unit will be comparable to the qoute for the 120,000 cfm unit.

Estimated uncontrolled emissions

Emissions are from painting activities only.

Assumed that gun and line cleaning solvent activities are recovered and not emitted.

Control Technology: **Thermal Oxidizer - Callidus w preheater**

Table 2. Annual Cost

				Annual Cost	Reference
Direct Costs					
2-1	Operating labor		0.5 hrs/shift @ $102.63/hr	$19,397	Boeing/EP/
2-2	Supervisory labor		included in labor rate	$0	Boeing
2-3	Maintenance labor		0.5 hr/shift@$102.63/hr	$19,397	Boeing/EP/
2-4	Maintenance materials		100% of maintenance lbr	$19,397	EPA
Utilities					
	Electricty	$0.06	per kwh	$3,992	Boeing
	Fuel	$9	per MMBtu	$2,165,486	Boeing
Total Direct Cost				$2,227,669	
Indirect Costs					
	Administrative charges	0.02	of total capital cost	$55,381	EPA
	property tax	0.01	of total capital cost	$27,690	EPA
	Insurance	0.01	of total capital cost	$27,690	EPA
Total Annual Costs Excluding Capital Recovery				$2,338,431	
	Capital recovery			$374,507	
	Interest		10.5%		Boeing
	Lifetime		15 years		Callidus
Total Annual Cost				$2,712,938	
Estimated uncontrolled emissions at 63 planes/month				6.50 lb/hr	
Estimated uncontrolled emissions at 63 planes/month + 25% safety				8.12 lb/hr	
Control Efficiency				98%	Callidus
Emission Reduction at 63 planes/month				9.63 tons/year	
Emission Reduction at 63 planes/month + 25% safety factor				12.04 tons/year	
Cost Effectiveness at 63 planes/month				$281,761.21 $/ton	
Cost Effectiveness at 63 planes/month + 25% safety factor				$225,408.97 $/ton	

References

EPA	EPA Capital Cost Factors for Thermal and Catalytic Incinerators
	EPA Air Pollution Control Cost Manual - Sixth Edition (EPA 452/B-02-001)
	Section 3 - VOC Controls
	Section 3.2 - VOC Destruction Controls
	Chapter 2 - Incinerators
Callidus	E-mail from Ania Guy, Callidus Technologies by Honeywell, 03/11/11 and phone conver
Boeing	Boeing capital project opportunity cost = 10.5%
	Boeing operating and maintenance labor cost = $102.63/hr
	Boeing projected natural gas = $9.30 per million Btu
	Boeing electricty cost = $0.06 per kwh

Control Technology: Thermal Oxidizer - Callidus w/o preheater

Given Parameters

			Reference
Annual operating hours	3024	hrs	Boeing
Exhaust flow rate, Q	140,000	acfm	Boeing
Estimated uncontrolled emissions	6.55	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month	9.825	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month + 25% safety factor	12.28	tons/year	Boeing
Interest rate	10.5%		Boeing
Equipment lifetime	15	years	Callidus
Fuel requirement	167.0	MMBtu/hr	Callidus
Electricty requirement	22	kw	Callidus

Table 1. Capital Cost Estimate

			Cost	Reference
Purchased Equipment				
Basic equipment and auxillaries	A		$750,000	Callidus
Freight	.05A		$37,500	EPA
Sales Tax		0.092	$72,450	
Total Purchased Equipment Cost	B		$859,950	
Direct Installation Cost				
Foundation and supports	.08B		$68,796	EPA
Erection and handling	.14B		$120,393	EPA
Electrical	.04B		$34,398	EPA
Piping	.02B		$17,199	EPA
Painting	.01B		$8,600	EPA
Insulation	.01B		$8,600	EPA
Building and site preparation not included				
Total Direct Installation Cost			$257,985	
Total Direct Cost			$1,117,935	
Indirect Cost				
Engineering and supervision	0.10B		$85,995	EPA
Construction and field expenses	0.05B		$42,998	EPA
Construction fee	0.10B		$85,995	EPA
Start-up	0.02B		$17,199	EPA
Performance test	0.01B		$8,600	EPA
Contingency	0.03B		$25,799	EPA
Total Indirect Cost			$266,585	
Total Capital Cost			**$1,384,520**	

Assumptions

Exhaust Flow Rates

Vendor quote is for a 120,000 cfm unit. Vendor confirmed that cost for a 140,000 cfm unit will be comparable to the qoute for the 120,000 cfm unit.

Estimated uncontrolled emissions

Emissions are from painting activities only.

Assumed that gun and line cleaning solvent activities are recovered and not emitted.

Control Technology: **Thermal Oxidizer - Callidus w/o preheater**

Table 2. Annual Cost

				Annual Cost	Reference
Direct Costs					
2-1	Operating labor		0.5 hrs/shift @ $102.63/hr	$19,397	Boeing/EP/
2-2	Supervisory labor		included in labor rate	$0	Boeing
2-3	Maintenance labor		0.5 hr/shift@$102.63/hr	$19,397	Boeing/EP/
2-4	Maintenance materials		100% of maintenance lbr	$19,397	EPA
Utilities					
	Electricty	$0.06	per kwh	$66,528	Boeing
	Fuel	$9	per MMBtu	$4,696,574	Boeing
Total Direct Cost				$4,821,294	
Indirect Costs					
	Administrative charges	0.02	of total capital cost	$27,690	EPA
	property tax	0.01	of total capital cost	$13,845	EPA
	Insurance	0.01	of total capital cost	$13,845	EPA
Total Annual Costs Excluding Capital Recovery				$4,876,674	
	Capital recovery			$187,253	
	Interest		10.5%		Boeing
	Lifetime		15 years		Callidus
Total Annual Cost				$5,063,928	
Estimated uncontrolled emissions at 63 planes/month				6.50 lb/hr	
Estimated uncontrolled emissions at 63 planes/month + 25% safety				8.12 lb/hr	
Control Efficiency				98%	Callidus
Emission Reduction at 63 planes/month				9.63 tons/year	
Emission Reduction at 63 planes/month + 25% safety factor				12.04 tons/year	
Cost Effectiveness at 63 planes/month				$525,931 $/ton	
Cost Effectiveness at 63 planes/month + 25% safety factor				$420,745 $/ton	

References

EPA	EPA Capital Cost Factors for Thermal and Catalytic Incinerators
	EPA Air Pollution Control Cost Manual - Sixth Edition (EPA 452/B-02-001)
	Section 3 - VOC Controls
	Section 3.2 - VOC Destruction Controls
	Chapter 2 - Incinerators
Callidus	E-mail from Ania Guy, Callidus Technologies by Honeywell, 03/11/11 and phone conversation 04/26/2011.
Boeing	Boeing capital project opportunity cost = 10.5%
	Boeing operating and maintenance labor cost = $102.63/hr
	Boeing projected natural gas = $9.30 per million Btu
	Boeing electricty cost = $0.06 per kwh

Control Technology: Regenerative Thermal Oxidizer w/ Zeolite Concentrator - Anguil

Given Parameters

			Reference
Annual operating hours	3024	hrs	Boeing
Exhaust flow rate, Q	140,000	acfm	Boeing
Estimated uncontrolled emissions	6.55	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month	9.825	tons/year	Boeing
Estimated uncontrolled emissions at 63 planes/month + 25% safety factor	12.28125	tons/year	Boeing
Interest rate	10.5%		Boeing
Equipment lifetime	10	years	Anguil
Fuel requirement	1.3	MMBtu/hr	Anguil
Electricty requirement	127	kw	Anguil

Table 1. Capital Cost Estimate

			Cost	Reference
Purchased Equipment				
Basic equipment and auxillaries	A		$1,400,000	Anguil
Freight	.05A		$70,000	EPA
Sales Tax		0.092	$135,240	
Total Purchased Equipment Cost	B		$1,605,240	
Direct Installation Cost				
Foundation and supports	.08B		$128,419	EPA
Erection and handling	.14B		$224,734	EPA
Electrical	.04B		$64,210	EPA
Piping	.02B		$32,105	EPA
Painting	.01B		$16,052	EPA
Insulation	.01B		$16,052	EPA
Building and site preparation not included				
Total Direct Installation Cost			$481,572	
Total Direct Cost			$2,086,812	
Indirect Cost				
Engineering and supervision	0.10B		$160,524	EPA
Construction and field expenses	0.05B		$80,262	EPA
Construction fee	0.10B		$160,524	EPA
Start-up	0.02B		$32,105	EPA
Performance test	0.01B		$16,052	EPA
Contingency	0.03B		$48,157	EPA
Total Indirect Cost			$497,624	
Total Capital Cost			**$2,584,436**	

Assumptions

Exhaust Flow Rates

Vendor quote is for a 120,000 cfm unit. It is assummed that a 140,000 cfm unit will be more expensive and using the qoute for the 120,000 cfm unit is a conservative estimate for cost.

Estimated uncontrolled emissions

Emissions are from painting activities only.

Assumed that gun and line cleaning solvent activities are recovered and not emitted.

Control Technology: **Regenerative Thermal Oxidizer w/ Zeolite Concentrator - Anguil**

Table 2. Annual Cost

				Annual Cost	Reference
Direct Costs					
2-1	Operating labor		0.5 hrs/shift @ $102.63/hr	$19,397	Boeing/EP/
2-2	Supervisory labor		included in labor rate	$0	Boeing
2-3	Maintenance labor		0.5 hr/shift@$102.63/hr	$19,397	Boeing/EP/
2-4	Maintenance materials		100% of maintenance lbr	$19,397	EPA
Utilities					
	Electricty	$0.06	per kwh	$23,043	Boeing
	Fuel	$9	per MMBtu	$36,560	Boeing
Total Direct Cost				$117,794	
Indirect Costs					
	Administrative charges	0.02	of total capital cost	$51,689	EPA
	property tax	0.01	of total capital cost	$25,844	EPA
	Insurance	0.01	of total capital cost	$25,844	EPA
Total Annual Costs Excluding Capital Recovery				$221,172	
	Capital recovery			$429,681	
	Interest		10.5%		Boeing
	Lifetime		10 years		Anguil
Total Annual Cost				$650,853	
Estimated uncontrolled emissions at 63 planes/month				4.33 lb/hr	
Estimated uncontrolled emissions at 63 planes/month + 25% safety				6.50 lb/hr	
Control Efficiency				98%	Anguil
Emission Reduction at 63 planes/month				6.42 tons/year	
Emission Reduction at 63 planes/month + 25% safety factor				9.63 tons/year	
Cost Effectiveness at 63 planes/month				$101,395 $/ton	
Cost Effectiveness at 63 planes/month + 25% safety factor				$67,597 $/ton	

References

EPA	EPA Capital Cost Factors for Thermal and Catalytic Incinerators
	EPA Air Pollution Control Cost Manual - Sixth Edition (EPA 452/B-02-001)
	Section 3 - VOC Controls
	Section 3.2 - VOC Destruction Controls
	Chapter 2 - Incinerators
Anguil	E-mail from Scott Bayon, Anguil, 04/25/2011.
Boeing	Boeing capital project opportunity cost = 10.5%
	Boeing operating and maintenance labor cost = $102.63/hr
	Boeing projected natural gas = $9.30 per million Btu
	Boeing electricty cost = $0.06 per kwh

APPENDIX D

Detailed Emission Calculations

Baseline Emissions

Table D-1 shows the 2009 and 2010 VOC emissions for each activity for the Boeing Renton site.

TABLE D-1
Baseline VOC Emissions (tpy)

	2009	2010	Average Baseline
Wing Assembly	61.6	62.2	61.9
Wing Coating	59.0	93.1	76.0
Final Assembly	14.2	14.4	14.3
Paint Hangar/Flightline	30.3	42.1	36.2
Combustion	0.9	0.9	0.9
Total	165.9	212.6	189.3
Airplane production	372	376	374.0

Note that the average baseline Wing Assembly emissions include emissions from the four Wing Panel Booths that will be shutdown. To adjust the baseline emissions for these booths which will not be operated, the emissions from those booths must be calculated. Table D-2 shows the emissions from the existing Wing Panel Booths in Building 4-20 based on a baseline 2-year average production of 374 airplanes per year. As shown in Table D-2 the total VOC emissions from the existing four Wing Panel Booths that will be shutdown are 3.3 tons per year.

TABLE D-2
Building 4-20 Wing Panel Booths - Baseline 374 Planes per Year

Number of Booths	4		
Number of Planes/yr	374		
	Gallons/Airplane	**lb VOC/gallon**	**lb VOC/plane**
MPK	0.75	7	5.25
BMS 5-45 Sealant	7	0.7	4.9
BMS 10-20 Primer	1.36	5.5	7.48
Total VOC (lb/airplane)			17.63
Total VOC (lb/airplane)			17.6
Total VOC (lb/booth-yr)			1,648
Total VOC (tons/booth-yr)			0.82
Total VOC (tpy)			3.30

Subtracting the 3.3 tons per year for the Wing Panel Booths that will be shutdown from the average baseline Wing Assembly emissions of 61.9 tons per year results in 58.6 tons per year, as shown in Table D-3. This represents the adjusted baseline emissions for the facility.

TABLE D-3
Adjusted Average Baseline VOC Emissions (tpy)

	Adjusted Average
Wing Assembly	58.6
Wing Coating	76.0
Final Assembly	14.3
Paint Hangar/Flightline	36.2
Combustion	0.9
Total	186.0

Projected Actual Emissions

Boeing proposes to increase airplane production to about 504 airplanes per year (42 airplanes per month). This increase will be made possible by debottlenecking the Wing Assembly and Wing Coating operations. To calculate the projected actual emissions from the existing debottlenecked sources, the baseline emissions are multiplied by the ratio of increased production, 504/374, and shown in Table D-4.

TABLE D-4
Projected VOC Emissions (tpy)

	Adjusted Average	Projected	Increase
Wing Assembly	58.6	78.96	20.37
Wing Coating	76.0	102.48	26.43
Final Assembly	14.3	19.27	4.97
Paint Hangar/Flightline	36.2	48.73	12.57
Combustion	0.9	1.65	0.75
Total	185.99	251.08	65.09

Note that the projected emissions assume most of the final decorative exterior coating will be applied at the Renton facility as a conservative assumption. Most airplanes are flown offsite for final exterior coating. Therefore, the increase in paint hangar emissions is likely an over-estimate. In addition, the purpose of this project is to increase the production capacity of 737s to 504 airplanes per year (42 per month). As stated in the Technical Support Document (TSD) for PSD-08-01, Amendment 1, Boeing Renton previously proposed and Ecology approved a project that was intended to increase the Boeing Renton's production capacity of 737s of 41 airplanes per month (492 airplanes per year) (see TSD for Final PSD-08-01, Amendment 1, Section 1.2.3). Now, Boeing Renton seeks to increase production capacity to 42 737s per month, 12 airplanes per year more than the 41 per month rate assumed in the emission increase calculations in the earlier PSD permitting analysis.

Since PSD-08-01 accounted for Renton's paint hangars and assembly operations emissions for a total of 492 airplanes per year, those emissions cannot be credited to this project. However,

although Boeing has not decided where to apply the final exterior coating on the additional 12 airplanes per year, it is physically possible that those 12 additional airplanes per year will be coated at the Boeing Renton facility. To estimate the emissions from painting 12 additional airplanes per year the paint hanger emissions from 2007 to 2009 were reviewed (Table D-5). For the year with the greatest emissions per plane, 2008, the average VOC emissions for exterior coating of completed 737s at Renton was 0.406 ton per airplane. If all 12 additional airplanes were coated in Renton, the result would be an additional 4.9 tons of VOC per year. This is considerably less than the estimated 12.57 tons per year estimated increase using the ratio of increased airplane production of 504/374. Therefore, the estimated 12.57 tons per year increase in Paint Hangar emissions more than accounts for the potential increase.

TABLE D-5
Paint Hangar VOC Emissions

	2007	2008	2009
No. of Airplanes	330	290	372
Paint Hangar Emissions (tpy)	114	118	140
Emissions per Airplane (tons/plane)	0.346	0.406	0.377

Potential VOC Emissions from New Wing Panel Booths

The four new Wing Panel Booths to be located in Building 4-20 will be capable of accommodating up to 756 airplanes per year. Since each wing has two panels and each airplane has two wings, this represents a total of 3,024 panels per year. Table D-6 shows the estimated potential emissions from the new Wing Panel Booths.

TABLE D-6
Potential VOC Emissions from New Wing Panel Booths (tpy)

Number of Booths	4		
Number of Panels/yr	3,024		
Number of Airplanes/yr	756		
	Gallons/Airplane	**lb VOC/gallon**	**lb VOC/plane**
MPK	0.75	7	5.25
BMS 5-45 Sealant	7	0.7	4.9
BMS 10-20 Primer	1.36	5.5	7.48
Total VOC (lb/airplane)			17.63
Total VOC (lb/airplane)			17.6
Total VOC (lb/booth-yr)			3,332
Total VOC (tons/booth-yr)			1.67
Total VOC (tpy)			6.66
Adjustment for changes in paints and wings, 25% (lb/airplane)			**22.04**
Adjustment for changes in paints and wings, 25% (tons/booth-yr)			**2.08**
Adjustment for changes in paints and wings, 25% (tpy)			**8.33**

Potential VOC Emissions from New and Modified Inspar Wing Booths

Boeing proposes to construct a new Inspar Wing Booth and modify another. The tops and bottoms of wing assembles will be cleaned, sealed, and coated in Inspar Wing Booths. The new and modified Inspar Wing Booths will have the capacity of painting one wing per day, 365 wings per year. Table D-7 shows the estimated potential VOC emissions from each booth.

TABLE D-7
Potential VOC Emissions from New Inspar Wing Booth

Number of Booths	1			
Number of Planes/yr	182.5			
Wings/Booth-yr	365			
Spray Time hr/wing	8			
Spray Time hr/booth-yr	2,920			
	Gallons/Airplane	**lb VOC/gallon**	**lb VOC/plane**	
BMS 10-79 GD (10P20-44) Primer	2	2.3	4.6	
BMS 5-95 Spray Seal	6	4.4	26.4	
BMS 10-60 Enamel	8	3.5	28	
Total			59	
	lb VOC	**planes**	**lb VOC/plane**	
Gun and Line Cleaning	13,050	290	45.0	

Note: 1572 is for toluene and it's a 50/50 mix

	Painting	**Cleaning**	**Total**
Total VOC (lb/airplane)	59	45	104
Total VOC (tons per airplane)	0.03	0.02	0.05
Total VOC (lb/booth-yr)	10,768	8,213	18,980
Total VOC (tons per booth-yr)	5.38	4.11	9.49
Adjustment for changes in paints and wings, 25% (tons/booth-yr)	6.73	5.13	11.86
Adjustment for changes in paints and wings, 25% (pounds per wing)			65
Adjustment for changes in paints and wings, 25% (pounds per plane)			130

Combustion Emissions

Baseline emissions for the combustion sources were based on the fuel consumption for 2008 and 2009 and either EPA emission factor or permit limits (Table D-8).

TABLE D-8
Baseline Combustion Emissions

Combustion Emission Calculations										
	Factors									
	Total Gas Used in Baseline Period:		6.63E+05	MMBtu/ 2-yr		3.32E+05	MMBtu/yr			
	Gas Used in Boilers 1-3 in Baseline Period:		1.88E+05	MMBtu/ 2-yr		9.38E+04	MMBtu/yr	28%		
	Gas Used in Boilers 4-6 in Baseline Period:		4.76E+05	MMBtu/ 2-yr		2.38E+05	MMBtu/yr	72%		
	Total Oil Used in Baseline Period:		9954	Gal/2-yr		4.977	1000 Gal/yr	140	MMBtu/1000 gal	
Baseline										
			CO	NOx <100 MMBtu	NOx > 100 MMBtu	NOx Total	PM	SO2	Lead	VOC
Gas	Emission Factor	lb/MMBtu (AP-42)	0.08	0.031	0.275		0.0075	0.00059	4.90E-07	0.00539
	Emissions	Ton/yr	13.26	1.47	32.63	34.10	1.24	0.10	0.0001	0.89
Oil	Emission Factor	lb/1000 gal (lb/MMBtu of GHG)	5	19	14		3.3	7.385	0.00126	0.2
	Emissions	Ton/yr	0.01	0.05	0.03	0.08	0.01	0.02	0.0000	0.00
	Total Baseline	Tons/yr	13.27	1.52	32.67	34.19	1.25	0.12	0.0001	0.89

To estimate the future actual combustion emissions, first the amount of heat used for each airplane was determined. As shown in Table D-9, the most natural gas used in the last five years occurred in 2006. That was divided by the number of airplanes produced in 2006, 302, to determine the heat input for each plane, 1,209 MMBtu/plane, from natural gas.

TABLE D-9
Combustion Fuel Usage

Year	Oil #6 (gal)	Oil #2 (gal)	Natural Gas 10-100 MMBtu/Hr (1000 Therms)	Natural Gas < 10 MMBtu/Hr (1000 Therms)	Natural Gas > 100 MMBtu/Hr (1000 Therms)	Total Oil (MMBtu)	Total Gas (MMBtu)	Gas (MMBtu/plane)
2002		-	594	32	4,358	-	498,400	1,994
2003	800	60	452	22	3,318	120	379,200	2,084
2004	31,548	200	431	20	3,159	4,445	361,000	1,695
2005	16,000	00	403		2,743	2,310	314,600	1,470
2006	12,000	500	1,373		2,277	1,750	365,000	1,209
2007	16,312		1,361		2,082	2,284	344,300	1,043
2008	4,743	57	820		2,561	672	338,100	1,166
2009	5,154		1,055		2,194	722	324,900	873

Based on 1,209 MMBtu/plane and a project actual production of 504 planes per year, a total projected heat input of natural gas of 609,139 MMBtu/yr was projected (Table D-10). Renton uses some boilers that have capacities of less than 100 MMBtu/hr and some boilers have capacities of greater than 100 MMBtu/hr. The emission factors for each are different. To account for the difference between boiler sizes, the historical percentages of 28 percent of the heat input going to the smaller boilers and 72 percent going to the larger boiler were assumed.

TABLE D-10
Projected Actual Combustion Emissions

		Gas			Oil increase:				Fraction of fuel burned in Boilers 1-3:	Fraction of fuel burned in Boilers 4-6:
		1,209	MMBtu/plane						28%	72%
		504	plane/yr							
		609,139	MMBtu/yr					Gas:	172,268	436,871
					32.62	1000 gal/yr		Oil:	9.23	23.40
			CO	NOx <100 MMBtu	NOx > 100 MMBtu	NOx Total	PM	SO2	Lead	VOC
Gas	Emission Factor	lb/MMBtu	0.08	0.031	0.275		0.0075	0.00059	4.90E-07	0.00539
	Emissions	Ton/yr	24.37	2.70	59.96	62.66	2.28	0.18	0.00015	1.64
Oil	Emission Factor	lb/1000 gal (lb/MMBtu of GHG)	5	19	14		3.3	7.385	0.00126	0.2
	Emissions	Ton/yr	0.08	0.09	0.16	0.25	0.05	0.12	0.00002	0.00
	Projected	Tons/yr	24.45	2.79	60.13	62.92	2.34	0.30	0.00017	1.64

Similarly, 2007 used the most oil in the last five years, 16,312 gallons. To conservatively estimate the maximum oil burned in the future, this amount was doubled, to 32,620 and gallons. The same 28:72 percent split between the small and large boilers was assumed to calculate the projected actual emissions from combustion.

These estimates of projected emissions are likely over estimates because most of the heat generated at the Renton facility goes to space heating and other activities that are not directly proportional to airplane production.

Greenhouse Gas Emissions

The baseline greenhouse gas (GHG) emissions were based on 2006 – 2007 emissions. The GHG emissions are divided between those from combustion and those from other airplane assembly operations. As shown in Table A-4, the greatest amount of stationary GHG emissions per plane in the last five years was 79.5 tonnes, which occurred in 2008. Therefore, the GHG emission rates for 2008 were scaled up from 290 planes per year to 504 planes per year to determine the projected actual GHG emissions.