Revised Notice of Construction Supporting Information Report Project Genesis Quincy, Washington

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Prepared for

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THIS REPORT HAS BEEN PREPARED TO PROVIDE SUPPORTING DOCUMENTATION FOR WASHINGTON STATE DEPARTMENT OF ECOLOGY FORM NO. ECY 070-410, *NOTICE OF CONSTRUCTION APPLICATION: NEW PROJECT OR MODIFICATION OF EXISTING STATIONARY SOURCE*. EACH SECTION OF THIS REPORT PROVIDES A CROSS-REFERENCE TO THE SECTION OF FORM NO. ECY 070-410 FOR WHICH SUPPORTING DOCUMENTATION IS BEING PROVIDED.

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LIST OF ABBREVIATIONS AND ACRONYMS

$\mu g/m^3$	Microgram per Cubic Meter
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	Building Profile Input Program
CFR	Code of Federal Regulations
CO	Carbon Monoxide
DEEP	Diesel Engine Exhaust Particulate Matter
DOC	Diesel Oxidation Catalyst
DPF	Diesel Particulate Filter
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
g/kWm-hr	Grams per Mechanical Kilowatt-Hour
GEP	Good Engineering Practice
HAP	Hazardous Air Pollutant
MW	Megawatts Electrical Capacity
m	Meter
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NO_2	Nitrogen Dioxide
NOC	Notice of Construction
NO_x	Nitrogen Oxides
NSPS	New Source Performance Standard
NSR	New Source Review
NWS	National Weather Service
PM	Particulate Matter
$PM_{2.5}$	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
PRIME	Plume Rise Model Enhancements
PSD	Prevention of Significant Deterioration
PTE	Potential-to-Emit
PVMRM	Plume Volume Molar Reaction Model
RCW	Revised Code of Washington
RICE	Reciprocating Internal Combustion Engine
SCR	Selective Catalytic Reduction
SIT	Site Integrated Test
SO_2	Sulfur Dioxide
SQER	Small-Quantity Emission Rate
TAP	Toxic Air Pollutant
USGS	U.S. Geological Survey
VOC	Volatile Organic Compound
WAAQS	Washington Ambient Air Quality Standards
WAC	Washington Administrative Code

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1.0 PROJECT DESCRIPTION (SECTION III OF NOC APPLICATION FORM)

1.1 FACILITY DESCRIPTION

Yahoo! Inc. (Yahoo!) proposes to construct and operate a new data center building complex (Project Genesis) in Quincy, Washington (Figure 1). This document has been prepared for Yahoo! to support the submittal of a Notice of Construction (NOC) application for installation and operation of new emergency generators, under air quality regulations promulgated by the Washington State Department of Ecology (Ecology). Project Genesis will be located at 1500 M Street NE, immediately east of the existing data center buildings at 1010 Yahoo Way. Construction associated with installation of the emergency generators is scheduled for February 2016.

Project Genesis includes the construction of one 196,969-square-foot data center building complex. The new data center building will house banks of servers to support Yahoo!'s search, mail, and business data delivery services. The data center will be equipped with stable electrical power delivery systems, evaporative cooling units, air cleaning systems, boiler heating, and backup diesel power generation capability. The project will also include site infrastructure, such as the development of internal roads for traffic egress/access and internal circulation, and parking for employees and visitors, as well as all required utility corridors to support the data center building.

A site map for the proposed development is provided on Figure 2.

1.1.1 DIESEL-POWERED EMERGENCY GENERATORS

This section describes emissions from the exhaust stacks of the diesel-fired engines that are included with each generator. The generator includes a diesel-powered engine that drives an alternator section to produce electricity. The alternator section does not emit any air pollutants, so the overall emissions from a diesel generator are produced only from the diesel engine. The terms "generator" and "engine" are used interchangeably in this report. State and federal air quality regulations apply only to the emissions from the diesel engines.

Three diesel generator manufacturers are likely to bid for Project Genesis (Cummins, MTU, and Caterpillar). Appendix A includes specifications and manufacturer-provided emissions data for the various potential types of diesel generators to be used. The new data center building will be supported by 20 diesel-powered emergency generators, each rated at 2.0 megawatts electrical capacity (MW). In addition, four 2.75-MW diesel-powered emergency generators will serve as reserve generators, while the administration building will be supported by one 2.75-MW diesel generator. Therefore, the new data center building will require a total of 25 emergency generators. There will be no life/safety engines associated with Project Genesis.

Each generator will be operated only as an emergency generator, with generator usage and runtime hours limited to those for "emergency generators" by the federal New Source Performance Standard (NSPS) Subpart IIII. NSPS Subpart IIII requires that emergency engines satisfy Tier 2 emission standards as defined by the federal regulations (40 CFR Part 89). All emergency generators will satisfy Tier 2 standards as required and will use ultra-low sulfur diesel fuel (15 parts per million sulfur content).

Each of the emergency generators will be housed inside its own acoustical enclosure at the locations shown on Figure 2. Each generator enclosure will have its own 42-foot-tall vertical exhaust stack. Manufacturer, model, and serial number information for the proposed generators will be provided to Ecology once the generators have been ordered and the serial numbers are available from the manufacturer.

1.1.2 EVAPORATIVE COOLING UNITS

Evaporative cooling units will provide cold air to the building's air handling systems. The units are not a source of air emissions, but a description of the units is provided here for informational purposes. Technical information for the evaporative cooling units is provided in Appendix B.

The evaporative cooling units use direct evaporative cooling to cool computer rooms, which make up most of the data center complex. The cooling units evaporate well water into the airstream serving the computer rooms, and eventually discharge that air back into the atmosphere. The main impact of the system to the surrounding environment is increased moisture/humidity. No known contaminants will be introduced into the surrounding atmosphere.

Supporting critical infrastructure (such as network and electrical rooms) and administration space will be served by an air-cooled chiller plant, a closed, self-contained system that emits only heat into the surrounding environment.

Specific equipment models have not yet been selected for the project, but standard industry-available equipment will be used, as described in the information provided in Appendix B.

1.2 GENERATOR RUNTIME SCENARIOS

The emission estimates and ambient impact modeling presented in this permit application are based on emissions at "full-variable load," which corresponds to the characteristic worst-case emission load of each pollutant. Emission estimates are discussed in more detail in Section 2.0.

On an annual basis, Yahoo! requests a regulatory limitation to operate the generators no more than 100 hours per year and requests that compliance with per generator runtime limits be demonstrated by summing total actual operating hours for all generators in service and comparing that to the total number of permitted hours for all generators in service.

Generator operating scenarios for Project Genesis are as follows:

- **Unplanned Power Outage**: During a power outage at the site, 20 2.0-MW emergency generators and one 2.75-MW generator will activate in order to supplement power to the server system and the administrative building. If there is a problem with one or more of the 2.0-MW generators, one or more of the "reserve" 2.75-MW generators will engage the load.
- **Monthly Maintenance Testing**: Routine operation and maintenance on the emergency generators will be conducted on a monthly basis. This runtime activity will be conducted on one emergency generator at a time; therefore, multiple generators will not be run concurrently for this operating scenario. Monthly runtime for maintenance operations would take 1 hour or less per generator on average. However, on rare occasions when a problem is identified and a generator requires diagnosis and repair, it may be necessary to operate it longer than 1 hour per month. Operation for monthly maintenance will take place during daytime hours (7:00 a.m. to 7:00 p.m.).
- **Annual Load Bank Testing**: A load bank test will be conducted on each generator once per year. The load bank test will be conducted under "full-variable load" for up to 4 hours on one generator at a time. Multiple generators will not be run concurrently during load bank testing. Operation for annual load bank testing will take place during daytime hours (7:00 a.m. to 7:00 p.m.).
- **Generator Startup and Commissioning**: After installation, each generator will require commissioning, which will include up to 12 hours of individual operation under a range of loads followed by a 4-hour site integrated test (SIT), which will require operation of all generators in service for Project Genesis. One cold-startup event (per engine) is assumed will occur during the individual engine commissioning and another cold-startup for the SIT. Commissioning will be divided into no less than two phases. The first phase will involve startup of six 2.0-MW engines and two 2.75-MW engines. The remaining 14 2.0-MW and three 2.75-MW generators are assumed will be commissioned at least 1 year after the first commissioning event.
- **Triennial Stack Testing**: It is anticipated that Ecology will require exhaust stack emission testing of a single generator once every 3 years in order to demonstrate continued compliance with air quality standards. The duration of such a stack test can take up to 45 hours and involves several engine start-up and shutdown events. The worst-case scenario would be if the stack test failed, requiring follow-up of a second test in the same year. The worst-case runtime that could occur in a single year from stack testing would be operation of two 2.75-MW generator tests operating for 45 hours each. It is assumed that four cold-start events will occur per test.

Routine operational scenarios are presented in Table 1.

1.3 COMPLIANCE WITH STATE AND FEDERAL REGULATIONS

The engines on the proposed generators will comply with the following applicable air regulations, in accordance with the federal and state Clean Air Acts. These requirements are specified in:

- Chapter 70.94 Revised Code of Washington (RCW) (Washington Clean Air Act)

- Chapter 173-400 Washington Administrative Code (WAC) (General Regulations for Air Pollution Sources)
- Chapter 173-460 WAC (Controls for New Sources of Toxic Air Pollutants)
- 40 Code of Federal Regulations (CFR) Part 60 Subpart A (General Provisions)
- 40 CFR Part 60 Subpart IIII (Stationary Compression Ignition Internal Combustion Engines)
- 40 CFR Part 63 Subpart ZZZZ [National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines (RICEs)].

Specifically, the proposed 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 proposed facility will be located in an attainment area for all Clean Air Act criteria pollutants. Since the maximum potential-to-emit for all criteria pollutants will be less than 250 tons per year, the permittee is applying for an approval order to meet minor New Source Review (NSR) requirements. Facilities that produce more than 100 tons per year of any criteria pollutant are considered major sources under the federal regulation 40 CFR Part 70 and the state regulation WAC 173-410 et seq., and those that produce less than 100 tons per year are considered minor sources. Potential-to-emit estimates provided in Section 2.0 demonstrate that the facility will emit:

- Less than 100 tons per year of any criteria pollutant [particulate matter (PM), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and volatile organic compounds (VOCs)
- Less than 10 tons per year of any U.S. Environmental Protection Agency (EPA) hazardous air pollutant (HAP)
- Less than 25 tons per year of total HAPs.

As a result, neither a Prevention of Significant Deterioration NSR pre-construction permit nor a Title V operating permit is required.

All of the generators will be operated in a manner that satisfies the definition of "emergency engines" according to the federal regulations NSPS Subpart IIII and NESHAP Subpart ZZZZ. Therefore, NSPS Subpart IIII requires that each generator shall be manufactured and certified to meet EPA Tier 2 emission limits. The applicable sections of NESHAP Subpart ZZZZ indicate that compliance with the NESHAP for emergency engines requires each generator to meet the EPA Tier 2 emission standards, and each generator must be operated and maintained in accordance with the requirements of NSPS Subpart IIII.

2.0 AIR POLLUTANT EMISSION ESTIMATES (SECTIONS V AND VI OF NOC APPLICATION FORM)

Air pollutant emission rates were calculated for the generators per the requirements of WAC 173-400-103 and WAC 173-460-050. Emission rates were calculated for criteria pollutants and toxic air pollutants (TAPs) based on peak hourly (worst-case maximum) and long-term (annual maximum) operating scenarios. For comparison of emission rate standards of short-term durations, such as 1-hour, 8-hour, or 24-hour averaging periods, the peak hourly rate will be multiplied by the corresponding number of hours (i.e., maximum duration of a particular runtime activity). Emission calculation summary tables are provided in Appendix C and electronic calculation spreadsheets are provided on DVD in Appendix F.

As described in Section 1.1.1, the proposed generators will be guaranteed by the manufacturer to meet EPA Tier 2 emission standards for non-road diesel engines. Three diesel generator manufacturers are likely to bid for Project Genesis (Cummins, MTU, and Caterpillar). The manufacturer-reported "not to exceed" generator emission rates for CO, nitrogen oxides (NO_x), and PM were used to estimate these criteria pollutant emissions. Additionally, the manufacturer-provided hydrocarbon emission rate was used as the emission rate for total VOCs. Because the actual manufacturer of the "to-be installed" engines has yet to be determined, the vendor-specific emission rates of all three manufacturers were compared and the maximum worst-case emission rate (among all three vendor specifications) was assumed.

2.1 DERIVATION OF EMISSION FACTORS, FACILITY-WIDE EMISSION RATES, AND FUEL USAGE

During any event for which the emergency engines will supply power to the server system, the generators will activate at less than or equal to 100 percent load ("full-variable load"). Yahoo! is requesting the flexibility to operate at any load when power is being supplied to the server system, which will be set based on electrical demand. Therefore, considering that not all pollutant emission rates are maximum under the same operating load and because Yahoo! is requesting flexibility to operate at any load, the pollutant-specific maximum emission rate, under any load less than or equal to 100 percent, was assumed for calculating the worst-case emission rates. These emission rates were used in all operating scenarios that require "full-variable load."

It was conservatively assumed that the emission factors for diesel engine exhaust particulate matter (DEEP) will be equal to the reported emission rates provided by the manufacturers' not-to-exceed emissions value for PM (Table 2). Emissions of PM with an aerodynamic diameter of less than or equal to 10 microns (PM_{10}) and diameter of less than or equal to 2.5 microns ($PM_{2.5}$) are assumed to be equal to total PM emission rates. PM emission rates include an estimate for "front-half" (filterable PM) and "back-half" condensable PM for all modeling scenarios that demonstrate compliance with the National Ambient Air

Quality Standards (NAAQS). The filterable PM estimate is based on the manufacturer not-to-exceed emission factors and the condensable PM was derived as recommended by the manufacturer, by adding the not-to-exceed value for total hydrocarbons, which is considered equivalent to an estimate of EPA Method 202 condensable PM. All remaining pollutant emission rates will be calculated using emission factors from the EPA's AP-42, Volume I, Chapter 3.4, which provides emission factors for HAPs from large internal combustion diesel engines (EPA 1995).

Additionally, emissions of criteria pollutants (PM, CO, NO_x, and total VOCs) and volatile TAPs associated with cold-startup were scaled up using a "black puff" emission factor in order to account for slightly higher cold-start emissions during the first minute of each scheduled cold-start. These "black puff" factors are based on short-term concentration trends for VOC, CO, and NO_x emissions immediately following cold-start by a large diesel backup generator that were measured by the California Energy Commission in its document, *Air Quality Implications of Backup Generators in California* (CEC 2005). Derivation of cold-start emission factors is documented in Table 3 and in more detail in Appendix D.

As listed in the generator specification sheets provided in Appendix A, the hourly fuel consumption will vary depending on the generator load. If all 25 generators operated at the annual runtimes listed in Table 1, then the combined generators would use a total of 401,700 gallons of diesel fuel per year (see Table 4, Appendix C, and Appendix F for the derivation of this facility-wide fuel consumption).

Facility-wide emission rates are documented in Table 5.

3.0 EMISSION STANDARD COMPLIANCE (SECTION VII OF NOC APPLICATION FORM)

The emergency diesel generators will be subject to the emission control requirements under NSPS Subpart IIII, “Standards of Performance for Stationary Compression Ignition Internal Combustion Engines.” The runtime limits requested for the generators satisfy the definition of “emergency generator” as specified by NSPS Subpart IIII. Based on that definition of “emergency generators,” NSPS Subpart IIII indicates that the new generators will be subject to EPA Tier 2 emission limits as specified by 40 CFR Part 89.

Yahoo! will conduct all notifications, generator maintenance, recordkeeping, and reporting as required by NSPS Subpart IIII.

The new generators will also be subject to the NESHAP requirements under Subpart ZZZZ, “National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines (RICEs).” NESHAP Section 63.6590(c)(1) specifies requirements for emergency RICEs that are also subject to NSPS Subpart IIII. The Project Genesis facility will be an “area source” of federal HAPs; accordingly, NESHAP Section 63.6590(c)(1) indicates that the new emergency generators will not be required to comply with any portions of Subpart ZZZZ as long as the generators are equipped with EPA Tier 2 emission controls and Yahoo! operates the generators in compliance with NSPS Subpart IIII.

4.0 BEST AVAILABLE CONTROL TECHNOLOGY ANALYSIS (SECTION VIII OF NOC APPLICATION FORM)

4.1 GENERAL APPROACH FOR BEST AVAILABLE CONTROL TECHNOLOGY ASSESSMENT

Best available control technology (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. Most Ecology permit writers determine BACT using a "top-down" approach as described in the EPA's draft *New Source Review Workshop Manual: Prevention of Significant Deterioration and Non-Attainment Area Permitting* (EPA 1990). The following five steps are involved in the top-down process:

1. The first step in the top-down analysis is to identify all available control technologies that can be practicably applied for each emission unit.
2. The second step is to determine the technical feasibility of potential control options and to eliminate options that are demonstrated to be technically infeasible.
3. The third step is to rank all remaining options based on control effectiveness, with the most effective control alternative at the top.
4. The fourth step is to evaluate the remaining control alternatives. If the top-ranked control alternative is considered unacceptable based on disproportionate economic, environmental, and/or energy impacts, it is discarded. Justifications for discarding top-ranked control options must be approved by Ecology.
5. The fifth and final step is to choose the top-ranked alternative from the list of control options remaining after applying Steps 1 through 4. This option becomes the BACT, including the resulting emission rate.

Control options for potential reductions in criteria pollutant and, as practical, TAP emissions were identified for each source. In Washington State, the term BACT refers to the control technology applied to achieve reductions in criteria pollutant emission rates. The term "tBACT" refers to BACT applied to achieve reductions in TAP emission rates. Technologies were identified by considering Ecology's previous environmental permitting experience for diesel generators in Washington State. Available controls that are judged to be technically feasible are further evaluated based on an analysis of economic, environmental, and energy impacts.

This section summarizes the findings and recommended BACT determination. Detailed cost spreadsheets to support the BACT assessment are provided in Appendix E.

4.2 STEPS 1, 2, AND 3: IDENTIFY FEASIBLE CONTROL TECHNOLOGIES FOR DIESEL GENERATORS

Based on Landau Associates' experience with permitting diesel generators at computer data centers, the following technologies were considered to be commercially available and technically feasible for use at the new Project Genesis data center building:

- Tier 4/Integrated Control Package consisting of an integrated diesel particulate filter (DPF), diesel oxidation catalyst (DOC), and urea-based selective catalytic reduction (SCR). This system is highly efficient for control of NO_x (90 percent), $PM_{2.5}$/DEEP (85 percent of "front-half"), CO (85 percent), VOCs (80 percent), and gaseous TAPs, and meets Tier 4 emission standards as defined by the federal regulations (40 CFR Part 89). Note, when engine or emission control system manufacturers are producing Tier 4-compliant engines, they will typically weld the DOC to the DPF and call it a "catalyzed DPF."
- Urea-SCR system consisting of a urea-based SCR. This system is highly efficient for control of NO_x (90 percent) and NO_2.
- DPF by itself. This system is highly efficient for control of filterable ("front-half") $PM_{2.5}$/DEEP (85 percent). Note, DPFs do not remove condensable ("back-half") particulates. Our evaluation of a DPF by itself does not include a DOC or any form of catalyst welded to the DPF.
- DOC by itself. This system is highly efficient for removal of CO (85 percent), VOCs (80 percent), and gaseous TAPs. It is marginally effective for removal of $PM_{2.5}$/DEEP (20 percent).
- Emission controls inherent to EPA Tier 2-certified engines using ultra-low sulfur diesel fuel (15 parts per million sulfur content).

In previous permit applications for data centers, Ecology has also considered three-way catalysts to be technologically feasible for use on diesel generators. However, recent compliance stack tests required at another data center in Grant County, Washington indicated that three-way catalysts were ineffective for removal of NO_x, and that device actually increased the emission rate for NO_2. Based on those tests, three-way catalysts were dropped from consideration for this analysis.

4.3 STEP 4: EVALUATE TECHNICALLY FEASIBLE TECHNOLOGIES FOR DIESEL GENERATORS

All of the technologies listed above are assumed to be commercially available, reasonably reliable, and safe for use on backup diesel generators. None of them would pose unreasonable liabilities related to system reliability or energy consumption. One potential concern with the use of DOCs by themselves is their tendency to increase the emission rate for NO_2. Regardless of that concern, use of DOCs by themselves has not been eliminated from consideration based solely on that tendency.

4.3.1 METHODOLOGY FOR COST-EFFECTIVENESS ANALYSES FOR DIESEL GENERATORS

Detailed calculation spreadsheets for the BACT cost-effectiveness analyses are provided in Appendix E. For the individual pollutants, cost effectiveness was calculated by dividing the total life-cycle annual cost ($/year) by the tons of pollutant removed by the control device. The derived cost effectiveness was then compared to the following cost-effectiveness criteria values, which were developed by Ecology for previous BACT evaluations for diesel generators in Grant County:

- Criteria air pollutants: Range between $10,000 and $23,200 per ton of removed pollutants
- Toxic air pollutants: Range between $5,000 and $23,200 per ton of removed TAPs.

The cost-effectiveness analysis for this application was conducted using assumptions that provide a reasonable but conservatively low estimate of the capital and operating costs, and a reasonable but conservatively high estimate of the pollutant removal efficiencies. The capital cost, operating cost, life-cycle annualized cost, and cost effectiveness (dollars per ton of destroyed pollutant) were calculated using the methodology specified in the *EPA Air Pollution Control Cost Manual* (EPA 2002). Detailed cost spreadsheets are provided in Appendix E. Rough order of magnitude purchase price information for each control device to be evaluated and removal efficiencies for each pollutant were obtained from Cummins and MTU (Appendix A). Indirect cost factors to derive a conservatively low total installation cost were obtained from the *EPA Air Pollution Control Cost Manual* (EPA 2002). The annual capital recovery costs were calculated assuming a 25-year system lifetime and a 4 percent annual discount rate. Conservatively low estimates of annual operation and maintenance costs for each control option were derived by assuming that there would be no operating cost for electricity or equipment maintenance. To provide a conservatively low estimate of the annual operating cost, the operational unit costs for each control strategy were set to zero.

As described in the following sections, all of the add-on control technologies are considered to be economically prohibitive based on their unacceptable cost effectiveness (expressed as life-cycle annual cost per ton of removed pollutant). Tables 6 and 7 rank and summarize the BACT cost-effectiveness analyses for each control option for criteria air pollutants. As described in the following sections, the cost effectiveness for each add-on control option is prohibitively high, based on the individual-pollutant criteria and the multi-pollutant criteria.

Therefore, this assessment concludes that BACT for Project Genesis should be defined as EPA Tier 2-certified emergency generators.

4.3.2 COST-EFFECTIVENESS ANALYSIS FOR INTEGRATED CONTROL PACKAGE (DPF, DOC, PLUS SCR)

The Integrated Control Package (also known as Tier 4) is considered cost-prohibitive for the purpose of reducing air pollutant emissions. The individual-pollutant cost effectiveness for PM, CO, VOCs, and NO_x is presented in Table 7. The forecast cost-effectiveness values for each individual pollutant exceed their acceptable thresholds.

The Integrated Control Package would provide substantial removal efficiencies for multiple pollutants including PM, CO, VOCs, and NO_x. However, the integrated system failed the multi-pollutant BACT cost-effectiveness evaluation. Table 7 shows the multi-pollutant evaluation. The actual annual cost to own and operate the system would be $31,238 per combined ton of removed pollutant, which exceeds the presumptive cost criterion for the combined pollutants.

Note, this cost per ton estimate for a Tier 4-compliant engine assumes the use of a catalyzed DPF (i.e., a DPF welded to a DOC, along with an SCR).

4.3.3 Cost-Effectiveness Analysis for SCR Alone

The SCR control system (by itself) exhibits a prohibitively high cost effectiveness. The individual-pollutant cost effectiveness for NO_x, PM, CO, and VOCs is presented in Table 7. The forecast cost-effectiveness values for each individual pollutant exceed their acceptable thresholds.

The SCR Control Package would provide substantial removal efficiencies for NO_x. However, the SCR system failed the multi-pollutant cost-effectiveness evaluation. Table 7 shows the multi-pollutant evaluation. The combined cost effectiveness would be $19,535 per combined ton, which exceeds the presumptive acceptable cost criterion for the combined pollutants.

4.3.4 Cost-Effectiveness Analysis for DPF Alone

The DPF control option (by itself) exhibits a prohibitively high cost effectiveness. The individual-pollutant cost effectiveness for PM is presented in Table 7. The forecast cost-effectiveness value for PM exceeds acceptable thresholds.

The DPF control option would provide substantial removal efficiencies only for PM. The system failed the cost-effectiveness evaluation. Table 7 shows that the combined-pollutant cost effectiveness would be $1,491,601 per combined ton, which exceeds the cost criterion for individual or combined pollutants.

4.3.5 Cost-Effectiveness Analysis for DOC Alone

The DOC control option (by itself) exhibits a prohibitively high cost effectiveness. The individual-pollutant cost effectiveness for NO_x, PM, CO, and VOCs is presented in Table 7. The forecast cost-effectiveness values for each individual pollutant exceed their acceptable thresholds.

The DOC-Alone control option would provide substantial removal efficiencies for multiple pollutants including PM, CO, and VOCs. However, the system failed the multi-pollutant cost effectiveness evaluation. Table 7 shows the multi-pollutant cost effectiveness would be $50,761 per combined ton, which exceeds the acceptable cost criterion for the combined pollutants.

4.3.6 Best Available Control Technology for Toxic Air Pollutants

TAPs emitted by the emergency generators at rates exceeding the small-quantity emission rates (SQERs) include DEEP, benzene, 1,3-butadiene, naphthalene, CO, NO_2, and acrolein. The criteria air pollutant emission control options described previously would be effective at various ranges of efficiencies for control of TAPs. The cost-effectiveness calculations for each TAP control option are provided in Appendix E. Table 8 summarizes the calculated TAP cost effectiveness for each control option, and compares the calculated cost effectiveness to the presumed per ton of removed TAP threshold.

Control technologies and costs evaluated for PM are the same for DEEP, because DPFs remove only filterable ("front-half") particulates. The minimum treatment cost of $1,491,601 per ton of removed DEEP exceeds the cost-effectiveness threshold; therefore, DPFs are rejected as tBACT on the basis of the disproportionate cost analysis.

BACT was evaluated for CO as a criteria pollutant. The minimum treatment cost of $64,790 per ton of CO exceeds the cost-effectiveness threshold; therefore, all add-on controls are rejected as tBACT on the basis of the disproportionate cost analysis.

NO_2 is a minor component of NO_x; therefore, control technologies evaluated for NO_x are applicable to NO_2 and costs are proportionately applicable (the in-stack ratio of NO_2 to NO_x is assumed to be 10 percent). All of the control options exhibit prohibitively high cost effectiveness for NO_x and NO_2 (for example, the SCR system exhibits a cost effectiveness of $195,328 per ton of removed NO_2); therefore, compliance with the EPA's Tier 2 emission limits for NO_x is recommended as tBACT for NO_2.

Benzene, 1,3-butadiene, naphthalene, and acrolein emissions could be treated using the same control options applicable for VOCs. However, all of the evaluated control options exhibit prohibitively high cost effectiveness (Table 8). If costs were assumed to be comparable to those estimated for VOCs, the minimum treatment cost for benzene, 1,3-butadiene, naphthalene, or acrolein individually would be as follows:

- Benzene: $9,953,338 per ton removed
- 1,3-Butadiene: $197,539,396 per ton removed
- Acrolein: $980,176,444 per ton removed
- Naphthalene: $59,413,772 per ton removed.

Add-on controls for benzene, 1,3-butadiene, naphthalene, and acrolein control are therefore rejected as tBACT on the basis of the disproportionate cost analysis.

4.4 STEP 5: RECOMMENDED BEST AVAILABLE CONTROL TECHNOLOGY FOR DIESEL EMERGENCY GENERATORS

Although all of the add-on control technology options (the Integrated Control Package, Urea-SCR, DPF-alone, and DOC-alone) are technically feasible, each of them failed the BACT cost-effectiveness evaluation. Therefore, none of the add-on controls should be considered BACT. Instead, the emission controls inherent to EPA Tier 2-certified generators using ultra-low sulfur diesel fuel should be required as BACT. The proposed BACT for CO and VOCs is based on compliance with the EPA's Tier 2 emissions limitations for non-road diesel engines: 0.20 grams per mechanical kilowatt-hour (g/kWm-hr) for $PM_{2.5}$, 3.5 g/kWm-hr for CO, and 6.4 g/kWm-hr for combined NO_x plus VOCs.

4.5 INCREASED RUNTIME AND ENGINE SIZE ASSOCIATED WITH TIER 4 ENGINES

As described in Section 4.3.2, the Integrated Control Package, or Tier 4, is considered cost-prohibitive for the purpose of reducing air pollutant emissions. The BACT analysis above considers the cost per ton for Tier 4 emission controls based on the conservative assumption that engine size would remain the same if Tier 4 controls were used. However, installation of a DPF would increase the required runtime due to additional maintenance associated with the need to "regenerate" accumulated ash and soot from the DPF. This additional maintenance runtime is associated with DPF alone, as well as DPF as part of the Tier 4 control package.

Another drawback to the Tier 4 control package is that the SCR control system uses aqueous ammonia or urea in the catalytic process. Use of SCR alone or as part of the Tier 4 control package results in ammonia emissions; ammonia is not emitted by Tier 2 engines.

Landau Associates estimates that an additional 2 hours per 2.0-MW generator and an additional 10 hours per 2.75-MW generator per year would be required to regenerate the DPF. This increased annual runtime was accounted for in the BACT/tBACT evaluation. Additionally, the installed control equipment decreases power efficiency, and in some cases can require a larger engine size than would otherwise be required from a Tier 2 engine, which could generally increase emissions and equipment costs.

5.0 AMBIENT AIR QUALITY IMPACT ANALYSIS (SECTION IX OF NOC APPLICATION FORM)

This section presents the air dispersion modeling results and provides a comparison of the results to the National Ambient Air Quality Standards (NAAQS) and Washington Ambient Air Quality Standards (WAAQS) for criteria pollutants and the Washington State small-quantity emission rates (SQERs) and acceptable source impact levels (ASILs) for TAPs. Air dispersion model input values are provided in Appendix C. Electronic modeling files are provided in Appendix F.

As described in the following sections, the ambient impacts caused by the Project Genesis facility's emissions are less than the NAAQS and WAAQS, after adding local and regional background levels. With the exception of two TAPs (DEEP and NO_2), the ambient TAP impacts are less than the ASILs.

5.1 FIRST-TIER SCREENING OF TOXIC AIR POLLUTANT IMPACTS

The first-tier TAP assessment compares the forecast emission rates to the SQERs and compares the maximum ambient impacts at any ambient receptor to the ASILs. Table 9 shows the calculated emission rates for each TAP emitted from the Project Genesis emergency generators, and compares the emission rates to the SQERs. The SQERs are emission thresholds, below which Ecology does not require an air quality impact assessment for the listed TAP. Table 9 lists the "SQER Ratio" of the Project Genesis emission rate compared to the SQER. The maximum emission rates for DEEP, benzene, 1,3-butadiene, naphthalene, CO, NO_2, and acrolein exceed their respective SQERs, so an ambient impact assessment is required for those pollutants.

Ecology requires facilities to conduct a first-tier screening analysis for each TAP whose emissions exceed its SQER by modeling the 1st-highest 1-hour, 1st-highest 24-hour, and annual impacts at or beyond the project boundary, then comparing the modeled values to the ASILs (WAC 173-460-080). The 1-hour and 24-hour impacts were modeled for the worst-case screening scenario of a power outage lasting 24 hours per day for 365 days per year for 5 years, with AERMOD automatically selecting the highest 1-hour and 24-hour impacts. The annual impacts were modeled based on the maximum requested generator runtimes and generator loads listed in Table 1.

5.2 AIR DISPERSION MODELING – MODEL AND MODEL 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 modeling system, introduced by the American Meteorological Society (AMS)/EPA Regulatory Model Improvement

Committee, 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 project property boundary (fenceline).

AERMOD was used to calculate maximum ambient impact concentrations of criteria pollutants and TAPs that would be emitted from the facility. AERMOD requires input from several models in order to process meteorological parameters, downwash parameters, and terrain heights. The following sections contain a description of these input models, as provided in EPA, Electric Power Research Institute, and Lakes Environmental guidance documents.

Ambient air impacts will be modeled for all criteria pollutants and TAPs for which compliance is not demonstrated via emissions threshold screening. The Industrial Source Complex (ISC)-AERMOD View Version 8.1 interface provided by Lakes Environmental will be used for all air dispersion modeling.

The AERMOD interface provided by Lakes Environmental was used for all Project Genesis air dispersion modeling. This version of the Lakes Environmental software incorporates the most recent version of AERMOD (version 15181). AERMOD incorporates the data from the pre-processors described above with emission estimates and physical emission point characteristics to model ambient impacts at and beyond the fenceline. The model was used to estimate ambient concentrations based on various averaging times (e.g., 1 hour, 8 hours, annual, etc.) to demonstrate compliance with air quality standards for a network of receptors.

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

The AERMOD modeling for the facility-wide diesel generator emissions was done using a generator configuration consisting of 20 2.0-MW generators and 5 2.75-MW generators. The modeling setup for emissions at "full-variable load" included load-specific stack parameters (i.e., flow rate and exhaust exit temperature), which correspond to the characteristic worst-case emission load of each pollutant. For example, if the worst-case emission rate for one particular pollutant is at 80 percent load conditions, then the input stack parameters for the model predicting impact for that particular pollutant correspond to that flow rate and temperature reported for 80 percent operating load. For predicting annually averaged impacts, the modeling setup assumes total annual emissions (based on a 100-hour operating limit) divided by the number of hours in a year (8,760 hours).

5.2.1 STACK HEIGHTS AND BUILDING DOWNWASH INPUT PARAMETER MODELING

Generator stack heights and diameters were modeled as follows:

- 2.0-MW generator stack height = 42 feet; diameter = 1 ½ feet
- 2.75-MW generator stack height = 42 feet; diameter = 1 $^{2}/_{3}$ feet.

Building downwash occurs when the aerodynamic turbulence induced by nearby buildings causes a pollutant emitted from an elevated source to be mixed rapidly toward the ground (downwash), resulting in higher ground-level pollutant concentrations. The software program Building Profile Input Program (BPIP)-PRIME was used to determine if exhaust from emission units would be affected by nearby building structures. In general, these determinations are made if a stack's height is less than the height defined by the EPA's Good Engineering Practice (GEP) stack height.

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). The Project Genesis stacks will be lower than GEP stack height.

5.2.2 RECEPTOR GRID SPACING AND TERRAIN HEIGHT INPUT MODELING

To model complex terrain, AERMOD requires information about the surrounding terrain. This information includes a height scale and a base elevation for each receptor. The AMS/EPA Regulatory Model Terrain Pre-processor (AERMAP) was used to obtain a height scale and the base elevation for a receptor, and to develop receptor grids with terrain effects.

A receptor grid extended from beyond the facility boundary consisting of Cartesian flagpole receptor grids placed at a height of 1.5 meters (m) above ground to approximate the human breathing zone. The grid spacing varied with distance from the facility, as listed below:

- 12.5-m spacing from the property boundary to 150 m from the nearest emission source
- 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 between 2,000 m and 4,500 m
- 600-m spacing beyond 4,500 m (to 6,000 m maximum extent).

AERMAP requires the use of topographic data to estimate surface elevations above mean sea level. Digital topographic data (in the form of Shuttle Radar Topography Mission files) for the analysis region were obtained from the Web GIS website (www.webgis.com) and processed for use in AERMOD. The Shuttle Radar Topography Mission data used for this project have a resolution of approximately 30 m (1 arc-second).

AERMAP produces a Receptor Output File (*.rou) containing the calculated terrain elevations and scale height for each receptor. The *.rou file was used as an input runstream file (AERMOD Input File) for the Receptor Pathway in the Terrain Options page of the Control Pathway. AERMAP also produces a Source Output File (*.sou). This file contains the calculated base elevations for all sources.

5.2.3 METEOROLOGICAL INPUT PARAMETER MODELING

The AERMOD Meteorological Pre-Processor (AERMET, Version 15181) is the meteorological pre-processor model that estimates boundary layer parameters for use in AERMOD. AERMET processes three types of meteorological input data in three stages, and from this process it generates two input files for the AERMOD model. The two AERMOD input files produced by AERMET are: 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 three types of meteorological data used by AERMET for this project are described below:

- National Weather Service (NWS) hourly surface observations from the Grant County International Airport in Moses Lake, Washington located approximately 24 miles from the Project Genesis site. Five years (January 1, 2001 through December 31, 2005) of hourly surface data processed in AERMET.
- NWS twice-daily upper air soundings from Spokane, Washington. Five years (January 1, 2001 through December 31, 2005) of upper air data processed in AERMET.
- The site-specific data required for AERMET are Albedo, Bowen ratio, and surface roughness. Albedo is a measure of the solar radiation reflected back from earth into space. The Bowen ratio is an evaporation-related measurement and is 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. The Project Genesis site does not have an instrumentation tower to record these site-specific parameters for use in AERMET; therefore, site-specific data are approximated based on surface data from the meteorological tower at the Grant County International Airport. AERSURFACE was used to approximate the Albedo, Bowen ratio, and surface roughness within 12 equal sectors of a circle that has a 1-kilometer radius and is centered on the surface station tower. Looking at each sector individually, AERSURFACE determines the percentage of land-use type within each sector. Land cover data from the U.S. Geological Survey (USGS) National Land Cover Data 1992 archives were used as an input to AERSURFACE (USGS 1992). Default seasonal categories are used in AERSURFACE to represent the four seasonal categories as follows: 1) midsummer with lush vegetation; 2) autumn with unharvested cropland; 3) late autumn after frost and harvest, or winter with no continuous snow; and 4) transitional spring with partial green coverage or short annuals.

5.2.4 ANNUALLY AVERAGED MODELING SETUP

An annual average (70-year lifetime) scenario assumed (per engine) 84 hours (3.5 days) of power outages, 12 hours per year of monthly maintenance testing, and 4 hours of annual load bank testing; this expected annual runtime schedule is summarized in Table 1.

The calculated annual pounds of pollutant to be emitted (per engine) from these 100 hours of operation included estimated emissions from cold-start events and the total was divided by 8,760 hours (total number of hours in a year). This pounds per hour emission rate was input to the annual average modeling setup. The annual AERMOD setup included evaluations for:

- $PM_{2.5}$ annual NAAQS
- PM_{10} annual NAAQS
- NO_2 annual NAAQS
- TAPs with an annual averaging period (e.g., DEEP ASIL).

The results of this scenario are presented in Tables 10 and 11. The modeled annual average ambient impacts for NO_2, PM_{10}, and $PM_{2.5}$ are less than the NAAQS.

5.2.5 WORST-CASE 1-HOUR MODELING SETUP

To determine the worst-case ambient impacts for carbon monoxide (CO) and sulfur dioxide (SO_2), each with a 1-hour averaging period, the modeling setup assumed an emergency power outage. Twenty-five generators will be modeled as if operating 24 hours per day, 365 days per year, which will address the conservative consideration that an outage could occur at any time of day or night and any time of year. To account for a worst-case scenario, the hour of activation for an unplanned power outage scenario was assumed. This means that cold-start emissions of all 25 engines was accounted for in the single hour scenario. This modeling setup included:

- CO 1st-highest 1-hour NAAQS
- SO_2 1st-highest 1-hour NAAQS
- Any applicable TAP with a 1-hour averaging period (i.e., NO_2 and SO_2 ASIL).

The results of this scenario are presented in Tables 10 and 11. The modeled 1-hour average ambient impacts for CO and SO_2 are less than the NAAQS.

5.2.6 WORST-CASE 3-HOUR, 8-HOUR, OR 24-HOUR MODELING SETUP

To estimate worst-case ambient impacts for pollutants regulated on a short-term average (i.e., 3-hour, 8-hour, or 24-hour), the modeling setup assumed a worst-case unplanned power outage scenario. The air dispersion models were set up for all 25 generators to operate 24 hours per day, 365 days per year. A single cold-start event for each engine was assumed to occur once during each simulation. This modeling setup included:

- CO 1st-highest 8-hour NAAQS
- SO_2 1st-highest 3-hour NAAQS
- Any applicable TAP with a 24-hour averaging period (i.e., acrolein).

The results of this scenario are presented in Tables 10 and 11. The modeled 3-hour and 8-hour ambient impacts for CO and SO_2 are less than the NAAQS.

5.2.7 PM_{10} 24-HOUR NAAQS MODELING SETUP

The PM_{10} 24-hour NAAQS is not to be exceeded more than once per year on average over 3 years. Typically, compliance is demonstrated with this standard by comparing the 4th-highest daily average value in AERMOD to the PM_{10} 24-hour NAAQS. However, because the generators will be permitted to operate only during a power outage for a maximum of 3.5 days per year, the 4th-highest daily average value would occur on a day when the generators could operate only for 12 hours. Therefore, the model setup assumes that all 25 generators will operate for 12 hours per day, 365 days per year and the 1st-highest daily average value in AERMOD is compared to the PM_{10} 24-hour NAAQS. A single cold-start event for each engine was assumed to occur once during each simulation. The 12-hour emissions total for this event was divided by 24 hours to develop the hourly emission rate input into AERMOD.

The results of this scenario are presented in Table 10. The modeled 24-hour average ambient impact for PM_{10} is less than the NAAQS.

5.2.8 $PM_{2.5}$ 24-HOUR NAAQS MODELING SETUP

The $PM_{2.5}$ 24-hour NAAQS is based on the 98th percentile of ambient impacts during a 3-year rolling average period. The above-discussed worst-case scenarios are conservative maxima that are not expected to occur often, if at all. However, due to the variable emission scenarios that might occur on any given day (including arrangement of operating engines, weather conditions, the various generator operating regimes, and the likelihood of all worst-case conditions happening at the same time), it is difficult to determine which actual scenario might trigger an exceedance of the NAAQS at any given location and time.

For a screening-level approach, several combinations of operating regimes were characterized and ranked based on worst-case daily emissions output (Table 12). The 5th-highest emitting operating regime (based on the maximum approximate daily $PM_{2.5}$ emission) was chosen as the most probable emission scenario that may trigger an exceedance (within the 98th percentile) and was modeled in AERMOD to screen the possibility of project-related emissions contributing to an exceedance of the NAAQS. Note, the 1st- through 4th-highest ranked operating scenarios would occur during emergency power outages, with all generators operating concurrently. The 5th-through 8th-highest ranked operating scenarios would occur during a monthly maintenance testing event. The list in Table 12 is based on the number of days each operating regime is expected to occur (referencing annual runtime listed in Table 1). The worst-case modeling setup for the 5th-highest operating regime assumes testing 2.75-MW engines for 8 hours (one at a time). Compliance with the NAAQS has been demonstrated by modeling the 5th-highest emitting operating regime and using the 4th-highest AERMOD value. Eight cold-start events are assumed to occur per day for this simulation event. The 8-hour emissions total for this event was divided by 12 hours to develop the hourly emission rate input into AERMOD. However, modeled emission output is not restricted to operating during daylight hours; therefore, $PM_{2.5}$ 24-hour impacts are conservatively overestimated compared to actual maintenance testing, which will be restricted to daylight hours (7:00 a.m. to 7:00 p.m.).

The results of this scenario are presented in Table 10. The modeled 24-hour average ambient impacts for $PM_{2.5}$ are less than the NAAQS.

5.2.9 NO_2 1-HOUR NAAQS MODELING SETUP

The NO_2 1-hour NAAQS is based on the 98th percentile of the daily highest 1-hour ambient impacts during a 3-year rolling average period. The same screening-level approach, as described for evaluation of the $PM_{2.5}$ 24-hour NAAQS, was used to evaluate the NO_2 1-hour NAAQS. Table 13 lists and ranks each of the 1-hour operating regimes for NO_2 emissions from the Project Genesis site. The ranked 5th-highest emitting operating regime would also be during an annual load bank or monthly maintenance testing event. Compliance with the NAAQS has been demonstrated by modeling the 5th-highest emitting operating regime and using the 4th-highest AERMOD value. Emissions from a single cold-start event were included in the input emission rate and the air dispersion model was set up as if operating during daylight hours (7:00 a.m. to 7:00 p.m.). The results of this scenario are presented in Table 10.

Additional details for the modeling setup for evaluating all NO_2 emission impacts models include:

- The ambient NO_2 concentrations were modeled using the Plume Volume Molar Ratio Method (PVMRM) option to demonstrate compliance with the 1-hour and annual NAAQS and ASIL for NO_2. This AERMOD option calculated ambient NO_2 concentrations surrounding the site by applying a default NO_2/NO_x equilibrium ratio of 0.90 and a NO_2/NO_x in-stack ratio of 0.1.
- The estimated ambient ozone concentration of 49 parts per billion was the AERMOD input level for all corresponding NO_2 modeling setups. This value was taken from the NW AIRQUEST 2009-2011 design value of criteria pollutants website, provided by the Washington State University's Northwest International Air Quality Environmental Science and Technology Consortium, for the Quincy, Washington area (WSU website 2015).

The modeled 1-hour average ambient impacts for NO_2 are less than the NAAQS.

5.3 ASSUMED BACKGROUND IMPACTS

This evaluation included "regional background" values contributed by existing regional emission sources in the project vicinity (e.g., permitted sources, highway vehicles, area sources) and "local background" values contributed by the other data centers in the vicinity. Project coordinate-specific regional background values were obtained from the Washington State University NW Airquest website (WSU website 2015).

"Local background" values for $PM_{2.5}$, PM_{10}, and NO_2 consisted of the ambient impacts, at Project Genesis' maximum impact location, caused by emissions from the nearby emergency generators and industrial emission sources at the existing Yahoo! Data Center, Sabey Data Center, Vantage Data Center, Intuit Data Center, and the Celite facility. Emissions from each of these facilities were assumed to be equal to their respective permit limits. The location and date of the maximum impact caused by Project Genesis' proposed new generators were determined, and AERMOD was used to model the "local background" ambient impacts at the same location and date caused by simultaneous activity at each of the adjacent data centers and industrial facility. The modeled "local background" sources were as follows:

- 24-Hour $PM_{2.5}$. It was assumed that the existing cooling towers in the vicinity and the Celite facility would operate at their permitted limits.
- 1-Hour NO_2. It was assumed that the Celite facility would operate at its permitted limit.
- 24-hour PM_{10} (Power Outage). It was assumed that each nearby data center would operate at its permitted rate during a power outage on the same day that the Project Genesis facility would operate during a power outage, while the Celite facility would emit at its permitted rate.

5.4 TOXIC AIR POLLUTANT AMBIENT CONCENTRATION IMPACTS COMPARED TO ACCEPTABLE SOURCE IMPACT LEVELS

The first-tier ambient concentration screening analysis is summarized in Table 11. The modeled DEEP and NO_2 concentrations at the unoccupied facility boundary exceed their ASILs, but the impacts for all TAPs other than DEEP and NO_2 are less than their respective ASILs. The annual impacts listed in Table 11 are the maximum-annual values that account for full-buildout operations.

5.4.1 ANNUAL AVERAGE DEEP IMPACTS

The DEEP analysis was conducted by assuming all generators at the facility will operate at the worst-case generator loads described in Section 5.1. The modeled maximum annual average impact is 0.150 micrograms per cubic meter (µg/m^3), and exceeds the DEEP ASIL value of 0.0033 µg/m^3. The location of the maximum annual average DEEP impact is shown on Figure 3. A second-tier risk assessment for DEEP has been prepared and will be submitted to Ecology under separate cover.

5.4.2 1-HOUR NO_2 IMPACTS DURING FACILITY-WIDE POWER OUTAGE

A worst-case screening analysis was conducted as described in Section 5.1 and the maximum ambient NO_2 concentration was compared to the ASIL. The AERMOD/PVMRM model was set to assume that the Project Genesis facility would experience a facility-wide power outage for 365 days per year, 24 hours per day, and the model selected the 1st-highest 1-hour NO_2 impact. The maximum Project Genesis-only, 1-hour modeled ambient concentration of NO_2 at the project boundary for the full power outage scenario is 859 µg/m^3, which is greater than the NO_2 ASIL of 470 µg/m^3. The location of the modeled impact is shown on Figure 3.

A second-tier risk assessment for NO_2 has been prepared and will be submitted to Ecology under separate cover.

6.0 PROPOSAL TO REDUCE POTENTIAL IMPACTS FROM EXISTING EMERGENCY GENERATORS

Yahoo! currently operates a data center adjacent to the Project Genesis site. NOC Approval Order No. 11AQ-E399 was issued by Ecology in April 2011, and allows for the operation of 23 emergency generators at the adjacent data center. Yahoo! was originally permitted to operate generators R through 12 for up to 400 hours per year, as it was initially thought that there would be a need for that many hours. In 2011, Yahoo! agreed to a reduction from 400 hours to 200 hours/year due to increased confidence in electrical reliability. Yahoo! is now confident that 100 hours/year would meet the facility's needs for the R through 12 generators.

Yahoo! requests an administrative modification to reduce generator runtime limits (hours per year, fuel usage and load) on the existing emergency generators numbered R through 12. Yahoo! requests that the per hour and operating load limits that are currently in place for generators numbered 13 through 22 be applied to generators R through 12. The existing operating restrictions and proposed operating restrictions are summarized in Tables 14 and 15, respectively. Note, as shown in Table 15, proposed operations during maintenance testing and power outages will include operation at 0 percent load (idle). However, because manufacturers do not publish emission factors for idle operation, emissions factors for 10 percent load were used to estimate emissions for idle operation. Engines will not be operated at 10 percent load unless it is required for compliance stack testing.

As part of this administrative action, Landau Associates has calculated the new potential-to-emit (PTE) for each pollutant for the existing R through 12 generators. This requested change to operating limits would result in a PTE reduction for all pollutants from those emission units. Existing and new PTE estimates are presented in Table 16. The methods described in Section 2.0 were used to calculate the new PTE for R through 12and include the following assumptions:

- Calculations conservatively assume that all PM emitted from the engines is PM_{10} and $PM_{2.5}$.
- Emissions of $PM/PM_{10}/PM_{2.5}$, CO, NO_x, and total VOCs were scaled up using a "black puff" emissions factor to account for slightly higher emissions during the first minute of each engine cold-start.
- Estimates for $PM/PM_{10}/PM_{2.5}$ emissions account for "back-half" condensable PM.
- The DEEP emission estimate differs from the estimate of $PM/PM_{10}/PM_{2.5}$ in that it does not include an estimate of "back-half" condensable PM. Based on a discussion with Gary Palcisko, Ecology's toxicologist for this project, human health toxicological values for DEEP from the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) were developed based on exposure to measured levels of "front-half" filterable PM, not "back-half" condensable PM (Palcisko, G. 2015). Because OEHHA's toxicological profile for DEEP—which represents the most comprehensive human health toxicological profile available for DEEP—is used as the basis for evaluating project-related

DEEP impacts, the condensable fraction is not calculated as part of the DEEP emission rate for the existing R through 12 generators.

- Cooling tower PTE is not provided in this application because there is no proposed change to existing cooling towers and no new cooling towers are proposed.

While no changes are proposed to the emissions or operating restrictions for the existing engines 13 through R3 (listed in Table 17), at Ecology's request, new PTE for $PM/PM_{10}/PM_{2.5}$is calculated and presented in Table 16 to account for condensable PM. Additionally, the cumulative NAAQS air modeling demonstration accounts for condensable PM from all existing and proposed emergency generators.

No additional new restrictions on the existing R through 12 and 13 through R3 generators are proposed.

7.0 SIGNATURES

This document has been prepared under the supervision and direction of the following key staff.

LANDAU ASSOCIATES, INC.

Mark Brunner
Senior Planner

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Principal

MWB/CPH/ccy

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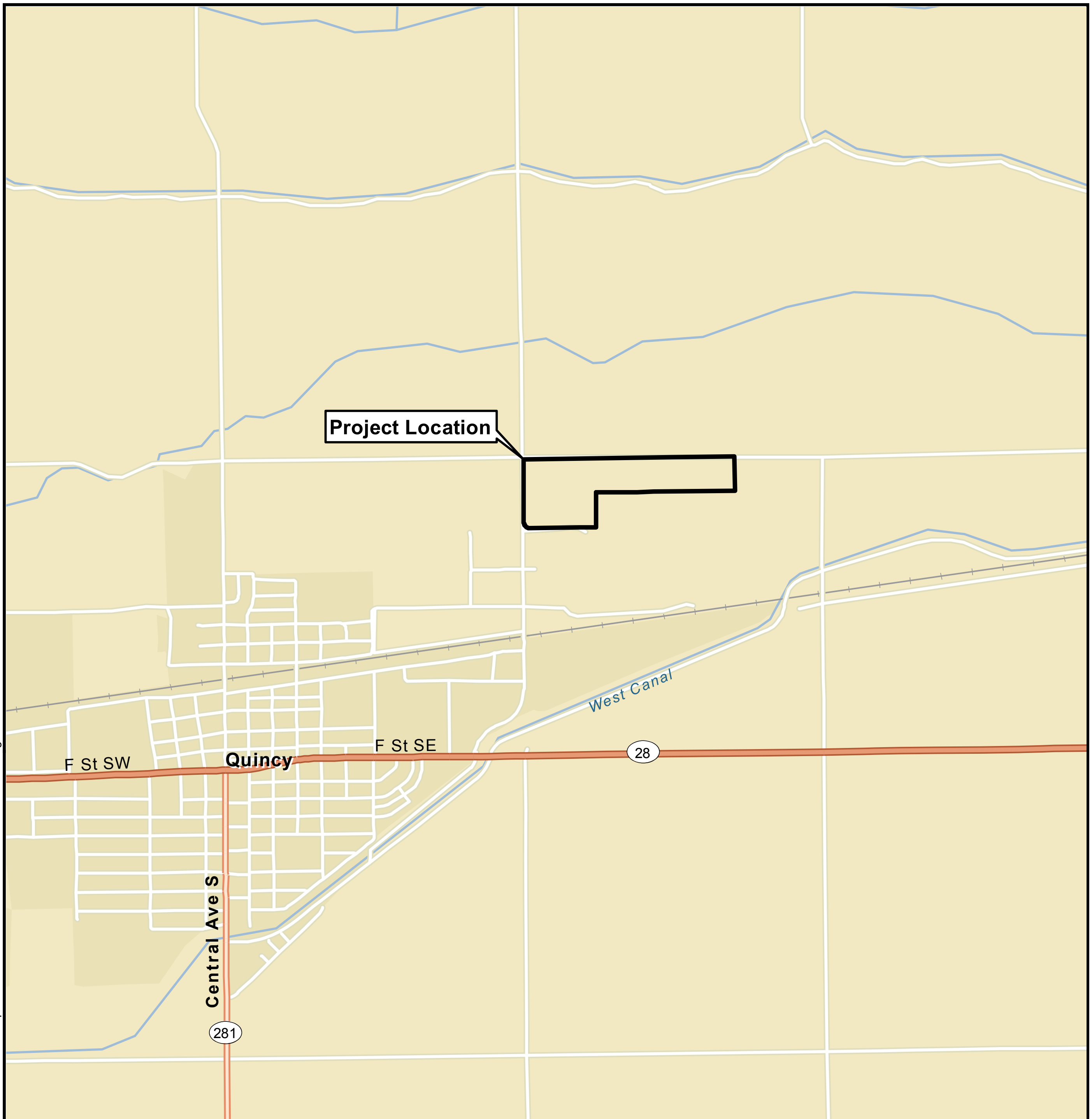
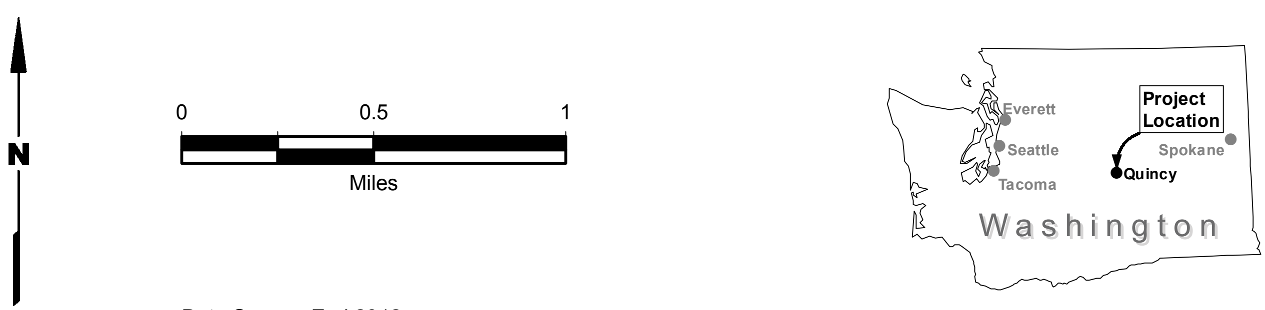




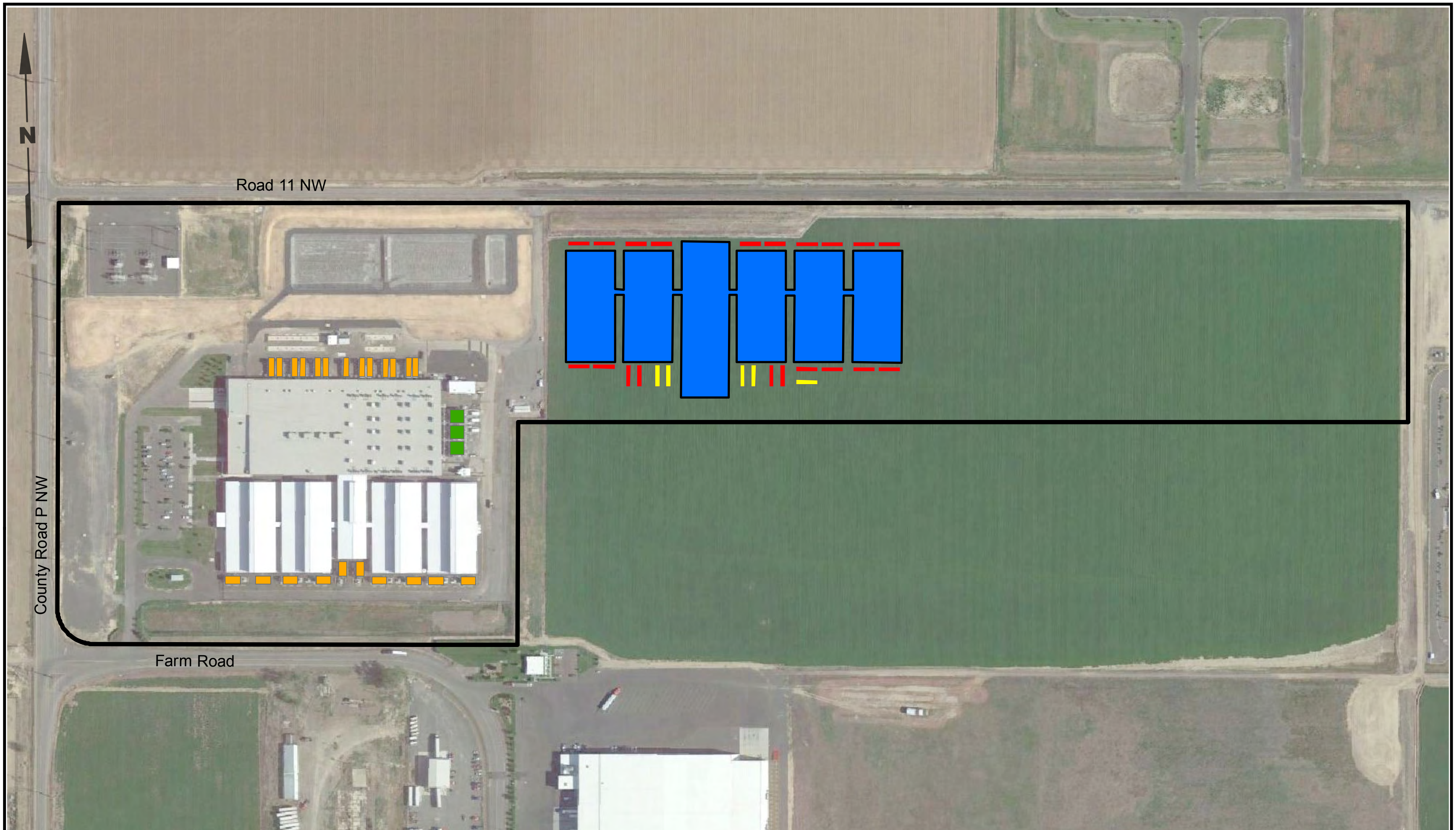
Data Source: Esri 2012.

G:\Projects\967\009\010\Project Genesis\Notice of Construction\F01VicMap.mxd 9/21/2015 NAD 1983 StatePlane Washington South FIPS 4602 Feet

Landau Associates

Project Genesis Quincy, Washington	**Vicinity Map**	Figure 1

G:\Projects\967\009\010\Project Genesis\Notice of Construction\F02 SitePlan.mxd 10/13/2015 NAD 1983 UTM Zone 11N



Legend

- Property Boundary
- Permitted Emergency Diesel Engine
- Permitted Cooling Tower
- Proposed 2.0-MW Emergency Engine
- Proposed 2.75-MW Emergency Engine
- Proposed Building

0 400 800

Scale in Feet

Data Source: © Google Earth Pro 2015; EKI Solutions Group 2015

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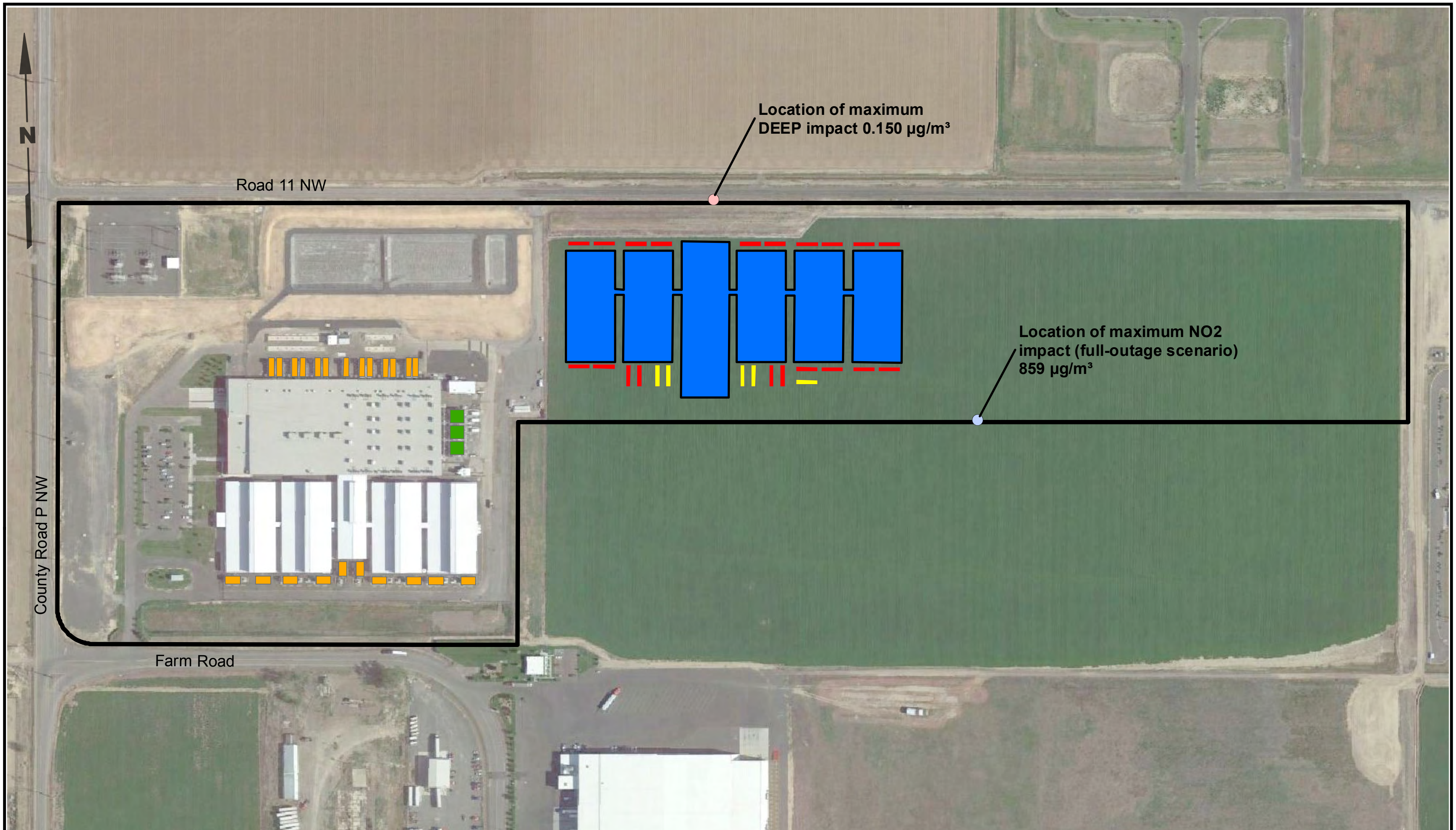
Project Genesis Quincy, Washington	**Site Map**	Figure 2

G:\Projects\967\009\010\Project Genesis\Notice of Construction\F03 Max Pollutant Impact Locations.mxd 10/13/2015 NAD 1983 UTM Zone 11N



Legend

- Property Boundary
- Permitted Emergency Diesel Engine
- Permitted Cooling Tower
- Proposed 2.0-MW Emergency Engine
- Proposed 2.75-MW Emergency Engine
- Proposed Building

0 400 800

Scale in Feet

Data Source: © Google Earth Pro 2015; EKI Solutions Group 2015

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Project Genesis Quincy, Washington	**Maximum Pollutant Impact Map**	Figure 3

TABLE 1
SUMMARY OF OPERATING SCENARIOS
PROJECT GENESIS
QUINCY, WASHINGTON

Activity	Operating Load	Max. No. Generators to Operate Concurrently	Max. Annual Operating Hours (per generator)
Emergency Power Outage	≤100%	25	84
Monthly Maintenance Testing	≤100%	1	12
Annual Load Testing	≤100%	1	4

TABLE 2
SUMMARY OF WORST-CASE EMISSIONS
PROJECT GENESIS
QUINCY, WASHINGTON

Generator Size		2.0 MW				2.75 MW			
Vendor		Caterpillar	Cummins	MTU	Worst-case (≤100% Load)	Caterpillar	Cummins	MTU	Worst-case (≤100% Load)
Fuel Consumption (gph)		138	141	147		214	187	186	
	Load	Vendor Reported NTE Emissions (lb/hr)				Vendor Reported NTE Emissions (lb/hr)			
Hydrocarbons	10%	0.98	0.87	0.42		2.91	1.34	0.73	2.91
	25%	0.91	0.88	0.89		2.28	1.98	1.31	
	50%	1.14	0.93	0.85	1.14	2.34	1.98	1.46	
	75%	1.12	0.74	0.87		1.33	2.05	1.79	
	100%	0.97	0.88	0.85		1.46	2.13	1.86	
Nitrogen Oxide (NO_x)	10%	6.45	4.18	4.07		7.75	7.44	5.57	
	25%	9.31	6.07	7.03		8.37	10.46	8.78	
	50%	12.80	13.81	13.81		20.71	19.76	17.90	
	75%	22.61	30.76	25.24		47.42	38.36	32.31	
	100%	42.31	44.34	42.69	44.34	70.92	74.40	62.32	74.40
Carbon Monoxide (CO)	10%	3.95	4.13	4.02		7.86	3.27	4.64	
	25%	3.92	3.06	4.52		12.10	2.55	7.29	
	50%	2.01	3.02	3.77		7.82	2.41	6.30	
	75%	1.85	2.41	3.77		14.30	3.22	6.46	14.30
	100%	3.49	4.12	5.02	5.02	12.76	7.69	5.97	
Sulfur Dioxide (SO_2)(a)	10%	0.01	-	0.01		0.01	-	0.00	
	25%	0.01	0.01	0.01		0.02	0.01	0.00	
	50%	0.02	0.02	0.01		0.03	0.02	0.00	
	75%	0.02	0.02	0.01		0.03	0.03	0.00	
	100%	0.03	0.03	0.01	0.03	0.04	0.04	0.00	0.04
Diesel Engine Exhaust Particulate Matter (DEEP)	10%	0.44	0.29	0.48		0.75	0.60	0.54	
	25%	0.57	0.85	0.60		0.91	0.61	0.66	0.91
	50%	0.27	0.88	0.63	0.88	0.46	0.56	0.83	
	75%	0.24	0.36	0.53		0.52	0.84	0.55	
	100%	0.26	0.48	0.40		0.49	0.89	0.53	
Particulate Matter (FH+BH)(b)	10%	1.78	1.46	1.12		4.58	2.43	1.58	4.58
	25%	1.85	2.15	1.87		3.98	3.24	2.46	
	50%	1.76	2.27	1.85	2.27	3.49	3.17	2.86	
	75%	1.71	1.38	1.74		2.32	3.61	2.92	
	100%	1.54	1.70	1.57		2.44	3.78	2.98	

Notes:
(a) SO_2 emissions for Caterpillar and Cummins were not provided as NTE. Instead, the emission factor for sulfur oxides from AP-42 Section 3.4 was used and assumed fuel sulfur content of 15 ppm.
(b) The estimated inter-site variability for calculating FH+BH emissions is 25%
FH ("front-half" filterable emissions)
BH ("back-half" condensable emissions)
PM (particulate matter) attributable to front-half and back-half emissions is assumed equal to the sum of vendor NTE values for PM and hydrocarbons.
NTE (not to exceed)
DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

TABLE 3
COLD-START EMISSION ESTIMATES
PROJECT GENESIS
QUINCY, WASHINGTON

"Black-Puff" Emissions Test Data (see Appendix D)

	Spike Duration (sec.)	Concentration (ppm) Cold-emission spike	Concentration (ppm) Warm-state emissions	Cold-Start Emission Factor
PM+HC	14	900	30	4.3
NO_x	8	40	38	0.9
CO	20	750	30	9.0

Full-variable Load (≤100% Load) Emissions

	Worst-case (≤100% Load) Warm Emission Rate (lb/hr)		Cold-start Emission Rate (lb/hr) (a)	
Generator Size	**2.0 MW**	**2.75 MW**	**2.0 MW**	**2.75 MW**
HC	1.14	2.91	4.86	12.40
NO_x	44.34	74.40	41.54	69.70
CO	5.02	14.30	45.20	128.71
SO_2	0.03	0.04	N/A	N/A
DEEP	0.88	0.91	3.78	3.86
PM (FH+BH)	2.27	4.58	9.68	19.52

Notes:
(a) Cold-start emission factor applies to the first 60 seconds of emissions after engine startup.
FH ("front-half" filterable emissions)
BH ("back-half" condensable emissions)
DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.
NTE (not to exceed)
N/A (not applicable)

TABLE 4
FUEL-BASED EMISSION ESTIMATES
PROJECT GENESIS
QUINCY, WASHINGTON

Generator Size	2.0 MW	2.75 MW
No. of Generators	20	5
Fuel Usage (gph) per genset	147	214

Parameter	Units	Value		
Fuel Type		EPA Diesel		
Fuel Density	lbs/gallon	7		
Fuel Heat Content	Btu/gallon	137,000		
Fuel Sulfur Content	ppm weight	15		
Duration	--	Per Hour	Per Day	Per Year
Fuel Usage (per period)	Gallons	4,017	96,408	401,700
Heat Input (per period)	MMBtu	550	13,208	55,033

Project Emissions

Pollutant	CAS Number	Emission Factor			Emission Rate		
		Factor	Units	Source	(lbs/hr) (a)	(lbs/day)	(TPY)
NO_2	10102-44-0	10% of primary NO_x			-	-	6.3
SO_2	7446-09-5	1.52E-03	lbs/MMBTU	AP-42 Sec 3.4 (b)	0.88	20	4.2E-02
Benzene	71-43-2	7.76E-04	lbs/MMBTU	AP-42 Sec 3.4 (b)	0.45	10	2.2E-02
Toluene	108-88-3	2.81E-04	lbs/MMBTU	AP-42 Sec 3.4 (b)	0.16	3.7	7.8E-03
Xylenes	95-47-6	1.93E-04	lbs/MMBTU	AP-42 Sec 3.4 (b)	0.11	2.6	5.4E-03
1,3-Butadiene	106-99-0	3.91E-05	lbs/MMBTU	AP-42 Sec 3.3 (b)	2.3E-02	0.52	1.1E-03
Formaldehyde	50-00-0	7.89E-05	lbs/MMBTU	AP-42 Sec 3.4 (b)	4.6E-02	1.0	2.2E-03
Acetaldehyde	75-07-0	2.52E-05	lbs/MMBTU	AP-42 Sec 3.4 (b)	1.5E-02	0.33	7.0E-04
Acrolein	107-02-8	7.88E-06	lbs/MMBTU	AP-42 Sec 3.4 (b)	4.6E-03	0.10	2.2E-04
Benzo(a)pyrene	50-32-8	2.57E-07	lbs/MMBTU	AP-42 Sec 3.4 (b)	1.5E-04	3.4E-03	7.1E-06
Benzo(a)anthracene	56-55-3	6.22E-07	lbs/MMBTU	AP-42 Sec 3.4 (b)	3.6E-04	8.2E-03	1.7E-05
Chrysene	218-01-9	1.53E-06	lbs/MMBTU	AP-42 Sec 3.4 (b)	8.9E-04	2.0E-02	4.2E-05
Benzo(b)fluoranthene	205-99-2	1.11E-06	lbs/MMBTU	AP-42 Sec 3.4 (b)	6.4E-04	1.5E-02	3.1E-05
Benzo(k)fluoranthene	207-08-9	2.18E-07	lbs/MMBTU	AP-42 Sec 3.4 (b)	1.3E-04	2.9E-03	6.1E-06
Dibenz(a,h)anthracene	53-70-3	3.46E-07	lbs/MMBTU	AP-42 Sec 3.4 (b)	2.0E-04	4.6E-03	9.6E-06
Ideno(1,2,3-cd)pyrene	193-39-5	4.14E-07	lbs/MMBTU	AP-42 Sec 3.4 (b)	2.4E-04	5.5E-03	1.1E-05
Naphthalene	91-20-3	1.30E-04	lbs/MMBTU	AP-42 Sec 3.4 (b)	7.5E-02	1.72	3.6E-03
Propylene	115-07-1	2.79E-03	lbs/MMBTU	AP-42 Sec 3.4 (b)	1.6	37	7.7E-02

Notes:
(a) Fuel-based emission rates also account for cold-start emissions.
(b) EPA 1995.

TABLE 5
PROJECT EMISSIONS SUMMARY
PROJECT GENESIS
QUINCY, WASHINGTON

Pollutant (a)	Peak Hourly Emissions (lb/hr)	Annual Potential-to-Emit (TPY)
Criteria Pollutant		
NO_x	1.3E+03	62.93
CO	1.9E+02	8.79
SO_2 (b)	1.1E-04	0.22 lb/yr
$PM_{2.5}$ / PM_{10} (FH+BH)	72	3.44
VOCs	39	3764 lb/yr
Toxic Air Pollutants (TAPs)		
Primary NO_2 (c)	1.3E+02	6.29
DEEP (d)	23	1.12
Carbon monoxide	1.9E+02	8.79
Sulfur dioxide (b)	1.1E-04	1.1E-04
Carbon-based TAPs		
Acrolein	4.6E-03	2.2E-04
Benzene	0.45	2.2E-02
Propylene	1.62	7.7E-02
Toluene	0.16	7.8E-03
Xylenes	0.11	5.4E-03
Formaldehyde	4.6E-02	2.2E-03
Acetaldehyde	1.5E-02	7.0E-04
1,3-Butadiene	2.3E-02	1.1E-03
Polycyclic Aromatic Hydrocarbons		
Naphthalene	7.5E-02	3.6E-03
Benz(a)anthracene	3.6E-04	1.7E-05
Chrysene	8.9E-04	4.2E-05
Benzo(b)fluoranthene	6.4E-04	3.1E-05
Benzo(k)fluoranthene	1.3E-04	6.1E-06
Benzo(a)pyrene	1.5E-04	7.1E-06
Indeno(1,2,3-cd)pyrene	2.4E-04	1.1E-05
Dibenz(a,h)anthracene	2.0E-04	9.6E-06

Notes:
(a) Cold-start emissions are accounted for in the project emissions.
(b) SO_2 emissions for Caterpillar and Cummins were not provided as NTE. Instead, the emission factor for sulfur oxides from AP-42 Section 3.4 was used and assumed fuel sulfur content of 15 ppm.
(c) NO_2 is assumed to be 10% of the NO_x.
(d) Value assumed to equal the front-half NTE particulate emissions, as reported by the vendors.

FH ("front-half" filterable emissions)
BH ("back-half" condensable emissions)
FH+BH (Front-half and back-half emissions) are assumed equal to the sum of vendor NTE values for PM and hydrocarbons.
NTE (not to exceed)

TABLE 6
RANKING OF TECHNICALLY FEASIBLE CONTROL TECHNOLOGIES
PROJECT GENESIS
QUINCY, WASHINGTON

Control Device	Total Annual Cost	Project TPY Removed for Each Control Technology			
		PM	CO	VOCs	NOx
Tier-4, Integrated Control Package	$1,450,710	0.21	1.17	0.76	44.30
Urea-SCR for NO_x Control	$859,756	-	-	0.72	44.02
DPF by itself	$407,677	0.27	(0.13)	(0.04)	(1.97)
Diesel Oxidation Catalyst by itself	$170,025	0.06	2.62	0.67	-

Control Device	Total Annual Cost	Project TPY Removed for Each Control Technology								
		DEEP (FH)	CO	Carcinogenic VOCs	NO2 (10% of Nox)	Non-Carcinogenic VOCs	Benzene	1,3-Butadiene	Acrolein	Naphthalene
Tier-4, Integrated Control Package	$1,450,710	0.21	1.17	0.03	4.43	0.08	0.02	0.001	0.0002	0.003
Urea-SCR for NO_x Control	$859,756	0.08	(0.81)	0.02	4.40	0.08	0.02	0.0009	0.0002	0.003
DPF by itself	$407,677	0.27	(0.13)	(0.00)	(0.20)	(0.00)	(0.001)	(0.00005)	(0.00001)	(0.0002)
Diesel Oxidation Catalyst by itself	$170,025	0.06	2.62	0.02	0.00	0.07	0.02	0.0009	0.0002	0.003

Notes:
(Pollutant emissions are expected to increase due to added runtime associated with DPF regeneration)

TABLE 7
COST-EFFECTIVENESS ANALYSIS FOR COMBINED AND INDIVIDUAL CRITERIA POLLUTANTS
PROJECT GENESIS
QUINCY, WASHINGTON

Control Device	Cost-Effectiveness ($/ton)				
	Combined	PM (FH)	CO	Total VOCs	NO_x
Tier-4, Integrated Control Package	$31,238	$6,900,001	$1,242,113	$1,912,073	$32,744
Urea-SCR for NO_x Control	$19,535	-	-	-	$19,533
DPF by itself	$1,491,601	$1,491,601	-	-	-
Diesel Oxidation Catalyst by itself	$50,761	$2,982,384	$64,790	$254,430	-
Ecology Acceptable Unit Cost	---	$23,200	$5,000	$9,999	$10,000

TABLE 8
TBACT COST-EFFECTIVENESS ANALYSIS FOR TOXIC AIR POLLUTANTS
PROJECT GENESIS
QUINCY, WASHINGTON

Control Device	Cost-Effectiveness ($/ton)								
	DEEP	CO	Carcinogen VOCs	NO_2	Non-carcinogen VOCs	Benzene	1,3-Butadiene	Acrolein	Naphthalene
Tier-4, Integrated Control Package	$6,900,001	$1,242,113	$56,436,911	$327,442	$17,740,624	$74,800,508	$1,484,531,815	$7,366,141,367	$446,501,492
Urea-SCR for NO_x Control	-	-	$35,086,832	$195,328	$11,029,348	$46,503,481	$922,933,545	$4,579,530,659	$277,590,012
DPF by itself	$1,491,601	-	-	-	-	-	-	-	-
Diesel Oxidation Catalyst by itself	$2,982,384	$64,790	$7,509,784	-	$2,360,658	$9,953,338	$197,539,396	$980,176,444	$59,413,772
Ecology Acceptable Unit Cost	$23,200	$5,000	$9,999	$20,000	$9,999	$9,999	$9,999	$9,999	$9,999

TABLE 9
COMPARISON TO SQERs
PROJECT GENESIS
QUINCY, WASHINGTON

Pollutant	CAS#	Project Emissions		SQER Value		SQER Ratio	SQER Exceeded?
DEEP	--	2,243	lbs/yr	0.639	lbs/yr	3,510	Yes
CO	82115-62-3	195	lbs/hour	50.2	lbs/hour	3.9E+00	Yes
NO_2	10102-44-0	1.3E+03	lbs/hour	1.03	lbs/hour	1.2E+03	Yes
SO_2	7446-09-5	0.9	lbs/hour	1.45	lbs/hour	0.61	No
Benzene	71-43-2	43.1	lbs/yr	6.62	lbs/yr	6.5	Yes
Toluene	108-88-3	15.6	lbs/yr	657	lbs/yr	2.4E-02	No
Xylenes	95-47-6	10.7	lbs/yr	58	lbs/yr	0.18	No
1,3-Butadiene	106-99-0	2.2	lbs/yr	1.13	lbs/yr	1.9	Yes
Formaldehyde	50-00-0	4.4	lbs/yr	32	lbs/yr	0.14	No
Acetaldehyde	75-07-0	1.4	lbs/yr	71	lbs/yr	2.0E-02	No
Acrolein	107-02-8	0.10	lbs/day	0.00789	lbs/day	13	Yes
Benzo(a)pyrene	50-32-8	1.43E-02	lbs/yr	0.174	lbs/yr	0.08	No
Benzo(a)anthracene	56-55-3	3.45E-02	lbs/yr	1.74	lbs/yr	2.0E-02	No
Chrysene	218-01-9	8.50E-02	lbs/yr	17.4	lbs/yr	4.9E-03	No
Benzo(b)fluoranthene	205-99-2	6.16E-02	lbs/yr	1.74	lbs/yr	3.5E-02	No
Benzo(k)fluoranthene	207-08-9	1.21E-02	lbs/yr	1.74	lbs/yr	7.0E-03	No
Dibenz(a,h)anthracene	53-70-3	1.92E-02	lbs/yr	0.16	lbs/yr	0.12	No
Ideno(1,2,3-cd)pyrene	193-39-5	2.30E-02	lbs/yr	1.74	lbs/yr	1.3E-02	No
Naphthalene	91-20-3	7.2	lbs/yr	5.64	lbs/yr	1.3	Yes
Propylene	115-07-1	37	lbs/day	394	lbs/day	0.09	No

Notes:
Highlighting indicates exceedance of the SQER.

TABLE 10
COMPARISON TO NAAQS
PROJECT GENESIS
QUINCY, WASHINGTON

Criteria Pollutant/ Hazardous Air Pollutant	National Standards Primary ($\mu g/m^3$)	National Standards Secondary ($\mu g/m^3$)	Washington State Standards ($\mu g/m^3$)	Max. Project-Related Impact ($\mu g/m^3$)	Filename	Local Background ($\mu g/m^3$)	Regional Background ($\mu g/m^3$)(a)	Max. Cumulative Ambient Impact ($\mu g/m^3$)
Particulate Matter (PM_{10})								
Annual average	--	--	50	0.47	PM10_101115, PM10_101115b	1.1	--	1.6
24-hour average	150	150	150	56	PM10_101215, PM10_101315	18	62	136
Particulate Matter ($PM_{2.5}$)								
Annual average	15	15	12	0.47	PM10_101115, PM10_101115b	1.1	6.5	8
24-hour average	35	35	35	(b)	PM25_100515-COPY	12.6	21.0	34
Carbon Monoxide (CO)								
8-hour average	10,000	--	10,000	326	CO_100715b	--	3,308	3,634
1-hour average	40,000	--	40,000	637	CO_100715a	--	5,776	6,413
Nitrogen Oxides (NO_x)								
Annual average	100	100	100	7.71	NOx_101215, NOx_101215b	2.6	2.8	13
1-hour average	188	--	--	(b)	NOx_100715	105	16	121
Sulfur Dioxide (SO_2)								
Annual arithmetic mean	79	--	52	5.4E-03	SO2_100615a	--	0.26	0.27
24-hour average	370	--	260	0.9		--	1.0	2.0
3-hour average	--	1,310	1,310	1.6	SO2_100615b	--	2.1	3.7
1-hour average	200	--	200	2.3		--	2.6	4.9

Notes:
(a) Regional background level obtained from Ecology's Air Monitoring Network website (WSU website 2015).
(b) Modeled with local background; therefore, value in local background column accounts for project + local background.

TABLE 11
COMPARISON TO ASILS
PROJECT GENESIS
QUINCY, WASHINGTON

			DEVELOPMENT OF DISPERSION FACTORS			COMPLIANCE DEMONSTRATION USING DISPERSION FACTORS				
Toxic Air Pollutant	Filename		Modeled Project Emission Rate (lb/hr)	Modeled Max. Ambient Impact (µg/m^3)	Dispersion Factor	Project Emissions (lb/hr)	Maximum Ambient Impact (µg/m^3)	ASIL (µg/m^3)	Averaging Period	Over the ASIL?
DEEP	DEEP_100615a	(b)	0.26	0.15	0.6	<--	<--	0.00333	Year	Yes
Benzene	--	(c)	-->	-->	--	0.0049	0.0029	0.0345	Year	No
1,3-Butadiene	--	(c)	-->	-->	--	0.00025	0.00015	0.00588	Year	No
Naphthalene	--	(c)	-->	-->	--	0.00082	0.00048	0.0294	Year	No
CO	CO_100715a	(b)	195	637	--	<--	<--	23,000	1-hr	No
NO_2	NO2_100715	(a)(b)	1,257	859	--	<--	<--	470	1-hr	Yes
Acrolein	Acrolein_101415	(b)	4.3E-03	6.7E-03	--	<--	<--	0.06	24-hr	No

Highlighted items indicate a requirement for the health impact assessment.
µg/m^3 = Micrograms per cubic meter
ASIL = Acceptable source impact level

(a) Conservatively modeled using the maximum 1-hour emission rate, 8,760 hours per year.
(b) A dispersion factor was NOT used to approximate the impact.
(c) A dispersion factor was used to approximate the control emissions impact.

TABLE 12
RANK WORST-CASE DAY (FOR 24-HOUR $PM_{2.5}$ NAAQS)
PROJECT GENESIS
QUINCY, WASHINGTON

Day	Event	Duration (hrs)	Worst-case Max. Generators Concurrently Operating		Operating Load
			2.0 MW	2.75 MW	
1	Emergency Power Outage	24	20	5	≤100%
2	Emergency Power Outage	24	20	5	≤100%
3	Emergency Power Outage	24	20	5	≤100%
4	Emergency Power Outage	12	20	5	≤100%
5	Monthly Maintenance Testing	8	0	1	≤100%
6	Monthly Maintenance Testing	8	0	1	≤100%
7	Monthly Maintenance Testing	8	0	1	≤100%
8	Monthly Maintenance Testing	8	0	1	≤100%

Notes:
Boxed row represents 8th-highest operating scenario (i.e., equivalent to 98 percentile).

TABLE 13
RANK WORST-CASE HOUR (FOR 1-HOUR NO_x NAAQS)
PROJECT GENESIS
QUINCY, WASHINGTON

Day	Event	Duration (hrs)	Worst-case Max. Generators Concurrently Operating		Operating Load
			2.0 MW	2.75 MW	
1	Emergency Power Outage	1	20	5	≤100%
2	Emergency Power Outage	1	20	5	≤100%
3	Emergency Power Outage	1	20	5	≤100%
4	Emergency Power Outage	1	20	5	≤100%
5	Monthly Maintenance Testing	1	0	1	≤100%
6	Monthly Maintenance Testing	1	0	1	≤100%
7	Monthly Maintenance Testing	1	0	1	≤100%
8	Monthly Maintenance Testing	1	0	1	≤100%

Notes:
Boxed row represents 8th-highest operating scenario (i.e., equivalent to 98 percentile).

TABLE 14
EXISTING OPERATING RESTRICTIONS FOR PERMITTED GENERATORS R THROUGH 12
PROJECT GENESIS
QUINCY, WASHINGTON

Activity	Hours/year per generator	Operating load (%)	Diesel Fuel Gallons/year	No. Operating Concurrently
Maintenance Testing	12	100	24,648	1
Load Testing	4	100	8216	1
Electrical Bypass	36	100	73,944	2
Power Outage	148	100	303,992	13
Total	200		410,800	

TABLE 15
PROPOSED OPERATING RESTRICTIONS FOR PERMITTED GENERATORS R THROUGH 12
PROJECT GENESIS
QUINCY, WASHINGTON

Activity	Hours/year per generator	Operating load (%)	Diesel Fuel Gallons/year	No. Operating Concurrently
Maintenance Testing	12	0%	2,465	1
Load Testing	4	100%	7,660	1
Electrical Bypass	36	2 at 40% or 1 at 80%	55,926	2
Power Outage	48	8 at 90%, 2 at 0%	77,597	13
Total	100		143,648	

Notes:
Emissions for idle (0% operating load) are conservatively estimated based on manufacturer provided potential-to-emit at 10% operating load.

TABLE 16
FACILITY-WIDE POTENTIAL-TO-EMIT
PROJECT GENESIS
QUINCY, WASHINGTON

Pollutant	Phase 1 thru 4 (Unchanged) Cooling Towers	Phase 1 thru 4 ~~Former Genset (R thru 12)~~	Phase 1 thru 4 New (a) Genset (R thru 12)	Phase 5/6 Genset (13 thru R3)	Project Genesis Proposed Gensets	~~Former Facility Total~~	New Facility Total
Criteria Pollutant	**Potential-to-Emit (TPY)**						
2.1.1 NO_x	(b)	~~35~~	21	11	62.93	~~46~~	95
2.1.2 CO	(b)	~~13~~	3.0	6.1	8.79	~~19.1~~	17.9
2.1.3 SO_2	(b)	~~80 lb/yr~~	20 lb/yr	22 lb/yr	0.22 lb/yr	~~102 lb/yr~~	50 lb/yr
2.1.4 PM2.5 / PM10 (FH+BH) (c)	(b)	~~1.2~~	1.1	~~0.35~~ 1.01 (d)	3.44	~~1.6~~	5.5
2.1.5 VOCs	(b)	~~80 lb/yr~~	0.70	349 lb/yr	1.88	~~429 lb/yr~~	2.8
Toxic Air Pollutants (TAPs)	**Potential-to-Emit (TPY)**						
2.1.6 Primary NO_2	-	~~3.5~~	2.09E+00	1.1	6.29	~~4.6~~	9.5
2.1.7 DEEP (e)	-	~~1.2~~	0.368	0.35	1.12	~~1.6~~	1.8
2.1.8 Carbon monoxide	-	~~13~~	3.006	6.1	8.79	~~19.1~~	17.9
2.1.9 Sulfur dioxide	-	~~4.00E-02~~	1.50E-02	0.01	1.1E-04	~~5.10E-02~~	2.52E-02
Carbon-based TAPs	**Potential-to-Emit (TPY)**						
2.1.10 Acrolein	-	~~2.10E-04~~	7.82E-05	5.59E-05	2.2E-04	~~2.70E-04~~	3.53E-04
2.1.11 Benzene	-	~~2.10E-02~~	7.70E-03	5.50E-03	2.2E-02	~~2.60E-02~~	3.47E-02
2.1.12 Propylene	-	~~7.47E-02~~	2.77E-02	1.98E-02	7.7E-02	~~9.40E-02~~	1.25E-01
2.1.13 Toluene	-	~~7.50E-03~~	2.79E-03	1.99E-03	7.8E-03	~~9.50E-03~~	1.26E-02
2.1.14 Xylenes	-	~~5.20E-03~~	1.92E-03	1.37E-03	5.4E-03	~~6.50E-03~~	8.64E-03
2.1.15 Formaldehyde	-	~~2.10E-03~~	7.83E-04	5.60E-04	2.2E-03	~~2.70E-03~~	3.53E-03
2.1.16 Acetaldehyde	-	~~6.70E-04~~	2.50E-04	1.79E-04	7.0E-04	~~8.50E-04~~	1.13E-03
2.1.17 1,3-Butadiene (f)	-	-	3.88E-04	2.77E-04	1.1E-03	~~0.00E+00~~	1.75E-03
Polycyclic Aromatic Hydrocarbons	**Potential-to-Emit (TPY)**						
2.1.17 Naphthalene	-	~~3.50E-03~~	1.29E-03	9.22E-04	3.6E-03	~~4.40E-03~~	5.82E-03
2.1.18 Benz(a)anthracene	-	~~1.70E-05~~	6.18E-06	4.41E-06	1.7E-05	~~2.10E-05~~	2.79E-05
2.1.19 Chrysene	-	~~4.10E-05~~	1.52E-05	1.10E-05	4.2E-05	~~5.20E-05~~	6.87E-05
2.1.20 Benzo(b)fluoranthene	-	~~3.00E-05~~	1.10E-05	7.90E-06	3.1E-05	~~3.80E-05~~	4.97E-05
2.1.21 Benzo(k)fluoranthene	-	~~5.80E-06~~	2.16E-06	1.55E-06	6.1E-06	~~7.40E-06~~	9.77E-06
2.1.22 Benzo(a)pyrene	-	~~6.90E-06~~	2.55E-06	1.82E-06	7.1E-06	~~8.70E-06~~	1.15E-05
2.1.23 Indeno(1,2,3-cd)pyrene	-	~~1.10E-05~~	4.11E-06	2.94E-06	1.1E-05	~~1.40E-05~~	1.85E-05
2.1.24 Dibenz(a,h)anthracene	-	~~9.20E-06~~	3.44E-06	2.45E-06	9.6E-06	~~1.20E-05~~	1.55E-05

Notes:
(a) Former estimates for particulate matter included front-half emissions only. New estimates included front-half and back-half (condensables), as well as estimates for cold-start emissions.
(b) For potential-to-emit for existing cooling towers at the facility, refer to Table 2.2 of the existing Approval Order 11AQ-E399.
(c) For this evaluation, all PM is considered to be PM2.5 and PM10.
(d) A scaling factor of 2.9 was used to approximated FH+BH emissions of particulate mater for the Phase 5/6 engines.
(e) Value assumed to equal the front-half NTE PM emissions, as reported by the vendors.
(f) The estimated 1,3-butadiene emission rate for existing generators R through 12 was not included in the original 2007 NOC application for those emission units; however, for completeness it has been calculated and presented in this table. / estimated 1,3-butadiene emission rate for existing generators 13 through R3 were estimated and provided to Ecology in a NOC application addendum letter dated January 21, 2011 and are presented below for completeness.

FH ("front-half" filterable emissions)
BH ("back-half" condensable emissions)
DEEP (diesel engine exhaust particulate matter)

TABLE 17
IDENTIFICATION INFORMATION FOR EXISTING PERMITTED GENERATORS 13 THROUGH R3
PROJECT GENESIS
QUINCY, WASHINGTON

Phase	Unit ID	Engine Serial Number	Generator Serial Number	Manufacture Date
5	13	527107949	WA-575124-1110	2,010
5	14	NA	NA	NA
5	15	527107951	WA-575127-1110	2,010
5	16	527107950	WA-575140-1210	2,010
5	R2	527107948	WA-575180-1210	2,010
6	17	5272011221	WA-575153-1210	Feb-13
6	18	5272011219	WA-581655-0213	Feb-13
6	19	5272011218	WA-581627-0213	Feb-13
6	20	5272011220	WA-581653-0213	Feb-13
6	R3	5272011251	WA-581631-0313	Mar-13

Notes:
NA = Not applicable because engine has not been installed.

APPENDIX A

Generator Specifications

Model:	DQKAB
Frequency:	60
Fuel type:	Diesel
KW rating:	2000 standby 1825 prime
Emissions level:	EPA NSPS Stationary Emergency Tier 2

† Generator set data sheet

Power Generation

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Exhaust emission data sheet:	EDS-1065
Exhaust emission compliance sheet:	EPA-1099
Sound performance data sheet:	
Cooling performance data sheet:	MCP-158
Prototype test summary data sheet:	PTS-267
Standard set-mounted radiator cooling outline:	0500-4392
Optional set-mounted radiator cooling outline:	0500-4780
Optional heat exchanger cooling outline:	
Optional remote radiator cooling outline:	0500-4393

Fuel consumption

	Standby				Prime				Continuous
	kW (kVA)				kW (kVA)				kW (kVA)
Ratings	2000 (2500)				1825 (2281)				
Load	1/4	1/2	3/4	Full	1/4	1/2	3/4	Full	Full
US gph	46.5	82	107.3	141.3	43.4	75.1	100.6	124.1	
L/hr	176	311	407	535	164	285	381	470	

Engine

	Standby rating	Prime rating	Continuous rating
Engine manufacturer	Cummins Inc.		
Engine model	QSK60-G6 NR2		
Configuration	Cast iron, V 16 cylinder		
Aspiration	Turbocharged and low temperature aftercooled		
Gross engine power output, kWm (bhp)	2179 (2922)	1975 (2647)	
BMEP at set rated load, kPa (psi)	2420 (350)	2185 (316)	
Bore, mm (in)	159 (6.25)		
Stroke, mm (in)	190 (7.48)		
Rated speed, rpm	1800		
Piston speed, m/s (ft/min)	11.4 (2244)		
Compression ratio	14.5:1		
Lube oil capacity, L (qt)	334 (304)		
Overspeed limit, rpm	2100 ±50		
Regenerative power, kW	168		

Fuel flow

Maximum fuel flow, L/hr (US gph)	946 (250)	
Maximum fuel inlet restriction, kPa (in Hg)	30 (9.0)	
Maximum fuel inlet temperature, °C (°F)	71 (160)	

Air	Standby rating	Prime rating	Continuous rating
Combustion air, m^3/min (scfm)	178 (6295)	159 (5615)	
Maximum air cleaner restriction, kPa (in H_2O)	6.2 (25)		
Alternator cooling air, m^3/min (cfm)	204 (7300)		

Exhaust			
Exhaust flow at set rated load, m^3/min (cfm)	436 (15385)	385 (13580)	
Exhaust temperature, °C (°F)	488 (900)	466 (870)	
Maximum back pressure, kPa (in H_2O)	6.8 (27)		

Standard set-mounted radiator cooling			
Ambient design, °C (°F)	40 (104)		
Fan load, kW_m (HP)	57 (77)		
Coolant capacity (with radiator), L (US gal)	492 (130)		
Cooling system air flow, m^3/min (scfm)	1922 (67870)		
Total heat rejection, MJ/min (Btu/min)	99.5 (94395)	91.0 (86382)	
Maximum cooling air flow static restriction, kPa (in H_2O)	0.12 (0.5)		
Maximum fuel return line restriction kPa (in Hg)	30 (9.0)		

Optional set-mounted radiator cooling			
Ambient design, °C (°F)	50 (122)		
Fan load, kW_m (HP)	57 (77)		
Coolant capacity (with radiator), L (US gal)	617 (163)		
Cooling system air flow, m^3/min (scfm)	2795 (98700)		
Total heat rejection, MJ/min (Btu/min)	99.5 (94395)	91 (86382)	
Maximum cooling air flow static restriction, kPa (in H_2O)	0.12 (0.5)		
Maximum fuel return line restriction, kPa (in Hg)	30 (9.0)		

Optional heat exchanger cooling			
Set coolant capacity, L (US gal)			
Heat rejected, jacket water circuit, MJ/min (Btu/min)			
Heat rejected, aftercooler circuit, MJ/min (Btu/min)			
Heat rejected, fuel circuit, MJ/min (Btu/min)			
Total heat radiated to room, MJ/min (Btu/min)			
Maximum raw water pressure, jacket water circuit, kPa (psi)			
Maximum raw water pressure, aftercooler circuit, kPa (psi)			
Maximum raw water pressure, fuel circuit, kPa (psi)			
Maximum raw water flow, jacket water circuit, L/min (US gal/min)			
Maximum raw water flow, aftercooler circuit, L/min (US gal/min)			
Maximum raw water flow, fuel circuit, L/min (US gal/min)			
Minimum raw water flow at 27 °C (80 °F) inlet temp, jacket water circuit, L/min (US gal/min)			
Minimum raw water flow at 27 °C (80 °F) inlet temp, aftercooler circuit, L/min (US gal/min)			
Minimum raw water flow at 27 °C (80 °F) inlet temp, fuel circuit, L/min (US gal/min)			
Raw water delta P at min flow, jacket water circuit, kPa (psi)			
Raw water delta P at min flow, aftercooler circuit, kPa (psi)			
Raw water delta P at min flow, fuel circuit, kPa (psi)			
Maximum jacket water outlet temp, °C (°F)			
Maximum aftercooler inlet temp, °C (°F)			
Maximum aftercooler inlet temp at 25 °C (77 °F) ambient, °C (°F)			
Maximum fuel return line restriction, kPa (in Hg)			

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Optional remote radiator cooling[1]

Optional remote radiator cooling	Standby rating	Prime rating	Continuous rating
Set coolant capacity, L (USg gal)			
Max flow rate at max friction head, jacket water circuit, L/min (US gal/min)	1902 (502)		
Max flow rate at max friction head, aftercooler circuit, L/min (US gal/min)	606 (160)		
Heat rejected, jacket water circuit, MJ/min (Btu/min)	46.9 (44526)	44.1 (41824)	
Heat rejected, aftercooler circuit, MJ/min (Btu/min)	33.9 (32156)	30.4 (28887)	
Heat rejected, fuel circuit, MJ/min (Btu/min)			
Total heat radiated to room, MJ/min (Btu/min)	18.7 (17713)	16.5 (15671)	
Maximum friction head, jacket water circuit, kPa (psi)	69 (10)		
Maximum friction head, aftercooler circuit, kPa (psi)	48 (7)		
Maximum static head, jacket water circuit, m (ft)	18 (60)		
Maximum static head, aftercooler circuit, m (ft)	18 (60)		
Maximum jacket water outlet temp, °C (°F)	104 (220)	100 (212)	
Maximum aftercooler inlet temp at 25 °C (77 °F) ambient, °C (°F)	49 (120)		
Maximum aftercooler inlet temp, °C (°F)	66 (150)		
Maximum fuel flow, L/hr (US gph)			
Maximum fuel return line restriction, kPa (in Hg)	30 (9.0)		

Weights[2]

Unit dry weight kgs (lbs)	14628 (32249)
Unit wet weight kgs (lbs)	15155 (33410)

Notes:

[1] For non-standard remote installations contact your local Cummins Power Generation representative.

[2] Weights represent a set with standard features. See outline drawing for weights of other configurations.

Derating factors

Standby	Engine power available up to 447 m (1466 ft) at ambient temperatures up to 40 °C (104 °F). From 447 m (1466 ft) up to 2001 m (6562 ft) engine derates at 5.1% per 305 m (1000 ft) for 40 °C (104 °F). Above these elevations, derate an additional 5.8% per 305 m (1000 ft). For temperatures from 40 °C (104 °F) to 50 °C (122 °F) derate 14.6%. For temperatures above 50 °C (122 °F) derate 29% per 10 °C (50 °F).
Prime	Engine power available up to 447 m (1466 ft) at ambient temperatures up to 40 °C (104 °F). From 447 m (1466 ft) up to 2001 m (6562 ft) engine derates at 5.1% per 305 m (1000 ft) for 40 °C (104 °F). Above these elevations, derate an additional 5.8% per 305 m (1000 ft). For temperatures from 40 °C (104 °F) to 50 °C (122 °F) derate 14.6%. For temperatures above 50 °C (122 °F) derate 29% per 10 °C (50 °F).
Continuous	

Ratings definitions

Emergency standby power (ESP):	Limited-time running power (LTP):	Prime power (PRP):	Base load (continuous) power (COP):
Applicable for supplying power to varying electrical load for the duration of power interruption of a reliable utility source. Emergency Standby Power (ESP) is in accordance with ISO 8528. Fuel Stop power in accordance with ISO 3046, AS 2789, DIN 6271 and BS 5514.	Applicable for supplying power to a constant electrical load for limited hours. Limited Time Running Power (LTP) is in accordance with ISO 8528.	Applicable for supplying power to varying electrical load for unlimited hours. Prime Power (PRP) is in accordance with ISO 8528. Ten percent overload capability is available in accordance with ISO 3046, AS 2789, DIN 6271 and BS 5514.	Applicable for supplying power continuously to a constant electrical load for unlimited hours. Continuous Power (COP) is in accordance with ISO 8528, ISO 3046, AS 2789, DIN 6271 and BS 5514.

Alternator data

Voltage	Connection[1]	Temp rise degrees C	Duty[2]	Single phase factor[3]	Max surge kVA[4]	Winding No.	Alternator data sheet	Feature Code
380	Wye, 3-phase	150/125/105	S/P/C		7327	13	ADS-515	B595
380	Wye, 3-phase	125/105/80	S/P/C		7327	13	ADS-515	B598
380	Wye, 3-phase	105/80	S/P		7327	13	ADS-515	B599
380	Wye, 3-phase	80	S		7963	13	ADS-516	B660
440	Wye, 3-phase	125/105/80	S/P/C		7361	312	ADS-334	B663
440	Wye, 3-phase	105	S		7284	12	ADS-515	B665
480	Wye, 3-phase	125/105/80	S/P/C		7361	312	ADS-334	B462
480	Wye, 3-phase	105/80	S/P		7695	312	ADS-335	B463
480	Wye, 3-phase	125/105	P/C		6716	312	ADS-332	B464
480	Wye, 3-phase	80	S		8412	12	ADS-516	B601
480	Wye, 3-phase	80	P		8412	12	ADS-516	B694
480	Wye, 3-phase	105	S		7695	12	ADS-517	B796
600	Wye, 3-phase	125/105/80	S/P/C		7361	07	ADS-334	B465
600	Wye, 3-phase	105/80	S/P		7695	07	ADS-335	B301
600	Wye, 3-phase	125/105	P/C		6716	07	ADS-333	B466
600	Wye, 3-phase	80	S		7265	07	ADS-516	B604
4160	Wye, 3-phase	125/105/80	S/P/C		6307	51	ADS-518	B467
4160	Wye, 3-phase	105/80	S/P		6307	51	ADS-518	B313
4160	Wye, 3-phase	80	S		6307	51	ADS-518	B605
4160	Wye, 3-phase	105	S		6307	51	ADS-520	B795
12470-13800	Wye, 3-phase	125/105/80	S/P/C		6062	91	ADS-521	B448
12470	Wye, 3-phase	105/80	S/P		6038	87	ADS-521	B567
13200-13800	Wye, 3-phase	105/80	S/P		6062	91	ADS-521	B612
12470	Wye, 3-phase	80	S		6685	87	ADS-522	B607
13200-13800	Wye, 3-phase	80	S		8012	91	ADS-523	B628
13800	Wye, 3-phase	80	S		6833	91	ADS-521	B610
13800	Wye, 3-phase	105	S		6062	91	ADS-523	B797

Notes:

[1] Limited single phase capability is available from some three phase rated configurations. To obtain single phase rating, multipy the three phase kW rating by the Single Phase Factor[3]. All single phase ratings are at unity power factor.

[2] Standby (S), Prime (P) and Continuous ratings (C).

[3] Factor for the *Single Phase Output from Three Phase Alternator* formula listed below.

[4] Maximum rated starting kVA that results in a minimum of 90% of rated sustained voltage during starting.

Formulas for calculating full load currents:

Three phase output

$$\frac{\text{kW} \times 1000}{\text{Voltage} \times 1.73 \times 0.8}$$

Single phase output

$$\frac{\text{kW} \times \text{SinglePhaseFactor} \times 1000}{\text{Voltage}}$$

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Minneapolis, MN 55432 USA
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Fax: 763 574 5298

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Generator set data sheet

Power Generation

Model: DQLF
Frequency: 60
Fuel type: Diesel
KW rating: 2750 standby
2500 prime
2100 continuous
Emissions level: EPA NSPS Stationary Emergency Tier 2

Exhaust emission data sheet:	**EDS-1125**
Exhaust emission compliance sheet:	**EPA-1174**
Sound performance data sheet:	**MSP-1103**
Cooling performance data sheet:	**MCP-211**
Prototype test summary data sheet:	**PTS-299**
Remote radiator cooling outline:	**A049A843**
High ambient cooling system outline (ship loose):	**A049A845**
Enhanced high ambient cooling system outline (ship loose):	**A049A847**

Fuel consumption

	Standby				**Prime**				**Continuous**
	kW (kVA)				**kW (kVA)**				**kW (kVA)**
Ratings	2750 (3438)				2500 (3125)				2100 (2625)
Load	**1/4**	**1/2**	**3/4**	**Full**	**1/4**	**1/2**	**3/4**	**Full**	**Full**
US gph	63.3	103.4	143.4	183.4	59.7	96.1	132.5	168.9	145.5
L/hr	239	391	542	694	226	364	501	639	551

Engine

	Standby rating	**Prime rating**	**Continuous rating**
Engine manufacturer	Cummins Inc.		
Engine model	QSK78-G12		
Configuration	Cast Iron, V 18 cylinder		
Aspiration	Turbocharged and low temperature aftercooled		
Gross engine power output, kWm (bhp)	3028 (4060)	2737 (3670)	2271 (3045)
BMEP at set rated load, kPa (psi)	2599 (377)	2351 (341)	1951 (283)
Bore, mm (in)	170.0 (6.69)		
Stroke, mm (in)	190.0 (7.48)		
Rated speed, rpm	1800		
Piston speed, m/s (ft/min)	11.4 (2243)		
Compression ratio	15.5:1		
Lube oil capacity, L (qt)	413 (436)		
Overspeed limit, rpm	2100		
Regenerative power, kW	266		

Fuel flow	Standby rating	Prime rating	Continuous rating
Maximum fuel flow, L/hr (US gph)	2234 (590)		
Maximum fuel restriction at injection pump with clean filter, kPa (in Hg)	17 (5)		
Maximum fuel inlet temperature, °C (°F)	71 (160)		

Air

Combustion air, m^3/min (scfm)	239 (8451)	227 (8003)	207 (7302)
Maximum air cleaner restriction, kPa (in H_2O)	3.7 (15)		
Alternator cooling air, m^3/min (cfm)	270 (9535)		

Exhaust

Exhaust flow at set rated load, m^3/min (cfm)	570 (20134)	532 (18784)	480 (16965)
Exhaust temperature, °C (°F)	471 (879)	454 (850)	442 (827)
Maximum back pressure, kPa (in H_2O)	7 (28)		

High ambient cooling system (ship loose)

Ambient design °C (°F)	43 (109)	40 (104)	44 (111)
Fan load kWm (hp)	90 (121)		
Cooling capacity (with radiator), L (US gal)	738 (195)		
Cooling system air flow, m^3/min (scfm)	3060 (108000)		
Total heat rejection, MJ/min (Btu/min))	103.6 (98257)	94.6 (89618)	82.0 (77746)
Maximum cooling air flow static restriction, kPa (in H_2O)	0.12 (0.5)		

Enhanced high ambient cooling system (ship loose)

Ambient design, °C (°F)	51 (124)	49 (120)	50 (122)
Fan load, kW_m (HP)	107 (144)		
Coolant capacity (with radiator), L (US gal)	1061 (280)		
Cooling system air flow, m^3/min (scfm)	4560 (161000)		
Total heat rejection, MJ/min (Btu/min)	103.6 (98257)	94.6 (89618)	82.0 (77746)
Maximum cooling air flow static restriction, kPa (in H_2O)	0.12 (0.5)		

Remote radiator cooling at 25C, 110M[1]

Set coolant capacity, L (US gal)	223 (59)		
Max flow rate at max friction head, jacket water circuit, L/min (US gal/min)	2222 (587)		
Max flow rate at max friction head, aftercooler circuit, L/min (US gal/min)	988 (261)		
Heat rejected, jacket water circuit, MJ/min (Btu/min)	55.1 (52234)	51.1 (48459)	45.5 (43158)
Heat rejected, aftercooler circuit, MJ/min (Btu/min)	45.9 (43523)	40.8 (38659)	33.9 (32088)
Heat rejected, fuel circuit, MJ/min (Btu/min)	2.6 (2500)		
Total heat radiated to room, MJ/min (Btu/min)	23.4 (22179)	21.4 (20341)	18.3 (17400)
Maximum friction head, jacket water circuit, kPa (psi)	69 (10)		
Maximum friction head, aftercooler circuit, kPa (psi)	48 (7)		
Maximum static head, jacket water circuit, m (ft)	18.3 (60)		
Maximum static head, aftercooler circuit, m (ft)	18.3 (60)		
Maximum jacket water outlet temp, °C (°F)	104 (220)	100 (212)	100 (212)
Maximum aftercooler inlet temp at 25 °C (77 °F) ambient, °C (°F)	49 (120)		
Maximum aftercooler inlet temp, °C (°F)	71 (160)	66 (150)	
Maximum fuel flow, L/hr (US gph)	2234 (590)		
Maximum fuel return line restriction, kPa (in Hg)	34 (10)		

[1] For non-standard remote installations contact your local Cummins Power Generation representative.

Weights[2]

Unit dry weight kgs (lbs)	22824 (50318)
Unit wet weight kgs (lbs)	23603 (52036)

[2] Weights represent a set with standard features. See outline drawing for weights of other configurations.

Derating factors

Standby	Standard Cooling System: Full rated power available up to 1077 m (3536 ft) elevation at ambient temperatures up to 40 °C (104 °F). At 40 °C (104 °F) derate by 4.6% per 305m (1000 ft) from 1077 m (3536 ft) to 2000 m (6560 ft). Above these conditions derate by 7.5% per 305m (1000 ft) and by an additional 17.8% per 10 °C (18 °F). Enhanced Cooling System: Full rated power available up to 1240 m (4067 ft) elevation at ambient temperatures up to 40°C (104°F). At 40°C (104°F) derate by 4.6% per 305m (1000 ft) from 1240 m (4067 ft) to 2399 m (7872 ft), and above 2399 m (7872 ft) derate by 7.5% per 305m (1000 ft). Full rated power available up to 387 m (1269 ft) elevation at ambient temperatures up to 50°C (122°F). At 50°C (122°F) derate by 4.6% per 305m (1000 ft) from 387 m (1269 ft) to 1600 m (5248 ft), and above 1600 m (5248 ft) derate by 7.5% per 305m (1000 ft). At higher ambient temperatures, derate by an additional 21.3% per 10 °C (18°F). Remote Radiator Cooling Option: Full rated power available up to 728 m (2387 ft) at ambient temperature up to 40 °C (104 °F). Above these elevations, at 40 °C (104 °F), derate by an additional 7.75% per 305 m (1000 ft). Derate by 2.25% at sea level at ambient temperatures up to 50 °C (122 °F). Above these elevations, at 50 °C (122 °F), derate by an additional 7.4% per 305 m (1000 ft). At higher ambient temperatures, derate by an additional 19% per 10 °C (18 °F),
Prime	Full rated power available up to 394 m (1294 ft) at ambient temperature up to 40 °C (104 °F). Above these elevations, at 40 °C (104 °F), derate by an additional 8.5% per 305 m (1000 ft). Derate by 11.5% at sea level at ambient temperatures up to 50 °C (122 °F). Above these elevations, at 50 °C (122 °F), derate by an additional 8.25% per 305 m (1000 ft). At higher ambient temperatures, derate by an additional 22% per 10 °C (18 °F),
Continuous	Full rated power available at sea level at ambient temperature up to 40 °C (104 °F). Above these elevations, at 40 °C (104 °F), derate by an additional 9.75% per 305 m (1000 ft). Derate by 29% at sea level at ambient temperatures up to 50 °C (122 °F). Above these elevations, at 50 °C (122 °F), derate by an additional 8.5% per 305 m (1000 ft). At higher ambient temperatures, derate by an additional 28% per 10 °C (18 °F),

Ratings definitions

Emergency standby power (ESP):	Limited-time running power (LTP):	Prime power (PRP):	Base load (continuous) power (COP):
Applicable for supplying power to varying electrical load for the duration of power interruption of a reliable utility source. Emergency Standby Power (ESP) is in accordance with ISO 8528. Fuel Stop power in accordance with ISO 3046, AS 2789, DIN 6271 and BS 5514.	Applicable for supplying power to a constant electrical load for limited hours. Limited Time Running Power (LTP) is in accordance with ISO 8528.	Applicable for supplying power to varying electrical load for unlimited hours. Prime Power (PRP) is in accordance with ISO 8528. Ten percent overload capability is available in accordance with ISO 3046, AS 2789, DIN 6271 and BS 5514.	Applicable for supplying power continuously to a constant electrical load for unlimited hours. Continuous Power (COP) is in accordance with ISO 8528, ISO 3046, AS 2789, DIN 6271 and BS 5514.

Alternator data

Voltage	Connection[1]	Temp rise degrees C	Duty[2]	Single phase factor[3]	Max surge kVA[4]	Winding No.	Alternator data sheet	Feature Code
220/380	Wye	125	S		N/A	13	ADS-531	B407-2
380	Wye	150	S		7944	13	ADS-516	B814-2
440	Wye	150	S/P/C		9719	12	ADS-517	B813-2
380	Wye	125	P		7944	13	ADS-516	B815-2
380	Wye	80	C		N/A	13	ADS-517	B800-2
220/380	Wye	105	C		7944	13	ADS-516	B597-2
380	Wye	105	P		10049	13	ADS-517	B840-2
440	Wye	125	S/P/C		13024	12	ADS-531	B663-2
440	Wye	105	S/P		13024	12	ADS-531	B664-2
480	Wye	150	S		8412	12	ADS-516	B816-2
277/480	Wye	125	P		8412	12	ADS-516	B718-2
480	Wye	125	S/P/C		9719	12	ADS-517	B801-2
480	Wye	105	S		13024	12	ADS-531	B280-2
480	Wye	80	S		14781	12	ADS-532	B601-2
480	Wye	80	P		13024	12	ADS-531	B694-2
480	Wye	105	C		7267	12	ADS-515	B583-2
600	Wye	150	S		8189	7	ADS-516	B817-2

Notes:

[1] Single phase power can be taken from three phase generator sets at up to the value listed in the single phase factor column for the generator set nameplate kW rating at unity power factor.

[2] Standby (S), Prime (P) and Continuous ratings (C).

[3] Factor for the *Single Phase Output from Three Phase Alternator* formula listed below.

[4] Maximum rated starting kVA that results in a minimum of 90% of rated sustained voltage during starting.

Alternator data (continued)

Voltage	Connection[1]	Temp rise degrees C	Duty[2]	Single phase factor[3]	Max surge kVA[4]	Winding No.	Alternator data sheet	Feature Code
347/600	Wye	125	P		8189	7	ADS-516	B720-2
347/600	Wye	80	S		N/A	7	ADS-532	B604-2
600	Wye	80	P		12426	7	ADS-531	B695-2
347/600	Wye	105	C		7233	7	ADS-515	B582-2
347/600	Wye	105	S		12426	7	ADS-531	B839-2
2400/4160	Wye	105	P/C		7295	51	ADS-519	B571-2
13200-13800	Wye	125	P		6800	91	ADS-522	B804-2
13200	Wye	105	C		6800	91	ADS-522	B805-2
13200	Wye	125	S/P		11213	91	ADS-533	B819-2
13200	Wye	105	S		11213	91	ADS-533	B501-2
13200	Wye	80	P		13438	91	ADS-534	B566-2
13200	Wye	80	S		13438	91	ADS-534	B807-2
13200	Wye	80	C		11213	91	ADS-533	B808-2
13800	Wye	125	S		7993	91	ADS-523	B820-2
13800	Wye	105	P		7993	91	ADS-523	B821-2
13800	Wye	105	C		6800	91	ADS-522	B460-2
13800	Wye	80	S		13438	91	ADS-534	B610-2
13800	Wye	80	P		11213	91	ADS-533	B809-2
13800	Wye	80	C		6800	91	ADS-522	B565-2
12470	Wye	125	S		11213	91	ADS-533	B822-2
12470	Wye	105	P		11213	91	ADS-533	B823-2
12470	Wye	105	S		13438	91	ADS-534	B568-2
12470	Wye	80	P		13438	91	ADS-534	B812-2
12470	Wye	105	C		6800	91	ADS-522	B569-2
12470	Wye	80	C		11213	91	ADS-533	B570-2
13800	Wye	105	S		11213	91	ADS-533	B895-2
2400/4160	Wye	105	S		8752	51	ADS-520	B933-2
2400/4160	Wye	80	S		11185	51	ADS-545	B935-2
2400/4160	Wye	150	S/P/C		7295	51	ADS-519	B938-2
2400/4160	Wye	125	S		7295	51	ADS-519	B940-2
600	Wye	80	C		8189	7	ADS-516	B589-2
2400/4160	Wye	80	P		8752	51	ADS-520	B939-2

Notes:

[1] Single phase power can be taken from three phase generator sets at up to the value listed in the single phase factor column for the generator set nameplate kW rating at unity power factor.

[2] Standby (S), Prime (P) and Continuous ratings (C).

[3] Factor for the *Single Phase Output from Three Phase Alternator* formula listed below.

[4] Maximum rated starting kVA that results in a minimum of 90% of rated sustained voltage during starting.

Formulas for calculating full load currents:

Three phase output

$$\frac{\text{kW} \times 1000}{\text{Voltage} \times 1.73 \times 0.8}$$

Single phase output

$$\frac{\text{kW} \times \text{SinglePhaseFactor} \times 1000}{\text{Voltage}}$$

Warning: Back feed to a utility system can cause electrocution and/or property damage. Do not connect to any building's electrical system except through an approved device or after building main switch is open.

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Our energy working for you.™

Cummins Power Generation

D-3518d (5/15)

power.cummins.com

Power Generation

Exhaust Emission Data Sheet 2000DQKAB*

60 Hz Diesel Generator Set

Engine Information:

Model:	Cummins Inc QSK60-G6 NR2	Bore:	6.25 in. (158 mm)
Type:	4 Cycle, 60°V, 16 Cylinder Diesel	Stroke:	7.48 in. (189 mm)
Aspiration:	Turbocharged and Low Temperature Air Aftercooled	Displacement:	3673 cu. In. (60.1 liters)

Compression Ratio: 14.5:1
Emission Control Device: Turbocharged and Low Temperature Aftercooled

PERFORMANCE DATA	1/4 Standby	1/2 Standby	3/4 Standby	Full Standby	Full Prime
BHP @ 1800 RPM (60 Hz)	732	1462	2191	2922	2649
Fuel Consumption (gal/Hr)	46	78	106	141	126
Exhaust Gas Flow (CFM)	6205	9685	12216	15515	13667
Exhaust Gas Temperature (°F)	756	828	882	897	877
EXHAUST EMISSION DATA					
HC (Total Unburned Hydrocarbons)	0.32	0.16	0.09	0.08	0.09
NOx (Oxides of Nitrogen as NO2)	2.87	3.28	4.9	5.3	5.4
CO (carbon Monoxide)	0.94	0.46	0.24	0.32	0.26
PM (Particular Matter)	0.2	0.1	0.03	0.03	0.01
SO2 (Sulfur Dioxide)	0.01	0.01	0.01	0.01	0.004
Smoke (Bosch)	0.64	0.45	0.17	0.17	0.09

All values are Grams per HP-Hour, Smoke is Bosch#

TEST CONDITIONS

Data is representative of steady-state engine speed (± 25 RPM) at designated genset loads. Pressures, temperatures, and emission rates were stabilized.

Fuel Specification:	ASTM D975 No. 2-D diesel fuel with ULSD, and 40-48 cetane number
Fuel Temperature:	99 ± 9 °F (at fuel pump inlet)
Intake Air Temperature:	77 ± 9 °F
Barometric Pressure:	29.6 ± 1 in. Hg
Humidity:	NOx measurement corrected to 75 grains H2O/lb dry air
Reference Standard:	ISO 8178

The NOx, HC, CO and PM emission data tabulated here are representative of test data taken from a single engine under the test conditions shown above. Data for the other components are estimated. These data are subjected to instrumentation and engine-to-engine variability. Field emission test data are not guaranteed to these levels. Actual field test results may vary due to test site conditions, installation, fuel specification, test procedures and instrumentation. Engine operation with excessive air intake or exhaust restriction beyond published maximum limits, or with improper maintenance, may results in elevated emission levels.

Exhaust Emission Data Sheet
2750DQLF
60 Hz Diesel Generator Set
EPA Emission

Engine Information:

Model:	Cummins Inc. QSK78-G12	Bore:	6.69 in. (170 mm)
Type:	4 Cycle, 60°V, 18 Cylinder Diesel	Stroke:	7.48 in. (190 mm)
Aspiration:	Turbocharged and Low Temperature Aftercooled	Displacement:	4735 cu. In. (18.98 liters)
Compression Ratio:	15.5:1		
Emission Control Device:	Turbocharger and Aftercooled.		

PERFORMANCE DATA	1/4 Standby	1/2 Standby	3/4 Standby	Full Standby	Full Prime	Full Continuous
BHP @ 1800 RPM (60 Hz)	1015	2030	3045	4060	3670	3045
Fuel Consumption (gal/Hr)	59.6	107.0	145.5	186.6	169.1	145.5
Exhaust Gas Flow (CFM)	8409	13364	16965	20134	18784	16965
Exhaust Gas Temperature (°F)	762	811	827	879	851	827
EXHAUST EMISSION DATA						
HC (Total Unburned Hydrocarbons)	0.52	0.26	0.18	0.14	0.16	0.18
NOx (Oxides of Nitrogen as NO2)	3.60	3.40	4.40	6.40	5.60	4.60
CO (carbon Monoxide)	0.57	0.27	0.24	0.43	0.30	0.23
PM (Particular Matter)	0.11	0.05	0.05	0.04	0.04	0.05
SO2 (Sulfur Dioxide)	0.13	0.12	0.11	0.10	0.11	0.11
Smoke (Bosch)	0.4	0.3	0.3	0.3	0.3	0.3

All Values are Grams/HP-Hour, Smoke is Bosch #

TEST CONDITIONS

Data is representative of steady-state engine speed (± 36 RPM) at designated genset loads. Pressures, temperatures, and emission rates were stabilized.

Fuel Specification:	ASTM D975 No. 2-D diesel fuel with 0.03-0.05% sulfur content (by weight), and 40-60 cetane number.
Fuel Temperature:	104 ± 9 °F (at fuel pump inlet)
Intake Air Temperature:	77 ± 9 °F
Barometric Pressure:	29.6 ± 1 in. Hg
Humidity:	NOx measurement corrected to 75 grains H2O/lb dry air
Reference Standard:	ISO 8178

The NOx, HC, CO and PM emission data tabulated here are representative of test data taken from a single engine under the test conditions shown above. Data for the other components are estimated. These data are subjected to instrumentation and engine-to-engine variability. Field emission test data are not guaranteed to these levels. Actual field test results may vary due to test site conditions, installation, fuel specification, test procedures and instrumentation. Engine operation with excessive air intake or exhaust restriction beyond published maximum limits, or with improper maintenance, may results in elevated emission levels.

Customer Name: Cummins Northwest

Exhaust Emissions data for Genset Model DQKAE (QSK60-G6 AI @1800 rpm)

	Nominal Emission Levels per Type III report					**"Not to Exceed" Emission Levels per Type III report**				
Load	2922 hp, per 100% of rated genset standby load	2192 hp, per 75% of rated genset standby load	1461 hp, per 50% of rated genset standby load	731 hp, per 25% of rated genset standby load	292 hp, per 10% of rated genset standby load	2922 hp, per 100% of rated genset standby load	2192 hp, per 75% of rated genset standby load	1461 hp, per 50% of rated genset standby load	731 hp, per 25% of rated genset standby load	292 hp, per 10% of rated genset standby load
NOx (g/bhp-hr)	5.3	4.9	3.3	2.9	5.0	6.9	6.4	4.3	3.8	6.5
HC (g/bhp-hr)	0.08	0.09	0.17	0.32	0.80	0.14	0.15	0.29	0.54	1.36
CO (g/bhp-hr)	0.32	0.25	0.47	0.95	3.21	0.64	0.5	0.94	1.9	6.42
PM (g/bhp-hr)	0.03	0.03	0.11	0.21	0.18	0.08	0.08	0.28	0.53	0.45

Test Methods and Conditions

Test Methods:

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

Fuel Specification:

46.5 Cetane Number, 0.035 Wt.% Sulfur; Reference ISO8178-5, 40CFR86 Subpart D Appendix A, table 4; and ASTM D975 No. 2-D.

Reference Conditions for Nominal Emissions Test:

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 H 2 0/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.

Customer Name: Cummins Northwest

Exhaust Emissions data for Genset Model DQLF (QSK78-G12 @1800 rpm)

	Nominal Emission Levels per Type III report					**"Not to Exceed" Emission Levels per Type III report**				
Load	4060 hp, per 100% of rated genset standby load	3045 hp, per 75% of rated genset standby load	2030 hp, per 50% of rated genset standby load	1015 hp, per 25% of rated genset standby load	406 hp, per 10% of rated genset standby load	4060 hp, per 100% of rated genset standby load	3045 hp, per 75% of rated genset standby load	2030 hp, per 50% of rated genset standby load	1015 hp, per 25% of rated genset standby load	1015 hp, per 10% of rated genset standby load
NOx (g/bhp-hr)	6.4	4.4	3.4	3.6	6.4	8.3	5.7	4.4	4.7	8.3
HC (g/bhp-hr)	0.14	0.18	0.26	0.52	0.88	0.24	0.31	0.44	0.88	1.50
CO (g/bhp-hr)	0.43	0.24	0.27	0.57	1.83	0.86	0.48	0.54	1.14	3.66
PM (g/bhp-hr)	0.04	0.05	0.05	0.11	0.27	0.10	0.13	0.13	0.28	0.68

Test Methods and Conditions

Test Methods:

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

Fuel Specification:

46.5 Cetane Number, 0.035 Wt.% Sulfur; Reference ISO8178-5, 40CFR86 Subpart D Appendix A, table 4; and ASTM D975 No. 2-D.

Reference Conditions for Nominal Emissions Test:

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 H 2 0/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.

DIESEL GENERATOR SET
MTU 16V4000 DS2000

2000 kWe / 60 Hz / Standby
380 - 13.8kV

Reference MTU 16V4000 DS2000 (1800 kWe) for Prime Rating Technical Data

SYSTEM RATINGS

Standby

Voltage (L-L)	380V	480V**	600V	4160V	12470V	13200V	13800V
Phase	3	3	3	3	3	3	3
PF	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Hz	60	60	60	60	60	60	60
kW	2000	2000	2000	2000	2000	2000	2000
kVA	2500	2500	2500	2500	2500	2500	2500
Amps	3803	3007	2406	347	116	109	105
skVA@30% Voltage Dip	4300	5800	3600	5100	C/F	C/F	C/F
Generator Model*	744RSL4176	744RSL4054	744RSS4292	744FSM4374	1020FDH5582	1020FDH5582	1020FDH5582
Temp Rise	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C
Connection	4 BAR WYE	4 BAR WYE	4 BAR WYE	4 BAR WYE	4 BAR WYE	4 BAR WYE	4 BAR WYE

* Consult the factory for alternate configuration.
** UL 2200 Offered

CERTIFICATIONS AND STANDARDS

// **Emissions –** EPA Tier 2 Certified

// **Generator set is designed and manufactured in facilities certified to standards ISO 9001:2008 and ISO 14001:2004**

// **Seismic Certification – Optional**
– IBC Certification
– OSHPD Pre-Approval

// **UL 2200 / CSA – Optional**
– UL 2200 Listed
– CSA Certified

// **Performance Assurance Certification (PAC)**
- Generator Set Tested to ISO 8528-5 for Transient Response
- Verified product design, quality and performance integrity
- All engine systems are prototype and factory tested

// **Power Rating**
- Accepts Rated Load in One Step Per NFPA 110
- Permissible average power output during 24 hours of operation is approved up to 85%.

STANDARD FEATURES*

- // MTU Onsite Energy is a single source supplier
- // Global Product Support
- // 2 Year Standard Warranty
- // 16V 4000 Diesel Engine
  - 76.3 Liter Displacement
  - Common Rail Fuel Injection
  - 4-Cycle
- // Complete Range of Accessories
- // Generator
  - Brushless, Rotating Field Generator
  - 2/3 Pitch Windings
  - PMG (Permanent Magnet Generator) supply to regulator
  - 300% Short Circuit Capability
- // Digital Control Panel(s)
  - UL Recognized, CSA Certified, NFPA 110
  - Complete System Metering
  - LCD Display
- // Cooling System
  - Integral Set-Mounted
  - Engine Driven Fan

STANDARD EQUIPMENT*

// Engine

Air Cleaner
Oil Pump
Oil Drain Extension & S/O Valve
Full Flow Oil Filter
Closed Crankcase Ventilation
Jacket Water Pump
Inter Cooler Water Pump
Thermostats
Blower Fan & Fan Drive
Radiator - Unit Mounted
Electric Starting Motor - 24V
Governor – Electronic Isochronous
Base - Structural Steel
SAE Flywheel & Bell Housing
Charging Alternator - 24V
Battery Box & Cables
Flexible Fuel Connectors
Flexible Exhaust Connection
EPA Certified Engine

// Generator

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
Self-Ventilated and Drip-Proof
Superior Voltage Waveform
Digital, Solid State, Volts-per-Hertz Regulator
No Load to Full Load Regulation
Brushless Alternator with Brushless Pilot Exciter
4 Pole, Rotating Field
130 °C Maximum Standby Temperature Rise
1 Bearing, Sealed
Flexible Coupling
Full Amortisseur Windings
125% Rotor Balancing
3-Phase Voltage Sensing
±0.25% Voltage Regulation
100% of Rated Load - One Step
5% Maximum Total Harmonic Distortion

// Digital Control Panel(s)

Digital Metering
Engine Parameters
Generator Protection Functions
Engine Protection
CANBus ECU Communications
Windows®-Based Software
Multilingual Capability
Remote Communications to RDP-110 Remote Annunciator
Programmable Input and Output Contacts
UL Recognized, CSA Certified, CE Approved
Event Recording
IP 54 Front Panel Rating with Integrated Gasket
NFPA 110 Compatible

* Represents standard product only. Consult Factory/MTU Onsite Energy Distributor for additional configurations.

APPLICATION DATA

// Engine

Manufacturer	MTU
Model	16V 4000 G43
Type	4-Cycle
Arrangement	16-V
Displacement: L (in^3)	76.3 (4,656)
Bore: cm (in)	17 (6.69)
Stroke: cm (in)	21 (8.27)
Compression Ratio	16.5:1
Rated RPM	1,800
Engine Governor	Electronic Isochronous (ADEC)
Maximum Power: kWm (bhp)	2,280 (3,058)
Speed Regulation	±0.25%
Air Cleaner	Dry

// Liquid Capacity (Lubrication)

Total Oil System: L (gal)	300 (79.3)
Engine Jacket Water Capacity: L (gal)	175 (46.2)
After Cooler Water Capacity: L (gal)	50 (13.2)
System Coolant Capacity: L (gal)	651 (172)

// Electrical

Electric Volts DC	24
Cold Cranking Amps Under -17.8 °C (0 °F)	2,800

// Fuel System

Fuel Supply Connection Size	#16 JIC 37° Female 1" NPT Adapter Provided
Fuel Return Connection Size	#16 JIC 37° Female 1" NPT Adapter Provided
Maximum Fuel Lift: m (ft)	1 (3)
Recommended Fuel	Diesel #2
Total Fuel Flow: L/hr (gal/hr)	1,200 (317)

// Fuel Consumption

At 100% of Power Rating: L/hr (gal/hr)	558 (147.3)
At 75% of Power Rating: L/hr (gal/hr)	426 (112.6)
At 50% of Power Rating: L/hr (gal/hr)	299 (78.9)

// Cooling - Radiator System

Ambient Capacity of Radiator: °C (°F)	40 (104)
Maximum Restriction of Cooling Air, Intake, and Discharge Side of Rad.: kPa (in. H_20)	0.25 (1)
Water Pump Capacity: L/min (gpm)	1,350 (357)
After Cooler Pump Capacity: L/min (gpm)	583 (154)
Heat Rejection to Coolant: kW (BTUM)	840 (47,770)
Heat Rejection to After Cooler: kW (BTUM)	610 (34,690)
Heat Radiated to Ambient: kW (BTUM)	184 (10,478)
Fan Power: kW (hp)	99.4 (133.2)

// Air Requirements

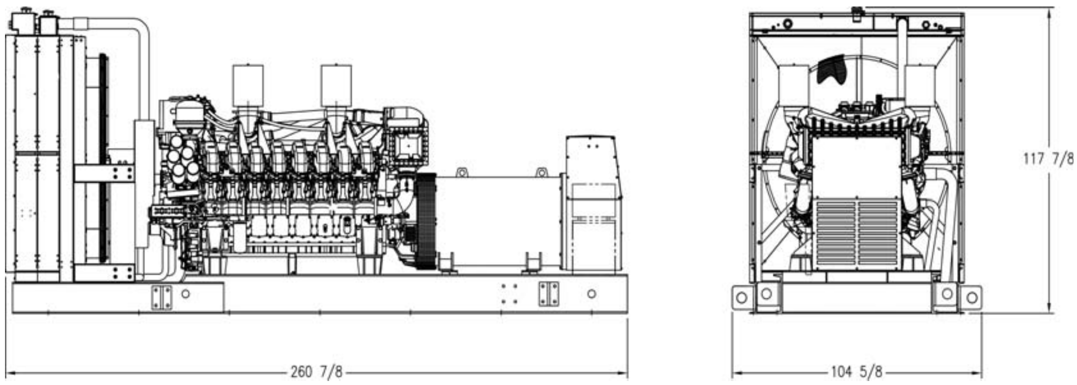
Aspirating: *m^3/min (SCFM)	186 (6,569)
Air Flow Required for Rad. Cooled Unit: *m^3/min (SCFM)	2,072 (73,173)
Remote Cooled Applications; Air Flow Required for Dissipation of Radiated Gen-set Heat for a Max of 25 °F Rise: *m^3/min (SCFM)	673 (23,631)

* Air density = 1.184 kg/m^3 (0.0739 lbm/ft^3)

// Exhaust System

Gas Temp. (Stack): °C (°F)	480 (896)
Gas Volume at Stack Temp: m^3/min (CFM)	456 (16,103)
Maximum Allowable Back Pressure: kPa (in. H_20)	8.5 (34.1)

WEIGHTS AND DIMENSIONS



Drawing above for illustration purposes only, based on standard open power 480 volt generator set. Lengths may vary with other voltages. Do not use for installation design. See website for unit specific template drawings.

System	Dimensions (L x W x H)	Weight (less tank)
Open Power Unit (OPU)	6,626 x 2,657 x 2,994 mm (260.9 x 104.6 x 117.9 in)	16,477 kg (36,326 lb)

Weights and dimensions are based on open power units and are estimates only. Consult the factory for accurate weights and dimensions for your specific generator set.

SOUND DATA

Unit Type	Standby Full Load
Level 0: Open Power Unit dB(A)	94.8

Sound data is provided at 7 m (23 ft). Generator set tested in accordance with ISO 8528-10 and with infinite exhaust.

EMISSIONS DATA

NO_x + NMHC	CO	PM
5.38	0.45	0.04

All units are in g/hp-hr and shown at 100% load (not comparable to EPA weighted cycle values). Emission levels of the engine may vary with ambient temperature, barometric pressure, humidity, fuel type and quality, installation parameters, measuring instrumentation, etc. The data was obtained in compliance with US EPA regulations. The weighted cycle value (not shown) from each engine is guaranteed to be within the US EPA Standards.

RATING DEFINITIONS AND CONDITIONS

// Standby ratings apply to installations served by a reliable utility source. The standby rating is applicable to varying loads for the duration of a power outage. No overload capability for this rating. Ratings are in accordance with ISO 8528-1, ISO 3046-1, BS 5514, and AS 2789. Average load factor: ≤ 85%.

// Deration Factor:
Altitude: Consult your local MTU Onsite Energy Power Generation Distributor for altitude derations.
Temperature: Consult your local MTU Onsite Energy Power Generation Distributor for temperature derations.

C/F = Consult Factory/MTU Onsite Energy Distributor
N/A = Not Available

DIESEL GENERATOR SET
MTU 20V4000 DS2800

2800 kWe / 60 Hz / Standby
380 - 13.8kV

Reference MTU 20V4000 DS2800 (2500 kWe) for Prime Rating Technical Data

SYSTEM RATINGS

Standby

Voltage (L-L)	380V	480V**	600V	4160V	12470V	13200V	13800V
Phase	3	3	3	3	3	3	3
PF	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Hz	60	60	60	60	60	60	60
kW	2800	2800	2800	2800	2800	2800	2800
kVA	3500	3500	3500	3500	3500	3500	3500
Amps	5324	4210	3368	486	162	153	146
skVA@30% Voltage Dip	4000	5400	5875	5250	5125	4875	6000
Generator Model*	1030FDL1110	1020FDL1106	1020FDS1124	1020FDM1182	1030FDH1254	1030FDH1252	1030FDH1254
Temp Rise	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C
Connection	6 LEAD WYE	6 LEAD WYE	6 LEAD WYE	6 LEAD WYE	6 LEAD WYE	6 LEAD WYE	6 LEAD WYE

* Consult the factory for alternate configuration.
** UL 2200 Offered

CERTIFICATIONS AND STANDARDS

// **Emissions –** EPA Tier 2 Certified

// **Generator set is designed and manufactured in facilities certified to standards ISO 9001:2008 and ISO 14001:2004**

// **UL 2200 Listed – Optional**

// **Performance Assurance Certification (PAC)**
- Generator Set Tested to ISO 8528-5 for Transient Response
- Verified product design, quality and performance integrity
- All engine systems are prototype and factory tested

// **Power Rating**
- Accepts Rated Load in One Step Per NFPA 110
- Permissible average power output during 24 hours of operation is approved up to 85%.

STANDARD FEATURES*

- // MTU Onsite Energy is a single source supplier
- // Global Product Support
- // 2 Year Standard Warranty
- // 20V 4000 Diesel Engine
  - 95.4 Liter Displacement
  - Common Rail Fuel Injection
  - 4-Cycle
- // Complete Range of Accessories
- // Generator
  - Brushless, Rotating Field Generator
  - 2/3 Pitch Windings
  - PMG (Permanent Magnet Generator) supply to regulator
  - 300% Short Circuit Capability
- // Digital Control Panel(s)
  - UL Recognized, CSA Certified, NFPA 110
  - Complete System Metering
  - LCD Display
- // Cooling System
  - Integral Set-Mounted
  - Engine Driven Fan

STANDARD EQUIPMENT*

// Engine

Air Cleaners
Oil Pump
Oil Drain Extension & S/O Valve
Full Flow Oil Filter
Closed Crankcase Ventilation
Jacket Water Pump
Inter Cooler Water Pump
Thermostats
Blower Fan & Fan Drive
Radiator - Unit Mounted
Electric Starting Motor - 24V
Governor – Electronic Isochronous
Base - Structural Steel
SAE Flywheel & Bell Housing
Charging Alternator - 24V
Battery Box & Cables
Flexible Fuel Connectors
Flexible Exhaust Connection
EPA Certified Engine

// Generator

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
Self-Ventilated and Drip-Proof
Superior Voltage Waveform
Digital, Solid State, Volts-per-Hertz Regulator
No Load to Full Load Regulation
Brushless Alternator with Brushless Pilot Exciter
4 Pole, Rotating Field
130 °C Maximum Standby Temperature Rise
2 Bearing, Sealed
Flexible Coupling
Full Amortisseur Windings
125% Rotor Balancing
3-Phase Voltage Sensing
±0.25% Voltage Regulation
100% of Rated Load - One Step
5% Maximum Total Harmonic Distortion

// Digital Control Panel(s)

Digital Metering
Engine Parameters
Generator Protection Functions
Engine Protection
CANBus ECU Communications
Windows®-Based Software
Multilingual Capability
Remote Communications to RDP-110 Remote Annunciator
Programmable Input and Output Contacts
UL Recognized, CSA Certified, CE Approved
Event Recording
IP 54 Front Panel Rating with Integrated Gasket
NFPA 110 Compatible

* Represents standard product only. Consult Factory/MTU Onsite Energy Distributor for additional configurations.

APPLICATION DATA

// Engine

Manufacturer	MTU
Model	20V 4000 G83 6 ECT
Type	4-Cycle
Arrangement	20-V
Displacement: L (in^3)	95.4 (5,822)
Bore: cm (in)	17 (6.69)
Stroke: cm (in)	21 (8.27)
Compression Ratio	16.4:1
Rated RPM	1,800
Engine Governor	Electronic Isochronous (ADEC)
Maximum Power: kWm (bhp)	3,010 (4,035)
Speed Regulation	±0.25%
Air Cleaner	Dry

// Liquid Capacity (Lubrication)

Total Oil System: L (gal)	390 (103)
Engine Jacket Water Capacity: L (gal)	205 (54.2)
After Cooler Water Capacity: L (gal)	30 (7.9)
System Coolant Capacity: L (gal)	860 (227)

// Electrical

Electric Volts DC	24
Cold Cranking Amps Under -17.8 °C (0 °F)	4,200

// Fuel System

Fuel Supply Connection Size	#16 JIC 37° Female 1" NPT Adapter Provided
Fuel Return Connection Size	#16 JIC 37° Female 1" NPT Adapter Provided
Maximum Fuel Lift: m (ft)	1 (3)
Recommended Fuel	Diesel #2
Total Fuel Flow: L/hr (gal/hr)	1,620 (428)

// Fuel Consumption

At 100% of Power Rating: L/hr (gal/hr)	704 (186)
At 75% of Power Rating: L/hr (gal/hr)	553 (146)
At 50% of Power Rating: L/hr (gal/hr)	394 (104)

// Cooling - Radiator System

Ambient Capacity of Radiator: °C (°F)	48 (118)
Maximum Allowable Static Pressure on Rad. Exhaust: kPa (in. H_20)	0.12 (0.5)
Water Pump Capacity: L/min (gpm)	1,567 (414)
After Cooler Pump Capacity: L/min (gpm)	567 (150)
Heat Rejection to Coolant: kW (BTUM)	1,040 (59,143)
Heat Rejection to After Cooler: kW (BTUM)	740 (42,083)
Heat Radiated to Ambient: kW (BTUM)	237 (13,475)
Fan Power: kW (hp)	60.6 (81.3)

// Air Requirements

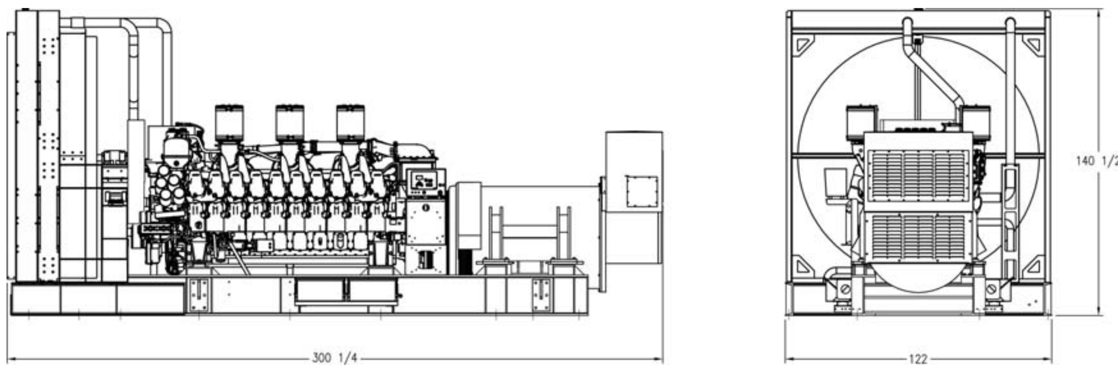
Aspirating: *m^3/min (SCFM)	240 (8,476)
Air Flow Required for Rad. Cooled Unit: *m^3/min (SCFM)	3,082 (108,843)
Remote Cooled Applications; Air Flow Required for Dissipation of Radiated Gen-set Heat for a Max of 25 °F Rise: *m^3/min (SCFM)	843 (29,603)

* Air density = 1.184 kg/m^3 (0.0739 lbm/ft^3)

// Exhaust System

Gas Temp. (Stack): °C (°F)	470 (878)
Gas Volume at Stack Temp: m^3/min (CFM)	594 (20,977)
Maximum Allowable Back Pressure: kPa (in. H_20)	8.5 (34.1)

WEIGHTS AND DIMENSIONS



Drawing above for illustration purposes only, based on standard open power 480 volt generator set. Lengths may vary with other voltages. Do not use for installation design. See website for unit specific template drawings.

System	Dimensions (L x W x H)	Weight (less tank)
Open Power Unit (OPU)	7,626 x 3,099 x 3,569 mm (300.3 x 122 x 140.5 in)	28,149 kg (62,056 lb)

Weights and dimensions are based on open power units and are estimates only. Consult the factory for accurate weights and dimensions for your specific generator set.

SOUND DATA

Unit Type	Standby Full Load
Level 0: Open Power Unit dB(A)	97.5

Sound data is provided at 7 m (23 ft). Generator set tested in accordance with ISO 8528-10 and with infinite exhaust.

EMISSIONS DATA

NO_x + NMHC	CO	PM
5.95	0.37	0.04

All units are in g/hp-hr and shown at 100% load (not comparable to EPA weighted cycle values). Emission levels of the engine may vary with ambient temperature, barometric pressure, humidity, fuel type and quality, installation parameters, measuring instrumentation, etc. The data was obtained in compliance with US EPA regulations. The weighted cycle value (not shown) from each engine is guaranteed to be within the US EPA Standards.

RATING DEFINITIONS AND CONDITIONS

// Standby ratings apply to installations served by a reliable utility source. The standby rating is applicable to varying loads for the duration of a power outage. No overload capability for this rating. Ratings are in accordance with ISO 8528-1, ISO 3046-1, BS 5514, and AS 2789. Average load factor: ≤ 85%.

// Deration Factor:
Altitude: Consult your local MTU Onsite Energy Power Generation Distributor for altitude derations.
Temperature: Consult your local MTU Onsite Energy Power Generation Distributor for temperature derations.

C/F = Consult Factory/MTU Onsite Energy Distributor
N/A = Not Available

Inhaltsverzeichnis
Contents

	Genset	Marine	O & G	Rail	C & I
Application	x				
Engine model	16V4000G43				
Emission Stage	EPA2 (EPA2 parameter-setting/D2-Cycle)				
Optimisation					
Application group	3D				

Buchstabe/ Revision	Änderung Modifikation	Datum Date	Name Name		Datum/Date	Name/Name
b	Anfrage NOX/SO2 in ppm und 4% O2	11.04.14	Lenhof			
a	Hinzufügen „Not to exceed Werte“	21.01.14	Lenhof	Bearbeiter/Drawn by	11.01.2012	Lenhof
-	Freigabe	08.02.12	Link	Geprüft/Checked	08.02.2012	Rehm
				Org.-Einheit/Dept.	TKF	Veser

MTU Friedrichshafen GmbH

Benennung/Title

Emissionsdatenblatt
Emission Data Sheet

Zeichnungs-Nr./Drawing No.

EDS 4000 0406

Vers.2.0

Revision *Change index*					

Emissions Daten Blatt (EDS)

emission Data Sheet (EDS)

	Genset	Marine	O & G	Rail	C & I
Application	x				
Engine model	16V4000G43				
Emission Stage	EPA2 (EPA2 parameter-setting/D2-Cycle)				
Optimisation					
Application group	3D				
Date	11.01.2012				
fuel sulphur content [ppm]	5				
mg/mN³ values base on residual oxygen value of [%]	measured				

Engine raw emissions*

Cycle point	[-]	n1	n2	n3	n4	n5	n6	n7	n8
Power (P/PN)	[-]	1	0,75	0,50	0,25	0,10			
Power	[kW]	2280	1710	1140	570	228			
Speed (n/nN)	[-]	1	1	1	1	1			
Speed	[rpm]	1800	1800	1800	1800	1800			
Exhaust temperature after turbine	[°C]	443	386	352	310	277			
Exhaust massflow	[kg/h]	16298	12846	10492	7544	6056			
Exhaust back pressure	[mbar]	-	-	-	-	-			
NOx	[g/kWh]	7,1	5,6	4,5	4,6	6,8			
	[mg/mN³]	1540	1145	755	531	382			
CO	[g/kWh]	0,6	0,6	0,9	2,0	4,5			
	[mg/mN³]	106	105	134	202	225			
HC	[g/kWh]	0,11	0,15	0,23	0,47	0,55			
	[mg/mN³]	22	28	34	48	28			
O2	[%]	12,0	12,1	13,4	14,8	16,2			
Particulate measured	[g/kWh]	0,06	0,10	0,18	0,34	0,68			
	[mg/mN³]	10,54	18,09	26,06	35,24	34,36			
Particulate calculated	[g/kWh]	-	-	-	-	-			
	[mg/mN³]	-	-	-	-	-			
Dust (only TA-Luft)	[mg/mN³]	-	-	-	-	-			
FSN	[-]	0,5	0,6	1,0	1,1	1,4			
NO/NO2**	[-]	-	-	-	-	-			
CO2	[g/kWh]	648,2	663,6	699,8	822,0	1267,5			
	[mg/mN³]	125002	121600	103865	84099	64006			
SO2	[g/kWh]	0,002	0,002	0,002	0,003	0,004			
	[mg/mN³]	0,4	0,4	0,3	0,3	0,2			

* Emission data measurement procedures are consistent with the respective emission evaluation process. Noncertified engines are measured to sales data (TVU/TEN) standard conditions.
These boundary conditions might not be representative for detailed dimensioning of exhaust gas aftertreatment, in this case it is recommended to contact the responsible department for more information.
Measurements are subject to variation. The nominal emission data shown is subject to instrumentation, measurement, facility, and engine-to-engine variations.
All data applies to an engine in new condition. Over extended operating time deterioration may occur which might have an impact on emission.
Exhaust temperature depends on engine ambient conditions.

** No standard test. To be measured on demand.

				MTU Friedrichshafen GmbH			Benennung/Title: **Emissionsdatenblatt Emission Data Sheet**
b	Anfrage NOX/SO2 in ppm und 4% O2	11.04.14	Lenhof		Datum/Date	Name/Name	Zeichnungs-Nr./Drawing No.
a	Hinzufügen „Not to exceed Werte“	21.01.14	Lenhof	Bearbeiter/Drawn by	11.01.2012	Lenhof	**EDS 4000 0406**
-	Freigabe	08.02.12	Link	Geprüft/Checked	08.02.2012	Rehm	
Buchstabe/ Revision	Änderung Modifikation	Datum Date	Name Name	Org.-Einheit/Dept.	TKF	Veser	

Vers.2.0

Revision *Change index*	a				

Not to exceed Werte
not to exceed values

	Genset	Marine	O & G	Rail	C & I
Application	x				
Engine model	16V4000G43				
Emission Stage	EPA2 (EPA2 parameter-setting/D2-Cycle)				
Optimisation					
Application group	3D				
Date	21.01.2014				
fuel sulphur content [ppm]	5				
mg/mN³ values base on residual oxygen value of [%]	measured				

Engine raw emissions - Not to exceed

Cycle point	[-]	n1	n2	n3	n4	n5	n6	n7	n8
Power (P/PN)	[-]	1	0,75	0,50	0,25	0,10			
Power	[kW]	2280	1710	1140	570	228			
Speed (n/nN)	[-]	1	1	1	1	1			
Speed	[rpm]	1800	1800	1800	1800	1800			
NOx	[g/kWh]	8,5	6,7	5,5	5,6	8,1			
	[mg/mN³]	1848	1374	907	638	459			
NO2**	[g/kWh]	1,0	0,8	0,6	0,7	0,9			
	[mg/mN³]	216	160	106	74	54			
CO	[g/kWh]	1,0	1,0	1,6	3,6	8,0			
	[mg/mN³]	191	189	242	364	405			
HC	[g/kWh]	0,17	0,23	0,34	0,71	0,83			
	[mg/mN³]	33	42	51	73	42			
O2	[%]	12,0	12,1	13,4	14,8	16,2			
Particulate measured	[g/kWh]	0,08	0,14	0,25	0,48	0,95			
	[mg/mN³]	15	25	36	49	48			

GASEOUS EMISSIONS DATA MEASUREMENTS ARE CONSISTENT WITH THOSE DESCRIBED IN EPA 40 CFR PART 60 SUBPART IIII AND ISO 8178 FOR MEASURING HC, CO, PM, AND NOX.

Locality	Agency	Regulation	Tier/Stage	Max Limits - G/(KW – HR)
U.S. (INCL CALIF)	EPA	STATIONARY	EMERGENCY STATIONARY	NOx + HC: 6.4 CO: 3.5 PM: 0.20

** No standard test. To be measured on demand.

				MTU Friedrichshafen GmbH			Benennung/Title: **Emissionsdatenblatt Emission Data Sheet**
b	Anfrage NOX/SO2 in ppm und 4% O2	11.04.14	Lenhof		Datum/Date	Name/Name	Zeichnungs-Nr./Drawing No.
a	Hinzufügen „Not to exceed Werte“	21.01.14	Lenhof	Bearbeiter/Drawn by	11.01.2012	Lenhof	
-	Freigabe	08.02.12	Link	Geprüft/Checked	08.02.2012	Rehm	**EDS 4000 0406**
Buchstabe/ Revision	Änderung Modifikation	Datum Date	Name Name	Org.-Einheit/Dept.	TKF	Veser	

Vers.2.0

Revision *Change index*	b				

Engine data

	Genset	Marine	O & G	Rail	C & I
Application	x				
Engine model	16V4000G43				
Emission Stage	EPA2				
Optimisation					
Application group	3D				
Date	10.04.2014				
fuel sulphur content [ppm]	15				
mg/mN³ values base on residual oxygen value of [%]	measured				

Engine raw emissions*

Cycle point	[-]	n1	n2	n3	n4	n5	n6	n7	n8
Power (P/PN)	[-]	1	0,75	0,50	0,25	0,10			
Power	[kW]	2280	1710	1140	570	228			
Speed (n/nN)	[-]	1	1	1	1	1			
Speed	[rpm]	1800	1800	1800	1800	1800			
NOx	[ppmv @ 4% O2]	1326	1005	779	678	638			
SO2	[g/kWh]	0,006	0,006	0,007	0,008	0,012			
	[mg/mN³]	1,2	1,2	1,0	0,8	0,6			
	[ppmv @ 4% O2]	0,9	0,9	0,8	0,6	0,5			

* Emission data measurement procedures are consistent with the respective emission evaluation process. Noncertified engines are measured to sales data (TVU/TEN) standard conditions.
These boundary conditions might not be representative for detailed dimensioning of exhaust gas aftertreatment, in this case it is recommended to contact the responsible department for more information.
Measurements are subject to variation. The nominal emission data shown is subject to instrumentation, measurement, facility, and engine-to-engine variations.
All data applies to an engine in new condition. Over extended operating time deterioration may occur which might have an impact on emission.
Exhaust temperature depends on engine ambient conditions.

** No standard test. To be measured on demand.

				MTU Friedrichshafen GmbH			Benennung/Title: **Emissionsdatenblatt Emission Data Sheet**
b	Anfrage NOX/SO2 in ppm und 4% O2	11.04.14	Lenhof		Datum/Date	Name/Name	Zeichnungs-Nr./Drawing No.
a	Hinzufügen „Not to exceed Werte“	21.01.14	Lenhof	Bearbeiter/Drawn by	11.01.2012	Lenhof	
-	Freigabe	08.02.12	Link	Geprüft/Checked	08.02.2012	Rehm	**EDS 4000 0406**
Buchstabe/ Revision	Änderung Modifikation	Datum Date	Name Name	Org.-Einheit/Dept.	TKF	Veser	

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	Genset	Marine	O & G	Rail	C & I
Application	x				
Engine model	20V4000G83 - 6ETC				
Emission Stage	EPA2 (EPA2 parameter-setting/D2-Cycle)				
Optimisation					
Application group	3D				

				MTU Friedrichshafen GmbH			Benennung/Title **Emissionsdatenblatt** **Emission Data Sheet**
					Datum/Date	Name/Name	Zeichnungs-Nr./Drawing No.
a	Hinzufügen „Not to exceed" Werte	21.01.14	Lenhof	Bearbeiter/Drawn by	09.05.2012	Lenhof	
-	Freigabe	06.06.12	Zwisler	Geprüft/Checked	04.06.2012	Rehm	**EDS 4000 0469**
Buchstabe/ Revision	Änderung Modifikation	Datum Date	Name Name	Org.-Einheit/Dept.	TKF	Veser	

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Revision *Change index*					

Emissions Daten Blatt (EDS)

emission Data Sheet (EDS)

	Genset	Marine	O & G	Rail	C & I
Application	x				
Engine model	20V4000G83 - 6ETC				
Emission Stage	EPA2 (EPA2 parameter-setting/D2-Cycle)				
Optimisation					
Application group	3D				
Date	09.05.2012				
fuel sulphur content [ppm]	5				
mg/mN³ values base on residual oxygen value of [%]	measured				

Engine raw emissions*

Cycle point	[-]	n1	n2	n3	n4	n5	n6	n7	n8
Power (P/PN)	[-]	1	0,75	0,50	0,25	0,10			
Power	[kW]	3010	2257	1505	752	301			
Speed (n/nN)	[-]	1	1	1	1	1			
Speed	[rpm]	1800	1800	1800	1800	1800			
Exhaust temperature after turbine	[°C]	446	417	385	337	303			
Exhaust massflow	[kg/h]	17802	16060	12748	8668	6643			
Exhaust back pressure	[mbar]	68	51	30	12	6			
NOx	[g/kWh]	7,8	5,4	4,5	4,4	7,0			
	[mg/mN³]	2052	1168	809	583	479			
CO	[g/kWh]	0,5	0,7	1,0	2,4	3,9			
	[mg/mN³]	124	140	167	287	237			
HC	[g/kWh]	0,18	0,24	0,29	0,52	0,73			
	[mg/mN³]	43	47	47	62	45			
O2	[%]	10,2	11,6	12,6	14,0	15,4			
Particulate measured	[g/kWh]	0,06	0,08	0,18	0,29	0,58			
	[mg/mN³]	12,88	14,93	28,73	33,99	35,33			
Particulate calculated	[g/kWh]	-	-	-	-	-			
	[mg/mN³]	-	-	-	-	-			
Dust (only TA-Luft)	[mg/mN³]	-	-	-	-	-			
FSN	[-]	0,3	0,5	0,9	0,9	0,9			
NO/NO2**	[-]	-	-	-	-	-			
CO2	[g/kWh]	624,9	660,0	699,3	800,9	1218,6			
	[mg/mN³]	147188	128154	113289	94609	74422			
SO2	[g/kWh]	0,002	0,002	0,002	0,003	0,004			
	[mg/mN³]	0,5	0,4	0,4	0,3	0,2			

* Emission data measurement procedures are consistent with the respective emission evaluation process. Noncertified engines are measured to sales data (TVU/TEN) standard conditions.
These boundary conditions might not be representative for detailed dimensioning of exhaust gas aftertreatment, in this case it is recommended to contact the responsible department for more information.
Measurements are subject to variation. The nominal emission data shown is subject to instrumentation, measurement, facility, and engine-to-engine variations.
All data applies to an engine in new condition. Over extended operating time deterioration may occur which might have an impact on emission.
Exhaust temperature depends on engine ambient conditions.

** No standard test. To be measured on demand.

				MTU Friedrichshafen GmbH			Benennung/Title **Emissionsdatenblatt Emission Data Sheet**
					Datum/Date	Name/Name	Zeichnungs-Nr./Drawing No.
a	Hinzufügen „Not to exceed“ Werte	21.01.14	Lenhof	Bearbeiter/Drawn by	09.05.2012	Lenhof	
-	Freigabe	06.06.12	Zwisler	Geprüft/Checked	04.06.2012	Rehm	**EDS 4000 0469**
Buchstabe/ Revision	Änderung Modifikation	Datum Date	Name Name	Org.-Einheit/Dept.	TKF	Veser	

Vers.2.0

Revision *Change index*	a				

Not to exceed Werte
not to exceed values

	Genset	Marine	O & G	Rail	C & I
Application	x				
Engine model	20V4000G83 - 6ETC				
Emission Stage	EPA2 (EPA2 parameter-setting/D2-Cycle)				
Optimisation					
Application group	3D				
Date	21.01.2014				
fuel sulphur content [ppm]	5				
mg/mN³ values base on residual oxygen value of [%]	measured				

Engine raw emissions - Not to exceed

Cycle point	[-]	n1	n2	n3	n4	n5	n6	n7	n8
Power (P/PN)	[-]	1	0,75	0,50	0,25	0,10			
Power	[kW]	3010	2257	1505	752	301			
Speed (n/nN)	[-]	1	1	1	1	1			
Speed	[rpm]	1800	1800	1800	1800	1800			
NOx	[g/kWh]	9,4	6,5	5,4	5,3	8,4			
	[mg/mN³]	2463	1402	971	699	575			
NO2**	[g/kWh]	1,1	0,8	0,6	0,6	1,0			
	[mg/mN³]	287	164	113	82	67			
CO	[g/kWh]	0,9	1,3	1,9	4,4	7,0			
	[mg/mN³]	222	252	300	516	427			
HC	[g/kWh]	0,28	0,36	0,44	0,79	1,10			
	[mg/mN³]	65	70	71	93	67			
O2	[%]	10,2	11,6	12,6	14,0	15,4			
Particulate measured	[g/kWh]	0,08	0,11	0,25	0,40	0,81			
	[mg/mN³]	18	21	40	48	49			

GASEOUS EMISSIONS DATA MEASUREMENTS ARE CONSISTENT WITH THOSE DESCRIBED IN EPA 40 CFR PART 60 SUBPART IIII AND ISO 8178 FOR MEASURING HC, CO, PM, AND NOX.

Locality	Agency	Regulation	Tier/Stage	Max Limits - G/(KW – HR)
U.S. (INCL CALIF)	EPA	STATIONARY	EMERGENCY STATIONARY	NOx + HC: 6.4 CO: 3.5 PM: 0.20

** No standard test. To be measured on demand.

				MTU Friedrichshafen GmbH			Benennung/Title: **Emissionsdatenblatt Emission Data Sheet**
					Datum/Date	Name/Name	Zeichnungs-Nr./Drawing No.
a	Hinzufügen „Not to exceed“ Werte	21.01.14	Lenhof	Bearbeiter/Drawn by	09.05.2012	Lenhof	
-	Freigabe	06.06.12	Zwisler	Geprüft/Checked	04.06.2012	Rehm	**EDS 4000 0469**
Buchstabe/ Revision	Änderung Modifikation	Datum Date	Name Name	Org.-Einheit/Dept.	TKF	Veser	

Vers.2.0

3516C Generator Set

Electric Power

Caterpillar is leading the power generation marketplace with Power Solutions engineered to deliver unmatched flexibility, expandability, reliability, and cost-effectiveness.

Specifications

Generator Set Specifications	
Minimum Rating	1650 ekW
Maximum Rating	2500 ekW
Voltage	220 to 13800 volts
Frequency	60 Hz
Speed	1800 RPM

Generator Set Configurations	
Emissions/Fuel Strategy	EPA Certified for Stationary Emergency Application (Emits Equivalent U.S. EPA Tier 2 Nonroad Standards)

Engine Specifications	
Engine Model	3516C, ATAAC, V-16,4-Stroke Water-Cooled Diesel
Bore	170 mm (6.69 in)
Stroke (Std)	190 mm (7.48 in)
Stroke (HD)	215 mm (8.46 in)
Compression Ratio	14.7:1
Aspiration	TA
Governor Type	Adem™3
Fuel System	Electronic unit injection
Exhaust Flange Size (Internal Diameter)	203.2 mm (8.0 in)

Benefits And Features

Cat™ Diesel Engine

- Reliable, rugged, durable design
- Field-proven in thousands of applications worldwide
- Four-stroke-cycle diesel engine combines consistent performance and excellent fuel economy with minimum weight

Generator

- Matched to the performance and output characteristics of Cat engines
- Industry leading mechanical and electrical design
- Industry leading motor starting capabilities
- High Efficiency

Cat EMCP Control Panel

The EMCP controller features the reliability and durability you have come to expect from your Cat equipment. EMCP4 is a scalable control platform designed to ensure reliable generator set operation, providing extensive information about power output and engine operation. EMCP4 systems can be further customized to meet your needs through programming and expansion modules.

Seismic Certification

- Seismic Certification available.
- Anchoring details are site specific, and are dependent on many factors such as generator set size, weight, and concrete strength. IBC Certification requires that the anchoring system used is reviewed and approved by a Professional Engineer
- Seismic Certification per Applicable Building Codes: IBC 2000, IBC 2003, IBC 2006, IBC 2009, CBC 2007, CBC 2010
- Pre-approved by OSHPD and carries an OSP-0321-10 for use in healthcare projects in California

Design Criteria

The generator set accepts 100% rated load in one step per NFPA 110 and meets ISO 8528-5 transient response.

UL 2200 / CSA - Optional

- UL 2200 listed packages
- CSA Certified
- Certain restrictions may apply.
- Consult with your Cat® Dealer.

Single-Source Supplier

Fully prototype tested with certified torsional vibration analysis available

World Wide Product Support

Cat Dealers provide extensive post sale support including maintenance and repair agreements. Cat dealers have over 1,800 dealer branch stores operating in 200 countries. The Cat® S•O•SSM program cost effectively detects internal engine component condition, even the presence of unwanted fluids and combustion by-products.

Standard Equipment

Air Inlet

- Air Cleaner

Cooling

- Package mounted radiator

Exhaust

- Exhaust flange outlet

Fuel

- Primary fuel filter with integral water separator
- Secondary fuel filter
- Fuel priming pump

Generator

- Matched to the performance and output characteristics of Cat engines
- IP23 Protection

Power Termination

- Bus Bar

Control Panel

- EMCP 4 Genset Controller

General

- Paint - Caterpillar Yellow except rails and radiators gloss black

Optional Equipment

Exhaust

- Exhaust mufflers

Generator

- Anti-condensation heater
- Internal excitation (IE)
- Permanent magnet excitation (PMG)
- Oversize and premium generators

Power Termination

- Circuit breakers, UL listed
- Circuit breakers, IEC compliant

Control Panels

- EMCP 4.2
- EMCP 4.3
- EMCP 4.4
- Generator temperature monitoring & protection
- Load share module
- Digital I/O module
- Remote monitoring software

Mounting

- Rubber anti-vibration mounts
- Spring-type vibration isolator
- IBC isolators

Starting/Charging

- Battery chargers
- Oversize batteries
- Jacket water heater
- Heavy-duty starting system
- Charging alternator
- Air starting motor with control and silencer

General

- The following options are based on regional and product configuration:
- Seismic Certification per applicable building codes: IBC 2000, IBC 2003, IBC 2006, IBC 2009, CBC 2007
- UL 2200 package
- EU Certificate of Conformance (CE)
- CSA Certification
- EEC Declaration of Conformity
- Enclosures: sound attenuated, weather protective
- Automatic transfer switches (ATS)
- Integral & sub-base fuel tanks
- Integral & sub-base UL listed dual wall fuel tanks

ELECTRIC POWER - Technical Spec Sheet
STANDARD

3516C
2000 ekW/ 2500 kVA/ 60 Hz/ 1800 rpm/ 480 V/ 0.8 Power Factor

Rating Type: MISSION CRITICAL STANDBY

Emissions: EPA Certified for Stationary Emergency Application (Emits Equivalent U.S. EPA Tier 2 Nonroad Standards)

3516C

2000 ekW/ 2500 kVA
60 Hz/ 1800 rpm/ 480 V

Image shown may not reflect actual configuration

	Metric	English
Package Performance		
Genset Power Rating with Fan @ 0.8 Power Factor	2000 ekW	
Genset Power Rating	2500 kVA	
Aftercooler (Separate Circuit)	N/A	N/A
Fuel Consumption		
100% Load with Fan	522.5 L/hr	138.0 gal/hr
75% Load with Fan	406.8 L/hr	107.5 gal/hr
50% Load with Fan	293.6 L/hr	77.5 gal/hr
25% Load with Fan	169.7 L/hr	44.8 gal/hr
Cooling System[1]		
Engine Coolant Capacity	233.0 L	61.6 gal
Inlet Air		
Combustion Air Inlet Flow Rate	185.5 m³/min	6548.9 cfm
Max. Allowable Combustion Air Inlet Temp...	N/A	N/A
Exhaust System		
Exhaust Stack Gas Temperature	400.1 ° C	752.1 ° F
Exhaust Gas Flow Rate	433.1 m³/min	15292.8 cfm
Exhaust System Backpressure (Maximum Allowable)	6.7 kPa	27.0 in. water

3516C
2000 ekW/ 2500 kVA/ 60 Hz/ 1800 rpm/ 480 V/ 0.8 Power Factor

Rating Type: MISSION CRITICAL STANDBY

Emissions: EPA Certified for Stationary Emergency Application (Emits Equivalent U.S. EPA Tier 2 Nonroad Standards)

Heat Rejection		
Heat Rejection to Jacket Water	759 kW	43150 Btu/min
Heat Rejection to Exhaust (Total)	1788 kW	101696 Btu/min
Heat Rejection to Aftercooler	672 kW	38240 Btu/min
Heat Rejection to Atmosphere from Engine	133 kW	7564 Btu/min
Heat Rejection to Atmosphere from Generator	108 kW	6113 Btu/min

Alternator[2]	
Motor Starting Capability @ 30% Voltage Dip	4647 skVA
Current	3007 amps
Frame Size	825
Excitation	PM
Temperature Rise	130 ° C

Emissions (Nominal)[3]		
NOx	2749.5 mg/Nm³	5.5 g/hp-hr
CO	142.8 mg/Nm³	0.3 g/hp-hr
HC	45.2 mg/Nm³	0.1 g/hp-hr
PM	10.3 mg/Nm³	0.0 g/hp-hr

DEFINITIONS AND CONDITIONS

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

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

3. Emissions data measurement procedures are consistent with those described in EPA CFR 40 Part 89, 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.

Applicable Codes and Standards:
AS1359, CSA C22.2 No100-04, UL142,UL489, UL869, UL2200,
NFPA37, NFPA70, NFPA99, NFPA110, IBC, IEC60034-1, ISO3046, ISO8528,
NEMA MG1-22,NEMA MG1-33, 72/23/EEC, 98/37/EC, 2004/108/EC

Note: Codes may not be available in all model configurations. Please consult your local Cat Dealer representative for availability.

3516C
2000 ekW/ 2500 kVA/ 60 Hz/ 1800 rpm/ 480 V/ 0.8 Power Factor

Rating Type: MISSION CRITICAL STANDBY

Emissions: EPA Certified for Stationary Emergency Application (Emits Equivalent U.S. EPA Tier 2 Nonroad Standards)

MISSION CRITICAL STANDBY: Output available with varying load for the duration of the interruption of the normal source power. Average power output is 85% of the standby power rating. Typical peak demand up to 100% of standby rated ekW for 5% of the operating time. Typical operation is 200 hours per year, with maximum expected usage of 500 hours per year.

Ratings are based on SAE J1349 standard conditions. These ratings also apply at ISO3046 standard conditions

Fuel Rates are based on fuel oil of 35º API [16º C (60º F)] gravity having an LHV of 42 780 kJ/kg (18,390 Btu/lb) when used at 29º C (85º F) and weighing 838.9 g/liter (7.001 lbs/U.S. gal.). Additional ratings may be available for specific customer requirements, contact your Cat representative for details. For information regarding Low Sulfur fuel and Biodiesel capability, please consult your Cat dealer.

www.Cat-ElectricPower.com

Performance No.: DM9168-01

Feature Code: 516DE7E

Generator Arrangement: 2628106

Date: 10/07/2014

Source Country: U.S.

DIESEL GENERATOR SET

Image shown may not reflect actual package.

STANDBY
3000 ekW 3750 kVA
60 Hz 1800 rpm 480 Volts

Caterpillar is leading the power generation marketplace with Power Solutions engineered to deliver unmatched flexibility, expandability, reliability, and cost-effectiveness.

FEATURES

FUEL/EMISSIONS STRATEGY
- EPA Certified for Stationary Emergency Application (EPA Tier 2 emissions levels)

DESIGN CRITERIA
- The generator set accepts 100% rated load in one step per NFPA 110 and meets ISO 8528-5 transient response.

FULL RANGE OF ATTACHMENTS
- Wide range of bolt-on system expansion attachments, factory designed and tested
- Flexible packaging options for easy and cost effective installation

SINGLE-SOURCE SUPPLIER
- Fully prototype tested with certified torsional vibration analysis available

WORLDWIDE PRODUCT SUPPORT
- Cat dealers provide extensive post sale support including maintenance and repair agreements
- Cat dealers have over 1,800 dealer branch stores operating in 200 countries
- The Cat® S•O•S℠ program cost effectively detects internal engine component condition, even the presence of unwanted fluids and combustion by-products

CAT® C175-16 DIESEL ENGINE
- Reliable and durable
- Four-stroke diesel engine combines superior performance with excellent fuel economy
- Advanced electronic engine control
- Low installation and operating cost

CAT GENERATOR
- Matched to the performance and output characteristics of Cat engines
- Industry leading mechanical and electrical design
- Industry leading motor starting capabilities
- High Efficiency

CAT EMCP 4 CONTROL PANELS
- Simple user friendly interface and navigation
- Scalable system to meet a wide range of customer needs
- Integrated Control System and Communications Gateway

SEISMIC CERTIFICATION
- Seismic Certification available
- Anchoring details are site specific, and are dependent on many factors such as generator set size, weight, and concrete strength.
  IBC Certification requires that the anchoring system used is reviewed and approved by a Professional Engineer
- Seismic Certification per Applicable Building Codes: IBC 2000, IBC 2003, IBC 2006, IBC 2009, CBC 2007
- Pre-approved by OSHP and carries an OPA#(OSP-0084-01) for use in healthcare projects in California

FACTORY INSTALLED STANDARD & OPTIONAL EQUIPMENT

System	Standard	Optional
Air Inlet	• Air cleaner, 4 x single element canister with service indicator(s) • Plug group for air inlet shut-off	[ ] Air cleaner, 4 x dual element with service indicator(s) [ ] Air inlet adapters
Circuit Breakers		[ ] Circuit breakers, UL 100% rated, 3 pole with shunt trip [ ] Circuit breakers, IEC rated, 3 or 4 pole with shunt
Cooling	• SCAC cooling • Jacket water and AC inlet/outlet flanges	[ ] Package mounted vertical SCAC radiator [ ] Remote horizontal SCAC radiator [ ] Remote fuel cooler
Crankcase Systems	• Open crankcase ventilation	[ ] Crankcase explosion relief valve
Exhaust	• Dry exhaust manifold • Bolted flange (ANSI 6" & DIN 150) with bellow for each turbo (qty 4)	[ ] Engine Exhaust Temperature Module [ ] Mufflers (15 dBA,25 dBA, or 40 dBA) [ ] Dual 16" or single 20" vertical exhaust collector [ ] Weld flange ANSI 20"
Fuel	• Primary fuel filter with water separator • Secondary fuel filters (engine mounted)	
Generator	• 3 phase brushless, salient pole • IEC platinum stator RTD's • Cat digital voltage regulator (CDVR)	[ ] Space heater [ ] Oversize generators [ ] Power connection arrangement
Governor	• ADEM™ A4	[ ] Redundant shutdown
Control Panels	• EMCP 4	[ ] Local & remote annunciator modules [ ] Digital I/O module [ ] Generator temperature monitoring & protection [ ] Remote monitoring software [ ] Load share module
Lube	• Lubricating oil • Oil filter, filler and dipstick • Oil drain line with valves • Fumes disposal • Electric prelube pumps • Integral lube oil cooler	
Mounting	• Rails-engine / generator • Rubber anti-vibration mounts (shipped loose)	[ ] Spring type linear vibration isolator [ ] IBC vibration isolators
Starting/Charging	• Dual 24 volt electric starting motors • Batteries with rack and cables • Battery disconnect switch	[ ] Oversize batteries [ ] 75 amp charging alternator [ ] Battery chargers (20,35 or 50 Amp) [ ] Jacket water heater [ ] Redundant Electric Starter
General	• RH service (Except LH Service Oil Filter) • Paint - Caterpillar Yellow with high gloss black rails • SAE standard rotation • Flywheel and flywheel housing - SAE No. 00	[ ] Barring group- manual or air powered [ ] Factory test reports

SPECIFICATIONS

CAT GENERATOR

Frame size.. 1866
Excitation.. Permanent Magnet
Pitch.. 0.6667
Number of poles.. 4
Number of bearings.. 2
Number of Leads.. 006
Insulation....................... UL 1446 Recognized Class H with tropicalization and antiabrasion
- Consult your Caterpillar dealer for available voltages
IP Rating.. IP23
Alignment.. Closed Coupled
Overspeed capability.. 125
Wave form Deviation (Line to Line)................................ 5%
Voltage regulator............. 3 Phase sensing with selectible volts/Hz
Voltage regulation............Less than +/- 1/2% (steady state)
Less than +/- 1/2% (with 3% speed change)

CAT DIESEL ENGINE

C175 SCAC, V-16, 4-Stroke Water-cooled Diesel
Bore... 175.00 mm (6.89 in)
Stroke.. 220.00 mm (8.66 in)
Displacement..84.67 L (5166.88 in³)
Compression Ratio... 15.3:1
Aspiration... Turbo Aftercooled
Fuel System.. Common Rail
Governor Type.. ADEM™ A4

CAT EMCP 4 SERIES CONTROLS

EMCP 4 controls including:
- Run / Auto / Stop Control
- Speed and Voltage Adjust
- Engine Cycle Crank
- 24-volt DC operation
- Environmental sealed front face
- Text alarm/event descriptions

Digital indication for:
- RPM
- DC volts
- Operating hours
- Oil pressure (psi, kPa or bar)
- Coolant temperature
- Volts (L-L & L-N), frequency (Hz)
- Amps (per phase & average)
- ekW, kVA, kVAR, kW-hr, %kW, PF

Warning/shutdown with common LED indication of:
- Low oil pressure
- High coolant temperature
- Overspeed
- Emergency stop
- Failure to start (overcrank)
- Low coolant temperature
- Low coolant level

Programmable protective relaying functions:
- Generator phase sequence
- Over/Under voltage (27/59)
- Over/Under Frequency (81 o/u)
- Reverse Power (kW) (32)
- Reverse reactive power (kVAr) (32RV)
- Overcurrent (50/51)

Communications:
- Six digital inputs (4.2 only)
- Four relay outputs (Form A)
- Two relay outputs (Form C)
- Two digital outputs
- Customer data link (Modbus RTU)
- Accessory module data link
- Serial annunciator module data link
- Emergency stop pushbutton

Compatible with the following:
- Digital I/O module
- Local Annunciator
- Remote CAN annunciator
- Remote serial annunciator

TECHNICAL DATA

Open Generator Set - - 1800 rpm/60 Hz/480 Volts	DM8448	
EPA Certified for Stationary Emergency Application (EPA Tier 2 emissions levels)		
Generator Set Package Performance		
Genset Power rating @ 0.8 pf	3750 kVA	
Genset Power rating with fan	3000 ekW	
Fuel Consumption		
100% load with fan	810.7 L/hr	214.2 Gal/hr
75% load with fan	625.8 L/hr	165.3 Gal/hr
50% load with fan	493.6 L/hr	130.4 Gal/hr
Cooling System[1]		
Air flow restriction (system)	0.12 kPa	0.48 in. water
Engine coolant capacity	303.5 L	80.2 gal
Inlet Air		
Combustion air inlet flow rate	276.7 m^3/min	9771.6 cfm
Exhaust System		
Exhaust stack gas temperature	477.7 ° C	891.9 ° F
Exhaust gas flow rate	725.6 m^3/min	25624.3 cfm
Exhaust flange size (internal diameter)	150 mm	6 in
Exhaust system backpressure (maximum allowable)	6.7 kPa	26.9 in. water
Heat Rejection		
Heat rejection to coolant (total)	1379 kW	78424 Btu/min
Heat rejection to exhaust (total)	3149 kW	179083 Btu/min
Heat rejection to atmosphere from engine	147 kW	8360 Btu/min
Heat rejection to atmosphere from generator	112.0 kW	6369.4 Btu/min
Alternator[2]		
Motor starting capability @ 30% voltage dip	7322 skVA	
Frame	1866	
Temperature Rise	150 ° C	270 ° F
Emissions (Nominal)[3]		
NOx g/hp-hr	6.07 g/hp-hr	
CO g/hp-hr	.73 g/hp-hr	
HC g/hp-hr	.11 g/hp-hr	
PM g/hp-hr	.034 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] UL 2200 Listed packages may have oversized generators with a different temperature rise and motor starting characteristics. Generator temperature rise is based on a 40 degree C ambient per NEMA MG1-32.

[3] Emissions data measurement procedures are consistent with those described in EPA CFR 40 Part 89, Subpart D & E and ISO8178-1 for measuring HC, CO, PM, NOx. Data shown is based on steady state operating conditions of 77ºF, 28.42 in HG and number 2 diesel fuel with 35º 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.

RATING DEFINITIONS AND CONDITIONS

Meets or Exceeds International Specifications: AS1359, CSA, IEC60034-1, ISO3046, ISO8528, NEMA MG 1-22, NEMA MG 1-33, UL508A, 72/23/EEC, 98/37/EC, 2004/108/EC

Standby - Output available with varying load for the duration of the interruption of the normal source power. Average power output is 70% of the standby power rating. Typical operation is 200 hours per year, with maximum expected usage of 500 hours per year. Standby power in accordance with ISO8528. Fuel stop power in accordance with ISO3046. Standby ambients shown indicate ambient temperature at 100% load which results in a coolant top tank temperature just below the shutdown temperature.

Ratings are based on SAE J1349 standard conditions. These ratings also apply at ISO3046 standard conditions.

Fuel rates are based on fuel oil of 35º API [16º C (60º F)] gravity having an LHV of 42 780 kJ/kg (18,390 Btu/lb) when used at 29º C (85º F) and weighing 838.9 g/liter (7.001 lbs/U.S. gal.). Additional ratings may be available for specific customer requirements, contact your Cat representative for details. For information regarding Low Sulfur fuel and Biodiesel capability, please consult your Cat dealer.

DIMENSIONS

Package Dimensions		
Length	6631.6 mm	261.09 in
Width	2089.4 mm	82.26 in
Height	2207.9 mm	86.93 in

NOTE: For reference only - do not use for installation design. Please contact your local dealer for exact weight and dimensions. (General Dimension Drawing #3269431).

PERFORMANCE PARAMETERS [DM1176] **APRIL 15, 2014**

For Help Desk Phone Numbers Click here

Performance Number: DM1176 **Change Level:** 07

TMI EMISSION DATA USERS

Guideline for the use of factory emissions data for use in local air permit applications.

For sample emission letter see DM9549.

Emission Data Level:

Emission data is expressed as two values. The "Nominal" value presents data measured from an engine operated at ISO 8178 conditions. The Nominal value does not include a "Tolerance Factor" to allow for engine to engine, ambient, or measurement variation. Because the Nominal value represents the average expected emissions from this particular engine model and rating, the Nominal value can be used to develop a reasonable estimate of expected emissions from the entire population of this engine model and rating located in the airshed (if the total population and average operating hours are known). The Nominal value **does not** represent the highest emissions level expected during on-site measurement. Likewise, on site measured emissions should not be used to determine permit limits as they represent only one sample of the entire engine population.

The other value provided is called "Potential Site Variation", which replaces "Not To Exceed" values that Caterpillar provided in the past. These Potential Site Variation emissions values include potential site variation due to engine-to-engine variability,ambient conditions, and emissions measurement methods. Consequently, these values are always higher than the Nominal values. These numbers are based on Caterpillar experience and expected variation in emissions during on site tests.

The Potential Site Variation values are provided by engine load. Points in between published load points can be derived by linear interpolation. Care should be taken to permit only to one unit of measure. For example, Caterpillar strongly recommends mass/hour for the regulated pollutant. Power specific values(e.g. g/hp-hr or g/kW-hr) introduce more measurement error in the field. The simplest means of checking emissions performance on site is verifying that the concentration of regulated pollutants in the exhaust is at or below Potential Site Variation values (in ppm or mg/nm3)at a specified steady-state load.

Note: Crankcase Emissions
For engines with open crankcase ventilation (OCV) systems, the crankcase emissions are not included in the Nominal or Potential Site Variation data. For engines with closed crankcase ventilation (CCV) systems, the crankcase emissions are included in the Nominal and Potential Site variation data.

Note: NOx (NO2)
NOx Emissions are presented as NO2. It is assumed that all NO emissions are converted to NO2 when exposed to the atmosphere.

Unit of Measure:

The units provided are (g/bhp-hr), (g/hr), (mg/normal cubic meter at 5 % O2), (ppm at 5% O2), or (lb/hr). If opacity data is required, contact Caterpillar (Application Support Center).

Note:
g/bhp-hr emission unit is calculated using observed power during factory testing. The column heading is shown as corrected power, Reference DM9600, to match the general performance data section in TMI. Observed power was used to represent site conditions.

Measurement Procedure:

The measurement procedures used to obtain the emission data provided to the EPA are consistent with those described in 40 CFR Parts 89, 94, 1033, 1039, 1042 and 1065 and ISO 8178 for measuring HC, CO, CO2, NOx and particulate matter.

TMI emission data are determined with measurement methods similar to 40 CFR Parts 89, 94, 1033, 1039, 1042, 1065 and ISO 8178 for measuring HC, CO, CO2, NOx, and particulate matter, with minor modifications from those procedures. For example, test fuel, back pressure, or load points may be different for TMI data publication purposes but the data collection process is representative of these methods.

Data presented in TMI is for an engine that has had some reasonable break-in period. This can range from 40 to 80 hours. A proper break-in period for the engine being tested on site will generally improve agreement between TMI data and on-site test data.

Humidity correction to the NOx concentration is found in 40 CFR section 1065.670. Humidity correction should be applied first to the concentration and then corrected to the appropriate oxygen level.

Concentration data, ppm and mg/normal meter cubed, are corrected to standard oxygen levels to accurately compare concentration levels from different sources.

Concentration Corrected @ %O2Ref = (Concentration Measured)x(20.9 - %O2Ref)/(20.9 - %StackO2)

Concentration Corrected = Exhaust Concentration corrected to reference O2 concentration.

%O2Ref = Typically 5% for Metric units and 15% for English units. See local requirements for guidance.

%StackO2 = The measured exhaust oxygen content in %.

Particulate Matter:

The laboratory PM measurement method is not the same as "on-site" or field EPA methods. EPA specifies several methods for measuring particulate matter in the field. The most common is Method 5. Method 5 has larger measurement error than laboratory methods.

Caterpillar measures particulate matter for stationary and off-highway certification with a micro-dilution tunnel system. The system follows ISO 8178 procedures and is used to certify engines for non-road applications for both CARB and EPA.

Method 5 can be used to measure particulate matter in two ways.

The first requires a hot filter sample and accompanying front half wash. This means that the sampling system from the stack to the filters must be flushed with solvent and the extract weighed. When this procedure is used, the results of Method 5 can be slightly less than results obtained with the ISO procedure. This is because the filter temperature used in Method 5 is higher than the filter temperature used in the ISO procedure. The lower filter temperature of the micro-dilution system condenses more soluble organic matter and thus gives a higher particulate matter weight than Method 5.

The second way to use Method 5 requires a front and back half wash. If this procedure is used, additional organic fractions are condensed after the filter by passing the sample through a condenser with outlet gas temperature of 20 Deg C (68 Deg F). Generally, an impinger in an ice bath is used thereby increasing condensation of volatile organics. With this procedure, many of the hydrocarbons in the exhaust will be measured as particulate matter. For air permitting purposes, if a back half wash is to be used in a stack test, the hydrocarbons produced by the engine should be added to the particulate matter data in TMI.

Tests that require back half wash with Method 5 will also be influenced by the fuel sulfur level. If any form of Method 5 is to be used in the field test, contact Caterpillar (Application Support Center).

Sulfur Oxides:

All sulfur present in the fuel is assumed to be converted to SO2 during combustion and in the atmosphere.

SO2 (g/kw-hr)=0.01998x(fuel rate g/bkw-hr)x(% fuel Sulfur by weight)

Where the factor 0.01998 is:
0.01998 = (molecular weight of SO2)/(molecular weight of S)
0.01998 = (molecular weight of S+O+O)/(molecular weight of S x 100%)
0.01998 = (32.06 + 15.9994 + 15.9994)/(32.06 x 100)

Molecular weight of Sulfur, S = 32.06
Molecular weight of Oxygen, O = 15.9994

For SO2 in terms of lb/bhp-hr, use a fuel rate measured in lb/bhp-hr
For SO2 in terms of lb/hr, use a fuel rate measured in lb/hr
For SO2 in terms of g/hr, use a fuel rate measured in g/hr
For SO2 in terms of g/bkw-hr, use a fuel rate measured in g/bkw-hr

Example Calculation:
If fuel has 0.2% Sulfur content
If fuel Rate = 200 g/bkw-hr

SO2 = 0.01998 x (200 g/bkw-hr) x (0.2 % sulfur)
SO2 = 0.799 g/bkw-hr

If SOx is provided in the emission data, the following sentence should be included with the data:

The SOx value is based on fuel sulfur content of 0.2% by weight.

Date Released : 06/27/12

PERFORMANCE DATA[DM8263]

August 21, 2015

Performance Number: DM8263 **Change Level: 03**

SALES MODEL:	3516C	**COMBUSTION:**	DI
ENGINE POWER (BHP):	2,937	**ENGINE SPEED (RPM):**	1,800
GEN POWER WITH FAN (EKW):	2,000.0	**HERTZ:**	60
COMPRESSION RATIO:	14.7	**FAN POWER (HP):**	114.0
RATING LEVEL:	STANDBY	**ASPIRATION:**	TA
PUMP QUANTITY:	2	**AFTERCOOLER TYPE:**	ATAAC
FUEL TYPE:	DIESEL	**AFTERCOOLER CIRCUIT TYPE:**	JW+OC, ATAAC
MANIFOLD TYPE:	DRY	**INLET MANIFOLD AIR TEMP (F):**	122
GOVERNOR TYPE:	ADEM3	**JACKET WATER TEMP (F):**	210.2
ELECTRONICS TYPE:	ADEM3	**TURBO CONFIGURATION:**	PARALLEL
CAMSHAFT TYPE:	STANDARD	**TURBO QUANTITY:**	4
IGNITION TYPE:	CI	**TURBOCHARGER MODEL:**	GTA5518BN-56T-1.12
INJECTOR TYPE:	EUI	**CERTIFICATION YEAR:**	2006
FUEL INJECTOR:	2664387	**CRANKCASE BLOWBY RATE (FT3/HR):**	2,937.9
REF EXH STACK DIAMETER (IN):	12	**FUEL RATE (RATED RPM) NO LOAD (GAL/HR):**	13.7
MAX OPERATING ALTITUDE (FT):	3,117	**PISTON SPD @ RATED ENG SPD (FT/MIN):**	2,244.1

INDUSTRY	SUBINDUSTRY	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 (BMEP)	BRAKE SPEC FUEL CONSUMPTN (BSFC)	VOL FUEL CONSUMPTN (VFC)	INLET MFLD PRES	INLET MFLD TEMP	EXH MFLD TEMP	EXH MFLD PRES	ENGINE OUTLET TEMP
EKW	%	BHP	PSI	LB/BHP-HR	GAL/HR	IN-HG	DEG F	DEG F	IN-HG	DEG F
2,000.0	100	2,937	307	0.329	138.0	78.3	121.2	1,118.5	71.5	752.1
1,800.0	90	2,641	276	0.331	124.9	73.1	119.6	1,067.5	65.7	716.0
1,600.0	80	2,353	246	0.337	113.1	68.0	118.2	1,027.0	60.0	693.3
1,500.0	75	2,212	231	0.340	107.5	65.2	117.5	1,008.1	57.2	684.6
1,400.0	70	2,071	216	0.344	101.8	62.3	116.8	989.4	54.4	676.9
1,200.0	60	1,795	188	0.352	90.1	55.5	115.4	952.0	48.0	662.8
1,000.0	50	1,521	159	0.357	77.5	46.5	113.7	913.4	40.1	654.0
800.0	40	1,250	131	0.357	63.8	34.8	111.8	863.8	30.3	655.0
600.0	30	977	102	0.365	50.9	24.2	110.6	803.8	22.0	650.0
500.0	25	839	88	0.374	44.8	19.7	110.2	767.0	18.7	641.7
400.0	20	699	73	0.388	38.8	15.7	109.8	724.6	15.7	629.0
200.0	10	411	43	0.450	26.4	9.0	109.1	596.9	10.9	552.8

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	COMPRESSOR OUTLET PRES	COMPRESSOR OUTLET TEMP	WET INLET AIR VOL FLOW RATE	ENGINE OUTLET WET EXH GAS VOL FLOW RATE	WET INLET AIR MASS FLOW RATE	WET EXH GAS MASS FLOW RATE	WET EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)	DRY EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)
EKW	%	BHP	IN-HG	DEG F	CFM	CFM	LB/HR	LB/HR	FT3/MIN	FT3/MIN
2,000.0	100	2,937	83	454.3	6,548.9	15,292.8	28,512.8	29,478.4	6,205.0	5,738.7
1,800.0	90	2,641	77	428.8	6,318.7	14,243.0	27,390.5	28,264.7	5,956.5	5,533.7
1,600.0	80	2,353	72	404.5	6,073.3	13,331.0	26,220.6	27,012.9	5,685.0	5,301.6
1,500.0	75	2,212	69	392.7	5,932.2	12,897.9	25,568.0	26,319.7	5,542.0	5,176.6
1,400.0	70	2,071	66	380.9	5,777.2	12,448.0	24,862.1	25,573.8	5,384.8	5,037.5
1,200.0	60	1,795	59	353.9	5,397.2	11,422.5	23,141.0	23,771.1	5,003.4	4,694.0
1,000.0	50	1,521	50	318.8	4,857.3	10,138.7	20,731.5	21,274.5	4,476.2	4,208.4
800.0	40	1,250	38	271.1	4,090.0	8,488.8	17,357.1	17,803.6	3,744.5	3,524.2
600.0	30	977	27	225.0	3,394.1	6,989.6	14,328.5	14,684.4	3,097.0	2,920.6
500.0	25	839	22	204.1	3,103.5	6,328.1	13,075.2	13,388.4	2,825.1	2,668.8
400.0	20	699	18	184.1	2,840.4	5,696.0	11,947.2	12,218.4	2,572.5	2,435.7
200.0	10	411	11	148.5	2,409.4	4,478.2	10,105.7	10,290.7	2,174.6	2,076.8

Heat Rejection Data

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	REJECTION TO JACKET WATER	REJECTION TO ATMOSPHERE	REJECTION TO EXH	EXHUAST RECOVERY TO 350F	FROM OIL COOLER	FROM AFTERCOOLER	WORK ENERGY	LOW HEAT VALUE ENERGY	HIGH HEAT VALUE ENERGY
EKW	%	BHP	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN
2,000.0	100	2,937	43,150	7,564	101,696	49,615	15,778	38,240	124,558	296,234	315,563
1,800.0	90	2,641	40,179	7,175	92,069	43,106	14,280	34,105	111,977	268,102	285,596
1,600.0	80	2,353	37,427	6,907	84,225	38,510	12,931	30,201	99,774	242,774	258,615
1,500.0	75	2,212	36,092	6,791	80,632	36,523	12,286	28,303	93,784	230,664	245,715
1,400.0	70	2,071	34,737	6,671	77,064	34,629	11,640	26,432	87,835	218,548	232,809
1,200.0	60	1,795	31,877	6,341	69,432	30,722	10,302	22,179	76,103	193,426	206,048
1,000.0	50	1,521	28,631	6,026	60,835	26,675	8,865	17,129	64,508	166,434	177,294
800.0	40	1,250	24,910	5,810	50,784	22,387	7,288	11,280	53,005	136,837	145,766
600.0	30	977	21,252	5,496	41,420	18,139	5,820	6,677	41,431	109,268	116,397
500.0	25	839	19,405	5,303	37,082	16,055	5,124	4,986	35,574	96,210	102,488
400.0	20	699	17,492	5,098	32,738	13,986	4,431	3,593	29,634	83,193	88,622
200.0	10	411	13,286	4,670	23,481	8,473	3,022	1,516	17,448	56,745	60,447

Emissions Data

RATED SPEED POTENTIAL SITE VARIATION: 1800 RPM

GENSET POWER WITH FAN		EKW	2,000.0	1,500.0	1,000.0	500.0	200.0
PERCENT LOAD		%	100	75	50	25	10
ENGINE POWER		BHP	2,937	2,212	1,521	839	411
TOTAL NOX (AS NO2)		G/HR	19,098	10,213	5,798	4,218	2,932
TOTAL CO		G/HR	1,564	847	905	1,772	1,794
TOTAL HC		G/HR	423	513	512	409	443
PART MATTER		G/HR	103.2	99.5	123.9	256.7	203.1
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	3,299.4	2,320.1	1,852.8	2,379.4	2,855.8
TOTAL CO	(CORR 5% O2)	MG/NM3	257.0	181.1	277.5	896.4	1,715.8
TOTAL HC	(CORR 5% O2)	MG/NM3	60.1	93.7	132.1	194.2	379.5
PART MATTER	(CORR 5% O2)	MG/NM3	14.4	18.5	35.1	120.0	161.3
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,607	1,130	902	1,159	1,391
TOTAL CO	(CORR 5% O2)	PPM	206	145	222	717	1,373
TOTAL HC	(CORR 5% O2)	PPM	112	175	247	363	708
TOTAL NOX (AS NO2)		G/HP-HR	6.54	4.64	3.82	5.04	7.13
TOTAL CO		G/HP-HR	0.54	0.38	0.60	2.12	4.36
TOTAL HC		G/HP-HR	0.15	0.23	0.34	0.49	1.08
PART MATTER		G/HP-HR	0.04	0.05	0.08	0.31	0.49
TOTAL NOX (AS NO2)		LB/HR	42.10	22.52	12.78	9.30	6.46
TOTAL CO		LB/HR	3.45	1.87	2.00	3.91	3.95
TOTAL HC		LB/HR	0.93	1.13	1.13	0.90	0.98
PART MATTER		LB/HR	0.23	0.22	0.27	0.57	0.45

RATED SPEED NOMINAL DATA: 1800 RPM

GENSET POWER WITH FAN		EKW	2,000.0	1,500.0	1,000.0	500.0	200.0
PERCENT LOAD		%	100	75	50	25	10
ENGINE POWER		BHP	2,937	2,212	1,521	839	411
TOTAL NOX (AS NO2)		G/HR	15,915	8,511	4,832	3,515	2,443
TOTAL CO		G/HR	869	471	503	984	997
TOTAL HC		G/HR	318	385	385	308	333
TOTAL CO2		KG/HR	1,383	1,068	762	430	250
PART MATTER		G/HR	73.7	71.1	88.5	183.4	145.1
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	2,749.5	1,933.4	1,544.0	1,982.8	2,379.8
TOTAL CO	(CORR 5% O2)	MG/NM3	142.8	100.6	154.2	498.0	953.2
TOTAL HC	(CORR 5% O2)	MG/NM3	45.2	70.4	99.3	146.0	285.3
PART MATTER	(CORR 5% O2)	MG/NM3	10.3	13.2	25.1	85.7	115.2
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,339	942	752	966	1,159
TOTAL CO	(CORR 5% O2)	PPM	114	80	123	398	763
TOTAL HC	(CORR 5% O2)	PPM	84	131	185	273	533
TOTAL NOX (AS NO2)		G/HP-HR	5.45	3.87	3.19	4.20	5.94
TOTAL CO		G/HP-HR	0.30	0.21	0.33	1.18	2.42
TOTAL HC		G/HP-HR	0.11	0.18	0.25	0.37	0.81

PART MATTER	G/HP-HR	0.03	0.03	0.06	0.22	0.35
TOTAL NOX (AS NO2)	LB/HR	35.09	18.76	10.65	7.75	5.39
TOTAL CO	LB/HR	1.92	1.04	1.11	2.17	2.20
TOTAL HC	LB/HR	0.70	0.85	0.85	0.68	0.73
TOTAL CO2	LB/HR	3,049	2,356	1,681	947	551
PART MATTER	LB/HR	0.16	0.16	0.20	0.40	0.32
OXYGEN IN EXH	%	10.8	12.3	13.3	14.2	15.8
DRY SMOKE OPACITY	%	0.3	0.5	1.2	3.7	3.0
BOSCH SMOKE NUMBER		0.15	0.21	0.43	1.25	1.12

Altitude Derate Data

ALTITUDE CORRECTED POWER CAPABILITY (BHP)

AMBIENT OPERATING TEMP (F)	50	60	70	80	90	100	110	120	130	NORMAL
ALTITUDE (FT)										
0	2,937	2,937	2,937	2,937	2,937	2,937	2,937	2,937	2,937	2,937
1,000	2,937	2,937	2,937	2,937	2,937	2,937	2,937	2,937	2,937	2,937
2,000	2,937	2,937	2,937	2,937	2,937	2,937	2,937	2,937	2,937	2,937
3,000	2,937	2,937	2,937	2,937	2,937	2,937	2,937	2,896	2,847	2,937
4,000	2,937	2,937	2,937	2,937	2,937	2,886	2,835	2,786	2,739	2,937
5,000	2,937	2,937	2,933	2,879	2,826	2,776	2,727	2,680	2,634	2,937
6,000	2,930	2,874	2,820	2,767	2,717	2,669	2,622	2,576	2,533	2,890
7,000	2,816	2,762	2,710	2,660	2,611	2,565	2,520	2,476	2,434	2,796
8,000	2,706	2,654	2,604	2,555	2,509	2,464	2,421	2,379	2,339	2,705
9,000	2,598	2,548	2,500	2,454	2,409	2,366	2,325	2,285	2,246	2,616
10,000	2,495	2,447	2,400	2,356	2,313	2,272	2,232	2,193	2,156	2,530
11,000	2,394	2,348	2,303	2,261	2,220	2,180	2,142	2,105	2,069	2,445
12,000	2,296	2,252	2,210	2,169	2,129	2,091	2,054	2,019	1,985	2,362
13,000	2,202	2,159	2,119	2,079	2,042	2,005	1,970	1,936	1,903	2,281
14,000	2,110	2,070	2,031	1,993	1,957	1,922	1,888	1,855	1,824	2,202
15,000	2,022	1,983	1,945	1,909	1,875	1,841	1,809	1,778	1,747	2,125

Cross Reference

Engine Arrangement			
Arrangement Number	**Effective Serial Number**	**Engineering Model**	**Engineering Model Version**
2666137	SBJ00001	GS334	-
3994236	DD600001	GS717	-

Test Specification Data						
Test Spec	**Setting**	**Effective Serial Number**	**Engine Arrangement**	**Governor Type**	**Default Low Idle Speed**	**Default High Idle Speed**
0K6996	GG0395	SBJ00001	2666137	ADEM3		
3457917	LL5712	SBJ00001	2666137	ADEM3		
3704959	GG0602	DD600001	3994236	ADEM3		

General Notes

General Notes DM8263 - 03
SOUND PRESSURE DATA FOR THIS RATING CAN BE FOUND IN PERFORMANCE NUMBER - DM8779

Performance Parameter Reference

Parameters Reference:DM9600-08
PERFORMANCE DEFINITIONS

<h2>PERFORMANCE DEFINITIONS DM9600</h2>
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APPLICATION:
Engine performance tolerance values below are representative of a typical production engine tested in a calibrated dynamometer test

cell at SAE J1995 standard reference conditions. Caterpillar maintains ISO9001:2000 certified quality management systems for engine test Facilities to assure accurate calibration of test equipment. Engine test data is corrected in accordance with SAE J1995. Additional reference material SAE J1228, J1349, ISO 8665, 3046-1:2002E, 3046-3:1989, 1585, 2534, 2288, and 9249 may apply in part or are similar to SAE J1995. Special engine rating request (SERR) test data shall be noted.
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PERFORMANCE PARAMETER TOLERANCE FACTORS:

Power	+/- 3%
Torque	+/- 3%
Exhaust stack temperature	+/- 8%
Inlet airflow	+/- 5%
Intake manifold pressure-gage	+/- 10%
Exhaust flow	+/- 6%
Specific fuel consumption	+/- 3%
Fuel rate	+/- 5%
Specific DEF consumption	+/- 3%
DEF rate	+/- 5%
Heat rejection	+/- 5%
Heat rejection exhaust only	+/- 10%
Heat rejection CEM only	+/- 10%

</br>
Heat Rejection values based on using treated water.
</br>
Torque is included for truck and industrial applications, do not use for Gen Set or steady state applications.
</br>
On C7 - C18 engines, at speeds of 1100 RPM and under these values are provided for reference only, and may not meet the tolerance listed.
</br>
These values do not apply to C280/3600. For these models, see the tolerances listed below.
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C280/3600 HEAT REJECTION TOLERANCE FACTORS:

Heat rejection	+/- 10%
Heat rejection to Atmosphere	+/- 50%
Heat rejection to Lube Oil	+/- 20%
Heat rejection to Aftercooler	+/- 5%

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TEST CELL TRANSDUCER TOLERANCE FACTORS:

Torque	+/- 0.5%
Speed	+/- 0.2%
Fuel flow	+/- 1.0%
Temperature	+/- 2.0 C degrees
Intake manifold pressure	+/- 0.1 kPa

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OBSERVED ENGINE PERFORMANCE IS CORRECTED TO SAE J1995 REFERENCE AIR AND FUEL CONDITIONS.
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REFERENCE ATMOSPHERIC INLET AIR
<u>FOR 3500 ENGINES AND SMALLER</u>
SAE J1228 AUG2002 for marine engines, and J1995 JAN2014 for other engines, reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity at the stated aftercooler water temp, or inlet manifold temp.

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<u>FOR 3600 ENGINES</u>
Engine rating obtained and presented in accordance with ISO 3046/1 and SAE J1995 JANJAN2014 reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity and 150M altitude at the stated aftercooler water temperature.

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MEASUREMENT LOCATION FOR INLET AIR TEMPERATURE
Location for air temperature measurement air cleaner inlet at stabilized operating conditions.
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REFERENCE EXHAUST STACK DIAMETER
The Reference Exhaust Stack Diameter published with this dataset is only used for the calculation of Smoke Opacity values displayed in this dataset. This value does not necessarily represent the actual stack diameter of the engine due to the variety of exhaust stack adapter options available. Consult the price list, engine order or general dimension drawings for the actual stack diameter size ordered or options available.

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</br>
REFERENCE FUEL
<u>DIESEL</u>
Reference fuel is #2 distillate diesel with a 35API gravity;
A lower heating value is 42,780 KJ/KG (18,390 BTU/LB) when used at 29 (84.2), where the density is 838.9 G/Liter (7.001 Lbs/Gal).
</br>
<u>GAS</u>
Reference natural gas fuel has a lower heating value of 33.74 KJ/L (905 BTU/CU Ft). Low BTU ratings are based on 18.64 KJ/L (500 BTU/CU FT) lower heating value gas. Propane ratings are based on 87.56 KJ/L (2350 BTU/CU Ft) lower heating value gas.

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ENGINE POWER (NET) IS THE CORRECTED FLYWHEEL POWER (GROSS) LESS EXTERNAL AUXILIARY LOAD
Engine corrected gross output includes the power required to drive standard equipment; lube oil, scavenge lube oil, fuel transfer, common rail fuel, separate circuit aftercooler and jacket water pumps. Engine net power available for the external (flywheel) load is calculated by subtracting the sum of auxiliary load from the corrected gross flywheel out put power. Typical auxiliary loads are radiator cooling fans, hydraulic pumps, air compressors and battery charging alternators. For Tier 4 ratings additional Parasitic losses would also include Intake, and Exhaust Restrictions.

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ALTITUDE CAPABILITY
Altitude capability is the maximum altitude above sea level at standard temperature and standard pressure at which the engine could develop full rated output power on the current performance data set.
</br>
Standard temperature values versus altitude could be seen on TM2001.
</br>
When viewing the altitude capability chart the ambient temperature is the inlet air temp at the compressor inlet.

</br>
Engines with ADEM MEUI and HEUI fuel systems operating at conditions above the defined altitude capability derate for atmospheric pressure and temperature conditions outside the values defined, see TM2001.
</br>
Mechanical governor controlled unit injector engines require a setting change for operation at conditions above the altitude defined on the engine performance sheet. See your Caterpillar technical representative for non standard ratings.
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REGULATIONS AND PRODUCT COMPLIANCE
TMI Emissions information is presented at 'nominal' and 'Potential Site Variation' values for standard ratings. No tolerances are applied to the emissions data. These values are subject to change at any time. The controlling federal and local emission requirements need to be verified by your Caterpillar technical representative.
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Customer's may have special emission site requirements that need to be verified by the Caterpillar Product Group engineer.
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EMISSIONS DEFINITIONS:
Emissions : DM1176
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HEAT REJECTION DEFINITIONS:

PERFORMANCE DATA[DM8263]

Diesel Circuit Type and HHV Balance : DM9500
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HIGH DISPLACEMENT (HD) DEFINITIONS:
3500: EM1500
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RATING DEFINITIONS:
Agriculture : TM6008
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Fire Pump : TM6009
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Generator Set : TM6035
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Generator (Gas) : TM6041
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Industrial Diesel : TM6010
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Industrial (Gas) : TM6040
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Irrigation : TM5749
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Locomotive : TM6037
</br>
Marine Auxiliary : TM6036
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Marine Prop (Except 3600) : TM5747
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Marine Prop (3600 only) : TM5748
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MSHA : TM6042
</br>
Oil Field (Petroleum) : TM6011
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Off-Highway Truck : TM6039
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On-Highway Truck : TM6038
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SOUND DEFINITIONS:
Sound Power : DM8702
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Sound Pressure : TM7080

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<h5 align="right">Date Released : 7/7/15</h5>

PERFORMANCE DATA[DM8448]

August 21, 2015

Performance Number: DM8448 **Change Level: 06**

SALES MODEL:	C175-16
ENGINE POWER (BHP):	4,423
GEN POWER WITH FAN (EKW):	3,000.0
COMPRESSION RATIO:	15.3
RATING LEVEL:	STANDBY
PUMP QUANTITY:	2
FUEL TYPE:	DIESEL
MANIFOLD TYPE:	DRY
GOVERNOR TYPE:	ADEM4
ELECTRONICS TYPE:	ADEM4
CAMSHAFT TYPE:	STANDARD
IGNITION TYPE:	CI
INJECTOR TYPE:	CR
FUEL INJECTOR:	3198470
REF EXH STACK DIAMETER (IN):	14
COMBUSTION:	DI
ENGINE SPEED (RPM):	1,800
HERTZ:	60
FAN POWER (HP):	187.7
ASPIRATION:	TA
AFTERCOOLER TYPE:	SCAC
AFTERCOOLER CIRCUIT TYPE:	JW+OC+1AC, 2AC
AFTERCOOLER TEMP (F):	115
JACKET WATER TEMP (F):	210.2
TURBO CONFIGURATION:	PARALLEL
TURBO QUANTITY:	4
TURBOCHARGER MODEL:	GTB6251BN-48T-1.38
CERTIFICATION YEAR:	2008
CRANKCASE BLOWBY RATE (FT3/HR):	2,436.4
FUEL RATE (RATED RPM) NO LOAD (GAL/HR):	25.1
PISTON SPD @ RATED ENG SPD (FT/MIN):	2,598.4

INDUSTRY	SUBINDUSTRY	APPLICATION
ELECTRIC POWER	STANDARD	PACKAGED GENSET

General Performance Data

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	BRAKE MEAN EFF PRES (BMEP)	BRAKE SPEC FUEL CONSUMPTN (BSFC)	VOL FUEL CONSUMPTN (VFC)	INLET MFLD PRES	INLET MFLD TEMP	EXH MFLD TEMP	EXH MFLD PRES	ENGINE OUTLET TEMP
EKW	%	BHP	PSI	LB/BHP-HR	GAL/HR	IN-HG	DEG F	DEG F	IN-HG	DEG F
3,000.0	100	4,423	377	0.339	214.2	91.5	131.3	1,229.8	64.3	891.9
2,700.0	90	3,999	341	0.338	192.9	81.4	129.6	1,193.4	56.5	879.2
2,400.0	80	3,576	305	0.340	173.9	73.0	128.3	1,163.0	50.0	869.4
2,250.0	75	3,364	286	0.344	165.3	69.5	127.8	1,150.7	47.5	865.8
2,100.0	70	3,152	268	0.351	158.2	67.1	127.6	1,142.6	45.8	864.2
1,800.0	60	2,729	232	0.371	144.5	62.7	127.3	1,127.7	42.8	861.6
1,500.0	50	2,305	196	0.396	130.4	57.5	126.9	1,109.9	39.5	858.0
1,200.0	40	1,882	160	0.417	112.2	46.4	125.8	1,083.9	32.9	848.4
900.0	30	1,458	124	0.440	91.6	34.8	124.5	1,041.6	25.3	834.7
750.0	25	1,246	106	0.453	80.6	29.0	123.8	1,014.2	21.3	826.5
600.0	20	1,035	88	0.467	69.1	23.2	123.2	961.6	17.6	797.3
300.0	10	611	52	0.514	44.9	11.7	122.1	752.4	10.6	649.3

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	COMPRESSOR OUTLET PRES	COMPRESSOR OUTLET TEMP	WET INLET AIR VOL FLOW RATE	ENGINE OUTLET WET EXH GAS VOL FLOW RATE	WET INLET AIR MASS FLOW RATE	WET EXH GAS MASS FLOW RATE	WET EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)	DRY EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)
EKW	%	BHP	IN-HG	DEG F	CFM	CFM	LB/HR	LB/HR	FT3/MIN	FT3/MIN
3,000.0	100	4,423	92	451.5	9,772.2	25,620.0	42,761.1	44,259.6	9,320.0	8,667.2
2,700.0	90	3,999	82	414.6	8,943.0	23,086.1	38,888.2	40,238.8	8,477.9	7,889.0
2,400.0	80	3,576	74	384.7	8,243.6	20,980.8	35,642.2	36,860.0	7,761.6	7,230.7
2,250.0	75	3,364	70	373.0	7,953.8	20,121.0	34,304.6	35,462.7	7,463.6	6,958.6
2,100.0	70	3,152	68	366.1	7,753.3	19,531.3	33,379.1	34,486.9	7,254.0	6,770.2
1,800.0	60	2,729	65	354.0	7,382.3	18,480.5	31,695.8	32,707.6	6,876.9	6,433.3
1,500.0	50	2,305	60	339.0	6,952.0	17,314.7	29,788.0	30,700.3	6,460.8	6,059.1
1,200.0	40	1,882	50	308.0	6,076.8	15,264.4	25,920.8	26,704.4	5,737.4	5,392.5
900.0	30	1,458	39	267.2	5,160.3	12,786.8	21,909.9	22,550.1	4,857.0	4,574.5
750.0	25	1,246	33	243.5	4,701.8	11,409.7	19,919.4	20,483.0	4,361.8	4,112.2
600.0	20	1,035	27	217.8	4,243.2	9,964.4	17,938.9	18,422.6	3,897.7	3,682.5
300.0	10	611	14	160.9	3,325.6	6,901.7	14,007.7	14,322.1	3,060.0	2,917.8

Heat Rejection Data

PUMP POWER IS INCLUDED IN HEAT REJECTION BALANCE, BUT IS NOT SHOWN.

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	REJECTION TO JACKET WATER	REJECTION TO ATMOSPHERE	REJECTION TO EXH	EXHUAST RECOVERY TO 350F	FROM OIL COOLER	FROM 2ND STAGE AFTERCOOLER	WORK ENERGY	LOW HEAT VALUE ENERGY	HIGH HEAT VALUE ENERGY
EKW	%	BHP	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN
3,000.0	100	4,423	78,436	8,336	179,063	101,475	24,486	28,224	187,548	459,719	489,716
2,700.0	90	3,999	70,525	7,773	161,695	89,988	22,085	23,040	169,590	414,639	441,694
2,400.0	80	3,576	63,777	7,308	147,071	80,799	19,915	18,972	151,631	373,899	398,296
2,250.0	75	3,364	60,840	7,112	140,788	77,146	18,917	17,358	142,651	355,157	378,331
2,100.0	70	3,152	58,599	6,984	136,398	74,726	18,070	16,328	133,672	339,264	361,402
1,800.0	60	2,729	54,754	6,750	128,972	70,419	16,496	14,928	115,714	309,709	329,917
1,500.0	50	2,305	50,870	6,524	120,720	65,533	14,875	13,738	97,755	279,270	297,493
1,200.0	40	1,882	45,639	6,304	106,679	55,828	12,823	11,188	79,796	240,744	256,453
900.0	30	1,458	38,952	6,092	88,655	45,754	10,475	8,227	61,838	196,664	209,497
750.0	25	1,246	35,102	5,988	78,431	40,805	9,211	6,848	52,858	172,945	184,229
600.0	20	1,035	30,773	5,789	67,509	34,336	7,896	5,681	43,879	148,253	157,927
300.0	10	611	20,277	4,828	43,873	17,588	5,132	4,028	25,920	96,361	102,649

Sound Data

SOUND DATA REPRESENTATIVE OF NOISE PRODUCED BY THE "ENGINE ONLY"

EXHAUST: Sound Power (1/3 Octave Frequencies)

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	OVERALL SOUND	100 HZ	125 HZ	160 HZ	200 HZ	250 HZ	315 HZ	400 HZ	500 HZ	630 HZ	800 HZ
EKW	%	BHP	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
3,000.0	100	4,423	134.5	109.7	115.8	113.7	115.5	116.0	119.0	119.9	121.5	120.4	121.2
2,700.0	90	3,999	133.2	110.2	116.1	112.6	114.3	114.5	117.3	118.4	120.1	118.3	119.5
2,400.0	80	3,576	132.0	111.6	116.6	111.0	112.7	113.0	115.6	116.9	118.4	116.5	117.7
2,250.0	75	3,364	131.4	112.4	116.8	110.2	111.9	112.3	114.8	116.2	117.6	115.6	116.8
2,100.0	70	3,152	130.7	113.2	117.1	109.3	111.1	111.6	114.0	115.5	116.8	114.7	115.9
1,800.0	60	2,729	129.5	114.8	117.6	107.5	109.4	110.2	112.3	114.1	115.1	113.0	114.0
1,500.0	50	2,305	128.2	116.3	118.1	105.8	107.8	108.7	110.6	112.6	113.4	111.2	112.2
1,200.0	40	1,882	127.0	117.9	118.6	104.1	106.1	107.3	108.9	111.2	111.8	109.5	110.3
900.0	30	1,458	125.7	119.5	119.1	102.3	104.4	105.9	107.3	109.8	110.1	107.7	108.5
750.0	25	1,246	125.1	120.2	119.3	101.4	103.6	105.2	106.4	109.1	109.3	106.8	107.6
600.0	20	1,035	124.4	121.0	119.6	100.6	102.8	104.5	105.6	108.4	108.4	105.9	106.7
300.0	10	611	123.2	122.6	120.0	98.8	101.1	103.0	103.9	106.9	106.8	104.2	104.8

EXHAUST: Sound Power (1/3 Octave Frequencies)

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	1000 HZ	1250 HZ	1600 HZ	2000 HZ	2500 HZ	3150 HZ	4000 HZ	5000 HZ	6300 HZ	8000 HZ	10000 HZ
EKW	%	BHP	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
3,000.0	100	4,423	122.2	122.6	123.5	124.9	124.7	123.1	122.4	121.6	120.1	119.0	123.4
2,700.0	90	3,999	120.7	121.0	122.2	123.5	123.2	121.5	120.8	120.0	118.7	117.8	123.8
2,400.0	80	3,576	119.4	119.7	120.8	122.5	121.9	120.4	119.8	119.0	117.7	117.1	123.5
2,250.0	75	3,364	118.8	119.1	120.1	122.0	121.3	119.9	119.4	118.6	117.2	116.8	123.3
2,100.0	70	3,152	118.1	118.5	119.4	121.5	120.6	119.3	119.0	118.2	116.7	116.5	123.1
1,800.0	60	2,729	116.9	117.3	118.0	120.4	119.4	118.3	118.1	117.3	115.6	115.9	122.6
1,500.0	50	2,305	115.6	116.2	116.6	119.4	118.1	117.3	117.2	116.4	114.6	115.3	122.1
1,200.0	40	1,882	114.3	115.0	115.1	118.4	116.8	116.3	116.4	115.6	113.6	114.7	121.6
900.0	30	1,458	113.1	113.8	113.7	117.4	115.6	115.3	115.5	114.7	112.6	114.1	121.1
750.0	25	1,246	112.4	113.2	113.0	116.9	114.9	114.8	115.1	114.3	112.1	113.8	120.9
600.0	20	1,035	111.8	112.6	112.3	116.4	114.3	114.2	114.7	113.9	111.6	113.5	120.7
300.0	10	611	110.5	111.4	110.9	115.4	113.0	113.2	113.8	113.0	110.6	112.9	120.2

PERFORMANCE DATA[DM8448]

Sound Data (Continued)

MECHANICAL: Sound Power (1/3 Octave Frequencies)

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	OVERALL SOUND	100 HZ	125 HZ	160 HZ	200 HZ	250 HZ	315 HZ	400 HZ	500 HZ	630 HZ	800 HZ
EKW	%	BHP	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
3,000.0	100	4,423	125.9	89.8	105.6	98.4	100.6	104.5	108.3	111.6	113.3	112.5	114.1
2,700.0	90	3,999	125.8	89.4	105.5	97.9	100.9	103.3	108.7	111.1	112.7	112.2	113.8
2,400.0	80	3,576	126.0	89.0	105.0	97.8	99.8	102.4	108.0	111.0	111.8	111.9	113.0
2,250.0	75	3,364	126.1	88.8	104.7	97.8	99.1	102.1	107.5	111.0	111.3	111.7	112.6
2,100.0	70	3,152	126.2	88.5	104.3	97.8	98.4	101.7	107.0	111.0	110.8	111.6	112.2
1,800.0	60	2,729	126.5	88.1	103.7	97.8	96.9	100.9	106.0	111.0	109.8	111.2	111.4
1,500.0	50	2,305	126.7	87.7	103.0	97.8	95.4	100.2	105.1	111.0	108.8	110.9	110.5
1,200.0	40	1,882	127.0	87.3	102.4	97.7	94.0	99.4	104.1	110.9	107.8	110.6	109.7
900.0	30	1,458	127.2	86.9	101.7	97.7	92.5	98.6	103.1	110.9	106.8	110.2	108.9
750.0	25	1,246	127.3	86.7	101.4	97.7	91.8	98.2	102.6	110.9	106.3	110.1	108.5
600.0	20	1,035	127.4	86.4	101.0	97.7	91.0	97.9	102.1	110.9	105.8	109.9	108.1
300.0	10	611	127.7	86.0	100.4	97.7	89.6	97.1	101.2	110.9	104.8	109.6	107.2

MECHANICAL: Sound Power (1/3 Octave Frequencies)

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	1000 HZ	1250 HZ	1600 HZ	2000 HZ	2500 HZ	3150 HZ	4000 HZ	5000 HZ	6300 HZ	8000 HZ	10000 HZ
EKW	%	BHP	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
3,000.0	100	4,423	112.7	113.9	114.6	115.3	115.0	112.7	110.9	111.9	114.3	113.4	117.8
2,700.0	90	3,999	112.5	113.7	114.5	115.0	114.5	112.3	110.4	111.1	113.6	112.9	119.2
2,400.0	80	3,576	112.2	113.2	113.8	114.4	114.2	111.9	110.0	110.7	113.2	112.6	121.4
2,250.0	75	3,364	112.0	112.9	113.4	114.0	114.2	111.7	109.8	110.5	112.9	112.6	122.6
2,100.0	70	3,152	111.8	112.6	113.0	113.7	114.1	111.4	109.6	110.3	112.7	112.5	123.8
1,800.0	60	2,729	111.3	112.1	112.2	113.1	113.9	111.0	109.3	110.0	112.3	112.3	126.2
1,500.0	50	2,305	110.9	111.5	111.4	112.4	113.7	110.6	109.0	109.6	111.9	112.1	128.6
1,200.0	40	1,882	110.5	110.9	110.5	111.7	113.5	110.2	108.6	109.3	111.5	111.9	131.0
900.0	30	1,458	110.1	110.3	109.7	111.1	113.4	109.8	108.3	109.0	111.0	111.8	133.4
750.0	25	1,246	109.9	110.0	109.3	110.7	113.3	109.6	108.1	108.8	110.8	111.7	134.6
600.0	20	1,035	109.7	109.7	108.9	110.4	113.2	109.3	107.9	108.6	110.6	111.6	135.8
300.0	10	611	109.3	109.2	108.1	109.7	113.0	108.9	107.6	108.3	110.2	111.4	138.2

Emissions Data

RATED SPEED POTENTIAL SITE VARIATION: 1800 RPM

GENSET POWER WITH FAN		EKW	3,000.0	2,250.0	1,500.0	750.0	300.0
PERCENT LOAD		%	100	75	50	25	10
ENGINE POWER		BHP	4,423	3,364	2,305	1,246	611
TOTAL NOX (AS NO2)		G/HR	32,004	21,429	9,376	3,795	3,518
TOTAL CO		G/HR	5,743	6,479	3,534	5,489	3,566
TOTAL HC		G/HR	647	597	1,048	1,031	1,300
PART MATTER		G/HR	210.2	221.1	203.5	409.7	343.1
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	3,736.7	3,329.4	1,866.7	1,263.6	2,259.3
TOTAL CO	(CORR 5% O2)	MG/NM3	586.2	854.4	602.3	1,594.3	1,701.1
TOTAL HC	(CORR 5% O2)	MG/NM3	54.2	69.1	157.2	265.0	625.2
PART MATTER	(CORR 5% O2)	MG/NM3	18.2	25.6	31.4	103.5	158.0
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,820	1,621	909	616	1,101
TOTAL CO	(CORR 5% O2)	PPM	469	684	482	1,275	1,361
TOTAL HC	(CORR 5% O2)	PPM	101	129	294	495	1,167
TOTAL NOX (AS NO2)		G/HP-HR	7.28	6.40	4.08	3.05	5.76
TOTAL CO		G/HP-HR	1.31	1.93	1.54	4.41	5.84
TOTAL HC		G/HP-HR	0.15	0.18	0.46	0.83	2.13
PART MATTER		G/HP-HR	0.05	0.07	0.09	0.33	0.56
TOTAL NOX (AS NO2)		LB/HR	70.56	47.24	20.67	8.37	7.75
TOTAL CO		LB/HR	12.66	14.28	7.79	12.10	7.86
TOTAL HC		LB/HR	1.43	1.32	2.31	2.27	2.87
PART MATTER		LB/HR	0.46	0.49	0.45	0.90	0.76

RATED SPEED NOMINAL DATA: 1800 RPM

PERFORMANCE DATA[DM8448]

August 21, 2015

GENSET POWER WITH FAN		EKW	3,000.0	2,250.0	1,500.0	750.0	300.0
PERCENT LOAD		**%**	**100**	**75**	**50**	**25**	**10**
ENGINE POWER		**BHP**	**4,423**	**3,364**	**2,305**	**1,246**	**611**
TOTAL NOX (AS NO2)		G/HR	26,670	17,858	7,813	3,162	2,931
TOTAL CO		G/HR	3,190	3,599	1,963	3,050	1,981
TOTAL HC		G/HR	486	449	788	776	977
TOTAL CO2		KG/HR	2,143	1,609	1,236	751	416
PART MATTER		G/HR	150.1	157.9	145.3	292.7	245.1
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	3,113.9	2,774.5	1,555.6	1,053.0	1,882.8
TOTAL CO	(CORR 5% O2)	MG/NM3	325.6	474.7	334.6	885.7	945.0
TOTAL HC	(CORR 5% O2)	MG/NM3	40.7	51.9	118.2	199.3	470.1
PART MATTER	(CORR 5% O2)	MG/NM3	13.0	18.3	22.5	73.9	112.8
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,517	1,351	758	513	917
TOTAL CO	(CORR 5% O2)	PPM	261	380	268	709	756
TOTAL HC	(CORR 5% O2)	PPM	76	97	221	372	878
TOTAL NOX (AS NO2)		G/HP-HR	6.07	5.33	3.40	2.54	4.80
TOTAL CO		G/HP-HR	0.73	1.07	0.85	2.45	3.24
TOTAL HC		G/HP-HR	0.11	0.13	0.34	0.62	1.60
PART MATTER		G/HP-HR	0.03	0.05	0.06	0.24	0.40
TOTAL NOX (AS NO2)		LB/HR	58.80	39.37	17.22	6.97	6.46
TOTAL CO		LB/HR	7.03	7.94	4.33	6.72	4.37
TOTAL HC		LB/HR	1.07	0.99	1.74	1.71	2.15
TOTAL CO2		LB/HR	4,723	3,547	2,724	1,655	917
PART MATTER		LB/HR	0.33	0.35	0.32	0.65	0.54
OXYGEN IN EXH		%	9.9	10.6	11.8	12.6	14.4
DRY SMOKE OPACITY		%	0.5	0.7	0.6	4.8	4.7
BOSCH SMOKE NUMBER			0.19	0.28	0.24	1.25	1.24

Altitude Derate Data

ALTITUDE DERATE DATA IS BASED ON THE ASSUMPTION OF A 20 DEGREES CELSIUS(36 DEGREES FAHRENHEIT) DIFFERENCE BETWEEN AMBIENT OPERATING TEMPERATURE AND ENGINE INLET MANIFOLD TEMPERATURE (IMAT). AMBIENT OPERATING TEMPERATURE IS DEFINED AS THE AIR TEMPERATURE MEASURED AT THE TURBOCHARGER COMPRESSOR INLET.

ALTITUDE CORRECTED POWER CAPABILITY (BHP)

AMBIENT OPERATING TEMP (F)	30	40	50	60	70	80	90	100	110	120	130	140	NORMAL
ALTITUDE (FT)													
0	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,413	4,423
1,000	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,362	4,423
2,000	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,382	4,323	4,233	4,423
3,000	4,360	4,360	4,360	4,360	4,360	4,360	4,360	4,360	4,359	4,294	4,200	4,107	4,360
4,000	4,185	4,185	4,185	4,185	4,185	4,185	4,184	4,182	4,181	4,139	4,080	4,021	4,185
5,000	4,019	4,019	4,019	4,019	4,019	4,019	4,018	4,015	4,013	3,992	3,963	3,935	4,019
6,000	3,867	3,867	3,867	3,867	3,867	3,867	3,866	3,862	3,858	3,853	3,846	3,839	3,867
7,000	3,746	3,746	3,746	3,746	3,746	3,746	3,745	3,741	3,737	3,731	3,725	3,718	3,746
8,000	3,626	3,626	3,626	3,626	3,626	3,626	3,624	3,620	3,615	3,610	3,604	3,597	3,626
9,000	3,511	3,511	3,511	3,511	3,511	3,511	3,509	3,505	3,500	3,495	3,489	3,483	3,511
10,000	3,401	3,401	3,401	3,401	3,401	3,401	3,399	3,394	3,390	3,384	3,379	3,373	3,401
11,000	3,290	3,290	3,290	3,290	3,290	3,290	3,288	3,284	3,279	3,274	3,269	3,264	3,290
12,000	3,180	3,180	3,180	3,180	3,180	3,180	3,178	3,173	3,169	3,164	3,159	3,154	3,180
13,000	3,080	3,080	3,080	3,080	3,080	3,080	3,079	3,075	3,071	3,067	3,063	3,059	3,080
14,000	2,982	2,982	2,982	2,982	2,982	2,982	2,981	2,978	2,976	2,973	2,970	2,967	2,982
15,000	2,885	2,885	2,885	2,885	2,885	2,885	2,884	2,882	2,881	2,879	2,877	2,876	2,885

Cross Reference

Engine Arrangement			
Arrangement Number	**Effective Serial Number**	**Engineering Model**	**Engineering Model Version**
3079788	WYB00001	GS265	-

Test Specification Data						
Test Spec	**Setting**	**Effective Serial Number**	**Engine Arrangement**	**Governor Type**	**Default Low Idle Speed**	**Default High Idle Speed**
0K8532	LL6018	WYB00001	3079788	ADEM4		

PERFORMANCE DATA[DM8448]

Performance Parameter Reference

Parameters Reference:DM9600-08
PERFORMANCE DEFINITIONS

<h2>PERFORMANCE DEFINITIONS DM9600</h2>
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APPLICATION:
Engine performance tolerance values below are representative of a typical production engine tested in a calibrated dynamometer test cell at SAE J1995 standard reference conditions. Caterpillar maintains ISO9001:2000 certified quality management systems for engine test Facilities to assure accurate calibration of test equipment. Engine test data is corrected in accordance with SAE J1995. Additional reference material SAE J1228, J1349, ISO 8665, 3046-1:2002E, 3046-3:1989, 1585, 2534, 2288, and 9249 may apply in part or are similar to SAE J1995. Special engine rating request (SERR) test data shall be noted.
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PERFORMANCE PARAMETER TOLERANCE FACTORS:

Power	+/- 3%
Torque	+/- 3%
Exhaust stack temperature	+/- 8%
Inlet airflow	+/- 5%
Intake manifold pressure-gage	+/- 10%
Exhaust flow	+/- 6%
Specific fuel consumption	+/- 3%
Fuel rate	+/- 5%
Specific DEF consumption	+/- 3%
DEF rate	+/- 5%
Heat rejection	+/- 5%
Heat rejection exhaust only	+/- 10%
Heat rejection CEM only	+/- 10%

</br>
Heat Rejection values based on using treated water.
</br>
Torque is included for truck and industrial applications, do not use for Gen Set or steady state applications.
</br>
On C7 - C18 engines, at speeds of 1100 RPM and under these values are provided for reference only, and may not meet the tolerance listed.
</br>
These values do not apply to C280/3600. For these models, see the tolerances listed below.
</br>
</br>

C280/3600 HEAT REJECTION TOLERANCE FACTORS:

Heat rejection	+/- 10%
Heat rejection to Atmosphere	+/- 50%
Heat rejection to Lube Oil	+/- 20%
Heat rejection to Aftercooler	+/- 5%

</br>
</br>

TEST CELL TRANSDUCER TOLERANCE FACTORS:

Torque	+/- 0.5%
Speed	+/- 0.2%
Fuel flow	+/- 1.0%
Temperature	+/- 2.0 C degrees
Intake manifold pressure	+/- 0.1 kPa

</br>
OBSERVED ENGINE PERFORMANCE IS CORRECTED TO SAE J1995 REFERENCE AIR AND FUEL CONDITIONS.
</br>
</br>

REFERENCE ATMOSPHERIC INLET AIR
<u>FOR 3500 ENGINES AND SMALLER</u>
SAE J1228 AUG2002 for marine engines, and J1995 JAN2014 for other engines, reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity at the stated aftercooler water temp, or inlet manifold temp.

</br>
<u>FOR 3600 ENGINES</u>
Engine rating obtained and presented in accordance with ISO 3046/1

and SAE J1995 JANJAN2014 reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity and 150M altitude at the stated aftercooler water temperature.

</br>
</br>
MEASUREMENT LOCATION FOR INLET AIR TEMPERATURE
Location for air temperature measurement air cleaner inlet at stabilized operating conditions.
</br>
</br>

REFERENCE EXHAUST STACK DIAMETER
The Reference Exhaust Stack Diameter published with this dataset is only used for the calculation of Smoke Opacity values displayed in this dataset. This value does not necessarily represent the actual stack diameter of the engine due to the variety of exhaust stack adapter options available. Consult the price list, engine order or general dimension drawings for the actual stack diameter size ordered or options available.

</br>
</br>
REFERENCE FUEL
<u>DIESEL</u>
Reference fuel is #2 distillate diesel with a 35API gravity;
A lower heating value is 42,780 KJ/KG (18,390 BTU/LB) when used at 29 (84.2), where the density is 838.9 G/Liter (7.001 Lbs/Gal).
</br>
<u>GAS</u>
Reference natural gas fuel has a lower heating value of 33.74 KJ/L (905 BTU/CU Ft). Low BTU ratings are based on 18.64 KJ/L (500 BTU/CU FT) lower heating value gas. Propane ratings are based on 87.56 KJ/L (2350 BTU/CU Ft) lower heating value gas.

</br>
</br>
ENGINE POWER (NET) IS THE CORRECTED FLYWHEEL POWER (GROSS) LESS EXTERNAL AUXILIARY LOAD
Engine corrected gross output includes the power required to drive standard equipment; lube oil, scavenge lube oil, fuel transfer, common rail fuel, separate circuit aftercooler and jacket water pumps. Engine net power available for the external (flywheel) load is calculated by subtracting the sum of auxiliary load from the corrected gross flywheel out put power. Typical auxiliary loads are radiator cooling fans, hydraulic pumps, air compressors and battery charging alternators. For Tier 4 ratings additional Parasitic losses would also include Intake, and Exhaust Restrictions.

</br>
</br>
ALTITUDE CAPABILITY
Altitude capability is the maximum altitude above sea level at standard temperature and standard pressure at which the engine could develop full rated output power on the current performance data set.
</br>
Standard temperature values versus altitude could be seen on TM2001.
</br>
When viewing the altitude capability chart the ambient temperature is the inlet air temp at the compressor inlet.

</br>
Engines with ADEM MEUI and HEUI fuel systems operating at conditions above the defined altitude capability derate for atmospheric pressure and temperature conditions outside the values defined, see TM2001.
</br>
Mechanical governor controlled unit injector engines require a setting change for operation at conditions above the altitude defined on the engine performance sheet. See your Caterpillar technical representative for non standard ratings.
</br>
</br>

REGULATIONS AND PRODUCT COMPLIANCE
TMI Emissions information is presented at 'nominal' and 'Potential Site Variation' values for standard ratings. No tolerances are applied to the emissions data. These values are subject to change at any time. The controlling federal and local emission requirements need to be verified by your Caterpillar technical

representative.
</br>

Customer's may have special emission site requirements that need
to be verified by the Caterpillar Product Group engineer.
</br>
</br>

EMISSIONS DEFINITIONS:
Emissions : DM1176
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</br>

HEAT REJECTION DEFINITIONS:
Diesel Circuit Type and HHV Balance : DM9500
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HIGH DISPLACEMENT (HD) DEFINITIONS:
3500: EM1500
</br>
</br>

RATING DEFINITIONS:
Agriculture : TM6008
</br>
Fire Pump : TM6009
</br>
Generator Set : TM6035
</br>
Generator (Gas) : TM6041
</br>
Industrial Diesel : TM6010
</br>
Industrial (Gas) : TM6040
</br>
Irrigation : TM5749
</br>
Locomotive : TM6037
</br>
Marine Auxiliary : TM6036
</br>
Marine Prop (Except 3600) : TM5747
</br>
Marine Prop (3600 only) : TM5748
</br>
MSHA : TM6042
</br>
Oil Field (Petroleum) : TM6011
</br>
Off-Highway Truck : TM6039
</br>
On-Highway Truck : TM6038
</br>
</br>

SOUND DEFINITIONS:
Sound Power : DM8702
</br>
Sound Pressure : TM7080

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</br>
<h5 align="right">Date Released : 7/7/15</h5>

2000 kW / 2500 kVA

Horse power at 100% load = 2922 BHP

Model	DQKAB EPA T2	DQKAB DOC only	DQKAB DPF only	DQKAL SCR only	DQKAL T4 Compliant
HC	0.08	~(-80%) 0.016	0.08	0.00	0.00
NOx	5.30	5.30	5.30	0.45	0.48
CO	0.32	~(-85%) 0.048	0.32	0.20	0.23
PM	0.03	~(-20%) 0.024	0.00	0.01	0.00
	From data sheet @ 100% load	Approximate reduction @100%	Same as T2 with zero particulate matter	From data sheets @ 100% load	

All numbers are in Grams per BHP hour
These numbers will not match EPA D2 cycle testing

2750 kW / 3537 kVA

Horse power at 100% load = 4060 BHP

Model	DQLF EPA T2	DQLF DOC only	DQLF DPF only	DQLH SCR only	DQLH T4 Compliant
HC	0.14	~(-80%) 0.028	0.14	0.02	0.02
NOx	6.40	6.40	6.40	0.62	0.61
CO	0.43	~(-85%) 0.065	0.43	1.14	1.50
PM	0.04	~(-20%) 0.032	0.00	0.06	0.00
	From data sheet @ 100% load	Approximate reduction @100%	Same as T2 with zero particulate matter	From data sheets @ 100% load	

All numbers are in Grams per BHP hour
These numbers will not match EPA D2 cycle testing

Tom Tomlinson, Cummins Northwest, 8-14-15

Vendor	2000kW Tier 2 Budget Pricing	Tier 4 adder (field install for 2MW) Budget Pricing	2750kW Tier 2 Budget Pricing	Tier 4 adder (field install for 2.75MW) Budget Pricing
Pacific Power (MTU)	$ 750.000.00 Ea	$ 270,000.00 Ea	$ 1,010,000.00 Ea	$ 300,000.00 Ea

Tier 4 adder (field install for 2MW):

DOC/DPF = $ 72,500.00 (single unit)
SCR = $ 135,000.00
Misc Parts = $ 11,000.00
Labor to Install = $ 51,500.00

Tier 4 adder (field install for 2.75MW):

DOC/DPF = $ 89,750.00 (single unit)
SCR = $ 141,250.00
Misc Parts = $ 12,500.00
Labor to Install = $ 56,500.00

APPENDIX B

Evaporative Cooling Unit Technical Information

SECTION 237454 – DIRECT EVAPORATIVE AIR HANDLING UNITS

PART 1 - GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.2 SUMMARY

A. Variable-air-volume, direct evaporative computer room air handling units (ICM’s).

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods

B. Section 230593: Testing, Adjusting and Balancing

C. Section 230902: Variable Frequency Drives (VFD)

D. Division 26: Electrical

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event]."

1.5 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide air handling units that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Certifications: Provide certified ratings of units based on tests performed in accordance with ARI 430, "Central-Station Air Handling Units."

C. Codes and Standards: Provide air handling units conforming to the requirements of the latest addition of the following:

1. Air Movement and Control Association (AMCA):

    a. 99 - Standards Handbook
    b. 210 - Laboratory Methods of Testing Fans for Rating [Unit shall bear AMCA Certified Rating Seal]
    c. 300 - Reverberant Room Method for Sound Testing of Fans [Unit shall bear AMCA Certified Rating Seal]
    d. 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data
    e. 500 - Test Method for Louvers, Dampers, and Shutters

2. American National Standards Institute (ANSI):

    a. 9 - Load Ratings and Fatigue Life for Ball Bearings
    b. 11 - Load Ratings and Fatigue Life for Roller Bearings
    c. 900 - Test Performance of Air Filter Units

3. Air-Conditioning, Heating and Refrigeration Institute (AHRI):

    a. 410 - Forced-Circulation Air-Cooling and Air-Heating Coils
    b. 430 - Central-Station Air-Handling Units

4. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

    a. 15 - Safety Code for Mechanical Refrigeration

5. National Electrical Manufacturers Association (NEMA): Except for motors, provide electrical components required as part of air handling units, which comply with NEMA Standards.
6. National Fire Protection Association (NFPA): Provide air handling unit internal insulation having flame spread rating not higher than 25 and smoke developed rating not higher than 50:

    a. 70 - National electrical Code
    b. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems
    c. 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems

7. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Comply with applicable SMACNA standards including "HVAC Duct Construction Standards - Metal and Flexible."
8. Underwriters Laboratories, Inc. (UL): Except for motors, provide electrical components required as part of air handling units, which have been listed and labeled by UL.
9. Units shall be listed and labeled by either UL or ETL for air handler construction.

1.6 SOURCE QUALITY CONTROL

A. Equipment Qualification

1. Prior to unit shipment, the following qualifications shall be performed and documented:

   a. All fans shall be balanced and factory run tested to ensure design integrity.
   b. All bearings shall be provided with a full complement of grease.
   c. All factory piping shall be leak tested to ensure integrity.
   d. All electrical circuits shall be tested to ensure correct operation.

B. Sound Power Verification and Certification

1. The manufacturer shall perform a sound test on one selected AHU in accordance with AMCA Standard 300-96, Reverberant Room Method for sound testing of fans, and AMCA Standard 210, Laboratory Methods of Testing Fans for rating. The mechanical engineer shall select the test AHU after review of the submittal.
2. If the AHU manufacturer is incapable of performing the AMCA Standard 300 sound test, a substitute method shall be proposed for review by the mechanical engineer. The proposed substitute method shall clearly identify the measurement instrumentation, the reference to a nationally known test standard and the qualifications of personnel who will perform the test.
3. Sound power data determined from computer simulation and not from actual unit test shall not be considered.
4. When completed, the tested air handling unit sound power data shall be submitted for review by the Owner's representative. Sound power data shall be given for the supply air connection(s), return air connection(s) and for the radiated sound power from the cabinet.
5. The mechanical and acoustical engineers, and the owner, shall be allowed to witness the sound test. The AHU manufacturer shall notify the mechanical engineer a minimum of ten (10) days prior to test as to the location and date of the sound test. The travel costs incurred by test witnesses shall be borne by the equipment manufacturer. Sound testing shall be performed at the same time as other required unit tests.
6. If the sound test indicates the AHU noise levels exceed the levels specified, the Contractor shall take corrective measures to reduce the sound. Any modifications that are necessary to meet scheduled sound levels shall be applied to all AHU's represented by the test unit. Test results shall be submitted to the Owner's Representative for approval prior to shipment of any equipment.

C. Air Delivery Testing

1. The manufacturer shall perform an air performance test on one selected unit in accordance to AMCA 210-85/ANSI 51-1985 "Standard for Laboratory Measurement of Airflow". Air handling unit air performance data shall be submitted for review by the Owner's representative.
2. The mechanical engineer shall be allowed to witness the airflow test. The AHU manufacturer shall notify the mechanical engineer a minimum of ten (10) days prior to test as to the location and date of the test. The travel costs incurred by test witnesses shall be borne by the equipment manufacturer. Air delivery testing shall be performed at the same time as other required unit tests.

D. Vibration

1. The manufacturer shall provide a baseline vibration test. Baseline vibration levels will be provided to the owner with O&M manuals. Vibration readings denoting failure mode will also be submitted as part of O&M manuals. Vibration data is to be used for predictive maintenance purposes.

2. Each of the AHU fans will have vibration sensors installed as a permanent installation and shall, through the BMS system, provide vibration feedback.

E. Cabinet Air Leakage and Deflection Testing

1. Manufacturer must have a documented quality control procedure that includes random, ongoing cabinet leak testing within the factory. Criteria for random testing shall be a minimum SMACNA Class 5 performance.
2. An air handling unit air leakage test shall be performed on the selected test unit and the data submitted for review by the Owner's representative. Test criteria shall be SMACNA Class 5 performance or better. The mechanical engineer shall be allowed to witness the leakage test. The AHU manufacturer shall notify the engineer a minimum of ten (10) days prior to test as to the location and date of the test. A copy of the test procedure shall be provided to the engineer for review prior to the test. The travel costs incurred by test witnesses shall be borne by the equipment manufacturer. Cabinet air leakage testing shall be performed at the same time as other required unit tests.
3. A unit deflection test that confirms submitted criteria shall be performed in conjunction with the cabinet air leakage test.

1.7 PRODUCT SUBSTITUTIONS

A. **The Contractor shall certify the following items are correct when using substituted products other than those scheduled or shown on the drawings as a basis of design:**

1. The proposed substitution does not affect dimensions shown on drawings.
2. The Contractor shall pay for changes to building design, including engineering design, detailing, structural supports, and construction costs caused by proposed substitution.
3. The proposed substitution has no adverse effect on other trades, construction schedule, or specified warranty requirements.
4. Maintenance and service parts available locally are readily obtainable for the proposed substitute.

B. The Contractor further certifies function, appearance, and quality of proposed substitution are equivalent or superior to specified item.

C. The Contractor agrees that the terms and conditions for the substituted product that are found in the contract documents apply to this proposed substitution.

1.8 ACTION SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for air handling units showing

1. Dimensions and weights. Unit plans and elevations. Size and exact dimensions to all points of connection
2. Cabinet material, metal thickness, finishes, insulation, and accessories.
3. Fan including:

   a. Certified fan-performance curves with system operating conditions indicated.
   b. Certified fan-sound power ratings.
   c. Fan construction and accessories.

d. Motor ratings, electrical characteristics, and motor accessories.
e. Fan assembly vibration and balance test report.

4. Certified performance ratings with system operating conditions indicated.
5. Retain both subparagraphs below if items are furnished as parts of air-handling units.
6. Dampers, including housings, linkages, and operators.
7. Filters with performance characteristics.
8. Wiring diagrams for power, signal and control wiring. All electrical requirements for power to the AHU.

B. Shop Drawings: Submit shop drawings showing unit dimensions, weight loadings, required clearances, field connection details and methods of support. Draw to a scale of one half inch to one foot. Include field fabricated mixing boxes, dampers and duct connections.

C. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals. Provide as part of submittal a recommended spare parts list.

1.9 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For air-handling units, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

C. Field quality-control reports.

1.10 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Deliver unit to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect unit against dirt, water, chemical, and mechanical damage. Do not install damaged unit - remove from project site.

1.12 START-UP SERVICE

A. A manufacturer trained service engineer shall provide factory start-up supervision for each air-handling unit. Physical connections and start-up services are to be performed by the installing contractor.

B. Manufacturer shall provide complete Installation, Operation & Maintenance manuals at time of shipment for each air handler.

1.13 WARRANTY

A. Provide one-year (12 months) warranty from date of startup or 18 months from date of shipment, whichever occurs first. The manufacturer's warranty shall include parts and labor to provide factory authorized service. Please provide the owner a cost (acceptance to be determined later) of an additional 3 years of warranty.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Scheduled Manufacturer or approved equal by Emerson, United Metal, Alliance, Energy Labs, Haakon Industries, Silent-Air or BASX Solutions. By listing manufacturers it is not intended to imply that their standard construction is approved or that they are equal. All manufacturers must meet, or exceed, minimum requirements of these specifications and all other standard or optional features provided by the scheduled basis of design air handler.

2.2 DIRECT EVAPORATIVE AIR COOLERS

F. General: The direct evaporative cooling unit shall be a factory assembled package, complete with direct evaporative media, supply air fans, intake and outlet openings, water distribution manifold and nozzles, overflow, and drain.

G. Cabinet

1. Cabinets shall be constructed in a water and airtight manner and shall have a leakage performance equal or better than SMACNA Class 5.
2. Units shall comply with UL1995 and NFPA90.
3. Units shipping in multiple sections shall be designed for ease of field joining. Field joining shall be accomplished using instructions and materials supplied by the unit manufacturer, and shall be capable of providing a factory quality seal.

H. Base

1. Each unit shall be constructed on a base fabricated from ASTM A36 welded structural steel channel. Tubular or formed bases are not acceptable.
2. To provide adequate strength and L/200 rigidity for uniform lifting, bases shall be sized as a function of air handling unit length as follows:

AHU UNIT LENGTH	MINIMUM BASE CHANNEL SIZE
Up to 10’	4” x 1 5/8” (5.4lbs/lin. ft.)

11’ to 20’	6” x 2” (8.2lbs/lin. ft.)
21’ to 30’	8” x 2 1/2 (11.5lbs/lin. ft.)
41’ and longer	12” x 3” (20.7lbs/lin. ft.)

3. Heavy duty lifting lugs shall be added to the perimeter channel along the longest length of the unit to facilitate hoisting and field attachment to the building structure. After fabrication, the base frame shall be thoroughly cleaned, primed and painted with an industrial grade, high solids polyurethane paint. The paint system shall meet ASTM B117 salt spray test criteria for a minimum of 2,000 hours.
4. The unit floor shall be fabricated of 14-gauge G90 galvanized steel sheets. Walking areas shall be covered by non-slip 0.125” tread plate. Flooring shall be supported by structural and 12-gauge formed galvanized steel members spaced on 24”, or closer, centers. Floor support members shall be welded for maximum strength. The entire floor shall be insulated with water impervious foam, minimum R14 total insulating value protected by a G90 galvanized steel under liner. Glass fiber insulation is not acceptable.
5. Floor sheets shall maintain a water and airtight seal and be capable of supporting a 300lb. load with maximum L/200 deflection at any floor seam. Flooring shall be mechanically attached and feature a true thermal break. Floor drains shall be provided in sections as indicated on the Plan drawings. All floor openings shall include a 12 gauge galvanized steel flange around the entire perimeter duct connection. Floor openings larger than 8”x8” shall be covered with galvanized steel grating designed to support a minimum of 100lbs/sq. ft. No fastener penetrations thru the floor sheets shall be acceptable.

I. Housing

1. Cabinet shall utilize a modular panel type construction.
2. Exterior wall and roof panels shall feature a Class A thermal break and shall be constructed of 20-gauge galvanized steel with a mill applied, industrial grade, high solids polyurethane paint. Paint shall provide a durable, “wet look” finish with excellent color and gloss retention, shall meet ASTM B117 salt spray performance criteria for a minimum rating of 1,000 hours, and shall be covered by a 10 year manufacturer’s limited warranty.
3. All panels shall be securely attached to each other, to the roof, and to the base and all seams shall be sealed to create a water and airtight assembly.
4. Wall and roof panel insulation shall be 2” thick (R-14 minimum), moisture resistant polyisocyanurate foam protected by a solid interior liner.
5. Inner liners shall be 20-gauge galvanized steel with a mill applied, industrial grade, high solids polyurethane paint.
6. Paint shall provide a durable finish and gloss retention, shall meet ASTM B117 salt spray performance criteria for a minimum rating of 1,000 hours, and shall be covered by a 10 year manufacturer’s limited warranty.
7. Air handling unit housing shall meet NFPA 90A smoke and flame spread limits.

J. Doors

1. Hinged, double wall, man size access doors shall be provided in all sections requiring access for maintenance or service as indicated in the Plan documents.
2. Door thickness, insulation and exterior and interior materials shall match those of its associated section.
3. The door frame shall be extruded aluminum.
4. All doors installed downstream of the cooling coil shall exhibit a Class A thermal break.

5. Access doors shall be fully sealed with a dual set of closed cell, replaceable neoprene gasket. Door gasket shall be installed to allow for easy removal and replacement in case of damage.
6. Door hinges and latches shall be adjustable, without the use of shims or special tools. Hinges shall be stainless steel or cast aluminum.
7. Provide door detail drawings with submittal package.
8. Door handles shall be composite, fiber reinforced nylon equal to those by Allegis Corporation. The latch mechanism shall be a thermal break assembly which can be operated from outside or inside of the cabinet.
9. Doors shall open against pressure or shall include a built-in safety catch to release cabinet operating pressure prior to opening the door.
10. Fan section door(s) shall be equipped with a switch interlocked with the fan starter to stop the fan before the access door is opened.
11. Include a capped pressure test port in each door.
12. Include an 8” x 12” wire reinforced double pane glass view window in each fan and coil access door.

K. Fan Assembly

1. Fans shall be of the size and type shown in the project Schedule and shall perform as indicated. The fan wheel diameter shall not be less than that shown on the equipment schedule. Fans shall be constructed to AMCA Standards for the Class Rating as indicated on the Equipment Schedule.
2. Fan performance shall be adjusted to reflect fans running inside the cabinet so as to include any affects from the unit cabinet and other internal components.
3. Fan and motor shall be mounted on an internal, fully welded, rigid steel assembly. Each individual fan assembly shall be free-floating at all four corners on minimum 2” deflection spring type isolators with earthquake restraints. The spring isolators shall be mounted to structural steel members and shall be rated for a minimum of 1G. The fan discharge shall be isolated from the cabinet by means of a neoprene-coated flexible connection.
4. Manufacturers who submit on units without individually spring isolated fans must provide comparable isolation for the entire air handling unit. In addition, the purchasing contractor will be responsible for all additional costs associated with providing external isolation including, but not limited to, the cost of external pipe, conduit and duct flexible connections. Units utilizing non-spring isolated fans shall be furnished with one spare, factory balanced fan/motor assembly to allow the unit to operate at 100% design conditions should a fan need to be returned to the factory for motor replacement, repair or rebalancing.
5. An overhead motor removal rail shall be provided. The rail shall be sized for the specific motor weight and be labeled accordingly.

L. Direct Drive Fans

1. Multiple Arrangement #4 plenum fan assemblies shall be provided. Fans shall be arranged to provide even air distribution within the unit cabinet. Minimum/maximum fan quantity shall be as indicated in the project Schedule. Total fan BHP and motor HP shall not be exceeded. Scheduled motor efficiencies are considered to be the minimum allowed.
2. Individual fan performance shall be based on tests run in an AMCA certified laboratory and administered in accordance with AMCA Standards 210 and 300. Fans shall be licensed to bear the AMCA seal for air and sound performance. Submitted fan

performance shall be adjusted to reflect multiple fans running inside the cabinet and to reflect any affects from the unit cabinet and other internal components. Fans shall be minimum Class 2 or Class 3 construction as shown on the Schedule.

3. The fan wheel shall be aluminum with extruded aluminum airfoil blades continuously welded to the fan side plates. The fan back plane shall be bolted to a cast aluminum fan hub with keyway. Fans not using airfoil blades, or using steel construction, will not be considered. Fan inlets shall be isolated from the cabinet by means of a neoprene-coated flexible connection.
4. Motors shall be either be EBM Pabst EC motors or premium AC efficiency to meet or exceed the requirements in EISA 2007. AC Motors shall be TEFC, NEMA frame, cast iron casing, ball bearing type complete with grease lubricated bearings and zerk fittings for field lubrication. AC Motors shall have a NEMA Class F insulation rating with Class B temperature rise, and have a 1.15 service factor. BHP values as shown on the Schedule are considered the maximum allowable.
5. Fans shall be provided with thrust restraints.
6. Each fan shall be mounted into its final intended assembly and balanced to ISO Standard BV5. A copy of the balance test data, including a balance nomograph, shall be made available to the engineer and owner at time of unit shipment. Balance reports where the fan & motor assemblies are balanced on a test fixture, and not in point of use, will not be accepted.
7. Each motor shall be provided with a shaft grounding device that will bleed potential induced motor shaft voltage to ground.
8. For the safety of service personnel, provide inlet screens.
9. Each fan shall be provided with sound absorbing acoustic baffles that do not extend unit cabinet length. Sound attenuation shall be included in the Schedule values for unit sound performance.
10. Multiple fan arrays shall be provided with one manually installed shut off plate per array. Shut off plate to be used in the event of a motor failure to prevent air bypass through the off fan.

M. Direct Evaporative Cooling Media

1. The direct evaporative media shall consist of GLASdek, as manufactured by Munters Corporation. This media shall be made from large glass fibers bounded together by inorganic, non-crystal line fibers to provide the maximum evaporation with a minimum of deposition of solids. It shall be UL approved with a UL900, class 2 rating. Required for ETL listing.
2. The media shall not experience water carryover at air velocities below 700 feet per minute.

N. Water Distribution System

1. The water distribution manifold shall be constructed of copper piping.
2. The spay nozzles shall be brass, designed to provide uniform distribution over the entire heat exchanger.
3. The water make-up valve shall have a brass body with an adjustable float valve.
4. The water distribution system to include an overflow, a drain connection, and an adjustable bleed valve to prevent buildup of solids.
5. Solenoid valves shall be provided as scheduled for staging control of the media.
6. Water circulating pump shall be external to the unit and furnished by others. The performance, size, and electrical characteristic of the pump shall be as scheduled to meet the water requirements of the direct evaporative media.

7. Water distribution system and nozzles shall be protected with inline cleanable strainer. Strainer shall have type 304 stainless-steel screen.
8. Each AHU will be supported with (1) water zones. Each zone will be turned off/on through the controls system. Each water zone will be provided with its own solenoid control with a water balancing valve for adjustable water flow. Each water zone is to be controlled individually.

O. Bypass Dampers

1. Dampers shall be supplied with ultra-low leak extruded 6063T5 aluminum airfoil blades.
2. Blades shall be supplied with dual durometer, Santoprene™, bulb type edge seals and stainless steel arc end seals.
3. Edge seals shall be backed by the damper blade to assure a positive seal in the closed position.
4. Dampers shall be provided with nylon bearings within extruded openings.
5. Damper leakage shall not exceed 6 CFM/ft2 at 5.0” of static pressure. Leakage rating shall be determined by testing performed in accordance with AMCA Standard 500, figure 5.5, and tests shall have been performed by an independent testing laboratory.
6. 100% outdoor air section dampers shall be opposed blade type sized for not greater than 1200 fpm face velocity based upon gross damper area.
7. Furnish full height, 24” wide access doors for damper and linkage service.

P. Electrical Power Service

1. Fan motors shall be factory wired to a motor control center with flexible conduit of adequate length so that it will not affect vibration isolation.
2. Motor control center shall include motor overload protection, short circuit protection, manual disconnecting means and a power distribution block for connection to the VFD. Or each fan motor shall be factory wired to an individual factory supplied VFD using flexible conduit of adequate length so that there is no impact on vibration isolation.
3. Provide single source power panels (SSPP) that are constructed to NEC regulations and carry a UL 508 listing. Panels shall be NEMA 3R and shall have door(s) for direct access to the electrical components. Panels shall be surface mounted.
4. Separate panels shall be provided; one for the supply air fan(s) and low voltage controls and one for the return air fan(s). Panels shall have a minimum Short Circuit Capacity Rating (SCCR) of 25,000amps.
5. Each panel shall include an externally operated non-fused main disconnect switch and a 1.5KVA, 115V transformer.
6. Wiring shall be clearly labeled to allow for ease of final field connections, and shall be run in EMT conduit. Raceways are not acceptable.
7. The air handling unit manufacturer, for the purpose of sole source responsibility, shall manufacture all electrical panel assemblies supplied for the air handlers. The air handling unit manufacturer shall be a UL 508 listed panel shop.

Q. Unit Controls

1. To facilitate field control wiring, the air handling unit manufacturer shall install empty, matching junction boxes on the interior and exterior of each section as indicated on the project drawings. External junction boxes shall be connected by 3/4” EMT conduit, terminating at a sheet metal enclosure mounted on the air handling unit. Conduit to the interior boxes shall be the responsibility of the controls contractor. Units that require field cutting or drilling of the unit panels to install conduit are not acceptable.

R. Lights

1. Provide factory installed marine type light fixtures in each air handling unit section serviced by a door. Cabinets wider than 14' shall have two fixtures per section. Fixtures to be factory wired to a single toggle switch located on the unit exterior at the supply fan section door. A 15 amp GFCI convenience outlet shall be mounted with the light switch. The electrical installer/contractor shall bring a separate 120/60/1 power service to operate the GFCI and lighting circuit. Lamps to be mini-fluorescent.

S. Variable Frequency Drives

1. Variable frequency drives (VFD) shall be provided as shown on the Schedule.
2. All VFDs and their associated options shall be UL508 listed, and shall comply with the applicable requirements of the latest standards of ANSI, NEMA, National Electric Code (NEC), NEPU-70, IEEE 519-1992, FCC Part 15 Subpart J, and CE96.
3. VFDs mounted in a NEMA 12 enclosure shall be UL™ listed for plenum mounting.
4. The variable frequency drive(s) shall be surface mounted on the unit exterior in a NEMA 3R box. All mounting hardware and wiring shall be provided by the AHU manufacturer with the drives shipped loose for field installation.

T. Unit Piping

1. Evaporative water supply, drain and overflow connections shall be factory piped to the unit exterior.
2. Connection penetrations shall be factory sealed at the inside and exterior surfaces of the panel.
3. All pipe insulation shall be supplied and installed in the field by the piping contractor and shall match that used on external piping.

U. Louvers

1. Louvers are to be integrated with the air handlers. Louvers shall be provided with the following minimum specifications:

   a. Louvers to be 6" deep, 35° drainable fixed blade design, constructed of galvanized steel or extruded aluminum, or as specified on the plans.
   b. Frames to be constructed of 6" deep channel, aluminum or galvanized steel.
   c. Provide with 1/4" x 0.047 aluminum mesh birdscreen mounted on backside of louver.
   d. Finish/color per architect/engineer's review of manufacturers color chart or custom color matching if required.
   e. Manufacturer: Greenheck ESD-635 or equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Install in accordance with manufacturer's instructions.

B. Examine site to verify if site is ready to receive work. Provide a layout drawing of air handler and fan locations to electrical installer.

C. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

D. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Air Handler Mounting:

1. Base Mounted: Install air-handling units on equipment base as described and specified elsewhere

   a. Concrete: Comply with requirements for equipment bases and foundations specified in Division 03.
   b. If return fans are configured to drawing inlet air from a raised curb, curb access must be provided for field installation and service of measuring devices and smoke detectors.

2. Isolation and Seismic Control: Comply with requirements for vibration isolation and seismic control devices.
3. Arrange installation of units to provide access space around air-handling units for service and maintenance.
4. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
5. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.3 CONNECTIONS

A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

B. Comply with requirements for piping specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

C. Install piping adjacent to air-handling unit to allow service and maintenance.

D. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233113 - Air Distribution.

F. Control installers shall install all wiring associated with control signals into the air handlers.

G. Electrical installer shall install all line voltage power wiring and conduit. Coordinate with Division 26 work.

3.4 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that zone dampers fully open and close for each zone.
7. Verify that face-and-bypass dampers provide full face flow.
8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
9. Install new, clean filters.
10. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

C. Adjusting

1. Adjust damper linkages for proper damper operation.
2. Comply with requirements in Section 230593 - Testing, Adjusting, and Balancing for air-handling system testing, adjusting, and balancing.

D. Cleaning

1. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

E. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237454

APPENDIX C

Emissions Calculation Summary Tables

TABLE C-1
ANNUAL OPERATION EMISSIONS
PROJECT GENESIS
QUINCY, WASHINGTON

		Operating Assumptions			
	Generator Size	2.0 MW		2.75 MW	
	Operating Conditon	Cold-start	Warm	Cold-start	Warm
Number of events per year	Monthly Maintenance Testing	12	12	12	12
	Annual Load Testing	1	1	1	1
	Emergency Power Outage	3.5	3.5	3.5	3.5
Duration of each event (hours)	Monthly Maintenance Testing	0.02	0.98	0.02	0.98
	Annual Load Testing	0.02	3.98	0.02	3.98
	Emergency Power Outage	0.02	23.98	0.02	23.98
Hours at each runtime mode	Monthly Maintenance Testing	0.20	11.80	0.20	11.80
	Annual Load Testing	0.02	3.98	0.02	3.98
	Emergency Power Outage	0.06	83.94	0.06	83.94
Operating Hours per Year (per Genset)		**0.3**	**99.7**	**0.3**	**99.7**
		Worst-case (≤100% Load) Emission Rate (lb/hr)			
Worst-case (≤100% Load) Emission Rate	HC	4.9	1.1	12.4	2.9
	NOx	42	44	70	74
	CO	45	5.0	129	14
	SO_2	2.9E-02		4.4E-02	
	DEEP	3.8	0.88	3.9	0.91
	PM (FH+BH)	9.7	2.3	20	4.6

		Facility Wide Emission (Tons / year)	
Project Annual Emissions	Generator Size	2.0 MW	2.75 MW
	No. Generators (Total)	20	5
	total VOCs	1.9	
	NOx	63	
	CO	8.8	
	SO2	1.1E-04	
	DEEP	1.1	
	PM (FH+BH)	3.4	

	Regulatory Demonstration	AERMOD INPUT (lb/hr) per Genset	
INDIVIDUAL GENSET Annually Averaged Modeling Setup	Generator Size	2.0 MW	2.75 MW
	NOx (annual) NAAQS	0.51	0.85
	SO2 (annual) NAAQS	3.3E-04	5.1E-04
	DEEP ASIL*	1.0E-02	1.0E-02
	PM10/PM2.5 (annual) NAAQS	2.6E-02	5.3E-02
	Acrolein (ASIL)	1.6E-02	2.3E-02
	Worst-case Exhaust Temp. (°F)	531	577
	Worst-case Exhaust Flow (cfm)	4,478	5,802

* Model was used to develop dispersion factors for estimating annual impacts of benzene, 1,3-butadiene, acrolein, and napthalene.

TABLE C-2
AERMOD SUMMARY
PROJECT GENESIS
QUINCY, WASHINGTON

AERMOD INPUT (1-hour Average)
Event: 1-hour Unplanned Power Outage

	Operating Assumptions (≤100%)			
Generator Size	2.0 MW		2.75 MW	
Operating Condition	Cold-start	Warm	Cold-start	Warm
Number of events	1	1	1	1
Duration of each event (hours)	0.02	0.98	0.02	0.98
Hours at each runtime mode	0.02	0.98	0.02	0.98
Number of engines operating concurrently	20		5	
Regulatory Demonstration	**AERMOD SETUP (lb/hr)**			
NO_2 ASIL	44		74	
Load Specific Exhaust Temp. (°F)	897		879	
Load Specific Exhaust Flow (cfm)	15,515		20,134	
CO (1-hour) NAAQS / ASIL	5.7		16	
Load Specific Exhaust Temp. (°F)	829		866	
Load Specific Exhaust Flow (cfm)	7,212		20,121	
SO_2 (1-hour, 3-hour, 24-hour) NAAQS	2.9E-02		4.4E-02	
Load Specific Exhaust Temp. (°F)	897		892	
Load Specific Exhaust Flow (cfm)	15,515		25,620	

* Model was used to develop dispersion factors for estimating 1-hour impacts of benzene, 1,3-butadiene, acrolein, and napthalene.

AERMOD INPUT (8-hour Average)
Event: 8-hour Unplanned Power Outage

	Operating Assumptions (≤100%)			
Generator Size	2.0 MW		2.75 MW	
Operating Condition	Cold-start	Warm	Cold-start	Warm
Number of events	1	1	1	1
Duration of each event (hours)	0.02	7.98	0.02	7.98
Hours at each runtime mode	0.02	7.98	0.02	7.98
Number of engines operating concurrently	20		5	
Regulatory Demonstration	**AERMOD SETUP (lb/hr)**			
CO (8-hour) NAAQS	5.1		15	
Load Specific Exhaust Temp. (°F)	829		866	
Load Specific Exhaust Flow (cfm)	7,212		20,121	

AERMOD INPUT (24-hour Average)
Event: 24-hour Unplanned Power Outage

	Operating Assumptions (≤100%)			
Generator Size	2.0 MW		2.75 MW	
Operating Condition	Cold-start	Warm	Cold-start	Warm
Number of events	1	1	1	1
Duration of each event (hours)	0.02	11.98	0.02	11.98
Hours at each runtime mode	0.02	11.98	0.02	11.98
Number of engines operating concurrently	20		5	
Regulatory Demonstration	**AERMOD SETUP (lb/hr)**			
PM_{10} (24-hour) NAAQS	1.1		2.3	
Load Specific Exhaust Temp. (°F)	828		649	
Load Specific Exhaust Flow (cfm)	9,685		6,902	

	Operating Assumptions (≤100%)			
Generator Size	2.0 MW		2.75 MW	
Operating Condition	Cold-start	Warm	Cold-start	Warm
Number of events	1	1	1	1
Duration of each event (hours)	0.02	23.98	0.02	23.98
Hours at each runtime mode	0.02	23.98	0.02	23.98
Number of engines operating concurrently	20		5	
Regulatory Demonstration	**AERMOD SETUP (lb/hr)**			
Acrolein ASIL	1.6E-04		2.3E-04	
Load Specific Exhaust Temp. (°F)	654		649	
Load Specific Exhaust Flow (cfm)	10,139		6,902	

Event: Monthly Maintenance Testing

Source	Genesis (1x 2.75 MW)
Regulatory Demonstration	**AERMOD SETUP (lb/hr)**
NO2 (1-hour) NAAQS	74
Load Specific Exhaust Temp. (°F)	879.0
Load Specific Exhaust Flow (cfm)	20,134
Stack Diameter (ft)	2
Release Hieght (ft)	42

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Event: Monthly Maintenance Testing

Source	Genesis (1x 2.75 MW)
Regulatory Demonstration	**AERMOD SETUP (lb/hr)**
PM2.5 24-hour NAAQS	3.2 *
Load Specific Exhaust Temp. (°F)	649.3
Load Specific Exhaust Flow (cfm)	6,902
Stack Diameter (ft)	2
Release Hieght (ft)	42

* Based on 8 hours of operation in a day.

APPENDIX D

Derivation of Cold-Start Emission Factors

DIESEL GENERATOR "COLD START SPIKE" ADJUSTMENT FACTORS

Short-term concentration trends for VOC, CO and NOx emissions immediately following a cold start by a large diesel backup generator were measured by the California Energy Commission in their document entitled Air Quality Implications of Backup Generators in California, dated July 2005. They used continuous monitors to measure the following trends, which are shown in the attached figure.

As shown in the following figure, during the first 14 seconds after a cold start, the VOC concentration spiked to a maximum value of 900 ppm before dropping back to the steady state value of 30 ppm. The triangular area under the measured 14-second concentration-vs-time curve represents a "VOC spike" of 6,300 ppm-seconds.

On the other hand, the NOx concentration did not "spike". To the contrary, it took 8 seconds for the NOx concentration to ramp up from the initial value of zero to its steady state value of 38 ppm. The area under the concentration-vs-time curve represents the "NOx deficit" of 160 ppm-seconds.

The California Energy Commission was unable to measure the time trend of DPM concentrations during the first several seconds after a cold start. Therefore, for purposes of estimating the DPM trend, it was assumed that DPM would exhibit the same concentration-vs-time trend as VOC emissions.

The numerical value of the Cold Start Spike Adjustment Factor was derived by dividing the area under the "cold start spike" by the area under the steady-state concentration profile for the 1-minute averaging period.

Example: Cold Start Spike Factor for VOC, first 1-minute after cold start at low load.

The "VOC spike" was measured 14-second after cold start and reached a concentration of 6,300 ppm-seconds. The triangular area under the curve is $\frac{14\text{ seconds } \times 900\ ppm}{2} = 6{,}300$ *ppm-seconds*.

The steady-state VOC concentration is 30 *ppm*. For the 1-minute (60-seconds) steady-state period the area under the curve is $(60\ seconds - 14\ seconds) \times 30\ ppm\ = 1{,}380$ *ppm-seconds.*

Therefore, the cold-start emission factor (to be applied to the warm-emission rate estimate for the first 1-minute after cold-start) is expected to be $\frac{6{,}300\ ppm{-}seconds + 1{,}380\ ppm{-}seconds}{30\ ppm \times 60\ seconds}$.

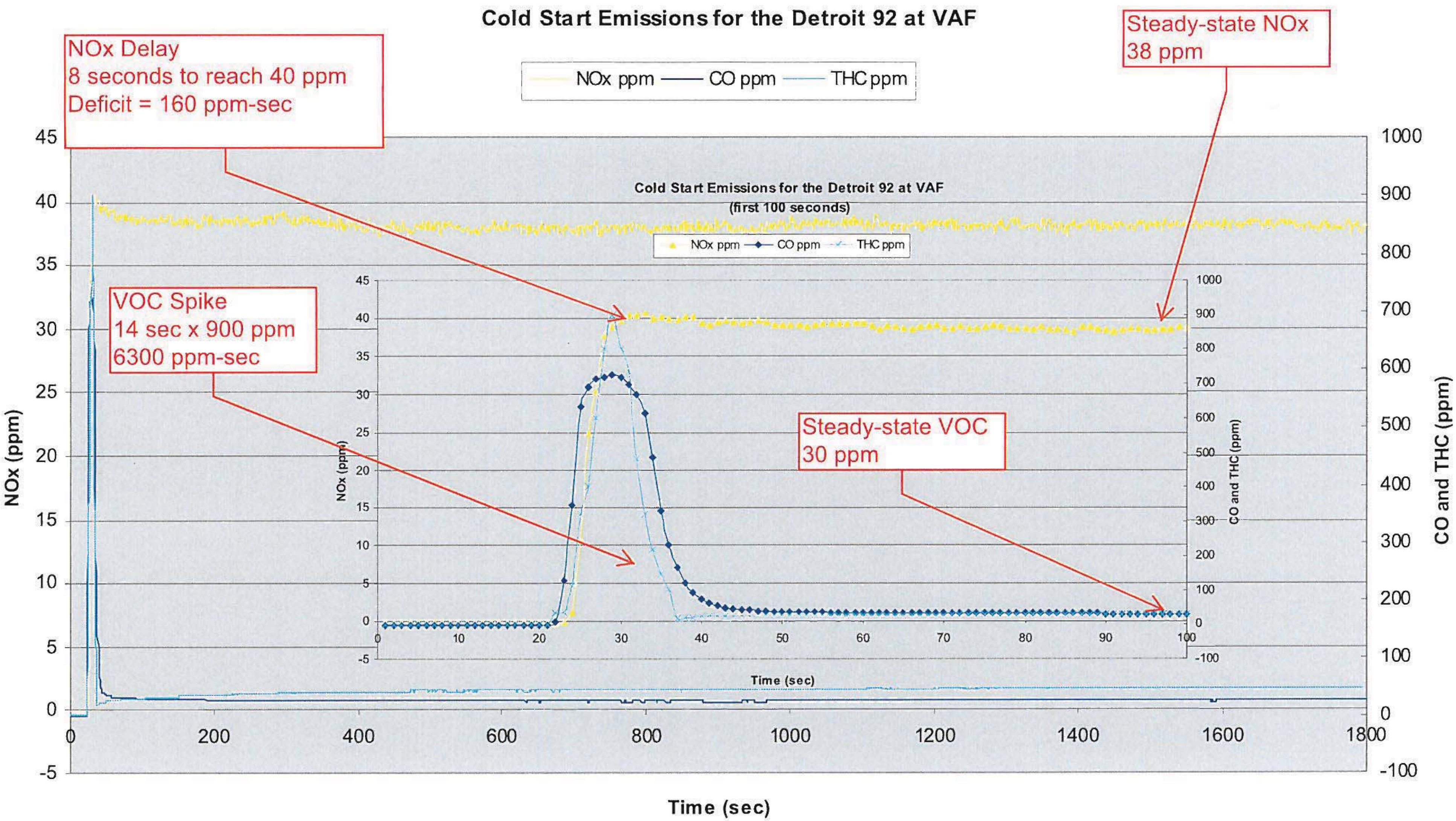

Figure 19. Cold-start emissions for CO and NO_X as a function of time

APPENDIX E

Best Available Control Technology Cost Summary Tables

APPENDIX E-1
DOC-CAPITAL COST
PROJECT GENESIS
QUINCY, WASHINGTON

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
2750 kWe emission control package	Cost estimate by Cummins		5	$54,000	$270,000
2750 kWe miscellaneous parts	Cost estimate by Cummins			$3,667	$18,333
2000 kWe emission control package	Cost estimate by Cummins		20	$32,000	$640,000
2000 kWe miscellaneous parts	Cost estimate by Cummins			$3,667	$73,333
Combined systems FOB cost					$1,001,667
Instrumentation	Assumed no cost		0	$0	$0
Sales Tax	WA state tax	WA state tax	6.5%	--	$65,108
Shipping	0.05A	EPA Cost Manual	5.0%	--	$50,083
Subtotal Purchased Equipment Cost (PEC)					$1,116,858
Direct Installation Costs					
Enclosure structural supports	Assumed no cost		0	$0	$0
On-site Installation	Cost estimate by EKI Solutions Group (contractor)		25	$12,000	$300,000.00
Electrical	Assumed no cost		0	$0	$0
Piping	Assumed no cost		0	$0	$0
Insulation	Assumed no cost		0	$0	$0
Painting	Assumed no cost		0	$0	$0
Subtotal Direct Installation Costs (DIC)					$300,000
Site Preparation and Buildings (SP)	Assumed no cost		0	$0	$0
Total Direct Costs, (DC = PEC + DIC + SP)					$1,416,858
Indirect Costs (Installation)					
Engineering	0.025*PEC	1/4 of EPA Cost Manual	2.5%	--	$27,921
Construction and field expenses	0.025*PEC	1/2 of EPA Cost Manual	2.5%	--	$27,921
Contractor Fees	From DIS data center	From DIS data center	6.8%	--	$94,955
Startup	0.02*PEC	EPA Cost Manual	2.0%	--	$22,337
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$11,169
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$33,506
Subtotal Indirect Costs (IC)					$217,810
Total Capital Investment (TCI = DC+IC)					$1,634,668

APPENDIX E-2
DPF-CAPITAL COST
PROJECT GENESIS
QUINCY, WASHINGTON

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
2750 kWe emission control package	Cost estimate by Cummins		5	$130,000	$650,000
2750 kWe miscellaneous parts	Cost estimate by Cummins			$3,667	$18,333
2000 kWe emission control package	Cost estimate by Cummins		20	$100,000	$2,000,000
2000 kWe miscellaneous parts	Cost estimate by Cummins			$3,667	$73,333
Combined systems FOB cost					$2,741,667
Instrumentation	Assumed no cost		0	$0	$0
Sales Tax	WA state tax	WA state tax	6.5%	--	$178,208
Shipping	0.05A	EPA Cost Manual	5.0%	--	$137,083
Subtotal Purchased Equipment Cost (PEC)					$3,056,958
Direct Installation Costs					
Enclosure structural supports	Assumed no cost		0	$0	$0
On-site Installation	Cost estimate by EKI Solutions Group (contractor)		25	$12,000	$300,000.00
Electrical	Assumed no cost		0	$0	$0
Piping	Assumed no cost		0	$0	$0
Insulation	Assumed no cost		0	$0	$0
Painting	Assumed no cost		0	$0	$0
Subtotal Direct Installation Costs (DIC)					$300,000
Site Preparation and Buildings (SP)	Assumed no cost		0	$0	$0
Total Direct Costs, (DC = PEC + DIC + SP)					$3,356,958
Indirect Costs (Installation)					
Engineering	0.025*PEC	1/4 of EPA Cost Manual	2.5%	--	$76,424
Construction and field expenses	0.025*PEC	1/2 of EPA Cost Manual	2.5%	--	$76,424
Contractor Fees	From DIS data center	From DIS data center	6.8%	--	$226,300
Startup	0.02*PEC	EPA Cost Manual	2.0%	--	$61,139
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$30,570
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$91,709
Subtotal Indirect Costs (IC)					$562,565
Total Capital Investment (TCI = DC+IC)					$3,919,524

APPENDIX E-3
SCR-CAPITAL COST
PROJECT GENESIS
QUINCY, WASHINGTON

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
2750 kWe emission control package	Cost estimate by Cummins		5	$240,000	$1,200,000
2750 kWe miscellaneous parts	Cost estimate by Cummins			$3,667	$18,333
2000 kWe emission control package	Cost estimate by Cummins		20	$195,000	$3,900,000
2000 kWe miscellaneous parts	Cost estimate by Cummins			$3,667	$73,333
Combined systems FOB cost					$5,191,667
Instrumentation	Assumed no cost		0	$0	$0
Sales Tax	WA state tax	WA state tax	6.5%	--	$337,458
Shipping	0.05A	EPA Cost Manual	5.0%	--	$259,583
Subtotal Purchased Equipment Cost (PEC)					$5,788,708
Direct Installation Costs					
Enclosure structural supports	Assumed no cost		0	$0	$0
Onsite Installation	Cost estimate by EKI Solutions Group (contractor)		25	$14,000	$350,000.00
Electrical	Assumed no cost		0	$0	$0
Piping	Assumed no cost		0	$0	$0
Insulation	Assumed no cost		0	$0	$0
Painting	Assumed no cost		0	$0	$0
Subtotal Direct Installation Costs (DIC)					$350,000
Site Preparation and Buildings (SP)	Assumed no cost		0	$0	$0
Total Direct Costs, (DC = PEC + DIC + SP)					$6,138,708
Indirect Costs (Installation)					
Engineering	0.025*PEC	1/4 of EPA Cost Manual	2.5%	--	$144,718
Construction and field expenses	0.025*PEC	1/2 of EPA Cost Manual	2.5%	--	$144,718
Contractor Fees	From DIS data center	From DIS data center	6.8%	--	$411,240
Startup	0.02*PEC	EPA Cost Manual	2.0%	--	$115,774
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$57,887
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$173,661
Subtotal Indirect Costs (IC)					$1,047,997
Total Capital Investment (TCI = DC+IC)					$7,186,706

APPENDIX E-4
TIER 4-CAPITAL COST
PROJECT GENESIS
QUINCY, WASHINGTON

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
2750 kWe emission control package	Cost estimate by Cummins		5	$424,000	$2,120,000
2750 kWe miscellaneous parts	Cost estimate by Cummins			$11,000	$55,000
2000 kWe emission control package	Cost estimate by Cummins		20	$327,000	$6,540,000
2000 kWe miscellaneous parts	Cost estimate by Cummins			$11,000	$220,000
Combined systems FOB cost					$8,935,000
Instrumentation	Assumed no cost		0	$0	$0
Sales Tax	WA state tax	WA state tax	6.5%	--	$580,775
Shipping	0.05A	EPA Cost Manual	5.0%	--	$446,750
Subtotal Purchased Equipment Cost (PEC)					$9,962,525
Direct Installation Costs					
Enclosure structural supports	Assumed no cost		0	$0	$0
Onsite Installation	Cost estimate by EKI Solutions Group (contractor)		25	$16,000	$400,000.00
Electrical	Assumed no cost		0	$0	$0
Piping	Assumed no cost		0	$0	$0
Insulation	Assumed no cost		0	$0	$0
Painting	Assumed no cost		0	$0	$0
Subtotal Direct Installation Costs (DIC)					$400,000
Site Preparation and Buildings (SP)	Assumed no cost		0	$0	$0
Total Direct Costs, (DC = PEC + DIC + SP)					$10,362,525
Indirect Costs (Installation)					
Engineering	0.025*PEC	1/4 of EPA Cost Manual	2.5%	--	$249,063
Construction and field expenses	0.025*PEC	1/2 of EPA Cost Manual	2.5%	--	$249,063
Contractor Fees	From DIS data center	From DIS data center	6.8%	--	$693,807
Startup	0.02*PEC	EPA Cost Manual	2.0%	--	$199,251
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$99,625
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$298,876
Subtotal Indirect Costs (IC)					$1,789,685
Total Capital Investment (TCI = DC+IC)					$12,152,210

APPENDIX E-5
DOC-COST EFFECTIVENESS
PROJECT GENESIS
QUINCY, WASHINGTON

Item	Quantity	Units	Unit Cost	Subtotal
Annualized Capital Recovery				
Total Capital Cost				$1,634,668
Capital Recovery Factor, 25 yrs, 4% discount rate				0.064
Subtotal Annualized 25-year Capital Recovery Cost				$104,638
Direct Annual Costs				
Annual Admin charges	2% of TCI (EPA Manual)		0.02	$32,693
Annual Property tax	1% of TCI (EPA Manual)		0.01	$16,347
Annual Insurance	1% of TCI (EPA Manual)		0.01	$16,347
Annual operation/labor/maintenance costs: Upper-bound estimate would assume CARB's value of $0.20/hp/year and would result in $28,000/year. Lower-bound estimate would assume zero annual O&M. Mid-range value would account for fuel for pressure drop, increased inspections, periodic OEM visits, and the costs for Ecology's increased emission testing requirements. **For this screening-level analysis we assumed the lower-bound annual O&M cost of zero.**				$0
Subtotal Direct Annual Costs				$65,387
Total Annual Cost (Capital Recovery + Direct Annual Costs)				**$170,025**
Uncontrolled Emissions (Combined Pollutants)				52.6
Annual Tons Removed (Combined Pollutants)				3.35
Cost Effectiveness ($ per tons combined pollutant destroyed)				**$50,761**

Criteria Pollutants Multi-Pollutant Cost-Effectiveness (Reasonable vs. Actual Control Cost)

Pollutant	Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (tons/yr)	Subtotal Reasonable Annual Cost ($/year)	
NO_x	$10,000	0.00	$0	per year
CO	$5,000	2.62	$13,121	per year
VOCs	$9,999	0.67	$6,682	per year
PM	$23,200	0.06	$1,323	per year
Other				
Total Reasonable Annual Control Cost for Combined Pollutants			**$21,126**	**per year**
Actual Annual Control Cost			**$170,025**	**per year**
Is The Control Device Reasonable?			**NO (Actual >> Acceptable)**	

Criteria Pollutants Removal Tonnages (Nominal-Controlled)

Pollutant	PM	CO	VOCs	NO_x
Tier-2 Uncontrolled Emissions TPY	0.29	3.09	0.84	48.4
Controlled Emissions TPY	0.23	0.46	0.17	48.41
TPY Removed	0.06	2.62	0.67	0.0
Combined Uncontrolled TPY	52.62			
Combined TPY Removed	3.35			
Quoted Removal Effcy	20%	85%	80%	0%
Annualized Cost ($/yr)	$170,025	$170,025	$170,025	$170,025
Indiv Poll $/Ton Removed	$2,982,384	$64,790	$254,430	-

TAPs Multi-Pollutant Cost-Effectiveness (Reasonable vs. Actual Control Cost)

Pollutant	Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (tons/yr)	Subtotal Reasonable Annual Cost ($/year)	
DEEP (FH)	$23,200	0.057	$1,323	per year
CO	$5,000	2.62	$13,121	per year
Carcinogen VOCs	$9,999	2.26E-02	$226	per year
NO_2	$20,000	0.00	$0	per year
Non-carcinogen VOCs	$5,000	7.20E-02	$360	per year
Benzene	$20,000	1.71E-02	$342	per year
1,3-Butadiene	$20,000	8.61E-04	$17	per year
Acrolein	$20,000	1.73E-04	$3	per year
Naphthalene	$20,000	2.86E-03	$57	per year
Total Reasonable Annual Control Cost for Combined Pollutants			**$15,450**	**per year**
Actual Annual Control Cost			**$170,025**	**per year**
Is The Control Device Reasonable?			**NO (Actual >> Acceptable)**	

TAPs Removal Tonnages (Nominal-Controlled)

Pollutant	DEEP (FH)	CO	Carcinogenic VOCs	NO_2 (10% of No_x)	Non-Carcinogenic VOCs	Benzene	1,3-Butadiene	Acrolein	Naphthalene
Tier-2 Uncontrolled TPY	0.29	3.09	2.83E-02	4.84	9.00E-02	2.14E-02	1.08E-03	2.17E-04	3.58E-03
Controlled TPY	0.23	0.46	5.66E-03	4.84	1.80E-02	4.27E-03	2.15E-04	4.34E-05	7.15E-04
Tons Removed/Year	0.06	2.62	2.26E-02	0.00	7.20E-02	1.71E-02	8.61E-04	1.73E-04	2.86E-03
Combined Uncontrolled Tons/yr	8.36								
Combined tons/yr Removed	2.80								
Overall Cold-Start Removal Effcy	20%	85%	80%	0%	80%	80%	80%	80%	80%
Annualized Cost ($/yr)	$170,025	$170,025	$170,025	$170,025	$170,025	$170,025	$170,025	$170,025	$170,025
Indiv Poll $/Ton Removed	$2,982,384	$64,790	$7,509,784	-	$2,360,658	$9,953,338	$197,539,396	$980,176,444	$59,413,772
Combined TAPs $/Ton Removed	$60,790								

FH = "front half" filterable particulate matter

APPENDIX E-6
DPF-COST EFFECTIVENESS
PROJECT GENESIS
QUINCY, WASHINGTON

Item	Quantity	Units	Unit Cost	Subtotal
Annualized Capital Recovery				
Total Capital Cost				$3,919,524
Capital Recovery Factor, 25 yrs, 4% discount rate				0.064
Subtotal Annualized 25-year Capital Recovery Cost				$250,896
Direct Annual Costs				
Annual Admin charges	2% of TCI (EPA Manual)		0.02	$78,390
Annual Property tax	1% of TCI (EPA Manual)		0.01	$39,195
Annual Insurance	1% of TCI (EPA Manual)		0.01	$39,195
Annual operation/labor/maintenance costs: Upper-bound estimate would assume CARB's value of $0.20/hp/year and would result in $28,000/year. Lower-bound estimate would assume zero annual O&M. Mid-range value would account for fuel for pressure drop, increased inspections, periodic OEM visits, and the costs for Ecology's increased emission testing requirements. **For this screening-level analysis we assumed the lower-bound annual O&M cost of zero.**				$0
Subtotal Direct Annual Costs				$156,781
Total Annual Cost (Capital Recovery + Direct Annual Costs)				**$407,677**
Uncontrolled Emissions (Combined Pollutants)				52.6
Annual Tons Removed (Combined Pollutants)				0.27
Cost Effectiveness ($ per tons combined pollutant destroyed)				**$1,491,601**

Criteria Pollutants Multi-Pollutant Cost-Effectiveness (Reasonable vs. Actual Control Cost)

Pollutant	Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (tons/yr)	Subtotal Reasonable Annual Cost ($/year)	
NO_x	$10,000	-1.97	$0	per year
CO	$5,000	-0.13	$0	per year
VOCs	$9,999	-0.04	$0	per year
PM	$23,200	0.27	$6,341	per year
Other				
Total Reasonable Annual Control Cost for Combined Pollutants			**$6,341**	**per year**
Actual Annual Control Cost			**$407,677**	**per year**
Is The Control Device Reasonable?			**NO (Actual >> Acceptable)**	

Criteria Pollutants Removal Tonnages (Nominal-Controlled)

Pollutant	PM	CO	VOCs	NO_x
Tier-2 Uncontrolled Emissions TPY	0.29	3.09	0.84	48.41
Controlled Emissions TPY	0.01	3.22	0.87	50.38
TPY Removed	0.27	-0.13	-0.04	-1.97
Combined Uncontrolled TPY	52.62			
Combined TPY Removed	0.27			
Quoted Removal Effcy	96%	-4%	-5%	-4%
Annualized Cost ($/yr)	$407,677	$407,677	$407,677	$407,677
Indiv Poll $/Ton Removed	$1,491,601	-	-	-

TAPs Multi-Pollutant Cost-Effectiveness (Reasonable vs. Actual Control Cost)

Pollutant	Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (tons/yr)	Subtotal Reasonable Annual Cost ($/year)	
DEEP (FH)	$23,200	0.273	$6,341	per year
CO	$5,000	-0.13	$0	per year
Carcinogen VOCs	$9,999	-1.30E-03	$0	per year
NO_2	$20,000	-0.20	$0	per year
Non-carcinogen VOCs	$5,000	-4.15E-03	$0	per year
Benzene	$20,000	-9.83E-04	$0	per year
1,3-Butadiene	$20,000	-4.95E-05	$0	per year
Acrolein	$20,000	-9.99E-06	$0	per year
Naphthalene	$20,000	-1.65E-04	$0	per year
Total Reasonable Annual Control Cost for Combined Pollutants			**$6,341**	**per year**
Actual Annual Control Cost			**$407,677**	**per year**
Is The Control Device Reasonable?			**NO (Actual >> Acceptable)**	

TAPs Removal Tonnages (Nominal-Controlled)

Pollutant	DEEP (FH)	CO	Carcinogenic VOCs	NO_2 (10% of NO_x)	Non-Carcinogenic VOCs	Benzene	1,3-Butadiene	Acrolein	Naphthalene
Tier-2 Uncontrolled TPY	0.29	3.09	2.83E-02	4.84	9.00E-02	2.14E-02	1.08E-03	2.17E-04	3.58E-03
Controlled TPY	0.01	3.22	2.96E-02	5.04	9.42E-02	2.23E-02	1.13E-03	2.27E-04	3.74E-03
Tons Removed/Year	0.27	-0.13	-1.30E-03	-0.20	-4.15E-03	-9.83E-04	-4.95E-05	-9.99E-06	-1.65E-04
Combined Uncontrolled Tons/yr	8.36								
Combined tons/yr Removed	0.27								
Overall Cold-Start Removal Effcy	96%	-4%	-5%		-5%	-5%	-5%	-5%	-5%
Annualized Cost ($/yr)	$407,677	$407,677	$407,677	$407,677	$407,677	$407,677	$407,677	$407,677	$407,677
Indiv Poll $/Ton Removed	$1,491,601	-	-	-	-	-	-	-	-
Combined TAPs $/Ton Removed	$1,491,601								

FH = "front half" filterable particulate matter

APPENDIX E-7
SCR-COST EFFECTIVENESS
PROJECT GENESIS
QUINCY, WASHINGTON

Item	Quantity	Units	Unit Cost	Units	Subtotal
Annualized Capital Recovery					
Total Capital Cost					$7,186,706
Capital Recovery Factor:	25	years	4%	discount	0.064
Subtotal Annualized 25-year Capital Recovery Cost					$460,035
Direct Annual Cost					
Maintenance (EPA Manual)	1.5%	of Total Capital Investment			$107,801
Increased Fuel Consumption	Insignificant				$0
Reagent Consumption (EPA Manual)					
25% aqueous Urea Flow Rate	22,260	lb/yr	$0.20	per lb	$4,452
Catalyst Replacement (EPA Manual)	Insignificant				$0
Subtotal Direct Annual Cost					**$112,252**
Indirect Annual Costs					
Annual Admin charges (EPA Manual)	2.0%	of Total Capital Investment			$143,734
Annual Property tax (EPA Manual)	1.0%	of Total Capital Investment			$71,867
Annual Insurance (EPA Manual)	1.0%	of Total Capital Investment			$71,867
Subtotal Indirect Annual Costs					**$287,468**
Total Annual Cost (Capital Recovery + Direct Annual Costs + Indirect Annual Costs)					**$859,756**
Uncontrolled Emissions (Combined Pollutants)					52.6
Annual Tons Removed (Combined Pollutants)					44.01
Cost Effectiveness ($ per tons combined pollutant destroyed)					**$19,535**

Criteria Pollutants Multi-Pollutant Cost-Effectiveness (Reasonable vs. Actual Control Cost)

Pollutant	Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (tons/yr)	Subtotal Reasonable Annual Cost ($/year)	
NO_x	$10,000	44.02	$440,161	per year
CO	$5,000	-0.81	$0	per year
VOCs	$9,999	0.72	$7,232	per year
PM	$23,200	0.08	$1,944	per year
Other				
Total Reasonable Annual Control Cost for Combined Pollutants			**$449,336**	**per year**
Actual Annual Control Cost			**$859,756**	**per year**
Is The Control Device Reasonable?			**NO (Actual >> Acceptable)**	

Criteria Pollutants Removal Tonnages (Nominal-Controlled)

Pollutant	PM	CO	VOCs	NO_x
Tier-2 Uncontrolled Emissions TPY	0.29	3.09	0.84	48.41
Controlled Emissions TPY	0.20	3.90	0.11	4.40
TPY Removed	0.08	-0.81	0.72	44.0
Combined Uncontrolled TPY	52.62			
Combined TPY Removed	44.01			
Quoted Removal Effcy	29%	-26%	87%	91%
Annualized Cost ($/yr)	$859,756	$859,756	$859,756	$859,756
Indiv Poll $/Ton Removed	$10,262,337	-	$1,188,736	$19,533

TAPs Multi-Pollutant Cost-Effectiveness (Reasonable vs. Actual Control Cost)

Pollutant	Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (tons/yr)	Subtotal Reasonable Annual Cost ($/year)	
DEEP (FH)	$23,200	0.084	$1,944	per year
CO	$5,000	-0.81	$0	per year
Carcinogen VOCs	$9,999	2.45E-02	$245	per year
NO_2	$20,000	4.40	$88,032	per year
Non-carcinogen VOCs	$5,000	7.80E-02	$390	per year
Benzene	$20,000	1.85E-02	$370	per year
1,3-Butadiene	$20,000	9.32E-04	$19	per year
Acrolein	$20,000	1.88E-04	$4	per year
Naphthalene	$20,000	3.10E-03	$62	per year
Total Reasonable Annual Control Cost for Combined Pollutants			**$91,065**	**per year**
Actual Annual Control Cost			**$859,756**	**per year**
Is The Control Device Reasonable?			**NO (Actual >> Acceptable)**	

TAPs Removal Tonnages (Nominal-Controlled)

Pollutant	DEEP (FH)	CO	Carcinogenic VOCs	NO_2 (10% of No_x)	Non-Carcinogenic VOCs	Benzene	1,3-Butadiene	Acrolein	Naphthalene
Tier-2 Uncontrolled TPY	0.29	3.09	2.83E-02	4.84	9.00E-02	2.14E-02	1.08E-03	2.17E-04	3.58E-03
Controlled TPY	0.20	3.90	3.80E-03	0.44	1.21E-02	2.86E-03	1.44E-04	2.91E-05	4.80E-04
Tons Removed/Year	0.08	-0.81	2.45E-02	4.40	7.80E-02	1.85E-02	9.32E-04	1.88E-04	3.10E-03
Combined Uncontrolled Tons/yr	8.36								
Combined tons/yr Removed	3.80								
Overall Cold-Start Removal Effcy	29%	-26%	87%	91%	87%	87%	87%	87%	87%
Annualized Cost ($/yr)	$859,756	$859,756	$859,756	$859,756	$859,756	$859,756	$859,756	$859,756	$859,756
Indiv Poll $/Ton Removed	$10,262,337	-	$35,086,832	$195,328	$11,029,348	$46,503,481	$922,933,545	$4,579,530,659	$277,590,012
Combined TAPs $/Ton Removed	$226,383								

FH = "front half" filterable particulate matter

APPENDIX E-8
TIER 4-COST EFFECTIVENESS
PROJECT GENESIS
QUINCY, WASHINGTON

Item	Quantity	Units	Unit cost	Units	Subtotal
Annualized Capital Recovery					
Total Capital Cost					$12,152,210
Capital Recovery Factor:	25	years	4%	discount	0.064
Subtotal Annualized 25-year Capital Recovery Cost					$777,887
Direct Annual Cost					
Maintenance (EPA Manual)	1.5%	of Total Capital Investment			$182,283
Increased Fuel Consumption	Insignificant				$0
Reagent Consumption (EPA Manual)					
25% aqueous Urea Flow Rate	22,260	lb/yr	$0.20	per lb	$4,452
Catalyst Replacement (EPA Manual)	Insignificant				$0
Subtotal Direct Annual Cost					**$186,735**
Indirect Annual Costs					
Annual Admin charges (EPA Manual)	2.0%	of Total Capital Investment			$243,044
Annual Property tax (EPA Manual)	1.0%	of Total Capital Investment			$121,522
Annual Insurance (EPA Manual)	1.0%	of Total Capital Investment			$121,522
Subtotal Indirect Annual Costs					**$486,088**
Total Annual Cost (Capital Recovery + Direct Annual Costs + Indirect Annual Costs)					**$1,450,710**
Uncontrolled Emissions (Combined Pollutants)					52.6
Annual Tons Removed (Combined Pollutants)					46.44
Cost Effectiveness ($ per tons combined pollutant destroyed)					**$31,238**

Criteria Pollutants Multi-Pollutant Cost-Effectiveness (Reasonable vs. Actual Control Cost)

Pollutant		Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (tons/yr)	Subtotal Reasonable Annual Cost ($/year)	
NO_x		$10,000	44.30	$443,043	per year
CO		$5,000	1.17	$5,840	per year
VOCs		$9,999	0.76	$7,586	per year
PM		$23,200	0.21	$4,878	per year
Other					
Total Reasonable Annual Control Cost for Combined Pollutants				**$461,347**	**per year**
Actual Annual Control Cost				**$1,450,710**	**per year**
Is The Control Device Reasonable?				**NO (Actual >> Acceptable)**	

Criteria Pollutants Removal Tonnages (Nominal-Controlled)

Pollutant	PM	CO	VOCs	NO_x
Tier-2 Uncontrolled Emissions TPY	0.29	3.09	0.84	48.41
Controlled Emissions TPY	0.07	1.92	0.08	4.11
TPY Removed	0.21	1.17	0.76	44.3
Combined Uncontrolled TPY	52.62			
Combined TPY Removed	46.44			
Quoted Removal Effcy	74%	38%	91%	92%
Annualized Cost ($/yr)	$1,450,710	$1,450,710	$1,450,710	$1,450,710
Indiv Poll $/Ton Removed	$6,900,001	$1,242,113	$1,912,073	$32,744

TAPs Multi-Pollutant Cost-Effectiveness (Reasonable vs. Actual Control Cost)

Pollutant		Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (tons/yr)	Subtotal Reasonable Annual Cost ($/year)	
DEEP (FH)		$23,200	0.210	$4,878	per year
CO		$5,000	1.17	$5,840	per year
Carcinogen VOCs		$9,999	2.57E-02	$257	per year
NO_2		$20,000	4.43	$88,609	per year
Non-carcinogen VOCs		$5,000	8.18E-02	$409	per year
Benzene		$20,000	1.94E-02	$388	per year
1,3-Butadiene		$20,000	9.77E-04	$20	per year
Acrolein		$20,000	1.97E-04	$4	per year
Naphthalene		$20,000	3.25E-03	$65	per year
Total Reasonable Annual Control Cost for Combined Pollutants				**$100,468**	**per year**
Actual Annual Control Cost				**$1,450,710**	**per year**
Is The Control Device Reasonable?				**NO (Actual >> Acceptable)**	

TAPs Removal Tonnages (Nominal-Controlled)

Pollutant	DEEP (FH)	CO	Carcinogenic VOCs	NO_2 (10% of No_x)	Non-Carcinogenic VOCs	Benzene	1,3-Butadiene	Acrolein	Naphthalene
Tier-2 Uncontrolled TPY	0.29	3.09	2.83E-02	4.84	9.00E-02	2.14E-02	1.08E-03	2.17E-04	3.58E-03
Controlled TPY	0.07	1.92	2.60E-03	0.41	8.26E-03	1.96E-03	9.87E-05	1.99E-05	3.28E-04
Tons Removed/Year	0.21	1.17	2.57E-02	4.43	8.18E-02	1.94E-02	9.77E-04	1.97E-04	3.25E-03
Combined Uncontrolled Tons/yr	8.36								
Combined tons/yr Removed	5.94								
Overall Cold-Start Removal Effcy	74%	38%	91%	92%	91%	91%	91%	91%	91%
Annualized Cost ($/yr)	$1,450,710	$1,450,710	$1,450,710	$1,450,710	$1,450,710	$1,450,710	$1,450,710	$1,450,710	$1,450,710
Indiv Poll $/Ton Removed	$6,900,001	$1,242,113	$56,436,911	$327,442	$17,740,624	$74,800,508	$1,484,531,815	$7,366,141,367	$446,501,492
Combined TAPs $/Ton Removed	$244,231								

FH = "front half" filterable particulate matter

APPENDIX F

AERMOD Files

(on DVD)