

**TECHNICAL MEMORANDUM**

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## **Information Request #3 – Autoclaves, Airport Generators, Carbon Kiln, Particulate Controls, Fuel Tanks, Incinerators**

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This memorandum provides the information requested on April 15, 2022, by Mr. Dave Jones of the Alaska Department of Environmental Conservation (ADEC) regarding the Donlin Gold Project Construction Permit AQ0934CPT02 Application.

### **Table of Contents**

---

1.0 Introduction .....	3
2.0 Autoclaves EU 77 and 81 .....	4
2.1 ADEC Request Item 1 .....	4
2.2 Item 1 Response .....	5
2.2.1 Exhaust Characteristics and Gas Conditioning .....	5
2.2.2 Emission Reduction and Costs .....	6
3.0 Airport Generators EU 13 and 14 .....	7
3.1 ADEC Request Item 2 .....	7
3.2 Item 2 Response .....	8
4.0 Carbon Regeneration Kiln EU 88 .....	9
4.1 ADEC Request Item 3 .....	9
4.2 Item 3 Response .....	9
4.3 ADEC Request Item 4 .....	11
4.4 Item 4 Response .....	11
5.0 Particulate Controls (Various EUs) .....	12
5.1 ADEC Request Item 5 .....	12
5.2 Item 5 Response .....	13
6.0 Fuel Tanks EU 126-142 .....	14

6.1 ADEC Request Item 6 .....	14
6.2 Item 6 Response .....	14
7.0 Incinerators EU 27 and 28 .....	15
7.1 ADEC Request Item 7 .....	15
7.2 Item 7 Response .....	16
8.0 References .....	20

## Tables

Table 1. Autoclaves: Catalytic Oxidation Cost Effectiveness.....	6
Table 2. Autoclaves: Catalytic Oxidation Cost Effectiveness Per Pollutant .....	7
Table 3. Autoclaves: Catalytic Oxidation Auxiliary Fuel Consumption and GHG Emissions.....	7
Table 4. Airport Generators: Catalytic Oxidation Cost Effectiveness.....	8
Table 5. Airport Generators: Catalytic Oxidation Cost Effectiveness Per Pollutant .....	9
Table 6. Carbon Regeneration Kiln: Catalytic Oxidation Cost Effectiveness .....	10
Table 7. Carbon Regeneration Kiln: Catalytic Oxidation Cost Effectiveness Per Pollutant .....	10
Table 8. Carbon Regeneration Kiln: Catalytic Oxidation Auxiliary Fuel Consumption and GHG Emissions.....	11
Table 9. Carbon Regeneration Kiln: Particulate Controls Cost Effectiveness .....	12
Table 10. Hot Cure Tanks, EW Cells, and Retort: Particulate Controls Cost Effectiveness.....	14
Table 11. Tanks: VOC Controls Cost Effectiveness .....	15
Table 12. Incinerators: Control Efficiencies Needed to Meet NSPS.....	17
Table 13. Incinerators: Particulate, NOx and CO Controls Cost Effectiveness .....	19

## Appendices

Appendix A – BACT Cost Calculations

Appendix B – Cost Analysis Workbooks and the Memorandum Reference Documents

## 1.0 Introduction

Per ADEC's request, the cost effectiveness of emission controls for the autoclaves, airport generators, carbon regeneration kiln, hot cure tanks, electrowinning (EW) cells, mercury retort, diesel fuel tanks, and incinerators have been re-evaluated. The results are summarized below:

- Autoclaves (EU 77 and 81): Oxidation catalyst does not meet the criteria of BACT based on the following:
  - Oxidation catalyst has not been demonstrated in a commercial application for ore processing autoclaves. Therefore, it is not considered a technologically feasible control option.
  - As a hypothetical innovated control technology, an oxidation catalyst would require significant fuel producing over 4,000 tons per year of carbon dioxide equivalent (CO<sub>2e</sub>) per autoclave and would cost between \$1,200 and \$8,300 per ton of carbon monoxide (CO) removed and over \$2 million per ton of volatile organic compounds (VOC) removed.
- Airport Generators (EU 13 and 14): Oxidation catalyst does not meet the criteria of BACT based on a cost effectiveness of over \$12,000 per ton of CO removed and over \$200,000 per ton of VOC removed.
- Carbon Regeneration Kiln (EU 88):
  - Oxidation catalyst does not meet the criteria of BACT based on a cost effectiveness of over \$56,000 per ton of CO removed and over \$112,000 per ton of VOC removed.
  - Add-on particulate control systems do not meet the criteria of BACT based on a cost effectiveness of over \$76,000 to \$113,000 per ton of particulate matter (PM) removed.
- Hot Cure Tanks (EU 85-87): Add-on particulate control systems do not meet the criteria of BACT based on a cost effectiveness of over \$67,000 to \$106,000 per ton of PM removed.
- EW Cells (EU 91-94): Add-on particulate control systems do not meet the criteria of BACT based on a cost effectiveness of over \$334,000 to \$388,000 per ton of PM removed.

- Mercury Retort (EU 97): Add-on particulate control systems do not meet the criteria of BACT based on a cost effectiveness of over \$862,000 to \$1.4 million per ton of PM removed.
- Diesel Tanks (EU 126-140): Neither a floating roof nor a vapor recovery system meet the criteria of BACT based on a cost effectiveness of over \$52,000 to \$608,000 per ton of VOC removed.
- Incinerators (EU 27 and 28):
  - Add-on particulate control systems do not meet the criteria of BACT based on a cost effectiveness of over \$12,000 to \$31,000 per ton of particulate matter (PM) removed.
  - Selective non-catalytic reduction (SNCR) and selective catalytic reduction (SCR) do not meet the criteria of BACT based on a cost effectiveness of over \$168,000 to \$729,000 per ton of nitrogen oxides (NO<sub>x</sub>) removed.
  - Oxidation catalyst does not meet the criteria of BACT based on a cost effectiveness of over \$89,000 to \$307,000 per ton of CO removed.
  - Regardless of the high-cost effectiveness of add-on controls, Donlin Gold proposes the appropriate add-on controls and/or combustion control technologies necessary to meet the NSPS Subparts CCCC and LLLL emission limits as BACT.

Discussions of the above results are provided in the following sections of this memorandum.

## **2.0 Autoclaves EU 77 and 81**

### **2.1 ADEC Request Item 1**

*The Department verified that there are no autoclaves in the RBLC other than the pitch Impregnation source identified by Donlin in their application (RBLC Source SC-0142). However, the Department notes that this source is employing a thermal oxidizer for CO and VOC controls. Donlin's autoclaves EUs 77 and 81 have potential combined CO emissions of 771 tpy and VOC emissions of 0.4 tpy. Regarding possible CO and VOC controls for the autoclave, Donlin's application states the following: Possible add-on control options for CO include thermal and catalytic oxidation. The level of control that may be achieved by thermal and catalytic oxidation systems is unknown as there are no applications of these controls on ore autoclaves. In addition, because there are no commercial installations of these controls on this source type, they are not considered viable control options.*

1. Please verify that thermal and catalytic oxidation is not a technologically feasible control option for the autoclaves, or submit economic analyses demonstrating that potential emissions reductions for these control types are not economically feasible, or propose controls for these EUs.

## 2.2 Item 1 Response

As noted above, there are no BACT determinations and no other installations of thermal or catalytic oxidation systems for ore processing autoclaves. In addition, EPA's Air Pollution Control Technology Fact Sheet for catalytic oxidizers does not list ore processing autoclaves as an industry type that uses this technology (EPA 2003a). Because this control technology has not been demonstrated in a commercial application for ore processing autoclaves, it is not a demonstrated or transferable technology for the purpose of a BACT analysis. However, the following subsections provide an economic analysis for a catalytic oxidizer as a hypothetical innovated control technology for the Donlin Gold autoclaves.

### 2.2.1 Exhaust Characteristics and Gas Conditioning

In the autoclave pressure oxidation circuit, the ore (or ore concentrate) is mixed with water to produce a water/ore slurry. This slurry is pumped through autoclaves, where the ore is oxidized using heat, pressure, and oxygen. The resulting exhaust from the autoclaves is hot and saturated with water. The exhaust is quenched and then ducted through venturi wet scrubbers to remove particulates. Further gas conditioning would be required prior to treatment for other constituents such as mercury, VOCs, and CO.

The Donlin Gold autoclave exhaust gas treatment system is described in the PSD Construction Permit Application Report (Application) as follows:

*Exhaust gas from each autoclave will discharge into a vent gas quench vessel. The quench vessel will reduce the temperature of the exhaust gas and the quantity of steam (through condensation) that will be fed to downstream exhaust treatment equipment. Vent gas from the quench vessel will be piped to a condenser vessel (17-VEA-103, 203), where cooling water will accomplish further gas cooling and steam condensation. The gas will then pass through a venturi scrubber (17-SBW-101, 201), where it will be further cleaned of particulates. Finally, the gas will pass through a two-chamber carbon filter (17-VEA-104A, 204A). The first chamber will contain activated carbon to remove organic compounds followed by sulfur-impregnated carbon in the second chamber, specifically designed to adsorb mercury.*

(Air Sciences 2021, p. 9)

By the time the gas exits the carbon filter it is cool (approximately 100 °F) and dry (<10% moisture). Following the carbon filter would be the most logical point in the gas stream for a catalytic oxidizer. However, the exhaust gas would require significant heating prior to the

oxidizer. Placing the catalytic oxidizer before the carbon filter is impractical because it would require both heating prior to the oxidizer and then cooling after the oxidizer to prevent overheating the carbon filter, and potentially causing the carbon to catch fire.

## 2.2.2 Emission Reduction and Costs

The CO emissions from the autoclaves of 88 pounds per hour per autoclave is conservatively based on pilot plant testing. Test data from similar size autoclaves at the Nevada Goldstrike mine showed CO emissions of 10 to 16 pounds per hour (13 pounds per hour on average). The following cost-effectiveness analysis was completed for both emission levels.

As discussed in Section 2.2.1, the gas stream exiting the carbon filter would require heating prior to catalytic oxidation. Using EPA's Microsoft Excel cost analysis workbook (file: oxidizers\_calc\_sheet\_finalversion\_1-16-2018.xlsm) (EPA 2018), the equipment, operating, and auxiliary fuel costs were estimated for controlling CO and VOC emissions from the Donlin Gold autoclaves with catalytic oxidizers. The workbooks are available for download via the link provided in Appendix B. The following inputs were used in each workbook:

- The EPA default emission reduction efficiency of 99% (EPA 2018)
- The EPA default life expectancy of the control system of 20 years (EPA 2018)
- The EPA default catalyst operating temperature of 900 °F (EPA 2018)
- The 2022 Chemical Engineering Plant Cost Index (CEPCI) of 785.9 (Towering Skills 2022)
- The Donlin Gold project borrowing interest rate of eight percent (Annett, K. 2022)
- CO emission based on: 1) the permitted BACT level of 88 pounds per hour per autoclave, and 2) the actual test data from similar units averaging 13 pounds per hour.

The results of the catalytic oxidizer cost calculations are summarized in Table 1.

**Table 1. Autoclaves: Catalytic Oxidation Cost Effectiveness**

EU ID	EU Description	CO Emission Basis	Total Capital Investment (\$)	Annual Cost (\$/yr)	CO+VOC Reduced (ton/yr)	Cost Effectiveness (\$/ton)
77, 81	Each Autoclave	Permit	\$618,499	\$457,791	381.76	\$1,199
77, 81	Each Autoclave	Test Data	\$618,767	\$470,454	56.54	\$8,320

Table 1 shows a control cost effectiveness of \$1,199 per ton of combined CO and VOC removed for the permitted emission basis and \$8,320 per ton of combined CO and VOC removed for the test data emission basis. In both cases, autoclave CO emissions were conservatively estimated at a maximum operating schedule of 8,760 hours per year. The control cost effectiveness per pollutant is summarized in Table 2. Table 3 summarizes the auxiliary fuel consumption and resulting greenhouse gas emissions (GHG) from the catalytic oxidation systems.

**Table 2. Autoclaves: Catalytic Oxidation Cost Effectiveness Per Pollutant**

EU ID	CO Emission Basis	Emission Reduction, Each			Annual Cost, Each (\$/yr)	Cost Effectiveness (\$/ton)		
		CO	VOC	CO+VOC		CO	VOC	CO+VOC
77, 81	Permit	381.59	0.17	381.76	\$457,791	\$1,200	\$2,639,355	\$1,199
77, 81	Test Data	56.37	0.17	56.54	\$470,454	\$8,346	\$2,712,364	\$8,320

**Table 3. Autoclaves: Catalytic Oxidation Auxiliary Fuel Consumption and GHG Emissions**

EU ID	CO Emission Basis	Fuel, Each (scfm)	Fuel, Each (MMscf/yr)	CO <sub>2e</sub> Emission Factor (lb/MMscf)	CO <sub>2e</sub> Emissions, Each (ton/yr)
77, 81	Permit	136.61	71.80	119,440	4,288
77, 81	Test Data	142.86	75.09	119,440	4,484

In summary, catalytic oxidation has not been demonstrated in a commercial application for ore processing autoclaves. Therefore, it is not considered a technologically feasible control option. In addition, the control costs shown in Table 1 and Table 2 are above the amounts considered as cost effective. Lastly, the oxidation of CO emissions from the autoclaves would result in adverse environmental impacts from fossil fuel combustion and greenhouse gas emissions. Because the CO emissions do not pose a health risk in the rural area surrounding the Donlin Gold project, these environmental impacts are unnecessary.

### 3.0 Airport Generators EU 13 and 14

#### 3.1 ADEC Request Item 2

*Donlin has proposed EPA Nonroad Tier 4 generators to power the airport (non-emergency generators). The application states a proposed emission rate of 4.38 g/kWh (EPA Tier 4 with 1.25 not to exceed factor of safety) which equates to 8.4 tpy for each generator.*

2. Please verify that these Tier 4 engines are already equipped with a catalyst control system for CO and obtain actual CO emission rates from the engine vendor/manufacturer if they are in fact lower than the EPA Tier 4 standard with a not to exceed factor safety, or provide an economic analysis demonstrating that potential emissions reductions for an oxidation catalyst is not economically feasible, or propose controls for these EUs.

### 3.2 Item 2 Response

Because the airport generators have not yet been procured, the actual CO emissions and control method utilized by the manufacturer to meet the Tier 4 emission levels is not defined. It is, however, expected that the actual CO emissions will be considerably below the Tier 4 limits and not-to-exceed factor. The EPA Microsoft Excel cost analysis workbook (file: oxidizers\_calc\_sheet\_finalversion\_1-16-2018.xlsm) (EPA 2018) was used to determine the cost effectiveness of controlling the maximum CO and VOC emissions from the airport generators with catalytic oxidizers. This workbook is available for download via the link provided in Appendix B. The following inputs were used in the workbook:

- The EPA default emission reduction efficiency of 99% (EPA 2018)
- The EPA default life expectancy of the control system of 20 years (EPA 2018)
- A catalyst operating temperature equal to the generator exhaust temperature of 916 °F
- The 2022 Chemical Engineering Plant Cost Index (CEPCI) of 785.9 (Towering Skills 2022)
- The Donlin Gold project borrowing interest rate of eight percent (Annett, K. 2022)
- CO and VOC emissions based on the Tier 4 limits multiplied by the not-to-exceed factor

The results of the catalytic oxidizer cost calculations are summarized in Table 4.

**Table 4. Airport Generators: Catalytic Oxidation Cost Effectiveness**

EU ID	EU Description	Total Capital Investment (\$)	Annual Cost (\$/yr)	CO+VOC Reduced (ton/yr)	Cost Effectiveness (\$/ton)
13	Airport Generator #1	\$152,307	\$101,803	8.85	\$11,509
14	Airport Generator #2	\$152,307	\$101,803	8.85	\$11,509

Table 4 shows a control cost effectiveness of \$11,509 per ton of combined CO and VOC removed based on the maximum emissions and a maximum operating schedule of 8,760 hours per year. The control cost effectiveness per pollutant is summarized in Table 5. The control costs shown



in these tables are above the amounts considered as cost effective. However, regardless of the high-cost effectiveness, the oxidation catalyst may be utilized by the manufacturer to meet the EPA Tier 4 standards.

**Table 5. Airport Generators: Catalytic Oxidation Cost Effectiveness Per Pollutant**

EU ID	Emission Reduction			Annual Cost (\$/yr)	Cost Effectiveness (\$/ton)		
	CO	(\$/yr)	CO+VOC		CO	VOC	CO+VOC
13	8.37	0.48	8.85	\$101,803	\$12,165	\$213,432	\$11,509
14	8.37	0.48	8.85	\$101,803	\$12,165	\$213,432	\$11,509

## 4.0 Carbon Regeneration Kiln EU 88

### 4.1 ADEC Request Item 3

*The carbon regeneration kiln has potential CO emissions of 3.8 tpy and VOC emissions of 1.9 tpy (5.8 tpy combined) and potential particulate emissions of 1.9 tpy.*

3. Please provide economic analyses demonstrating that potential emissions reductions for thermal and catalytic oxidation control types are not economically feasible, or propose controls for these EUs.

### 4.2 Item 3 Response

The Donlin Gold carbon regeneration kiln exhaust gas treatment system is described in the Application as follows:

*The exhaust gas from the carbon regeneration kiln will pass through an off-gas cooler (56-CDO-300) and a carbon filter (56-FIL-205) before exiting to the atmosphere.*  
(Air Sciences 2021, p. 10)

By the time the gas exits the carbon filter it is cool (approximately 100 °F) and dry (<10% moisture). Following the carbon filter would be the most logical point in the gas stream for a catalytic oxidizer. However, the exhaust gas would require significant heating prior to the oxidizer. Placing the catalytic oxidizer before the carbon filter is impractical because it would require both heating prior to the oxidizer and then cooling after the oxidizer to prevent overheating the carbon filter, and potentially causing the carbon to catch fire.

Using EPA's Microsoft Excel cost analysis workbook (file: oxidizers\_calc\_sheet\_finalversion\_1-16-2018.xlsm) (EPA 2018), the equipment, operating, and auxiliary fuel costs were estimated for controlling CO and VOC emissions from the carbon regeneration kiln with a catalytic oxidizer.

This workbook is available for download via the link provided in Appendix B. The following inputs were used in the workbook:

- The EPA default emission reduction efficiency of 99% (EPA 2018)
- The EPA default life expectancy of the control system of 20 years (EPA 2018)
- The EPA default catalyst operating temperature of 900 °F (EPA 2018)
- The 2022 Chemical Engineering Plant Cost Index (CEPCI) of 785.9 (Towering Skills 2022)
- The Donlin Gold project borrowing interest rate of eight percent (Annett, K. 2022)
- Emissions based on the permitted BACT levels of 0.88 pounds per hour of CO and 0.44 pounds per hour of VOC

The results of the catalytic oxidizer cost calculations are summarized in Table 6.

**Table 6. Carbon Regeneration Kiln: Catalytic Oxidation Cost Effectiveness**

EU ID	EU Description	Total Capital Investment (\$)	Annual Cost (\$/yr)	CO+VOC Reduced (ton/yr)	Cost Effectiveness (\$/ton)
88	Carbon Regen. Kiln	\$321,504	\$213,810	5.72	\$37,355

Table 6 shows a control cost effectiveness of \$37,355 per ton of combined CO and VOC removed based on the maximum emissions and a maximum operating schedule of 8,760 hours per year. The control cost effectiveness per pollutant is summarized in Table 7. Table 8 summarizes the auxiliary fuel consumption and resulting greenhouse gas emissions from the catalytic oxidation system.

**Table 7. Carbon Regeneration Kiln: Catalytic Oxidation Cost Effectiveness Per Pollutant**

EU ID	Emission Reduction			Annual Cost (\$/yr)	Cost Effectiveness (\$/ton)		
	CO	VOC	CO+VOC		CO	VOC	CO+VOC
88	3.82	1.91	5.72	\$213,810	\$56,032	\$112,064	\$37,355

**Table 8. Carbon Regeneration Kiln: Catalytic Oxidation Auxiliary Fuel Consumption and GHG Emissions**

EU ID	Fuel (scfm)	Fuel (MMscf/yr)	CO <sub>2e</sub> Emission Factor (lb/MMscf)	CO <sub>2e</sub> Emissions (ton/yr)
88	43.36	22.79	119,440	1,361

The control costs shown in Table 6 and Table 7 are above the amounts considered as cost effective. In addition, the oxidation of CO emissions from the carbon regeneration kiln would result in adverse environmental impacts from fossil fuel combustion and greenhouse gas emissions shown in Table 8. Because the CO emissions do not pose a health risk in the rural area surrounding the Donlin Gold project, these environmental impacts are unnecessary.

### 4.3 ADEC Request Item 4

*The Department notes that a wet-off gas cooler was proposed to control particulate emissions. However, a dust collector, ESP, or wet scrubber could provide potentially higher levels of control.*

*4. Please provide economic analyses demonstrating that potential emissions reductions from a dust collector, ESP, or wet scrubber is not economically feasible, or propose the top level control.*

### 4.4 Item 4 Response

As discussed in Section 4.2, the carbon regeneration kiln exhaust passes through an off-gas cooler prior to the carbon filter. The primary purpose of this cooler is to reduce the temperature of the exhaust gas and the quantity of steam (through condensation). This process also has the secondary effect of removing particulates. Reducing the temperature and moisture in the gas stream is a necessary gas treatment step for proper operation of the carbon filter.

The gas exiting the carbon filter is cool (approximately 100 °F) and dry (<10% moisture). Control options for further PM reduction of this gas stream include a dust collector, wet scrubber, and ESP.

The EPA Control Cost Manual, Section 6 – Particulate Matter Control, Chapter 1 – Baghouses and Filters (EPA 1998), Chapter 2 – Wet Scrubbers for Particulate Matter (EPA 2002), and Chapter 3 – Electrostatic Precipitators (EPA 1999) were used to determine the cost effectiveness of controlling particulate matter from the carbon regeneration kiln. The control cost workbook is available for download via the link provided in Appendix B. The following inputs were used in the workbook:

- The emission reduction efficiency cited for fabric filters of 99.45% (EPA 1998, p. 1-4), venturi scrubbers of 98.45% (EPA 2002, p. 2-43), and ESPs of 99.45% (EPA 2003b, p. 1)
- The EPA default life expectancy for fabric filters of 20 years (EPA 1998, p. 1-55), venturi scrubbers of 15 years (EPA 2002, p. 2-51), and ESPs of 20 years (EPA 1999, p. 3-50)
- The Consumer Price Index to adjust EPA costs in the year of the data (2002 or earlier) to 2022 dollars
- Labor costs from the U.S. Bureau of Labor and Statistics (BLS 2020) and electrical costs from Alaska commercial rates (Electrical Local 2022)
- The Donlin Gold project borrowing interest rate of eight percent (Annett, K. 2022)
- Emissions based on the permitted BACT level of 0.44 pounds per hour

The results of the control cost calculations are summarized in Table 9. These control costs are above the amounts considered as cost effective.

**Table 9. Carbon Regeneration Kiln: Particulate Controls Cost Effectiveness**

EU ID	EU Desc.	Control Option	Control Efficiency	Total Capital Investment (\$)	Annual Cost (\$/yr)	PM Reduced (ton/yr)	Cost Effectiveness (\$/ton)
88	Kiln	Dry ESP	99.45%	\$343,698	\$147,538	1.92	\$76,979
		Venturi	98.45%	\$168,180	\$215,183	1.90	\$113,413
		Filter	99.45%	\$79,318	\$197,058	1.92	\$102,816

## 5.0 Particulate Controls (Various EUs)

### 5.1 ADEC Request Item 5

*The application has numerous emissions units with particulate emissions that have technologically feasible controls available and no economic analyses to prove that they would be cost ineffective. These include the pressure oxidation hot cure EUs 85 -87 (1.8 tpy), electrowinning cells EUs 91-94 (0.8 tpy), and mercury retort EU 97 (0.13 tpy).*

*5. Please provide economic analyses demonstrating that potential emissions reductions from a dust collector (when technologically feasible), ESP, or wet scrubber is not economically feasible, or propose the top level control for each EU type. Note that an analysis showing a control to be economically infeasible on the higher emitting EUs could be extrapolated for the lower emitting mercury retort.*

## 5.2 Item 5 Response

The control options for PM reduction from the hot cure tanks and EW cells include a wet scrubber and a wet ESP. A fabric filter is not a viable control option due to the high moisture in the exhaust streams for these processes. The control options for PM reduction from the mercury retort include a dust collector, wet scrubber, and dry ESP.

The EPA Control Cost Manual, Section 6 – Particulate Matter Control, Chapter 1 – Baghouses and Filters (EPA 1998), Chapter 2 – Wet Scrubbers for Particulate Matter (EPA 2002), and Chapter 3 – Electrostatic Precipitators (EPA 1999) were used to determine the cost effectiveness of controlling particulate matter from the hot cure tanks, EW cells, and mercury retort. The control cost workbook is available for download via the link provided in Appendix B. The following inputs were used in the workbook:

- The emission reduction efficiency cited for fabric filters of 99.45% (EPA 1998, p. 1-4), venturi scrubbers of 98.45% (EPA 2002, p. 2-43), and ESPs of 99.45% (EPA 2003b, p. 1) (EPA 2003c, p. 1)
- The EPA default life expectancy for fabric filters of 20 years (EPA 1998, p. 1-55), venturi scrubbers of 15 years (EPA 2002, p. 2-51), and ESPs of 20 years (EPA 1999, p. 3-50)
- The Consumer Price Index to adjust EPA costs in the year of the data (2002 or earlier) to 2022 dollars
- The Donlin Gold project borrowing interest rate of eight percent (Annett, K. 2022)
- Emissions based on the permitted BACT level of 0.4, 0.19, and 0.03 pounds per hour for the hot cure tanks, EW cells, and mercury retort, respectively

The results of the control cost calculations are summarized in Table 10. These control costs are above the amounts considered as cost effective.

**Table 10. Hot Cure Tanks, EW Cells, and Retort: Particulate Controls Cost Effectiveness**

EU ID	EU Desc.	Control Option	Control Efficiency	Total Capital Investment (\$)	Annual Cost (\$/yr)	PM Reduced (ton/yr)	Cost Effectiveness (\$/ton)
85-87	Hot Cure	Wet ESP	99.45%	\$170,957	\$117,197	1.74	\$67,263
		Venturi	98.45%	\$38,390	\$183,245	1.72	\$106,239
91-94	EW Cells	Wet ESP	99.45%	\$1,387,864	\$321,316	0.83	\$388,240
		Venturi	98.45%	\$327,840	\$274,436	0.82	\$334,963
97	Retort	Dry ESP	99.45%	\$141,039	\$112,739	0.13	\$862,730
		Venturi	98.45%	\$50,513	\$185,612	0.13	\$1,434,811
		Filter	99.45%	\$32,939	\$182,092	0.13	\$1,393,448

## 6.0 Fuel Tanks EU 126-142

### 6.1 ADEC Request Item 6

*These fuel tanks have combined potential VOC emissions of 1.7 tpy and no economic analyses were performed to demonstrate that the top level controls would be economically infeasible.*

*6. Please provide economic analyses demonstrating that vapor combustion units would be economically infeasible for the tanks and that a floating roof design would be economically infeasible for the large diesel tanks EUs 126 - 140, or propose the top level control.*

### 6.2 Item 6 Response

Control options for the 2.5-million-gallon ultra-low sulfur diesel (ULSD) storage tanks (EU 126-140) are vapor recovery, internal floating roof, and fixed roof with submerge fill. A vapor recovery unit (VRU) is not expected to be a technically feasible control option due to the low concentration of organic vapors from ULSD. For example, the vapor pressure of VOCs within the tanks are only 0.0031 psia,<sup>1</sup> less than 0.02% of the total pressure and volume of the gas above the tank. At this vapor pressure, the temperature would need to be decreased to less than minus 100 °F to promote condensation.<sup>2</sup> However, an economic analysis for a VRU to collect and condense VOCs from the storage tanks has been conducted using the EPA Control Cost Manual, Section 3 – VOC Controls, Section 3.1 – VOC Recapture Controls, Chapter 2 –

<sup>1</sup> See Appendix B, p. 107 of the Application for the EPA Tanks 4.0.9d summary report.

<sup>2</sup> This is based on the temperature where saturated vapor pressure of hexane is less than 0.0031 psia (DDB 2022). Hexane is the highest emitting VOC-HAP listed for diesel fuel in the Application, Appendix B, p. 109

Refrigerated Condensers (EPA 2017b) and using the EPA publication on installing VRUs on crude oil storage tanks (EPA 2006). The control cost workbook is available for download via the link provided in Appendix B. The following inputs were used in the workbook:

- The emission reduction efficiency of 90% (EPA 2017b, p. 2-1)
- The EPA default life expectancy for VRUs of 15 years (EPA 2017b, p. 2-30)
- The Consumer Price Index to adjust EPA costs in the year of the data (2006) to 2022 dollars
- Labor costs from the U.S. Bureau of Labor and Statistics (BLS 2020) and electrical costs from Alaska commercial rates (Electrical Local 2022)
- The Donlin Gold project borrowing interest rate of eight percent (Annett, K. 2022)
- Emissions based on the permitted BACT level of 1.7 tons per year, total for all tanks

In addition, pricing was obtained for installing a floating roof in each tank from Allentech (Moneta, N. 2022). The annualized cost was estimated using the EPA Control Cost Manual, Section 1 – Introduction, Chapter 2 – Cost Estimation: Concepts and Methodology (EPA 2017a). The level of control was calculated by running the EPA Tanks 4.0.9d program for a 2,500,000 ULSD tank with an internal floating roof for comparison to the fixed-roof tank runs provided in the Application.

The results of the control cost calculations are summarized in Table 11. These control costs are above the amounts considered as cost effective.

**Table 11. Tanks: VOC Controls Cost Effectiveness**

EU ID	Control Option	Control Efficiency	Total Capital Investment (\$)	Annual Cost (\$/yr)	VOC Reduced (ton/yr)	Cost Effectiveness (\$/ton)
126-140	Floating Roof	65%	\$4,620,000	\$671,971	1.11	\$608,118
	Vapor Recovery	90%	\$97,857	\$80,027	1.53	\$52,305

## 7.0 Incinerators EU 27 and 28

### 7.1 ADEC Request Item 7

*The larger waste camp incinerator EU 27 has potential CO emissions of 0.35 tpy, NOx emissions of 0.8 tpy, and particulate emissions of 0.32 tpy. The smaller sewage sludge incinerator EU 28 has potential CO*

*emissions of 0.1 tpy, NOx emissions of 0.06 tpy, and particulate emissions of 0.009 tpy. The application includes no controls for the incinerators other than good combustion practices. The RBLC has at least one example each of incinerators using the following controls: SCR, SNCR, low NOx burners, and flue gas recirculation to control NOx emissions, an oxidation catalyst to control CO emissions, and a dust collector/fabric filter to control particulate emissions.*

*7. Please provide economic analyses demonstrating that potential emissions reductions from the controls listed above are not economically feasible or propose the top level control. Note that an economic analysis showing a control to be economically infeasible on the higher emitting camp waste incinerator could be extrapolated for the lower emitting sewage sludge incinerator.*

## **7.2 Item 7 Response**

Because the camp waste incinerator and the sewage sludge incinerator have not yet been procured, the specific control methods to be utilized by the manufacturer to meet the emission standards of the applicable New Source Performance Standards (NSPS) are not defined. However, it is expected that the manufacturer will use the controls reviewed by EPA in its regulatory cost analysis of the controls needed to meet the incinerator NSPS emission limits:

*The control analysis considered fabric filters to be the primary control device for particulate matter, cadmium, and lead control; packed bed scrubbers and dry sorbent injection for hydrogen chloride and sulfur dioxide control; activated carbon injection for mercury and dioxins/furans control; selective non-catalytic reduction (SNCR) for oxides of nitrogen; and afterburner retrofits, regenerative thermal oxidizers, tune-ups, advanced combustion controls, and oxidation catalysts for carbon monoxide controls.*

*(EPA 2011, p. 2-1)*

The final rule for 40 CFR 60 Subpart CCCC, Standards of Performance for Commercial and Industrial Solid Waste Incineration Units, establishes specific operating limits for the following control systems that will typically be employed to comply with this subpart under § 60.2110: wet scrubbers, fabric filters, ESPs, activated carbon sorbent injection, SNCRs, and dry scrubbers. Under § 60.2115, if you do not use one of these control systems, you must petition the EPA Administrator for specific operating limits to be established during the initial performance test.

Donlin Gold has proposed to purchase incinerators equipped with the controls necessary to meet the NSPS emission standards under Subparts CCCC and LLLL. See Appendix C, pages C1-8 and C1-9 of the Application. These controls are expected to be commensurate with the controls reviewed by EPA described above. Based on the AP-42 uncontrolled emission factors for refuse and sewage sludge incinerators, the control efficiencies needed to meet the NSPS emission limits are shown in Table 12.



**Table 12. Incinerators: Control Efficiencies Needed to Meet NSPS**

EU ID	Uncontrolled Emissions <sup>[1]</sup>			NSPS Limits (BACT)			Control Efficiency		
	PM lb/hr	NO <sub>x</sub> lb/hr	CO lb/hr	PM lb/hr	NO <sub>x</sub> lb/hr	CO lb/hr	PM %	NO <sub>x</sub> %	CO %
27	12.42	1.76	0.68	0.0729	0.1782	0.0802	99.4%	90%	88%
28	3.33	0.06	0.22	0.0061	0.0437	0.0066	99.8%	30%	97%

<sup>[1]</sup> AP-42 Section 2.1 Refuse Combustion (10/96) and Section 2.2 Sewage Sludge Incineration (1/95). The highest emission factor per pollutant from Tables 2.1-2, 4, 5, 6, 7, and 9 and Tables 2.2-1, 6, and 9 were used to determine the maximum uncontrolled emissions.

As shown by the control efficiencies in Table 12, control technologies will be required for PM, NO<sub>x</sub>, and CO to meet the NSPS limits. To determine the cost effectiveness of potential control technologies for these pollutants, a BACT cost analysis was conducted for the following incinerator add-on controls: a dry ESP, a venturi scrubber, a fabric filter, an oxidation catalyst, an SNCR, and an SCR.

The EPA Control Cost Manual, Section 6 – Particulate Matter Control, Chapter 1 – Baghouses and Filters (EPA 1998), Chapter 2 – Wet Scrubbers for Particulate Matter (EPA 2002), and Chapter 3 – Electrostatic Precipitators (EPA 1999) were used to determine the cost effectiveness of controlling particulate matter from the incinerators. The following EPA Microsoft Excel cost analysis workbooks were used to determine the cost effectiveness of controlling CO and NO<sub>x</sub> from the incinerators:

- oxidizers\_calc\_sheet\_finalversion\_1-16-2018.xlsm (EPA 2018)
- snrcrcontrolcostmanual\_costcalculationspreadsheetvf\_march\_2021.xlsm (EPA 2019a)
- scrcostmanualspreadsheet\_june-2019vf.xlsm (EPA 2019b)

The control cost workbooks are available for download via the link provided in Appendix B. The following inputs were used in these workbooks:

- The emission reduction efficiencies cited for the following controls:
  - fabric filter – 99.45% (EPA 1998, p. 1-4)
  - venturi scrubber – 98.45% (EPA 2002, p. 2-43)
  - ESP – 99.45% (EPA 2003b, p. 1)
  - oxidation catalyst – 99% (EPA 2018)
  - SNCR – 50% (EPA 2019a)

- SCR – 85% (EPA 2019b)
- The EPA default life expectancy cited for the following controls:
  - fabric filters – 20 years (EPA 1998, p. 1-55)
  - venturi scrubbers – 15 years (EPA 2002, p. 2-51)
  - ESP – 20 years (EPA 1999, p. 3-50)
  - oxidation catalyst – 20 years (EPA 2018)
  - SNCR – 20 years (EPA 2019a)
  - SCR – 25 years (EPA 2019b)
- For the PM controls, the Consumer Price Index to adjust EPA costs in the year of the data (2002 or earlier) to 2022 dollars
- For the oxidation catalyst, SNCR, and SCR, the 2022 Chemical Engineering Plant Cost Index (CEPCI) of 785.9 (Towering Skills 2022)
- The Donlin Gold project borrowing interest rate of eight percent (Annett, K. 2022)
- The maximum annual uncontrolled emissions based on AP-42 Sections 2.1 and 2.2 (see Table 12)

The results of the control cost calculations are summarized in Table 13.

**Table 13. Incinerators: Particulate, NOx and CO Controls Cost Effectiveness**

EU ID	EU Desc.	Control Option	Control Efficiency	Total Capital Investment (\$)	Annual Cost (\$/yr)	Emissions Reduced (ton/yr)	Cost Effectiveness (\$/ton)
27	Waste	Dry ESP	99.45%	\$167,367	\$117,260	6.83	\$17,160
		Venturi	98.45%	\$153,405	\$210,813	6.76	\$31,164
		Filter	99.45%	\$70,755	\$194,295	6.83	\$28,433
28	Sewage	Dry ESP	99.45%	\$141,039	\$59,840	4.84	\$12,369
		Venturi	98.45%	\$24,391	\$62,773	4.79	\$13,108
		Filter	99.45%	\$29,412	\$63,118	4.84	\$13,047
27	Waste	SNCR	50%	\$696,086	\$82,192	0.487	\$168,678
		SCR	85%	\$1,815,622	\$182,999	0.828	\$220,915
28	Sewage	SNCR	50%	\$129,895	\$15,290	0.045	\$336,253
		SCR	85%	\$543,799	\$56,396	0.077	\$729,536
27	Waste	Ox. Cat.	99%	\$219,380	\$114,012	0.371	\$307,073
28	Sewage	Ox. Cat.	99%	\$29,172	\$29,137	0.325	\$89,777

As shown in Table 13, all add-on control costs are above the amounts considered as cost effective. The high add-on control cost effectiveness for the Donlin Gold incinerators is a result of their small size (11.88 tons per day of camp waste and 0.058 tons per day of sewage sludge). Only the large municipal waste incinerators (325 to 2,106 tons per day) listed in the RBLIC used add-on controls (fabric filter, oxidation catalyst, and SNCR or SCR). In addition, the RBLIC listed a venturi scrubber for the Delaware County Regional Water Quality Control Authority (DELCORA) sewage treatment plant incinerator. Although the throughput was not specified in the RBLIC, this is also a large municipal incinerator.

Based on the control efficiencies shown in Table 12 necessary to achieve compliance with the NSPS emission limits, it is expected that add-on control and/or combustion technologies, such as flue gas recirculation, low-NOx burners, and other combustion control technologies, will be needed. These control technologies will be specified and designed by the manufacturer of the incinerators. Therefore, Donlin Gold proposes add-on controls and/or combustion control technologies sufficient to meet the NSPS Subparts CCCC and LLLL emission limits as BACT, regardless of the high-cost effectiveness of such controls shown in Table 13.

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## **Appendix A - BACT Cost Calculations**

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<p style="text-align: center;"><b>AIR SCIENCES INC.</b></p> <p style="text-align: center;"><b>AIR EMISSION CALCULATIONS</b></p>	<b>Project Title</b>	<b>By</b>	
	Donlin	K. Lewis	
	<b>Project No</b>	<b>Page</b>	<b>of Sheet</b>
	281-22B-1	1	2 Autoclaves
	<b>Subject:</b>	<b>Date:</b>	
	Autoclave CO+VOC Control Costs	May 5, 2022	

#### Autoclave CO+VOC Control Costs

Interest Rate for Capital Recovery Factor (CRF): 8% (Annett, K. 2022)

EU ID	EU Description	Design Rating (ton/hr)	Design Exhaust (wscfm)	Design Exhaust (F)	Annual Hours (hr/yr)
77	Autoclave 17-AUT-101	210	7,764	104	8,760
81	Autoclave 17-AUT-201	210	7,764	104	8,760

#### Fixed Bed Catalytic Oxidizer Cost (File: oxidizers\_calc\_sheet\_finalversion\_1-16-2018.xls (EPA 2018))

EU ID	EU Description	CO Emissions	Ox Cat	Ox Cat	Ox Cat	Ox Cat
		Basis	CO (lb/hr)	VOC (lb/hr)	TCI (\$)	Annual Cost (\$/yr)
77, 81	Each Autoclave	Permit	88	0.04	\$618,499	\$457,791
77, 81	Each Autoclave	Test Data	13	0.04	\$618,767	\$470,454

381.759

56.544

Test data is based on similar source test data from the Goldstrike mine.

#### Cost per criteria pollutant

EU ID	Emission Basis	CO Emissions (ton/yr)			EPA Default Control	Ox Cat Reduction (ton/yr)			Annual Cost (\$/yr)	Ox Cat Cost Effectiveness (\$/ton)		
		CO	VOC	CO+VOC		CO	VOC	CO+VOC		CO	VOC	CO+VOC
77, 81	Permit	385.44	0.18	385.62	99%	381.59	0.17	381.76	\$457,791	\$1,200	\$2,639,355	\$1,199
77, 81	Test Data	56.94	0.18	57.12	99%	56.37	0.17	56.54	\$470,454	\$8,346	\$2,712,364	\$8,320

#### Conversions:

2,000 lb/ton  
 386.5 scf/lb-mol  
 28.01 lb CO/lb-mol  
 86.17 lb VOC (as hexane)/lb-mol  
 1E+06 unit/million units  
 2.20462 lb/kg  
 1,020 Btu/scf, natural gas

EPA: oxidizers\_calc\_sheet\_finalversion\_1-16-2018.xlsm

<p style="text-align: center;"><b>AIR SCIENCES INC.</b></p>  <p style="text-align: center;"><b>AIR EMISSION CALCULATIONS</b></p>	<b>Project Title</b>	<b>By</b>
	Donlin	K. Lewis
	<b>Project No</b>	<b>Page of Sheet</b>
	281-22B-1	2 2 Autoclaves
	<b>Subject:</b>	<b>Date:</b>
	Autoclave CO+VOC Control Costs	May 5, 2022

## Autoclave CO+VOC Control Costs - continued

### Conversion of lb/hr to ppm

EU ID	77	81
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88 lb CO	lb-mol	386.5 scf	min	hr	1.E+06	=	2,607 ppmv CO
hr	28.01 lb CO	lb-mol	7,764 scf	60 min			
Test Data <u>13 lb CO</u>						=	385 ppmv CO
	hr						
0.04 lb VOC	lb-mol	386.5 scf	min	hr	1.E+06	=	0.4 ppmv VOC
hr	86.17 lb VOC	lb-mol	7,764 scf	60 min			

### Oxidation Catalyst Cost Effectiveness

		CO Emission Basis	TCI (\$)	Annual Cost (\$/yr)	CO+VOC Reduced (ton/yr)	Ox Cat Cost (\$/ton)
77, 81	Each Autoclave	Permit	\$618,499	\$457,791	381.76	\$1,199
77, 81	Each Autoclave	Test Data	\$618,767	\$470,454	56.54	\$8,320

### Oxidation Catalyst Cost Effectiveness Per Pollutant

EU ID	CO	Ox Cat			Annual	Ox Cat		
	Emission	Reduction (ton/yr)			Cost	Cost Effectiveness (\$/ton)		
	Basis	CO	VOC	CO+VOC	(\$/yr)	CO	VOC	CO+VOC
77_81	Permit	381.59	0.17	381.76	\$457,791	\$1,200	\$2,639,355	\$1,199
77_81	Test Data	56.37	0.17	56.54	\$470,454	\$8,346	\$2,712,364	\$8,320

### Oxidation Catalyst Auxiliary Fuel Consumption and GHG Emissions

EU ID	CO	Auxiliary Fuel			
	Emission	Natural Gas	CO2e	CO2e	
	Basis	(scfm)	MMscf/yr	lb/MMscf (ton/yr)	
77, 81	Permit	136.61	71.80	119,440	4,288
77, 81	Test Data	142.86	75.09	119,440	4,484

## GHG Emission Factors

Fuel	CO2	CH4	N2O	CO2e	CO2e
(kg/MMBtu)					(lb/MMscf)
Natural Gas	53.06	0.001	0.0001	53.11	119,440

40 CFR 98 Tab. C-1 and C-2

## Global Warming Potential

CH <sub>4</sub>	25
N <sub>2</sub> O	298

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40 CFR 98 Tab. A-1



<p style="text-align: center;"><b>AIR SCIENCES INC.</b></p>  <p style="text-align: center;"><b>AIR EMISSION CALCULATIONS</b></p>	Project Title	By
	Donlin	K. Lewis
	Project No	Page of Sheet
	281-22B-1	1 2 Airport Gens
	Subject:	Date:
	Airport Generator CO Control Costs	May 5, 2022

### Airport Generator CO Control Costs

Interest Rate for Capital Recovery Factor (CRF): 8% (Annett, K. 2022)

EU ID	EU Description	Design Rating (kWe)	Design Exhaust (scfm)	Design Exhaust (F)	Annual Hours (hr/yr)	BACT CO (g/kW-hr)	BACT VOC (g/kW-hr)
13	Airport Generator #1	200	609	916	8,760	4.38	0.24
14	Airport Generator #2	200	609	916	8,760	4.38	0.24

Fixed Bed Catalytic Oxidizer Cost (File: oxidizers\_calc\_sheet\_finalversion\_1-16-2018.xls (EPA 2018))

EU ID	EU Description	CO Emission	Emission Limit		Ox Cat	Ox Cat	Ox Cat	Ox Cat
		Basis	CO (lb/hr)	VOC (lb/hr)	TCI (\$)	Annual Cost (\$/yr)	CO+VOC Reduced (ton/yr)	Cost Effectiveness (\$/ton)
13	Airport Generator ; Permit		1.93	0.11	\$152,307	\$101,803	8.85	\$11,509
14	Airport Generator ; Test Data		1.93	0.11	\$152,307	\$101,803	8.85	\$11,509

Test data is based on similar source test data from the Goldstrike mine.

Cost per criteria pollutant

EU ID	CO	Ox Cat			EPA	Ox Cat			Annual	Ox Cat		
	Emission	Emissions (ton/yr)			Default	Reduction (ton/yr)			Cost	Cost Effectiveness (\$/ton)		
	Basis	CO	VOC	CO+VOC	Control	CO	VOC	CO+VOC	(\$/yr)	CO	VOC	CO+VOC
13	Permit	8.45	0.48	8.94	99%	8.37	0.48	8.85	\$101,803	\$12,165	\$213,432	\$11,509
14	Test Data	8.45	0.48	8.94	99%	8.37	0.48	8.85	\$101,803	\$12,165	\$213,432	\$11,509

Conversions:

2,000 lb/ton

386.5 scf/lb-mol EPA: oxidizers\_calc\_sheet\_finalversion\_1-16-2018.xlsm

28.01 lb CO/lb-mol

78.11 lb VOC (as benzene)/lb-mol

1E+06 unit/million units

0.97 site pressure

459.67 R at 0F 77 F, EPA STD Temperature for the Catalytic Oxidizer Cost Workbook

2.20462 lb/kg      453.592 g/lb

1,020 Btu/scf, natural gas

<p style="text-align: center;">AIR SCIENCES INC.</p> <p style="text-align: center;">AIR EMISSION CALCULATIONS</p>	Project Title	Donlin	By	K. Lewis
	Project No	281-22B-1	Page of Sheet	2 2 Airport Gens
	Subject:	Airport Generator CO Control Costs	Date:	May 5, 2022

#### Airport Generator CO Control Costs - continued

Conversion of lb/hr to ppm

EU ID 13 14

1.93 lb CO	lb-mol	386.5 scf	min	hr	1.E+06	=	729 ppmv CO
hr	28.01 lb CO	lb-mol	609 scf	60 min			
0.11 lb VOC	lb-mol	386.5 scf	min	hr	1.E+06	=	14.9 ppmv VOC
hr	78.11 lb VOC	lb-mol	609 scf	60 min			

#### Oxidation Catalyst Cost Effectiveness

EU ID	EU Description	TCI (\$)	Annual Cost (\$/yr)	CO+VOC Reduced (ton/yr)	Ox Cat Cost (\$/ton)
13	Airport Generator #	\$152,307	\$101,803	8.85	\$11,509
14	Airport Generator #	\$152,307	\$101,803	8.85	\$11,509

#### Oxidation Catalyst Cost Effectiveness Per Pollutant

EU ID	CO	Ox Cat Reduction (ton/yr)	VOC	CO+VOC	Annual Cost (\$/yr)	CO	Ox Cat Cost Effectiveness (\$/ton)	VOC	CO+VOC
13	8.37	0.48	8.85	\$101,803	\$12,165	\$213,432	\$11,509		
14	8.37	0.48	8.85	\$101,803	\$12,165	\$213,432	\$11,509		

<p style="text-align: center;"><b>AIR SCIENCES INC.</b></p> <p style="text-align: center;"><b>AIR EMISSION CALCULATIONS</b></p>	<b>Project Title</b>	Donlin		<b>By</b>	K. Lewis	
	<b>Project No</b>	281-22B-1		<b>Page</b>	<b>of</b>	<b>Sheet</b>
	<b>Subject:</b>	Carbon Kiln CO+VOC Control Costs		<b>Date:</b>	May 5, 2022	

#### Carbon Kiln CO+VOC Control Costs

Interest Rate for Capital Recovery Factor (CRF): 8% (Annett, K. 2022)

EU ID	EU Description	Design Rating (ton/hr)	Design Exhaust (dscfm)	Design Exhaust (F)	Annual Hours (hr/yr)
88	Carbon Regeneration Kiln 56-KLN-100	1.65	2,346	102	8,760

#### Fixed Bed Catalytic Oxidizer Cost (File: oxidizers\_calc\_sheet\_finalversion\_1-16-2018.xls (EPA 2018))

EU ID	EU Description	CO Emission Basis	CO Emission Limit (lb/hr)	VOC Emission Limit (lb/hr)	Ox Cat TCI (\$)	Ox Cat Annual Cost (\$/yr)	Ox Cat CO+VOC Reduced (ton/yr)	Ox Cat Cost Effectiveness (\$/ton)
88	Carbon Regen. Kiln	Permit	0.88	0.44	\$321,504	\$213,810	5.72	\$37,355

5.724

Test data is based on similar source test data from the Goldstrike mine.

#### Cost per criteria pollutant

EU ID	CO Emission Basis	CO Emissions (ton/yr)	Ox Cat Emissions (ton/yr)	CO+VOC Emissions (ton/yr)	EPA Default Control	CO Reduction (ton/yr)	Ox Cat Reduction (ton/yr)	CO+VOC Reduction (ton/yr)	Annual Cost (\$/yr)	CO Cost Effectiveness (\$/ton)	Ox Cat Cost Effectiveness (\$/ton)	CO+VOC Cost Effectiveness (\$/ton)
88	Permit	3.85	1.93	5.78	99%	3.82	1.91	5.72	\$213,810	\$56,032	\$112,064	\$37,355

#### Conversions:

2,000 lb/ton  
 386.5 scf/lb-mol  
 28.01 lb CO/lb-mol  
 86.17 lb VOC (as hexane)/lb-mol  
 1E+06 unit/million units  
 2.20462 lb/kg  
 1,020 Btu/scf, natural gas

EPA: oxidizers\_calc\_sheet\_finalversion\_1-16-2018.xlsm

AIR SCIENCES INC.				Project Title		By	
				Donlin		K. Lewis	
				Project No		Page of Sheet	
AIR EMISSION CALCULATIONS				281-22B-1		22Kiln CO+VOC	
				Subject:		Date:	
				Carbon Kiln CO+VOC Control Costs		May 5, 2022	

Carbon Kiln CO+VOC Control Costs - continued

Conversion of lb/hr to ppm

EU ID88

0.88 lb CO	lb-mol	386.5 scf	min	hr	1.E+06	=	86 ppmv CO
hr	28.01 lb CO	lb-mol	2,346 scf	60 min			

0.44 lb VOC	lb-mol	386.5 scf	min	hr	1.E+06	=	14 ppmv VOC
hr	86.17 lb VOC	lb-mol	2,346 scf	60 min			

Oxidation Catalyst Cost Effectiveness

		TCI	Annual	CO+VOC	Ox Cat
		(\$)	Cost	Reduced	Cost
EU ID	EU Description		(\$/yr)	(ton/yr)	(\$/ton)
88	Carbon Regen. Kiln	\$321,504	\$213,810	5.72	\$37,355

Oxidation Catalyst Cost Effectiveness Per Pollutant

	Ox Cat			Annual	Ox Cat		
	Reduction (ton/yr)			Cost	Cost Effectiveness (\$/ton)		
EU ID	CO	VOC	CO+VOC	(\$/yr)	CO	VOC	CO+VOC
88	3.82	1.91	5.72	\$213,810	\$56,032	\$112,064	\$37,355

Oxidation Catalyst Auxiliary Fuel Consumption and GHG Emissions

	Auxiliary Fuel			
	Natural Gas	CO2e	CO2e	
EU ID	(scfm)	MMscf/yr	lb/MMscf	(ton/yr)
88	43.36	22.79	119,440	1,361

GHG Emission Factors

Fuel	CO2	CH4	N2O	CO2e	CO2e
(kg/MMBtu)					(lb/MMscf)
Natural Gas	53.06	0.001	0.0001	53.11	119,440

40 CFR 98 Tab. C-1 and C-2

Global Warming Potential

CH4	25
N2O	298

40 CFR 98 Tab. A-1

<p>AIR SCIENCES INC.</p> <p>AIR EMISSION CALCULATIONS</p>	Project Title	By
	Donlin Gold	K. Lewis
	Project No	Page of Sheet
	281-22B-1	1 11 PM Controls
	Subject:	Date:
	PM Control Costs	May 5, 2022

#### PM Control Costs

Interest Rate for Capital Recovery Factor (CRF): 8% (Annett, K. 2022)

EU ID	EU Description	Limit PM (lb/hr)	Design Exhaust (acfm)	Design Exhaust (wscfm)	Design Exhaust (dscfm)	Design Exhaust (F)	Annual Hours (hr/yr)	Moisture
85-87	Hot Cure Tank 17-TNK-302 to 304, each	0.4	137	109	0	212	8,760	100%
88	Carbon Regeneration Kiln 56-KLN-100	0.44	2,629	2,437	2,346	102	8,760	3.73%
91-94	Electrowinning Circuit Cell 37-EWN-100 to 40C	0.19	9,991	8,118	4,189	181	8,760	48.4%
97	Mercury Retort 19-VEZ-100	0.03	237	218	203	106	8,760	7%

#### PM Control Cost Effectiveness Per Emission Unit

EU ID	EU Description	Control	Control Efficiency	TCI (\$)	Annual Cost (\$/yr)	PM Reduced (ton/yr)	Control Cost (\$/ton)
85-87	Hot Cure Tank	Wet ESP	99.45%	\$170,957	\$117,197	1.74	\$67,263
		Venturi Scrubber	98.45%	\$38,390	\$183,245	1.72	\$106,239
88	Carbon Regen. Kiln	Dry ESP	99.45%	\$343,698	\$147,538	1.92	\$76,979
		Venturi Scrubber	98.45%	\$168,180	\$215,183	1.90	\$113,413
		Fabric Filter	99.45%	\$79,318	\$197,058	1.92	\$102,816
91-94	EW Cells	Wet ESP	99.45%	\$1,387,864	\$321,316	0.83	\$388,240
		Venturi Scrubber	98.45%	\$327,840	\$274,436	0.82	\$334,963
97	Mercury Retort	Dry ESP	99.45%	\$141,039	\$112,739	0.13	\$862,730
		Venturi Scrubber	98.45%	\$50,513	\$185,612	0.13	\$1,434,811
		Fabric Filter	99.45%	\$32,939	\$182,092	0.13	\$1,393,448

#### Conversions

8,760 hr/yr  
2,000 lb/ton  
0.97 atm, site pressure  
459.67 R at 0F 77 F, EPA STD Temperature for the Cost Manual

AIR SCIENCES INC.				Project Title		By	
				Donlin Gold		K. Lewis	
AIR EMISSION CALCULATIONS				Project No		Page of Sheet	
				281-22B-1		2 11 PM Controls	
				Subject:		Date:	
				PM Control Costs		May 5, 2022	

EU ID	85-87	Wet ESP	99.45%	Control	EPA Fact Sheet, Wet Electrostatic Precipitator (ESP) - Wire-Plate TyF (EPA 2003c)		
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Cost Item	Cost	Comment
<u>Direct Cost</u>		
Purchase Equipment Costs	1,000 scfm	Minimum flow for industrial ESPs is 1,000 cfm
Equipment Cost (2002)	\$40 /scfm	\$40,000 EPA Fact Sheet, Wet Electrostatic Precipitator (ESP) - Wire-Plate TyF (EPA 2003c)
Equipment Cost (2022)	1.59	\$63,600
Instrumentation	0.10	\$6,360 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999 (EPA 1999)
Sales Tax	0.00	\$0 No sales tax in Alaska
Freight	0.10	\$6,360 EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)
Purchase equipment cost		\$76,320
Direct installation costs		
Foundation and supports	0.04	\$3,053 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Handling and erection	0.50	\$38,160 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Electrical	0.08	\$6,106 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Piping	0.01	\$763 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Insulation for ductwork	0.02	\$1,526 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Painting	0.02	\$1,526 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Direct installation cost		\$51,134
Site preparation	0.00	\$0 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Facilities and buildings	0.00	\$0 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Total Direct Cost		\$127,454
<u>Indirect Costs (installation)</u>		
Engineering	0.20	\$15,264 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Construction and field expenses	0.20	\$15,264 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Contractor fees	0.10	\$7,632 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Start-up	0.01	\$763 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Performance test	0.01	\$763 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Model study	0.02	\$1,526 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Contingencies	0.03	\$2,290 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Total Indirect Cost		\$43,502
Total Capital Investment		\$170,957
<u>Direct Annual Costs</u>		
Operating labor	1,369 hr/yr	\$23.44 \$32,084 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999 and (BLS 2020)
Supervisory labor	15%	\$4,813 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999
Coordinator	33%	\$10,695 EPA Cost Manual, Sec 6, Ch 3, p. 3-58, 9/1999
Maintenance		
Labor	330 hr/yr	\$23.44 \$7,735 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999 and (BLS 2020)
Material	1%	\$763 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999
Total O&M cost		\$56,089
Utilities		
Electricity-fan	7,103 kWh	\$0.1682 \$1,195 EPA Cost Manual, Sec 6, Ch 3, p. 3-48 & 3-58, 9/1999 and (Electrical Local 2022)
Electricity-oper	11,945 kWh	\$0.1682 \$2,009 EPA Cost Manual, Sec 6, Ch 3, p. 3-48 & 3-58, 9/1999 and (Electrical Local 2022)
Total Direct Annual Cost		\$59,293
<u>Indirect Annual Costs</u>		
Overhead	60%	\$33,653 EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Administrative charges	2%	\$3,419 EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Property Tax	1%	\$1,710 EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Insurance	1%	\$1,710 EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Capital recovery	10.2%	\$17,412 20 yr life EPA Cost Manual, Sec 6, Ch 3, p. 3-50, 9/1999
Total Indirect Annual Costs		\$57,904
Total Annual Cost		\$117,197

CPI Inflation Calculator 1/2002 to 1/2022:	1.59	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>
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AIR SCIENCES INC.				Project Title		By	
				Donlin Gold		K. Lewis	
AIR EMISSION CALCULATIONS				Project No		Page of Sheet	
				281-22B-1		3 11 PM Controls	
				Subject:		Date:	
				PM Control Costs		May 5, 2022	
EU ID	85-87	Venturi Scrubber	98.45%	Control	EPA Cost Manual, Sec 6, Ch 2, p. 2-43, 7/2002 (EPA 2002)		
Cost Item				Cost	Comment		
<u>Direct Cost</u>							
Purchase Equipment Costs							
Equipment Cost (2002)	137 acfm	\$10,534	EPA Cost Manual, Sec 6, Ch 2, Table 2.5, 7/2002 (Alloy C-276)			(EPA 2002)	
Equipment Cost (2022)	1.59	\$16,749	EPA Cost Manual, Sec 6, Ch 2, Table 2.5, 7/2002 (Alloy C-276)				
Instrumentation	0.10	\$1,675	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Sales Tax	0.00	\$0	No sales tax in Alaska				
Freight	0.10	\$1,675	EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK)			(EPA 2017a)	
Purchase equipment cost		\$20,099					
Direct installation costs							
Foundation and supports	0.06	\$1,206	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Handling and erection	0.40	\$8,040	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Electrical	0.01	\$201	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Piping	0.05	\$1,005	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Insulation for ductwork	0.03	\$603	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Painting	0.01	\$201	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Direct installation cost		\$11,256					
Site preparation	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Facilities and buildings	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Total Direct Cost		\$31,355					
<u>Indirect Costs (installation)</u>							
Engineering	0.10	\$2,010	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Construction and field expenses	0.10	\$2,010	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Contractor fees	0.10	\$2,010	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Start-up	0.01	\$201	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Performance test	0.01	\$201	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Model study	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Contingencies	0.03	\$603	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002				
Total Indirect Cost		\$7,035					
Total Capital Investment		\$38,390					
<u>Direct Annual Costs</u>							
Operating labor	2190 hr/yr	\$23.44	EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002 and (BLS 2020)				
Supervisory labor	15%	\$7,700	EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002				
Maintenance							
Labor	1095 hr/yr	\$23.44	EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002 and (BLS 2020)				
Material	100%	\$25,667	EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002				
Total O&M cost		\$110,367					
Utilities							
Fan	3,526 kWh	\$0.1682	EPA Cost Manual, Sec 6, Ch 2, Table 2.3, 7/2002				
Pump	209 kWh	\$0.1682	EPA Cost Manual, Sec 6, Ch 2, Table 2.3, 7/2002				
Water	27 kgal/yr	\$0.3180	EPA Cost Manual, Sec 6, Ch 2, p. 2-52 and 2-58, 7/2002				
Total Direct Annual Cost		\$111,004					
<u>Indirect Annual Costs</u>							
Overhead	60%	\$66,220	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002				
Administrative charges	2%	\$768	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002				
Property Tax	1%	\$384	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002				
Insurance	1%	\$384	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002				
Capital recovery	11.7%	\$4,485	15 yr life	EPA Cost Manual, Sec 6, Ch 2, p. 2-51, 7/2002		8% interest	
Total Indirect Annual Costs		\$72,241					
Total Annual Cost		\$183,245					
CPI Inflation Calculator 1/2002 to 1/2022:		1.59	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>				

AIR SCIENCES INC.			Project Title		By	
			Donlin Gold		K. Lewis	
AIR EMISSION CALCULATIONS			Project No		Page of Sheet	
			281-22B-1		4 11 PM Controls	
			Subject:		Date:	
			PM Control Costs		May 5, 2022	

EU ID	88	Dry ESP	99.45%	Control	EPA Fact Sheet, Dry Electrostatic Precipitator (ESP) - Wire-Plate Type (EPA 2003b)	
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Cost Item		Cost	Comment
Direct Cost			
Purchase Equipment Costs	2,437 scfm		Design flow rate
Equipment Cost (2002)	\$33 /scfm	\$80,418	EPA Fact Sheet, Dry Electrostatic Precipitator (ESP) - Wire-Plate Typ (EPA 2003b)
Equipment Cost (2022)	1.59	\$127,864	
Instrumentation	0.10	\$12,786	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/199 (EPA 1999)
Sales Tax	0.00	\$0	No sales tax in Alaska
Freight	0.10	\$12,786	EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)
Purchase equipment cost		\$153,437	
Direct installation costs			
Foundation and supports	0.04	\$6,137	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Handling and erection	0.50	\$76,718	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Electrical	0.08	\$12,275	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Piping	0.01	\$1,534	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Insulation for ductwork	0.02	\$3,069	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Painting	0.02	\$3,069	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Direct installation cost		\$102,803	
Site preparation	0.00	\$0	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Facilities and buildings	0.00	\$0	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Total Direct Cost		\$256,239	
Indirect Costs (installation)			
Engineering	0.20	\$30,687	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Construction and field expenses	0.20	\$30,687	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Contractor fees	0.10	\$15,344	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Start-up	0.01	\$1,534	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Performance test	0.01	\$1,534	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Model study	0.02	\$3,069	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Contingencies	0.03	\$4,603	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Total Indirect Cost		\$87,459	
Total Capital Investment		\$343,698	
Direct Annual Costs			
Operating labor	1,369 hr/yr	\$23.44	\$32,084 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999 and (BLS 2020)
Supervisory labor	15%	\$4,813	EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999
Coordinator	33%	\$10,695	EPA Cost Manual, Sec 6, Ch 3, p. 3-58, 9/1999
Maintenance			
Labor	330 hr/yr	\$23.44	\$7,735 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999 and (BLS 2020)
Material	1%	\$1,534	EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999
Total O&M cost		\$56,860	
Utilities			
Electricity-fan	17,310 kWh	\$0.1682	\$2,912 EPA Cost Manual, Sec 6, Ch 3, p. 3-48 & 3-58, 9/1999 and (Electrical Local 2022)
Electricity-opei	29,109 kWh	\$0.1682	\$4,896 EPA Cost Manual, Sec 6, Ch 3, p. 3-48 & 3-58, 9/1999 and (Electrical Local 2022)
Total Direct Annual Cost		\$64,668	
Indirect Annual Costs			
Overhead	60%	\$34,116	EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Administrative charges	2%	\$6,874	EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Property Tax	1%	\$3,437	EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Insurance	1%	\$3,437	EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Capital recovery	10.2%	\$35,006	20 yr life EPA Cost Manual, Sec 6, Ch 3, p. 3-50, 9/1999
Total Indirect Annual Costs		\$82,870	8% interest
Total Annual Cost		\$147,538	

CPI Inflation Calculator 1/2002 to 1/2022:	1.59	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>
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AIR SCIENCES INC.			Project Title		By	
			Donlin Gold		K. Lewis	
			Project No		Page	of
			281-22B-1		5	11
AIR EMISSION CALCULATIONS			Subject:		Date:	
			PM Control Costs		May 5, 2022	

EU ID	88	Venturi Scrubber	98.45%	Control	EPA Cost Manual, Sec 6, Ch 2, p. 2-43, 7/2002	(EPA 2002)
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Cost Item		Cost	Comment
<u>Direct Cost</u>			
Purchase Equipment Costs			
Equipment Cost (2002)	2,629 acfm	\$46,149	EPA Cost Manual, Sec 6, Ch 2, Table 2.5, 7/2002 (Alloy C-276) (EPA 2002)
Equipment Cost (2022)	1.59	\$73,377	EPA Cost Manual, Sec 6, Ch 2, Table 2.5, 7/2002 (Alloy C-276)
Instrumentation	0.10	\$7,338	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Sales Tax	0.00	\$0	No sales tax in Alaska
Freight	0.10	\$7,338	EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)
Purchase equipment cost		\$88,052	
Direct installation costs			
Foundation and supports	0.06	\$5,283	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Handling and erection	0.40	\$35,221	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Electrical	0.01	\$881	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Piping	0.05	\$4,403	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Insulation for ductwork	0.03	\$2,642	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Painting	0.01	\$881	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Direct installation cost		\$49,309	
Site preparation	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Facilities and buildings	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Total Direct Cost		\$137,362	
<u>Indirect Costs (installation)</u>			
Engineering	0.10	\$8,805	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Construction and field expenses	0.10	\$8,805	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Contractor fees	0.10	\$8,805	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Start-up	0.01	\$881	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Performance test	0.01	\$881	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Model study	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Contingencies	0.03	\$2,642	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Total Indirect Cost		\$30,818	
Total Capital Investment		\$168,180	
<u>Direct Annual Costs</u>			
Operating labor	2190 hr/yr	\$23.44	\$51,334 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002 and (BLS 2020)
Supervisory labor		15%	\$7,700 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002
Maintenance			
Labor	1095 hr/yr	\$23.44	\$25,667 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002 and (BLS 2020)
Material		100%	\$25,667 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002
Total O&M cost		\$110,367	
Utilities			
Fan	67,671 kWh	\$0.1682	\$11,382 EPA Cost Manual, Sec 6, Ch 2, Table 2.3, 7/2002
Pump	4,002 kWh	\$0.1682	\$673 EPA Cost Manual, Sec 6, Ch 2, Table 2.3, 7/2002
Water	516 ggal/yr	\$0.3180	\$164 EPA Cost Manual, Sec 6, Ch 2, p. 2-52 and 2-58, 7/2002
Total Direct Annual Cost		\$122,587	
<u>Indirect Annual Costs</u>			
Overhead	60%	\$66,220	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002
Administrative charges	2%	\$3,364	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002
Property Tax	1%	\$1,682	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002
Insurance	1%	\$1,682	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002
Capital recovery	11.7%	\$19,648	15 yr life EPA Cost Manual, Sec 6, Ch 2, p. 2-51, 7/2002 8% interest
Total Indirect Annual Costs		\$92,596	
Total Annual Cost		\$215,183	

CPI Inflation Calculator 1/2002 to 1/2022:	1.59	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>
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AIR SCIENCES INC.				Project Title Donlin Gold		By K. Lewis		
AIR EMISSION CALCULATIONS				Project No 281-22B-1		Page 6	of 11	Sheet PM Controls
				Subject: PM Control Costs		Date: May 5, 2022		
EU ID	88	Fabric Filter	99.45%	Control	EPA Cost Manual, Sec 6, Ch 1, p. 1-4, 12/1998 (EPA 1998)			
Cost Item		Cost		Comment				
<u>Direct Cost</u>								
Purchase Equipment Costs								
Equipment Cost (1998)		561	ft2 of cloth	EPA Cost Manual, Sec 6, Ch 1, p. 1-50, 12/1998				
Fabric filter w/ insulati		2,629	acfm	\$8,614	EPA Cost Manual, Sec 6, Ch 1, p. 1-50 and 1-51, 12/1998 (EPA 1998)			
Bags and cages		42	bags	\$1,409	EPA Cost Manual, Sec 6, Ch 1, p. 1-50 and 1-51, 12/1998			
Auxiliary equipment				\$7,424	EPA Cost Manual, Sec 6, Ch 1, Table 1.10, 12/1998			
Equipment Cost (2022)		1.73		\$30,182				
Instrumentation		0.10		\$3,018	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Sales Tax		0.00		\$0	No sales tax in Alaska			
Freight		0.10		\$3,018	EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)			
Purchase equipment cost				\$36,218				
Direct installation costs								
Foundation and supports		0.04		\$1,449	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Handling and erection		0.50		\$18,109	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Electrical		0.08		\$2,897	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Piping		0.01		\$362	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Insulation for ductwork		0.07		\$2,535	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Painting		0.04		\$1,449	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Direct installation cost				\$26,802				
Site preparation		0.00		\$0	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Facilities and buildings		0.00		\$0	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Total Direct Cost				\$63,020				
<u>Indirect Costs (installation)</u>								
Engineering		0.10		\$3,622	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Construction and field expenses		0.20		\$7,244	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Contractor fees		0.10		\$3,622	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Start-up		0.01		\$362	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Performance test		0.01		\$362	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Contingencies		0.03		\$1,087	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Total Indirect Cost				\$16,298				
Total Capital Investment				\$79,318				
<u>Direct Annual Costs</u>								
Operating labor		2190	hr/yr	\$23.44	\$51,334 EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998 and (BLS 2020)			
Supervisory labor			15%		\$7,700 EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998			
Maintenance								
Labor		1095	hr/yr	\$23.44	\$25,667 EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998 and (BLS 2020)			
Material			100%		\$25,667 EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998			
Total O&M cost				\$110,367				
Replacement bags		\$2,844	56.1%	\$1,595	2 yr life	EPA Cost Manual, Sec 6, Ch 1, p. 1-46 and 1-52, 8% interest		
Utilities								
Electricity		42,940	kWh	\$0.1682	\$7,222 EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Compressed A		2,763,914	scf	\$0.0003	\$691 EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Total Direct Annual Cost				\$119,876				
<u>Indirect Annual Costs</u>								
Overhead			60%	\$66,220	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Administrative charges			2%	\$1,586	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Property Tax			1%	\$793	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Insurance			1%	\$793	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Capital recovery			10.2%	\$7,789	20 yr life	EPA Cost Manual, Sec 6, Ch 1, p. 1-55, 12/1998 8% interest		
Total Indirect Annual Costs				\$77,182				
Total Annual Cost				\$197,058				
CPI Inflation Calculator 5/1998 to 1/2022:				1.73	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>			

AIR SCIENCES INC.			Project Title Donlin Gold		By K. Lewis	
AIR EMISSION CALCULATIONS			Project No 281-22B-1		Page of Sheet 7 of 11 PM Controls	
			Subject: PM Control Costs		Date: May 5, 2022	

EU ID	91-94	Wet ESP	99.45%	Control	EPA Fact Sheet, Wet Electrostatic Precipitator (ESP) - Wire-Plate Type (EPA 2003c)	
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Cost Item	Cost	Comment
<u>Direct Cost</u>		
Purchase Equipment Costs	8,118 scfm	Design flow rate
Equipment Cost (2002)	\$40 /scfm	\$324,729 EPA Fact Sheet, Wet Electrostatic Precipitator (ESP) - Wire-Plate Type (EPA 2003c)
Equipment Cost (2022)	1.59	\$516,319
Instrumentation	0.10	\$51,632 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999 (EPA 1999)
Sales Tax	0.00	\$0 No sales tax in Alaska
Freight	0.10	\$51,632 EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)
Purchase equipment cost		\$619,582
Direct installation costs		
Foundation and supports	0.04	\$24,783 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Handling and erection	0.50	\$309,791 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Electrical	0.08	\$49,567 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Piping	0.01	\$6,196 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Insulation for ductwork	0.02	\$12,392 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Painting	0.02	\$12,392 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Direct installation cost		\$415,120
Site preparation	0.00	\$0 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Facilities and buildings	0.00	\$0 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Total Direct Cost		\$1,034,702
<u>Indirect Costs (installation)</u>		
Engineering	0.20	\$123,916 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Construction and field expenses	0.20	\$123,916 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Contractor fees	0.10	\$61,958 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Start-up	0.01	\$6,196 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Performance test	0.01	\$6,196 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Model study	0.02	\$12,392 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Contingencies	0.03	\$18,587 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Total Indirect Cost		\$353,162
Total Capital Investment		\$1,387,864
<u>Direct Annual Costs</u>		
Operating labor	1,369 hr/yr	\$23.44 \$32,084 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999 and (BLS 2020)
Supervisory labor	15%	\$4,813 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999
Coordinator	33%	\$10,695 EPA Cost Manual, Sec 6, Ch 3, p. 3-58, 9/1999
Maintenance		
Labor	330 hr/yr	\$23.44 \$7,735 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999 and (BLS 2020)
Material	1%	\$6,196 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999
Total O&M cost		\$61,522
Utilities		
Electricity-fan	57,666 kWh	\$0.1682 \$9,699 EPA Cost Manual, Sec 6, Ch 3, p. 3-48 & 3-58, 9/1999 and (Electrical Local 2022)
Electricity-oper	96,972 kWh	\$0.1682 \$16,311 EPA Cost Manual, Sec 6, Ch 3, p. 3-48 & 3-58, 9/1999 and (Electrical Local 2022)
Total Direct Annual Cost		\$87,532
<u>Indirect Annual Costs</u>		
Overhead	60%	\$36,913 EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Administrative charges	2%	\$27,757 EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Property Tax	1%	\$13,879 EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Insurance	1%	\$13,879 EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Capital recovery	10.2%	\$141,357 20 yr life EPA Cost Manual, Sec 6, Ch 3, p. 3-50, 9/1999 8% interest
Total Indirect Annual Costs		\$233,785
Total Annual Cost		\$321,316

CPI Inflation Calculator 1/2002 to 1/2022:	1.59	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>
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AIR SCIENCES INC.			Project Title		By	
			Donlin Gold		K. Lewis	
			Project No		Page of Sheet	
			281-22B-1		8 11 PM Controls	
AIR EMISSION CALCULATIONS			Subject:		Date:	
			PM Control Costs		May 5, 2022	

EU ID	91-94	Venturi Scrubber	98.45%	Control	EPA Cost Manual, Sec 6, Ch 2, p. 2-43, 7/2002	(EPA 2002)
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Cost Item		Cost	Comment
<u>Direct Cost</u>			
Purchase Equipment Costs			
Equipment Cost (2002)	9,991 acfm	\$89,960	EPA Cost Manual, Sec 6, Ch 2, Table 2.5, 7/2002 (Alloy C-276) (EPA 2002)
Equipment Cost (2022)	1.59	\$143,037	EPA Cost Manual, Sec 6, Ch 2, Table 2.5, 7/2002 (Alloy C-276)
Instrumentation	0.10	\$14,304	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Sales Tax	0.00	\$0	No sales tax in Alaska
Freight	0.10	\$14,304	EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)
Purchase equipment cost		\$171,644	
Direct installation costs			
Foundation and supports	0.06	\$10,299	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Handling and erection	0.40	\$68,658	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Electrical	0.01	\$1,716	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Piping	0.05	\$8,582	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Insulation for ductwork	0.03	\$5,149	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Painting	0.01	\$1,716	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Direct installation cost		\$96,121	
Site preparation	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Facilities and buildings	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Total Direct Cost		\$267,765	
<u>Indirect Costs (installation)</u>			
Engineering	0.10	\$17,164	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Construction and field expenses	0.10	\$17,164	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Contractor fees	0.10	\$17,164	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Start-up	0.01	\$1,716	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Performance test	0.01	\$1,716	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Model study	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Contingencies	0.03	\$5,149	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Total Indirect Cost		\$60,075	
Total Capital Investment		\$327,840	
<u>Direct Annual Costs</u>			
Operating labor	2190 hr/yr	\$23.44	\$51,334 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002 and (BLS 2020)
Supervisory labor		15%	\$7,700 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002
Maintenance			
Labor	1095 hr/yr	\$23.44	\$25,667 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002 and (BLS 2020)
Material		100%	\$25,667 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002
Total O&M cost			\$110,367
Utilities			
Fan	257,146 kWh	\$0.1682	\$43,252 EPA Cost Manual, Sec 6, Ch 2, Table 2.3, 7/2002
Pump	15,207 kWh	\$0.1682	\$2,558 EPA Cost Manual, Sec 6, Ch 2, Table 2.3, 7/2002
Water	1961 kgal/yr	\$0.3180	\$623 EPA Cost Manual, Sec 6, Ch 2, p. 2-52 and 2-58, 7/2002
Total Direct Annual Cost		\$156,801	
<u>Indirect Annual Costs</u>			
Overhead	60%	\$66,220	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002
Administrative charges	2%	\$6,557	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002
Property Tax	1%	\$3,278	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002
Insurance	1%	\$3,278	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002
Capital recovery	11.7%	\$38,301	15 yr life EPA Cost Manual, Sec 6, Ch 2, p. 2-51, 7/2002 8% interest
Total Indirect Annual Costs		\$117,635	
Total Annual Cost		\$274,436	

CPI Inflation Calculator 1/2002 to 1/2022:	1.59	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>
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AIR SCIENCES INC.			Project Title		By	
			Donlin Gold		K. Lewis	
AIR EMISSION CALCULATIONS			Project No		Page of Sheet	
			281-22B-1		9 11 PM Controls	
			Subject:		Date:	
			PM Control Costs		May 5, 2022	

EU ID	97	Dry ESP	99.45%	Control	EPA Fact Sheet, Dry Electrostatic Precipitator (ESP) - Wire-Plate Type (EPA 2003b)	
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Cost Item		Cost	Comment
<u>Direct Cost</u>			
Purchase Equipment Costs	1,000 scfm		Minimum flow for industrial ESPs is 1,000 cfm
Equipment Cost (2002)	\$33 /scfm	\$33,000	EPA Fact Sheet, Dry Electrostatic Precipitator (ESP) - Wire-Plate Typ (EPA 2003b)
Equipment Cost (2022)	1.59	\$52,470	
Instrumentation	0.10	\$5,247	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/199 (EPA 1999)
Sales Tax	0.00	\$0	No sales tax in Alaska
Freight	0.10	\$5,247	EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)
Purchase equipment cost		\$62,964	
Direct installation costs			
Foundation and supports	0.04	\$2,519	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Handling and erection	0.50	\$31,482	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Electrical	0.08	\$5,037	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Piping	0.01	\$630	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Insulation for ductwork	0.02	\$1,259	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Painting	0.02	\$1,259	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Direct installation cost		\$42,186	
Site preparation	0.00	\$0	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Facilities and buildings	0.00	\$0	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Total Direct Cost		\$105,150	
<u>Indirect Costs (installation)</u>			
Engineering	0.20	\$12,593	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Construction and field expenses	0.20	\$12,593	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Contractor fees	0.10	\$6,296	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Start-up	0.01	\$630	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Performance test	0.01	\$630	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Model study	0.02	\$1,259	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Contingencies	0.03	\$1,889	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Total Indirect Cost		\$35,889	
Total Capital Investment		\$141,039	
<u>Direct Annual Costs</u>			
Operating labor	1,369 hr/yr	\$23.44	\$32,084 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999 and (BLS 2020)
Supervisory labor	15%	\$4,813	EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999
Coordinator	33%	\$10,695	EPA Cost Manual, Sec 6, Ch 3, p. 3-58, 9/1999
Maintenance			
Labor	330 hr/yr	\$23.44	\$7,735 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999 and (BLS 2020)
Material	1%	\$630	EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999
Total O&M cost		\$55,955	
Utilities			
Electricity-fan	7,103 kWh	\$0.1682	\$1,195 EPA Cost Manual, Sec 6, Ch 3, p. 3-48 & 3-58, 9/1999 and (Electrical Local 2022)
Electricity-opei	11,945 kWh	\$0.1682	\$2,009 EPA Cost Manual, Sec 6, Ch 3, p. 3-48 & 3-58, 9/1999 and (Electrical Local 2022)
Total Direct Annual Cost		\$59,159	
<u>Indirect Annual Costs</u>			
Overhead	60%	\$33,573	EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Administrative charges	2%	\$2,821	EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Property Tax	1%	\$1,410	EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Insurance	1%	\$1,410	EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Capital recovery	10.2%	\$14,365	20 yr life EPA Cost Manual, Sec 6, Ch 3, p. 3-50, 9/1999
Total Indirect Annual Costs		\$53,580	8% interest
Total Annual Cost		\$112,739	

CPI Inflation Calculator 1/2002 to 1/2022:	1.59	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>
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AIR SCIENCES INC.				Project Title		By		
				Donlin Gold		K. Lewis		
				Project No		Page	of	Sheet
				281-22B-1		10	11	PM Controls
AIR EMISSION CALCULATIONS				Subject:		Date:		
				PM Control Costs		May 5, 2022		
EU ID	97	Venturi Scrubber	98.45%	Control	EPA Cost Manual, Sec 6, Ch 2, p. 2-43, 7/2002 (EPA 2002)			
Cost Item		Cost	Comment					
<u>Direct Cost</u>								
Purchase Equipment Costs								
Equipment Cost (2002)	237 acfm	\$13,861	EPA Cost Manual, Sec 6, Ch 2, Table 2.5, 7/2002 (Alloy C-276) (EPA 2002)					
Equipment Cost (2022)	1.59	\$22,039	EPA Cost Manual, Sec 6, Ch 2, Table 2.5, 7/2002 (Alloy C-276)					
Instrumentation	0.10	\$2,204	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Sales Tax	0.00	\$0	No sales tax in Alaska					
Freight	0.10	\$2,204	EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)					
Purchase equipment cost		\$26,447						
Direct installation costs								
Foundation and supports	0.06	\$1,587	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Handling and erection	0.40	\$10,579	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Electrical	0.01	\$264	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Piping	0.05	\$1,322	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Insulation for ductwork	0.03	\$793	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Painting	0.01	\$264	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Direct installation cost		\$14,810						
Site preparation	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Facilities and buildings	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Total Direct Cost		\$41,257						
<u>Indirect Costs (installation)</u>								
Engineering	0.10	\$2,645	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Construction and field expenses	0.10	\$2,645	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Contractor fees	0.10	\$2,645	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Start-up	0.01	\$264	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Performance test	0.01	\$264	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Model study	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Contingencies	0.03	\$793	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002					
Total Indirect Cost		\$9,256						
Total Capital Investment		\$50,513						
<u>Direct Annual Costs</u>								
Operating labor	2190 hr/yr	\$23.44	\$51,334 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002 and (BLS 2020)					
Supervisory labor	15%	\$7,700	EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002					
Maintenance								
Labor	1095 hr/yr	\$23.44	\$25,667 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002 and (BLS 2020)					
Material	100%	\$25,667	EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002					
Total O&M cost		\$110,367						
Utilities								
Fan	6,105 kWh	\$0.1682	\$1,027 EPA Cost Manual, Sec 6, Ch 2, Table 2.3, 7/2002					
Pump	361 kWh	\$0.1682	\$61 EPA Cost Manual, Sec 6, Ch 2, Table 2.3, 7/2002					
Water	47 kgal/yr	\$0.3180	\$15 EPA Cost Manual, Sec 6, Ch 2, p. 2-52 and 2-58, 7/2002					
Total Direct Annual Cost		\$111,470						
<u>Indirect Annual Costs</u>								
Overhead	60%	\$66,220	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002					
Administrative charges	2%	\$1,010	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002					
Property Tax	1%	\$505	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002					
Insurance	1%	\$505	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002					
Capital recovery	11.7%	\$5,901	15 yr life	EPA Cost Manual, Sec 6, Ch 2, p. 2-51, 7/2002				
Total Indirect Annual Costs		\$74,142	8% interest					
Total Annual Cost		\$185,612						
CPI Inflation Calculator 1/2002 to 1/2022:		1.59	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>					

AIR SCIENCES INC.				Project Title Donlin Gold		By K. Lewis		
AIR EMISSION CALCULATIONS				Project No 281-22B-1		Page 11	of 11	Sheet PM Controls
				Subject: PM Control Costs		Date: May 5, 2022		
EU ID	97	Fabric Filter	99.45%	Control	EPA Cost Manual, Sec 6, Ch 1, p. 1-4, 12/1998 (EPA 1998)			
Cost Item		Cost		Comment				
<u>Direct Cost</u>								
Purchase Equipment Costs								
Equipment Cost (1998)		51	ft2 of cloth	EPA Cost Manual, Sec 6, Ch 1, p. 1-50, 12/1998				
Fabric filter w/ insulati		237	acfm	\$3,823	EPA Cost Manual, Sec 6, Ch 1, p. 1-50 and 1-51, 12/1998 (EPA 1998)			
Bags and cages		4	bags	\$127	EPA Cost Manual, Sec 6, Ch 1, p. 1-50 and 1-51, 12/1998			
Auxiliary equipment				\$3,295	EPA Cost Manual, Sec 6, Ch 1, Table 1.10, 12/1998			
Equipment Cost (2022)		1.73		\$12,534				
Instrumentation		0.10		\$1,253	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Sales Tax		0.00		\$0	No sales tax in Alaska			
Freight		0.10		\$1,253	EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)			
Purchase equipment cost				\$15,041				
Direct installation costs								
Foundation and supports		0.04		\$602	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Handling and erection		0.50		\$7,520	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Electrical		0.08		\$1,203	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Piping		0.01		\$150	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Insulation for ductwork		0.07		\$1,053	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Painting		0.04		\$602	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Direct installation cost				\$11,130				
Site preparation		0.00		\$0	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Facilities and buildings		0.00		\$0	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Total Direct Cost				\$26,171				
<u>Indirect Costs (installation)</u>								
Engineering		0.10		\$1,504	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Construction and field expenses		0.20		\$3,008	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Contractor fees		0.10		\$1,504	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Start-up		0.01		\$150	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Performance test		0.01		\$150	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Contingencies		0.03		\$451	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Total Indirect Cost				\$6,768				
Total Capital Investment				\$32,939				
<u>Direct Annual Costs</u>								
Operating labor		2190	hr/yr	\$23.44	\$51,334 EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998 and (BLS 2020)			
Supervisory labor			15%		\$7,700 EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998			
Maintenance								
Labor		1095	hr/yr	\$23.44	\$25,667 EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998 and (BLS 2020)			
Material			100%		\$25,667 EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998			
Total O&M cost				\$110,367				
Replacement bags		\$257	56.1%	\$144	2 yr life	EPA Cost Manual, Sec 6, Ch 1, p. 1-46, 12/1998 8% interest		
Utilities								
Electricity		3,874	kWh	\$0.1682	\$652 EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Compressed A		249,335	scf	\$0.0003	\$62 EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Total Direct Annual Cost				\$111,225				
<u>Indirect Annual Costs</u>								
Overhead		60%		\$66,220	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Administrative charges		2%		\$659	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Property Tax		1%		\$329	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Insurance		1%		\$329	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Capital recovery		10.2%		\$3,329	20 yr life	EPA Cost Manual, Sec 6, Ch 1, p. 1-55, 12/1998 8% interest		
Total Indirect Annual Costs				\$70,867				
Total Annual Cost				\$182,092				
CPI Inflation Calculator 5/1998 to 1/2022:				1.73	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>			

<p>AIR SCIENCES INC.</p> <p>AIR EMISSION CALCULATIONS</p>	Project Title	Donlin Gold	By	K. Lewis
	Project No	281-22B-1	Page of Sheet	1 3 Tanks
	Subject:	Large Diesel Tank VOC Control Costs	Date:	May 5, 2022

### Large Diesel Tank VOC Control Costs

Interest Rate for Capital Recovery Factor (CRF) 8% (Annett, K. 2022)

EU ID	EU Description	VOC Control System	VOC Control Efficiency	No. of Tanks	Per Tank Capacity gal	Per Tank Throughput gal/yr	Per Tank breath lb/yr	Per Tank work lb/yr	Per Tank VOC lb/yr	Total VOC ton/yr	Limit VOC ton/yr
126-140	Tank Farm Tanks #1 - #15	Submerge Fill <sup>[1]</sup>	NA	15	2,500,000	7,500,000	71.96	131.01	202.97	1.52	1.7
		Floating Roof <sup>[1]</sup>	65%	15	2,500,000	7,500,000	1.02	70.08	71.10	0.53	
		Vapor Recovery	90%	15	2,500,000	7,500,000			20.297	0.15	

<sup>[1]</sup> EPA's Tanks 4.0.9d model

### Vapor Recovery Unit (VRU) size for all 15 tanks

Working Gas Volume

$$\frac{7,500,000 \text{ gal}}{\text{yr}} \times \frac{\text{cf}}{7.48052 \text{ gal}} \times 15 \text{ tanks} \times \frac{\text{Mcf}}{1,000 \text{ cf}} \times \frac{\text{yr}}{365 \text{ day}} = \frac{41.20 \text{ Mcf}}{\text{day}}$$

Breathing Gas Volume

$$\frac{71.96 \text{ lb VOC}}{\text{yr}} \times 15 \text{ tanks} \times \frac{\text{lb-mol}}{188 \text{ lb VOC}} \times \frac{386.5 \text{ scf}}{\text{lb-mol}} \times \frac{\text{yr}}{365 \text{ day}} \times \frac{\text{Mcf}}{1,000 \text{ cf}} = \frac{14.2 \text{ psia, site pressure}}{0.0031 \text{ psia, VOC partial}}$$

$$= \frac{27.85 \text{ Mcf}}{\text{day}}$$

Total Flow to VRU 69 Mcf/day

### VOC Control Cost Effectiveness

EU ID	EU Description	Control Option	Control Efficiency	TCI (\$)	Annual Cost (\$/yr)	VOC Reduced (ton/yr)	Control Cost (\$/ton)
126-140	Tank Farm Tanks #1 - #15	Floating Roof	65%	\$4,620,000	\$671,971	1.11	\$608,118
		Vapor Recovery	90%	\$97,857	\$80,027	1.53	\$52,305

### Conversions

365 day/yr  
 2,000 lb/ton  
 1,000 cf/Mcf  
 7.48052 gal/ft3  
 386.5 scf/lb-mol  
 188 lb VOC (No. 2 distillate)/lb-mol  
 14.2 psia, site pressure



AIR SCIENCES INC.			Project Title Donlin Gold		By K. Lewis	
AIR EMISSION CALCULATIONS			Project No 281-22B-1		Page 2	of 3
			Subject: Large Diesel Tank VOC Control Costs		Sheet Tanks	
					Date: May 5, 2022	
EU ID	126-140	Vapor Recovery Unit	90%	Control	EPA Cost Manual, Sec 3.1, Ch 2, p. 2-1, 11/2017 (EPA 2017b)	
Cost Item			Cost	Comment		
<u>Direct Cost</u>						
Purchase Equipment Costs						
Equipment Cost (2006)			31,728	100 Mcf/day design capacity (EPA 2006)		
Equipment Cost (2022)			1.42	45,054		
Instrumentation			0.10	\$4,505 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/20 (EPA 2017b)		
Sales Tax			0.00	\$0 No sales tax in Alaska		
Freight			0.10	\$4,505 EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)		
Purchase equipment cost				\$54,065		
Direct installation costs						
Foundation and supports			0.14	\$7,569 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Handling and erection			0.08	\$4,325 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Electrical			0.08	\$4,325 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Piping			0.02	\$1,081 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Insulation			0.10	\$5,406 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Painting			0.01	\$541 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Direct installation cost				\$23,248		
Site preparation			0.00	\$0 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Facilities and buildings			0.00	\$0 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Total Direct Cost				\$77,312		
<u>Indirect Costs (installation)</u>						
Engineering			0.10	\$5,406 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Construction and field expenses			0.05	\$2,703 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Contractor fees			0.10	\$5,406 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Start-up			0.02	\$1,081 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Performance test			0.01	\$541 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Contingencies			0.10	\$5,406 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Total Indirect Cost				\$20,545		
Total Capital Investment				\$97,857		
<u>Direct Annual Costs</u>						
Operating labor			547.5 hr/yr	\$23.44	\$12,833 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.7, 11/2017 and (BLS 2020)	
Supervisory labor				15%	\$1,925 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017	
Maintenance						
Labor			547.5 hr/yr	\$23.44	\$12,833 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.7, 11/2017 and (BLS 2020)	
Material				100%	\$12,833 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017	
Total O&M cost				\$40,425		
Utilities						
Electricity			0 kWh	\$0.1682	\$0.00 Not calculable due to negligible VOC for condensation	
Total Direct Annual Cost				\$40,425		
<u>Indirect Annual Costs</u>						
Overhead				60%	\$24,255 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.4, 11/2017	
Administrative charges				2%	\$1,957 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.4, 11/2017	
Property Tax				1%	\$979 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.4, 11/2017	
Insurance				1%	\$979 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.4, 11/2017	
Capital recovery			11.7%	\$11,433	15 yr life	EPA Cost Manual, Sec 3.1, Ch 2, Table 2.4, 11/20 8% interest
Total Indirect Annual Costs				\$39,602		
Total Annual Cost				\$80,027		
CPI Inflation Calculator 1/2006 to 1/2022: 1.42 <a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>						

AIR SCIENCES INC.			Project Title Donlin Gold		By K. Lewis	
AIR EMISSION CALCULATIONS			Project No 281-22B-1		Page of Sheet 3 3 Tanks	
			Subject: Large Diesel Tank VOC Control Costs		Date: May 5, 2022	
EU ID	126-140	Internal Floating Roof	65%	Control	Tanks	4.0.9d
<hr/>						
<hr/>						
Cost Item		Cost	Comment			
<hr/>						
Purchase equipment and installation cost		\$308,000	Design, fabricate, and install cost per tank (freight not included)			(Moneta, N. 2022)
Total Capital Investment		15	\$4,620,000 Total cost for 15 tanks			
<hr/>						
<u>Direct Annual Costs</u>						
Operating labor		547.5 hr/yr	\$23.44	\$12,833 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.7, 11/2017 and (BLS 2020)		
Supervisory labor			15%	\$1,925 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Maintenance						
Labor		547.5 hr/yr	\$23.44	\$12,833 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.7, 11/2017 and (BLS 2020)		
Material			100%	\$12,833 EPA Cost Manual, Sec 3.1, Ch 2, Table 2.3, 11/2017		
Total O&M cost			\$40,425			
<hr/>						
<u>Indirect Annual Costs</u>						
Overhead			60%	\$24,255 EPA Cost Manual, Sec 1, Ch 2, p. 35, 11/2017 (EPA 2017a)		
Administrative charges			2%	\$92,400 EPA Cost Manual, Sec 1, Ch 2, p. 35, 11/2017		
Property Tax			1%	\$46,200 EPA Cost Manual, Sec 1, Ch 2, p. 35, 11/2017		
Insurance			1%	\$46,200 EPA Cost Manual, Sec 1, Ch 2, p. 35, 11/2017		
Capital recovery			9.1%	\$422,490	27 yr life	Life of mine
Total Indirect Annual Costs			\$631,545			
Total Annual Cost			\$671,971			

<p style="text-align: center;"><b>AIR SCIENCES INC.</b></p> <p style="text-align: center;"><b>AIR EMISSION CALCULATIONS</b></p>	<b>Project Title</b>	Donlin Gold			<b>By</b>	K. Lewis		
	<b>Project No</b>	281-22B-1			<b>Page of Sheet</b>	1	8	Incinerator
	<b>Subject:</b>	Incinerator Control Costs			<b>Date:</b>	May 5, 2022		

#### Incinerator Control Costs

Interest Rate for Capital Recovery Factor (CRF): 8% (Annett, K. 2022)

EU ID	EU Description	Design Rating lb/hr	Design Rating ton/day	Design Rating MMBtu/hr	Annual Rate ton/yr	Design Exhaust acfm	Design Exhaust wscfm	Design Exhaust dscfm	Design Exhaust (F)	Annual Hours hr/yr	Moisture
27	Camp Waste Incinerator	990	11.88	4.455	547.5	2,188	1,187	1,068	500	8,760	10%
28	Sewage Sludge Incinerator	14.5	0.058	0.112	21.15	55	30	27	500	2,920	10%

#### AP-42 Uncontrolled Emission Factors

EU ID	PM lb/ton	NOx lb/ton	CO lb/ton	VOC lb/ton	Reference
27	25.1	3.56	1.37	0	Highest factor of AP-42 Tables 2.1-2, 4, 5, 6, 7, and 9, 10/96
28	460	8.6	31	1.7	Highest factor of AP-42 Tables 2.2-1, 6, and 9, 1/95

EU ID	Uncontrolled Emissions Based on AP-42 (highest factors)						NSPS Limits (Proposed BACT)			Required Control Efficiency		
	PM ton/yr	NOx ton/yr	CO ton/yr	PM lb/hr	NOx lb/hr	CO lb/hr	PM lb/hr	NOx lb/hr	CO lb/hr	PM %	NOx %	CO %
27	6.87	0.97	0.38	12.42	1.76	0.68	0.0729	0.1782	0.0802	99.4%	90%	88%
28	4.86	0.09	0.33	3.33	0.06	0.22	0.0061	0.0437	0.0066	99.8%	30%	97%

#### PM Control Cost Effectiveness

EU ID	EU Description	Control	Control Efficiency	TCI (\$)	Annual Cost (\$/yr)	PM Reduced (ton/yr)	Control Cost (\$/ton)
27	Camp Waste Incinerator	Dry ESP	99.45%	\$167,367	\$117,260	6.83	\$17,160
		Venturi Scrubber	98.45%	\$153,405	\$210,813	6.76	\$31,164
		Fabric Filter	99.45%	\$70,755	\$194,295	6.83	\$28,433
28	Sewage Sludge Incinerator	Dry ESP	99.45%	\$141,039	\$59,840	4.84	\$12,369
		Venturi Scrubber	98.45%	\$24,391	\$62,773	4.79	\$13,108
		Fabric Filter	99.45%	\$29,412	\$63,118	4.84	\$13,047

#### NOx Control Cost Effectiveness

EU ID	EU Description	Control	Control Efficiency	TCI (\$)	Annual Cost (\$/yr)	NOx Reduced (ton/yr)	Control Cost (\$/ton)
27	Camp Waste Incinerator	SNCR	50%	\$696,086	\$82,192	0.487	\$168,678
		SCR	85%	\$1,815,622	\$182,999	0.828	\$220,915
28	Sewage Sludge Incinerator	SNCR	50%	\$129,895	\$15,290	0.045	\$336,253
		SCR	85%	\$543,799	\$56,396	0.077	\$729,536

#### CO Control Cost Effectiveness

EU ID	EU Description	Control	Control Efficiency	TCI (\$)	Annual Cost (\$/yr)	CO Reduced (ton/yr)	Control Cost (\$/ton)
27	Camp Waste Incinerator	Ox. Cat.	99%	\$219,380	\$114,012	0.371	\$307,073
28	Sewage Sludge Incinerator	Ox. Cat.	99%	\$29,172	\$29,137	0.325	\$89,777

#### Conversions

60 min/hr      24 hr/day      365 day/yr      8,760 hr/yr  
 2,000 lb/ton  
 9,570 dscf/MMBtu @ 0% O<sub>2</sub>  
 4,500 Btu/lb solid waste      7,700 Btu/lb dry sludge  
 7 % excess O<sub>2</sub>  
 459.67 R at 0F      77 F, EPA STD Temperature for the Cost Manual      0.97 atm, site pressure

AIR SCIENCES INC.			Project Title Donlin Gold		By K. Lewis	
AIR EMISSION CALCULATIONS			Project No 281-22B-1		Page of Sheet 2 of 8 Incinerator	
			Subject: Incinerator Control Costs		Date: May 5, 2022	

EU ID	27	Dry ESP	99.45%	Control	EPA Fact Sheet, Dry Electrostatic Precipitator (ESP) - Wire-Plate Type (EPA 2003b)	
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Cost Item	Cost	Comment
<u>Direct Cost</u>		
Purchase Equipment Costs	1,187 scfm	Design flow rate
Equipment Cost (2002)	\$33 /scfm	\$39,160 EPA Fact Sheet, Dry Electrostatic Precipitator (ESP) - Wire-Plate Typ (EPA 2003b)
Equipment Cost (2022)	1.59	\$62,264
Instrumentation	0.10	\$6,226 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/199 (EPA 1999)
Sales Tax	0.00	\$0 No sales tax in Alaska
Freight	0.10	\$6,226 EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)
Purchase equipment cost		\$74,717
Direct installation costs		
Foundation and supports	0.04	\$2,989 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Handling and erection	0.50	\$37,359 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Electrical	0.08	\$5,977 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Piping	0.01	\$747 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Insulation for ductwork	0.02	\$1,494 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Painting	0.02	\$1,494 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Direct installation cost		\$50,061
Site preparation	0.00	\$0 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Facilities and buildings	0.00	\$0 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Total Direct Cost		\$124,778
<u>Indirect Costs (installation)</u>		
Engineering	0.20	\$14,943 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Construction and field expenses	0.20	\$14,943 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Contractor fees	0.10	\$7,472 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Start-up	0.01	\$747 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Performance test	0.01	\$747 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Model study	0.02	\$1,494 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Contingencies	0.03	\$2,242 EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Total Indirect Cost		\$42,589
Total Capital Investment		\$167,367
<u>Direct Annual Costs</u>		
Operating labor	1,369 hr/yr	\$23.44 \$32,084 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999 and (BLS 2020)
Supervisory labor	15%	\$4,813 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999
Coordinator	33%	\$10,695 EPA Cost Manual, Sec 6, Ch 3, p. 3-58, 9/1999
Maintenance		
Labor	330 hr/yr	\$23.44 \$7,735 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999 and (BLS 2020)
Material	1%	\$747 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999
Total O&M cost		\$56,073
Utilities		
Electricity-fan	8,429 kWh	\$0.1682 \$1,418 EPA Cost Manual, Sec 6, Ch 3, p. 3-48 & 3-58, 9/1999 and (Electrical Local 2022)
Electricity-opei	14,175 kWh	\$0.1682 \$2,384 EPA Cost Manual, Sec 6, Ch 3, p. 3-48 & 3-58, 9/1999 and (Electrical Local 2022)
Total Direct Annual Cost		\$59,875
<u>Indirect Annual Costs</u>		
Overhead	60%	\$33,644 EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Administrative charges	2%	\$3,347 EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Property Tax	1%	\$1,674 EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Insurance	1%	\$1,674 EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Capital recovery	10.2%	\$17,047 20 yr life EPA Cost Manual, Sec 6, Ch 3, p. 3-50, 9/1999 8% interest
Total Indirect Annual Costs		\$57,385
Total Annual Cost		\$117,260

CPI Inflation Calculator 1/2002 to 1/2022:	1.59	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>
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AIR SCIENCES INC.			Project Title		By	
			Donlin Gold		K. Lewis	
			Project No		Page of Sheet	
			281-22B-1		3 8 Incinerator	
AIR EMISSION CALCULATIONS			Subject:		Date:	
			Incinerator Control Costs		May 5, 2022	
EU ID	27	Venturi Scrubber	98.45%	Control	EPA Cost Manual, Sec 6, Ch 2, p. 2-43, 7/2002 (EPA 2002)	
Cost Item			Cost	Comment		
<u>Direct Cost</u>						
Purchase Equipment Costs						
Equipment Cost (2002)	2,188 acfm	\$42,095	EPA Cost Manual, Sec 6, Ch 2, Table 2.5, 7/2002 (Alloy C-276) (EPA 2002)			
Equipment Cost (2022)	1.59	\$66,931	EPA Cost Manual, Sec 6, Ch 2, Table 2.5, 7/2002 (Alloy C-276)			
Instrumentation	0.10	\$6,693	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Sales Tax	0.00	\$0	No sales tax in Alaska			
Freight	0.10	\$6,693	EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)			
Purchase equipment cost		\$80,317				
Direct installation costs						
Foundation and supports	0.06	\$4,819	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Handling and erection	0.40	\$32,127	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Electrical	0.01	\$803	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Piping	0.05	\$4,016	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Insulation for ductwork	0.03	\$2,410	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Painting	0.01	\$803	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Direct installation cost		\$44,977				
Site preparation	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Facilities and buildings	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Total Direct Cost		\$125,294				
<u>Indirect Costs (installation)</u>						
Engineering	0.10	\$8,032	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Construction and field expenses	0.10	\$8,032	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Contractor fees	0.10	\$8,032	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Start-up	0.01	\$803	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Performance test	0.01	\$803	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Model study	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Contingencies	0.03	\$2,410	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002			
Total Indirect Cost		\$28,111				
Total Capital Investment		\$153,405				
<u>Direct Annual Costs</u>						
Operating labor	2190 hr/yr	\$23.44	\$51,334 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002 and (BLS 2020)			
Supervisory labor	15%	\$7,700	EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002			
Maintenance						
Labor	1095 hr/yr	\$23.44	\$25,667 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002 and (BLS 2020)			
Material	100%	\$25,667	EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002			
Total O&M cost		\$110,367				
Utilities						
Fan	56,304 kWh	\$0.1682	\$9,470 EPA Cost Manual, Sec 6, Ch 2, Table 2.3, 7/2002			
Pump	3,330 kWh	\$0.1682	\$560 EPA Cost Manual, Sec 6, Ch 2, Table 2.3, 7/2002			
Water	429 ggal/yr	\$0.3180	\$137 EPA Cost Manual, Sec 6, Ch 2, p. 2-52 and 2-58, 7/2002			
Total Direct Annual Cost		\$120,534				
<u>Indirect Annual Costs</u>						
Overhead	60%	\$66,220	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002			
Administrative charges	2%	\$3,068	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002			
Property Tax	1%	\$1,534	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002			
Insurance	1%	\$1,534	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002			
Capital recovery	11.7%	\$17,922	15 yr life	EPA Cost Manual, Sec 6, Ch 2, p. 2-51, 7/2002 8% interest		
Total Indirect Annual Costs		\$90,279				
Total Annual Cost		\$210,813				
CPI Inflation Calculator 1/2002 to 1/2022:			1.59	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>		

AIR SCIENCES INC.				Project Title Donlin Gold		By K. Lewis			
AIR EMISSION CALCULATIONS				Project No 281-22B-1		Page 4	of 8	Sheet Incinerator	
				Subject: Incinerator Control Costs		Date: May 5, 2022			
EU ID	27	Fabric Filter	99.45%	Control	EPA Cost Manual, Sec 6, Ch 1, p. 1-4, 12/1998 (EPA 1998)				
Cost Item		Cost		Comment					
<u>Direct Cost</u>									
Purchase Equipment Costs									
Equipment Cost (1998)		466	ft2 of cloth	EPA Cost Manual, Sec 6, Ch 1, p. 1-50, 12/1998					
Fabric filter w/ insulati		2,188	acfm	\$7,729	EPA Cost Manual, Sec 6, Ch 1, p. 1-50 and 1-51, 12/1998 (EPA 1998)				
Bags and cages		35	bags	\$1,172	EPA Cost Manual, Sec 6, Ch 1, p. 1-50 and 1-51, 12/1998				
Auxiliary equipment				\$6,661	EPA Cost Manual, Sec 6, Ch 1, Table 1.10, 12/1998				
Equipment Cost (2022)		1.73		\$26,923					
Instrumentation		0.10		\$2,692	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Sales Tax		0.00		\$0	No sales tax in Alaska				
Freight		0.10		\$2,692	EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)				
Purchase equipment cost				\$32,308					
Direct installation costs									
Foundation and supports		0.04		\$1,292	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Handling and erection		0.50		\$16,154	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Electrical		0.08		\$2,585	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Piping		0.01		\$323	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Insulation for ductwork		0.07		\$2,262	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Painting		0.04		\$1,292	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Direct installation cost				\$23,908					
Site preparation		0.00		\$0	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Facilities and buildings		0.00		\$0	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Total Direct Cost				\$56,216					
<u>Indirect Costs (installation)</u>									
Engineering		0.10		\$3,231	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Construction and field expenses		0.20		\$6,462	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Contractor fees		0.10		\$3,231	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Start-up		0.01		\$323	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Performance test		0.01		\$323	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Contingencies		0.03		\$969	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998				
Total Indirect Cost				\$14,539					
Total Capital Investment				\$70,755					
<u>Direct Annual Costs</u>									
Operating labor		2190	hr/yr	\$23.44	\$51,334 EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998 and (BLS 2020)				
Supervisory labor			15%	\$7,700	EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998				
Maintenance									
Labor		1095	hr/yr	\$23.44	\$25,667 EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998 and (BLS 2020)				
Material			100%	\$25,667	EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998				
Total O&M cost				\$110,367					
Replacement bags		\$2,367	56.1%	\$1,327	2 yr life	EPA Cost Manual, Sec 6, Ch 1, p. 1-46, 12/1998			8% interest
Utilities									
Electricity		35,727	kWh	\$0.1682	\$6,009 EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998				
Compressed A		2,299,625	scf	\$0.0003	\$575 EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998				
Total Direct Annual Cost				\$118,279					
<u>Indirect Annual Costs</u>									
Overhead		60%		\$66,220	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998				
Administrative charges		2%		\$1,415	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998				
Property Tax		1%		\$708	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998				
Insurance		1%		\$708	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998				
Capital recovery		10.2%		\$6,965	20 yr life	EPA Cost Manual, Sec 6, Ch 1, p. 1-55, 12/1998			8% interest
Total Indirect Annual Costs				\$76,016					
Total Annual Cost				\$194,295					
CPI Inflation Calculator 5/1998 to 1/2022:				1.73	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>				



AIR SCIENCES INC.			Project Title Donlin Gold		By K. Lewis	
AIR EMISSION CALCULATIONS			Project No 281-22B-1		Page of Sheet 5 8 Incinerator	
			Subject: Incinerator Control Costs		Date: May 5, 2022	

EU ID	28	Dry ESP	99.45%	Control	EPA Fact Sheet, Dry Electrostatic Precipitator (ESP) - Wire-Plate Type (EPA 2003b)	
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Cost Item		Cost	Comment
<u>Direct Cost</u>			
Purchase Equipment Costs	1,000 scfm		Minimum flow for industrial ESPs is 1,000 cfm
Equipment Cost (2002)	\$33 /scfm	\$33,000	EPA Fact Sheet, Dry Electrostatic Precipitator (ESP) - Wire-Plate Typ (EPA 2003b)
Equipment Cost (2022)	1.59	\$52,470	
Instrumentation	0.10	\$5,247	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/199 (EPA 1999)
Sales Tax	0.00	\$0	No sales tax in Alaska
Freight	0.10	\$5,247	EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)
Purchase equipment cost		\$62,964	
Direct installation costs			
Foundation and supports	0.04	\$2,519	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Handling and erection	0.50	\$31,482	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Electrical	0.08	\$5,037	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Piping	0.01	\$630	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Insulation for ductwork	0.02	\$1,259	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Painting	0.02	\$1,259	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Direct installation cost		\$42,186	
Site preparation	0.00	\$0	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Facilities and buildings	0.00	\$0	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Total Direct Cost		\$105,150	
<u>Indirect Costs (installation)</u>			
Engineering	0.20	\$12,593	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Construction and field expenses	0.20	\$12,593	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Contractor fees	0.10	\$6,296	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Start-up	0.01	\$630	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Performance test	0.01	\$630	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Model study	0.02	\$1,259	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Contingencies	0.03	\$1,889	EPA Cost Manual, Sec 6, Ch 3, Table 3.16, 9/1999
Total Indirect Cost		\$35,889	
Total Capital Investment		\$141,039	
<u>Direct Annual Costs</u>			
Operating labor	456 hr/yr	\$23.44	\$10,695 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999 and (BLS 2020)
Supervisory labor	15%	\$1,604	EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999
Coordinator	33%	\$3,565	EPA Cost Manual, Sec 6, Ch 3, p. 3-58, 9/1999
Maintenance			
Labor	330 hr/yr	\$23.44	\$7,735 EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999 and (BLS 2020)
Material	1%	\$630	EPA Cost Manual, Sec 6, Ch 3, p. 3-47, 9/1999
Total O&M cost		\$24,228	
Utilities			
Electricity-fan	2,368 kWh	\$0.1682	\$398 EPA Cost Manual, Sec 6, Ch 3, p. 3-48 & 3-58, 9/1999 and (Electrical Local 2022)
Electricity-opei	3,982 kWh	\$0.1682	\$670 EPA Cost Manual, Sec 6, Ch 3, p. 3-48 & 3-58, 9/1999 and (Electrical Local 2022)
Total Direct Annual Cost		\$25,296	
<u>Indirect Annual Costs</u>			
Overhead	60%	\$14,537	EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Administrative charges	2%	\$2,821	EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Property Tax	1%	\$1,410	EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Insurance	1%	\$1,410	EPA Cost Manual, Sec 6, Ch 3, Table 3.21, 9/1999
Capital recovery	10.2%	\$14,365	20 yr life EPA Cost Manual, Sec 6, Ch 3, p. 3-50, 9/1999
Total Indirect Annual Costs		\$34,544	8% interest
Total Annual Cost		\$59,840	

CPI Inflation Calculator 1/2002 to 1/2022:	1.59	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>
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AIR SCIENCES INC.			Project Title		By	
			Donlin Gold		K. Lewis	
			Project No		Page of Sheet	
			281-22B-1		6 8 Incinerator	
AIR EMISSION CALCULATIONS			Subject:		Date:	
			Incinerator Control Costs		May 5, 2022	

EU ID	28	Venturi Scrubber	98.45%	Control	EPA Cost Manual, Sec 6, Ch 2, p. 2-43, 7/2002 (EPA 2002)	
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Cost Item		Cost	Comment
<u>Direct Cost</u>			
Purchase Equipment Costs			
Equipment Cost (2002)	55 acfm	\$6,693	EPA Cost Manual, Sec 6, Ch 2, Table 2.5, 7/2002 (Alloy C-276) (EPA 2002)
Equipment Cost (2022)	1.59	\$10,642	EPA Cost Manual, Sec 6, Ch 2, Table 2.5, 7/2002 (Alloy C-276)
Instrumentation	0.10	\$1,064	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Sales Tax	0.00	\$0	No sales tax in Alaska
Freight	0.10	\$1,064	EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)
Purchase equipment cost		\$12,770	
Direct installation costs			
Foundation and supports	0.06	\$766	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Handling and erection	0.40	\$5,108	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Electrical	0.01	\$128	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Piping	0.05	\$639	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Insulation for ductwork	0.03	\$383	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Painting	0.01	\$128	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Direct installation cost		\$7,151	
Site preparation	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Facilities and buildings	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Total Direct Cost		\$19,922	
<u>Indirect Costs (installation)</u>			
Engineering	0.10	\$1,277	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Construction and field expenses	0.10	\$1,277	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Contractor fees	0.10	\$1,277	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Start-up	0.01	\$128	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Performance test	0.01	\$128	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Model study	0.00	\$0	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Contingencies	0.03	\$383	EPA Cost Manual, Sec 6, Ch 2, Table 2.8, 7/2002
Total Indirect Cost		\$4,470	
Total Capital Investment		\$24,391	
<u>Direct Annual Costs</u>			
Operating labor	730 hr/yr	\$23.44	\$17,111 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002 and (BLS 2020)
Supervisory labor		15%	\$2,567 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002
Maintenance			
Labor	365 hr/yr	\$23.44	\$8,556 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002 and (BLS 2020)
Material		100%	\$8,556 EPA Cost Manual, Sec 6, Ch 2, Table 2.9, 7/2002
Total O&M cost		\$36,789	
Utilities			
Fan	474 kWh	\$0.1682	\$80 EPA Cost Manual, Sec 6, Ch 2, Table 2.3, 7/2002
Pump	28 kWh	\$0.1682	\$5 EPA Cost Manual, Sec 6, Ch 2, Table 2.3, 7/2002
Water	4 kgal/yr	\$0.3180	\$1 EPA Cost Manual, Sec 6, Ch 2, p. 2-52 and 2-58, 7/2002
Total Direct Annual Cost		\$36,875	
<u>Indirect Annual Costs</u>			
Overhead	60%	\$22,073	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002
Administrative charges	2%	\$488	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002
Property Tax	1%	\$244	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002
Insurance	1%	\$244	EPA Cost Manual, Sec 6, Ch 2, p. 2-58, 7/2002
Capital recovery	11.7%	\$2,850	15 yr life EPA Cost Manual, Sec 6, Ch 2, p. 2-51, 7/2002
Total Indirect Annual Costs		\$25,899	8% interest
Total Annual Cost		\$62,773	

CPI Inflation Calculator 1/2002 to 1/2022:	1.59	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>
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AIR SCIENCES INC.				Project Title Donlin Gold		By K. Lewis		
AIR EMISSION CALCULATIONS				Project No 281-22B-1		Page 7	of 8	Sheet Incinerator
				Subject: Incinerator Control Costs		Date: May 5, 2022		
EU ID	28	Fabric Filter	99.45%	Control	EPA Cost Manual, Sec 6, Ch 1, p. 1-4, 12/1998 (EPA 1998)			
Cost Item		Cost		Comment				
<u>Direct Cost</u>								
Purchase Equipment Costs								
Equipment Cost (1998)		12	ft2 of cloth	EPA Cost Manual, Sec 6, Ch 1, p. 1-50, 12/1998				
Fabric filter w/ insulati		55	acfm	\$3,459	EPA Cost Manual, Sec 6, Ch 1, p. 1-50 and 1-51, 12/1998 (EPA 1998)			
Bags and cages		1	bags	\$30	EPA Cost Manual, Sec 6, Ch 1, p. 1-50 and 1-51, 12/1998			
Auxiliary equipment				\$2,981	EPA Cost Manual, Sec 6, Ch 1, Table 1.10, 12/1998			
Equipment Cost (2022)		1.73		\$11,192				
Instrumentation		0.10		\$1,119	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Sales Tax		0.00		\$0	No sales tax in Alaska			
Freight		0.10		\$1,119	EPA Cost Manual, Sec 1, Ch 2, p. 26, 11/2017 (upper value for AK) (EPA 2017a)			
Purchase equipment cost				\$13,430				
Direct installation costs								
Foundation and supports		0.04		\$537	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Handling and erection		0.50		\$6,715	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Electrical		0.08		\$1,074	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Piping		0.01		\$134	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Insulation for ductwork		0.07		\$940	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Painting		0.04		\$537	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Direct installation cost				\$9,938				
Site preparation		0.00		\$0	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Facilities and buildings		0.00		\$0	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Total Direct Cost				\$23,369				
<u>Indirect Costs (installation)</u>								
Engineering		0.10		\$1,343	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Construction and field expenses		0.20		\$2,686	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Contractor fees		0.10		\$1,343	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Start-up		0.01		\$134	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Performance test		0.01		\$134	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Contingencies		0.03		\$403	EPA Cost Manual, Sec 6, Ch 1, Table 1.9, 12/1998			
Total Indirect Cost				\$6,044				
Total Capital Investment				\$29,412				
<u>Direct Annual Costs</u>								
Operating labor		730	hr/yr	\$23.44	\$17,111 EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998 and (BLS 2020)			
Supervisory labor			15%	\$2,567	EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998			
Maintenance								
Labor		365	hr/yr	\$23.44	\$8,556 EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998 and (BLS 2020)			
Material			100%	\$8,556	EPA Cost Manual, Sec 6, Ch 1, p. 1-44, 12/1998			
Total O&M cost				\$36,789				
Replacement bags		\$60	56.1%	\$34	2 yr life	EPA Cost Manual, Sec 6, Ch 1, p. 1-46, 12/1998		8% interest
Utilities								
Electricity		301	kWh	\$0.1682	\$51 EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Compressed A		19,379	scf	\$0.0003	\$5 EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Total Direct Annual Cost				\$36,878				
<u>Indirect Annual Costs</u>								
Overhead		60%		\$22,073	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Administrative charges		2%		\$588	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Property Tax		1%		\$294	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Insurance		1%		\$294	EPA Cost Manual, Sec 6, Ch 1, Table 1.11, 12/1998			
Capital recovery		10.2%		\$2,990	20 yr life	EPA Cost Manual, Sec 6, Ch 1, p. 1-55, 12/1998		8% interest
Total Indirect Annual Costs				\$26,240				
Total Annual Cost				\$63,118				
CPI Inflation Calculator 5/1998 to 1/2022:				1.73	<a href="https://data.bls.gov/cgi-bin/cpicalc.pl">https://data.bls.gov/cgi-bin/cpicalc.pl</a>			

<p>AIR SCIENCES INC.</p> <p>AIR EMISSION CALCULATIONS</p>	Project Title	Donlin Gold	By	K. Lewis
	Project No	281-22B-1	Page of Sheet	8 of 8 Incinerator
	Subject:	Incinerator Control Costs	Date:	May 5, 2022

#### Incinerator Control Costs - continued

Conversion of daily average lb/hr to ppm

EU ID 27

$$\frac{600 \text{ people}}{1} \times \frac{5 \text{ lb waste}}{\text{person-day}} \times \frac{1 \text{ day}}{24 \text{ hr}} \times \frac{1 \text{ ton}}{2,000 \text{ lb}} \times \frac{1.37 \text{ lb CO}}{\text{ton}} = \frac{0.08563 \text{ lb CO}}{\text{hr}}$$

$$\frac{0.08563 \text{ lb CO}}{\text{hr}} \times \frac{1 \text{ lb-mol}}{28.01 \text{ lb CO}} \times \frac{386.5 \text{ scf}}{1 \text{ lb-mol}} \times \frac{1 \text{ min}}{1,187 \text{ scf}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times 1.E+06 = 16.59 \text{ ppmv CO}$$

0.3750375 TRUE

EU ID 28

$$\frac{600 \text{ people}}{1} \times \frac{70.5 \text{ lb sewage}}{\text{person-yr}} \times \frac{1 \text{ yr}}{365 \text{ day}} \times \frac{1 \text{ day}}{8 \text{ hr}} \times \frac{1 \text{ ton}}{2,000 \text{ lb}} \times \frac{31 \text{ lb CO}}{\text{ton}} = \frac{0.22454 \text{ lb CO}}{\text{hr}}$$

$$\frac{0.22454 \text{ lb CO}}{\text{hr}} \times \frac{1 \text{ lb-mol}}{28.01 \text{ lb CO}} \times \frac{386.5 \text{ scf}}{1 \text{ lb-mol}} \times \frac{1 \text{ min}}{30 \text{ scf}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times 1.E+06 = 1,721.29 \text{ ppmv CO}$$

0.327825 TRUE

Conversions:

24 hr/day

365 day/yr

2,000 lb/ton

386.5 scf/lb-mol

28.01 lb CO/lb-mol

1E+06 unit/million units

EPA: oxidizers\_calc\_sheet\_finalversion\_1-16-2018.xlsm

## **Appendix B – Cost Analysis Workbooks and the Memorandum Reference Documents**

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The cost analysis workbooks for the autoclaves, airport generators, carbon regeneration kiln, hot cure tanks, EW cells, mercury retort, diesel fuel tanks, and incinerators; and the reference documents for this memorandum are available for download via the following link:

<https://ftps.airsci.com/?ShareToken=DEF119B5A5C5FD9D495BB9519A779EC58939236C>