GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

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MEMORANDUM

January 6, 2020

To: James Boylan
Thru: Byeong-Uk Kim
From: Henian Zhang
Subject: **Modeling Analysis for Ethylene Oxide - UPDATE**
Sterilization Services of Georgia, Atlanta, Fulton County, GA

On December 20, 2019, Sterilization Services of Georgia submitted updated model input parameters (location, height, diameter, and exit velocity for the dry bed reactor stack) to the Georgia Environmental Protection Division. The updated stack parameters were reviewed and deemed appropriate. This memorandum contains updates to the modeling memorandum dated December 19, 2019 ***(All changes made to the December 19 memorandum are italicized and bolded)***.

GENERAL INFORMATION

Air dispersion modeling of ethylene oxide was conducted by the Georgia Environmental Protection Division (GA EPD) to assess the impacts of ethylene oxide emissions from sources at Sterilization Services of Georgia (hereafter SSG) on ambient air surrounding the facility. Although this modeling is not required for issuance of an air quality permit, GA EPD followed the procedures described in GA EPD's Guideline for Ambient Impact Assessment of Toxic Air Pollutant Emissions[1] (hereafter "Georgia Air Toxics Guideline").

Computer models are used to predict the concentrations of toxic air pollutants (TAPs) being analyzed using facility information provided by the source and other information developed by GA EPD staff. The modeling results are compared to the 15-min, 24-hour, and annual Acceptable Ambient Concentrations (AACs). GA EPD's 15-min and 24-hour AACs are derived from Occupational Safety and Health Administration (OSHA) permissible exposure limits. GA EPD's annual AACs are derived from U.S. EPA's risk values which are found in EPA's Integrated Risk Information System (IRIS) database. Appendix B contains detailed calculations for the 15-min, 24-hour, and annual ethylene oxide AACs.

GA EPD uses AACs as a screening tool to ensure that public health is protected. No further evaluation is needed if the modeled concentrations are below the corresponding AACs. If the modeled concentration is above the AAC, GA EPD requires the company to consider a reduction in pollutant emission rates, additional controls, and/or an increase in stack heights, followed by a site-specific risk assessment.

After performing a site-specific risk assessment, if it is infeasible for the applicant to comply with the AAC, the Director at his/her discretion may approve control technology which reflects the maximum degree of reduction in emissions of hazardous air pollutants that the Director determines is achievable by the source, provided that such control technology is no less effective than the level of emission control which is achieved in practice by the best controlled similar source.

[1] https://epd.georgia.gov/air-protection-branch-technical-guidance-0/toxic-impact-assessment-guideline

This memo discusses modeling results and the input data used to perform the ethylene oxide dispersion modeling. Emissions for the current scenario and a proposed scenario that includes additional controls were modeled. The current scenario models the impact of SSG's emissions prior to installation of the back vent controls. The proposed scenario models the impact of SSG's emissions after the back vent controls are installed. The back vent controls are required to be installed and operational on or before December 31, 2019 by the amended permit that was issued on November 7, 2019. With the current scenario, the modeled maximum ground-level concentration (MGLC) for the 15-min averaging period was below its corresponding AAC. However, the MGLC for the 24-hour averaging period and the modeled annual averaged ground-level concentrations across the 5-year period (AAGLCs) at the three closest residential areas exceeded their corresponding AACs. With the proposed scenario, the MGLCs for the 15-min and 24-hour averaging periods were below their corresponding AACs. However, the modeled AAGLC at one of the three closest residential areas exceeded the annual AAC. The results are summarized in the following sections of this memorandum.

INPUT DATA

1. **Meteorological Data** – Hourly meteorological data (2014 to 2018)[2] were generated by GA EPD. Surface measurements were obtained from the Hartsfield-Jackson Atlanta International Airport, Atlanta, GA. Upper air observations were obtained from the Atlanta Regional Airport – Falcon Field, Peachtree City, GA. These measurements were processed using the AERSURFACE (v13016), AERMINUTE (v15272), and AERMET (v18081) with the adjusted surface friction velocity option (ADJ_U*).

2. **Source Data** – Emission release parameters and emission rates for the current and proposed scenarios were provided by SSG and reviewed by the GA EPD Stationary Source Permitting Program (see Tables A1 and A2 of Appendix A for details). In the proposed scenario, the new dry bed outlet stack is expected to be located at (***723866*** E, ***3734447*** N) with a diameter of ***0.508 m, height of 20.32 meters***, exit temperature of 325 K, and exit velocity of ***13.97 m/s, per email communication with SSG on December 20, 2019***.

3. **Receptor Locations** – Discrete receptors with 50-meter intervals were placed along the property line. For the proposed scenario, receptors extend outwards from the property line at 100-meter intervals on a Cartesian grid to approximately 3 km and at 250-meter intervals to approximately 6 km. This domain (approximately 12 km by 12 km) is sufficient to capture the maximum impact from the proposed scenario. For the current scenario, additional receptors were added to the proposed scenario domain at 1500-meter intervals from approximately 6 km to approximately 16 km. This domain (approximately 33 km by 33 km) is sufficient to capture all concentrations above 0.00033 $\mu g/m^3$. Additional receptors were placed at the three closest residential areas. All receptor locations are represented in the Universal Transverse Mercator (UTM) projections, Zone 16, North American Datum 1983.

4. **Terrain Elevation** – Topography was found to be generally flat in the site vicinity. Terrain data from the USGS 1-sec National Elevation Dataset (NED) were extracted to obtain the elevations of all sources, buildings, and receptors by the AERMAP terrain processor (v18081).

5. **Building Downwash** – The potential effect for building downwash was evaluated via the "Good Engineering Practice (GEP)" stack height analysis and was based on the building parameters submitted by SSG (Table A3 in Appendix A) using the BPIPPRM program (v04274). The BPIPPRM model

[2] https://epd.georgia.gov/air-protection-branch-technical-guidance-0/air-quality-modeling/georgia-aermet-meteorological-data

was used to derive building dimensions for the downwash assessment and the assessment of cavity-region concentrations.

AIR TOXICS ASSESSMENT

The impacts of facility-wide ethylene oxide emissions were evaluated according to the Georgia Air Toxics Guideline. The 15-min, 24-hour, and annual AACs were reviewed based on OSHA Permissible Exposure Limit (PEL), OSHA Total Weight Average (TWA) PEL, and U.S. EPA IRIS Risk Based Air Concentration (RBAC) according to the Georgia Air Toxics Guideline. For this assessment, GA EPD used the annual AAC derived according to the Georgia Air Toxics Guideline (see Appendix B for details). The EPA's 2014 National Air Toxic Assessment (NATA) used a higher annual AAC value (see Appendix C for details). The modeled 1-hour, 24-hour, and annual ground-level concentrations were calculated using the AERMOD dispersion model (v19191).

Table 1 summarizes the MGLCs and the AAC levels for the two scenarios. The 15-min MGLC is based on the 1-hour MGLC multiplied by a factor of 1.32. The 15-min MGLCs were below the corresponding AAC for both scenarios. The 24-hour MGLC exceeded the 24-hour AAC for the current scenario but did not exceed the 24-hour AAC for the proposed scenario. The annual MGLCs exceeded the corresponding AAC with both scenarios. Figure 1 shows the spatial distribution of the AAGLCs for the current scenario. Figure 2 shows a close-up of Figure 1 with the closest three residential areas labeled (R1, R2, and R3). R1, R2, and R3 represent the closest residential home within a group of homes or subdivisions. Figure 3 shows the spatial distribution of the AAGLCs for the proposed scenario with the closest three residential areas labeled. Table 2 contains the AAGLCs for the current and proposed scenarios at the three closest residential areas (R1, R2, and R3). For the current scenario, R1, R2, and R3 are all above the annual AAC. For the proposed scenario, only R1 is above the annual AAC.

Table 1. Modeled MGLCs for the Current and Proposed Scenarios and their Respective AACs.

Averaging Period	MGLC (μg/m^3) Current Scenario	MGLC (μg/m^3) Proposed Scenario	AAC (μg/m^3)
Annual	0.59	***0.0094***	0.00033
24-hour	3.54	***0.069***	1.43
15-min	12.25	***0.24***	900

Table 2. Risk Analysis for Residential Areas with Modeled AAGLCs for the Current and Proposed Scenarios.

Residential Areas	Receptor UTM Zone:16		Modeled AAGLC* (μg/m^3) Current Scenario	Modeled AAGLC* (μg/m^3) Proposed Scenario	Averaging Period	AAC (μg/m^3)	Ratio of AAGLC (μg/m^3) to AAC (μg/m^3) Current Scenario	Ratio of AAGLC (μg/m^3) to AAC (μg/m^3) Proposed Scenario
	Easting (meter)	Northing (meter)						
R1	724,111.95	3,734,192.72	0.06645	***0.0014***	Annual	0.00033	201.4	***4.2***
R2	723,267.63	3,732,490.42	0.00094	0.00002			2.8	0.06
R3	722,627.75	3,734,805.43	0.00732	***0.00016***			22.2	***0.5***

*AAGLC is the annual averaged ground-level concentration across the 5-year period.

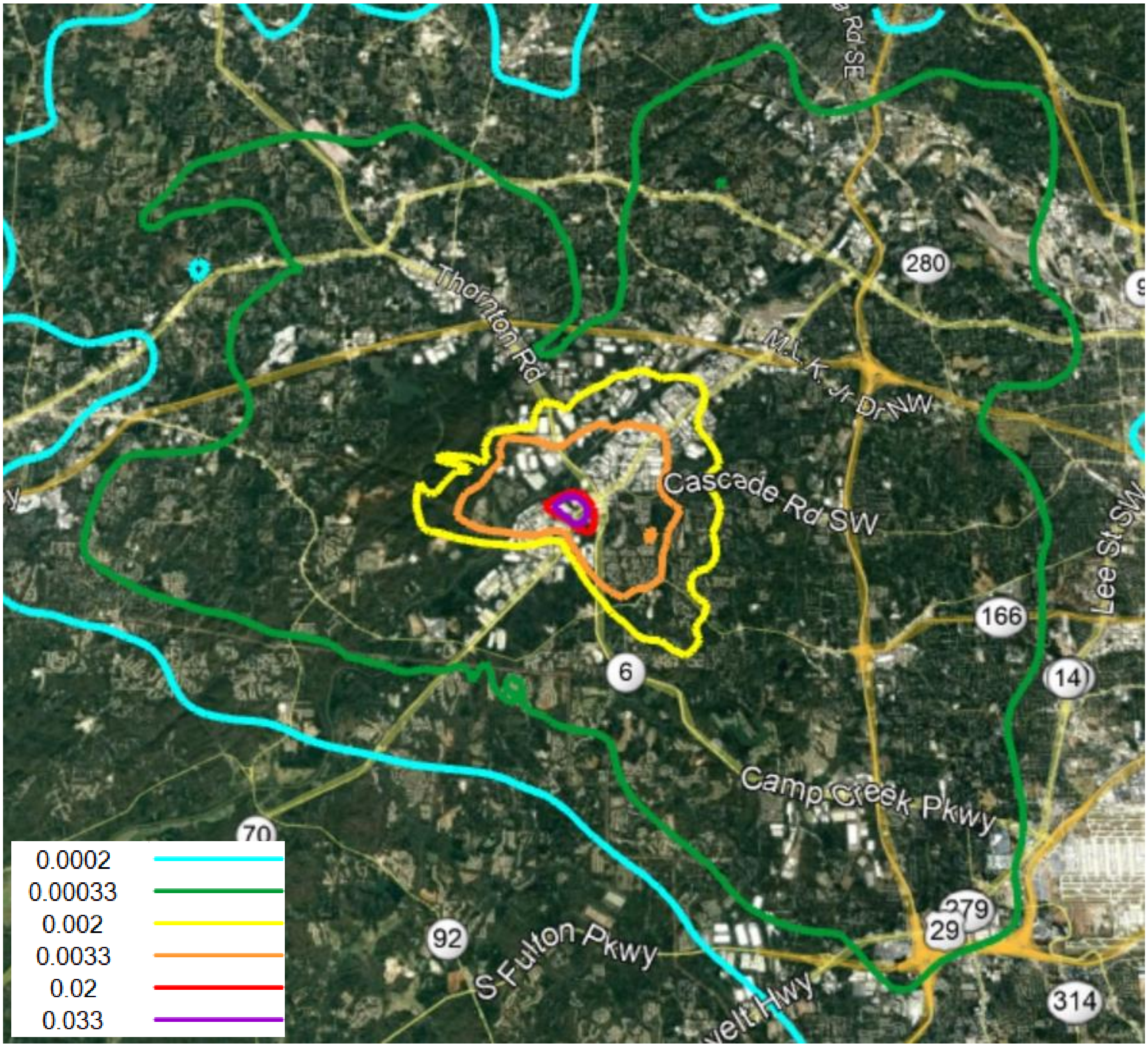

Figure 1. Contours of modeled annual averaged ground-level concentrations across the 5-year period (in $\mu g/m^3$) for the current scenario overlaid on a Google Earth map.

Figure 2. A close-up of Figure 1 with the closest residential areas labeled (R1, R2, and R3).

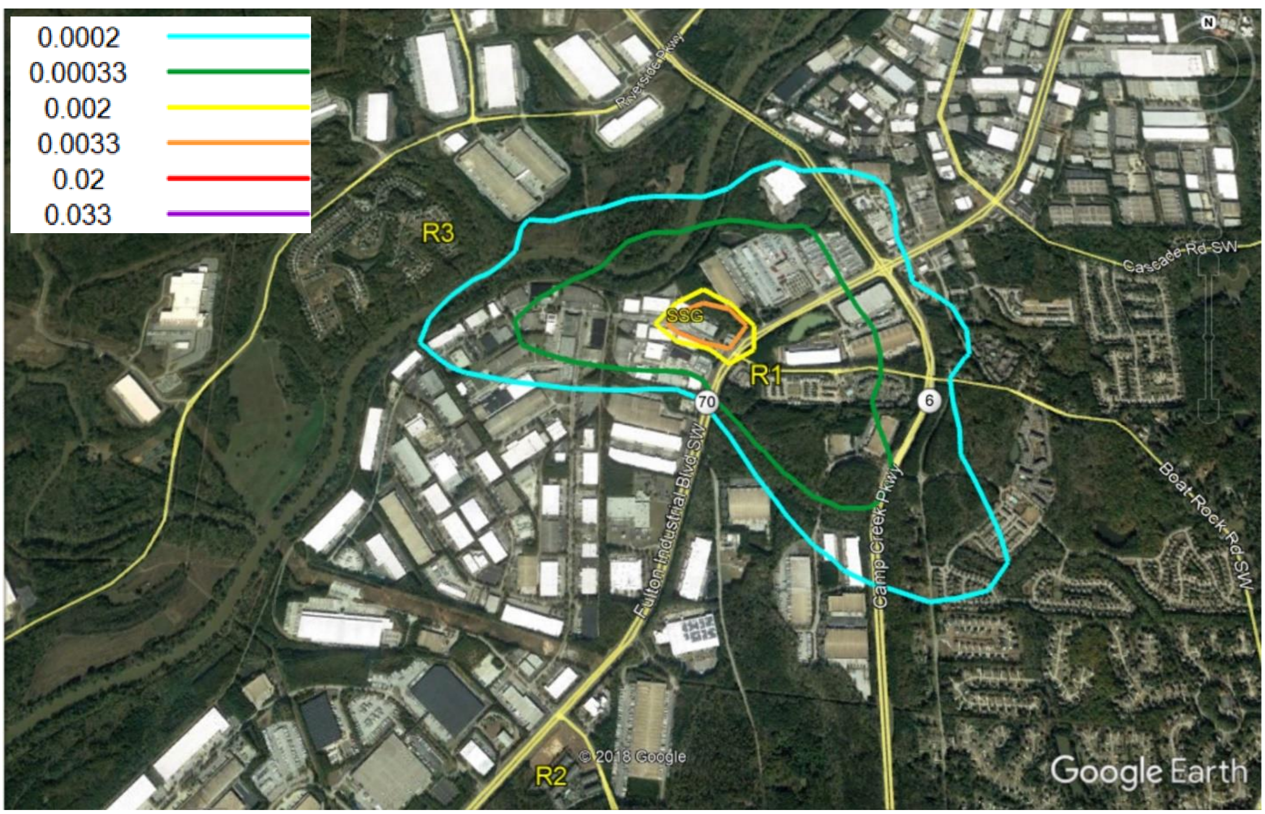

Figure 3. Contours of modeled annual averaged ground-level concentrations across the 5-year period (in μg/m^3) for the proposed scenario overlaid on a Google Earth map with the closest residential areas labeled (R1, R2, and R3).

CONCLUSIONS

The dispersion modeling analyses for ethylene oxide show exceedances of the annual AACs with the current and proposed scenarios. Site-specific risk assessments show that the modeled annual average ground-level concentrations across the 5-year period are above the annual AAC at the three closest residential areas (2.8 – 201.4 times) with the current scenario and above the annual AAC at one residential area ***(4.2 times)*** with the proposed scenario. For the current scenario, the modeled 15-min maximum ground-level concentration did not exceed its respective AAC, but the modeled 24-hour maximum ground-level concentration did exceed its respective AAC. For the proposed scenario, the modeled 15-min and 24-hour maximum ground-level concentrations did not exceed their respective AACs.

Appendix A

Emissions and Model Input Parameters

Table A1. Emission Rates

Current Scenario (Total Emission 1339.5 lbs/yr)

Chamber 1 Use average lb/hr	5.752	EO to Vacuum Pumps	95%	Scrubber Inlet average lb/hr	14.379
Chamber 2 Use average lb/hr	3.632	EO to Aeration	4%	Scubber Efficiency	99.99%
Chamber 3 Use average lb/hr	5.752	EO to Back Vents	1%	Oxidizer Inlet average lb/hr	0.605
				Oxidizer Efficiency	99.98%

Emission Point	lb/hr
Stack #1 EP1	0.0575
Stack #2 EP2	0.0363
Stack #3 EP3	0.0575
Stack #4 EP4	0.00144
Stack #5 EP5	0.000121

Proposed Scenario (Total Emission 26.9 lbs/yr)

Chamber 1 Use average lb/hr	5.752	EO to Vacuum Pumps	95%	Scrubber Inlet average lb/hr	14.379
Chamber 2 Use average lb/hr	3.632	EO to Aeration	4%	Scubber Efficiency	99.99%
Chamber 3 Use average lb/hr	5.752	EO to Back Vents	1%	Oxidizer Inlet average lb/hr	0.605
				Oxidizer Efficiency	99.98%
				Dry Bed System Inlet average lb/hr	0.151
				Dry Bed Efficiency	99.0%

Emission Point	lb/hr
Stack #1 EP1	0.00151
Stack #4 EP4	0.00144
Stack #5 EP5	0.000121

Table A2. Stack Parameters

Oxidizer Emission Points A1:K29Outlet Stack

	Datum Coordinates (SE Corner of Facility)	Longitude: 84° 35' 02"	Latitude: 33° 43' 33"

Source ID	Emission Type	Description	X (m) (from datum)	Y (m) (from datum)	Stack Base Elevation (m)	Stack Height (m)	Temperature (K)	Exit Velocity (m/s)	Diameter (m)
EP1	Point	Chamber 1 Back Vent Stack	-23.9	54.7	234.7	22.86	322.039	11.843	0.39
EP2	Point	Chamber 2 Back Vent Stack	-22.6	57.1	234.7	22.86	322.039	11.843	0.39
EP3	Point	Chamber 3 Back Vent Stack	-23.5	55.5	234.7	22.86	322.039	11.843	0.39
EP4	Point	Scrubber 1	-23	56.3	234.7	22.86	294.261	43.465	0.076
EP5	Point	Oxidizer Outlet Stack	-14.6	78.7	234.7	13.716	388.706	9.521	0.762

Building Description		Refereance Point (SW Corner)					
(All are rectangluar sections)	Base Elevation (m)	X (m) (from datum)	Y (m) (from datum)	X - Length (m)	Y - Length (m)	Angle of Rotation (deg)	Height (m)
Appendage 1	234.7	-20.2	67.2	10.1	16.4	-28.5	6.25
Appendage 2	234.7	-11.3	62.3	8.4	11.9	-28.5	6.25
Appendage 3	234.7	1.8	55.2	6.1	16.4	-28.5	6.25
Main Building	234.7	-108.5	58.9	123.4	49.4	-28.5	7.32

Table A3. Locations of Buildings, Stacks, and Fence Line

The following are spatial definitions of buildings, stacks, and the fence line. All locations are represented in the UTM projections, Zone 16.

Main Building

	Easting	Northing
SW	723757.5	3734441.8
NW	723781.8	3734484.8
NE	723889.3	3734424.0
SE	723865.0	3734381.0

Chamber 1 Room Appendage

SW	723867.2	3734436.5
NW	723874.6	3734449.6
NE	723878.9	3734447.1
SE	723871.5	3734434.1

Scrubber Room Appendage

SW	723851.8	3734445.2
NW	723857.5	3734455.2
NE	723864.7	3734451.1
SE	723859.1	3734441.1

Chamber 2 and Chamber 3 Room Appendage

SW	723844.2	3734449.6
NW	723852.0	3734463.4
NE	723859.6	3734459.1
SE	723851.8	3734445.2

Chamber 1 Back Vent Stack

	723840.0	3734434.7

Chamber 3 Back Vent Stack

	723840.4	3734435.4

Scrubber Stack

	723840.8	3734436.1

Chamber 1 Back Vent Stack

	723841.2	3734436.8

Oxidizer Stack

	723849.5	3734460.5

Lot (Fence) Line

SW	723741.8	3734432.8
NW	723788.4	3734515.0
NE	723908.3	3734442.3
SE	723864.0	3734364.0

Appendix B

GA EPD Calculation of the 15-min, 24-hour, and Annual AACs
for Ethylene Oxide

GA EPD Calculation of the 15-min, 24-hour, and Annual AACs for Ethylene Oxide

According to the GA EPD's *Guideline for Ambient Impact Assessment of Toxic Air Pollutant Emissions*, the 15-min, 24-hour, and annual AACs for ethylene oxide are calculated as following:

15-min AAC

The OSHA 15-min permissible exposure limit (PEL) for ethylene oxide is 5 ppm. To convert the PEL from ppm to mg/m^3, the following conversion formula from the guidance is used:

$$(5 \text{ ppm} \times 44.05 \text{ g/mol}) / (24.45 \text{ L/mol}) = 9 \text{ mg/m}^3$$

where, 44.05 is the molecular weight for ethylene oxide and 24.45 is the molar volume at $25^{o}C$ and 760 mmHg. After applying a safety factor of 10 for acute sensory irritants, the 15-min AAC is calculated as:

$$\text{15-min AAC} = (9 \text{ mg/m}^3 \times 1{,}000 \text{ µg/mg}) / 10 \text{ (safety factor)}$$

15-min AAC = 900 $\mu g/m^3$

24-hour AAC

The OSHA 8-hour Time Weighted Average (TWA) PEL for ethylene oxide is 1 ppm. To convert the TWA PEL from ppm to mg/m^3, the following conversion formula from the guidance is used:

$$(1 \text{ ppm} \times 44.05 \text{ g/mol}) / (24.45 \text{ L/mol}) = 1.8 \text{ mg/m}^3$$

where, 44.05 is the molecular weight for ethylene oxide and 24.45 is the molar volume at $25^{o}C$ and 760 mmHg. After converting the 8-hour average weekly exposure to a 24-hour average weekly exposure and applying a safety factor of 300 for known human carcinogens, the 24-hour AAC is calculated as:

$$\text{24-hour AAC} = \frac{1.8 \text{ mg/m}^3 \times 1{,}000 \text{ µg/mg} \times (8 \text{ hours/day} \times 5 \text{ days/week})}{300 \text{ (safety factor)} \times (24 \text{ hours/day} \times 7 \text{ days/week})}$$

24-hour AAC = 1.43 $\mu g/m^3$

Annual AAC

In the EPA Integrated Risk Information System (IRIS)[3], the Inhalation Unit Risk (IUR) for ethylene oxide is 3×10^{-3} per $\mu g/m^3$. Since ethylene oxide is carcinogenic to humans, it belongs to Group A[4] with a cancer risk of 1/1,000,000. Therefore, the annual AAC is calculated as:

$$\text{Annual AAC} = \text{Cancer Risk / IUR} = (1/1{,}000{,}000)/(0.003/\mu g/m^3)$$

Annual AAC = 0.00033 $\mu g/m^3$

[3] https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/1025_summary.pdf

[4] https://www.epa.gov/fera/risk-assessment-carcinogenic-effects

Appendix C

EPA Calculation of the Annual AAC
for Ethylene Oxide

EPA Calculation of the Annual AAC for Ethylene Oxide

According to EPA's IRIS, inhalation unit risk (IUR) for ethylene oxide (EtO) is 3×10^{-3} per µg/m^3 (as discussed in Appendix B). However, because of the elevated risk due to the mutagenic mode of action through early-life exposures, EPA multiplied the IUR by 1.6:

Modified IUR for EtO = 3×10^{-3} per µg/m^3 × 1.6 = 0.005/µg/m^3

EPA's NATA used (100/1,000,000) individual risk for the purpose of determining "acceptable risk" (AR) in their national assessment.

AR Exposure Concentration = Cancer Risk / IUR = (100/1,000,000)/(0.005/µg/m^3) **= 0.02 µg/m^3**