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Colorado Department of Public Health and Environment
Air Pollution Control Division
APCD-SS-B1
4300 Cherry Creek Drive South
Denver, CO 80246-1530

Re: Application to Revise Construction Permit 19AR0178, Amazon Data Services, Inc., DEN-22 Back-up electric power supply facility.

To Whom It May Concern:

Amazon Data Services, Inc. (Amazon) operates a back-up power facility at its data center located at Buckley Air Force Base. With the reclassification of the Denver North Front Range Metro area to severe nonattainment for the 2008 ozone standard, Amazon seeks to reduce the potential emissions of nitrogen oxides to less than the major source threshold. The application proposes to create an enforceable limitation on diesel fuel consumption for the engines that provide mechanical power to the electric generators.

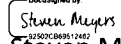
This application is being submitted in electronic form per the current guidance from the Air Pollution Control Division (the Division). This application contains all elements required for a complete permit application per Regulation 3 and on-line guidance at the Air Pollution Control Division's website.

- Executive Summary
- Modification Description
- Emission Calculation Methodology
- Regulatory Analysis
- Appendix A: Air Pollution Emission Notice (APEN) Fee Payment Receipt
- Appendix B: Revised APEN
- Appendix C: Detailed Emission Calculations and Supporting Documentation
- Appendix D: APCD Form 114, Modeling Requirements Determination Form

Per the Division's requirements, the APCD Form 114 was submitted separately to the Modeling Permitting Unit. This form is included here for reference.

If you have questions regarding this application, please direct them to Blake Carruthers at bcarrut@amazon.com or 940.704.1439.

Sincerely,

DocuSigned by

Steven Meyers

Authorized Representative, Amazon Data Services, Inc.

Dated: February 2, 2023

CONSTRUCTION PERMIT 19AR0178 REVISION TO REDUCE EMISSIONS

Amazon Data Services, Inc. / DEN-22

Prepared By:

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November 2022

Trinity Consultants Project No. 220601.0072



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1. EXECUTIVE SUMMARY

Amazon Data Services, Inc. (Amazon) operates a back-up electric power supply facility for a data center located 19650 Winter Park Avenue, Buckley Air Force Base, Arapahoe County, CO 80011. The facility, DEN-22 holds Construction Permit 19AR0178, Issuance 2 and is identified as , AIRS ID number 005/1722.

DEN-22 is permitted for 18 diesel fuel powered reciprocating internal combustion engines that provide mechanical power to electrical generators. The potential-to-emit nitrogen oxides (NOx) is 39.2 tons per year (tpy). The facility is located in the Denver Metro Front Range Ozone Nonattainment Area, currently classified as Serious for the 2008 ozone standard and expected to be classified as Severe for this standard soon.

In this permit revision application, Amazon seeks to reduce the enforceable potential-to-emit for NOx to less than 25 tpy to preserve the minor source status of the facility under the Nonattainment New Source Review Program (NNSR). Upon approval, DEN-22 will remain a synthetic minor source for volatile organic compounds (VOC) and NOx under the NNSR and Title V programs and a synthetic minor source for all other regulated pollutants under the New Source Review and Title V programs. Allowable emissions from DEN-22 upon issuance of the revised permit are summarized in the table below.

Table 1-1 DEN-22 Requested Allowable Emissions After Revision

Pollutant	SO₂	PM	PM₁₀	PM_{2.5}	CO	NO_x	VOC
Requested Allowable Emissions (tpy)	3.7	1.7	1.7	1.7	4.8	24.3	1.3
NNSR Major Source Threshold (tpy)	n/a	n/a	n/a	n/a	n/a	25	25
NSR Major Source Threshold (tpy)	250	250	250	250	250	n/a	n/a
Title V Major Source Threshold (tpy)	100	100	100	100	100	100	100

Other than reducing emissions by voluntarily reducing the annual consumption of diesel fuel, no other physical or operational changes are being made at the DEN-22 facility. As described in this permit revision application, there are no changes at the associated data center that would result in an increase of any regulated pollutant.

The DEN-22 facility was initially authorized to construct in May, 2019 (19AR0178, Issuance 1). The permit was modified August 11, 2020 (Issuance 2). Subsequent to the initial authorization, 15 of the 18 authorized engines have been installed. Installations have been governed by the build out of data center operations. Amazon intends to install the remaining authorized engines in anticipation of the final data center build out. By this permit modification, Amazon seeks confirmation that approval to construct the remaining three authorized engines is intact.

2. MODIFICATION DESCRIPTION

The modification proposed in this permit application is to reduce the total annual fuel consumption at the DEN-22 facility to reduce the potential-to-emit of NO_x to maintain synthetic minor source status under NNSR. No other physical or operational changes are proposed at DEN-22 or the associated data center.

3. EMISSION CALCULATION METHODOLOGY

The following section details the methodology and calculations used to estimate emissions from the generator engines. Only the formulas and data sources are described here. Complete, detailed emission calculations are found in Appendix C.

3.1 Methodology

The objective of the emission calculations presented in this section is to determine which, if any, of the federal NSR requirements apply to the facility after modification. The DEN-22 is located in Arapahoe County, which is designated as an attainment/unclassifiable for particulate matter (PM), including PM with an aerodynamic diameter of less than 10 and 2.5 microns in size (PM₁₀ and PM_{2.5}, respectively), nitrogen dioxide (NO₂), and sulfur dioxide (SO₂), and maintenance for carbon monoxide (CO). As a result, federal Prevention of Significant Deterioration (PSD) or NNSR requirements would be applicable if the project resulted in a major modification (a significant emissions increase and a significant net emission increase) for any of these pollutants.

Arapahoe County is designated serious non-attainment for ozone.¹ As a result, federal non-attainment new source review (NNSR) would be applicable if there was a significant emission increase and a significant net emission increase in ozone precursors, volatile organic compounds (VOC) or nitrogen oxides (NOx).

As described previously, this modification proposes a reduction in emissions for all regulated pollutants by reducing annual fuel consumption. This change does not trigger major modification review.

3.2 Affected Units

The engines are the only emission sources affected by this modification. The other potential source of regulated emissions are the various storage tanks and other activities, but as described below, these sources continue to be APEN-exempt.

3.2.1 CI RICE Generator Engines

The narrative from the initial application concerning engine emissions is unchanged and replicated here.

For flexibility, [Amazon] is proposing to implement an annual fuel-usage cap for all engines. The manufacturer's emission factors ("mass pollutant/hp-hr") at the sea-level power rating were used to calculate fuel-based emission factors ("mass pollutant/gallon fuel consumed"). Because power requirements vary during back-up usage, engine loads will also vary. To maintain power load flexibility, the highest emission factor at loads between 25% - 100% for each pollutant was used. This approach provides a conservative estimate of emissions.

¹ On December 27, 2019, U.S. EPA reclassified the Denver-Boulder-Greeley-Ft. Collins-Loveland, Colorado non-attainment area from "moderate" to "serious" with respect to the 2008 national ambient air quality standards (NAAQS) for ozone. The classification became effective on January 27, 2020. A reclassification to "severe" for the 2008 standard is pending but has not been adopted as of the submittal of this application.

Particulate emissions are the sum of the filterable and condensable particulate. To represent the latter, the hydrocarbon emissions (Total HC) were added to the particulate emissions reported in the manufacturer's specifications.

While engine hours of operation will be tracked for maintenance purposes, engine run time is not explicitly included in the emission calculations and is not requested as a permit limit.

The manufacturer specifications for the proposed generator engines are included in this section.

3.2.2 Fuel Storage Tanks

The narrative from the initial application concerning storage tank emissions is unchanged and replicated here.

The fuel storage for the back-up power facility will include belly tanks (~5,000-gallon capacity each) integral to each engine and will also include up to six auxiliary fixed roof storage tanks, each with capacity of 40,000 gallons. Regardless, based on the liquid stored (diesel fuel) and total annual throughput (less than 400,000 gallons), the fuel storage tanks are APEN exempt per Regulation 3, Part A, II.D.1.fff. APEN exempt source emissions are not included in the emission calculations.

3.2.3 Other APEN-Exempt Sources

The narrative from the initial application concerning other APEN-exempt sources is unchanged and replicated here.

Other APEN exempt-sources may include air conditioning and ventilation (II.D.1.c.), fuel burning equipment (II.D.1.k.), chemical storage tanks and areas (II.D.1.n. and mm.), welding operations (II.D.1.r.), aerosol can usage (II.D.1.u.), and lubricating oil storage (II.D.1.aaa.). APEN exempt source emissions are not included in the emission calculations. The Facility will not employ cooling towers.

4. REGULATORY ANALYSIS

This section addresses the potential applicability of the current federal and state regulatory standards to the DEN-22 facility as a result of this modification, including the following:

- New Source Performance Standards (NSPS) in 40 CFR Part 60;
- National Emissions Standards for Hazardous Air Pollutants (NESHAP) in 40 CFR Part 63; and
- PSD and NNSR.

4.1 New Source Performance Standards

The NSPS subparts in 40 CFR Part 60 that are potentially applicable to this request are listed in Table 4-1. Detailed applicability determinations for each potentially applicable subpart follow.

Table 4-1 Potentially Applicable NSPS Subparts

Subpart	Description	Affected Sources	Applicability
40 CFR 60, Subpart A	General Provisions	CI RICE in AIRS 001	Yes
40 CFR 60, Subpart Kb	Standards of Performance Organic Liquid Storage Tanks	Auxiliary storage tanks	No
40 CFR 60, Subpart IIII	Standards of Performance CI RICE	CI RICE in AIRS 001	Yes

4.1.1 Subpart A – General Provisions

Any source subject to a source-specific NSPS is also subject to the general provisions of NSPS subpart A. Unless specifically excluded by the source-specific NSPS, subpart A generally requires initial construction notification, initial startup notification, performance tests, performance test date initial notification, general monitoring requirements, general recordkeeping requirements, and semiannual monitoring and/or excess emission reports.

4.1.2 Subpart Kb – Standards of Performance Organic Liquid Storage Tanks

This subpart applies to each storage vessel with a capacity greater than or equal to 75 m³ (19,812.9 gallons) used to store volatile organic liquids for which construction, modification, or reconstruction commenced after July 23, 1984. This subpart does not apply to tanks that have capacity greater than 151 m³ storing a liquid with a maximum true vapor pressure less than 3.5 kilopascals (kPa). Six auxiliary fixed roof storage tanks have been installed at DEN-22, each with capacity of 40,000 gallons (151.4 m³) to ensure sufficient on-site fuel storage. The stored fuel has a maximum vapor pressure of 0.25 kPa at 100 °F and therefore this subpart does not apply.

4.1.3 Subpart IIII – Standards of Performance for Compression Ignition RICE

This subpart applies to owners and operators of compression ignition (CI) internal combustion engines (ICE) that commenced construction after July 11, 2005 and are manufactured after April 1, 2006. For purposes of

this part, “commenced construction” means the date the unit was ordered from the manufacturer. Amazon has and will continue to comply with all requirements under this subpart that apply to the CI ICE at the Facility.

Amazon operates these engines as emergency stationary ICE, defined in §60.4219 as:

Emergency stationary internal combustion engine means any stationary reciprocating internal combustion engine that meets all of the criteria in paragraphs (1) through (3) of this definition. All emergency stationary ICE must comply with the requirements specified in §60.4211(f) in order to be considered emergency stationary ICE. If the engine does not comply with the requirements specified in § 60.4211(f), then it is not considered to be an emergency stationary ICE under this subpart.

(1) The stationary ICE is operated to provide electrical power or mechanical work during an emergency situation. Examples include stationary ICE used to produce power for critical networks or equipment (including power supplied to portions of a facility) when electric power from the local utility (or the normal power source, if the facility runs on its own power production) is interrupted, or stationary ICE used to pump water in the case of fire or flood, etc.

(2) The stationary ICE is operated under limited circumstances for situations not included in paragraph (1) of this definition, as specified in § 60.4211(f).

(3) The stationary ICE operates as part of a financial arrangement with another entity in situations not included in paragraph (1) of this definition only as allowed in § 60.4211(f)(2)(ii) or (iii) and § 60.4211(f)(3)(

§60.4211(f) provides allowance for limited operation in non-emergency modes (e.g., maintenance and testing) or in cases where utility provided power deviates from voltage or frequency standards by 5% or more. There is no time limit on the use of emergency ICE in emergency situations.

§60.4205(b) specifies that the CI ICE with displacement less than 30 liters per cylinder must meet the emission standards specified in §60.4202(b)(2) which in turn points to the Tier 2 standards for all pollutants as shown in §89.112, Table 1 and §60.4212².

Additional requirements that apply to the engines include:

- §60.4207(a) requires the use of ultra-low sulfur fuel.
- §60.4211(a) lists compliance requirements for all ICE subject to emission standards under this subpart.
- §60.4211(f) list compliance requirements for emergency ICE.
- §60.4214(b) specifies that initial notification is not required for emergency ICE.

4.2 National Emission Standards for Hazardous Air Pollutants

NESHAPs are federal regulations that apply to major and area sources of HAPs. The 40 CFR 63 subparts that are potentially relevant to this request are listed in Table 4-2 below. Detailed applicability determinations for each potentially applicable subpart are included in the subsections following Table 4-2.

² Note per 60.4212, an owner or operator demonstrating compliance with the manufacturer Tier 2 emission limits in 89.112, must not exceed 1.25 the standard limit.

Table 4-2 Potentially Applicable NESHAP Subparts

Subpart	Description	Affected Sources	Applicability
40 CFR 63, Subpart A	General Provisions	CI RICE in AIRS 001	Yes
40 CFR 63, Subpart ZZZZ	Standards of Performance for RICE	CI RICE in AIRS 001	Yes

4.2.1 Subpart A

Any source subject to a pollutant- or source-specific NESHAP is also subject to the general provisions of NESHAP subpart A. Unless specifically excluded by the pollutant- or source-specific NESHAP, subpart A generally requires initial notifications, performance tests, general monitoring requirements, general recordkeeping requirements, and semiannual monitoring and/or excess emission reports.

4.2.2 Subpart ZZZZ – Standards of Performance for RICE

NESHAP ZZZZ applies to reciprocating ICE at area sources of Hazardous Air Pollutants (HAP). The back-up power facility is an area source of HAP and the ICE are considered “new” for purposes of this subpart since construction of these engines commenced construction after June 12, 2006. For purposes of this subpart “commenced construction” means the date the affected source was installed on-site.

Pursuant to §63.6590(c)(1), new ICE located at an area source must meet the requirements of NESHAP ZZZZ by meeting the requirements of 40 CFR Part 60 Subpart IIII. No further requirements under NESHAP ZZZZ apply to these engines.

4.3 Permit Applicability

The NSR permitting program generally requires a stationary source to obtain a permit and undertake other obligations prior to construction of any project at an industrial facility if the proposed project results in the potential to emit air pollutants in excess of certain threshold levels. The NSR program is comprised of two elements: NNSR and PSD. The NNSR program potentially applies to new construction or modifications that result in emission increases of a particular pollutant for which the area where the facility is located is classified as “nonattainment” for that pollutant. The PSD program potentially applies to new construction or modifications that result in emission increases of criteria pollutant(s) for which the area where the facility is located is classified as “attainment” or “unclassifiable.” Colorado has incorporated the provisions of the federal PSD and NNSR programs into Colorado AQCC Regulation No. 3, Part D.

4.3.1 NNSR Review Applicability

The requirements in this rule do not apply to this request because the proposed emissions for the ozone nonattainment area precursor pollutants (VOC and NOx) are below the corresponding NNSR significant emissions rate.

4.3.2 PSD Review Applicability

This project is not subject to PSD review because the project emission increases are below the PSD significant emissions rate thresholds for all NSR pollutants for which Arapahoe County is designated attainment/unclassifiable or maintenance.

4.4 Colorado State Regulations

In addition to federal air regulations, the Colorado AQCC establishes regulations applicable at the emission unit level (source-specific) and at the facility level for stationary sources. The rules also contain requirements related to the need for construction and/or operating permits.

4.4.1 Colorado AQCC Regulation Number 1

Regulation Number 1, Section II details requirements for new and existing stationary sources limiting opacity to 20% or less during normal operation and 30% or less at startup using the visible emissions measurements in EPA Method 9. The engines are subject to this requirement. Section III has requirements for emissions of particulate matter from fuel-burning equipment. The engines are subject to III.A.1.a; particulate emissions may not exceed 0.5 lb per MMBTU heat input. Section VI has requirements for SO₂ emissions. The tier certification, design rated heat input, and combustion of ultra-low sulfur diesel fuel ensures compliance with the particulate and SO₂ requirements for both engines.

4.4.2 Colorado AQCC Regulation Number 3, Part A – Technical Modeling Requirements

Regulation Number 3, Part A, Section VIII.A requires that all estimates of ambient concentrations required under this Regulation be based on requirements specifically approved by the APCD. The APCD has issued an addendum to the Colorado Modeling Guideline for Air Quality Permits (May 2022). The addendum states that modeling or a modeling determination are presumptively not required when a permit modification involves emission reductions³. This permit application proposes emission reductions and therefore no modeling or modeling determination is required.

4.4.3 Colorado AQCC Regulation Number 3, Part A – APEN Requirements

Regulation Number 3, Part A, Section II details Colorado's APEN submittal requirements. Amazon is submitting an APEN, included in Appendix B, per the requirements of Regulation No. 3, Part A, Section II.C.1.d. The APEN submittal fee has been paid by Amazon; the receipt is attached in Appendix A.

4.4.4 Colorado AQCC Regulation Number 3, Part B

Regulation Number 3, Part B, Section III.D.2 requires Reasonably Available Control Technology (RACT) for all new or modified minor sources, including new and modified minor emission units at a major stationary source, of VOC, CO, NO_x, SO₂, and PM₁₀, unless the source or emission unit is exempt from construction permitting requirements. The original permit application included a complete RACT analysis.

³ Permitting Section Addendum to the Modeling Guideline, September 21, 2022, page 2.

4.4.5 Colorado AQCC Regulation Number 3, Part C

The facility emissions are less than Title V thresholds, and will continue to be below Title V thresholds after the nonattainment area classification is downgraded to severe. The part does not apply.

**COLORADO****Air Pollution Control Division**

Department of Public Health & Environment

Dedicated to protecting and improving the health and environment of the people of Colorado

New Source Performance Standards (NSPS) – 40 CFR Part 60, Subpart IIII Applicability Air Pollutant Emission Notice (APEN) Addendum Form for Diesel Engines

Company Name: Amazon Data Services, Inc.Engine Information¹Make: Caterpillar Model: 3516-HD SN: See Addendum

1. Date of Engine Manufacture: See Addendum
2. Has this engine operated outside of the state of Colorado?

☐ Yes
☒ No
3. If you answered "Yes" to question 2, please answer the following question. (If you answered "No" to question 2, please leave this field blank.) What is the date of first entry into Colorado? N/A
4. This engine was manufactured to meet the following tier level standards² (e.g., Tier 1, Tier 2): Tier 2

Permit #³: 19AR0178AIRS ID³: 005 / 1722 / 001

A copy of this form, along with appropriate supporting documentation⁴, shall be maintained on-site or at a local field office, with stationary source responsibility, with a copy of the construction permit, exemption letter or general permit approval letter issued by the Colorado Air Pollution Control Division (the Division) for this emissions source. These records may be kept in either electronic or hard copy format provided that they can be promptly supplied to the Division or agents thereof upon request.

This engine shall comply with the New Source Performance Standards (NSPS) requirements of Colorado Air Quality Control Commission Regulation No. 6, Part A, Subpart IIII, Standards of Performance for Stationary Compression Ignition Internal Combustion Engines (CI ICE) including, but not limited to, the following:

[The requirements below reflect the rule language of 40 CFR Part 60 Subpart IIII published in the Federal Register on 01/30/2013. However, if revisions to this Subpart are published at a later date, the owner or operator is subject to the requirements contained in the revised version of 40 CFR Part 60, Subpart IIII.]

- I. All fuel used shall meet the following specifications:
 - A. Sulfur content shall not exceed 15 ppm
 - B. Have a minimum cetane index of 40 or have a maximum aromatic compound content of 35% by volume
 - C. Compliance shall be demonstrated by maintaining copies of the fuel specifications provided by the supplier on-site or in a readily accessible location and made available to the Division for inspection upon request.
- II. The engine and control devices must be installed, configured, operated and maintained according to the specifications and instructions provided by the engine manufacturer.
- III. If the engine is equipped with a diesel particulate filter, the filter must be installed with a backpressure monitor that notifies the owner or operator when the high backpressure limit of the engine is approached. Records shall be kept of any corrective action taken after the backpressure monitor has notified the owner or operator that the high backpressure limit is approached.
- IV. If the engine is used for emergency purposes, a non-resettable hour meter must be installed prior to start-up.
- V. If the diesel fuel-fired engine referenced herein avoids tier 4 or 4i requirements by being an emergency generator, the engine shall not be used for any purpose except emergency power generation and for the purpose of maintenance

4300 Cherry Creek Drive S., Denver, CO 80246-1530 P 303-692-2000 www.colorado.gov/cdphe
 John W. Hickenlooper, Governor | Larry Wolk, MD, MSPH, Executive Director and Chief Medical Officer



checks and readiness testing, provided that the tests are recommended by Federal, State or local government, the manufacturer, the vendor or the insurance company associated with the engine. Maintenance checks and readiness testing of such units is limited to 100 hours per year. There is no time limit on the use of emergency stationary ICE in emergency situations. The owner or operator may petition the Administrator for approval of additional hours to be used for maintenance checks and readiness testing, but a petition is not required if the owner or operator maintains records indicating that Federal, State, or local standards require maintenance and testing of emergency ICE beyond 100 hours per year. Emergency stationary ICE may operate up to 50 hours per year in non-emergency situations, but those 50 hours are counted towards the 100 hours per year provided for maintenance and testing. The 50 hours per year for non-emergency situations cannot be used for peak shaving or to generate income for a facility to supply power to an electric grid or otherwise supply non-emergency power as part of a financial arrangement with another entity. For owners and operators of emergency engines, any operation other than emergency operation, maintenance and testing, and operation in non-emergency situations for 50 hours per year, as permitted in this section, is prohibited.

VI. Emission Standards:

- A. The engine referenced herein shall meet all the emissions standards applicable to the engine.
- B. Compliance with the NSPS Subpart IIII Emissions Standards for Non-Methane Hydrocarbons (NMHC), Nitrogen Oxides (NOx), Carbon Monoxide (CO) and Particulate Matter (PM) shall be demonstrated by filing a copy of the unit's certification documentation of compliance with the NSPS Subpart IIII emissions standards, with the associated application.

VII. The following requirements of Regulation No. 6, Part A, Subpart A, General Provisions, shall apply:

- A. At all times, including periods of start-up, shutdown, and malfunction, the engine and control equipment shall, to the extent practicable, be maintained and operated in a manner consistent with good air pollution control practices for minimizing emissions. Determination of whether or not acceptable operating and maintenance procedures are being used will be based on information available to the Division, which may include, but is not limited to, monitoring results, opacity observations, review of operating and maintenance procedures, and inspection of the source. (Reference: Regulation No. 6, Part A. General Provisions from 40 CFR 60.11)
- B. No article, machine, equipment or process shall be used to conceal an emission which would otherwise constitute a violation of an applicable standard. Such concealment includes, but is not limited to, the use of gaseous diluents to achieve compliance with an opacity standard or with a standard which is based on the concentration of a pollutant in the gases discharged to the atmosphere. (§ 60.12)
- C. Written notification of construction and initial startup dates shall be submitted to the Division as required under § 60.7.
- D. Records of startups, shutdowns, and malfunctions shall be maintained, as required under § 60.7.

VIII. This engine meets all the requirements in New Source Performance Standard (NSPS) Subpart IIII as applicable to the specific engine, including the standards required for relocating into Colorado as set forth in Regulation No. 6, Part B, Section I.C.

I hereby certify that all information contained herein is complete, true and correct. I certify that this source is and will be operated in full compliance with the applicable tier standards of Colorado Air Quality Control Commission Regulation No. 6, Part A, Subpart IIII, Standards of Performance for Stationary Compression Ignition Internal Combustion Engines (CI ICE) as well as all other requirements referenced herein.

Steven Meyers

Name of Legally Authorized Person (Please Print)

DocuSigned by:
Steven Meyers
92502CB69512462

Signature of Legally Authorized Person

Authorized Representative

Title

February 2, 2023

Date

¹ If the engine has not been selected or ordered as of the date of submission of the construction permit application, this form must be completed and submitted to the Colorado Air Pollution Control Division, for an affected engine, within one hundred and eighty (180) days after the commencement of construction/operation.

² This information can be obtained from the engine manufacturer.

³ Please enter this information if this form is being submitted after the date of submission of the construction permit application and a permit number and AIRS ID number have been assigned. Otherwise, leave these fields blank.

⁴ Supporting documentation includes: document(s) proving the date of first entry into Colorado (purchase receipt, delivery receipt, etc.) and tier standard certification information from the manufacturer, as applicable.

APPENDIX C. DETAILED EMISSION CALCULATIONS AND SUPPORTING DOCUMENTATION

DIESEL ENGINE - EMISSIONS**Amazon Data Services, Inc DEN-22 Backup Generator Engines**

Number of Engines (Units) = 18
 Engine Make and Model = Caterpillar 3516C-HD ATAAC, V-16
 US EPA Tier Rating II
 Engine Maximum Brake Horsepower = 3,634 hp¹
 Fuel Type = Diesel
 Fuel Lower Heat Value = 18,390 Btu/lb²
 Fuel Lower Heat Value = 128,730 Btu/gal
 Total All Units, Maximum Estimated Monthly Fuel Use = 30,000 gal/month
 Total All Units, Annual Fuel Use = 165,000 gal/yr
 Avg Brake Specific Fuel Consumption = 0.334 lb/hp-hr³
 Avg Brake Specific Fuel Consumption = 0.046 gal/hp-hr (calculated)
 Per Unit Average Hourly Fuel Consumption at 100% Load = 173.50 gal/hr

Pollutant / Speciated Organics	Emission Factor	Units	Emission Factor (lb/gallon fuel) ⁴	Annual Emissions (tpy) ⁵
NO _x	--	--	0.295	24.3
CO	--	--	0.058	4.8
PM/PM ₁₀ /PM _{2.5} ⁶	--	--	0.021	1.7
SO ₂	2.05E-03	lb/hp-hr ⁷	0.045	3.7
Total HC	--	--	0.016	1.3
Benzene	9.33E-04	lb/MMBtu input ⁷	1.20E-04	0.01
Toluene	4.09E-04	lb/MMBtu input ⁷	5.27E-05	0.00
Xylene	2.85E-04	lb/MMBtu input ⁷	3.67E-05	0.00
1,3-Butadiene	3.91E-05	lb/MMBtu input ⁷	5.03E-06	0.00
Formaldehyde	1.18E-03	lb/MMBtu input ⁷	1.52E-04	0.01
Acetaldehyde	7.67E-04	lb/MMBtu input ⁷	9.87E-05	0.01
Acrolein	9.25E-05	lb/MMBtu input ⁷	1.19E-05	0.00
Total PAH	1.68E-04	lb/MMBtu input ⁷	2.16E-05	0.00
Total HAPs				0.04

¹ CAT Standby 2500 ekW 3125 kVA Diesel Generator Set. Not site derated for elevation above sea level.

² CAT Standby 2500 ekW 3125 kVA Diesel Generator Set, Technical Data.

³ CAT Standby 2500 ekW 3125 kVA Diesel Generator Set, General Performance Data, 100% load.

⁴ NO_x, CO, PM, and HC factors are the worst-case factors based on 100%, 75%, and 50% load scenarios. The factors were calculated by converting by multiplying the g/hp-hr factors by the respective hp at each load and dividing by the gal/hr fuel consumption at each load. Emission factors are per specification sheet for CAT Standby 2500 ekW 3125 kVA Diesel Generator Set, Rated Speed Potential Site Variation. PM includes Total HC to represent condensible PM + filterable PM.

⁵ Annual Emissions (tpy) = Annual Fuel Throughput (gal/yr) * Emission Factor (lb/gal) / 2,000 (lb/ton)

Annual Emissions NO _x (tpy) =	0.29 lb	165,000 gal	ton	=	24.30 ton
	gal	yr	2,000 lb		yr

⁶ All particulate matter is assumed to be less than 10 µm, therefore the emission factor and the calculated emissions are the same for PM and PM₁₀. PM₁₀/PM_{2.5} is assumed to equal PM. Includes Total HC to account for condensible PM.

⁷ Emission factors are taken from AP-42, Chapter 3, Section 3, Table 3.3-1 (*Emission Factors for Gasoline and Diesel Industrial Engines October 1996*), Table 3.3-2 (*Speciated Organic Compound Emission Factors for Uncontrolled Stationary Diesel Engines*).

DIESEL ENGINE - EMISSIONS

STANDBY 2500 ekW 3125 kVA

60 Hz 1800 rpm 480 Volts

**TECHNICAL DATA**

Open Generator Set - 1800 rpm/60 Hz/480 Volts		DMR266	
EPA Certified for Stationary Emergency Application (EPA Tier 2 emissions levels)			
Generator Set Package Performance			
Genset Power rating @ 0.8 pf		3125 kVA	
Genset Power rating with fan		2500 ekW	
Fuel Consumption			
100% load with fan		656.8 L/hr	173.5 Gal/hr
75% load with fan		510.8 L/hr	134.9 Gal/hr
50% load with fan		372.4 L/hr	98.4 Gal/hr
Cooling System¹			
Air flow restriction (system)		0.12 kPa	0.48 in. water
Air flow (max @ rated speed for radiator arrangement)		2800 m ³ /min	98881 cfm
Engine Coolant capacity with radiator/exp. tank		504.0 L	133.1 gal
Engine coolant capacity		233.0 L	61.6 gal
Radiator coolant capacity		271.0 L	71.6 gal
Inlet Air			
Combustion air inlet flow rate		204.2 m ³ /min	7211.3 cfm
Exhaust System			
Exhaust stack gas temperature		490.7 °C	915.3 °F
Exhaust gas flow rate		654.5 m ³ /min	10682.0 cfm
Exhaust flange size (internal diameter)		203.2 mm	8.0 in
Exhaust system backpressure (maximum allowable)		6.7 kPa	26.9 in. water
Heat Rejection			
Heat rejection to coolant (total)		826 kW	46975 Btu/min
Heat rejection to exhaust (total)		2502 kW	142288 Btu/min
Heat rejection to aftercooler		786 kW	44700 Btu/min
Heat rejection to atmosphere from engine		161 kW	9156 Btu/min
Heat rejection to atmosphere from generator		101.5 kW	5772.3 Btu/min
Alternator²			
Motor starting capability @ 30% voltage dip		6560 ekVA	
Frame		1842	
Temperature Rise		150 °C	270 °F
Lube System			
Sump refill with filter		466.0 L	123.1 gal
Emissions (Nominal)³			
NOx g/hp-hr		5.32 g/hp-hr	
CO g/hp-hr		.42 g/hp-hr	
HC g/hp-hr		.1 g/hp-hr	
PM g/hp-hr		.037 g/hp-hr	

¹ For ambient and altitude capabilities consult your Cat dealer. Air flow restriction (system) is added to existing restriction from factory.

² Generator temperature rise is based on a 40 degree C ambient per NEMA MG1-32. UL 2200 Listed packages may have oversized generators with a different temperature rise and motor starting characteristics.

³ Emissions data measurement procedures are consistent with those described in EPA CFR 40 Part 80, Subpart D & E and ISO8178-1 for measuring HC, CO, PM, NOx. Data shown is based on steady state operating conditions of 77°F, 28.42 in HG and number 2 diesel fuel with 35° API and LHV of 18,390 btu/lb. The nominal emissions data shown is subject to instrumentation, measurement, facility and engine to engine variations. Emissions data is based on 100% load and thus cannot be used to compare to EPA regulations which use values based on a weighted cycle.

DIESEL ENGINE - EMISSIONS

PERFORMANCE DATA[DM8266]

April 25, 2016

Performance Number: DM8266

Change Level: 04

SALES MODEL:	3516C	COMBUSTION:	DI
ENGINE POWER (BHP):	3,634	ENGINE SPEED (RPM):	1,800
GEN POWER WITH FAN (KW):	2,500.0	HERTZ:	60
COMPRESSION RATIO:	14.7	FAN POWER (BHP):	130.1
RATING LEVEL:	STANDARD	ASPIRATION:	TA
PUMP QUANTITY:	2	AFTERCOOLER TYPE:	ATAAC
FUEL TYPE:	DIESEL	AFTERCOOLER CIRCUIT TYPE:	JWOC ATAAC
MANIFOLD TYPE:	CI	INLET MANIFOLD AIR TEMP (F):	122
GOVERNOR TYPE:	ADCM3	JACKET WATER TEMP (F):	210.2
ELECTRONICS TYPE:	ADCM3	TURBO CONFIGURATION:	PARALLEL
CAMSHAFT TYPE:	STANDARD	TURBO QUANTITY:	4
IGNITION TYPE:	CI	TURBOCHARGER MODEL:	G75041BN-48T 1 10
INJECTOR TYPE:	EUI	CERTIFICATION YEAR:	2006
FUEL INJECTOR:	2501358	CRANKCASE BLOWBY RATE (FT3/HR):	3.6194
REF. EXH. STACK DIAMETER (IN):	12	FUEL RATE (RATED RPM) NO LOAD (GAL/HR):	16.2
MAX OPERATING ALTITUDE (FT):	2,953	Piston SPD @ RATED ENG SPD (FT/HR):	2,539.4

EMITTERY	SUBSIDIARY	APPLICATION
ELECTRIC POWER	STANDARD	PACKAGED GENSET
OIL AND GAS	LAND PRODUCTION	PACKAGED GENSET

General Performance Data

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	BRAKE MEAN EFF PRES (PSI)	ENGINE SPEED (RPM)	VOL FUEL CONSUMPTION (GAL/HR)	INLET MFLD PRES (PSI)	INLET MFLD TEMP	EXH MFLD TEMP	EXH MFLD PRES	ENGINE OUTLET TEMP
BHP	%	BHP	PSI	LEVER HP PSI	GAL/HR	INLET PSI	DEG F	DEG F	INLET PSI	DEG F
2500.0	100	3,633	336	0.838	173.5	78.1	121.9	1,235.6	67.6	815.2
2250.0	90	3,283	303	0.335	157.1	71.3	118.4	1,190.0	61.3	881.2
2000.0	80	2,935	271	0.338	142.3	64.3	115.9	1,158.9	55.3	884.0
1,875.0	75	2,780	255	0.342	134.9	60.7	115.8	1,145.6	52.3	858.3
1,750.0	70	2,596	239	0.345	127.6	57.0	114.7	1,132.3	49.3	854.6
1,625.0	60	2,337	217	0.354	113.0	49.5	110.7	1,110.4	43.2	851.2
1,250.0	50	1,889	174	0.385	98.4	41.3	110.0	1,091.8	36.8	850.7
1,000.0	40	1,547	143	0.375	82.5	31.4	109.4	1,081.5	29.3	855.6
750.0	30	1,203	111	0.385	66.2	21.7	107.9	1,010.3	22.1	848.2
625.0	25	1,029	95	0.394	57.9	17.2	107.2	968.3	18.7	831.1
500.0	20	854	79	0.408	49.2	12.7	106.4	902.0	15.5	798.1
250.0	10	487	48	0.447	31.3	4.8	106.1	700.7	9.8	647.3

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	COMPRESSION OUTLET PRES	COMPRESSION OUTLET TEMP	WET INLET AIR VOL. FLOW RATE	ENGINE OUTLET WET EXH GAS VOL. FLOW RATE	WET INLET AIR BASE FLOW RATE	WET EXH GAS BASE FLOW RATE	WET EXH GAS FLOW RATE (2% DILUTION F AND 20.0% IN H2O)	WET EXH GAS FLOW RATE (2% DILUTION F AND 20.0% IN H2O)
BHP	%	BHP	PSI	DEG F	CFM	CFM	LEVER PSI	LEVER PSI	FT3/MIN	FT3/MIN
2500.0	100	3,633	85	486.7	7,212.2	19,578.8	32,044.3	33,360.4	7,001.7	6,362.4
2250.0	90	3,283	78	443.0	6,831.8	17,980.7	30,219.3	31,318.8	6,593.0	6,013.7
2000.0	80	2,935	70	417.8	6,404.5	16,580.6	28,284.6	29,277.2	6,151.5	5,625.4
1,875.0	75	2,780	66	404.7	6,173.3	15,883.2	27,261.3	28,282.4	5,926.1	5,497.0
1,750.0	70	2,596	63	391.2	5,929.3	15,232.6	26,198.0	27,085.0	5,684.4	5,222.0
1,625.0	60	2,337	55	363.5	5,411.9	13,878.0	23,847.5	24,739.5	5,205.5	4,778.1
1,250.0	50	1,889	48	334.6	4,843.3	12,413.0	21,444.3	22,133.2	4,667.5	4,283.2
1,000.0	40	1,547	38	297.5	4,121.4	10,868.5	18,262.0	18,840.0	3,963.0	3,647.2
750.0	30	1,203	25	249.8	3,423.0	8,763.8	15,175.3	15,640.3	3,264.6	3,037.8
625.0	25	1,029	21	223.4	3,104.5	7,844.6	13,785.1	14,171.8	2,988.1	2,760.8
500.0	20	854	18	197.2	2,791.2	6,873.5	12,976.2	12,722.2	2,871.7	2,476.1
250.0	10	487	7	152.3	2,237.9	4,800.2	9,917.8	10,136.8	2,132.0	1,988.8

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Emission Factor Calculations

NOx					CO				
	100% Load	75% Load	50% Load	25% Load		100% Load	75% Load	50% Load	25% Load
g/hp-hr	6.38	5.15	3.74	3.50	g/hp-hr	0.76	0.48	0.58	1.47
lb fuel/bhp-hr	0.33	0.34	0.37	0.39	lb fuel/bhp-hr	0.33	0.34	0.37	0.39
bhp	3633.00	2760.00	1889.00	1029.00	bhp	3633.00	2760.00	1889.00	1029.00
lb fuel/hr	1213.42	943.92	691.37	405.43	lb fuel/hr	1213.42	943.92	691.37	405.43
lb pollutant/hr	51.10	31.34	15.58	7.94	lb pollutant/hr	6.09	2.92	2.42	3.33
gal fuel/hr	173.5	134.9	98.4	57.9	gal fuel/hr	173.5	134.9	98.4	57.9
EF: lb/gal emissions	0.29	0.23	0.16	0.14	EF: lb/gal emissions	0.04	0.02	0.02	0.06
Max EF	0.29				Max EF	0.06			
HC					PM				
	100% Load	75% Load	50% Load	25% Load		100% Load	75% Load	50% Load	25% Load
g/hp-hr	0.14	0.18	0.29	0.40	g/hp-hr	0.05	0.06	0.07	0.14
lb fuel/bhp-hr	0.33	0.34	0.37	0.39	lb fuel/bhp-hr	0.33	0.34	0.37	0.39
bhp	3633.00	2760.00	1889.00	1029.00	bhp	3633.00	2760.00	1889.00	1029.00
lb fuel/hr	1213.42	943.92	691.37	405.43	lb fuel/hr	1213.42	943.92	691.37	405.43
lb pollutant/hr	1.12	1.10	1.21	0.91	lb pollutant/hr	0.40	0.37	0.29	0.32
gal fuel/hr	173.5	134.9	98.4	57.9	gal fuel/hr	173.5	134.9	98.4	57.9
EF: lb/gal emissions	0.006	0.008	0.012	0.016	EF: lb/gal emissions	0.002	0.003	0.003	0.005
Max EF	0.016				Max EF	0.005			

DIESEL ENGINE - EMISSIONS

Emissions Data

RATED SPEED POTENTIAL SITE VARIATION: 1800 RPM

GENERATOR POWER WITH FAN	BHP	2,500.0	1,875.0	1,350.0	825.0	250.0
PERCENT LOAD	%	100	75	50	25	10
ENGINE POWER	BHP	3,000	2,250	1,650	1,050	657
TOTAL NOX (AS NO2)	GHR	22,948	14,101	7,004	3,558	3,185
TOTAL CO	GHR	2,726	1,304	1,092	1,485	2,096
TOTAL HC	GHR	500	499	543	408	437
PART MATTER	GHR	185.5	129.7	132.1	139.5	141.0
TOTAL NOX (AS NO2) (CORR 5% O2)	MG/MM3	2,818.9	2,229.5	1,544.3	1,352.7	2,230.2
TOTAL CO (CORR 5% O2)	MG/MM3	351.8	213.9	252.3	594.6	1,552.7
TOTAL HC (CORR 5% O2)	MG/MM3	55.9	72.8	108.8	140.7	282.4
PART MATTER (CORR 5% O2)	MG/MM3	19.7	16.5	25.8	48.5	88.2
TOTAL NOX (AS NO2) (CORR 5% O2)	PPM	1,373	1,086	752	659	1,086
TOTAL CO (CORR 5% O2)	PPM	281	171	202	476	1,242
TOTAL HC (CORR 5% O2)	PPM	104	136	203	263	527
TOTAL NOX (AS NO2)	GHP4HR	8.88	5.15	3.74	3.53	6.47
TOTAL CO	GHP4HR	0.76	0.48	0.58	1.47	4.26
TOTAL HC	GHP4HR	0.14	0.18	0.29	0.40	0.89
PART MATTER	GHP4HR	0.05	0.05	0.07	0.14	0.29
TOTAL NOX (AS NO2)	LBAHR	50.59	31.09	15.44	7.87	7.02
TOTAL CO	LBAHR	6.01	2.88	2.41	3.30	4.62
TOTAL HC	LBAHR	1.10	1.10	1.20	0.90	0.96
PART MATTER	LBAHR	0.41	0.27	0.29	0.31	0.31