New Source Review Application
Supporting Information Report
Sunnyside RNG LLC
Proposed Renewable Natural Gas Facility
Yakima County, Washington

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Prepared for

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LIST OF ABBREVIATIONS AND ACRONYMS

AC ..... activated carbon
AERMAP ..... AMS/EPA regulatory model terrain pre-processor
AERMET ..... AERMOD meteorological pre-processor
AERMOD ..... AMS/EPA regulatory model
AMS ..... American Meteorological Society
ASIL ..... acceptable source impact level
BACT ..... best available control technology
BPIP PRIME ..... Building Profile Input Program-Plume Rise Model Enhancements
CAS ..... Chemical Abstracts Service
cfm ..... cubic feet per minute
CFR ..... Code of Federal Regulations
CO ..... carbon monoxide
CO_2 ..... carbon dioxide
CO_2e ..... equivalent CO_2 emissions
CrVI ..... hexavalent chromium
DEEP ..... diesel engine exhaust particulate matter
Ecology ..... Washington State Department of Ecology
EPA ..... US Environmental Protection Agency
GEP ..... good engineering practice
GHG ..... greenhouse gas
H_2S ..... hydrogen sulfide
HAP ..... hazardous air pollutant
HC ..... hydrocarbon
hr ..... hour
IDEQ ..... Idaho Department of Environmental Quality
km ..... kilometer
Landau ..... Landau Associates, Inc.
$\mu g/m^3$ ..... microgram per cubic meter
m ..... meter
m/s ..... meters per second
MACT ..... maximum achievable control technology
MMBtu ..... million British thermal units
NAAQS ..... National Ambient Air Quality Standards
NED ..... National Elevation Data
NESHAP ..... National Emission Standards for Hazardous Air Pollutants
NO_2 ..... nitrogen dioxide
NSR ..... New Source Review

LIST OF ABBREVIATIONS AND ACRONYMS (CONTINUED)

NO_X ..... nitrogen oxides
NSPS ..... New Source Performance Standards
NWS ..... National Weather Service
O_2 ..... oxygen
PM ..... particulate matter
$PM_{2.5}$ ..... PM with an aerodynamic diameter less than or equal to 2.5 microns
PM_{10} ..... PM with an aerodynamic diameter less than or equal to 10 microns
ppm ..... parts per million
ppmvd ..... parts per million by volume dry
RCW ..... Revised Code of Washington
RICE ..... reciprocating internal combustion engine
RNG ..... renewable natural gas
SIL ..... significant impact level
SO_2 ..... sulfur dioxide
SQER ..... small-quantity emission rate
SR ..... State Route
TAP ..... toxic air pollutant
tBACT ..... BACT for toxic air pollutants
tpy ..... tons per year
VOC ..... volatile organic compound
WAAQS ..... Washington Ambient Air Quality Standards
WAC ..... Washington Administrative Code
YRCAA ..... Yakima Regional Clean Air Agency

1.0 SUMMARY

Sunnyside RNG LLC is proposing to build a new renewable natural gas (RNG) facility near Sunnyside, Washington (Figure 1). Landau Associates, Inc. (Landau) prepared this document to support the submittal of a New Source Review (NSR) application for the new emission units, under air quality regulations promulgated by the Yakima Regional Clean Air Agency (YRCAA) and the Washington State Department of Ecology (Ecology). The Sunnyside RNG facility will be developed on approximately 50 acres located approximately 2 miles south of Sunnyside, Washington along the west side of State Route (SR) 241.

The RNG facility will produce between 800,000 and 950,000 million British thermal units (MMBtu) of RNG per year through anaerobic digestion of feedstocks delivered from several dairies located near the facility. The facility will provide a highly effective nutrient management system for nearby dairies and the RNG produced will offset more than 155,000 metric tons of carbon dioxide equivalent per year. Five anaerobic digester trains will convert feedstock into biogas, the biogas will be upgraded into RNG, and the RNG will be compressed and injected into the nearby Williams natural gas pipeline.

The emission units evaluated for this NSR application consist of the following:

- Four natural gas-fired boilers, two with an individual heat input capacity of 10 MMBtu per hour (MMBtu/hr) and two with a heat capacity of 2.0 MMBtu/hr
- One biogas upgrader with a Paques THIOPAQ® (Thiopaq) scrubbing system followed by granulated activated carbon (AC) beds
- One Tier 2-certified diesel-fired emergency generator set
- One enclosed flare, for when the biogas upgrader system is not operational
- One cellulose grinder with a dust collection system
- Fugitive emissions from roadways and the processed digestate storage.

A site plan of the proposed facility is provided on Figure 2.

This NSR application supporting information report provides information about the proposed RNG facility necessary for YRCAA to review and determine whether the proposed project satisfies NSR requirements.

The proposed RNG facility will comply with all applicable federal and state emission standards and each emission unit will employ best available control technology (BACT) for criteria pollutants and toxic air pollutants (tBACT). Potential emissions from each proposed emission unit were calculated using the findings from the BACT/tBACT analysis, vendor-provided emissions data, manufacturer guarantees, and emission factors developed by the US Environmental Protection Agency (EPA) and California's air toxics program (VCAPCD 2001).

Air dispersion modeling was conducted for criteria air pollutants and toxic air pollutants (TAPs.) The results of modeling demonstrate that ambient criteria pollutant concentrations attributable to operations at the RNG facility will not cause or contribute to a violation of the National Ambient Air Quality Standards (NAAQS). Additionally, the modeling results demonstrate that ambient TAP concentrations attributable to operations at the RNG facility will be less than applicable Washington acceptable source impact levels (ASILs).

2.0 INTRODUCTION

Landau prepared this NSR application supporting information report on behalf of Sunnyside RNG to request that YRCAA issue an Order of Approval that will allow construction and operation of an RNG facility under air quality regulations promulgated by YRCAA and Ecology. The RNG facility will be located off of SR 241 near Sunnyside, Washington, on Yakima County Parcel Nos. 22090141404, 22090114007, and the eastern half of 22090113001. The RNG facility will be located in an area designated as in attainment or unclassifiable for all NAAQS.

This NSR application supporting information report provides YRCAA with a project description, a summary of potential emissions from each emission unit, a regulatory analysis, and an air quality impact analysis. A completed YRCAA NSR application form is provided in Appendix A.

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3.0 PROJECT DESCRIPTION

3.1 Facility Description

The RNG facility location is shown on Figure 1, and a site plan showing the locations of the facility emission units is provided on Figure 2. A simplified process flow diagram of facility equipment and operations is provided on Figure 3.

3.1.1 Feedstock Delivery and Handling

Facility feedstocks will include dairy manure slurry and cellulosic material. Incoming manure will be received at one of five "reception pits" and then pumped to five mix tanks. Each mix tank will feed a single digester line composed of three primary digesters operated in parallel. Bales of cellulosic material will be delivered by truck and stored in the southwestern portion of the site. The size of the cellulosic material will be reduced using an electric grinder. Fugitive dust generated by the cellulose grinding process will be captured using an enclosure, dust pick-ups, and a dust collection system controlled by a baghouse. The cellulosic material will be transferred in a fully enclosed closed conveyor to three of the five mix tanks, where the mix tanks will contain a combined feedstock of the manure slurry and the cellulosic material.

Sunnyside RNG plans to pave all onsite areas and roadways with expected truck traffic. An unpaved area located in the northern portion of the property will have traffic only from employee and truck driver's personal vehicles.

3.1.2 Anaerobic Digesters

Five anaerobic digester trains, each of which will consist of three primary digester tanks in parallel, will be located at the RNG facility. Each digester tank will include double-walled biogas storage membranes that capture, store, and desulfurize the generated biogas through a methanogenesis process (Rother 2016; accessed January 11, 2023). This process takes approximately 23 days to occur with the chosen feedstocks of manure slurry and agricultural residue. Each digestor tank will have pressure relief valves that will operate in emergency situations when the pressure may reach an unsafe level in the digester tank. The collected biogas will be transported by pipeline to the biogas upgrading equipment. The final digestate will be pumped to one digestate buffer tank before it is separated into fiber (solid) and thin (water) fractions by primary solids separation equipment. The fiber fraction will be stored under a covered area for up to 3 days before being loaded into trucks and shipped off site, while the thin fraction will be stored in one onsite covered lagoon.

There will be one enclosed flare on site to safely combust any excess biogas generated while the biogas upgrading plant and/or pipeline injection system is not operational. Sunnyside RNG has conservatively estimated that this flare will be used no more than 176 hours per year, which is based on the assumption that the biogas upgrading and/or pipeline injection equipment will be unavailable no more than 2 percent of the time on an annual basis.

3.1.3 Biogas Upgrading

Biogas leaving the anaerobic digester storage tank membranes will be chilled and transferred to the biogas upgrading plant. An amine-based gas upgrading system will be used. The lean amine solution absorbs carbon dioxide (CO_2), hydrogen sulfide (H_2S) and other acidic gases from the raw biogas. Raw biogas flows first through the absorption column, where the lean amine solution washes the biogas and absorbs the CO_2, H_2S, and other acidic gases. Scrubbed methane (99.9 percent pure) exits the top of the absorption column. Following dehydration using a liquid desiccant to remove water vapor, the methane will be compressed and injected into the natural gas pipeline.

The rich amine solution flows out the bottom of the column, then enters the scrubbing tower where it is boiled to strip the CO_2 and H_2S gases from the solution. Scrubbed lean amine solution is then recycled to the absorption tower to repeat the cycle. Appendix B has the Dow monoethanolamine safety data sheet, which is used in the amine solution. Tailgas emitted from the amine-based upgrading system will go through a Thiopaq scrubber. The tailgas containing H_2S comes in contact with a wash solution to form an H_2S liquid, which enters a bioreactor where the sulfide oxidizes into elemental sulfur. The detailed chemical reactions are available in the vendor literature provided in Appendix B. The Thiopaq system is expected to remove 99 percent of H_2S from the biogas upgrading system tailgas. Granulated AC beds will used in series to further reduce the H_2S concentration in the Thiopaq scrubber tailgas before it is vented to the atmosphere.

3.1.4 Boilers and Emergency Generator

Sunnyside RNG plans to install two natural gas-fired steam boilers and two natural gas-fired hot water boilers to provide steam and hot water for the anaerobic digesters and biogas upgrading plant. The maximum heat input capacity of each steam boiler will be 10 MMBtu/hr and each hot water boiler will be 2 MMBtu/hr.

Back-up emergency power for the facility will be provided by a generator set powered by a 2,923 brake horsepower, diesel-fired, EPA Tier 2-certified engine. Total operation of the emergency generator will be limited to 160 hours per year, including 100 hours for readiness and maintenance checks.

4.0 AIR POLLUTANT EMISSION ESTIMATES

Criteria pollutant and TAP emissions were calculated for each emission unit proposed by Sunnyside RNG for the facility per the requirements of Washington Administrative Code (WAC) 173-400-103 and WAC 173-460-050. Worst-case short-term and annual maximum emission rates were calculated for criteria pollutants and TAPs based on peak hourly and annual operating scenarios.

The facility-wide criteria pollutant potentials-to-emit are summarized in Table 1. Facility-wide potential TAP emissions are summarized in Table 2 and compared with applicable small-quantity emission rates (SQERs) from WAC 173-460-150. Detailed emission calculations are provided in Appendix B.

Table 1: Potential Annual Emissions Summary

Pollutant	Boilers (tpy)	Biogas Upgrading System (tpy)	Emergency Generator (tpy)	Backup Flare (tpy)	Straw Grinding (tpy)	Roadway Fugitives (tpy)	Project Total (tpy)
NO_X	1.2	--	3.5	1.3	--	--	6.0
CO	2.3	--	0.80	6.0	--	--	9.1
PM_{10}	0.8	--	0.11	0.14	0.44	1.80	3.3
$PM_{2.5}$	0.8	--	0.11	0.14	0.44	0.31	1.8
SO_2	0.06	--	0.003	13.7	--	--	13.7
VOCs	0.57	--	0.06	0.02	--	--	0.65
Total HAPs	0.01	--	0.04	0.002	--	--	0.04
CO_2e	12,309	34,857	271	3,855	--	--	51,293

Abbreviations and Acronyms:

CO = carbon monoxide
CO_2e= equivalent CO_2 emissions
HAP = hazardous air pollutant
NO_X = nitrogen oxides
$PM_{2.5}$ = particulate matter with an aerodynamic diameter less than or equal to 2.5 microns
PM_{10} = particulate matter with an aerodynamic diameter less than or equal to 10 microns
SO_2 = sulfur dioxide
tpy = tons per year
VOCs = volatile organic compounds

Table 2: Project Emissions Compared to Small-Quantity Emission Rates

Pollutant	CAS No.	Averaging Period	Emission Rate	SQER (a)	Modeling Required?
			(pounds per averaging period)		
Nitrogen Dioxide	10102-44-0	1-hr	29	0.87	Yes
Carbon Monoxide	630-08-0	1-hr	36	43	--
Sulfur Dioxide	7446-09-05	1-hr	68	1.2	Yes
Diesel Engine Exhaust Particulate Matter	DPM	year	102	0.54	Yes
1,3-Butadiene	106-99-0	year	5.2	5.4	--
Acetaldehyde	75-07-0	year	20	60	--
Acrolein	107-02-8	24-hr	0.01	0.026	--
Ammonia	7664-41-7	24-hr	28.2	37	--
Arsenic	7440-38-2	year	0.038	0.049	--
Benzene	71-43-2	year	6	21	--
Cadmium	7440-43-9	year	0.036	0.039	--
Chlorobenzene	108-90-7	24-hr	1.5E-05	74	--
Chromium VI	18540-29-9	year	2.4E-03	0.00065	Yes
Copper	7440-50-8	1-hr	3.1E-04	0.19	--
Ethylbenzene	100-41-4	year	2.5	65	--
Formaldehyde	50-00-0	year	45	27	Yes
Hexane	110-54-3	24-hr	0.02	52	--
Hydrogen Chloride	7647-01-0	24-hr	0.014	0.67	--
Hydrogen Sulfide	7783-06-4	24-hr	19.03	0.15	Yes
Lead	7439-92-1	year	0.20	14	--
Manganese	7439-96-5	24-hr	2.3E-04	0.022	--
Mercury	7439-97-6	24-hr	1.5E-04	0.0022	--
Naphthalene	91-20-3	year	0.5	4.8	--
Nickel	7440-02-0	year	0.093	0.62	--
Propylene	115-07-1	24-hr	1.7	220	--
Selenium	7782-49-2	24-hr	1.6E-04	1.5	--
Toluene	108-88-3	24-hr	0.09	370	--
Xylene	1330-20-7	24-hr	0.064	16	--

Notes:

(a) Small-quantity emission rates from WAC 173-460-150.

CAS = Chemical Abstracts Service

4.1 Boiler Emissions

The four boilers will be two Cleaver Brooks CBEX-2W Low-NO_X steam boilers and two Cleaver Brooks CFC-E Low-NO_X hot water boilers, or equivalent. Manufacturer-provided exhaust concentrations that reflect the proposed BACT levels summarized in Section 5.2 were used to calculate NO_X and CO emissions. All remaining criteria pollutant emissions were calculated using emission factors from the EPA's AP-42, Volume I, Chapter 1.4 (External Natural Gas Combustion; EPA 1998). Greenhouse gas (GHG) emissions were calculated using natural gas combustion emission factors from the EPA's Mandatory GHG Reporting Rule (Title 40 Part 98, Subpart C of the Code of Federal Regulations [CFR]). TAP emissions were calculated using emission factors from California's air toxics program (AB 2588; VCAPCD 2001) for natural gas combustion units with a maximum heat input capacity less than 10 MMBtu/hr.

Hourly emissions were based on maximum-rated firing rates, daily emissions were based on continuous operation (i.e., 24 hours/day) at the maximum hourly rate, and annual emissions were based on continuous annual operation (i.e., 8,760 hours/year), also at the maximum hourly rate.

4.2 Biogas Upgrading Emissions

There are no combustion emissions associated with the biogas upgrading system. Heat for the biogas upgrading plant systems will be provided by boilers. Tailgas from the biogas upgrading plant will be treated by a Thiopaq bioscrubber system in series with AC beds to reduce H_2S concentrations in the vent stream to less than 9 part per million (ppm).

Hourly emissions were based on vendor design specifications for exhaust flow rate and H_2S concentration, daily emissions were based on continuous operation (i.e., 24 hours/day), and annual emissions were based on continuous annual operation (i.e., 8,760 hours/year.)

4.3 Emergency Generator Emissions

The EPA Tier 2-certified emergency generator will be a Kohler KD2000 powered by an EPA Tier 2-certified, diesel-fired engine, or equivalent. Manufacturer-reported not-to-exceed generator emission factors for CO, NO_X, and particulate matter (PM) were used to calculate emission rates. Additionally, the manufacturer-provided hydrocarbon (HC) emission factor was assumed to be equivalent to a total VOC emission factor.

Emissions of diesel engine exhaust particulate matter (DEEP) were conservatively assumed to be equal to the not-to-exceed PM emission factors provided by the manufacturer. The emission factors for PM_{10} and $PM_{2.5}$ include both "front-half" (i.e., filterable PM) and "back-half" (i.e., condensable PM) emissions. The filterable PM estimate is equal to the manufacturers' not-to-exceed emission factor for PM. An estimate of condensable PM is assumed to be equal to the not-to-exceed HC emission factor provided by the manufacturer. The SO_2 emission rate was calculated using an emission factor formula

from the EPA's AP-42, Volume I, Chapter 3.4 (Large Stationary Diesel and All Stationary Dual-Fuel Engines; EPA 1996), and the maximum sulfur content of the fuel, ultra-low sulfur diesel, which has a maximum sulfur content of 15 ppm by weight.

GHG emissions were calculated using diesel fuel combustion emission factors from the EPA's Mandatory GHG Reporting Rule (40 CFR 98, Subpart C), and TAP emissions were calculated using emission factors from California's air toxics program (AB 2588; VCAPCD 2001) for diesel-fired internal combustion engines.

Hourly emissions were based on the maximum engine power rating and maximum fuel usage rate with testing limited to no more than 30 minutes, daily emissions were based on one 30-minute test per day, and annual emissions were based on a maximum of 160 hours per year of non-emergency usage and emergency usage.

4.4 Flare Emissions

An enclosed flare will be used to safely combust excess biogas generated by the anaerobic digester lines when the biogas upgrading plant and/or the injection system is not operating. The peak hourly biogas production rate from all five lines combined is 2,700 cubic feet per minute (cfm). The generated biogas is expected to contain H_2S at a maximum concentration of 2,500 ppm, CO_2 at an average concentration of 42 percent, and have an average heat content of 600 Btu per cubic foot.

Flare SO_2 emissions were based on the assumption that all H_2S in the biogas would be oxidized to SO_2. NO_X and CO emissions from biogas flaring were calculated using emission factors from the EPA's AP-42, Volume I, Chapter 13.5 (Industrial Flares; EPA 2018). All remaining criteria pollutant emissions from biogas flaring were calculated using emission factors from the EPA's AP-42, Volume I, Chapter 1.4 (External Natural Gas Combustion; EPA 1998). GHG emissions were calculated using natural gas combustion emission factors from the EPA's Mandatory GHG Reporting Rule (40 CFR 98, Subpart C) and the assumed average CO_2 concentration in the biogas. TAP emissions were calculated using emission factors from California's air toxics program (AB 2588; VCAPCD 2001) for natural gas combustion sources with a maximum heat input capacity of between 10 and 100 MMBtu/hr. Flaring emission factors for petroleum refining were not used because they are not representative of biogas flaring.

Hourly emissions were based on flaring a maximum of 2,700 cfm of biogas in an hour, daily emissions were based on continuous flaring (i.e., 24 hours/day) at the maximum hourly rate, and annual emissions were based on flaring for 400 hours/year at the maximum hourly rate.

4.5 Cellulose Grinding Emissions

The size of cellulose material delivered to the facility will be reduced using an electric grinder within an enclosed structure. A fan will be used to keep the structure under negative pressure, and the

exhaust from the structure will be filtered through a dust collection system located outside of the structure. Dust collector exhaust emissions were calculated using the maximum daily cellulose processing rate (200 tons/day) and a representative PM emission factor from the EPA's AP-42, Volume I, Chapter 9.9.1 (Grain Elevators and Processes; EPA 2003) that reflects control by a baghouse. PM_{10} and $PM_{2.5}$ emissions were conservatively assumed to be equivalent to PM emissions. Annual emissions were based on continuous operation (i.e., 365 day/year). The baghouse was assumed to achieve 99.9 percent control efficiency at a minimum.

4.6 Roadway Emissions

Fugitive dust from paved roadways was calculated using site-specific truck traffic information (i.e., vehicle weight and vehicle miles traveled), assumed road surface silt content, and emission factors from the EPA's AP-42, Volume I, Chapters 13.2.1 (Paved Roads; EPA 2011). Sunnyside RNG will implement dust minimization techniques (e.g., trackout minimization and onsite vehicle speed limits) to reduce fugitive dust emissions from onsite roadways. An overall control efficiency of 70 percent was applied to account for the combined dust minimization techniques.

Fugitive dust from unpaved roads were calculated using the same site-specific traffic information and assuming for the same dust minimization techniques. Unpaved roadway emission factors are based on the EPA's AP-42 Volume 1, Chapter 13.2.2 (Unpaved Roads; EPA 2006) and a surface silt content of 48 percent was used due to the higher silt content found in Yakima soils(Kuhns et al. 2010).

4.7 Solid Digestate Storage Emissions

After digestate solids separation, the fiber fraction will be stored in a covered building for up to 3 days before being loaded into trucks and shipped off site. There is expected to be a small amount of fugitive ammonia emissions during storage that stems from the amount of nitrogen in the solids digestate and natural volatilization during the storage. An academic study seeking to measure the ammonia emissions from anaerobic digesting activities was used as a basis to estimate the fugitive ammonia emissions from the volatilization from the fiber storage (Bell et al. 2016).

The study provides an equation to estimate volatilized ammonia emissions based on a regression of variables including substrate temperature, air exchange, and NH4-N content. For Sunnyside RNG, the substrate temperature was conservatively assumed to be the high average of the hottest month at the site, which is 87.1 degrees Fahrenheit in July. The air exchange rate in the building was assumed to be 2 per hour, and the NH4-N content is 3.9 grams per kilogram based on an analysis of the site's specific incoming slurry and straw data provided in Appendix B. An ammonia volatilization rate of 484 milligrams per square meter per hour was calculated. Using the 1,100 square meter surface area of the solids pile, the total hourly emission rate for ammonia was calculated at 1.2 pounds per hour. Daily emissions were based on continuous storage (i.e., 24 hours/day) at the maximum hourly rate, and annual emissions were based on continuous storage (8,760 hours/year) at the maximum hourly rate.

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5.0 EMISSION STANDARD COMPLIANCE

5.1 Compliance with State and Federal Regulations

The RNG facility will comply with the following applicable air regulations, in accordance with the federal and state Clean Air Acts. These requirements are adopted by reference in YRCAA Regulation 1 and specified in:

- Chapter 70.94 Revised Code of Washington (RCW) (Washington Clean Air Act)
- Chapter 173-400 WAC (General Regulations for Air Pollution Sources)
- Chapter 173-460 WAC (Controls for New Sources of Toxic Air Pollutants; updated December 30, 2019)
- 40 CFR Part 60 (New Source Performance Standards)
- 40 CFR Part 63 (National Emission Standards for Hazardous Air Pollutants).

Specifically, the project includes sources of air contaminants and will follow applicable air contaminant regulations as listed in:

- RCW 70.94.152
- WAC 173-400-113
- WAC 173-460-040.

The area in which the project is located is in attainment, or unclassifiable, of all federal Clean Air Act criteria pollutants. Facilities that produce more than 100 tons per year of any criteria pollutant, 10 tons per year of individual hazardous air pollutant (HAP), or 25 tons per year of combined HAPs are considered major sources under the federal regulation 40 CFR Part 70 and the state regulation WAC 173-410 et seq. Potential-to-emit estimates provided in Section 4.0 demonstrate that the facility will emit:

- Less than 100 tons per year of any criteria pollutant (PM, CO, SO_2, VOCs, and nitrogen dioxide [NO_2])
- Less than 10 tons per year of any individual HAP
- Less than 25 tons per year of combined HAPs.

As a result, a Title V operating permit is not required. Likewise, a Prevention of Significant Deterioration NSR pre-construction permit is not required because emissions of all federally regulated NSR pollutants will be less than the major source threshold of 250 tons per year.

5.2 Best Available Control Technology

BACT/tBACT is required as part of NSR and is intended to minimize criteria and toxic air pollutant emissions. BACT is an emission limitation based on the maximum degree of reduction that can be feasibly achieved for each air pollutant emitted from any new or modified stationary source.

Washington guidance for BACT determinations indicates using either presumptive BACT or a "top-down" approach (Ecology 2021). As part of the pre-application meeting for the prior permit with YRCAA on March 9, 2022, Sunnyside RNG discussed presumptive BACT for the new emission units associated with the RNG facility. A summary of presumptive BACT for each emission unit is summarized in Table 3.

Table 3: Proposed BACT/tBACT for Project

Pollutant	Proposed BACT/tBACT
Boilers	
NO_X	9 ppmvd @ 3% O_2
CO	30 ppmvd @ 3% O_2
VOC/TAPs	Good Combustion Practices
Biogas Upgrading	
H_2S	1 ppmvd through operation of Thiopaq scrubber and activated carbon beds
Emergency Generator	
Criteria/TAPs	EPA Tier 2 Emission Certification, Good Combustion Practices, and Ultra-Low Sulfur Diesel
Backup Flare	
Criteria/TAPs	Enclosed flare and Good Combustion Practices
Straw Grinding	
$PM_{10}/PM_{2.5}$	Baghouse 99.9% control efficiency

Abbreviations and Acronyms:

O_2 = oxygen

ppmvd = parts per million by volume dry

5.3 New Source Performance Standards

New Source Performance Standards (NSPS) are nationally uniform standards that apply to specific categories of stationary sources constructed, modified, or reconstructed after the standard was proposed. NSPS are found in 40 CFR 60. NSPS usually represent a minimum level of control that is required for a new source.

The following NSPS were evaluated to assess applicability to the RNG facility emission units:

- **40 CFR Part 60 Subpart Dc (Small Industrial-Commercial-Institutional Steam-Generating Units)**

  NSPS Subpart Dc applies to each steam-generating unit that is constructed after June 9, 1989 and has a maximum design heat input capacity of between 10 and 100 MMBtu/hr. This

subpart does not apply to the proposed hot water boilers because the proposed boilers have maximum heat input capacity less than 10 MMBtu/hr.

This subpart does apply to the two steam boilers because the maximum heat input capacity will be equal to 10 MMBtu/hr. Sunnyside will be required to monitor and record natural gas usage in each of the two steam boilers.

- **40 CFR Part 60 Subpart Kb (Volatile Organic Liquid Storage Vessels)**

  NSPS Subpart Kb applies to each storage vessel with a capacity greater than 75 cubic meters that is used to store volatile organic liquids that is constructed after July 23, 1984. This subpart does not apply because the anaerobic digester tanks will not be used to store volatile organic liquids.

- **40 CFR Part 60 Subpart IIII (Stationary Compression Ignition Internal Combustion Engines)**

  NSPS Subpart IIII applies to owners and operators of stationary compression ignition engines that commence construction after July 11, 2005, and the engine is manufactured after April 1, 2006. The diesel generator will be subject to this subpart, and the RNG facility will operate the engine in a manner that satisfies the definition of "emergency engine" in NSPS Subpart IIII. Therefore, under NSPS Subpart IIII, the generator must be manufactured and certified to meet federal Tier 2 emission limits in 40 CFR Part 89. The RNG facility will install and operate a Tier 2-certified generator.

  The RNG facility will conduct all notifications, generator maintenance, recordkeeping, and reporting required by NSPS Subpart IIII.

5.4 National Emission Standards for Hazardous Air Pollutants

Prior to the 1990 Clean Air Act Amendments, National Emission Standards for Hazardous Air Pollutants (NESHAPs) were risk-based emission standards for eight HAPs. Under the provisions of Section 112 of the 1990 Clean Air Act Amendments, Congress required the EPA to regulate the emissions of 189 HAPs from all stationary and mobile sources. The EPA has promulgated regulations for specific industry categories that require controls tailored to the major sources of emissions and the HAPs of concern associated with that industry. The rules promulgated under Section 112 generally specify the maximum achievable control technology (MACT) that must be applied by a given industry category. Consequently, these rules are often called MACT standards.

There are two types of NESHAPs, one for "major" sources of HAP emissions and one for "area" sources of HAP emissions. Major sources are facilities that have the potential to emit more than 10 tons of a single HAP per year, or 25 tons per year of all HAPs combined. Area sources are facilities that are not major sources. The RNG facility will be an area source of HAP emissions.

The following NESHAPs were evaluated to determine their applicability to the RNG facility emission units:

- **40 CFR Part 63 Subpart ZZZZ (NESHAP for Reciprocating Internal Combustion Engines [RICEs])**

  NESHAP Subpart ZZZZ establishes emission limits for stationary RICEs located at major and area sources of HAP emissions. The proposed diesel emergency generator engine satisfies NESHAP Subpart ZZZZ requirements by meeting the requirements of NSPS Subpart IIII.[1] There are no additional requirements for the engines under this subpart.

- **40 CFR Part 63 Subpart JJJJJJ (NESHAP for Industrial, Commercial, and Institutional Boiler Area Sources)**

  NESHAP Subpart JJJJJJ establishes emission limits for boilers located at an area source of HAP emissions. This subpart is not applicable to the proposed boilers because gas-fired boilers are not regulated under this subpart.[2]

[1] 40 CFR 63.6590(c).

[2] 40 CFR 63.11195(e).

6.0 AMBIENT AIR QUALITY IMPACT ANALYSIS

This section presents the air dispersion modeling methodology and results, and provides an assessment of compliance with the NAAQS and Washington Ambient Air Quality Standards (WAAQS) for criteria pollutants, as well as comparisons to the Washington State screening thresholds for TAPs. Copies of the electronic modeling files prepared in support of the project will be provided to YRCAA via a file transfer site.

As discussed in the following subsections, the modeled ambient impacts expected from project emissions are either less than the significant impact levels (SILs) or less than the NAAQS and WAAQS, after summing with background concentrations. All model-predicted ambient TAP impacts are less than the acceptable source impact levels (ASILs).

6.1 Model Methodology and Assumptions

Air dispersion modeling was conducted in general accordance with the EPA's Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule (EPA 2005). The AERMOD[3] modeling system was used in accordance with the EPA's Revision to the Guideline on Air Quality Models (EPA 2005) to estimate ambient pollutant concentrations beyond the site property boundary.

Ambient air impacts were modeled for all criteria pollutants and TAPs for which compliance was not demonstrated via emissions threshold screening. The most recent version of AERMOD (Version v22112) was used at the time the modeling was completed. AERMOD requires input from several pre-processors, described below, for meteorological parameters, downwash parameters, and terrain heights. AERMOD uses data from pre-processor programs (i.e., meteorology and terrain) as well as emission estimates and physical exhaust release point characteristics to predict ambient concentrations attributable to the proposed project. The model calculates concentrations based on various averaging times (e.g., 1 hour, 24 hours, annual, etc.) for a defined network of receptors; these concentrations are used to assess compliance with regulations that use ambient concentrations as criteria.

The AERMOD model was used to estimate the short-term impacts (i.e., 24-hour average or less) of $PM_{2.5}$, PM_{10}, NO_2, SO_2, CO, and H_2S emissions, and long-term impacts (i.e., annual average) of $PM_{2.5}$, PM_{10}, NO_2, SO_2, DEEP, hexavalent chromium (CrVI), and formaldehyde.

6.1.1 Stack Parameters

A variety of emission units are proposed by RNG Sunnyside for the facility. The locations of emission units are shown on Figure 2. Table 4 summarizes the stack parameters associated with each emission unit including stack heights above grade in meters (m), exhaust temperatures in degrees Kelvin (K),

[3] American Meteorological Society (AMS)/US Environmental Protection Agency (EPA) Regulatory Model.

exit velocities in meters per second (m/s), stack diameters in meters, and the orientation of the exhaust when it exits the stack.

Table 4: Point Source Stack Parameters

Stack ID	Description	UTM Coordinates (a)		Stack Height (m)	Exhaust Temp. (K) (c)	Exhaust Velocity (m/s) (d)	Stack Diameter (m)	Release Orient. (e)
		Easting-X (m) (b)	Northing-Y (m)					
BLR1	Steam Boiler No. 1	730964.09	5131082.43	6.1	446	7.6	0.5	V
BLR2	Steam Boiler No. 2	730964.25	5131077.15	6.1	446	7.6	0.5	V
BLR4	HW Boiler No. 1	730957.48	5131082.31	6.1	344	8.7	0.2	V
BLR3	HW Boiler No. 2	730957.52	5131076.99	6.1	344	8.7	0.2	V
THIO	Thiopaq Bioscrubber	730980.71	5131067.69	12.8	311	12.5	0.3	V
EGEN	Emergency Generator	730982.39	5131099.18	10.7	773	37.1	0.5	V
FLARE	Enclosed Flare	731017.46	5131092.98	14.6	1073	8.1	3.8	V
BAGH1	Grinder Baghouse	730801.99	5130872.30	6.1	Ambient	21.2	0.6	V

Notes:
(a) Universal Transverse Mercator, Zone 10, North American Datum of 1983 (NAD83)
(b) meters
(c) Kelvin
(d) meters per second
(e) vertical uninterrupted (V).

Entrained dust emissions from trucks operated on paved and unpaved surfaces at the facility were represented in the modeling as volume sources using a methodology from the EPA's Haul Road Workgroup final report (EPA 2012). Two hundred fifty-five (255) volume sources representing paved roads with initial release heights of 3.0 m, initial sigma-z values of 2.37 m, and initial sigma-y values of 7.09 m were included in the modeling to represent the fugitive PM emissions associated with onsite paved areas. Fifty-one (51) volume sources representing unpaved roads with initial release heights of 3.0 m, initial sigma-z values of 2.37 m, and initial sigma-y values of 7.09 m were included in the modeling to represent the fugitive PM emissions associated with onsite unpaved areas.

6.1.2 Building Downwash

Building downwash occurs when the aerodynamic turbulence in the wake of buildings or structures causes exhaust from an elevated source (i.e., a stack) to mix with winds and be rapidly conveyed toward the ground, resulting in elevated ground-level pollutant concentrations. The software program Building Profile Input Program-Plume Rise Model Enhancements (BPIP PRIME) was used to determine whether exhaust from emission units would be affected by nearby building structures. In general, a stack is considered to be affected by a given structure if the height of the stack is less than the height defined by the EPA's Good Engineering Practice (GEP) stack height methodology.

GEP stack height is defined as the height of the nearby structure(s) measured from the ground-level elevation at the base of the stack plus 1.5 times the lesser dimension, height, or projected width of the nearby structure(s). All RNG Sunnyside exhaust stacks will be less than the calculated GEP heights, and, therefore, influenced by building downwash. To account for this potential building downwash, parameters calculated by BPIP PRIME were provided as inputs to AERMOD. A summary of buildings and structures is provided in Table 5. Figure 4 shows the facility site plan with the labeled buildings and stack locations.

Table 5: Building and Structure Information

Building/Structure Description	Length (feet)	Width (feet)	Height (feet)
Lab Storage	20	10	13
Digester Tanks (a)	--	100	59
Mix tanks (b)	--	76	45
Biogas Pretreatment	100	50	40
Amine Building	100	75	52
Gen Enclosure	20	8	17
Administration	50	50	16
Grindhouse	212	119	24
Maintenance Control Room	105	70	16
Fiber Storage	101	273	16
Boiler House	121	73	17

Notes:
(a) Digester tank diameter equal to 100 feet.
(b) Mix tank diameter equal to 76 feet.

6.1.3 Receptor Grid

To include the effects of terrain on calculated ambient concentrations, AERMOD requires information about the surrounding terrain. The AMS/EPA Regulatory Model Terrain pre-processor (AERMAP, version 18081), as implemented by Lakes Environmental software, was used to obtain the hill height scale and the base elevation for each receptor.

The receptor grid spacing increases with distance from the facility, as listed below:

- 12.5-m spacing along the ambient air boundary and from the property boundary to 150 m
- 25-m spacing from 150 m to 400 m
- 50-m spacing from 400 m to 900 m
- 100-m spacing from 900 m to 2,000 m
- 300-m spacing from 2,000 m to 4,500 m

- 600-m spacing from 4,500 m to 9,600 m.

AERMAP requires the use of topographic data to estimate surface elevations above mean sea level. Digital topographic data, in the form of National Elevation Data (NED) files, for the analysis region were obtained from the US Geological Survey national map downloader website (USGS; accessed December 2, 2022) and processed for use in AERMOD. The NED used for this project have a resolution of approximately 10 m (⅓ arc-second).

The implementation of AERMAP produces a receptor file (*.rec) that contains the calculated terrain elevations and hill height scales for each receptor. A separate *.rec file produced for each receptor spacing group was used as an input file provided to AERMOD.

6.1.4 Meteorology

The AERMOD meteorological pre-processor (AERMET; Version 22112) is the meteorological pre-processor model that calculates boundary-layer parameters for use in AERMOD. AERMET is used to process formatted meteorological data from observation stations and to generate two input files for the AERMOD model: the Surface File with hourly boundary-layer parameter estimates; and the Profile File with multi-level observations of wind speed, wind direction, temperature, and standard deviations of fluctuating wind components. The meteorological observation data processed by AERMET in support of this project are described below.

- National Weather Service (NWS) hourly surface observations from Yakima Air Terminal in Yakima, Washington located near the RNG Sunnyside site. Five years (i.e., January 1, 2017 through December 31, 2021) of hourly surface data were processed using AERMET. AERMINUTE was run to reduce the instance of "calms." A potential concern related to the use of meteorological data for dispersion modeling is the high incidence of "calms," or periods of time with wind speeds that are less than the wind speed sensor's level of detection. NWS and Federal Aviation Administration data coding defines a wind speed of less than 3 knots as "calm" and assigns a value of 0 knots. This results in an overestimation of the occurrence of calm conditions. Similarly, if the wind direction varies by more than 60 degrees during a 2-minute period and the wind speed is 6 knots or less, the wind direction is reported as "missing." AERMINUTE reprocesses Automated Surface Observing System 1-minute wind data at a lower threshold and calculates hourly average wind speed and directions to supplement the standard hourly data processed using AERMET.
- NWS twice-daily upper air soundings from Spokane, Washington. Five years (i.e., January 1, 2017 through December 31, 2021) of upper air data were processed using AERMET.
- Surface characteristics, specifically albedo, Bowen ratio, and surface roughness, are used by AERMET to calculate the parameters required by AERMOD. Albedo is a measure of the solar radiation reflected by earth into space. The Bowen ratio is an evaporation-related measurement defined as the ratio of sensible heat to latent heat. The surface roughness length is the theoretical height above ground where the wind speed becomes zero.

  AERSURFACE version 20060 and land-use data from the 2016 National Land Cover Database (USGS 1992) were used to calculate the albedo, Bowen ratio, and surface roughness in the

area surrounding the surface observation site. AERSURFACE calculates the fraction of each land-use type within each of 12 equal sectors (i.e., 30 degrees each) centered on the surface observation station. Default study radii of 1 kilometer (km) for surface roughness and 10 km for the Bowen ratio and albedo were used. Default month assignments were used for the four seasonal categories used by AERSURFACE, which are as follows: 1) mid-summer with lush vegetation; 2) autumn with unharvested cropland; 3) winter with continuous snow; and 4) transitional spring with partial green coverage or short annuals. The surface data were from an airport location.

Monthly precipitation data for Yakima were obtained from the Western Regional Climate Center database for each year of meteorological data used (i.e., January 1, 2017 through December 31, 2021). The monthly precipitation values from the 5 years of data used were compared with 30th percentile and 70th percentile precipitation values for the past 30 years to determine the conditions for each month based on "dry" (i.e., less than the 30th percentile), "average" (i.e., between the 30th and 70th percentiles), or "wet" (i.e., greater than the 70th percentile).

6.1.5 NO_X to NO_2 Conversion

Ambient NO_2 concentrations were calculated by AERMOD using the ARM2 option. The ARM2 option is based on applying an ambient ratio of NO_2/NO_X to a modeled NO_X concentration to estimate ambient NO_2 concentrations. The ARM2 parameters used for all proposed combustion sources were as follows:

- Default NO_2/NO_X upper ratio of 0.9
- Default NO_2/NO_X lower ratio of 0.5.

6.1.6 Background Concentration

This evaluation includes background concentrations contributed by existing regional and local background sources. Regional background concentrations were obtained from NW AIRQUEST through the Idaho Department of Environmental Quality website (IDEQ; accessed December 1, 2022). Regional and local background concentrations were added to the modeled project concentrations to estimate the projected cumulative concentrations for those pollutants and averaging periods with results above the SIL.

6.1.7 First-Tier Screening of Toxic Air Pollutant Impacts

A first-tier TAP assessment includes a comparison of expected maximum emission rates with the SQERs and, for TAPs with emission rates that exceed the SQERs, a comparison of predicted maximum ambient concentrations with the ASILs. Table 2 shows the facility-wide emission rates for each TAP expected to be released by the RNG Sunnyside facility and compares each emission rate with the corresponding SQER. An SQER is an emission rate threshold, below which YRCAA does not require an air quality impact assessment for the corresponding TAP. As shown in Table 2, maximum facility-wide emissions of NO_2, SO_2, DEEP, CrVI, formaldehyde, and hydrogen sulfide are expected to be greater than their corresponding SQERs, so an ambient impact analysis was completed for those TAPs.

6.2 Predicted Criteria Pollutant Ambient Concentrations

The results of the criteria pollutant SIL analysis are provided in Table 6. As shown in Table 6, the model-predicted annual SO_2 and short-term CO concentrations are less than the applicable SILs, and are therefore assumed to not have the potential to cause or contribute to an exceedance of an ambient standard. For all other criteria pollutants, averaged over the periods indicated in Table 6, a cumulative NAAQS analysis is required to assess compliance with the corresponding ambient standards.

Table 6: Results for Significant Impact Level Analysis

Pollutant	Averaging Period (a)	Maximum Modeled Concentration ($\mu g/m^3$)	Significant Impact Level ($\mu g/m^3$)	Cumulative NAAQS Analysis Required
$PM_{2.5}$ (b)	24-hour (g)	4.75	1.2	**Yes**
	Annual (g)	1.76	0.2	**Yes**
PM_{10} (c)	24-hour	40.17	5	**Yes**
NO_2 (d)	1-hour (g)	233.19	7.5	**Yes**
	Annual	1.80	1	**Yes**
SO_2 (e)	1-hour (g)	108.23	7.8	**Yes**
	3-hour	100.58	25	**Yes**
	24-hour	13.53	5	**Yes**
	Annual	0.10	1	No
CO (f)	1-hour	69.29	2,000	No
	8-hour	29.87	500	No

Notes:

(a) Unless otherwise stated, the modeled concentration is the maximum overall result predicted by the model.

(b) Particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers.

(c) Particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers.

(d) Nitrogen dioxide.

(e) Sulfur dioxide.

(f) Carbon monoxide.

(g) Maximum 5-year mean of the modeled concentrations at each receptor.

The results of the criteria pollutant cumulative impact analysis are provided in Table 7. The model-predicted ambient impacts plus background for all criteria pollutants and averaging periods are less than the NAAQS, which indicates that the proposed project does not have the potential to cause or contribute to an exceedance of an ambient standard.

Table 7: Results for Cumulative Analysis

Pollutant	Averaging Period	Modeled Design Concentration (µg/m³) (a)	Background Concentration (µg/m³)	Total Impact (µg/m³)	NAAQS (µg/m³)
$PM_{2.5}$ (b)	24-hour (f)	3.9	27.1	31.0	35
	Annual (g)	1.8	7.3	9.1	12
PM_{10} (c)	24-hour (h)	28.1	79.0	107	150
NO_2 (d)	1-hour (f)	134.5	26.7	161	188
	Annual	1.8	5.3	7.1	100
SO_2 (e)	1-hour (i)	101.7	4.7	106	196
	3-hour (j)	101	6.4	107	1,300
	24-hour (j)	13.5	2.1	16	365

Notes:

(a) Micrograms per cubic meter

(b) Particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers.

(c) Particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers.

(d) Nitrogen dioxide.

(e) Sulfur dioxide.

(f) Maximum of 5-year means of 8th-highest modeled concentrations for each year modeled.

(g) Maximum of 5-year means of maximum modeled concentrations for each year modeled.

(h) Maximum of 6th highest modeled concentrations for a 5-year period.

(i) Maximum of 5-year means of 4th-highest modeled concentrations for each year modeled.

(j) Maximum modeled concentrations.

6.3 Predicted Toxic Air Pollutant Ambient Concentrations

The first-tier ambient concentration screening analyses are summarized in Table 8. These screening analyses were conducted for TAPs with expected maximum emission rates that exceed the applicable SQERs (see Table 2). As shown in Table 8, all maximum modeled ambient concentrations are less than the applicable ASILs.

Table 8: Results for Toxic Air Pollutant Analysis

TAP	CAS No.	Averaging Period	Maximum Modeled Impact ($\mu g/m^3$) (a)	ASIL (b) ($\mu g/m^3$)
NO_2	10102-44-0	1-hr	233.19	470
SO_2	7446-09-05	1-hr	108.23	660
DEEP	DPM	year	0.00198	0.0033
CrVI	18540-29-9	year	4.63E-08	0.000004
Formaldehyde	50-00-0	year	0.0030	0.17
H_2S	7783-06-4	24-hr	1.90	2

Notes:

(a) Micrograms/cubic meter.

(b) ASIL values from WAC 173-460-150

7.0 USE OF THIS REPORT

This report has been prepared for the exclusive use of Pacific Ag, LLC and applicable regulatory agencies for specific application to the Sunnyside RNG, LLC renewable natural gas facility project. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau, shall be at the user's sole risk. Landau warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. Landau makes no other warranty, either express or implied.

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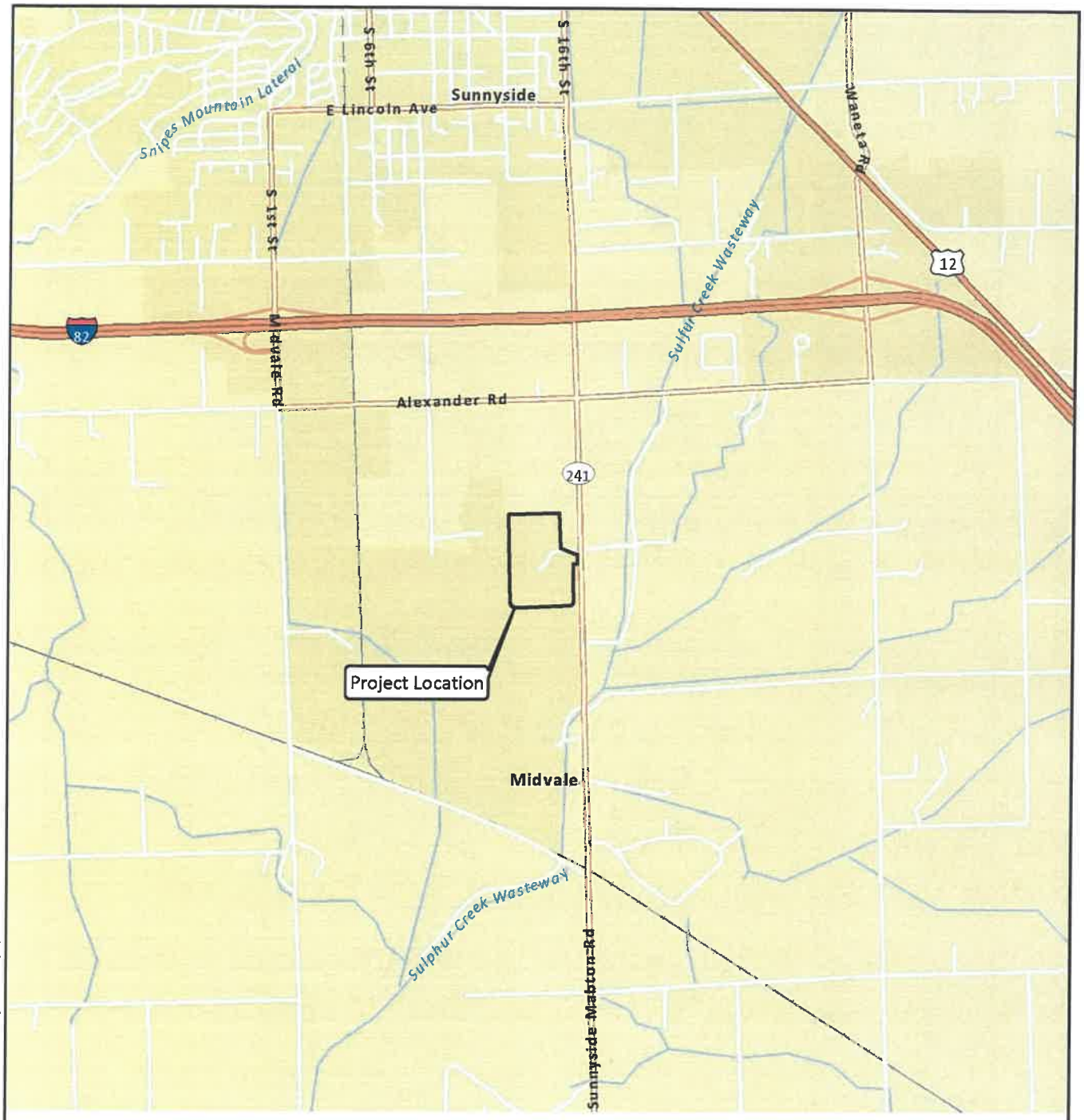

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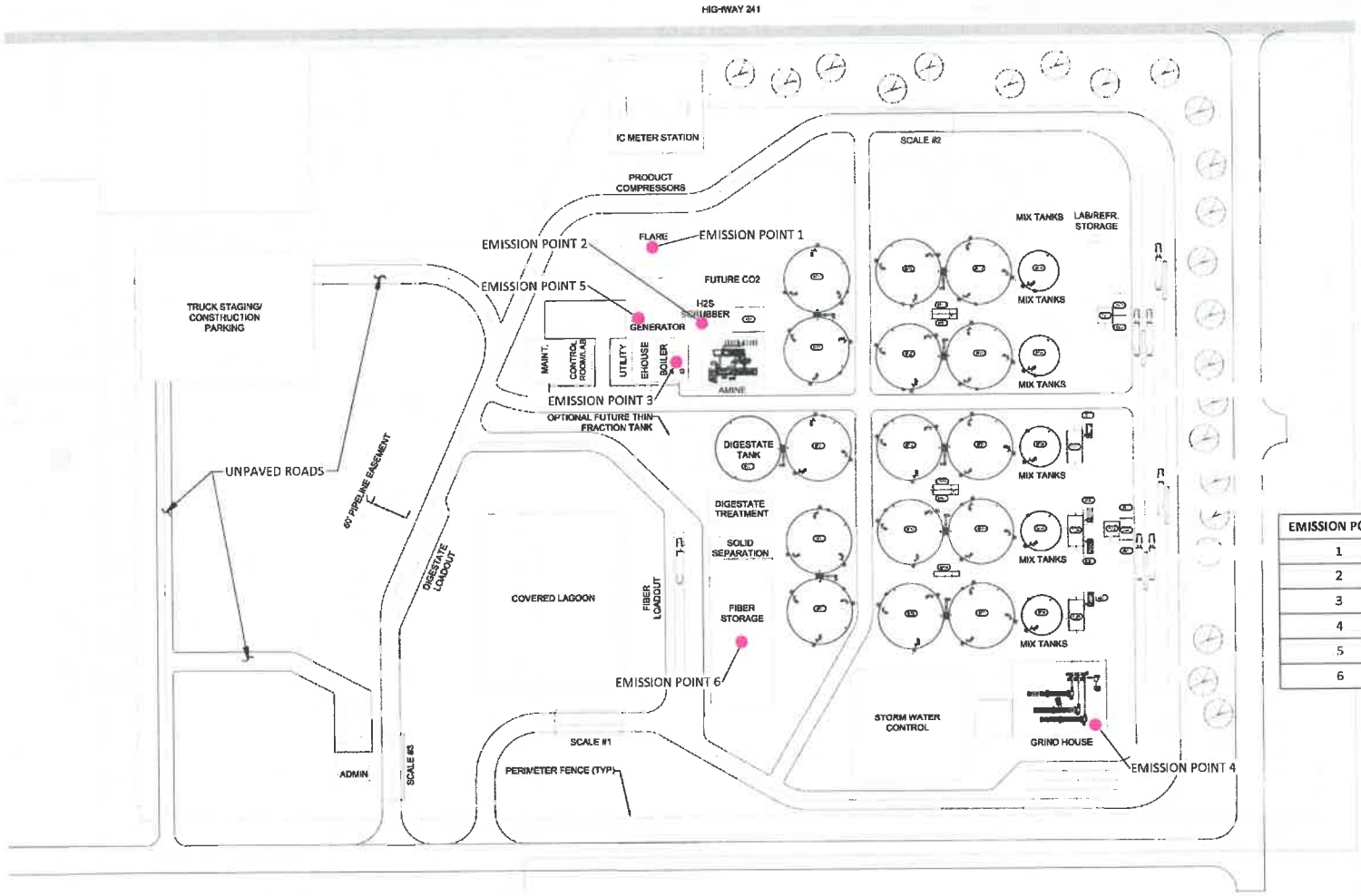
Sunnyside RNG Facility Yakima County, Washington	**Vicinity Map**	Figure 1



EMISSION POINT	DESCRIPTION
1	FLARE
2	TAIL GAS
3	BOILERS
4	GRIND BAGHOUSE EMISSIONS
5	GENERATOR
6	FIBER STORAGE FUGITIVES

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

N

0 175 350

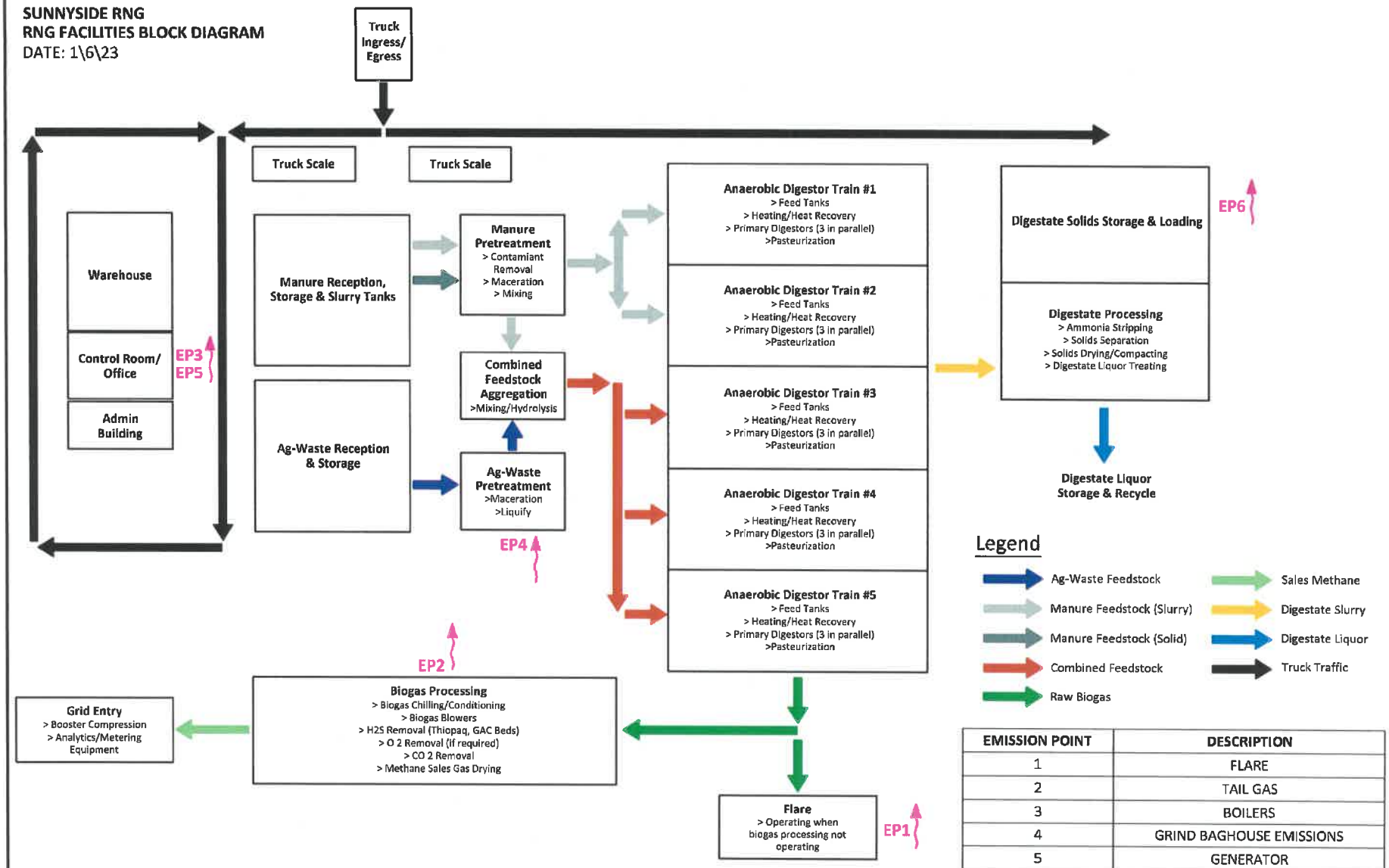
Scale in Feet

Source: Symbiont, October 2022

Sunnyside RNG Facility Yakima County, Washington	**Emissions Plan Overall Layout**	Figure 2

LANDAU ASSOCIATES

SUNNYSIDE RNG
RNG FACILITIES BLOCK DIAGRAM
DATE: 1\6\23



EMISSION POINT	DESCRIPTION
1	FLARE
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Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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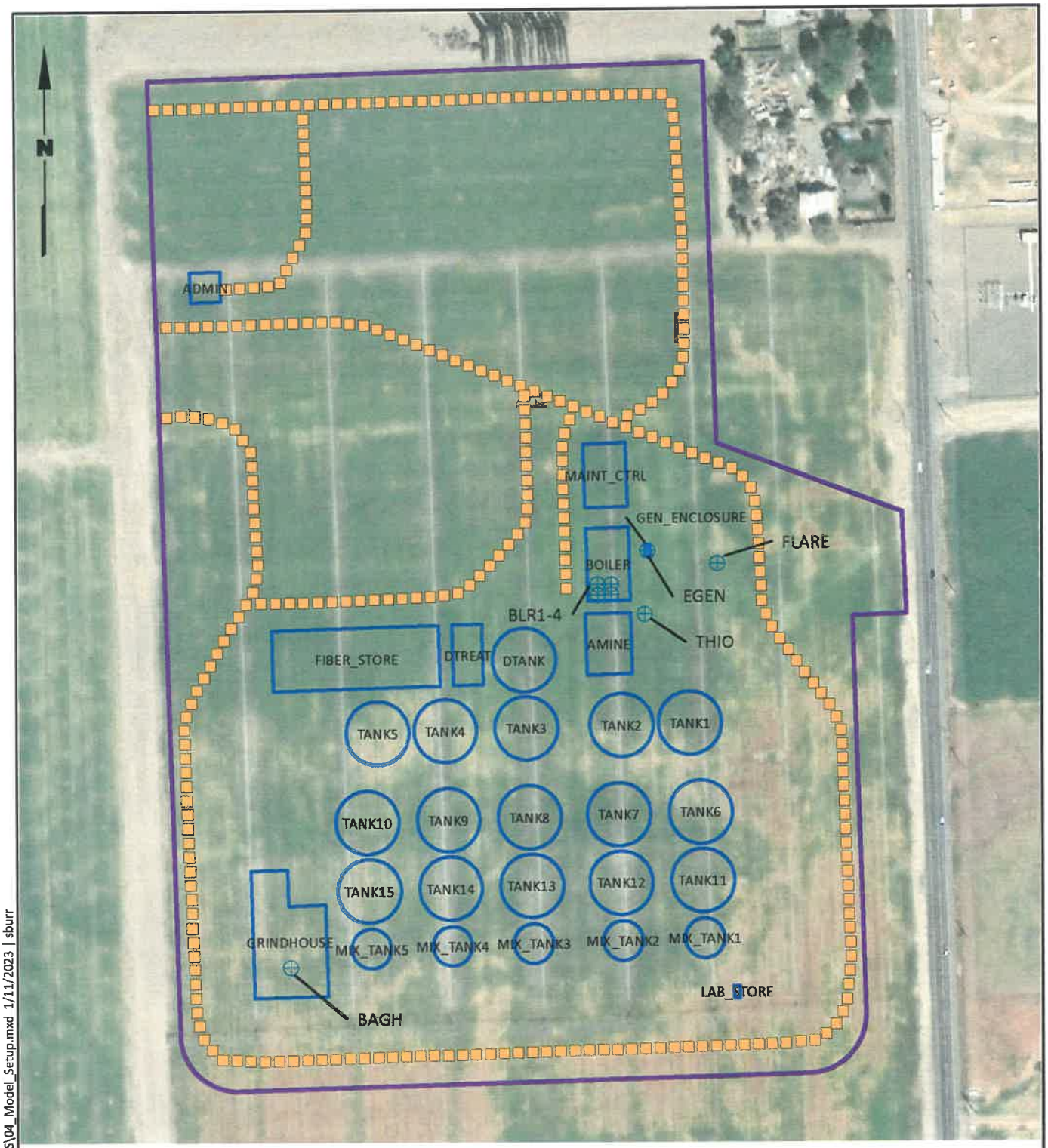
Sunnyside RNG Facility
Yakima County, Washington

Simplified Process Flow Diagram

Figure 3



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Legend

- Volume Sources
- Point Sources
- Buildings Property
- Boundary

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Scale in Feet

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Base Map Source: Esri World Imagery, 2023.

LANDAU ASSOCIATES

Sunnyside RNG Facility Yakima County, Washington	**Facility Site Plan**	Figure 4

APPENDIX A

New Source Review Application Form

YAKIMA REGIONAL CLEAN AIR AGENCY

186 Iron Horse Court, Suite 101. Yakima, WA. 98901
Phone: (509) 834-2050 Fax: (509) 834-2060
Website: http://www.yakimacleanair.org

Filing Fee: $400.00*

***Pursuant to WAC 173-400-111(1) (e)-an application is not complete until the permit application filling fee required by YRCAA has been paid.**

OFFICAL USE ONLY

YRCAA NSR No: _____ Date Fee Paid: _____

Received by: _____ Filing Fee: **$400.00**

☐ YRCAA is the lead agency for the SEPA process. Processing Fee $400.00

Review of the application will not begin, until the application filling fee is paid. A surcharge fee for the time required for preparing and processing the application for approval will be invoiced after the permit to operate is issued.

New Source Review (NSR) Application General

Stationary/Permanent Source

INSTALLATION OR ESTABLISHMENT OF NEW AIR CONTAMINANT SOURCES

NSR Application is Required for Construction, Installation or Establishment of an Air Pollution Source
Or
Replacement or Substantial Alteration of Emission Control Technology on an Air Pollution Source or Equipment

I. General Information:

BUSINESS NAME Sunnyside RNG, LLC

NATURE OF BUSINESS Renewable Natural Gas Production Facility

MAILING ADDRESS 1000 S Hwy 395, Ste A#506, Hermiston, OR 97838

FACILITY ADDRESS (if different): Parcel # 22090141404, # 22090114007, and #22090113001

PHONE and FAX NUMBERS (415) 699-1543 Email: barbara.treat@pacificag.com

TYPE OF PROCESS, EQUIPMENT, OR APPARATUS Natural Gas-Fired Boilers, Emergency Generator, Anaerobic Digesters, Biomass Grinder, RNG Upgrading Equipment, Compressor, and Backup Enclosed Flare

LIST OF AIR CONTAMINANT(S) WHICH WILL BE PRODUCED AND/OR CONTROLLED Natural Gas Combustion Emissions, Diesel Combustion Emissions, Process Vent from RNG Upgrading System, Particulate from Grinding, and Limited emissions from biogas flaring. All emissions units will comply with BACT and tBACT requirements.

ESTIMATED STARTING DATE: Commence Construction in 2023

ESTIMATED COMPLETION DATE: Start RNG Production in 2023/2024

Compliance with SEPA (State Environmental Policy Act) - Check One of the Options Below:

- ☐ A DNS or EIS has been Issued by Another Agency for this Project and a Copy is Attached.
- ☐ If no DNS or EIS Exists for this Project, a Completed Checklist for this Project and the SEPA Processing Fee are Attached. *YRCAA SEPA checklist is available by phone, or by our website.*
- ☐ The city/county has established an exemption for this project.
- ☐ I certify that the SEPA has been satisfied or this project is exempt:

Sunnyside RNG submitted SEPA Checklist Submitted to City of Sunnyside

Date *by* *Government Agency*

Previous NSR/Air Permits Number issued by YRCAA for the Facility, if any Not Applicable

Describe Input to Output Process (Attach drawings, schematics, prints, or block diagrams)
Process Description and Simplified Process Flow Diagram are enclosed with NSR Application

ESTIMATED COSTS: OF BASIC SOURCE EQUIPMENT $ To Be Determined

OF CONTAMINANT CONTROL APPARATUS $ To Be Determined

Process: Production Output per Year (tons, pounds, etc) ~800,000 - 950,000 MMBtu Methane/yr

Maximum Output per Hour (tons, pounds, etc) ~80 - 92 MMBtu Methane/hr

Percentage of Production (%)

Dec - Feb 25 Mar – May 25

Jun - Aug 25 Sep – Nov 25

Operating Schedule: Hrs/Day 24 Days/Wk 7 Wks/Yr 52

II. Emissions Estimations and Calculations:

1. Criteria Pollutants (gr/dscf, tons/yr, lbs/hr., ppm, etc.)

Particulate (PM_{10},$PM_{2.5}$) 2.2 lb/hr and 3.3 tpy PM10; 1.8 lb/hr and 1.8 tpy PM2.5

Volatile Organic Compounds 0.63 lb/hr and 0.65 tpy

Nitrogen Oxides 0.26 lb/hr (normal); 28.7 lb/hr (egen testing and flaring), and 6.0 tpy

Sulfur Oxides 0.014 lb/hr (normal), 68 lb/hr (flaring), and 13.7 tpy

Carbon Monoxide 0.53 lb/hr (normal), 35.6 lb/hr (egen testing and flaring), and 9.1 tpy

Lead 0.12 lb/yr

2. Toxic Air Pollutants (Name) Quantity (in gr/dscf, tons/yr, lbs/hr. ppm, etc.)

See Table 2 in NSR Application and Appendix B of NSR Application for full list of TAPs.

3.	Fugitive Pollutants (Source)	Quantity (in gr/dscf, tons/yr, lbs/hr. ppm, etc.)
	Paved and Unpaved Roadways	0.50 lb/hr and 1.8 tpy PM10

4. Air Pollution Modeling

Results Less than applicable SILs, NAAQS, and ASILs

Computer Printout Attached? ☒Yes ☐No

III. Emission Data:

1. Stack

Height (Feet) 20 (Steam Boiler) Inside Diameter (feet) 1.7 (Steam Boiler)

Gas Exit Temp (degrees F) 343 (Boiler) Gas Exit Velocity (ft/min) 1,503 (Steam Boiler)

Flow Rate (cfm) 3,278 (Steam Boiler)

Shared Stack? N If a shared stack, identify process (es) or point(s) which share the stack.

Distance from Stack to Property Line ~130 feet

2. Discharge Point or points (if no stack or other than stack) **See Table 4 in NSR Application for all Stacks**

Height (feet)_____ Inside Diameter (feet)_____

Gas Exit Temp (degrees F)_____ Gas Exit Velocity (ft/min)_____

Flow Rate (cfm) _____

Shared discharge point? If a shared discharge point, identify process (es) or point(s) which share the discharge point. _____

Distance from discharge point to Property Line _____

3. Fuel

Type NG / Diesel % Sulfur Negligable / 0.0015%

% Ash Negligable Unit of Measure (gal./cu.ft./etc.) scf / gal

BTU per Unit of Measure 1,020 / 139,000 Consumption Units per Year See Appendix B

Maximum Consumption Units per Hour See Appendix B

4. Building Dimensions **See Table 5 in NSR Application for All Building Dimensions**

Height (feet)_____ Length (feet)_____ Width (feet)_____

IV. Air Pollution Control Equipment:

Baghouse

Type Kice — Model #, Serial # R132-10N (or Equivalent)

Efficiency 99.9 — $PM_{2.5}$: 99.9 — and PM_{10}: 99.9

Bag Height (feet) 4.5 (estimate) — Bag Diameter (feet) 0.83 (estimate)

Filter Area (feet squared) 1,555 (estimate) — Blower Flow Rate (cfm) 11,000 (estimate)

Filter Media Felt — Dimensions (feet) 20 exhaust stack

Discharge Area Dimensions (feet) 1.83 diameter

Cleaning Mechanism (shake) (air psi) Compressed Air (10 - 15 psig)

Other Data

Scrubber

Type Not Applicable — Model #, Serial #

Efficiency

Gas Differential Pressure (psi) — Liquor Differential Pressure (psi)

Liquor Flow (gpm) — Discharge Area Dimensions ($feet^2$)

Gas Flow (cfm) — Other Data

Cyclone

Type Not Applicable — Model #, Serial #

Efficiency — $PM_{2.5}$: — and PM_{10}:

Gas Flow (cfm) — Discharge Area Dimensions ($feet^2$)

Other Data

Precipitator

Type Not Applicable — Model #, Serial #

Efficiency

Gas Flow (cfm) — Gas Velocity (ft/sec)

Residence Time — Gas Differential Pressure (psi)

Precipitation Rate (ft/sec) — Discharge Area Dimensions ($feet^2$)

Other Data

Ad/Absorp

Type Not Applicable — Model #, Serial #

Efficiency

Gas Flow — Gas Velocity (ft/sec)

Gas Temp (degree F) — Bed Volume (ft^3)

Bed Dimensions (feet) — Capacity (hours)

Contaminant (lb/day) — Regeneration time (hours)

Other Type _____ Model #, Serial # _____

Efficiency _____

Gas Flow (cfm) _____ Discharge Area Dimensions (feet) _____

Other Data _____

V. Additional Information:

1. Attach Related Information on Chemicals or Materials that will be emitted. (MSDS Sheets, Company Information, etc.)

   Note: Indicate how much quantity are used per MSDSs

   ☒ Yes ☐ No, if not why? SDS attached in Appendix B

2. Fugitive Dust Control Plan (Attach if Necessary)
3. Attach Operation and Maintenance Manual of Pollution Control Equipment.

   ☐ Yes ☒ No, if not, why? Control equipment not purchased yet
4. Attach Vendor Information or Manufacturer's Instructions on Pollution Control Equipment.

   ☒ Yes ☐ No, if not, why? _____

APPLICANT: I hereby certify that the information contained in this application, including supplemental forms and data, when required, is, to the best of my knowledge, complete and correct. I also agree to all fees for processing this permit and grant permission for YRCAA staff to enter the premises for inspection.

Signature _____ Date 2/15/23

Title CFO PacificAg for Sunnyside RNG, LLC Date _____

Name and Title of Individual Filling out Form:

Name (print) Barbara Laflin Treat

Signature _____

Name and Title of Contact Person, if Different than Above:

Name Barbara Laflin Treat

Title President of PacificAg Renewables

Name and Title of the Responsible Official for the permit, if Different than Above:

Name Nathan Drake

Title CFO PacificAg for Sunnyside RNG, LLC

APPENDIX B

Detailed Emission Calculations and Vendor Specification Sheets

Sunnyside RNG Project
Sunnyside, WA

Summary of Project Emissions

Pollutant		Boilers	Thiopaq	Emergency Gen.	Flare	Straw Grinding	Roadway Fugitives	Digestate	Totals
NO_X	lb/hr	0.26	--	21.9	6.6	--	--	--	28.74
	tpy	1.2	--	3.5	1.32	--	--	--	5.98
CO	lb/hr	0.53	--	5.0	30	--	--	--	35.65
	tpy	2.3	--	0.80	6.0	--	--	--	9.1
PM_{10}	lb/hr	0.18	--	0.70	0.72	0.10	0.50	--	2.21
	tpy	0.8	--	0.112	0.145	0.44	1.80	--	3.28
$PM_{2.5}$	lb/hr	0.18	--	0.70	0.72	0.10	0.09	--	1.79
	tpy	0.8	--	0.112	0.145	0.44	0.31	--	1.78
SO_2	lb/hr	0.014	--	0.018	68	--	--	--	68.44
	tpy	0.062	--	0.0028	13.7	--	--	--	13.75
VOC	lb/hr	0.13	--	0.38	0.12	--	--	--	0.63
	tpy	0.57	--	0.062	0.023	--	--	--	0.65
CO_2e	tpy	12,309	34,857	271	3855	--	--	--	51,293

Sunnyside RNG Project
Sunnyside, WA

Summary of Project Emissions

Toxic Air Pollutant Emissions

Pollutant	CAS	Averaging Period	Emissions (lb/ave. period)						De Minimis	< De Minimis	SQER	> SQER
			Boilers	THIO	EGEN	Flare	Digestate	Total	lb/period		lb/period	
Nitrogen Dioxide	10102-44-0	1-hr	0.26	--	21.87	6.61	--	29	0.46	No	0.87	Yes
Carbon Monoxide	630-08-0	1-hr	0.53	--	4.99	30.13	--	36	1.1	No	43	No
Sulfur Dioxide	7446-09-05	1-hr	0.01	--	0.02	68.41	--	68	0.46	No	1.2	Yes
Diesel Particulate Matter	DPM	year	--	--	101.89	--	--	102	0.027	No	0.54	Yes
1,3-Butadiene	106-99-0	year	--	--	5.18	--	--	5.2	0.27	No	5.4	No
Acetaldehyde	75-07-0	year	0.89	--	18.67	0.12	--	20	3	No	60	No
Acrolein	107-02-8	24-hr	1.52E-03	--	2.53E-03	0.01	--	0.01	0.0013	No	0.026	No
Ammonia	7664-41-7	24-hr	--	--	--	--	28.18	28.2	1.9	No	37	No
Arsenic	7440-38-2	year	--	--	0.04	--	--	0.038	0.0025	No	0.049	No
Benzene	71-43-2	year	1.65	--	4.44	0.22	--	6	1	No	21	No
Cadmium	7440-43-9	year	--	--	0.04	--	--	0.036	0.0019	No	0.039	No
Chlorobenzene	108-90-7	24-hr	--	--	1.49E-05	--	--	1.5E-05	3.7	Yes	74	No
Chromium VI	18540-29-9	year	--	--	2.38E-03	--	--	2.4E-03	0.000033	No	0.00065	Yes
Copper	7440-50-8	1-hr	--	--	3.05E-04	--	--	3.1E-04	0.0093	Yes	0.19	No
Ethylbenzene	100-41-4	year	1.96	--	0.26	0.26	--	2.5	3.2	Yes	65	No
Formaldehyde	50-00-0	year	3.50	--	41.15	0.47	--	45	1.4	No	27	Yes
Hexane	110-54-3	24-hr	3.56E-03	--	2.00E-03	0.01	--	0.02	2.6	Yes	52	No
Hydrogen Chloride	7647-01-0	24-hr	--	--	0.01	--	--	0.014	0.033	Yes	0.67	No
Hydrogen Sulfide	7783-06-4	24-hr	--	1.57	--	17.47	--	19.03	0.0074	No	0.15	Yes
Lead	7439-92-1	year	--	--	0.20	--	--	0.20	10	Yes	14	No
Manganese	7439-96-5	24-hr	--	--	2.31E-04	--	--	2.3E-04	0.0011	Yes	0.022	No
Mercury	7439-97-6	24-hr	--	--	1.49E-04	--	--	1.5E-04	0.00011	No	0.0022	No
Naphthalene	91-20-3	year	0.06	--	0.47	0.01	--	0.5	0.24	No	4.8	No
Nickel	7440-02-0	year	--	--	0.09	--	--	0.093	0.031	No	0.62	No
Propylene	115-07-1	24-hr	0.41	--	0.03	1.21	--	1.7	11	Yes	220	No
Selenium	7782-49-2	24-hr	--	--	1.64E-04	--	--	1.6E-04	0.074	Yes	1.5	No
Toluene	108-88-3	24-hr	0.02	--	0.01	0.06	--	0.09	19	Yes	370	No
Xylene	1330-20-7	24-hr	0.02	--	3.16E-03	0.05	--	0.064	0.82	Yes	16	No

Sunnyside RNG Project
Sunnyside, WA

Summary of Project Emissions

Hazardous Air Pollutant Emissions

Pollutant	CAS	Emissions (tpy)					
		Boilers	Thiopaq	EGEN	Flare	Digestate	Total
1,1,2,2-Tetrachloroethane	79-34-5	--	--	--	--	--	--
1,1,2-Trichloroethane	79-00-5	--	--	--	--	--	--
1,1-Dichloroethane	75-34-3	--	--	--	--	--	--
1,2-Dichloroethane	107-06-2	--	--	--	--	--	--
1,2-Dichloropropane	78-87-5	--	--	--	--	--	--
1,3-Butadiene	106-99-0	--	--	2.59E-03	--	--	2.59E-03
1,3-Dichloropropene	542-75-6	--	--	--	--	--	--
Acetaldehyde	75-07-0	4.43E-04	--	0.01	5.91E-05	--	0.01
Acrolein	107-02-8	2.78E-04	--	4.04E-04	5.15E-05	--	7.34E-04
Arsenic	7440-38-2	--	--	1.91E-05	--	--	1.91E-05
Benz(a)anthracene	56-55-3	--	--	--	--	--	--
Benzene	71-43-2	8.24E-04	--	2.22E-03	1.11E-04	--	3.16E-03
Benzo(a)pyrene	50-32-8	--	--	--	--	--	--
Benzo(b)flouranthene	205-99-2	--	--	--	--	--	--
Benzo(k)fluoranthene	207-08-9	--	--	--	--	--	--
Cadmium	7440-43-9	--	--	1.79E-05	--	--	1.79E-05
Carbon Tetrachloride	56-23-5	--	--	--	--	--	--
Chlorobenzene	108-90-7	--	--	2.38E-06	--	--	2.38E-06
Chloroethane	75-00-3	--	--	--	--	--	--
Chloroform	67-66-3	--	--	--	--	--	--
Chromium VI	18540-29-9	--	--	1.19E-06	--	--	1.19E-06
Dibenz(a,h)anthracene	53-70-3	--	--	--	--	--	--
Ethylbenzene	100-41-4	9.79E-04	--	1.30E-04	1.32E-04	--	1.24E-03
Ethylene Dibromide	106-93-4	--	--	--	--	--	--
Formaldehyde	50-00-0	1.75E-03	--	0.02	2.34E-04	--	0.02
Hexane	110-54-3	6.49E-04	--	3.21E-04	8.77E-05	--	1.06E-03
Hydrogen Chloride	7647-01-0	--	--	2.22E-03	--	--	2.22E-03
Indeno(1,2,3-c,d)pyrene	193-39-5	--	--	--	--	--	--
Lead	7439-92-1	--	--	9.89E-05	--	--	9.89E-05
Manganese	7439-96-5	--	--	3.70E-05	--	--	3.70E-05
Mercury	7439-97-6	--	--	2.38E-05	--	--	2.38E-05
Methanol	67-56-1	--	--	--	--	--	--
Methylene Chloride	75-09-2	--	--	--	--	--	--
Naphthalene	91-20-3	3.09E-05	--	2.35E-04	5.72E-06	--	2.71E-04
Nickel	7440-02-0	--	--	4.65E-05	--	--	4.65E-05
Phenol	108-95-2	--	--	--	--	--	--
Selenium	7782-49-2	--	--	2.62E-05	--	--	2.62E-05
Styrene	100-42-5	--	--	--	--	--	--
Toluene	108-88-3	3.77E-03	--	1.26E-03	5.05E-04	--	0.01
Vinyl Chloride	75-01-4	--	--	--	--	--	--
Xylene	1330-20-7	2.80E-03	--	5.05E-04	3.75E-04	--	3.68E-03

0.05 Total HAP emissions (tpy)

Sunnyside RNG Project
Sunnyside, WA

Boiler Emission Calculations

	Steam Boiler (CBEX-2W)	Hot Water Boiler (CFC-E)	
No. Boilers	2	2	
NG Heat Input per Boiler	10	2	mmbtu/hr
Annual Operating Hours	8760	8760	hrs/yr
NOx (lb/MMBtu)	0.011	0.011	
CO (lb/MMBtu)	0.022	0.022	

Criteria Air Pollutant	Emission Factor [b] (lb/mmbtu)	Total Hourly Emissions [d] (lb/hr)	Total Annual Emissions [d] (tpy)
NOx [a]	--	0.26	1.2
CO [a]	--	0.53	2.3
SO2	0.00059	0.01	0.062
PM	0.0075	0.18	0.8
PM10	0.0075	0.18	0.8
PM2.5	0.0075	0.18	0.8
VOC	0.0054	0.13	0.6
CO2e [c]	117	2,810	12,309

Notes:

a - NOx/CO emissions from NG burners based on 9 ppmv and 30 ppmv, respectively.

b - Natural Gas combustion criteria pollutants from AP-42 Section 1.4, converted to lb/mmbtu using 1020 btu/scf.

c - GHG Emission factors from 40 CFR Part 98, Tables C-1 and C-2. CO_2e is calculated using the methodology in 40 CFR 98.2(b)(4) and Table A-1: $CO_2e = S(GHG \times GWP)$, where GHG is the mass emissions of each greenhouse gas and GWP is the global warming potential.

d - Hourly Emissions calculated using emission factors (lb/MMBtu), 2 steam boilers at 10.0 MMBtu/hr per boiler; 2 hot water boilers at 2.0 MMBtu/hr per boiler; and annual emissions based on 8,760 hours of operation per year.

Toxic Air Pollutant	CAS	Emission Factor [a] (lb/MMBtu)	Emission Factor [a] (lb/MMscf)	Hourly Emissions [c] (lb/hr)	Daily Emissions [d] (lb/day)	Annual Emissions [e] (lb/yr)
NO2 [b]	10102-44-0	--	--	2.64E-01	6.34E+00	2.31E+03
SO_2 [b]	7446-09-05	5.9E-04	0.6	1.41E-02	3.39E-01	1.24E+02
CO [b]	630-08-0	--	--	5.28E-01	1.27E+01	4.63E+03
Benzene	71-43-2	7.8E-06	8.00E-03	1.88E-04	4.52E-03	1.65E+00
Formaldehyde	50-00-0	1.7E-05	1.70E-02	4.00E-04	9.60E-03	3.50E+00
Naphthalene	91-20-3	2.9E-07	3.00E-04	7.06E-06	1.69E-04	6.18E-02
Acetaldehyde	75-07-0	4.2E-06	4.30E-03	1.01E-04	2.43E-03	8.86E-01
Acrolein	107-02-8	2.6E-06	2.70E-03	6.35E-05	1.52E-03	5.57E-01
Propylene	115-07-1	7.2E-04	7.31E-01	1.72E-02	4.13E-01	1.51E+02
Toluene	108-88-3	3.6E-05	3.66E-02	8.61E-04	2.07E-02	7.54E+00
Xylenes	1330-20-7	2.7E-05	2.72E-02	6.40E-04	1.54E-02	5.61E+00
Ethylbenzene	100-41-4	9.3E-06	9.50E-03	2.24E-04	5.36E-03	1.96E+00
Hexane	110-54-3	6.2E-06	6.30E-03	1.48E-04	3.56E-03	1.30E+00

Notes:

a - Emission factors for toxic air pollutants from AB2588 Combustion Emission Factors, <10 MMBtu/hr (converted to lb/mmbtu using 1020 btu/scf) obtained from Ventura County Air Pollution Control District.

b - NOx, SO2, and CO emission factors from criteria pollutant calculations.

c - Hourly Emissions calculated using emission factors (lb/MMBtu) and 24.0 MMBtu/hr for all 4 boilers.

d - Daily Emissions calculated using hourly emissions and 24 hours of operation per day.

e - Annual Emissions calculated using hourly emissions and 8,760 hours of operation per day.

Sunnyside RNG Project
Sunnyside, WA

Biogas upgrader and Thiopaq bioscrubber

Process Flow	1345 scfm	
Incoming Tail Gas	84.9 vol% CO2	
Incoming Tail Gas	0.01 Vol%CH4	
Inlet Tail Gas H2S	6000 ppm	
Bioscrubber efficiency	99.00%	Based on conservative estimate of Thiopaq claim
Venting of H2S	60.00 ppm	
Emissions from GAC Beds	9.0 ppm	Based on exhaust from Activated Carbon beds
Annual Operating Hours	8760 hrs/yr	

Criteria Air Pollutant	Hourly Emissions [c] (lb/hr)	Annual Emissions [c] (tpy)
CO2e [c]	7,958	34,857

Notes:

c - GHG Emission factors from 40 CFR Part 98, Tables C-1 and C-2. CO_2e is calculated using the methodology in 40 CFR 98.2(b)(4) and Table A-1: CO_2e = S(GHG x GWP), where GHG is the mass emissions of each greenhouse gas and GWP is the global warming potential. Also includes process CO2 passing through control system.

Toxic Air Pollutant	CAS	Hourly Emissions (lb/hr)	Daily Emissions [b] (lb/day)	Annual Emissions [c] (Tons/yr)
Hydrogen Sulfide [a]	7783-06-4	0.0653	1.57	0.286

Notes:

a - Hourly emissions based on data from Vendor for exhaust from activated carbon beds.

b - Daily Emissions calculated using hourly emissions and 24 hours of operation per day.

c - Annual Emissions calculated using hourly emissions and 8,760 hours of operation per day.

Sunnyside RNG Project
Sunnyside, WA

Enclosed Cellulosic Grinder with Process Cyclone and Dust Collector

Straw Processing	200	tons/day
Annual Operating Hours	365	days/yr

Criteria Air Pollutant	Emission Factor [a] (lb/ton)	Hourly Emissions [b] (lb/hr) - daily average	Annual Emissions [b] (tpy)
PM	0.012	0.10	0.44
PM_{10}	0.012	0.10	0.44
$PM_{2.5}$	0.012	0.10	0.44

Notes:

a - Emission factors for shredding operation (controlled by baghouse) based on AP-42 Chapter 9.9.1 (Hammermill operations.) PM10 and PM2.5 conservatively set equal to PM emissions.

b - Hourly Emissions calculated using emission factors, hourly shredding throughput 200 tons/day; and annual emissions based on 365 days of operation per year.

Sunnyside RNG Project
Sunnyside, WA

Emergency Generator Kohler KD2000 Standby Tier 2 Engine

- ULSD Fuel

	Engine Specifications	
Testing Time	30 minutes/test	
Total Operating Hours	160 hour/year	
Gen. Set Output Rating	2,923 hp	(bhp, spec sheet)
Diesel Fuel Heat Content	139 MMBtu/Mgal	
Engine Information		
Exhaust Gas Volume Flow	17,586 cfm	
Maximum Fuel Use Rate	149.0 gal/hr	Source: Kohler KD2000.pdf
Exhaust Exit Diameter		
Exhaust Temperature	932 F	
Power Rating	2,180 ekW	

Pollutant Emissions

CAS	Compound	Emission Factor				Emissions [g]		
		Testing g/kw-hr	lb/hp-hr	lb/mgal [c]	lb/mmBtu	lb/hr	lb/day	lb/yr
10102-44-0	NOx [a]	--	--	--	--	2.19E+01	2.19E+01	7.00E+03
630-08-0	CO [a]	--	--	--	--	4.99E+00	4.99E+00	1.60E+03
PM	PM [a]	--	--	--	--	7.03E-01	7.03E-01	2.25E+02
PM10	PM10 [a]	--	--	--	--	7.03E-01	7.03E-01	2.25E+02
PM2.5	PM2.5 [a]	--	--	--	--	7.03E-01	7.03E-01	2.25E+02
7446-09-05	SO2 [b]	--	1.2E-05	--	--	1.77E-02	1.77E-02	5.68E+00
VOC	VOC [a]	--	--	--	--	3.84E-01	3.84E-01	1.23E+02
CO2	CO2 [e]	--	--	--	1.6E+02	1.69E+03	1.69E+03	5.40E+05
CH4	CH4 [e]	--	--	--	6.6E-03	6.85E-02	6.85E-02	2.19E+01
N2O	N2O [e]	--	--	--	1.3E-03	1.37E-02	1.37E-02	4.38E+00
CO2e	CO2e [f]	--	--	--	--	1.69E+03	1.69E+03	5.42E+05
106-99-0	1,3 Butadiene	--	--	0.2174	--	1.62E-02	1.62E-02	5.18E+00
75-07-0	Acetaldehyde	--	--	0.7833	--	5.84E-02	5.84E-02	1.87E+01
107-02-8	Acrolein	--	--	0.0339	--	2.53E-03	2.53E-03	8.08E-01
71-43-2	Benzene	--	--	0.1863	--	1.39E-02	1.39E-02	4.44E+00
108-90-7	Chlorobenzene	--	--	0.0002	--	1.49E-05	1.49E-05	4.77E-03
DPM	Diesel Engine Particulate [d]	--	--	--	--	3.18E-01	7.03E-01	1.02E+02
50-00-0	Formaldehyde	--	--	1.7261	--	1.29E-01	1.29E-01	4.12E+01
91-20-3	Naphthalene	--	--	0.0197	--	1.47E-03	1.47E-03	4.70E-01
115-07-1	Propylene	--	--	0.4670	--	3.48E-02	3.48E-02	1.11E+01
110-54-3	Hexane	--	--	0.0269	--	2.00E-03	2.00E-03	6.41E-01
108-88-3	Toluene	--	--	0.1054	--	7.85E-03	7.85E-03	2.51E+00
1330-20-7	Xylenes	--	--	0.0424	--	3.16E-03	3.16E-03	1.01E+00
100-41-4	Ethyl Benzene	--	--	0.0109	--	8.12E-04	8.12E-04	2.60E-01
7647-01-0	Hydrogen Chloride	--	--	0.1863	--	1.39E-02	1.39E-02	4.44E+00
7440-38-2	Arsenic	--	--	0.0016	--	1.19E-04	1.19E-04	3.81E-02
7440-43-9	Cadmium	--	--	0.0015	--	1.12E-04	1.12E-04	3.58E-02
18540-29-9	Chromium VI	--	--	0.0001	--	7.45E-06	7.45E-06	2.38E-03
7440-50-8	Copper	--	--	0.0041	--	3.05E-04	3.05E-04	9.77E-02
7439-92-1	Lead	--	--	0.0083	--	6.18E-04	6.18E-04	1.98E-01
7439-96-5	Manganese	--	--	0.0031	--	2.31E-04	2.31E-04	7.39E-02
7439-97-6	Mercury	--	--	0.0020	--	1.49E-04	1.49E-04	4.77E-02
7440-02-0	Nickel	--	--	0.0039	--	2.91E-04	2.91E-04	9.30E-02
7782-49-2	Selenium	--	--	0.0022	--	1.64E-04	1.64E-04	5.24E-02

notes:

a - NOx, CO, PM, and Hydrocarbon emission factors based on Tier 2 Not to Exceed Emission data from Kohler (maximum emissions across all load test

b - Emission factors from AP-42 Section 3.4, Large Stationary Diesel and Duel-Fuel Engines (October 1996). Fuel sulfur content of ULSD is 0.0015%.

c - Emission factors for toxic air pollutants from AB2588 Combustion Emission Factors for diesel internal combustion obtained from Ventura

d - Diesel Engine Particulate emissions based on filterable PM only.

e - Greenhouse Gas emission factors from 40 CFR 98, Subpart C, Table C-1.

f - CO2e calculated based on global warming potential (GWP) for each Greenhouse gas: CO2 = 1; CH4 = 25; and N2O = 298 (40 CFR Part 98, Subpart A).

g - Hourly emissions based on 2923 hp-hr/hr, fuel cosumption rate of 149.0 gal/hr, testing emission rate based on 30 minutes/test, one test per day, and annual emissions based on 160 hrs/yr.

Sunnyside RNG Project
Sunnyside, WA

One flare for all digestor lines

Source type	Enclosed Flare
Model number	Perennial Energy Enclosed Flare

No. Flares	1	- one per the facility layout
Raw Biogas Heat Content	600	btu/scf
Raw Biogas Sulfur Conter	2500	ppmv H2S
Incoming Raw Biogas	42	vol% CO2
Flare Destruction Efficiency	98%	
Hourly Peak Biogas Gene	2700	scfm
Total Hourly Heat Input	97.2	mmbtu/hr
Total Annual Heat Input	38880	mmbtu/yr
Annual Operating Hours	400	hrs/yr - Upgrader downtime

Criteria Air Pollutant	Emission Factor [c] (lb/mmbtu)	Hourly Emissions [e] (lb/hr)	Annual Emissions [e] (tpy)
NOx [a]	0.068	6.61	1.3
CO [a]	0.310	30.1	6.0
SO2 [b]	--	68.4	13.7
PM	0.0075	0.72	0.14
PM10	0.0075	0.72	0.14
PM2.5	0.0075	0.72	0.14
VOC [a]	0.0012	0.12	0.02
CO2e [d]	117	19,277	3855

Notes:

a - NOx, CO, and VOC emissions from AP-42 Section 13.5. VOC based on THC for enclosed ground flare (normal load)

b - Biogas combustion SO2 emissions based on sulfur content and 100% conversion to SO2.

c - Biogas combustion criteria pollutants based on natrual gas combustion from AP-42 Section 1.4, converted to lb/mmbtu using 1020 btu/scf.

d - GHG Emission factors from 40 CFR Part 98, Tables C-1 and C-2. CO_2e is calculated using the methodology in 40 CFR 98.2(b)(4) and Table A-1: CO_2e = S(GHG x GWP), where GHG is the mass emissions of each greenhouse gas and GWP is the global warming potential. Also includes process CO2 passing through control system.

e - Hourly Emissions calculated using emission factors (lb/MMBtu), 97.2 MMBtu/hr per flaring event; and annual emissions based on 400 hours of flaring per year.

Toxic Air Pollutant	CAS	Emission Factor [a] (lb/MMBtu)	Emission Factor [a] (lb/MMscf)	Hourly Emissions [c] (lb/hr)	Daily Emissions [d] (lb/day)	Annual Emissions [e] (lb/yr)
NO2 [b]	10102-44-0	0.068	--	6.61E+00	1.59E+02	2.64E+03
SO_2 [b]	7446-09-05	--	--	6.84E+01	1.64E+03	2.74E+04
CO [b]	630-08-0	0.310	--	3.01E+01	7.23E+02	1.21E+04
Hydrogen Sulfide [c]	7783-06-4	--	--	7.28E-01	1.75E+01	2.91E+02
Benzene	71-43-2	5.7E-06	5.80E-03	5.53E-04	1.33E-02	2.21E-01
Formaldehyde	50-00-0	1.2E-05	1.23E-02	1.17E-03	2.81E-02	4.69E-01
Naphthalene	91-20-3	2.9E-07	3.00E-04	2.86E-05	6.86E-04	1.14E-02
Acetaldehyde	75-07-0	3.0E-06	3.10E-03	2.95E-04	7.09E-03	1.18E-01
Acrolein	107-02-8	2.6E-06	2.70E-03	2.57E-04	6.18E-03	1.03E-01
Propylene	115-07-1	5.2E-04	5.30E-01	5.05E-02	1.21E+00	2.02E+01
Toluene	108-88-3	2.6E-05	2.65E-02	2.53E-03	6.06E-02	1.01E+00
Xylenes	1330-20-7	1.9E-05	1.97E-02	1.88E-03	4.51E-02	7.51E-01
Ethylbenzene	100-41-4	6.8E-06	6.90E-03	6.58E-04	1.58E-02	2.63E-01
Hexane	110-54-3	4.5E-06	4.60E-03	4.38E-04	1.05E-02	1.75E-01

Notes:

a - Emission factors for toxic air pollutants from AB2588 Combustion Emission Factors for external natural gas combustion, 10-100 MMBtu/hr (converted to lb/mmbtu using 1020 btu/scf) obtained from Ventura County Air Pollution Control District. Petroleum refinery flare VOC/HAP emission factors are not representative of combustion biogas.

b - NOx, SO2, and CO emission factors from criteria pollutant calculations.

c - H2S emissions based on 98% destruction of H2S in biogas.

d - Hourly Emissions calculated using emission factors (lb/MMBtu) and 97.2 MMBtu/hr.

e - Daily Emissions calculated using hourly emissions and 24 hours of operation per day.

f - Annual Emissions calculated using hourly emissions and 400 hours of flaring per year.

Sunnyside RNG Project
Sunnyside, WA

Fugitive dust from paved roadways.

							Veh. Wt.	Annual Emission Factors			Daily Controlled Emissions (70% Reduction)			Annual Controlled Emissions (70% Reduction)		
							W	E for PM	E for PM10	E for PM2.5	PM Emiss.	PM10 Emiss.	PM2.5 Emiss.	PM Emiss.	PM10 Emiss.	PM2.5 Emiss.
Source type	Class		Trips/day	Trips/year	Miles/trip	VMT/year	(tons)	lbs/VMT	lbs/VMT	lbs/VMT	lb/day	lb/day	lb/day	tpy	tpy	tpy
Feedstock Delivery Truc	Paved	Loaded	110	34320	0.37	12698.4	52.75	1.59	0.32	0.08	19.42	3.88	0.95	3.03	0.61	0.15
	Paved	Empty	110	34320	0.42	14414.4	15	0.44	0.09	0.02	6.11	1.22	0.30	0.95	0.19	0.05
External Supplier Trucks	Paved	Loaded	3	780	0.19	148.2	40	1.20	0.24	0.06	0.21	0.04	0.01	0.03	0.01	0.00
	Paved	Empty	3	780	0.19	148.2	15	0.44	0.09	0.02	0.08	0.02	0.00	0.01	0.00	0.00
Fiber Export Truck	Paved	Loaded	20	3120	0.20	624.0	52.75	1.59	0.32	0.08	1.91	0.38	0.09	0.15	0.03	0.01
	Paved	Empty	20	3120	0.13	405.6	17.5	0.52	0.10	0.03	0.40	0.08	0.02	0.03	0.01	0.00
Straw Trucks	Paved	Loaded	6	1560	0.19	296.4	52.75	1.59	0.32	0.08	0.54	0.11	0.03	0.07	0.01	0.00
	Paved	Empty	6	1560	0.19	296.4	17.5	0.52	0.10	0.03	0.18	0.04	0.01	0.02	0.00	0.00
Sunnyside - Personal Ve	Paved	Loaded	17	5356	0.13	696.3	2.5	0.07	0.014	0.003	0.05	0.01	0.00	0.01	0.00	0.00
	Paved	Empty	17	5356	0.13	696.3	2.5	0.07	0.014	0.003	0.05	0.01	0.00	0.01	0.00	0.00
Truck Driver - Personal V	Unpaved	Loaded	17	5148	0.15	772.2	2.5	10.05	4.06	0.41	7.69	3.11	0.31	1.16	0.47	0.05
	Unpaved	Empty	17	5148	0.15	772.2	2.5	10.05	4.06	0.41	7.69	3.11	0.31	1.16	0.47	0.05
										Total	44.32	12.00	2.04	6.64	1.80	0.31

Paved Roads

The emission factors for vehicle traffic on paved roads at industrial sites were derived from AP-42, "Paved Roads", Section 13.2.1, January 2011.

Equation 2: E=k*(sL)^0.91*(W)^1.02*[1-P/(4*365)]

where:

	PM	PM10	PM2.5
k= base emission factor (lb/VMT)	0.011	0.0022	0.00054
sL= road surface silt content (g/m2)	2.9	2.9	2.9
W= average vehicle weight (tons)	---see values above---		
E= Emission factor (lb/VMT)	---see values above---		

(upper range of corn mills, <500 ADT default at 0.6 g/m^2)

P= Number of Days with at least 0.01 inches of precipitation (57 days for Sunnyside, WA) - https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa8207

Unpaved Roads

The emission factors for vehicle traffic on unpaved roads at industrial sites were derived from AP-42, "Unpaved Roads", Section 13.2.2, November 2006.

Equation 1a: E=k*(s/12)^a*(W/3)^b*[(365-P)/365]

48% for pm10 conc from silt roads doc https://www.tandfonline.com/doi/full/10.1080/02786820903516844

where:

	PM	PM10	PM2.5
k= base emission factor (lb/VMT)	4.9	1.5	0.15
s= surface material silt content (%) - mean const	48	48	48
W= average vehicle weight (tons)	---see values above---		
a= empirical constant	0.7	0.9	0.9
b= empirical constant	0.45	0.45	0.45
E= Emission factor (lb/VMT)	---see values above---		

P= Number of Days with at least 0.01 inches of precipitation (57 days for Sunnyside, WA) - https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa8207

Sunnyside RNG Project
Sunnyside, WA

Ammonia emissions from Solid Digestate storage

Building Dimensions

Ammonia Emissions derived from Equation 9 from (a)
E=17.254* 1.060^TS*LD^0.274*TAN

					High average July	87.1
					Low average July	60.8
TS	Substrate Temperature	TS	30.611111 C	conservatively hottest month	Average July temp	73.95
LD	Air Exchange Rate	LD	2	assumed, test value		
TAN	NH4-N Content	TAN	3.9 g/kg	Total Nitrogen	5 g/kg	
				NH3 Content	1.1 g/kg	
				NH4-N Content	3.9 g/kg	

Ammonia	484.3	mg NH3/m2*h
Surface Area	1,100.0	m2
Total emissions	532,684.4	mg NH3/h
Total emissions	532.7	g NH3/Hr
Total emissions	1.2	lb/hr

Toxic Air Pollutant	CAS	Hourly Emissions (lb/hr)	Daily Emissions [b] (lb/day)	Annual Emissions [c] (lb/yr)	Annual Emissions (tons/year)
Ammonia	7664-41-7	1.2E+00	2.8E+01	1.0E+04	5.1E+00

a. Calculated using formula from: Bell, M.W., etal. Ammonia emissions from an anaerobic digestion plant estimated using atmospheric measurements and dispersion modelling. Waste Management (2016), http://dx.doi.org/10.1016/j.wasman.2016.06.002

b - Daily Emissions calculated using hourly emissions and 24 hours of operation per day.

c - Annual Emissions calculated using hourly emissions and 8,760 hours of operation per day.

Steam

Cleaver-Brooks Boiler Expected Emission Data — **With Economizer**

Producing Steam Firing — **Nat Gas**

BACKGROUND INFORMATION

Date: 12/20/22
Author: Richard Wheaton
Customer: Pacific AG
City & State: yakima, Washington

Boiler Model	CBEX Elite
Altitude (feet)	1095
Operating Pressure (psig)	110 00
Furnace Volume (cuft)	106.10
Furnace Heat Release (btu/hr/cu ft)	62,740
Heating Surface (sqft)	879
Nox System	9

Nat Gas		Firing Rate			
		25%	50%	75%	100%
Horsepower		63	125	188	250
Input , Btu/hr		2,495,000	4,976,000	7,504,000	10,038,000
CO	ppm	25	25	25	25
	lb/MMBtu	0.0187	0 0187	0.0187	0 0187
	lb/hr	0.05	0.09	0.14	0.19
	tpy	0 205	0.408	0 616	0.824
NOx	ppm	9	9	9	9
	lb/MMBtu	0.0105	0 0105	0.0105	0 0105
	lb/hr	0.03	0.05	0.08	0.11
	tpy	0.115	0.229	0 345	0.462
NO	ppm	7.7	7.7	7.7	7.7
	lb/MMBtu	0 009	0.009	0 009	0.009
	lb/hr	0.02	0.04	0.07	0.09
	tpy	0.09	0.18	0.28	0.37
NO_2	ppm	1.4	1.4	1.4	1.4
	lb/MMBtu	0 002	0.002	0 002	0.002
	lb/hr	0.00	0.01	0.01	0.02
	tpy	0.02	0.05	0.07	0.09
SOx	ppm	0.34	0.34	0.34	0.34
	lb/MMBtu	0.0006	0 0006	0.0006	0 0006
	lb/hr	0.0015	0 0029	0.0044	0 0059
	tpy	0 006	0.013	0 019	0.026
VOCs	ppm	8	8	8	8
(Non-Methane Only)	lb/MMBtu	0.0036	0 0036	0.0036	0 0036
	lb/hr	0 009	0.018	0 027	0.036
	tpy	0 039	0.078	0.117	0.157
VOCs does not include any background VOC emissions					
PM10 (Filterable)	ppm	N/A	N/A	N/A	N/A
	lb/MMBtu	0.0019	0 0019	0.0019	0 0019
	lb/hr	0 005	0.009	0 014	0.019
	tpy	0 020	0.041	0 061	0.082
PM10 (Condensable)	lb/MMBtu	0.0056	0 0056	0.0056	0 0056
	lb/hr	0 014	0.028	0 042	0.056
	tpy	0 061	0.122	0.184	0.246
PM2.5 (Filterable)	lb/MMBtu	0.0019	0 0019	0.0019	0 0019
	lb/hr	0 005	0.009	0 014	0.019
	tpy	0 020	0.041	0 061	0.082
PM2.5 (Condensable)	lb/MMBtu	0.0056	0 0056	0.0056	0 0056
	lb/hr	0 014	0.028	0 042	0.056
	tpy	0 061	0.122	0.184	0.246
Exhaust Data					
Temperature, F		289	310	328	343
Flow	ACFM	787	1,556	2,404	3,278
	SCFM (70 Degrees Fah.)	550	1 057	1 593	2 131
	DSCFM	495	947	1,428	1,910
	lb/hr	2,475	4,754	7,170	9,592
Velocity	ft/sec	6.01	11 89	18.35	25.03
	ft/min	361	713	1,101	1,502

Notes:

1) All ppm levels are corrected to dry at 3% oxygen.
2) Emission data based on actual boiler efficiency.
3) % H2O , by volume in exhaust gas is **16.05** % O2, by volume **3.81**
4) Water vapor in exhaust gas is **99.39** lbs/MMBtu of fuel fired
5) CO2 produced is **116.31** lbs/MMBtu of fuel fired
6) Particulate is exclusive of any particulates in combustion air or other sources of residual particulates from material.
PM level indicated on this form is based on combustion air and fuel being clean and turndown up to 4:1.
7) Heat input is based on high heating value (HHV).
8.) Emission produced in tons per year (tpy) is based on 24 hours per day for 365 days = 8,760 hours per year
9.) Exhaust data is based on a clean and properly sealed boiler.
10.) Emission data is based on a burner turndown of 4 to 1.
11.) Maximum flame temperature is 2800 degrees fahrenheit.

14) Fuel High Heating Value = **1000** Btu/FT^3

Table 2. Dimensions (Metric) Model CFC-E Hot water

ITEM	DIMENSIONS (mm)	500	750	1000	1500	2000	2500	3000	3500	4000	5000	6000
A	Overall Height	1982	1982	1982	2028	2028	2418	2418	2316	2316	2378	2378
B	Overall Width	886	886	886	908	908	907	907	1230	1230	1490	1490
C	Overall Dep h	1255	1255	1255	1422	1422	1422	1422	1738	1738	2048	2048
D	Width Less Casing	816	816	816	838	838	838	838	1160	1160	1420	1420
E	Gas Connec ion to Floor	1786	1786	1786	1877	1875	2167	2167	1974	1974	2019	2019
F	Side of Casing to Gas Connection	95	95	95	180	180	97	97	124	124	117	117
G	Side of Casing to Air Inlet	275	275	275	273	376	279	279	279	279	305	305
H	Top of Casing to Air Inlet	196	196	196	180	188	251	251	229	229	251	251
J	Floor to Condensate Drain	160	160	160	160	160	160	160	145	145	145	145
K	Floor to Bottom of Casing	279	279	279	279	279	290	290	290	290	305	305
L	Side of Base to Flue Outlet	189	189	189	217	217	198	198	224	224	254	254
M	Side of Base to Flue Outlet (Offset)	164	164	164	192	192	NA	NA	NA	NA	NA	NA
N	Rear of Base to Flue Outlet	165	165	165	190	190	191	191	224	224	249	249
P	Casing Depth	921	921	921	1077	1077	1077	1077	1334	1334	1577	1577
Q	Casing Height	1703	1703	1703	1749	1749	2129	2129	2027	2027	2073	2073
R	Floor to Lower Return Connection	428	428	428	428	428	429	429	427	427	470	470
S	Floor to Upper Return Connection	808	808	808	808	808	810	810	828	828	820	820
T	Floor to Supply Connection	1511	1511	1511	1511	1511	1788	1788	1582	1582	1608	1608
U	Floor to Air vent Connection	1683	1683	1683	1683	1683	1953	1953	1786	1786	1826	1826
V	Air Vent Line Projection From Rear of Casing	81	81	81	84	84	84	84	81	81	71	71

FORK POCKETS (mm)

LL	Pocket Height	102	102	102	102	102	102	102	102	102	102	102
MM	Pocket Width	300	300	300	300	300	300	300	399	399	447	447
NN	Overall Pocket Width	700	700	700	700	700	701	701	899	899	1001	1001

WEIGHTS

	Dry Weight (kg)	589	589	633	844	926	1098	1123	1621	1706	2223	2394
	Shipping Weight (kg)	641	641	686	901	983	983	983	1690	1775	2301	2472
	Operating Weight (kg)	939	939	969	1260	1280	1280	1280	2371	2406	3403	3474
	Water Volume (liter)	350	350	324	416	370	477	462	750	700	1180	1080

CLEARANCES (mm)

	500-4000	5000-6000
Top	356	457
Side	76	76
Rear	508	508
Front	914	914

Notes:

Boiler rear must be accessible for servicing.

Side clearance to wall or between boilers.

Side clearance typical each side.

Clearance dimensions are for servicing the boiler only. Refer to local and national electrical codes for proper minimum front panel service clearances.

Local code requirements, if more stringent, should take precedence.

Table 3. Model CFC-E Boiler Ratings (Sea Level to 2000 Feet)

		Boiler Size										
Description	**Units**	**500**	**750**	**1000**	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**5000**	**6000**
Input Max.	Btu/hr	500,000	750,000	1,000,000	1,500,000	2,000,000	2,500,000	3,000,000	3,500,000	4,000,000	5,000,000	6,000,000
	kcal/hr	126,000	189,000	252,000	378,000	504,000	630,000	756,000	882,000	1,008,000	1,260,000	1,512,000
Natural Gas	ft^3/hr	500	750	1000	1500	2000	2500	3000	3500	4000	5000	6000
Propane	ft^3/hr	200	300	400	600	800	1000	1200	1400	1600	2000	2400
Natural Gas	m^3/hr	14	21	28	42	57	71	85	99	113	142	170
Propane	m^3/hr	5.7	8.5	11	17	23	28	34	40	45	57	68
Output at 120/80 F [49/27 C] 100% Firing	Btu/hr	470,000	705,000	940,000	1,410,000	1,880,000	2,350,000	2,820,000	3,290,000	3,760,000	4,700,000	5,640,000
	kcal/hr	118,440	177,660	236,880	355,320	473,760	592,200	710,640	829,080	947,520	1,184,400	1,421,280
	bhp	14	21	28	42	56	70	84	98	112	140	168
	kW	138	207	275	413	551	689	826	964	1102	1377	1653
Output at 180/ 140 F [82/60 C] 100% Firing	Btu/hr	440,000	660,000	880,000	1,320,000	1,760,000	2,200,000	2,640,000	3,080,000	3,520,000	4,400,000	5,280,000
	kcal/hr	110,880	166,320	221,760	332,640	443,520	554,400	665,280	776,160	887,040	1,108,800	1,330,560
	bhp	13	20	26	39	53	66	79	92	105	131	158
	kW	129	193	258	387	516	645	774	903	1032	1290	1547
MAWP	psi	125	125	125	125	125	125	125	125	125	125	125
	bar	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6
MAWT	°F	210	210	210	210	210	210	210	210	210	210	210
	°C	99	99	99	99	99	99	99	99	99	99	99
Water Content	gallons	92	92	86	110	98	126	122	198	185	312	285
	liters	350	350	324	416	370	477	462	750	700	1180	1080
Weight w/o Water	pounds	1,298	1,298	1,396	1,861	2,041	2,420	2,475	3,574	3,761	4,901	5,278
	kg	589	589	633	844	926	1098	1123	1621	1706	2223	2394
Fireside Heating Surface	ft^2	193	193	252	388	489	546	593	889	1008	1262	1500
	m^2	18	18	23	36	45	51	55	83	94	117	139
Standby Heat Loss	Btu/hr	1000	1500	2000	3000	4000	5000	6000	7000	8000	10000	12000
	Watts	293	440	586	879	1172	1465	1758	2051	2344	2930	3516
ECM Blower Motor Size	Watts	335	335	335	1,700	1,700	1,200	2,400	2,400	2,400	6,000	6,000
Operating Voltage, Blower	Volts/ph/Hz	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60	460/3/60	460/3/60	460/3/60	460/3/60	460/3/60
Control Circuit	Volts/ph/Hz	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60
Max Current Draw, Blower	Amperes	4	4	4	13.5	13.5	13	4	4	4	12.7	12.7
Max Current Draw Control Circuit	Amperes	1.5	1.5	1.5	2	2	2	2	2	2	2	2
Max Over Current Protection	Amperes	20	20	20	20	20	20	20	20	20	20	20
Condensate Qty Firing Nat. Gas & operating @ 120/80 F.	gal/hr	3.5	5	7	10	13.5	17.6	20.6	24.0	27.0	34.0	40.5
Flue Gas Mass Flow @ 100% Firing	lb/hr	557	835	1,113	1,670	2,226	2,863	3,340	3,897	4,452	5,567	6,678
	kg/hr	252	379	505	758	1010	1299	1515	1768	2019	2525	3029

*CFC-E 2500 and 4000: 8% derate with 9 ppm NOx. If full capacity is required, contact your local Cleaver-Brooks representative for additional information.

Table 4. Altitude Correction for Input Capacity at Various Altitude Levels

Natural Gas MBTU/h at various altitudes

	700' ASL	2000'	4000'	6000'	8000'	10000'
CFC-E 500	500	500	473	438	406	389
CFC-E 750	750	750	750	707	655	628
CFC-E 1000	1000	1000	945	877	813	779
CFC-E 1500	1500	1500	1500	1500	1500	1472
CFC-E 2000	2000	2000	2000	1867	1730	1659
CFC-E 2500	2500	2500	2350	2209	1944	1594
CFC-E 3000	3000	3000	2820	2651	2333	1913
CFC-E 3500	3500	3500	3500	3290	2895	2374
CFC-E 4000	4000	4000	4000	3731	3060	2325
CFC-E 5000	5000	5000	5000	4700	4136	3392
CFC-E 6000	6000	6000	5640	4963	4070	3093

** Ratings assume 35% excess air, 80F combustion air.
Blower speed adjustments should be made to match performance and local conditions accordingly.
For minimum gas supply pressures see Table 14. Altitude corrections for supply pressure should be made per Table 15
Natural gas heating value of 1000 BTU/SCF assumed.

LP Gas MBTU/h at various altitudes

	700' ASL	2000'	4000'	6000'	8000'	10000'
CFC-E 500	500	500	500	472	437	419
CFC-E 750	750	750	750	750	724	694
CFC-E 1000	1000	1000	1000	926	858	822
CFC-E 1500	1500	1500	1500	1500	1500	1500
CFC-E 2000	2000	2000	2000	1867	1730	1659
CFC-E 2500	2500	2500	2350	2209	1944	1594
CFC-E 3000	3000	3000	3000	3290	2895	2374
CFC-E 3500	3500	3500	3500	3290	2895	2374
CFC-E 4000	4000	4000	3760	3309	2713	2062
CFC-E 5000	5000	5000	5000	4700	4136	3392
CFC-E 6000	6000	6000	5640	4963	4070	3093

** Ratings assume 40% excess air, 80F combustion air.
Blower speed adjustments should be made to match performance and local conditions accordingly.
For minimum gas supply pressures see Table 14. Altitude corrections for supply pressure should be made per Table 15\
LP (propane) gas heating value of 2500 BTU/SCF assumed.

PERFORMANCE DATA

Efficiency

The Model CFC-E is a "full condensing" boiler realizing efficiency gain at variable operating conditions. It is designed to extract the latent heat of condensation over a greater range than other designs. The nominal point of condensation is approximately 132° F (55.5 C). The ClearFire, due to its more efficient heat transfer design and lower stack temperature, is able to capture the latent heat of condensation over a broader range.

Fuel-to-water efficiency is relative to specific operating conditions. Operating efficiency will be greater in the "condensing" mode of operation as noted above, yet with its inherently greater heat transfer surfaces and superior premix burner, the ClearFire's efficiency under "traditional" hot water conditions is also outstanding. Table 5 shows the guaranteed efficiencies at various operating conditions and firing rates for Natural Gas. It should be noted that the efficiency is exceptional at high fire and low fire versus other designs where high efficiency is realized only with low fire or minimal firing rates and low temperature returns.

KOHLER®

KD2000

60 Hz. Diesel Generator Set
Tier 2 EPA Certified for Stationary Emergency Applications
EMISSION OPTIMIZED DATA SHEET

ENGINE INFORMATION

Model:	KD62V12	Bore:	175 mm (6.89 in.)
Type:	4-Cycle, 12-V Cylinder	Stroke:	215 mm (8.46 in.)
Aspiration:	Turbocharged, Intercooled	Displacement:	62 L (3783 cu. in.)
Compression ratio:	16:0:1		
Emission Control Device:	Direct Diesel Injection, Engine Control Module, Turbocharger, Charge Air Cooler		

NOMINAL EMISSION DATA

Cycle point	100% ESP	75% ESP	50% ESP	25% ESP
Power [kW]	2180	1635	1090	545
Speed [rpm]	1800	1800	1800	1800
Exhaust Gas Flow [kg/h]	13620	12480	9227	5486
Exhaust Gas Temperature [C]	431	436	451	458
NOx [g/kWh]	7.7	5.0	4.5	4.9
CO [g/kWh]	0.3	0.6	0.8	2.7
HC [g/kWh]	0.14	0.16	0.21	0.31
PM [g/kWh]	0.04	0.09	0.12	0.37

NOT TO EXCEED EMISSION DATA

Cycle point	100% ESP	75% ESP	50% ESP	25% ESP
NOx [g/kWh]	9.1	5.9	5.3	5.8
CO [g/kWh]	1.1	1.8	2.6	8.3
HC [g/kWh]	0.16	0.19	0.24	0.36
PM [g/kWh]	0.06	0.13	0.17	0.53

TEST METHODS AND CONDITIONS

Test Methods:

Steady-State emissions recorded per EPA CFR 40 Part 1065, and ISO8178-1 during operation at rated engine speed (+/-2%) and stated constant load (+/-2%) with engine temperatures, pressures and emission rated stabilized.

Fuel Specification:

40-48 Cetane Number, 0.05 Wt. % max. Sulfur; Reference ISO8178-5, 40CFR86.1313-98 Type 2-D and ASTM D975 No. 2-D.

Reference Conditions:

25 °C (77 °F) Air Inlet Temperature, 40 °C (104 °F) Fuel Inlet Temperature, 100 kPa (29.53 in Hg) Barometric Pressure; 10.7 g/kg (75 grains H2O/lb.) of dry air Humidity (required for NOx correction); Intake Restriction set to maximum allowable limit for clean filter; Exhaust Back pressure set to maximum allowable limit.

Data was taken from a single engine test according to the test methods, fuel specification and reference conditions stated above and is subjected to instrumentation and engine-to-engine variability. Tests conducted with alternate test methods, instrumentation, fuel or reference conditions can yield different results.

Data and specifications subject to change without notice.

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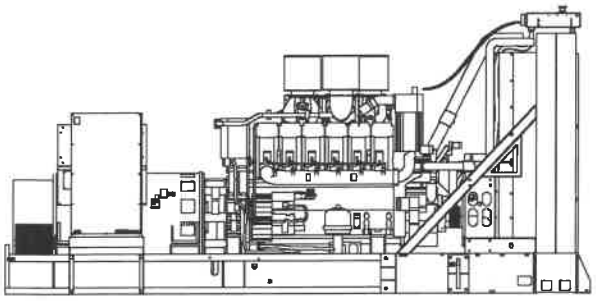
Industrial Diesel Generator Set - KD2000

Tier 2 EPA-Certified for Stationary Emergency Applications



KDxxxx designates a generator set with a Tier 2 EPA-Certified engine.
KDxxxx-F designates a 60 Hz generator set with a fuel optimized engine.

Ratings Range

		60 Hz
Standby:	**kW**	1990-2000
	kVA	2488-2500
Prime:	**kW**	1810
	kVA	2262

Standard Features

- Kohler Co. provides one-source responsibility for the generating system and accessories.
- The generator set and its components are prototype-tested, factory-built, and production-tested.
- The 60 Hz generator set offers a UL 2200 listing.
- The generator set accepts rated load in one step.
- The 60 Hz generator set meets NFPA 110, Level 1, when equipped with the necessary accessories and installed per NFPA standards.
- A standard three-year or 1000-hour limited warranty for standby applications. Five-year basic, five-year comprehensive, and ten-year extended limited warranties are also available.
- A standard two-year or 8700-hour limited warranty for prime power applications.
- Other features:
  - Kohler designed controllers for one-source system integration and remote communication. See Controllers on page 4.
  - The low coolant level shutdown prevents overheating (standard on radiator models only).

General Specifications

Orderable Generator Model Number	GMKD2000
Manufacturer	Kohler
Engine: model	KD62V12
Alternator Choices	KH04970TO4D KH06220TO4D KH06930TO4D KH07000TO4D KH07080TO4D KH07630TO4D KH07770TO4D KH08430TO4D KH09270TO4D
Performance Class	Per ISO 8528-5
One Step Load Acceptance	100%
Voltage	Wye, 600 V., 4160 V, or 6600-13800 V
Controller	APM603, APM802
Fuel Tank Capacity, L (gal.)	8577-16383 (2266-4328)
Fuel Consumption, L/hr (gal./hr) 100% at Standby	564 (149.1)
Fuel Consumption, L/hr (gal./hr) 100% at Prime Power	516 (136.3)
Emission Level Compliance (KDxxxx)	Tier 2
Open Unit Noise Level @ 7 m dB(A) at Rated Load	—
Data Center Continuous (DCC) Rating (Refer to TIB-101 for definitions)	Same as the Standby Rating below

Generator Set Ratings

				150°C Rise Standby Rating		130°C Rise Standby Rating		125°C Rise Prime Rating		105°C Rise Prime Rating	
Alternator	**Voltage**	**Ph**	**Hz**	**kW/kVA**	**Amps**	**kW/kVA**	**Amps**	**kW/kVA**	**Amps**	**kW/kVA**	**Amps**
KH04970TO4D	277/480	3	60	2000/2500	3008	2000/2500	3008	1810/2262	2721	1810/2262	2721
KH06930TO4D	220/380	3	60	2000/2500	3798	2000/2500	3798	1810/2262	3438	1810/2262	3438
	240/416	3	60	2000/2500	3470	2000/2500	3470	1810/2262	3140	1810/2262	3140
	277/480	3	60	2000/2500	3008	2000/2500	3008	1810/2262	2721	1810/2262	2721
	347/600	3	60	2000/2500	2406	2000/2500	2406	1810/2262	2177	1810/2262	2177
KH07770TO4D	220/380	3	60	1990/2488	3781	1990/2488	3781	1810/2262	3437	1810/2262	3437
	240/416	3	60	2000/2500	3470	2000/2500	3470	1810/2262	3140	1810/2262	3140
KH08430TO4D	220/380	3	60	2000/2500	3799	2000/2500	3799	1810/2262	3437	1810/2262	3437
	240/416	3	60	2000/2500	3470	2000/2500	3470	1810/2262	3140	1810/2262	3140
	277/480	3	60	2000/2500	3008	2000/2500	3008	1810/2262	2721	1810/2262	2721
	347/600	3	60	2000/2500	2406	2000/2500	2406	1810/2262	2177	1810/2262	2177
	2400/4160	3	60	2000/2500	347	2000/2500	347	1810/2262	314	1810/2262	314
KH06220TO4D	2400/4160	3	60	2000/2500	347	2000/2500	347	1810/2262	314	1810/2262	314
KH07000TO4D	347/600	3	60	2000/2500	2406	2000/2500	2406	1810/2262	2177	1810/2262	2177
	2400/4160	3	60	2000/2500	347	2000/2500	347	1810/2262	314	1810/2262	314

RATINGS: All three-phase units are rated at 0.8 power factor. *Standby Ratings:* The standby rating is applicable to varying loads for the duration of a power outage. There is no overload capability for this rating. *Prime Power Ratings:* At varying load, the number of generator set operating hours is unlimited. A 10% overload capacity is available for one hour in twelve. Ratings are in accordance with ISO-8528-1 and ISO-3046-1. For limited running time and continuous ratings, consult the factory. Obtain technical information bulletin (TIB-101) for ratings guidelines, complete ratings definitions, and site condition derates. The generator set manufacturer reserves the right to change the design or specifications without notice and without any obligation or liability whatsoever.

KOHLER.

Industrial Diesel Generator Set - KD2000

Tier 2 EPA-Certified for Stationary Emergency Applications

Alternator	Voltage	Ph	Hz	130°C Rise Standby Rating kW/kVA	Amps	105°C Rise Prime Rating kW/kVA	Amps
KH07080TO4D	3810/6600	3	60	2000/2500	219	1810/2262	198
	7200/12470	3	60	1990/2488	116	1810/2262	105
	7620/13200	3	60	1990/2488	109	1810/2262	99
	7970/13800	3	60	2000/2500	105	1810/2262	95
KH07630TO4D	3810/6600	3	60	2000/2500	219	1810/2262	198
	7200/12470	3	60	2000/2500	116	1810/2262	105
	7620/13200	3	60	2000/2500	110	1810/2262	99
	7970/13800	3	60	2000/2500	105	1810/2262	95
KH09270TO4D	3810/6600	3	60	2000/2500	219	1810/2262	198
	7200/12470	3	60	2000/2500	116	1810/2262	105
	7620/13200	3	60	2000/2500	110	1810/2262	99
	7970/13800	3	60	2000/2500	105	1810/2262	95

Engine Specifications	60 Hz
Manufacturer	Kohler
Engine: model	KD62V12
Engine: type	4-Cycle, Turbocharged, Intercooled
Cylinder arrangement	12-V
Displacement, L (cu. in.)	62 (3783)
Bore and stroke, mm (in.)	175 x 215 (6.89 x 8.46)
Compression ratio	16.0:1
Piston speed, m/min. (ft./min.)	774 (2539)
Main bearings: quantity, type	7, Precision Half Shells
Rated rpm	1800
Max. power at rated rpm, kWm (BHP)	2180 (2923)
Cylinder head material	Cast Iron
Crankshaft material	Steel
Valve (exhaust) material	Steel
Governor: type, make/model	KODEC Electronic Control
Frequency regulation, no-load to-full load	Isochronous
Frequency regulation, steady state	±0.25%
Frequency	Fixed
Air cleaner type, all models	Dry

Lubricating System	60 Hz
Type	Full Pressure
Oil pan capacity with filter (initial fill), L (qt.) §	335 (354)
Oil filter: quantity, type §	6, Cartridge
Oil cooler	Water-Cooled

§ Kohler recommends the use of Kohler Genuine oil and filters.

Fuel System	60 Hz
Fuel supply line, min. ID, mm (in.)	25 (1.0)
Fuel return line, min. ID, mm (in.)	19 (0.75)
Max. fuel flow, Lph (gph)	768 (202.9)
Min./max. fuel pressure at engine supply connection, kPa (in. Hg)	-30/30 (-8.8/8.8)
Max. return line restriction, kPa (in. Hg)	30 (8.9)
Fuel filter: quantity, type	2, Primary Engine Filter 2, Fuel/Water Separator
Recommended fuel	#2 Diesel ULSD

Fuel Consumption	60 Hz
Diesel, Lph (gph) at % load	**Standby Rating**
100%	564 (149.1)
75%	433 (114.3)
50%	308 (81.3)
25%	186 (49.1)
Diesel, Lph (gph) at % load	**Prime Rating**
100%	516 (136.3)
75%	401 (106.0)
50%	287 (75.8)
25%	172 (45.5)

Radiator System	60 Hz	
Ambient temperature, °C (°F)*	50 (122)	40 (104)
Engine jacket water capacity, L (gal.)	356 (94)	
Radiator system capacity, including engine, L (gal.)	643 (170)	539 (142)
Engine jacket water flow, Lpm (gpm)	2082 (550)	
Heat rejected to cooling water at rated kW, dry exhaust, kW (Btu/min.)	780 (44357)	
Charge cooler water flow, Lpm (gpm)	662 (174)	
Heat rejected to charge cooling water at rated kW, dry exhaust, kW (Btu/min.)	630 (35827)	
Water pump type	Centrifugal	
Fan diameter, including blades, mm (in.)	2235 (88)	1901 (75)
Fan, kWm (HP)	90 (120.7)	85 (114)
Max. restriction of cooling air, intake and discharge side of radiator, kPa (in. H_2O)	0.125 (0.5)	

* Enclosure with enclosed silencer reduces ambient temperature capability by 5°C (9°F).

Remote Radiator System†	60 Hz
Exhaust manifold type	Dry
Connection sizes:	Class 150 ANSI Flange
Water inlet/outlet, mm (in.)	216 (8.5) Bolt Circle
Intercooler inlet/outlet, mm (in.)	178 (7.0) Bolt Circle
Static head allowable above engine, kPa (ft. H_2O)	70 (23.5)

† Contact your local distributor for cooling system options and specifications based on your specific requirements.

Exhaust System	60 Hz
Exhaust flow at rated kW, m^3/min. (cfm)	498 (17586)
Exhaust temperature at rated kW at 25°C (77°F) ambient, dry exhaust, °C (°F)	500 (932)
Maximum allowable back pressure, kPa (in. Hg)	8.5 (2.5)
Exh. outlet size at eng. hookup, mm (in.)	See ADV drawing

Electrical System	60 Hz
Battery charging alternator:	
Ground (negative/positive)	Negative
Volts (DC)	24
Ampere rating	140
Starter motor qty. at starter motor power rating, rated voltage (DC)	Standard: 2 @ 9 kW, 24; Redundant (optional); 2 @ 15 kW, 24
Battery, recommended cold cranking amps (CCA):	
Quantity, CCA rating each, type (with standard starters)	4, 1110, AGM
Quantity, CCA rating each, type (with redundant starters)	8, 1110, AGM
Battery voltage (DC)	12

Air Requirements	60 Hz	
Radiator-cooled cooling air, m^3/min. (scfm)‡	50°C 2549 (90000)	40°C 2321 (82000)
Cooling air required for generator set when equipped with city water cooling or remote radiator, based on 14°C (25°F) rise, m^3/min. (scfm)‡	930 (32858)	
Combustion air, m^3/min. (cfm)	179 (6321)	
Heat rejected to ambient air:		
Engine, kW (Btu/min.)	100 (5687)	
Alternator, kW (Btu/min.)	160 (9099)	

‡ Air density = 1.20 kg/m^3 (0.075 lbm/ft^3)

Alternator Specifications		60 Hz
Type		4-Pole, Rotating-Field
Exciter type		Brushless, Permanent-Magnet Pilot Exciter
Voltage regulator		Solid-State, Volts/Hz
Insulation:		NEMA MG1, UL 1446, Vacuum Pressure Impregnated (VPI)
Material		Class H, Synthetic, Nonhygroscopic
Temperature rise		130°C, 150°C Standby
Bearing: quantity, type		1 or 2, Sealed
Coupling type		Flexible Disc or Coupling
Amortisseur windings		Full
Alternator winding type (up to 600 V)		Random Wound
Alternator winding type (above 600 V)		Form Wound
Rotor balancing		125%
Voltage regulation, no-load to full-load		±0.25%
Unbalanced load capability		100% of Rated Standby Current
Peak motor starting kVA:		(35% dip for voltages below)
480 V	KH04970TO4D	3750
480 V	KH06930TO4D	5990
480 V	KH07770TO4D	7170
480 V	KH08430TO4D	9908

Alternator Standard Features

- The pilot-excited, permanent magnet (PM) alternator provides superior short-circuit capability.
- All models are brushless, rotating-field alternators.
- NEMA MG1, IEEE, and ANSI standards compliance for temperature rise and motor starting.
- Sustained short-circuit current of up to 300% of the rated current for up to 10 seconds.
- Sustained short-circuit current enabling downstream circuit breakers to trip without collapsing the alternator field.
- Self-ventilated and dripproof construction.
- Superior voltage waveform from two-thirds pitch windings and skewed stator.
- Brushless alternator with brushless pilot exciter for excellent load response.

NOTE: See TIB-102 Alternator Data Sheets for alternator application data and ratings, efficiency curves, voltage dip with motor starting curves, and short circuit decrement curves.

Controllers

APM802 Controller
Provides advanced control, system monitoring, and system diagnostics for optimum performance and compatibility.

- 12-inch graphic display with touch screen and menu control provide easy local data access
- Measurements are selectable in metric or English units
- User language is selectable
- Two USB ports allow connection of a flash drive, mouse, or keypad
- Electrical data, mechanical data, and system settings can be saved to a flash drive
- Ethernet port allows connection to a PC type computer or Ethernet switch
- The controller supports Modbus® RTU and TCP protocols
- NFPA 110 Level 1 capability

Refer to G6-152 for additional controller features and accessories.

Modbus® is a registered trademark of Schneider Electric.

APM603 Controller
Provides advanced control, system monitoring, and system diagnostics for optimum performance and compatibility.

- 7-inch graphic display with touch screen and menu control provides easy local data access
- Measurements are selectable in metric or English units
- Paralleling capability to control up to 8 generators on an isolated bus with first-on logic, synchronizer, kW and kVAR load sharing, and protective relays
  Note: Parallel with other APM603 controllers only
- Generator management to turn paralleled generators off and on as required by load demand
- Load management to connect and disconnect loads as required
- Controller supports Modbus® RTU, Modbus® TCP, SNMP and BACnet®
- Integrated voltage regulator with ±0.25% regulation
- Built-in alternator thermal overload protection
- UL-listed overcurrent protective device
- NFPA 110 Level 1 capability

Refer to G6-162 for additional controller features and accessories.

BACNet® is a registered trademark of ASHRAE.

Codes and Standards

- Engine- generator set is designed and manufactured in facilities certified to ISO 9001.
- Generator set meets NEMA MG1, BS5000, ISO, DIN EN, and IEC standards, NFPA 110.
- Engine generator set is tested to ISO 8528-5 for transient response.
- The generator set and its components are prototype-tested, factory-built, and production-tested.

Third-Party Compliance

- Tier 2 EPA-Certified for Stationary Emergency Applications

Available Approvals and Listings

- ☐ California OSHPD Approval
- ☐ CSA Certified
- ☐ IBC Seismic Certification
- ☐ UL 2200 Listing
- ☐ cULus Listing (fuel tanks only)
- ☐ Florida Dept. of Environmental Protection (FDEP) Compliance (fuel tanks only)

Warranty Information

- A standard three-year or 1000-hour limited warranty for standby applications. Five-year basic, five-year comprehensive, and ten-year extended limited warranties are also available.
- A standard two-year or 8700-hour limited warranty for prime power applications.

Available Warranties for Standby Applications

- ☐ 5-Year Basic Limited Warranty
- ☐ 5-Year Comprehensive Limited Warranty
- ☐ 10-Year Major Components Limited Warranty

Standard Features

- Closed Crankcase Ventilation (CCV) Filters
- Customer Connection
- Local Emergency Stop Switch
- Oil Drain and Coolant Drain Extension
- Operation and Installation Literature
- Fan Bearing Grease Extension
- Fuel/Water Separator
- Generator Heater
- Spring Isolation Under the Skid

KOHLER.

Industrial Diesel Generator Set - KD2000
Tier 2 EPA-Certified for Stationary Emergency Applications

Available Options

Circuit Breakers

Type	Rating
❑ Magnetic Trip	❑ 80%
❑ Thermal Magnetic Trip	❑ 100%
❑ Electronic Trip (LI)	**Operation**
❑ Electronic Trip with Short Time (LSI)	❑ Manual
	❑ Electrically Operated (for paralleling)

Circuit Breaker Mounting

- ❑ Generator Mounted
- ❑ Remote Mounted
- ❑ Bus Bar (for remote mounted breakers)

Enclosed Remote Mounted Circuit Breakers

- ❑ NEMA 1 (15-5000 A)
- ❑ NEMA 3R (15-1200 A)

Engine Type

- ❑ KDxxxx Tier 2 EPA-Certified Engine
- ❑ KDxxxx-F Fuel Optimized Engine

Approvals and Listings

- ❑ California OSHPD Approval
- ❑ CSA Certified
- ❑ IBC Seismic Certification
- ❑ UL 2200 Listing
- ❑ cULus Listing (fuel tanks only)
- ❑ Florida Dept. of Environmental Protection (FDEP) Compliance (fuel tanks only)

Enclosed Unit

- ❑ Sound Level 1 Enclosure/Fuel Tank Package
- ❑ Sound Level 2 Enclosure/Fuel Tank Package

Open Unit

- ❑ Exhaust Silencer, Critical
- ❑ Exhaust Silencer, Hospital
- ❑ Flexible Exhaust Connector, Stainless Steel

Controller

- ❑ Input/Output, Digital
- ❑ Input/Output, Thermocouple (standard on 4160 V and above)
- ❑ Load Shed (APM802 only)
- ❑ Manual Key Switch
- ❑ Remote Emergency Stop Switch
- ❑ Lockable Emergency Stop Switch
- ❑ Remote Serial Annunciator Panel

Cooling System

- ❑ Block Heater; 9000 W, 208 V, (Select 1 Ph or 3 Ph) *
- ❑ Block Heater; 9000 W, 240 V, (Select 1 Ph or 3 Ph) *
- ❑ Block Heater; 9000 W, 380 V, 3 Ph *
- ❑ Block Heater; 9000 W, 480 V, (Select 1 Ph or 3 Ph) *

* Required for Ambient Temperatures Below 10°C (50°F)

Electrical System

- ❑ Battery, AGM (kit with qty. 4)
- ❑ Battery Charger
- ❑ Battery Heater; 100 W, 120 V, 1Ph
- ❑ Battery Rack and Cables
- ❑ Redundant Starters

Fuel System

- ❑ Flexible Fuel Lines
- ❑ Restriction Gauge (for fuel/water separator)

Literature

- ❑ General Maintenance
- ❑ NFPA 110
- ❑ Overhaul
- ❑ Production

Miscellaneous

- ❑ Air Cleaner, Heavy Duty
- ❑ Air Cleaner Restriction Indicator
- ❑ Automatic Oil Replenishment System
- ❑ Engine Fluids (oil and coolant) Added
- ❑ Rated Power Factor Testing

Electrical Package (Requires Enclosure selection)

- ❑ Basic Electrical Package (select 1 Ph or 3 Ph)
- ❑ Wire Battery Charger (1 Ph)
- ❑ Wire Block Heater (select 1 Ph or 3 Ph)
- ❑ Wire Controller Heater (1 Ph)
- ❑ Wire Generator Heater (1 Ph)

Warranty (Standby Applications only)

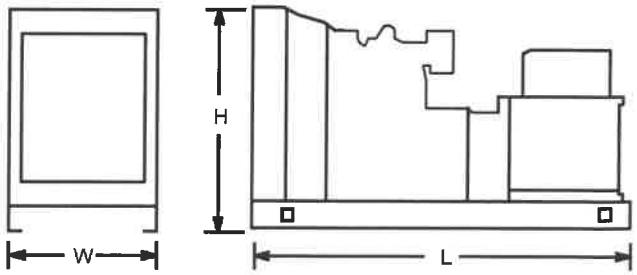
- ❑ 5-Year Basic Limited Warranty
- ❑ 5-Year Comprehensive Limited Warranty
- ❑ 10-Year Major Components Limited Warranty

Other

- ❑
- ❑

Dimensions and Weights

Overall Size, max., L x W x H, mm (in.):	6957 x 2852 x 3307 (273.9 x 112.3 x 130.2)
Weight, radiator model, max. wet, kg (lb.):	27033 (59598)



NOTE: This drawing is provided for reference only and should not be used for planning installation. Contact your local distributor for more detailed information.

KOHLER

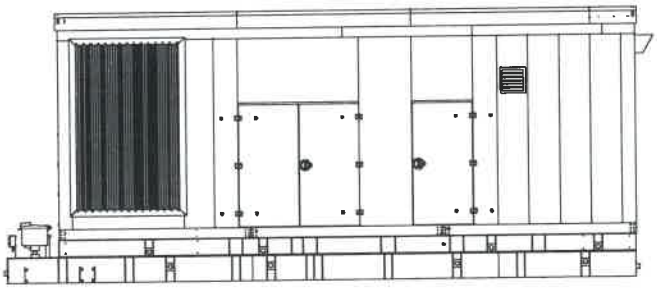
Industrial Diesel Generator Set - KD2000
Tier 2 EPA-Certified for Stationary Emergency Applications

KOHLER CO., Kohler, Wisconsin 53044 USA
Phone 920-457-4441, Fax 920-459-1646
For the nearest sales and service outlet in the US and Canada, phone 1-800-544-2444
KOHLERPower.com

Sound Enclosures and Subbase Fuel Tank

Sound Level 1 Enclosure Standard Features

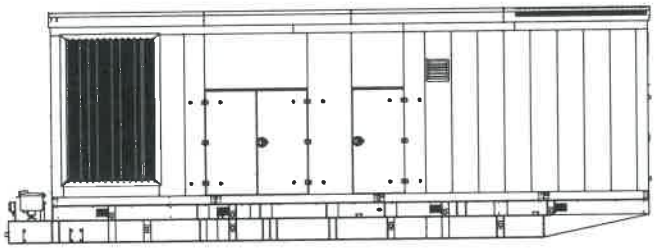
- Lift base or tank-mounted, aluminum construction enclosure with internal-mounted, exhaust silencers.
- Every enclosure has a sloped roof to reduce the buildup of moisture and debris.
- Sound attenuated enclosure that offers noise reduction using acoustic insulation, acoustic-lined air inlets and an acoustic-lined air discharge.
- Fade-, scratch-, and corrosion-resistant Kohler® Power Armor™ automotive-grade textured finish.
- Acoustic insulation that meets UL 94 HF1 flammability classification.
- Enclosure has large access doors that are hinged and removable which allow for easy maintenance.
- Lockable, flush-mounted door latches.
- Air inlet louvers reduce rain and snow entry.
- High wind bracing, 241 kph (150 mph).



Sound Level 1 Enclosure
(Shown with available spill containment)

Sound Level 2 Enclosure Standard Features

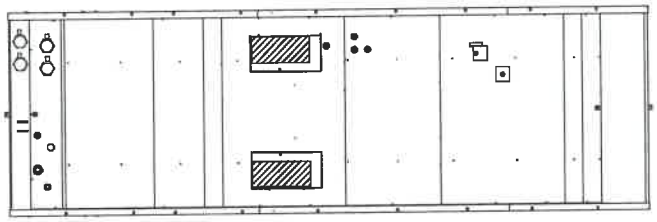
- Includes all of the sound level 1 enclosure features with the addition of up to 51 mm (2 in.) acoustic insulation material, intake sound baffles, vertical air discharge, and secondary silencers.
- Louvered air inlet and vertical outlet hood with 90 degree angles to redirect air and reduce noise.



Sound Level 2 Enclosure
(Shown with available spill containment)

Subbase Fuel Tank Features

- The fuel tank has a Power Armor Plus™ textured epoxy-based rubberized coating.
- The above-ground rectangular secondary containment tank mounts directly to the generator set, below the generator set skid (subbase).
- Both the inner and outer tanks have UL-listed emergency relief vents.
- Flexible fuel lines are provided with subbase fuel tank selection.
- The containment tank's construction protects against fuel leaks or ruptures. The inner (primary) tank is sealed inside the outer (secondary) tank. The outer tank contains the fuel if the inner tank leaks or ruptures.
- The above ground secondary containment subbase fuel tank meets UL 142 requirements.
- Features include:
  - Additional fittings for optional accessories (qty. 3)
  - Electrical stub-up area open to bottom
  - Emergency inner and outer tank relief vents
  - Fuel fill with lockable cap and 51 mm (2 in.) riser
  - Fuel leak detection switch
  - Fuel level mechanical gauge
  - Fuel level sender
  - Normal vent
  - Removable engine supply and return diptubes



Subbase Fuel Tank (Top View)

DISTRIBUTED BY:

BIOGAS ENCLOSED FLARE

FEATURES:

- Low NOx and CO
- Externally Adjustable Internal Primary Air Dampers
- Very Low Noise, Zero Rumble
- Low Manifold Pressure Requirements
- 100% Stainless Steel Burner with Refractory Venturi Inserts

BENEFITS:

- Meets Nationwide Emission Standards
- Easy to Tune During Source Testing, While Flare Is In Operation
- Ideal for Noise-Sensitive Areas
- Reduces Blower HP Requirements
- Long Burner Life

STANDARD EQUIPMENT:

- Stainless Steel Burner (2 Year Warranty)
- High Temperature Louvers
- U.L. Listed Frame Safeguard Control Panel
- 4" Ceramic Fiber Blanket Insulation (250°F Skin Temperature)
- Stainless Steel Weather & Heat Protection At Top of Flare
- 1200°F Paint System

OPTIONAL EQUIPMENT:

- Ladder & Platform
- Heat Shield
- Condensate Destruction System
- Purge Blower
- Auxiliary Fuel System
- Low NO_x Burner
- Micro Flare
- Other Fuels & Waste Gases
- Custom Ratings, Low Turndowns

Phone: (417) 256-2002
sales@perennialenergy.com

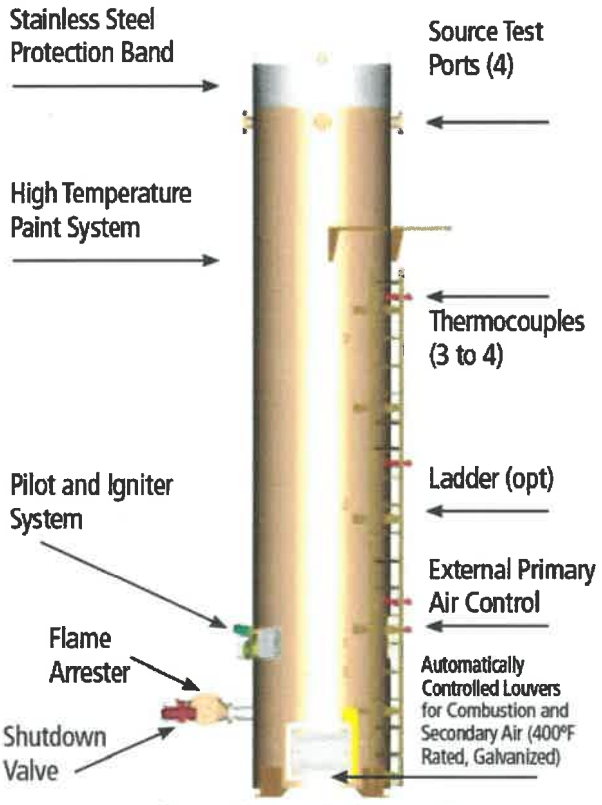
PEI PERENNIAL ENERGY
www.PerennialEnergy.com

PERENNIAL ENERGY ENCLOSED FLARE RATINGS

Maximum Btu/hr (Million)	Inlet Pipe Size	Flare Dimensions (Diameter x Height)	30% CH_4		40% CH_4		50% CH_4	
			Maximum Flow (scfm)	Minimum Flow (scfm)*	Maximum Flow (scfm)	Minimum Flow (scfm)*	Maximum Flow (scfm)	Minimum Flow (scfm)*
4	4"	4' Dia x 20' High	222	44	166	33	133	26
6	4"	4.5' Dia x 23' High	333	66	250	50	200	40
9	6"	5' Dia x 26' High	500	100	375	75	300	60
14	6"	6' Dia x 26' High	778	156	583	117	467	93
18	6"	6.5' Dia x 28' High	1,000	200	750	150	600	120
22	8"	7' Dia x 30' High	1,222	245	917	184	733	147
30	10"	8' Dia x 30' High	1,666	333	1,250	250	1,000	200
36	10"	9' Dia x 30' High	2,000	400	1,500	300	1,200	240
42	10"	9.5' Dia x 30' High	2,333	467	1,750	350	1,400	280
48	10"	10' Dia x 30' High	2,666	533	2,000	400	1,600	320
54	12"	10.5' Dia x 32' High	3,000	600	2,250	450	1,800	360
66	12"	10.5' Dia x 38' High	3,666	733	2,750	550	2,200	440
90	12"	12' Dia x 38' High	5,000	1,000	3,750	750	3,000	600
120	13" x 28"	12.5' Dia x 48' High	6,666	1,333	5,000	1,000	4,000	800

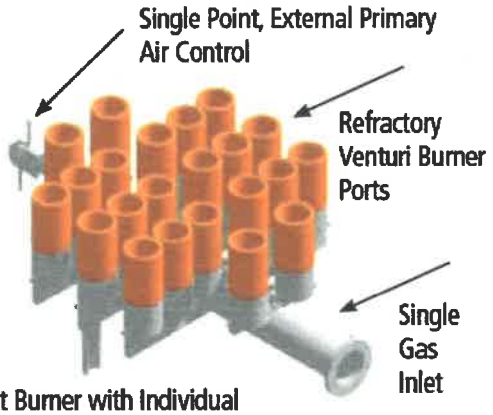
Assumes a standard 5:1 turndown. Greater turndowns are available, consult factory.

THE FLARE



Flare must be operated with approved flame safeguard controls (optional)

THE BURNER



Multi-Port Burner with Individual Refractory Burner Ports

PERENNIAL ENERGY
www.PerennialEnergy.com
Phone: (417) 256-2002
sales@perennialenergy.com

Sunnyside RNG

222-024

Q: Do we have a Nitrogen / Ammonia Problem in the AD Process?

Answer: No we don't have an N-Issue here.

Justification:

Nitrogen has a negative effect on the Microbiome in an anaerobic digester mainly due to inhibiting the biochemic process of the bacteria if present in the NH4 form (Ammonia).

Limiting Level in a mesophilic AD process for NH4 is regarded to be: 3.000 ppm*L^{-1} NH4 (1)

How much Nitrogen do we expect in total?

Cow Slurry is indicated to contain an average of 45.9 kg/to TS (2)

The Client has in addition given the following Data:

- 14% TS
- 78% VS

Straw is indicated to contain an average of 6.0 kg/to TS (3)

The Client has in addition given the following Data:

- 90% TS
- 90% VS

WELTEC BIOPOWER has calculated the Nutrient content based on these findings as follows:

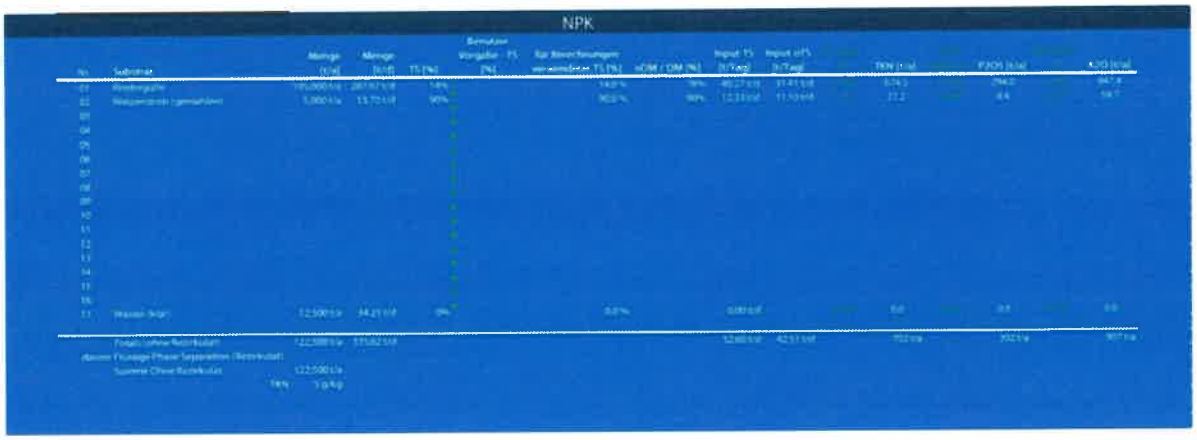


Figure 1: TKN calculation by WELTEC BIOPOWER

This calculation comes to the result, that we can expect a TOTAL Nitrogen content of 5g/kg or 5.000ppm

Now we must have a look in which chemical form Nitrogen is present.

The distribution between NH_3 and NH_4 (the most common forms) are determined by pH-Value and Temperature. (We ignore that some of the Nitrogen in the Digester is still bound on other organic molecules)

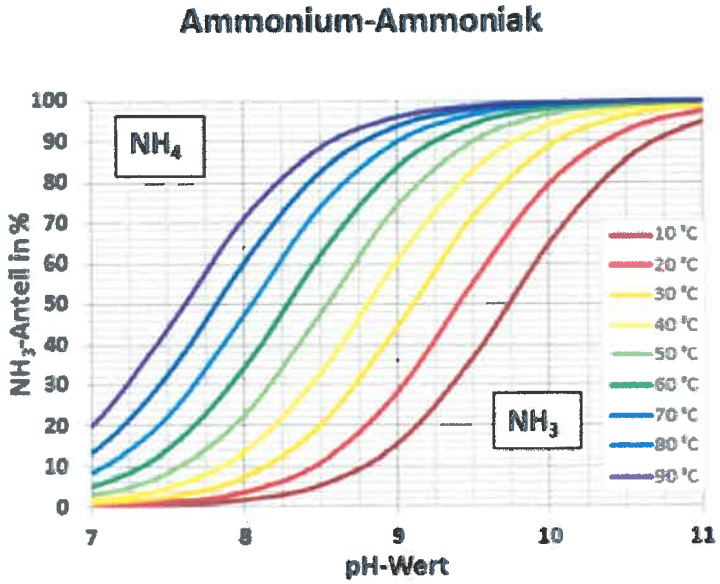


Figure 2: NH3 vs NH4 Balance pH/temp

For the AD process will be operating between 40°C and 50°C. This means we have to have a look at the area between the yellow and light green curve.

The digesters, under normal circumstances, operate in a pH-Value range between 7.2 and 8.

In conclusion we can assume that between 12% and 22% of the Total Nitrogen will be present as NH_3.

5.000 x 0.22 = 1.100 ppm of NH_3 can be anticipated in the substrate mix inside the digester.

This makes it reasonable to expect no inhibition of the biogas production by the present NH3.

The second factor we must look at is the possible inhibition resulting from undissociated NH_3.

The correlation between these is represented by the following equation:

$$c_{NH_3} = c_{NH_4} \cdot \frac{10^{pH}}{e^{\frac{6344}{273+T}} + 10^{pH}}$$

Equation 5.3: Calculation of ammonia concentration according to [5-30] (c_{NH_3} concentration of ammonia ($g \cdot l^{-1}$), c_{NH_4} concentration of ammonium ($g \cdot l^{-1}$), T temperature (°C))

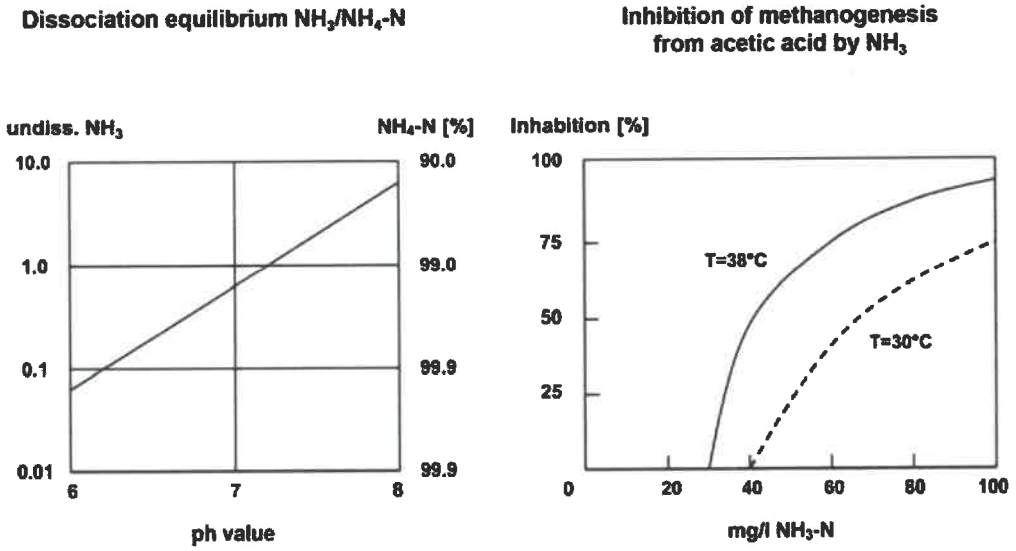


Figure 3:Inhibition of methanogenesis from acetic acid by NH3 (5)

As per this graph round about 2% of the NH_4 is indeed undissociated NH_3. In our case that's around 125ppm.

The Limiting Level for undiss. NH_3 is to be approx. 150ppm as per (4)[1]

Hence it is reasonable to also not expect an inhibition from the Level of undiss. NH_3.

[1] This experiment was conducted with anaerobic processing of sewage sludge, from domestic wastewater in mind. It is not clear how transferable the result really is towards biogas production in a CSTR Digester.

Literatur:

1. **McCarty, P.L.** *Anaerobic Waste Treatment Fundamentals.* 1964.

2. **Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V.** *Substrate Analysis.* 2005.

3. **Bayrische Landesanstallt für Landwirtschaft.** 2008.

4. **McCarty, P.L. and McKinney.** Salt toxicity in anaerobic digestion. *Journal Water Pollution Control Federation, Washinton D.C.* 1961, Vol. 33, 399.

5. **Kroiss, H.** Anaerobe Abwasserreinigung. [Buchverf.] Technische Universität Wien. *Wiener Mitteilungen Bd. 62.* Wien : Technische Universität Wien, 1985.

PAQUES

THIOPAQ®

Biogas desulfurization

Deep hydrogen sulfide removal from biogas at high uptime enables industries to meet stringent gas quality requirements.

revitalizing resources

Deep hydrogen sulfide removal

Biogas is an important renewable energy source. However, the gas originating from anaerobic digestion plants, anaerobic wastewater treatment plants and landfills often contains hydrogen sulfide (H_2S). Removal of H_2S is required for reasons of health, safety, environment and corrosion of equipment such as gas engines, boilers and piping.

The THIOPAQ® was developed by Paques in cooperation with universities, research institutes and customers. Fundamental and applied research into biological, physical and mechanical aspects of the system resulted in a cost-effective and reliable system.

Through continuous development Paques is able to provide every customer with a tailor-made gas treatment solution that enables the customer to transport biogas with reduced safety, environmental, and corrosion risks, and to fuel local gas-fired microgrids, or upgrade the gas to biomethane. Additionally, the elemental sulfur produced by the THIOPAQ® can be used as a high-quality fertilizer.

About THIOPAQ®

- Proven technology
  > 30 years operational experience
- > 300 THIOPAQ® references worldwide
- Continuous innovation
- In-house manufacturing and quality control
- Deep H_2S removal
- High uptime and reliable process
- Low total costs of ownership
- No air input in biogas
- Production of high-quality fertilizer

THIOPAQ®

Operation principle

The 'caustic' solution in the THIOPAQ® scrubber is continuously biologically regenerated. In the scrubber, the gas containing H_2S is brought into contact with the wash solution in counter-current. Absorption of H_2S under slightly alkaline conditions (pH 8-9) enables a chemical reaction with hydroxide ions:

$$H_2S_{gas} + OH^- \rightarrow HS^-_{liquid} + H_2O$$

In the bioreactor the sulfide is oxidised into elemental sulfur by autotrophic colorless sulfidogenic bacteria:

$$HS^-_{liquid} + \tfrac{1}{2} O_2 \rightarrow S^\circ + OH^-$$

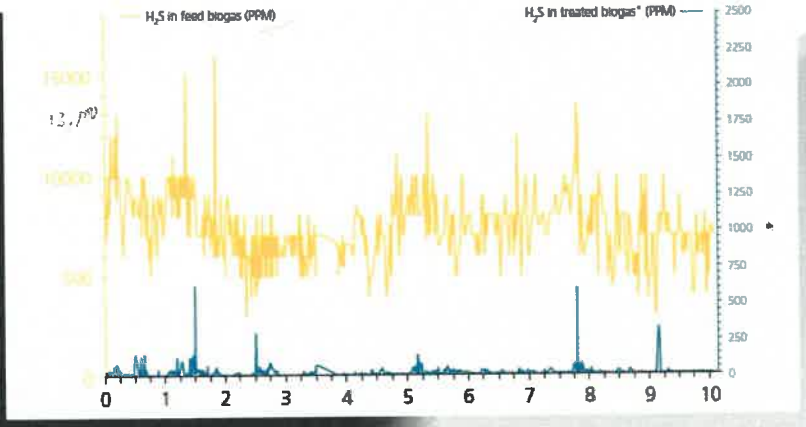
The hydroxide used in the scrubber is regenerated in the bioreactor. Since the wash solution entering the scrubber at the top is sulfide-free, a high concentration difference between the liquid and gas phase makes it possible to obtain a very high H_2S removal efficiency: exceeding 99.5%. Both the small bleed stream (consisting of sodium salts) and the produced sulfur are free of sulfide, so discharge is not a problem.

Application

The THIOPAQ® scrubber can be applied to a wide range of biogas streams containing H_2S and can be combined with all biological anaerobic systems. After treatment in the THIOPAQ® scrubber, the biogas can be used in a gas engine or boiler or can be transported and used to fuel a local gas-fired microgrid. Upgrading to biomethane, which can be brought into the gas distribution network or used as fuel for vehicles is another possibility.

- Gas flows from 50 to 2,500 Nm³/h
- Sulfur load up to 600 kg S/day
- Custom-made design for higher gas flows. References for > 10,000 Nm³/h and sulfur loads > 5 tons S/day

THIOPAQ®: influent independent, stable performance



THIOPAQ®: how it works

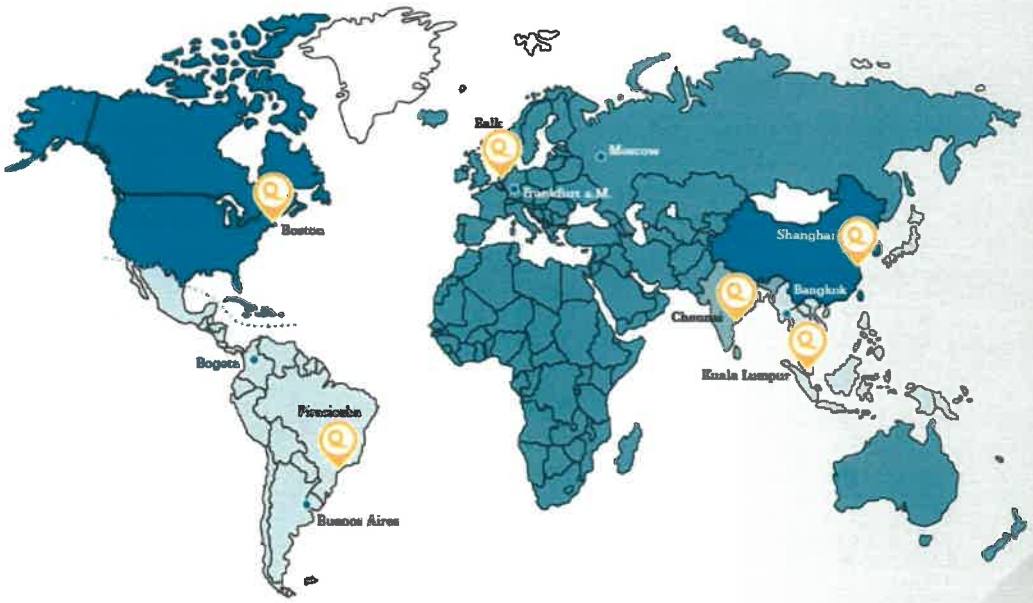
1. H_2S-rich gas in
2. Purified gas out
3. Alkaline wash solution, (absorbs H_2S from the gas)
4. Sulfide-rich solution from scrubber into bioreactor
5. Air for sulfur oxidation reaction (sulfide to elemental sulfur)
6. Sulfur separated
7. Elemental sulfur

Paques: leading in biological wastewater and gas treatment

For more than 40 years, Paques has been the world's leading company in the field of development and construction of cost-effective purification systems for water, wastewater and gases, based on innovative biotechnology. With over 3,000 reference installations worldwide, Paques has helped companies and municipalities succeed at to one of the major challenges of today: to reduce their water and carbon footprints and reclaim valuable resources.

The biogas produced by wastewater treatment plants can be used as green energy in boilers or gas engines. Beyond our headquarters in The Netherlands, Paques has subsidiaries and/or production locations in Russia, China, Brazil, Argentina, Colombia, India, Malaysia, Thailand, Vietnam, the United States and Canada. In many other countries, Paques is represented by licensed partners. This ensures our local presence and the best service for our clients worldwide.

Contact one of our branch offices:



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Kuala Lumpur, Malaysia
t +603 2169 6331
e info_my@paquesglobal.com

www.paquesglobal.com

Estimated Performance Summary

Customer Information					
Company:	GreenTec, LLC	Location:	Kinderhook, N.Y.	Email:	greene.tec.llc@gmail.com
Site Contact:	0	Phone:	(518) 951-5766	Project:	Pacific Ag- Sunnyside RNG- Scenario 2
Operating Conditions					
Gas Flow (scfm):	1345	Gas Pressure (psig):	1.00	Oxygen Conc (%):	0.60
Gas Temp (F):	100	Relative Humidity (%):	100%	H2S Contaminant Conc (ppm):	6000
Vessel Information					
Vessel ID (ft):	14	Vessel Configuration:	Single	Media Volume (lbs per vessel)	110,784
Vessle/Bed Height (ft):	30.0	Vessel Metallurgy:	n/a	Existing vessels(Y/N):	n/a
Performance Summary					
Operating time per vessel (days):	90	Flow Velocity (ft/min):	8.8	H2S Outlet (ppm):	<1
PD per vessel ("W.C.):	3.00	Carbon Consumed (lbs/yr)	447,596	H2S Removed (lbs/yr):	380,457
Financial Summary					
Product:	DARCO BG1	Media Cost ($/vessel):	[redacted]	H2S Removal Cost ($/SCFM):	[redacted]
Product cost ($/lb):	[redacted]	H2S Removal Cost ($/lb of H2S):	[redacted]	Annual Media Spend:	[redacted]
Norit Contact:	Howie Yerger		Email:	howard.yerger@norit.com	

Thank you for your business! www.norit.com

(1) Kid sunbeam not working

Estimated Performance Summary

Customer Information					
Company:	GreenTec, LLC	Location:	Kinderhook, N.Y.	Email:	greene.tec.llc@gmail.com
Site Contact:	0	Phone:	(518) 951-5766	Project:	Pacific Ag- Sunnyside RNG- Scenario 1
Operating Conditions					
Gas Flow (scfm):	1345	Gas Pressure (psig):	1.00	Oxygen Conc (%):	1.00
Gas Temp (F):	100	Relative Humidity (%):	100%	H2S Contaminant Conc (ppm):	60
Vessel Information					
Vessel ID (ft):	6	Vessel Configuration:	Single	Media Volume (lbs per vessel)	5,424
Vessle/Bed Height (ft):	8.0	Vessel Metallurgy:	n/a	Existing vessels(Y/N):	n/a
Performance Summary					
Operating time per vessel (days):	364	Flow Velocity (ft/min):	48.0	H2S Outlet (ppm):	<1
PD per vessel ("W.C.):	24.79	Carbon Consumed (lbs/yr)	5,435	H2S Removed (lbs/yr):	3,805
Financial Summary					
Product:	DARCO BG1	Media Cost ($/vessel):	[redacted]	H2S Removal Cost ($/SCFM):	[redacted]
Product cost ($/lb):	[redacted]	H2S Removal Cost ($/lb of H2S):	[redacted]	Annual Media Spend:	[redacted]
Norit Contact:	Howie Yerger		Email:	howard.yerger@norit.com	

Thank you for your business! www.norit.com

This is what Normal (2) system is to have to 60 ppm to <1 ppm

Safety Data Sheet (SDS)		
Paques bv		
	Date: 09.10.2008	Revision: 04.03.2016
Name: Sulphur cake		

1. IDENTIFICATION OF THE MIXTURE AND OF THE COMPANY

1.1. IDENTIFICATION OF THE MIXTURE

Name	: Thiopaq Sulphur cake
Chemical name	: Biologically produced elemental Sulphur originating from biogas or natural gas.
REACH	: This product is a mixture and exempted from registration according to REACH Regulation (EC) No 1907/2006

1.2. USAGE

Application	: Raw material for production of fertilizer.

1.3. COMPANY

Name	: Paques bv
Address	: T. de Boerstraat 24 P.O. Box 52 8560 AB BALK (The Netherlands)
Telephone	: +31 (0) 514 608 500
Facsimile	: +31 (0) 514 603 342
E-mail	: services@paques.nl

Telephone in case of emergency: +31 (0) 620 705 748

2. HAZARDS IDENTIFICATION

2.1.1. Classification of the substance or mixture according to Regulation (EC) No 1272/2008

Classification: Skin Irrit. 2

2.1.2. Label elements of the substance or mixture according to Regulation (EC) No 1272/2008

Hazard pictogram(s):

Signal word(s): Warning

Hazard statement(s): H315 Causes skin irritation

Precautionary statement(s):
P264 Wash thoroughly after handling
P280 Wear protective gloves/protective clothing/eye
P302+P352 IF ON SKIN: Wash with plenty of soap and water
P321 Specific treatment (see ... on this label)
P332+P313 If skin irritation occurs: Get medical advice/attention
P362 Take off contaminated clothing and wash before reuse

2.2 OTHER HAZARDS

The biomass in the substance can produce traces of hydrogen sulfide in the headspace. The substance does not meet the criteria for PBT or vPvB in accordance with Annex XIII of REACH.

3. COMPOSITION / INFORMATION ON INGREDIENTS

Cake from dewatered Sulphur slurry, natural excreted products and (micro) nutrient salts with process water. Cake contains 35 % water and approximately 65 % solids (biologically formed elemental sulphur particles). The cake can release traces of hydrogen sulphide in the headspace under anoxic conditions.

3.1. SUBSTANCES

Not applicable.

3.2. MIXTURES

Aqueous mixture with dangerous components listed below:

Component name	Conc.	CAS no.	EC no.	REACH no.	Classification
Sulphur	65%	7704-34-9	231-722-6	01-2119487295-27-xxxx	*Regulation (EC) No 1272/2008* Skin Irrit. 2; H315
Sodium Hydrogen Sulphide	< 0.01%	16721-80-5	240-778-0	Not available	*Regulation (EC) No 1272/2008* Acute Tox. 3; H301 Skin corr. 1B; H314 Met. Corr. 1; H290 Eye Dam. 1; H318 Aquatic Acute 1; H400

3.3 ADDITIONAL INFORMATION

All percentages given by weight unless stated otherwise.
Full text of H-phrases: see section 16

4. FIRST AID MEASURES

4.1. DESCRIPTION OF FIRST AID MEASURES

General information: In all cases, consult a doctor.
Never give anything by mouh to an unconscious person.

	Symptoms of poisoning may even occur after several hours; therefore medical observation for at least 48 hours afer the accident.
After inhalation:	Supply fresh air and consult a doctor/medical service. In case of unconsciousness place patient stably in side position for transportation. Suffocation hazard by H_2S poisoning (very toxic by inhalation)
After skin contact:	Wash immediately with water and soap. Rinse thoroughly. If skin irritation continues or rash occurs, seek medical advice and attention.
After eye contact:	Rinse immediately with plenty of water for 15 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Take victim to an ophtalmologist if irritation persists.
After swallowing:	Rinse mouth with water. Do not induce vomiting. If victim conscious and alert, give 1-2 glasses of water to drink. Consult a doctor/medical service if you feel unwell. Ingestion of large quantities: immediately to hospital.

4.2. MOST IMPORTANT SYMPTOMS AND EFFECTS< BOTH ACUTE AND DELAYED
No further relevant information available.

4.3. INDICATION OF IMMEDIATE MEDICAL ATTENTION AND SPECIAL TREATMENT
Treat symptomatically. For specialist advice physicians should contact the anti poison control centre

5. FIREFIGHTING MEASURES

5.1. EXTINGUISHING MEDIA

Suitable extinguishing agents:	CO2, powder or water spray. Fight larger fires with water spray or alcohol resistant foam.
Unsuitable:	Water with full jet

5.2. SPECIAL HAZARDS ARISING FROM THE SUBSTANCE OR MIXTURE
Under oxygen-free conditions some H2S can be formed from the anaerobic conversion of Sulphur components present in the liquid phase of the cake. If the cake is stored in a closed container this might result in elevated hydrogen Sulphide concentrations in the head space. The expected maximum concentration will be 0.01%, which could result in eye irritation and irritation of respiratory tract.

5.3. ADVICE FOR FIREFIGHTERS

Protective equipment:	Standard protective clothing for firefighters. Wear self-contained respiratory protective device.

6. ACCIDENTAL RELEASE MEASURES

6.1. PERSONAL PRECAUTIONS, PROTECTIVE EQUIPMENT AND EMERGENCY PROCEDURES

Wear protective equipment. Keep unprotected persons away. Ensure adequate ventilation. Use suitable protective equipment (see Chapter 8).

6.2. ENVIRONMENTAL PRECAUTION

Do not allow to enter sewers/ surface or ground water.

6.3. METHOD AND MATERIAL FOR CONTAINMENT AND CLEANING UP

Shut off leaks if without risk. Pick up mechanically. Dispose contaminated material as waste according to item 13.

6.4. REFERENCE TO OTHER SECTIONS

See Section 7 for information on safe handling.
See Section 8 for information on personal protection equipment.
See Section 13 for disposal information

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7. HANDLING AND STORAGE

7.1. PRECAUTION FOR SAFE HANDLING

Open and handle receptacle with care. Ensure good ventilation/exhaustion at the workplace. Wear mask and H2S detection; Wear mask and H2S detection, if the cake is stored in a closed container the headspace might contain up to 0.01% of H2S.

7.2. STORAGE

Store at +5°C to +40°C.
Do not store in direct sunlight.
Store in closed containers, or in plastic bags, not in the proximity of heat or ignition source. It is recommended to use containers or big bags with a water tight lining (< 40°C). Do not store together with acids.
Apply to local rules.
Handle in well ventilated spaces.
After use or opening containers should be emptied completely or filled up (> 90%) with water in order to minimize headspace.

7.3. PACKAGING MATERIALS

Suitable packaging materials:	Polyester Plastics Steel with rubber or plastic lining
Special demands to packaging materials:	Closable Correctly marked Apply to governmental rules

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8. EXPOSURE CONTROLS / PERSONAL PROTECTION

8.1. CONTROL PARAMETERS

· **Ingredients with limit values that require monitoring at the workplace:**	
7783-06-4 hydrogen sulphide	
WEL	Short-term value: 14 mg/m³, 10 ppm Long-term value: 7 mg/m³, 5 ppm

· **DNELs**		
16721-80-5 sodium hydrogensulphide		
Inhalative	DNEL (Long Term; Local)	1 mg/m³ (Workers)
	DNEL (Long Term; Systemic)	8 mg/m³ (Workers)
	DNEL (Short Term; Local)	2 mg/m³ (Workers)

· **PNECs**
16721-80-5 sodium hydrogensulphide
PNEC 0.00027 mg/l (Freshwater)
0.27 mg/l (Seawater)
0.0176 mg/kg dwt (Freshwater Sediment)
0.0176 mg/kg dwt (Seawater Sediment)
0.016 mg/l (Sewage Water Treatment Plant)
0.00027 mg/l (Water (intermittent emission))

8.2. EXPOSURE CONTROLS

Personal protective equipment:

Hand protection:
Material selection gloves:

Gloves.
Good resistance gives:butyl rubber,nitrile rubber,PVC.
Take advice to your gloves' supplier

Eye protection :
Skin and body protection:
Respiratory protection:

Protective goggles (EN166).
Wear suitable protective clothing (EN340).
In case of brief exposure or low pollution use respiratory filter device.
In case of intensive or longer exposure use self-contained respiratory protective device.
Short-term filter device: ABEK

Ventilation:

Provide sufficient mechanical (general and/or local exhaust) ventilation to mainain exposure below level of overexposure.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1. PHYSICAL STATE

Aggregation	: Cake
Odour	: Slight smell of rotten eggs
Colour	: White/yellow/grey viscous liquid (solids in suspension) or cake/clumps
Solubility	: Dispersible in water
Other properties	: Colloidal
Toxicity	: None

9.2. DATA PHYSICAL PROPERTIES

Boiling point	: > 100 °C
Density	: 1.4 kg/litre
Acidity (pH)	: 7 to 9.5

9.3 BIOLOGICAL DATA

Pathogenic bacteria: No E-coli or pathogenic organisms (those that can harm humans) are present.

10. STABILITY AND REACTIVITY

10.1. REACTIVITY

Stable at ambient temparures and under normal conditions of use.

10.2. CHEMICAL STABILITY

The product is stable if used and stored according to specifications.

10.3. POSSIBILITY OF HAZARDOUS REACTIONS

No dangerous reactions known.

10.4. CONDITIONS TO AVOID

Keep from heat sources/open flames/hot surfaces/ sparks and electrostatic charges.
Avoid sparks when opening the container.
Empty containers completely. Avoid contact with acids.

10.5. INCOMPATIBLE MATERIALS

Avoid contact with strong acids

10.6. HAZARDOUS DECOMPOSITION PRODUCTS

Under oxygen-free conditions some H2S can be formed from the anaerobic conversion of Sulphur components present in the liquid phase of the cake. If the cake is stored in a closed container this might result in elevated hydrogen sulphide concentrations in the head space. The expected maximum concentration will be 0.01%, which could result in eye irritation and irritation of respiratory tract.

11. TOXICOLOGICAL INFORMATION

11.1. ACUTE TOXICITY

Based on available data acute toxic effects are not expected. Under oxygen-free conditions some H2S can be formed from the anaerobic conversion of sulphur components present in the liquid phase of the cake. If the cake is stored in a closed container this might result in elevated hydrogen sulphide concentrations in the head space. The expected maximum concentration will be 0.01%, which could result in eye irritation and irritation of respiratory tract.

· **LD/LC50 values relevant for classification:**

ATE (Acute Toxicity Estimates)

Oral	LD50	7888 mg/kg (rat)
Dermal	LD50	66667 mg/kg
Inhalative	LC50/4 h	181 mg/l (rat)

7704-34-9 sulfur

Oral	LD50	> 2000 mg/kg (rat) (OECD 401)
Dermal	LD50	> 2000 mg/kg (rat) (OECD 402)
Inhalative	LC50/4 h	> 5.43 mg/l (rat) (OECD 403)

16721-80-5 sodium hydrogensulphide

Oral	LD50	105 mg/kg (rat) (OECD 401)

· **Primary irritant effect:**

· **on the skin:**

7704-34-9 sulfur

Irritation of skin	Skin Corrosion	+ (rabbit) (OECD 404) Irritating

· **on the eye:**

7704-34-9 sulfur

Irritation of eyes	Eye Corrosion	- (rabbit) (OECD 405) not irritating

16721-80-5 sodium hydrogensulphide

Irritation of eyes	Eye Corrosion	+ (rabbit) (OECD 405) Irreversible effects on the eye

· **Respiratory tract:** Not applicable.

· **Ingestion:** Not applicable.

· **Sensitisation:**

7704-34-9 sulfur

Irritation of skin	Skin Sensibilisation	-(Guinea Pigs) (OECD 406) not sensitizing

Additional toxicological information:

The product is not subject to classification according to the calculation method of the General EU Classification Guidelines for Preparations as issued in the latest version.

When used and handled according to specifications, the product does not have any harmful effects to our experience and the information provided to us.

· **Specific Target Organ Toxicity (STOT) single exposure:** Not applicable.	
· **Specific Target Organ Toxicity (STOT) repeated exposure:**	
7704-34-9 sulfur	
Oral	NOAEL (rep dose tox) | 1000 mg/kg bw/day (rat) (OECD 408)
· **Repeated dose toxicity**	
7704-34-9 sulfur	
Dermal	NOAEL (rep dose) | 400 mg/kg (rat) (OECD 410)
· **CMR effects (carcinogenity, mutagenicity and toxicity for reproduction)**	
· **Study results:**	
7704-34-9 sulfur	
Mutagenicity	- (rabbit) (OECD 471) negative without metabolic activation all strains tested negative with metabolic activation all strains tested

12. ECOLOGICAL INFORMATION

12.1. AQUATIC TOXICITY

This product is not classified as dangerous for the environment.

7704-34-9 sulfur	
EC50 (48h)	> 0.0005 mg/l (Daphnia Magna) (OECD 203) NOEC (48h): > 5 µg/l
NOEC (21d)	> 100 mg/l (Daphnia Magna) (OECD 211)
NOEC (72h)	> 0.005 mg/l (algae) (OECD 201)
NOEC (96h)	> 0.005 mg/l (Forel (oncorhynchus mykiss)) (OECD 203)
16721-80-5 sodium hydrogensulphide	
LL50 (96h)	0.1 mg/l (fish) ((H2S); OECD 203) species: Lepomis affinis
NOEC	0.002 mg/l (Lepomis Macrochirus) (EPA 440/5-86-001) LOEC (46d): 0.0014 mg/l

12.2. PERSISTENCE AND DEGRADABILITY

No further relevant information available.

12.3. BIOACCUMULATIVE POTENTIAL
No further relevant information available.

12.4. MOBILITY IN SOIL
No further relevant information available

General notes:
Water hazard class 1 (German Regulation) (Self-assessment): slightly hazardous for water. Do not allow undiluted product or large quantities of it to reach ground water, water course or sewage system.

12.5. RESULTS OF PBT AND VPVB ASSESSMENT
PBT:
Does not meet the specific criteria detailed in Annex XIII of Regulation 1907/2006 and the substance is not considered as a PBT
VPVB:
Does not meet the specific criteria detailed in Annex XIII of Regulation 1907/2006 and the substance is not considered as a vBvT

12.6. OTHER ADVERSE EFFECTS AND BIOLOGICAL DATA
No further relevant information available.

13. DISPOSAL CONSIDERATIONS

Clean up spilled product.
Collect product as much as possible in clean containers for reuse.
Rinse remaining material with lots of water.
This product is not classified as dangerous waste material.
Offer surplus to a licensed disposal company.
Do not dump in surface water or sewage.

14. TRANSPORT INFORMATION

In accordance with ADR / RID / IMDG / IATA / AND

14.1. UN NUMBER
Not regulated for transport

14.2. UN PROPER SHIPPING NAME
Not applicable

14.3. TRANSPORT HAZARD CLASS(ES)
Not applicable

14.4. PACKING GROUP
Not applicable

14.5. ENVIRONMENTAL HAZARDS
Other information : No supplementary information available.

14.6. SPECIAL PRECAUTIONS FOR USER

14.6.1. Overland transport
No additional information available

14.6.2. Transport by sea
No additional information available

14.6.3. Air transport
No additional information available

14.7. TRANSPORT IN BULK ACCORDING TO ANNEX II OF MARPOL 73/78 AND THE IBC CODE
Not applicable

15. REGULATORY INFORMATION

15.1. LABELLING ACCORDING TO EG GUIDELINES
Symbol: Irritating

16. OTHER INFORMATION

Version	: 2015v1
Revision date	: 22-01-2015
Date of issue	: 09-10-2008
Supersedes	: 27-06-2012
Indication of changes	: several

Data sources : BIG-database
ECHA Website: Information on Registered Substances
Handbook of Chemistry and Physics CRC Press Inc
Information from suppliers.

Abbreviations and acronyms : CLP = Classification, labelling and packaging
NOEC: No Observed Effect Concentration
DNEL = Derivative No Effect Level
PNEC = Predicted No Effect Concentration
IC50: Inhibition Concentration, 50 %
LC50: Lethal concentration, 50 percent
LD50: Lethal dose, 50 percent
Met. Corr. 1: corrosive to metals, Hazard Category 1
Acute Tox. 3: Acute toxicity, Hazard Category 3
Skin Corr. 1B: Skin corrosion/irritation, Hazard Category 1B
Skin Irrit. 2: Skin corrosion/irritation, Hazard Category 2
Eye Dam. 1: serious eye damage/eye irritation, Hazard Category 1
Aquatic acute 1: hazardous to the aquatic environment, Hazard Category 1
ADR: Accord européen sur le transport des marchandises dangereuses par Route (European Agreement concerning the International Carriage of Dangerous Goods by Road
IMDG: International Maritime Code for Dangerous Goods
IATA: International Air Transport Association
GHS: Globally Harmonised System of Classification and Labelling of Chemicals
EINECS: European Inventory of Existing Commercial Chemical Substances
ELINCS: European List of Notified Chemical Substances
CAS: Chemical Abstracts Service (division of the American Chemical Society)
REACH: Registration, evaluation and autorisation of chemicals.

Training advice : Before using/handling the product one must read carefully the SDS.

Full text of, H- and EUH-phrases:

H290	May be corrosive to metals
H301	Toxic if swallowed
H302	Harmful if swallowed
H314	Causes severe skin burns and eye damage
H315	Causes skin irritation
H318	Cauese serious eye damage
H400	Very toxic to aquatic life

Above data apply only to the product mentioned in chapter 1 and under the circumstances as mentioned in this material safety data sheet.
These data do not apply with restriction if this product is used in combination with other materials and with restrictions if it is used in a process.
Although this material safety data sheet is composed with great care, Paques bv cannot accept any liability for harmful effects that may occur when using this product. The user should convince himself before he starts using this product if the data is complete and the product is suitable for the process where it will be used in.

SAFETY DATA SHEET
THE DOW CHEMICAL COMPANY

Product name: Monoethanolamine

Issue Date: 06/06/2022
Print Date: 07/21/2022

THE DOW CHEMICAL COMPANY encourages and expects you to read and understand the entire (M)SDS, as there is important information throughout the document. We expect you to follow the precautions identified in this document unless your use conditions would necessitate other appropriate methods or actions.

1. IDENTIFICATION

Product name: Monoethanolamine

Recommended use of the chemical and restrictions on use
Identified uses: Gas treatment agent. Chemical intermediate. We recommend that you use this product in a manner consistent with the listed use. If your intended use is not consistent with the stated use, please contact your sales or technical service representative.

COMPANY IDENTIFICATION
THE DOW CHEMICAL COMPANY
2211 H.H. DOW WAY
MIDLAND MI 48674
UNITED STATES

Customer Information Number: 800-258-2436
SDSQuestion@dow.com

EMERGENCY TELEPHONE NUMBER
24-Hour Emergency Contact: CHEMTREC +1 800-424-9300
Local Emergency Contact: 800-424-9300

2. HAZARDS IDENTIFICATION

Hazard classification
GHS classification in accordance with the OSHA Hazard Communication Standard (29 CFR 1910.1200)
Flammable liquids - Category 4
Acute toxicity - Category 4 - Oral
Skin corrosion - Category 1B
Serious eye damage - Category 1

Label elements
Hazard pictograms

Signal word: **DANGER!**

Hazards
Combustible liquid.
Harmful if swallowed.
Causes severe skin burns and eye damage.

Precautionary statements

Prevention
Keep away from heat/ sparks/ open flames/ hot surfaces. No smoking.
Wash skin thoroughly after handling.
Do not eat, drink or smoke when using this product.
Wear protective gloves, protective clothing, eye protection and/or face protection.

Response
IF SWALLOWED: Call a POISON CENTER/ doctor if you feel unwell. Rinse mouth.
IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/ shower.
IF INHALED: Remove person to fresh air and keep comfortable for breathing. Immediately call a POISON CENTER and/or doctor.
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER and/or doctor.
Wash contaminated clothing before reuse.
In case of fire: Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide to extinguish.

Storage
Store in a well-ventilated place. Keep cool.
Store locked up.

Disposal
Dispose of contents and/or container to an approved waste disposal plant.

Other hazards
No data available

3. COMPOSITION/INFORMATION ON INGREDIENTS

Synonyms: Ethanolamine
This product is a substance.
Substance name: Monoethanolamine
CASRN: 141-43-5

Component	CASRN	Concentration
Monoethanolamine	141-43-5	>= 99.5 - <= 100.0 %
Diethanolamine	111-42-2	<= 0.2 %

4. FIRST AID MEASURES

Description of first aid measures
General advice:
First Aid responders should pay attention to self-protection and use the recommended protective clothing (chemical resistant gloves, splash protection). If potential for exposure exists refer to Section 8 for specific personal protective equipment.

Inhalation: Move person to fresh air and keep comfortable for breathing; consult a physician.

Skin contact: Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing. Seek medical attention if symptoms occur or irritation persists. Wash clothing before reuse. Suitable emergency safety shower facility should be immediately available.

Eye contact: Wash immediately and continuously with flowing water for at least 30 minutes. Remove contact lenses after the first 5 minutes and continue washing. Obtain prompt medical consultation, preferably from an ophthalmologist. Suitable emergency eye wash facility should be immediately available.

Ingestion: Do not induce vomiting. Give one cup (8 ounces or 240 ml) of water or milk if available and transport to a medical facility. Do not give anything by mouth unless the person is fully conscious.

Most important symptoms and effects, both acute and delayed:
Aside from the information found under Description of first aid measures (above) and Indication of immediate medical attention and special treatment needed (below), any additional important symptoms and effects are described in Section 11: Toxicology Information.

Indication of any immediate medical attention and special treatment needed
Notes to physician: Chemical eye burns may require extended irrigation. Obtain prompt consultation, preferably from an ophthalmologist. If burn is present, treat as any thermal burn, after decontamination. Due to irritant properties, swallowing may result in burns and/or ulceration of mouth, stomach and lower gastrointestinal tract with subsequent stricture. Aspiration of vomitus may cause lung injury. Suggest endotracheal or esophageal control if lavage is done. No specific antidote. Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient.

5. FIREFIGHTING MEASURES

Extinguishing media

Suitable extinguishing media: Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide..

Unsuitable extinguishing media: High volume water jet. Do not use direct water stream..

Special hazards arising from the substance or mixture

Hazardous combustion products: Carbon oxides. Nitrogen oxides (NOx).

Unusual Fire and Explosion Hazards: Flash back possible over considerable distance.. Exposure to combustion products may be a hazard to health.. Closed containers may rupture via pressure build-up when exposed to fire or extreme heat.. Vapours may form explosive mixtures with air..

Advice for firefighters

Fire Fighting Procedures: Use water spray to cool unopened containers.. Evacuate area.. Collect contaminated fire extinguishing water separately. This must not be discharged into drains.. Fire residues and contaminated fire extinguishing water must be disposed of in accordance with local regulations.. Contain fire water run-off if possible. Fire water run-off, if not contained, may cause environmental damage.. Use water spray to cool fire exposed containers and fire affected zone until fire is out and danger of reignition has passed.. Do not use a solid water stream as it may scatter and spread fire..
Use extinguishing measures that are appropriate to local circumstances and the surrounding environment. Remove undamaged containers from fire area if it is safe to do so.

Special protective equipment for firefighters: In the event of fire, wear self-contained breathing apparatus.. Use personal protective equipment..

6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures: Remove all sources of ignition. Use personal protective equipment. Follow safe handling advice and personal protective equipment recommendations.

Environmental precautions: Do not release the product to the aquatic environment above defined regulatory levels Prevent further leakage or spillage if safe to do so. Prevent spreading over a wide area (e.g. by containment or oil barriers). Retain and dispose of contaminated wash water. Local authorities should be advised if significant spillages cannot be contained.

Methods and materials for containment and cleaning up: Do NOT use absorbent materials such as: Cellulose-based absorbents. Sawdust Ground corn cobs. Non-sparking tools should be used. Soak up with inert absorbent material. Suppress (knock down) gases/vapours/mists with a water spray jet. Absorb with inert materials such as: Clay-based absorbents. Dirt. Sand. Clean up remaining materials from spill with suitable absorbant. Local or national regulations may apply to releases and disposal of this material, as well as those materials and items employed in the cleanup of releases. You will need to determine which regulations are applicable. For large spills, provide dyking or other appropriate containment to keep material from spreading. If dyked material can be pumped, store recovered material in appropriate container.
See sections: 7, 8, 11, 12 and 13.

7. HANDLING AND STORAGE

Precautions for safe handling: Do not get on skin or clothing. Do not breathe vapours or spray mist. Do not swallow. Do not get in eyes. Keep container tightly closed. Keep away from heat and sources of ignition. Take precautionary measures against static discharges. Take care to prevent spills, waste and minimize release to the environment. Do not use sodium nitrite or other nitrosating agents in formulations containing this product. Suspected cancer-causing nitrosamines could be formed. Spills of these organic materials on hot fibrous insulations may lead to lowering of the autoignition temperatures possibly resulting in spontaneous combustion. Handle in accordance with good industrial hygiene and safety practice. CONTAINERS MAY BE HAZARDOUS WHEN EMPTY. Since emptied containers retain product residue follow all (M)SDS and label warnings even after container is emptied.
Use with local exhaust ventilation. See Engineering measures under EXPOSURE CONTROLS/PERSONAL PROTECTION section.

Conditions for safe storage: Keep in properly labelled containers. Store locked up. Keep tightly closed. Keep in a cool, well-ventilated place. Do not store with: Strong acids. Strong bases Combustible liquid. Store in accordance with the particular national regulations. Keep away from heat and sources of ignition. Monoethanolamine can react with iron to form an unstable material that can decompose at temperatures above 130 °C in air. Use caution when thawing drummed material. If steam heating is necessary, use only low pressure steam and stainless steel coils.

Storage stability
Storage temperature: 10 - 32 °C (50 - 90 °F)

Storage Period:
Plastic drums.
24 Month
Bulk
6 Month

Do not store with the following product types: Strong oxidizing agents. Organic peroxides. Explosives. Gases.
Unsuitable materials for containers: Aluminium Copper Copper alloys Galvanized containers. Zinc

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control parameters
If exposure limits exist, they are listed below. If no exposure limits are displayed, then no values are applicable.

Component	Regulation	Type of listing	Value
Monoethanolamine	ACGIH	TWA	3 ppm
	ACGIH	STEL	6 ppm
	OSHA Z-1	TWA	6 mg/m3 3 ppm
Diethanolamine	Dow IHG	TWA	0.2 mg/m3
	Further information: SKIN: Absorbed via skin		
	ACGIH	TWA Inhalable fraction and vapor	1 mg/m3
	Further information: A3: Confirmed animal carcinogen with unknown relevance to humans; Skin: Danger of cutaneous absorption		

Exposure controls

Engineering controls: Use engineering controls to maintain airborne level below exposure limit requirements or guidelines. If there are no applicable exposure limit requirements or guidelines, use only with adequate ventilation. Local exhaust ventilation may be necessary for some operations.

Individual protection measures

Eye/face protection: Use chemical goggles. If exposure causes eye discomfort, use a full-face respirator.

Skin protection

Hand protection: Use gloves chemically resistant to this material. Examples of preferred glove barrier materials include: Polyethylene. Ethyl vinyl alcohol laminate ("EVAL"). Examples of acceptable glove barrier materials include: Butyl rubber. Avoid gloves made of: Chlorinated polyethylene. Polyvinyl alcohol ("PVA"). NOTICE: The selection of a specific glove for a particular application and duration of use in a workplace should also take into account all relevant workplace factors such as, but not limited to: Other chemicals which may be handled, physical requirements (cut/puncture protection, dexterity, thermal protection), potential body reactions to glove materials, as well as the instructions/specifications provided by the glove supplier.

Other protection: Use protective clothing chemically resistant to this material. Selection of specific items such as face shield, boots, apron, or full body suit will depend on the task.

Respiratory protection: Respiratory protection should be worn when there is a potential to exceed the exposure limit requirements or guidelines. If there are no applicable exposure limit requirements or guidelines, use an approved respirator. Selection of air-purifying or positive-pressure supplied-air will depend on the specific operation and the potential airborne concentration of the material. For emergency conditions, use an approved positive-pressure self-contained breathing apparatus.

The following should be effective types of air-purifying respirators: Organic vapor cartridge.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	
Physical state	Liquid.
Color	Colorless
Odor	Ammoniacal
Odor Threshold	No test data available
pH	12.1 *Literature* (50% aq. sol.)
Melting point/range	No test data available
Freezing point	10.5 °C (50.9 °F) *Literature*
Boiling point (760 mmHg)	170.3 °C (338.5 °F) at 1,013.25 hPa *Literature*
Flash point	**closed cup** 91 °C (196 °F) at 1.013 bar *ISO 2719* Pensky-Martens Closed Cup ASTM D 93
Evaporation Rate (Butyl Acetate = 1)	No data available
Flammability (solid, gas)	Not applicable to liquids
Flammability (liquids)	Not expected to be a static-accumulating flammable liquid.
Lower explosion limit	3.0 % vol *Literature*

Upper explosion limit	23.5 % vol *Literature*
Vapor Pressure	0.5 hPa at 20 °C (68 °F) *Literature*
Relative Vapor Density (air = 1)	2.1 at 20 °C (68 °F) *Literature*
Relative Density (water = 1)	1.02 *Literature*
Water solubility	1000 g/L at 20 °C (68 °F) *Literature*
Partition coefficient: n-octanol/water	log Pow: -2.3 *Measured*
Auto-ignition temperature	410 °C (770 °F) *Literature*
Decomposition temperature	No data available
Dynamic Viscosity	23.18 mPa.s at 20 °C (68 °F) *Literature*
Kinematic Viscosity	No test data available
Explosive properties	Not explosive
Oxidizing properties	No
Molecular weight	61.08 g/mol *Literature*

NOTE: The physical data presented above are typical values and should not be construed as a specification.

10. STABILITY AND REACTIVITY

Reactivity: Not classified as a reactivity hazard.

Chemical stability: Stable under normal conditions.

Possibility of hazardous reactions: Can react with strong oxidizing agents. Vapours may form explosive mixture with air.

Conditions to avoid: Heat, flames and sparks. Avoid moisture.

Incompatible materials: Heating above 60°C in the presence of aluminum can result in corrosion and generation of flammable hydrogen gas. Avoid contact with oxidizing materials. Avoid contact with: Acids Halogenated hydrocarbons Nitrites. Strong oxidizers. Combustible liquid. Avoid contact with metals such as: Aluminum. copper Galvanised metals Zinc.

Hazardous decomposition products: Decomposition products depend upon temperature, air supply and the presence of other materials..

11. TOXICOLOGICAL INFORMATION

Toxicological information appears in this section when such data is available.

Information on likely routes of exposure
Inhalation, Eye contact, Skin contact, Ingestion.

Acute toxicity (represents short term exposures with immediate effects - no chronic/delayed effects known unless otherwise noted)

Acute oral toxicity

Information for the Product:

Low toxicity if swallowed. Swallowing may result in gastrointestinal irritation or ulceration. Swallowing may result in burns of the mouth and throat.

Based on product testing:
LD50, Rat, 1,089 mg/kg

Information for components:

Monoethanolamine
LD50, Rat, 1,089 mg/kg

Diethanolamine
LD50, Rat, male and female, 1,600 mg/kg OECD 401 or equivalent

Acute dermal toxicity

Information for the Product:

Prolonged skin contact is unlikely to result in absorption of harmful amounts.

As product:
LD50, Rat, 2,504 mg/kg

Information for components:

Monoethanolamine
LD50, Rat, 2,504 mg/kg

Diethanolamine
LD50, Rabbit, male, > 8,200 mg/kg

Acute inhalation toxicity

Information for the Product:

Prolonged excessive exposure may cause adverse effects. Excessive exposure may cause irritation to upper respiratory tract (nose and throat).

As product:
LC50, Rat, 4 Hour, vapour, > 1.48 mg/l Estimated. No deaths occurred at this concentration.
Information for components:

Monoethanolamine
LC50, Rat, 4 Hour, vapour, > 1.48 mg/l Estimated. No deaths occurred at this concentration.

Diethanolamine
LC0, Rat, male, 4 Hour, dust/mist, 3.35 mg/l No deaths occurred at this concentration.

Skin corrosion/irritation

Information for the Product:

Based on product testing:
Brief contact may cause skin burns. Symptoms may include pain, severe local redness and tissue damage.
Classified as corrosive to the skin according to DOT guidelines.

Information for components:

Monoethanolamine
Brief contact may cause skin burns. Symptoms may include pain, severe local redness and tissue damage.
Classified as corrosive to the skin according to DOT guidelines.

Diethanolamine
Prolonged contact may cause skin irritation with local redness.
Repeated contact may cause skin burns. Symptoms may include pain, severe local redness, swelling, and tissue damage.
May cause more severe response if skin is abraded (scratched or cut).

Serious eye damage/eye irritation

Information for the Product:

Based on product testing:
May cause severe irritation with corneal injury which may result in permanent impairment of vision, even blindness. Chemical burns may occur.
Vapor may cause eye irritation experienced as mild discomfort and redness.

Information for components:

Monoethanolamine
May cause severe irritation with corneal injury which may result in permanent impairment of vision, even blindness. Chemical burns may occur.
Vapor may cause eye irritation experienced as mild discomfort and redness.

Diethanolamine
May cause severe eye irritation.
May cause severe corneal injury.
Effects may be slow to heal.

Sensitization

Information for the Product:

For skin sensitization:
Did not cause allergic skin reactions when tested in guinea pigs.

For respiratory sensitization:
No relevant data found.

Information for components:

Monoethanolamine

Did not cause allergic skin reactions when tested in guinea pigs.

For respiratory sensitization:
No relevant data found.

Diethanolamine
Did not cause allergic skin reactions when tested in guinea pigs.

For respiratory sensitization:
No relevant data found.

Specific Target Organ Systemic Toxicity (Single Exposure)

Information for the Product:

Material is corrosive. Material is not classified as a respiratory irritant; however, upper respiratory tract irritation or corrosivity may be expected.

Information for components:

Monoethanolamine
Material is corrosive. Upper respiratory tract irritation or corrosivity may be expected.

Diethanolamine
Evaluation of available data suggests that this material is not an STOT-SE toxicant.

Aspiration Hazard

Information for the Product:

Aspiration into the respiratory system may occur during ingestion or vomiting. Due to corrosivity, tissue damage or lung injury may occur.

Information for components:

Monoethanolamine
Aspiration into the respiratory system may occur during ingestion or vomiting. Due to corrosivity, tissue damage or lung injury may occur.

Diethanolamine
Based on physical properties, not likely to be an aspiration hazard.

Chronic toxicity (represents longer term exposures with repeated dose resulting in chronic/delayed effects - no immediate effects known unless otherwise noted)

Specific Target Organ Systemic Toxicity (Repeated Exposure)

Information for the Product:

In animals, effects have been reported on the following organs:
Kidney.
Liver.

Information for components:

Monoethanolamine
In animals, effects have been reported on the following organs:
Kidney.
Liver.

Diethanolamine
Results from repeated exposure tests on diethanolamine in laboratory animals include anemia (rats) and effects on kidney (rats and mice) and liver (mice). Heart and nervous system effects were also observed in animals given exaggerated doses of diethanolamine. Changes in other organs, causes of which are nonspecific, were judged secondary to the poor health of the animals due to the extremely high doses of diethanolamine given.

Carcinogenicity

Information for the Product:

Findings from a chronic diethanolamine skin painting study by NTP include liver and kidney tumors in mice; no tumors were observed in rats. Mechanistic studies indicate that tumor formation is of questionable relevance to humans. A number of factors may have influenced the results and are being considered in their interpretation.

Information for components:

Monoethanolamine
No relevant data found.

Diethanolamine
Findings from a chronic diethanolamine skin painting study by NTP include liver and kidney tumors in mice; no tumors were observed in rats. Mechanistic studies indicate that tumor formation is of questionable relevance to humans. A number of factors may have influenced the results and are being considered in their interpretation.

Carcinogenicity

Component	**List**	**Classification**
Diethanolamine	IARC	Group 2B: Possibly carcinogenic to humans
	ACGIH	A3: Confirmed animal carcinogen with unknown relevance to humans.

Teratogenicity

Information for the Product:

Has been toxic to the fetus in laboratory animals at doses toxic to the mother. However, the relevance of this to humans is unknown. Dose levels producing these effects were many times higher than any dose levels expected from exposure due to use.

Information for components:

Monoethanolamine
Has been toxic to the fetus in laboratory animals at doses toxic to the mother. However, the relevance of this to humans is unknown. Dose levels producing these effects were many times higher than any dose levels expected from exposure due to use.

Diethanolamine
Has been toxic to the fetus in laboratory animals at doses toxic to the mother. Did not cause birth defects in laboratory animals.

Reproductive toxicity

Information for the Product:

In animal studies, did not interfere with reproduction.

Information for components:

Monoethanolamine
In animal studies, did not interfere with reproduction.

Diethanolamine
In laboratory animal studies, effects on reproduction have been seen only at doses that produced significant toxicity to the parent animals. Repeated excessive exposures to high amounts may cause effects on testes and fertility in males.

Mutagenicity

Information for the Product:

In vitro genetic toxicity studies were negative. Animal genetic toxicity studies were negative.

Information for components:

Monoethanolamine
In vitro genetic toxicity studies were negative. Animal genetic toxicity studies were negative.

Diethanolamine
In vitro genetic toxicity studies were negative. Animal genetic toxicity studies were negative.

12. ECOLOGICAL INFORMATION

Ecotoxicological information appears in this section when such data is available.

Toxicity

Acute toxicity to fish
Material is moderately toxic to aquatic organisms on an acute basis (LC50/EC50 between 1 and 10 mg/L in the most sensitive species tested).

LC50, Cyprinus carpio (Carp), semi-static test, 96 Hour, 349 mg/l

Acute toxicity to aquatic invertebrates
EC50, Daphnia magna (Water flea), static test, 48 Hour, 65 mg/l

Acute toxicity to algae/aquatic plants
ErC50, Pseudokirchneriella subcapitata (green algae), 72 Hour, Growth rate inhibition, 2.5 mg/l, OECD Test Guideline 201 or Equivalent

NOEC, Pseudokirchneriella subcapitata (green algae), 72 Hour, Growth rate inhibition, 1 mg/l, OECD Test Guideline 201

Toxicity to bacteria
EC50, activated sludge, > 1,000 mg/l

Long-term (chronic) aquatic hazard
Chronic toxicity to fish
LOEC, Oryzias latipes (Orange-red killifish), 30 d, Other, 3.6 mg/l

Chronic toxicity to aquatic invertebrates
NOEC, Daphnia magna (Water flea), 21 d, number of offspring, 0.85 mg/l

Persistence and degradability

Biodegradability: Material is readily biodegradable. Passes OECD test(s) for ready biodegradability.
10-day Window: Pass
Biodegradation: > 90 %
Exposure time: 21 d
Method: OECD Test Guideline 301A or Equivalent

Theoretical Oxygen Demand: 2.36 mg/mg

Photodegradation
Sensitization: OH radicals
Atmospheric half-life: 0.45 d
Method: Estimated.

Bioaccumulative potential

Bioaccumulation: Bioconcentration potential is low (BCF < 100 or Log Pow < 3).
Partition coefficient: n-octanol/water(log Pow): -2.3 at 25 °C Measured

Mobility in soil

Partition coefficient (Koc): 1.17 Estimated.

13. DISPOSAL CONSIDERATIONS

Disposal methods: DO NOT DUMP INTO ANY SEWERS, ON THE GROUND, OR INTO ANY BODY OF WATER. All disposal practices must be in compliance with all Federal, State/Provincial and local laws and regulations. Waste characterizations and compliance with applicable laws are the responsibility solely of the waste generator. FOR UNUSED AND UNCONTAMINATED PRODUCT, always send to a licensed disposer per applicable regulations. Consult the local waste disposal expert for the appropriate waste disposal method. Recover or recycle, if possible. Otherwise, send it to a licensed disposer.

Contaminated packaging: Empty containers retain product residues. Follow label warnings even after container is emptied. Improper disposal or reuse of this container may be dangerous and illegal. Refer to applicable federal, state and local regulations.

14. TRANSPORT INFORMATION

DOT

Proper shipping name	Ethanolamine
UN number	UN 2491
Class	8
Packing group	III

Classification for SEA transport (IMO-IMDG):

Proper shipping name	ETHANOLAMINE
UN number	UN 2491
Class	8
Packing group	III
Marine pollutant	No
Transport in bulk according to Annex I or II of MARPOL 73/78 and the IBC or IGC Code	Consult IMO regulations before transporting ocean bulk

Classification for AIR transport (IATA/ICAO):

Proper shipping name	Ethanolamine
UN number	UN 2491
Class	8
Packing group	III

This information is not intended to convey all specific regulatory or operational requirements/information relating to this product. Transportation classifications may vary by container volume and may be influenced by regional or country variations in regulations. Additional transportation system information can be obtained through an authorized sales or customer service representative. It is the responsibility of the transporting organization to follow all applicable laws, regulations and rules relating to the transportation of the material.

15. REGULATORY INFORMATION

Superfund Amendments and Reauthorization Act of 1986 Title III (Emergency Planning and Community Right-to-Know Act of 1986) Sections 311 and 312
Flammable (gases, aerosols, liquids, or solids)
Acute toxicity (any route of exposure)
Skin corrosion or irritation
Serious eye damage or eye irritation

Superfund Amendments and Reauthorization Act of 1986 Title III (Emergency Planning and Community Right-to-Know Act of 1986) Section 313
This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

Pennsylvania Worker and Community Right-To-Know Act:
The following chemicals are listed because of the additional requirements of Pennsylvania law:

Components	CASRN
Monoethanolamine	141-43-5

California Prop. 65
WARNING: This product can expose you to chemicals including Diethanolamine, which is/are known to the State of California to cause cancer, and Ethylene glycol, which is/are known to the State of California to cause birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov.

United States TSCA Inventory (TSCA)
All components of this product are in compliance with the inventory listing requirements of the U.S. Toxic Substances Control Act (TSCA) Chemical Substance Inventory.

16. OTHER INFORMATION

Product Literature
Additional information on this product may be obtained by calling your sales or customer service contact.

Hazard Rating System
NFPA

Health	Flammability	Instability
3	2	0

Revision
Identification Number: 168147 / A001 / Issue Date: 06/06/2022 / Version: 10.0
Most recent revision(s) are noted by the bold, double bars in left-hand margin throughout this document.

Legend

ACGIH	USA. ACGIH Threshold Limit Values (TLV)
Dow IHG	Dow Industrial Hygiene Guideline
OSHA Z-1	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
STEL	Short-term exposure limit
TWA	8-hour, time-weighted average

Full text of other abbreviations
AIIC - Australian Inventory of Industrial Chemicals; ASTM - American Society for the Testing of Materials; bw - Body weight; CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act; CMR - Carcinogen, Mutagen or Reproductive Toxicant; DIN - Standard of the German Institute for Standardisation; DOT - Department of Transportation; DSL - Domestic Substances List (Canada); ECx - Concentration associated with x% response; EHS - Extremely Hazardous Substance; ELx - Loading rate associated with x% response; EmS - Emergency Schedule; ENCS - Existing and New Chemical Substances (Japan); ErCx - Concentration associated with x% growth rate response; ERG - Emergency Response Guide; GHS - Globally Harmonized System; GLP

- Good Laboratory Practice; HMIS - Hazardous Materials Identification System; IARC - International Agency for Research on Cancer; IATA - International Air Transport Association; IBC - International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk; IC50 - Half maximal inhibitory concentration; ICAO - International Civil Aviation Organization; IECSC - Inventory of Existing Chemical Substances in China; IMDG - International Maritime Dangerous Goods; IMO - International Maritime Organization; ISHL - Industrial Safety and Health Law (Japan); ISO - International Organisation for Standardization; KECI - Korea Existing Chemicals Inventory; LC50 - Lethal Concentration to 50 % of a test population; LD50 - Lethal Dose to 50% of a test population (Median Lethal Dose); MARPOL - International Convention for the Prevention of Pollution from Ships; MSHA - Mine Safety and Health Administration; n.o.s. - Not Otherwise Specified; NFPA - National Fire Protection Association; NO(A)EC - No Observed (Adverse) Effect Concentration; NO(A)EL - No Observed (Adverse) Effect Level; NOELR - No Observable Effect Loading Rate; NTP - National Toxicology Program; NZIoC - New Zealand Inventory of Chemicals; OECD - Organization for Economic Co-operation and Development; OPPTS - Office of Chemical Safety and Pollution Prevention; PBT - Persistent, Bioaccumulative and Toxic substance; PICCS - Philippines Inventory of Chemicals and Chemical Substances; (Q)SAR - (Quantitative) Structure Activity Relationship; RCRA - Resource Conservation and Recovery Act; REACH - Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals; RQ - Reportable Quantity; SADT - Self-Accelerating Decomposition Temperature; SARA - Superfund Amendments and Reauthorization Act; SDS - Safety Data Sheet; TCSI - Taiwan Chemical Substance Inventory; TECI - Thailand Existing Chemicals Inventory; TSCA - Toxic Substances Control Act (United States); UN - United Nations; UNRTDG - United Nations Recommendations on the Transport of Dangerous Goods; vPvB - Very Persistent and Very Bioaccumulative

Information Source and References
This SDS is prepared by Product Regulatory Services and Hazard Communications Groups from information supplied by internal references within our company.

THE DOW CHEMICAL COMPANY urges each customer or recipient of this (M)SDS to study it carefully and consult appropriate expertise, as necessary or appropriate, to become aware of and understand the data contained in this (M)SDS and any hazards associated with the product. The information herein is provided in good faith and believed to be accurate as of the effective date shown above. However, no warranty, express or implied, is given. Regulatory requirements are subject to change and may differ between various locations. It is the buyer's/user's responsibility to ensure that his activities comply with all federal, state, provincial or local laws. The information presented here pertains only to the product as shipped. Since conditions for use of the product are not under the control of the manufacturer, it is the buyer's/user's duty to determine the conditions necessary for the safe use of this product. Due to the proliferation of sources for information such as manufacturer-specific (M)SDSs, we are not and cannot be responsible for (M)SDSs obtained from any source other than ourselves. If you have obtained an (M)SDS from another source or if you are not sure that the (M)SDS you have is current, please contact us for the most current version.
US

CABOT
NORIT ACTIVATED CARBON

SAFETY DATA SHEET

According to Chinese National Standard GB/T 16483-2008 **Revision date:** 07-Dec-2015

According to Chinese National Standard GB/T 16483-2008, a Safety Data Sheet (SDS) must be provided for hazardous substances or mixtures. This product does not meet the classification criteria according to this standard. Therefore, such document is outside the scope of the standard and the requirements for each section do not apply.

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Product name: DARCO® BG1 Activated Carbon

Product code: BG1.DIR.MS

Synonyms: Activated carbon

Recommended use: Liquid and vapor applications (purification, decolorization, separation, catalyst and deodorization)

Restrictions on use: No information available

Supplier:

Cabot Corporation
157 Concord Road
Billerica, MA 01821
UNITED STATES
Tel: 1-978-663-3455
Fax: 1-978-670-6955

Emergency telephone International CHEMTREC: +1 703-741-5970 or +1-703-527-3887
China: CHEMTREC 4001 - 204937
CHEMTREC US 1-800-424-9300 or +1-703-527-3887

E-mail address: SDS@cabotcorp.com

2. HAZARDS IDENTIFICATION

GHS - Classification
Not hazardous according to the Globally Harmonized System (GHS).

Label Elements:

Pictogram: None

Signal Word: None

Hazard statements: None

Precautionary Statements: None

Hazards not otherwise classified (HNOC)

Odorless black granules or powder. Avoid contact with skin and eyes. Avoid breathing dust. Activated carbon (especially when wet) can deplete oxygen from air in enclosed spaces, and dangerously low levels of oxygen may result. Prior to entering a confined space that contains or previously contained activated carbon, the space should be evaluated for oxygen and carbon monoxide concentrations, and any other hazards, by a qualified person.

Workers should also take appropriate precautions when dealing with spent (used) activated carbons which may exhibit hazardous properties associated with the adsorbed materials.

Avoid dust formation. Powdered material may form an explosible dust-air mixture. If transferring product under pressure, avoid generation of dust if an ignition source is present.

Activated carbons have high surface area which may cause self-heating during oxidation. See Section 5.

Do not generate dust because airborne respirable crystalline silica may be generated.

Potential health effects

Principle Routes of Exposure:	Inhalation, Eye contact, Skin Contact
Eye Contact:	May cause mechanical irritation. Avoid contact with eyes.
Skin Contact:	May cause mechanical irritation. Avoid contact with skin.
Inhalation:	Dust may be irritating to respiratory tract. Provide appropriate local exhaust ventilation at machinery and at places where dust can be generated. See also Section 8.
Ingestion:	Adverse health effects are not known or expected under normal use.
Carcinogenicity:	See Section 11.
Target Organ Effects:	Lungs, Eyes, Skin
Medical Conditions Aggravated by Exposure:	Asthma, Respiratory disorder, Skin disorders
Potential Environmental Effects:	No special environmental precautions required. See also Section 12.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical name	CAS No	weight-%
Activated Carbon	7440-44-0	100

This product, which is manufactured from a naturally occurring raw material(s), contains <10% total crystalline silica (quartz, CASRN 14808-60-7).

4. FIRST AID MEASURES

FIRST AID MEASURES

Skin Contact Wash thoroughly with soap and water. Seek medical attention if symptoms develop.

Eye contact Flush eyes immediately with large amounts of water for 15 minutes. Seek medical attention if symptoms develop.

Inhalation If cough, shortness of breath or other breathing problems occur, move to fresh air. Seek medical attention if symptoms persist. If necessary, restore normal breathing through standard first aid measures.

Ingestion Do not induce vomiting. If conscious, give several glasses of water. Never give anything by mouth to an unconscious person.

Most important symptoms and effects, both acute and delayed

Symptoms: The most important known symptoms and effects are described in Section 2 and/or in Section 11.

Indication of any immediate medical attention and special treatment needed

Note to physicians: Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media:
Use foam, carbon dioxide (CO2), dry chemical or water spray. A fog is recommended if water is used.

Unsuitable Extinguishing Media:
DO NOT USE a solid water stream as it may scatter and spread fire. In the event of a fire, spreading large amounts of activated carbon is not recommended due to the risk of creating uncontrolled dust emissions.

Specific hazards arising from the chemical:
Burning produces irritant fumes. If transferring product under pressure, avoid generation of dust if an ignition source is present.

Activated carbons have high surface area which may cause self-heating during oxidation. An adequate air gap between packages of activated carbon is recommended to reduce risk of propagation of the event. Activated carbon is difficult to ignite and tends to burn slowly (smolder) without producing smoke or flame.

Hazardous combustion products:
Used activated carbon may produce additional combustion products which are based on the substance(s) adsorbed. Materials allowed to smolder for long periods in enclosed spaces may produce amounts of carbon monoxide which reach the lower explosive limit (carbon monoxide LEL = 12.5% in air). Carbon monoxide (CO). Carbon dioxide (CO2).

Protective equipment and precautions for firefighters:
In the event of fire, wear self-contained breathing apparatus. Wear suitable protective equipment.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures

Personal precautions: Avoid dust formation. Ensure adequate ventilation. Use personal protective equipment. See also Section 8.

Environmental Precautions:

Environmental Precautions: No special environmental precautions required. Local authorities should be advised if significant spillages cannot be contained.

Methods and material for containment and cleaning up

Methods for containment: Prevent further leakage or spillage if safe to do so.

Methods for cleaning up: Avoid dry sweeping and use water spraying or vacuum cleaning systems to prevent airborne dust generation. Use of a vacuum with high efficiency particulate air (HEPA) filtration is recommended. Do not create a dust cloud by using a brush or compressed air. Pick up and transfer to properly labelled containers. Spent granular activated carbon may be recyclable. Dispose of virgin (unused) carbon (surplus or spillage) in a facility permitted for non-hazardous wastes. Spent (used) carbon should be disposed of in accordance with applicable laws. Do not reuse empty bags: dispose of in a facility permitted for non-hazardous wastes. See Section 13.

7. HANDLING AND STORAGE

Precautions for safe handling

Advice on safe handling: Avoid contact with skin and eyes. Avoid dust formation. Do not breathe dust. Provide appropriate local exhaust ventilation at machinery and at places where dust can be generated. Do not create a dust cloud by using a brush or compressed air. Dust may form explosible mixture in air.

Activated carbons have high surface area which may cause self-heating during oxidation. Take precautionary measures against static discharges. All metal parts of the mixing and processing equipment must be earthed/grounded. Ensure all equipment is electrically earthed/grounded before beginning transfer operations. Fine dust is capable of penetrating electrical equipment and may cause electrical shorts. If hot work (welding, torch cutting, etc.) is required the immediate work area must be cleared of product and dust.

Conditions for safe storage, including any incompatibilities

Storage Conditions: Keep in a dry, cool and well-ventilated place. Keep away from heat and sources of ignition. Do not store together with strong oxidizing agents. Keep in properly labeled containers. Activated carbon is difficult to ignite and tends to burn slowly (smolder) without producing smoke or flame. Dust deposits should not be allowed to accumulate on surfaces, as these may form an explosible mixture if they are released in the atmosphere in sufficient concentrations. Prior to entering a confined space that contains or previously contained activated carbon, the space should be evaluated for oxygen and carbon monoxide concentrations, and any other hazards, by a qualified person.

Incompatible materials: Strong oxidizing agents. Strong acids.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure guidelines: .

Exposure limits for components or similar components are stated below.

Dust, or Particulates Not Otherwise Specified:	Austria MAK:	10 mg/m³, STEL 2x30 min, Inhalable dust 5 mg/m³, TWA, Inhalable dust
	Belgium:	10 mg/m³, TWA, Inhalable 3 mg/m³ TWA, Respirable
	Canada (Saskatchewan):	10 mg/m³, TWA, Inhalable 3 mg/m³ TWA, Respirable
	China:	8 mg/m³, TWA 10 mg/m³, STEL
	France:	10 mg/m³, TWA Inhalable dust 5 mg/m³, TWA Respirable dust
	Germany - TRGS 900:	10 mg/m³, TWA, Inhalable 3 mg/m³, Respirable fraction
	Hong Kong:	10 mg/m³, TWA
	Ireland:	10 mg/m³, TWA, Total Inhalable 4 mg/m³, TWA, Respirable
	Italy:	10 mg/m³, TWA, Inhalable 3 mg/m³, TWA, Respirable
	Japan:	3 mg/m³ TWA, Respirable
	Malaysia:	10 mg/m³, TWA, Inhalable 3 mg/m³, TWA, Respirable
	The Netherlands:	3.5 mg/m³, Inhalable
	Spain:	10 mg/m³, VLA, Inhalable 3 mg/m³, VLA, Respirable
	Sweden:	10 mg/m³, NGV, Total inhalable 5 mg/m³, NGV, Respirable
	United Kingdom - WEL:	10 mg/m³, TWA, Total Inhalable dust 4 mg/m³, TWA, Respirable dust
	US ACGIH - PNOS:	10 mg/m³, TWA, Inhalable 3 mg/m³, TWA, Respirable
	US OSHA - PEL:	15 mg/m³, TWA, Total dust 5 mg/m³, TWA, Respirable

Silica, Crystalline (Quartz) CAS RN 14808-60-7:	Austria MAK:	0.15 mg/m³, TWA (Respirable)
	Belgium:	0.1 mg/m³, TWA (Alveolar fraction)
	Denmark:	0.1 mg/m³, TWA (Respirable)
	Finland:	0.05 mg/m³, TWA (Respirable)
	France:	0.1 mg/m³, VME (Alveolar fraction)
	Ireland:	0.1 mg/m³, TWA (Respirable)
	Italy:	0.025 mg/m³, TWA (Respirable)
	Japan:	(3 mg/m³)/(1.19%SiO2 + 1) (Respirable)
	Switzerland:	0.15 mg/m³, TWA (Respirable)
	UK WEL:	0.1 mg/m³, TWA (Respirable)
	US OSHA PEL:	(10 mg/m³) /(%SiO2 + 2) (Respirable)
		(30 mg/m³)/(%SiO2 + 2) (Total)
	US ACGIH TLV:	0.025mg/m³ (Respirable)

MAK: Maximale Arbeitsplatzkonzentration (Maximum Workplace Concentration)
NGV: Nivå Gräns Värde (Level Limit Value)
PEL: Permissible Exposure Limit
STEL: Short Term Exposure Limit
TLV: Threshold Limit Value
TRGS: Technische Regeln für Gefahrstoffe (Technical Rule for Hazardous Materials)
TWA: Time Weighted Average
US ACGIH: United States American Conference of Governmental Industrial Hygienists
US OSHA: United States Occupational Safety and Health Administration
VLA: Valore Límite Ambientales (Environmental Limit Value)
WEL: Workplace Exposure Limit

Engineering Controls: Ensure adequate ventilation to maintain exposures below occupational limits. Provide appropriate exhaust ventilation at machinery and at places where vapors and dust can be generated.

Personal protective equipment [PPE]

Respiratory Protection: Approved respirator may be necessary if local exhaust ventilation is not adequate.

Hand Protection: Wear suitable gloves.

Eye/face Protection: Wear eye/face protection. Wear safety glasses with side shields (or goggles).

Skin and Body Protection: Wear suitable protective clothing. Wash clothing daily. Work clothing should not be allowed out of the workplace.

Other: Handle in accordance with good industrial hygiene and safety practice. Emergency eyewash and safety shower should be located nearby.

9. PHYSICAL AND CHEMICAL PROPERTIES

Information given is based on data obtained from this substance or from similar substances.

Physical State:	Solid	**Odor:**	Generally odorless. May produce slight sulfur smell when wet.
Appearance:	Granular	**Odor threshold:**	Not Applicable
Color:	Black		

Property	Values	Remarks • Method
pH:		Not Applicable
Melting point/freezing point:		Not Applicable
Boiling point / boiling range:		Not Applicable
Evaporation Rate:		Not Applicable
Vapor pressure:		Not Applicable
Vapor Density:		Not Applicable
Density:		No information available
Bulk Density:	27 - 30 lbs/ft³	
Specific Gravity at 20°C:		No information available
Water solubility:		Insoluble
Solubility(ies):		No information available
Partition Coefficient (n-octanol/water):		No information available
Decomposition temperature:		No information available
Viscosity:		No information available
Kinematic viscosity:		No information available
Dynamic viscosity:		No information available
Oxidizing Properties:		Not Applicable
Softening point:		No information available
VOC content (%):		Not Applicable
% Volatile (by Volume):		No information available
% Volatile (by Weight):		No information available
Surface Tension:		No information available
Explosive properties:		No information available
Flash Point:		Not Applicable
Flammability (solid, gas):		No information available
Flammability Limit in Air:		No information available
Explosion Limits in Air - Upper (g/m³):		No information available
Explosion Limits in Air - Lower (g/m³):		No information available
Autoignition Temperature:		No information available
Minimum Ignition Temperature:		No information available
		No information available
Minimum Ignition Energy:		No information available
Ignition Energy:		No information available
Maximum Absolute Explosion Pressure:		No information available
Maximum Rate of Pressure Rise:		No information available
Burn Velocity:		No information available
Kst Value:		No information available
Dust Explosion Classification:		No information available

10. STABILITY AND REACTIVITY

Reactivity: May react exothermically upon contact with strong oxidizers.

Stability: Stable under recommended handling and storage conditions.

Explosion data See also Section 9.

Sensitivity to Mechanical Impact: None.

Sensitivity to Static Discharge:	Dust may form explosible mixture in air. Do not create a dust cloud by using a brush or compressed air.
Possibility of hazardous reactions:	None under normal processing.
Hazardous polymerization:	Hazardous polymerization does not occur.
Conditions to avoid:	Keep away from heat and sources of ignition. Avoid dust formation. Activated carbon (especially when wet) can deplete oxygen from air in enclosed spaces, and dangerously low levels of oxygen may result. Activated carbons have high surface area which may cause self-heating during oxidation.
Incompatible materials:	Strong oxidizing agents. Strong acids.
Hazardous decomposition products:	Used activated carbon may produce additional combustion products which are based on the substance(s) adsorbed. Materials allowed to smolder for long periods in enclosed spaces may produce amounts of carbon monoxide which reach the lower explosive limit (carbon monoxide LEL = 12.5% in air). Carbon oxides.

11. TOXICOLOGICAL INFORMATION

Information given is based on data obtained from this substance or from similar substances.

Acute toxicity

Not classified.

Oral LD50:	LD50/oral/rat = >2000 mg/kg. (OECD 423).
Inhalation LC50:	LC50/inhalation/1h/rat = >8.5 mg/L (OECD 403)
Dermal LD50:	Absorption highly unlikely, no health effects known.
Skin corrosion/irritation:	Not classified Skin irritation test, rabbit (OECD 404): Not irritating
Serious eye damage/eye irritation:	Not classified. Eye irritation test, rabbit (OECD 405): Not irritating.
Sensitization:	Not classified. Not sensitizing based on Local Lymph Node Assay (OECD 429).
Mutagenicity:	Not classified. - Gene mutation in bacteria (Bacterial Reverse Mutation Assay/Ames) (OECD 471): not mutagenic. - In vitro Mammalian Chromosome Aberration Test (OECD 473): not clastogenic. - In vitro Mammalian Cell Gene Mutation Test (OECD 476).: non-mutagenic.
Carcinogenicity:	Not classified. Contains a component (crystalline silica) that is listed by IARC as group 1, by ACGIH as group A2, and by NTP as a known human carcinogen.

Reproductive Toxicity:	Not classified. Repeated dose inhalation toxicity test showed no reproductive target organ effects, and a toxicokinetic study showed no product migration to reproductive organs.
STOT - single exposure:	Not classified.
STOT - repeated exposure:	Not classified. Repeated dose toxicity study, inhalation (rat) 90 days (OECD 413): NOAEC 7.29 mg/m^3 (respirable). This test was conducted on activated carbon containing negligible crystalline silica; therefore activated carbon itself is not classified for STOT-RE. Although respirable crystalline silica is classified as STOT-RE1, this product contains <1% respirable crystalline silica, therefore it is not classified for STOT-RE.
Aspiration Hazard:	Based on industrial experience and available data, no aspiration hazard is expected.

12. ECOLOGICAL INFORMATION

Information given is based on data obtained from this substance or from similar substances.

Aquatic Toxicity:	Non toxic. The substance is highly insoluble in water and the substance is unlikely to cross biological membranes. No adverse ecological effects are known.
Terrestrial Toxicity:	Earthworm reproduction study (OECD 222), NOAEC for body weight reduction 1000 mg/kg soil; NOAEC for reproduction 3200 mg/kg soil. Non toxic in soil.

ENVIRONMENTAL FATE

Persistence and degradability	Not expected to degrade.
Bioaccumulation	Not expected due to physicochemical properties of the substance.
Mobility:	Not expected to migrate. Insoluble.
Distribution to Environmental Compartments:	Insoluble. Expected to remain on soil surface.
Other adverse effects:	No information available.

13. DISPOSAL CONSIDERATIONS

Disclaimer: Information in this section pertains to the product as shipped in its intended composition as described in Section 3 of this MSDS. Contamination or processing may change waste characteristics and requirements. Regulations may also apply to empty containers, liners or rinsate. State/provincial and local regulations may be different from federal regulations.

Disposal of wastes

Activated carbon, in its original state, is not a hazardous material or hazardous waste. Follow applicable regulations for waste disposal.

Spent (used) activated carbon may be classified as a hazardous waste depending upon its use, the substance(s) adsorbed, and how it is ultimately managed. Follow applicable regulations for disposal.

Recycling (reactivation) may be a viable alternative to disposal. Dust formation from residues in packaging should be avoided and suitable worker protection assured. Store used packaging in enclosed receptacles.

14. TRANSPORT INFORMATION

Not classified as dangerous in the meaning of transport regulations.

DOT

UN/ID no	Not regulated
Proper Shipping Name	Not regulated
Hazard Class	Not regulated
Packing group	Not regulated

ICAO (air)

UN/ID no	Not regulated
Proper Shipping Name	Not regulated
Hazard Class	Not regulated
Packing group	Not regulated

IATA

UN/ID no	Not regulated
Proper Shipping Name	Not regulated
Hazard Class	Not regulated
Packing group	Not regulated

IMDG

UN/ID no	Not regulated
Proper Shipping Name	Not regulated
Hazard Class	Not regulated
Packing group	Not regulated

RID

UN/ID no	Not regulated
Proper Shipping Name	Not regulated
Hazard Class	Not regulated
Packing group	Not regulated

ADR

UN/ID no	Not regulated
Proper Shipping Name	Not regulated
Hazard Class	Not regulated
Packing group	Not regulated

15. REGULATORY INFORMATION

International Inventories

TSCA - United States Toxic Substances Control Act Section 8(b) Inventory	Complies
DSL/NDSL - Canadian Domestic Substances List/Non-Domestic Substances List	Complies
EINECS/ELINCS - European Inventory of Existing Chemical Substances/European List of Notified Chemical Substances	Complies
ENCS - Japan Existing and New Chemical Substances	Complies
IECSC - China Inventory of Existing Chemical Substances	Complies
KECL - Korean Existing and Evaluated Chemical Substances	Complies
PICCS - Philippines Inventory of Chemicals and Chemical Substances	Complies
AICS - Australian Inventory of Chemical Substances	Complies
NZIoC - New Zealand Inventory of Chemicals	Complies
TCSI - Taiwan Chemical Substance Inventory	Complies

16. OTHER INFORMATION

Disclaimer:

The information set forth is based on information that Cabot Corporation believes to be accurate. No warranty, expressed or implied, is intended. The information is provided solely for your information and consideration and Cabot assumes no legal responsibility for use or reliance thereon. In the event of a discrepancy between the information on the non-English document and its English counterpart, the English version shall supersede.

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End of Safety Data Sheet