Final
Notice of Construction
Supporting Information Report
Microsoft Project Oxford Data Center
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
AZ	Activity Zone
BACT	Best Available Control Technology
BPIP	Building Profile Input Program
CFR	Code of Federal Regulations
CO	Carbon Monoxide
CNR	Core Network Room Buildings
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
kWe	Kilowatts Electrical Output
m	Meter
mg/L	Milligrams per Liter
Microsoft	The Microsoft Corporation
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
PVMRM	Plume Volume Molar Reaction Model
RCW	Revised Code of Washington
RICE	Reciprocating Internal Combustion Engines
SCR	Selective Catalytic Reduction
SO_2	Sulfur Dioxide
SQER	Small-Quantity Emission Rate
TAP	Toxic Air Pollutant
TDS	Total Dissolved Solids

LIST OF ABBREVIATIONS AND ACRONYMS (Cont.)

VOC	Volatile Organic Compound
WAAQS	Washington Ambient Air Quality Standards
WAC	Washington Administrative Code
WCTI	Water Conservation Technology International, Inc.

1.0 PROJECT DESCRIPTION (SECTION III OF NOC APPLICATION FORM)

1.1 FACILITY DESCRIPTION

This Final Notice of Construction (NOC) Supporting Information Report updates the version that was originally submitted to the Washington State Department of Ecology (Ecology) on March 13, 2014, to incorporate the information contained in follow-up submittals to Ecology after that date.

The Microsoft Corporation (Microsoft) proposes to construct and operate the Project Oxford Data Center in Quincy, Washington (Figure 1). This document has been prepared for Microsoft to support the submittal of an NOC application for installation and operation of new emergency generators and mechanical draft cooling towers, under air quality regulations promulgated by Ecology. The Project Oxford Data Center will be located approximately ¾ mile west of Microsoft's existing Columbia Data Center. Construction of the Project Oxford Data Center will be conducted in four phases. Phases 1 and 2 are expected to begin construction before the end of 2015, while the construction of Phases 3 and 4 will be based on market demand and is unlikely to begin before 2016. Under state regulations, an NOC approval becomes invalid if construction of the source is not commenced within 18 months of receipt of the NOC approval unless Ecology approves an extension of the NOC approval [WAC 173-400-111(7)]. Therefore, this NOC application addresses the air permitting requirements associated with the construction of Phases 1 and 2. Future phases of construction at the Project Oxford Data Center will be permitted, if appropriate, when actual plans and specifications are developed and when those phases are funded for construction.

Phases 1 and 2 collectively include the construction of eight "Activity Zone (AZ)" buildings that will house banks of servers to support Microsoft's services. Additional equipment will be housed in the "Core Network Room (CNR)" buildings and an administrative building. The data center will be equipped with stable electrical power delivery systems, air cooling and cleaning systems, and emergency back-up 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 buildings. A site plan for Phases 1 and 2 of 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.

Appendix A includes specifications for the Caterpillar diesel generators to be used. Each of the eight AZ buildings for Phases 1 and 2 will be supported by four diesel-powered emergency generators, each rated at 2,500 kilowatts electrical capacity (kWe). In addition, the combined CNR buildings will be supported by four 2,000-kWe diesel-powered emergency generators, while the administration building will be supported by one 750-kWe diesel generator. Therefore, the combined Phases 1 and 2 will require a total of 37 emergency generators.

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). Even though the federal regulations require the emergency generators to satisfy only U.S. Environmental Protection Agency (EPA) Tier 2 emission limits, Microsoft voluntarily proposes the use of an emission control package designed to satisfy the EPA Tier 4 (Final) emission standards based on the weighted average of testing at five engine loads. To achieve the more protective emission limits, Microsoft will equip each of the emergency generators with a catalyzed diesel particulate filter (DPF) to reduce particulate emissions and urea selective catalytic reduction (SCR) to reduce emissions of nitrogen oxides (NO_x) and nitrogen dioxide (NO_2). The SCR catalysts used to control NO_x emissions will emit small amounts of ammonia gas as a result of "ammonia slip." To provide a high removal efficiency for NO_x, urea must be injected into the catalyst system at nearly stoichiometric rates. A small amount of the injected urea nitrogen does not react with NO_x inside the catalyst, and that extra urea forms ammonia that is emitted through the exhaust stack.

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 46-foot-tall vertical exhaust stack. Serial numbers for the proposed generators will be provided to Ecology once the generators have been ordered and the serial numbers are available from the manufacturer. Specifications for the proposed new generators and their diesel engines are provided in Appendix A.

1.1.2 MECHANICAL DRAFT COOLING TOWERS

Technical information for the mechanical draft cooling towers is provided in Appendix B. As shown on Figure 2, each of the eight AZ buildings will be supported by four mechanical draft cooling towers, to provide cold air and water to the AZ buildings' air handling systems. The cooling towers will not be pre-treated with toxic chemicals, but the dissolved solids in the recirculation water will emit cooling tower drift droplets that will evaporate downwind to form particulate emissions. Each of the 32 cooling towers (eight AZ buildings, each with four cooling towers) will have multiple cells, and each cell will have its own induced draft fan.

Microsoft is currently considering options for the source of the water supplied to its cooling towers (City water supply from local wells, or pre-treated reused industrial wastewater to be provided by the City of Quincy). For this NOC permit application, the cooling tower water supply option that would result in the highest cooling tower emission rates is presented. The makeup water to the cooling towers is, therefore, assumed to be pre-treated wastewater from the City of Quincy's industrial wastewater treatment plant. The pre-treated wastewater will be treated further before being fed to the cooling towers, using a polishing treatment process consisting of a combination of coagulation, sand filtration, and possibly reverse osmosis treatment. It is uncertain at this time if the pre-treated water fed to the cooling towers will require further treatment using chlorine disinfection, so for this air quality permit application it was conservatively assumed that the water will be disinfected, and the emission inventory accounted for possible concentrations of residual chlorine disinfection byproducts that would eventually volatilize from the cooling towers. The approximate concentrations of trace metals and chlorine disinfection byproducts that were assumed to be present in the cooling tower makeup water are provided in Appendix B.

The recirculation water in the cooling towers will be pre-softened using the proprietary Water Conservation Technology International (WCTI) "pre-treatment system" to replace scale-forming mineral compounds (e.g., calcium and magnesium) with other non-toxic, non-scaling mineral compounds (e.g., sodium), which will allow the cooling towers to be operated with very high "cycles of concentration." The elevated cycles of concentration will cause total dissolved solids (TDS) in the recirculation water to reach concentrations of 69,000 milligrams per liter (mg/L). This will provide an overall water quality benefit because Microsoft will require less makeup water and will discharge only relatively low volumes of cooling tower blowdown to the municipal sewer system. However, the elevated TDS concentrations in the recirculation water will increase the drift particulate emissions from the cooling towers compared to similar towers that do not use the WCTI pre-treatment system. For the purpose of estimating drift emission rates, the key operational parameters for the 32 cooling towers are as follows:

- Water recirculation flow rate in each of the 32 cooling towers: 950 gallons per minute based on site-specific cooling system calculations (Cheng, R., 2014, personal communication).
- TDS concentration in recirculation water: 69,000 mg/L (46 cycles of concentration compared to the estimated TDS concentration of 1,500 mg/L in the cooling tower makeup water).
- Drift eliminator efficiency: Drift droplets limited to 0.0005 percent of recirculation flow rate.
- Based on the above assumptions, the calculated emission rate for evaporated solid particles (total suspended particulates) emitted as cooling tower drift is 0.1643 pounds per hour from each of the 32 cooling towers. For the purpose of AERMOD to demonstrate compliance with the National Ambient Air Quality Standards (NAAQS) for this NOC application, it was

determined that only 13 percent of the evaporated solid drift particles are smaller than 2.5 microns in diameter and only 56 percent are smaller than 10 microns diameter, based on manufacturer data on the size distribution of the liquid droplets emitted from the cooling towers (see Appendix B for an analysis of the size distribution of the liquid droplets and the evaporated solid particles).

In addition, the vapor emission rates of volatile chlorine disinfection byproducts present in the cooling tower makeup water provided by the City were calculated based on an estimated facility-wide makeup water flow rate of 300 gallons per minute (Cheng, R., 2014, personal communication), and based on historical aqueous concentrations of constituents found in the City water (see Appendix B for analytical data). It was assumed that all of the volatile constituents in the makeup water will be emitted as vapors.

Because Microsoft will pre-treat the cooling tower makeup water using the WCTI softening system, water treatment chemicals will not need to be added to prevent corrosion or scaling.

1.2 GENERATOR RUNTIME SCENARIOS AND PROPOSED GENERATOR RUNTIME LIMITS

The emission estimates and ambient impact modeling presented in this permit application are based on the following operating modes for the 37 new generators (summarized in Table 1), which are categorized based on the generator load during each activity. This section also describes Microsoft's proposed runtime limits to reduce emissions to comply with the NAAQS for NO_2 and particulate matter with an aerodynamic diameter less than or equal to 2.5 microns ($PM_{2.5}$). No runtime limits are required to comply with the Acceptable Source Impact Level (ASIL) for NO_2, which is governed by the emissions from all facility-wide generators during a full power outage. The emissions and annual-average ambient impacts for diesel engine exhaust particulate matter (DEEP) are governed by the annual runtime limits specified in Table 1. Microsoft requests that if Ecology sets annual hourly runtime limits in the Approval Order, then those runtime limits should be specified as the combined runtimes at each generator load with the averaging provisions listed in Table 1.

1.2.1 GENERATOR ACTIVITY AT IDLE LOAD (I.E., UP TO 10 PERCENT LOAD)

Microsoft will operate each generator for **up to 29 hours per year** at idle load, represented as a generator load of up to 10 percent. This category of runtime will include scheduled weekly generator testing, and "generator cooldown" when each generator that is operated for more than ½ hour at high load (i.e., greater than 50 percent load) must be cooled down by running at idle (i.e., up to 10 percent load) for 10 minutes to allow the generator to cool down. Manufacturer data for emissions at 10 percent load were used to represent emissions at idle conditions up to 10 percent load.

1.2.2 GENERATOR ACTIVITY DESIGNED FOR APPROXIMATELY 80 PERCENT AVERAGE GENERATOR LOAD

Microsoft will operate each generator for **up to 40 hours per year** for two combined runtime activities:

- **Unplanned power outages**. In the event of a power outage, all of the 37 generators would activate at an approximate average of 80 percent load for the duration of the outage.
- **Scheduled annual electrical bypass for switchgear and transformer maintenance**. Every year, each of the transformers within the AZ and CNR buildings will undergo preventive maintenance, during which time one generator at a time in each building will be operated at an average of approximately 80 percent load to bypass power around the transformer until the maintenance is completed. Microsoft proposes the following operational limits to ensure compliance with the NAAQS:
  - For the purpose of reducing emissions to comply with the 1-hour NAAQS for NO_2, Microsoft will limit the generator usage for electrical bypass transformer maintenance to no more than four generators operating simultaneously on any given hour, at an average generator load of approximately 80 percent (averaged across all generators being used on any given day for electrical bypass maintenance).
  - For the purpose of reducing emissions to comply with the 24-hour $PM_{2.5}$ NAAQS, Microsoft will limit the maximum daily generator usage for electrical bypass transformer maintenance to no more than 192,000 kWe-hours per day. That maximum daily limit is equivalent to four generators operating at 80 percent generator load for a full 24-hour day, but Microsoft may use more than four generators on any single day as long as the total usage is less than 192,000 kWe-hours per day.

1.2.3 GENERATOR ACTIVITY DESIGNED FOR A WIDE RANGE OF GENERATOR LOADS (UP TO 100 PERCENT LOAD)

Certain types of activities will require Microsoft to cycle the generators over a range of loads, from idle up to 100 percent. Microsoft will operate each generator for **up to 17.5 hours per year** for the three combined activities described below. For the purpose of simplifying the emission calculations, all generator runtime in these categories was assumed to be done at 100 percent generator load because that load represents a conservatively high emission rate.

- **Monthly Testing**. Each generator will be subject to load-bank testing, cycling between idle to 100 percent load.
- **Semiannual Testing and DPF Regeneration**. Every 6 months, each generator will be cycled between loads from idle to 100 percent. The amount of runtime at 100 percent load will be extended as needed to regenerate the DPFs, to burn off accumulated particulate matter.
- **As-Needed Corrective Testing**. If the weekly or monthly testing indicates a problem with any generator, then Microsoft may be required to conduct additional diagnostic testing on that generator.

For the purpose of reducing emissions to comply with the 1-hour NAAQS for NO_2, Microsoft will limit the generator usage for generator testing at 100 percent load to no more than three generators operating simultaneously during any given hour.

1.2.4 INFREQUENT OR ONE-TIME GENERATOR ACTIVITY

In addition to the routine annual scenarios described above and listed in the top section of Table 1, the AERMOD modeling for annual-average ambient impacts for criteria air pollutants and toxic air pollutants also accounted for emissions from the following occasional, one-time-only operating modes or occasional recurring operating modes:

- **Startup Commissioning (One Time Only)**. Each generator will undergo up to 50 hours of onsite commissioning testing before it is released by the supplier for use at the data center. The commissioning tests will be spread over approximately 12 operating days spread over a multi-week calendar period. Although commissioning testing will be done by running each generator across a range of loads, for this permit application the emission calculations assumed that all of the commissioning runtime will be done at an average of 80 percent load. The estimated fuel usage to commission each generator is 7,630 gallons. The commissioning emissions from each generator were distributed over a 70-year period for the purpose of modeling the 70-year annual-average emissions of DEEP. As described in the technical memorandum in Appendix C, the commissioning activity will not contribute to the theoretical maximum 12-month emission rates because there will be a substantial lag time between the end of generator commissioning and the start of routine data center operation. A detailed breakdown of the approximate operating conditions for commissioning a typical generator is shown in the table below.

Commissioning Test	Typical Runtime Hours	Typical Generator Load (percent electrical load)	No. of Generators at Same Time
Full Load Test	20	100%	Typically 1-2
Step Test	2	0-100% (average 50%)	Typically 1-2
Generator/Utility Transfer Test	4	0-100% (average 50%)	Typically 1-2
Electrical System Generator Compatibility Test	4	0-100% (average 50%)	Typically 1-2
Mechanical System Generator Compatibility Test	4	0-100% (average 50%)	Typically 1-2
Integrated System Test	4	50-100% (average 80%)(	4
Uninterrupted Power System Compatibility Test	10	0-100% (average 50%)	Typically 1-2
TOTALS	**Approx. 48**	**Overall average approximately 80%**	**Maximum of 4 generators at a time**

- **Recurring Compliance Stack Testing**. Ecology has required most data centers to conduct periodic stack emission testing for their diesel generators. Source testing requires engine runtime. As a conservative assumption for this NOC application, the emission estimates and ambient air quality analyses account for a conservatively high intensity of stack testing of up to two generators per year, on a 3-year recurring basis.

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 Clean Air Act. 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 (RICE)].

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 facility is 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 EPA hazardous air pollutant (HAP)
- Less than 25 tons per year of total HAPs.

As a result, neither a Prevention of Significant Deterioration (PSD) 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.

The mechanical draft cooling towers are not subject to the federal NESHAP (40 CFR Part 63 Subpart Q, Industrial Process Cooling Towers) because the Project Oxford Data Center will not emit hazardous air pollutants at rates high enough to designate the facility as a major source. Regardless, Microsoft will comply with the main operational restriction that would be required under that NESHAP. Microsoft will not use chromium-containing chemicals to pre-treat the cooling tower makeup water.

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

Air pollutant emission rates were calculated for the sources identified in Section 1.0 per the requirements of WAC 173-400-113 and WAC 173-460-050. Emission rates were quantified for criteria pollutants and toxic air pollutants (TAPs). The basis for emissions calculations is described in the following sections. Detailed emission calculation spreadsheets are provided in Appendix C.

2.1 GENERATOR RUNTIME SCENARIOS AND FACILITY-WIDE FUEL USAGE

Table 1 lists the forecast generator runtime modes and the anticipated maximum runtime during each mode of operation. If each generator operated at its maximum anticipated duration for each mode of operation, then each generator would operate for an average of 86.5 hours per year at a range of loads, not including initial generator commissioning or periodic stack emission testing. If initial commissioning and periodic stack testing are included, then the 70-year average runtime used to assess long-term DEEP emissions is equivalent to 88.3 hours per generator.

The maximum theoretical facility-wide generator runtime during the maximum 12-month period would occur while both Phase 1 and Phase 2 are operating, during a year when three generators are stack-tested. During that maximum 12-month period, each of the generators subject to stack testing could operate for up to 116 hours (86.5 hours for routine operation, plus 30 hours for stack emission testing). A detailed description of how the generator runtimes and generator emissions were derived for the theoretical maximum 12-month period is provided in Appendix C. The theoretical maximum 12-month emission rates are only slightly higher than the 70-year average emission rates, due to the conservatively high assumptions used to develop the 70-year averages. For example, the theoretical maximum 12-month DEEP emission rate is only 0.9 percent higher than the 70-year average.

As listed in the generator specification sheets provided in Appendix A, the hourly fuel consumption varies depending on the generator load. If all 37 generators operated at the maximum runtimes listed in Table 1, then the combined generators would use a total of 431,000 gallons per year during the maximum theoretical 12-month period of operation (see the calculation spreadsheets in Appendix C for the derivation of this facility-wide fuel consumption).

2.2 DERIVATION OF EMISSION FACTORS FOR DIESEL GENERATORS

2.2.1 LOAD-SPECIFIC STEADY-STATE EMISSION LIMITS

Two sets of load-specific emission forecasts were developed. The first set of data assumes the generators will emit in a manner consistent with the EPA Tier 2 emission standards, which would occur during the first 10 to 15 minutes after a cold start while the emission control catalysts heat up to their activation temperature. The load-specific emission factors for the "Tier 2 cold start period" are listed in Table 2. These load-specific emission data were derived from Tier 2 emission data provided by the generator manufacturers. The listed emission estimates for particulate matter include adjustment factors to account for condensable PM (the "back-half" particulate fraction measured by EPA Method 202). All of the emission calculations used for this permit application account for back-half PM. By doing so, this permit application provides a conservatively high estimate of the PM emissions. As described later, even with that conservative assumption the ambient impact assessment demonstrated compliance with all PM ambient limits.

The second set of emission data applies to the controlled, fully warmed up, steady-state condition that begins 10 to 15 minutes after a cold start, after the emission control catalysts are activated. These controlled emission rates are listed in Table 3. These controlled emission rates were derived from limited data from equipment manufacturers. The manufacturers' load-specific controlled emission data were adjusted upward so the resulting five-load weighted average emission rates are equal to the average emission limits allowed under the EPA Tier 4 (Final) regulation. Two sets of emission data for PM are listed in Table 3. One set of data shows the estimated emission rates of "filterable fraction" or "front-half fraction" measured by EPA Method 5. The second set of data shows the estimated emission rates for the combined front-half fraction plus back-half fraction measured by combined EPA Methods 5/202. All of the emission calculations used for this permit application account for back-half PM, to provide a conservatively high estimate of PM emission rates and ambient PM impacts.

The emission factors for gaseous organic TAPs were derived based on emission factors from EPA's AP-42 (EPA 1995), with an assumed 90 percent destruction efficiency provided by the oxidized DPF included in the emission control package. The DEEP emissions were assumed to be equal to the PM emission rates, including the sum of the front-half plus back-half particulates. The emission rate for primary NO_2 emitted directly from the generator exhaust stack was estimated to be 10 percent of the total oxides of nitrogen (NO_x).

2.2.2 COLD-START 'BLACK PUFF' INITIAL SPIKE FACTORS

The emission data described in the previous section are based on manufacturer test data that apply to steady-state operating conditions after the generator being tested has warmed up. However, most of the runtime scenarios at the Project Oxford facility require a "cold start." It is widely recognized that all diesel generators exhibit a brief "black puff" spike in emissions of PM, CO, and VOCs lasting for several seconds immediately after the generator is activated, during which time the generator burns off fuel and crankcase oil that has accumulated on the cold engine cylinders. To account for this, the initial 10- to 15-

minute average emission factors for PM, CO, VOCs, and NO_x were adjusted upward by the following "black puff cold start spike" factors:

- PM: 1.26
- CO: 1.56
- VOCs: 1.26
- NO_x: 1.00.

The "black puff cold start spike factors" were derived based on limited test data from the California Energy Commission document *Air Quality Implications of Backup Generators in California* (CEC 2005). Details on the derivation are provided in Appendix D. The cold-start adjusted emission factors used for emission calculations and air quality dispersion modeling for DEEP, CO, and VOCs were calculated by multiplying the steady-state emission factor times the relevant cold-start factor. A black-puff cold-start factor of 1.0 was used for NO_x because the California Energy Commission tests showed no short-term spike in NO_x emissions during a cold start. The black-puff cold-start spike factor applied to PM is conservatively high. In reality, it is likely PM emissions will experience a less intense short-term spike upon startup, because each generator will be equipped with a DPF that will likely remove solid particles from the generator emissions during the initial startup regardless of the initial exhaust temperature.

2.2.3 CATALYST COLD-START ACTIVATION DELAY PERIOD

After a cold start and the initial 10-second "black puff," some of the emission control devices do not begin to function until the catalysts heat up to their activation temperatures. The DPF functions immediately during a cold start, but the oxidation catalyst embedded in the DPF and the SCR catalyst experience cold-start delays. For the purpose of calculating emissions after a cold start, the following delay periods were assumed:

- Cold start under idle load (i.e., up to 10 percent load). It was assumed that the oxidation catalyst and the SCR catalyst would be delayed by 15 minutes, during which time the VOC, CO and NO_x emissions would be the equivalent of a generator equipped with EPA Tier 2 emission controls (Table 2). After the initial delay, subsequent emissions would be the equivalent of a generator capable of meeting EPA Tier 4 (Final) emission standards (Table 3).
- Cold start under high load. It was assumed that the oxidation catalyst and the SCR catalyst would be delayed by 10 minutes, during which time the VOC, CO and NO_x emissions would be the equivalent of a generator equipped with EPA Tier 2 emission controls (Table 2). After the initial 10-minute delay, subsequent emissions would be the equivalent of a generator capable of meeting EPA Tier 4 (Final) emission standards (Table 3).

2.2.4 AMMONIA SLIP EMISSION CALCULATION

Ammonia emissions were calculated based on an assumed emission factor of 0.32 pounds of ammonia per hour per MWe of electrical output, which was derived based on the allowable ammonia slip emissions for similar diesel-powered generators at the Vantage Data Center in Quincy. Ammonia slip occurs only during fully warmed-up operating conditions because the control system is designed to inject urea into the system only after the SCR catalyst reaches its normal operating temperature. Therefore, there are no "cold start" adjustments for ammonia emissions.

Emission calculations for the hourly, daily, and annual-average ammonia emission rates are presented in Appendix E.

2.3 FACILITY-WIDE EMISSION RATES FOR COMBINED PHASES 1 AND 2

2.3.1 EMISSIONS FROM DIESEL EMERGENCY GENERATORS

The bid specification issued by Microsoft requires that all generators be certified by the EPA to meet emission standards for emergency generators, and that each generator be equipped with emission controls to reduce the emissions to be "Tier 4 (Final)-Compliant" [i.e., the controlled emission rates must satisfy the EPA Tier 4 (Final) emission standards expressed as the five-load weighted average as specified by federal regulations 40 CFR Part 89].

Conservatively high load-specific emission rates for each pollutant were developed for this permit application by using the following general steps (detailed information on the emission calculations is provided in the calculation spreadsheets in Appendix C):

- The generators were assumed to exhibit gaseous pollutant emissions equivalent to a Tier 2 generator during the first 10 to 15 minutes after each cold start. Load-specific, vendor-supplied emissions data were obtained from three generator manufacturers (Cummins, Caterpillar, and MTU). At each load, the "uncontrolled" (Tier 2-compliant) emissions rate was selected as the highest of any of the values provided by the three manufacturers. Then, to further simulate the uncontrolled emissions during the initial period after a cold start, the "cold start spike factors" described previously were applied to the worst-case Tier 2-compliant emission rate. The resulting uncontrolled (Tier 2-compliant) emission rates are listed in Table 2.
- After the first 10 to 15 minutes after a cold start (consisting of the 10-second "black puff spike" followed by the catalyst cold start delay period), each generator was assumed to exhibit warmed-up emissions rates with a five-load weighted average equal to the EPA Tier 4 (Final) emissions standard. Field test data for load-specific emissions rates from a Tier 4 (Final)-compliant generator were obtained from Cummins. The load-specific emissions rates from the Cummins generator were scaled upward, until the five-load weighted average equaled the Tier 4 (Final) standard.
- Removal efficiency data for SCR control devices on controlled Caterpillar engines were obtained from Caterpillar. If the Caterpillar data indicated a higher emissions rate at any given load than the Cummins data, then the higher Caterpillar data were used.

- Load-specific information for condensable particulates (i.e., "back-half particulates") were available from Caterpillar and MTU. Those data were used to develop load-specific emissions rates for condensable PM.
- The resulting warmed-up emissions rates [Tier 4 (Final)-compliant rates] are listed in Table 3. Microsoft anticipates that if Ecology requires stack testing for demonstration of compliance with permit conditions, then all testing will be conducted under warmed-up conditions.

The facility-wide emission rates for each pollutant emitted by the emergency generators were calculated by applying the load-specific hourly emission rate data from Table 2 and Table 3 to the generator runtime forecasts listed in Table 1. Table 4 lists the forecast short-term and annual-average emission rates for the criteria pollutants (NO_x, PM, CO, and VOCs), for both the 70-year average emission rates and the theoretical maximum 12-month emission rates. The annual-average facility-wide emission calculations include runtimes for initial generator commissioning and periodic stack emission testing. The emission calculations include adjustment factors for the "initial spike cold start" and the 10- to 15-minute cold-start delay before the emission control catalysts reach their activation temperature. The emission calculations for PM include the sum of the front-half and back-half fractions.

Table 5 lists the forecast facility-wide emission rates for the TAPs regulated under WAC 173-460. The averaging period for each TAP is consistent with the averaging period specified by the Ecology regulation. The annual values listed in Table 5 apply to the maximum theoretical generator runtime during any 12-month period. For each pollutant, the forecast facility-wide emission rate is compared to its Small-Quantity Emission Rate (SQER), and a "SQER Ratio" is calculated by dividing the facility-wide emission rate by the SQER. If the SQER Ratio for a given TAP exceeds 1.0, then the ambient concentration for that TAP must be estimated using the American Meteorological Society (AMS)/EPA Regulatory Model (AERMOD) dispersion model, and the health impacts for that TAP must be accounted for. As listed in Table 5, the emission rates for only four TAPs were forecast to exceed their respective SQERs:

- DEEP
- NO_2
- CO
- Ammonia
- Acrolein.

2.3.2 EMISSION RATES FROM MECHANICAL DRAFT COOLING TOWERS

The emission rates for criteria pollutants and TAPs emitted from the 32 cooling towers for the combined Phases 1 and 2 were calculated using mass balances. Emission calculation spreadsheets for the cooling towers are provided in Appendix B. In summary, the cooling tower emission rates were calculated using the following approach:

- If the makeup water is chlorinated, then it will contain trace concentrations of volatile chlorination disinfection byproducts. It was assumed that all of the VOCs in the makeup water will volatilize from the cooling towers.
- The cooling towers will be operated with 46 "cycles of concentration," which will cause the TDS concentration in the recirculation water to increase to 69,000 mg/L.
- The cooling tower supplier will be required to certify that the drift eliminators installed on each cooling tower reduce the drift droplet rate to at most 0.0005 percent of the recirculation water flow rate.
- It was assumed that the non-volatile chemical concentrations in the drift droplets will be identical to the non-volatile aqueous concentrations in the recirculation water, and the drift droplets will quickly evaporate to form solid drift particles containing those non-volatile compounds.
- It is understood that the size distribution of the liquid droplets that penetrate the drift eliminators is large, so that after the droplets evaporate most of the resulting solid particles will be larger than 2.5 microns in diameter. A description of how the size distributions for the liquid droplets and the evaporated solid particles were determined is provided in Appendix B. The size distribution of the liquid droplets for mechanical draft cooling towers with a drift performance of 0.0005 percent was based on data from SPX/Marley, a major manufacturer of cooling towers. The size distribution of the evaporated solid particles was calculated based on the liquid droplet size distribution and the assumption that the TDS concentration inside the liquid droplets will be 69,000 mg/L (the same as the TDS concentration within the cooling tower recirculation water). Based on those factors, it was determined that the size distribution of the evaporated solid particles will be large, with only 56 percent of the evaporated particles smaller than 10 microns in diameter and only 13 percent smaller than 2.5 microns in diameter.

Table 4 lists the forecast cooling tower drift emission rate for total suspended particulates, $PM_{2.5}$, and PM_{10} for the 32 cooling towers for the combined Phases 1 and 2. Based on the droplet size analysis described above, the forecast $PM_{2.5}$ emission rate is 2.99 tons per year, with the conservative assumption that the cooling towers will operate continuously throughout the year at the rated capacity.

Table 5 lists the TAP emission rates for the trace metals and chlorination byproduct compounds forecast to be present in the cooling tower makeup water. The emission rates for each of those TAPs will be less than their respective SQERs. Note, the emission rates for particulate TAPs entrained in the cooling tower drift were not adjusted downward to account for the large particle size distribution.

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

The emergency diesel generators are 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 are subject to EPA Tier 2 emission limits as specified by 40 CFR Part 89.

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

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

The proposed mechanical draft cooling towers are not subject to the operational restrictions specified by NSPS Subpart Q "Industrial Process Cooling Towers" because the Project Oxford facility will not be a major source of HAP emissions. That regulation prohibits the use of water treatment chemicals containing hexavalent chromium. Microsoft will not use any such water treatment compounds.

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 F.

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 Project Oxford Data Center:

- Integrated Control Package consisting of an integrated diesel particulate filter (DPF), diesel oxidation catalyst (DOC), and urea-based selective catalytic reduction (SCR). This is the system that Microsoft proposes to install on each generator at the Project Oxford facility. This system is highly efficient for control of NO_x, $PM_{2.5}$/DEEP, CO, VOCs, and particulate and gaseous TAPs. This technology would provide the maximum removal efficiencies for all pollutants.
- Urea-SCR system consisting of a urea-based SCR. This system is highly efficient for control of NO_x and NO_2. Urea-SCR has been retained for this analysis.
- Catalyzed DPF, which includes a DPF and a DOC in a single package. This system is highly efficient for control of $PM_{2.5}$/DEEP, CO, VOCs, and particulate and gaseous TAPs.
- DOC by itself. This system is highly efficient for removal of CO, VOCs, and gaseous TAPs. It is marginally effective for removal of $PM_{2.5}$/DEEP.
- Emission controls inherent to EPA Tier 2-certified engines.

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 the Titan Data Center in Moses Lake, 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 for the Project Oxford Data Center.

Table 6 lists the estimated removal efficiencies provided by each of the candidate technologies. The estimated removal efficiencies listed for the proposed Integrated Control Package (which is proposed by Microsoft) are realistically low values that account for the catalyst cold-start delay periods. The listed removal efficiencies for the other technologies are conservatively high values that were provided by one generator manufacturer (Caterpillar Corporation), and which apply only to the warmed-up, steady-state operating condition. Information on Caterpillar's estimated removal efficiencies are provided in Appendix F.

4.3 STEP 4: EVALUATE TECHNICALLY FEASIBLE TECHNOLOGIES FOR DIESEL GENERATORS

All of the technologies listed in Table 6 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 F. For the individual pollutants, cost effectiveness was calculated by dividing the total life-cycle annual cost ($/year) by the tons of facility-wide pollutant removed by the control device. The derived cost effectiveness was then compared to the following cost-effectiveness criteria values, which were developed based on Landau Associates' understanding of Ecology's most recent BACT evaluation for diesel generators in eastern Washington as of December 2012:

- Criteria air pollutants: $10,000 per ton of removed pollutants
- Toxic air pollutants: $20,000 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 VOC) were calculated using the methodology specified in the *EPA Air Pollution Control Cost Manual* (EPA 2002). Detailed cost spreadsheets are provided in Appendix F. Rough order of magnitude purchase price information for each control device to be evaluated and removal efficiencies for each pollutant were obtained from one of the potential bidders for the diesel generators (Caterpillar Corporation, see Appendix F). 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). Table 7 summarizes 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, regardless of Microsoft's voluntary proposal to install add-on emission controls onto EPA Tier 2-certified generators, this assessment concludes that BACT for Microsoft's Project Oxford

Data Center should be defined as EPA Tier 2-certified emergency generators. Based on Microsoft's voluntary proposal to install additional emission controls on the emergency generators at the Project Oxford Data Center, it is anticipated that the permit conditions will be tied to the more protective emission limits proposed in this NOC application.

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

The Integrated Control Package (which is proposed by Microsoft for installation on all generators at the Project Oxford facility) is so expensive that it would normally be considered cost-prohibitive for the purpose of reducing air pollutant emissions. However, Microsoft proposes the use of the Integrated Control Package to protect ambient air quality and to minimize the emissions profile of the data center. 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 Integrated Control Package proposed by Microsoft will 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 $28,400 per combined ton of removed pollutant, which exceeds the presumptive cost criterion for the combined pollutants.

4.3.3 COST-EFFECTIVENESS ANALYSIS FOR SCR BY ITSELF

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 $$19,100 per combined ton, which exceeds the presumptive acceptable cost criterion for the combined pollutants.

4.3.4 COST-EFFECTIVENESS ANALYSIS FOR CATALYZED DPF (DPF PLUS DOC)

The Catalyzed DPF 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 Catalyzed DPF 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 combined-pollutant cost effectiveness would be $62,800 per combined ton, which exceeds the cost criterion for the combined pollutants.

4.3.5 COST-EFFECTIVENESS ANALYSIS FOR DOC ALONE

The DOC-Alone control option 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 $27,700 per combined ton, which exceeds the acceptable cost criterion for the combined pollutants.

4.3.6 TOXICS BEST AVAILABLE CONTROL TECHNOLOGY FOR TOXIC AIR POLLUTANTS

TAPs emitted by the emergency generators at rates exceeding the SQERs include DEEP, NO_2, CO, 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 F. Table 8 summarizes the calculated TAP cost effectiveness for each control option, and compares the calculated cost effectiveness to the presumed threshold of $20,000 per ton of removed TAP.

DEEP is identical to PM (including back-half) emitted from the emergency generator. Control technologies and costs evaluated for PM are the same for DEEP. The minimum treatment cost of $630,000 per ton of removed DEEP exceeds the cost-effectiveness threshold; therefore, DPFs 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 greater than $191,000 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.

BACT was evaluated for CO as a criteria pollutant in Section 4.4.5. Ecology currently considers costs greater than $20,000 per ton of TAPs removed to be disproportionately expensive. The minimum treatment cost of $34,000 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.

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. If costs were assumed to be comparable to those estimated for VOCs, the treatment cost for acrolein by itself would be billions of dollars per ton of removed acrolein. Add-on controls for 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 proposed by Microsoft, Urea-SCR, Catalyzed DPF, 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, regardless of Microsoft's voluntary proposal to install the Integrated Control Package on all of its generators. Instead, the emission controls inherent to EPA Tier 2-certified generators 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 BEST AVAILABLE CONTROL TECHNOLOGY FOR COOLING TOWER DRIFT

The Project Oxford facility will use 32 cooling towers. The cooling tower is used to cool non-contact process water to a temperature that is useful for the process. The direct contact between the cooling water and air results in entrainment of some of the liquid water into the air. The resulting drift droplets contain total dissolved solids (TDS) in the cooling tower water, which form solid particles after the drift droplets evaporate downwind of the towers.

The Project Oxford cooling towers will use high-efficiency drift eliminators, and will be constructed with a configuration that will achieve a liquid droplet drift rate of no more than 0.0005 percent of the recirculation flow rate within each cooling tower. Microsoft consulted with several cooling tower manufacturers to determine if they could provide cooling towers with more efficient drift eliminators. As described in the correspondence included in Appendix B, the manufacturers indicated that they cannot provide cooling towers with drift eliminators with efficiencies better than 0.0005 percent.

Therefore, the high-efficiency drift eliminators at the Project Oxford Data Center (0.0005 percent) are proposed as BACT.

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 Acceptable Source Impact Levels (ASILs) for TAPs. Air dispersion model input values are provided in Appendix G. Electronic modeling files have been provided to Ecology under separate cover, as cited in Appendix H.

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

5.1 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). AERMOD was used to estimate ambient pollutant concentrations at the facility's boundary associated with emissions from the facility. 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.

5.1.1 STACK HEIGHTS AND BUILDING DOWNWASH INPUT PARAMETER MODELING

All generator stacks were modeled to be 46-foot-tall vertical stacks on the individual generator enclosures. The parapet walls of the buildings were modeled to be 29.7 feet high.

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 concentrations. The Building Profile Input Program (BPIP) with Plume Rise Model Enhancements (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). All of the

Project Oxford facility's generator stacks will be approximately the same height as the nearby data center buildings, so all stacks will be lower than GEP stack height.

5.1.2 RECEPTOR GRID SPACING AND TERRAIN HEIGHT INPUT MODELING

Receptor heights were set at 1.5 meters (m) above ground height to approximate the human breathing zone height. 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.

The receptor grid beyond the facility boundary consists of Cartesian flagpole receptor grids placed at a height of 1.5 m above ground. The grid spacing varies with distance from the facility boundary, as listed below:

- 10-m spacing from emission source to 350 m
- 25-m spacing from 350 m to 800 m
- 50-m spacing from 500 m to 2,000 m
- 100 m spacing beyond 2,000 m.

AERMAP requires the use of topography data to estimate surface elevations above mean sea level. Digital topographical data (in the form of Digital Elevation Model 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.

5.1.3 METEOROLOGICAL INPUT PARAMETER MODELING

The AERMOD Meteorological Pre-Processor (AERMET) is the 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

AERMET input data are described below and consist of surface observations, upper air soundings, and site-specific data.

Five years of hourly surface data were used for AERMET from the National Weather Service (NWS) hourly surface observations, taken from Moses Lake, Washington. The 5 years of data processed cover the period 2001 to 2005.

Five years of upper air data were used for AERMET from the NWS twice-daily upper air soundings from Spokane, Washington. The 5 years of data processed cover the period 2001 to 2005.

The site-specific data required for AERMET include 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. Source information for the hourly surface air, upper air, and site-specific meteorological data is summarized in Table 9.

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 at Grant County International Airport in Moses Lake, Washington. Looking at each sector individually, AERSURFACE determined the percentage of land use type within each sector. Land cover data from the U.S. Geological Survey National Land Cover Data 1992 archives were used as an input to AERSURFACE (USGS 1992). Default seasonal categories were 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.

5.1.4 AERMOD AIR DISPERSION MODELING

The AERMOD interface provided by Lakes Environmental was used for all Project Oxford facility air dispersion modeling. This version of the Lakes Environmental software incorporates the most recent version of AERMOD (version 12345). 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 property boundary.

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

The AERMOD modeling for the facility-wide diesel generator emissions was originally done using a generator configuration consisting of 32 large generators (2,500 kWe) and five small generators

(1,500 kWe). After the AERMOD modeling was completed, Microsoft modified the design of the facility to include a different mix of generators [36 large generators (2,500 kWe) and one small generator (750 kWe)]. The facility-wide emission rates for the revised configuration increased by a small amount (a 2 to 6 percent increase, depending on the pollutant). To account for these small emission increases, the original ground-level concentrations predicted by AERMOD for the original generator configuration were manually scaled upward by adjustment factors ranging from 1.02 to 1.06. A table showing the specific adjustment factors for each pollutant and averaging period is provided in Appendix G. These adjustments were small (only 2 to 6 percent), and had a negligible impact on the conclusions of the ambient air quality analyses.

The preliminary AERMOD modeling of the facility-wide particulate emissions from the 32 cooling towers was originally done using assumed emission rates of either 0.33 or 0.39 pounds per hour from each tower. The two emission rates that were used for preliminary modeling were each based on a different set of preliminary design and operating assumptions. Because the latest understanding of cooling tower design and operations for the project have changed since preliminary modeling was conducted, those preliminary modeling results were used to develop a "dispersion factor" for downwind particulate impacts. The calculated particulate emission rates from the cooling towers were later reduced to the values listed in Table 4 (the PM_{10} emission rate is 0.0913 pounds per hour from each tower, and the $PM_{2.5}$ emission rate is 0.0213 pounds per hour from each tower). The cooling towers' ambient PM_{10} and $PM_{2.5}$ impacts presented in this application were finally calculated by multiplying the reduced per-tower emission rates times the original dispersion factors. A table showing the original dispersion factors, the final emission rates, and the final adjusted modeling results is provided in Appendix G.

5.1.5 DISPERSION FACTORS AND PLUME VOLUME MOLAR REACTION MODEL REACTIVE PLUME MODEL

The AERMOD model was used to derive "dispersion factors" to calculate the ground-level concentration of the non-reactive pollutant acrolein and SO_2. The acrolein and ammonia dispersion factors, based on a 24-hour averaging period, were developed assuming a 24-hour-long facility-wide power outage, which represents the worst-case emission condition for compliance with the ASILs for ammonia and acrolein. Similar methodologies were used to model the 1-hour average impacts for those two pollutants and the annual-average impact for ammonia for the purpose of including those pollutants in the cumulative non-cancer risk analysis for the second-tier risk assessment. Additionally, an annual average dispersion factor was developed for SO_2 assuming the generators would operate the maximum number of hours that Microsoft is requesting that these generators be allowed to operate, which represents the worst-case emission condition for compliance with the NAAQS for SO_2. The "dispersion factor" for a 24-hour averaging period has units of micrograms per cubic meter (μg/m^3) per gram/second of facility-wide emission rate. After the facility-wide emission rates were calculated for each regulated pollutant, the dispersion factor was applied to calculate the maximum ambient concentration for each pollutant and averaging period.

Ambient NO_2 concentrations were modeled using the Plume Volume Molar Reaction Model (PVMRM) module of AERMOD. It was assumed that the primary NO_2 emission rate was 10 percent of the primary NO_x emission rate; this is the same assumption that Ecology has required for PVMRM modeling for all other computer data centers in Washington. Additionally, it was assumed that the ambient ozone concentration was 49 parts per billion during the entire year based on project coordinate-specific design values obtained from the Washington State University NW Airquest website (WSU website 2013).

5.2 ASSUMED BACKGROUND CONCENTRATIONS

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 2013). The reported regional background values were:

- PM_{10} (24-hour average) 81 μg/m^3
- $PM_{2.5}$ (annual average) 6.5 μg/m^3
- $PM_{2.5}$ (24-hour average) 21 μg/m^3
- NO_2 (1-hour average) 15.6 μg/m^3.

"Local background" values for $PM_{2.5}$ and NO_2 consist of the ambient impacts, at Project Oxford's maximum impact location, caused by emissions from the nearby emergency generators and industrial emission sources at the Columbia Data Center, Dell Data Center, and ConAgra Foods. Emissions from each of those facilities were assumed to be equal to their respective permit limits. After the location and date of the maximum impact caused by Project Oxford's proposed new generators were determined, AERMOD was used to model the "local background" ambient impacts at that same location and date caused by simultaneous activity at each of the adjacent data centers and industrial facilities. The modeled "local background" values were as follows:

- 24-Hour $PM_{2.5}$ (Monthly Testing). It was assumed that each nearby data center would conduct its scheduled monthly maintenance testing on the same calendar day that the Project Oxford facility would conduct its annual electrical bypass maintenance. It was assumed that each data center would test one generator at a time at low load, and would test all of its generators in 1 calendar day. It was assumed that the ConAgra facility would emit at its permitted rate. The modeled "local background" value at Project Oxford's maximum impact point was 0.021 µg/m^3.

- 1-Hour NO_2 (Monthly testing). It was assumed that each nearby data center would conduct its scheduled monthly maintenance testing on the same hour that the Project Oxford facility would conduct its annual electrical bypass maintenance, while the ConAgra facility would emit at its permitted rates. It was assumed the Dell Data Center operates seven generators at high load while the Columbia Data Center operates five generators at low load, based on operating limits listed in those facilities' air quality permits. The modeled "local background" value at Project Oxford's maximum impact point is 0.28 µg/m^3.

5.3 CRITERIA AIR POLLUTANT IMPACTS

NAAQS set by the EPA include both primary and secondary standards for criteria pollutants. Primary standards are designed to establish limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

Air dispersion modeling was conducted to estimate ambient pollutant concentrations caused by emissions from the diesel emergency generators to show compliance with the NAAQS and WAAQS. To estimate worst-case ambient impacts of criteria pollutants for models with averaging periods greater than 1 hour (i.e., 3-hour, 8-hour, 24-hour, and annual averaging periods) and for the SO_2 model with a 1-hour averaging period, it was conservatively assumed that the generators would operate at their maximum emission rate 24 hours per day, 365 days per year, and the AERMOD model automatically selected the location and date of the maximum impact.

A summary of NAAQS compliance modeling is provided in Table 10, and the locations of the maximum modeled ambient impacts are shown on Figure 3. The listed annual impacts are the theoretical maximum-annual values that account for full-buildout operations, initial commissioning testing of three generators, and recurring stack testing.

5.3.1 24-HOUR PM_{10} NAAQS COMPLIANCE DURING A FACILITY-WIDE POWER OUTAGE

As described in this section, the modeled ambient impact for 24-hour PM_{10} is less than the NAAQS, after accounting for regional background levels.

For 24-hour PM_{10}, AERMOD was used to simulate the effects of a full power outage, lasting for a full calendar day, while the 32 cooling towers continue to operate at their design loads. This is a worst-case scenario that assumes that both of these occur on a single day and is the scenario with the highest emissions for PM_{10}. All days were modeled with these worst-case PM_{10} emissions using a worst-case screening scenario, whereby a facility-wide power outage affecting all generators was assumed to last 365 days per year, 24 hours per day, and the 32 cooling towers were assumed to operate continuously. The

AERMOD model selected the location and date for the 1st-highest 24-hour impact at any receptor for each modeling year.

As shown in Table 11, the resulting Project Oxford-only PM_{10} impact is 8.7 µg/m^3 for the cooling towers (assuming that 56 percent of the evaporated solid drift particles are smaller than 10 microns in diameter, as described in Appendix B) and 11 µg/m^3 for the generators, with a combined project-only impact of 20 µg/m^3. That impact associated with Project Oxford operations is only a small fraction of the NAAQS. As shown on Figure 3, the location of the maximum PM_{10} impact is on the eastern facility boundary, and the maximum impact occurs when the wind blows eastward. When the wind blows in that direction, the plumes from the local background sources (ConAgra Foods, Dell Data Center, and Columbia Data Center) would all blow away from the Project Oxford facility. Therefore, a model to estimate local background impacts was not run for $PM_{10,}$ and it was assumed that the local background impact would be negligible. The 1st-highest 24-hour PM_{10} impact during a full power outage is 101 µg/m^3, which is lower than the NAAQS of 150 µg/m^3.

5.3.2 24-Hour $PM_{2.5}$ NAAQS Compliance

As described in this section, the modeled ambient impact for 24-hour $PM_{2.5}$ emitted by the generators and the cooling towers is less than the NAAQS, after accounting for local and regional background levels. This section presents the compliance demonstration for the 24-hour $PM_{2.5}$ NAAQS, which is based on the 3-year rolling average of the 98th-percentile 24-hour impact in each year. The compliance demonstration is provided for the Project Oxford operating scenario for annual electrical bypass maintenance and continuous operation of the cooling towers. Electrical bypass maintenance exhibits the generators' highest daily-average $PM_{2.5}$ emission rate of any operating scenario other than emergency power outages, which are expected to occur no more than 1 or 2 days per year. Therefore, electrical bypass maintenance is the most appropriate operating scenario for evaluating compliance with the 24-hour $PM_{2.5}$ NAAQS. The key operating assumptions are:

- During annual electrical bypass maintenance, four generators (one generator in each of the four buildings closest to the northeastern boundary of the Phase 1 data center) will operate at 80 percent load for 24 hours in a calendar day. As a conservative assumption, the four generators to be used were placed in the four buildings closest to the northern facility boundary (see Figure 3).
- All 32 cooling towers were set to their normal full load operating conditions with the assumption that 13 percent of the solid evaporated cooling tower drift particles would be small enough to be regulated as $PM_{2.5}$ (see Appendix B for information on the particle size distribution of the drift particulate emissions).

The AERMOD model was set with the four generators and the 32 cooling towers operating continuously for 24 hours per day, 365 days per year, and the AERMOD model selected the 1st- through

8th-highest modeled values. The NAAQS compliance limit applies to the 8th-highest day each year. Because hypothetical power outages (which would cause a daily $PM_{2.5}$ emission rate higher than the daily emission rate for annual electrical bypass maintenance) could theoretically occur on several days per year, this analysis evaluated the 3-year rolling average of the 4th-highest daily impacts caused by the generators and cooling towers operating during electrical bypass maintenance.

Local background impacts were modeled by assuming that the Dell Data Center and Columbia Data Center will conduct their monthly maintenance testing simultaneously with the annual electrical bypass maintenance at the Project Oxford facility, while the ConAgra facility will emit continuously at its permitted rates.

The results of the ambient air quality analysis are listed in Table 12. The modeled Project Oxford-only $PM_{2.5}$ impact is 0.7 µg/m^3 for the cooling towers and 2.37 µg/m^3 for the generators, with the combined impact associated with Project Oxford operations modeled to be only 3 µg/m^3. The impact associated with Project Oxford operations is only a small fraction of the NAAQS. The combined impacts from the Project Oxford facility, local background levels, and regional background levels are 24 µg/m^3 and are less than the NAAQS.

5.3.3 1-HOUR NO_2 NAAQS COMPLIANCE DURING ANNUAL ELECTRICAL BYPASS MAINTENANCE

As described in this section, the modeled ambient impact for 1-hour NO_2 concentrations caused by annual electrical bypass maintenance is less than the NAAQS, after accounting for local and regional background levels.

For 1-hour NO_2, AERMOD/PVMRM was used to simulate the effects of annual electrical bypass maintenance. Four generators (one generator in each of the four buildings closest to the northeastern boundary of the Phase 1 data center) will operate at 80 percent load for 16 hours in a calendar day. This type of maintenance is expected to be done for 8 days or more per year on a rotating basis throughout the facility. Electrical bypass maintenance is expected to be done for at least 8 days per year, and exhibits the highest hourly NO_x emission rate of any operating scenario other than emergency power outages, which are expected to occur no more than 1 or 2 days per year. Therefore, electrical bypass maintenance is the most appropriate operating scenario for evaluating compliance with the 1-hour NO_2 NAAQS.

As a conservative assumption, the four generators to be used for electrical bypass maintenance were placed in the four buildings closest to the northern facility boundary (see Figure 3). It was conservatively assumed that the Columbia Data Center and the Dell Data Center conduct their monthly testing at the same time, while ConAgra operates its boilers at their permitted rates. All days were modeled with these emissions using a worst-case screening approach, whereby all generators are activated for 365 days per year, 24 hours per day, and the AERMOD model selects the 1st-highest 1-hour impact at any receptor. The maximum simulated value was used in the comparison with the NAAQS.

The 1-hour NO_2 NAAQS considers the 3-year average of the 98th percentile of the highest daily 1-hour NO_2 value per year. Using the EPA's standard post-processing software, this is the 8th-highest modeled value per year. However, to account for the possibility that unforeseen high-emission events such as occasional power outages might occasionally cause elevated ambient pollutant concentrations on several days per year, the 1st-highest AERMOD value was used to evaluate the impacts from monthly testing.

As shown in Table 13, the resulting 3-year rolling 1st-highest 1-hour Project Oxford-only impact is approximately 160 $\mu g/m^3$. After accounting for regional background and local background values, and assuming that the other nearby data centers are doing their own generator testing on the same day and hour as the Project Oxford facility, the total NO_2 impact is 176 $\mu g/m^3$, which is lower than the NAAQS. As shown on Figure 3, the maximum impact occurs at the northern boundary of the Project Oxford facility, during an hour when the plumes from Project Oxford and ConAgra overlap while the wind blows from the southeast.

5.4 FIRST-TIER SCREENING OF TOXIC AIR POLLUTANT IMPACTS

As described in this section, the modeled ambient pollutant concentration impacts for all TAPs, other than DEEP, are less than their respective ASILs.

5.4.1 TOXIC AIR POLLUTANT EMISSION RATES COMPARED TO SMALL-QUANTITY EMISSION RATES

The first-tier TAP assessment compares the forecast emission rates to the SQERs and compares the maximum ambient impacts at any sensitive receptor to the ASILs. Table 5shows the calculated emission rates for each TAP emitted from the Project Oxford emergency generators and cooling towers, 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. The table lists the "SQER Ratio" of the Project Oxford emission rate compared to the SQER. The maximum emission rates for DEEP, NO_2, CO, ammonia, 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 emission exceeds 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 facility-wide 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 for each of the 5 modeling years. The annual impacts were modeled based on the maximum requested generator runtimes and generator loads listed in Table 1. For TAPs emitted by the cooling towers, it was assumed that the cooling towers would run continuously throughout the year.

5.4.2 Toxic Air Pollutant Ambient Concentration Impacts Compared to ASILs

The first-tier ambient concentration screening analysis is summarized in Table 10. The modeled DEEP concentration at the unoccupied facility boundary exceeds its ASIL by a wide margin, but the impacts for all TAPs other than DEEP are less than their respective ASILs. The annual impacts listed in Table 10 are the theoretical maximum-annual values that account for full-buildout operations, initial commissioning testing, and compliance stack testing during the same year of operation.

5.4.3 Annual-Average DEEP Impacts

The DEEP analysis was conducted by assuming all generators at the facility will operate at the requested maximum runtimes and generator loads listed in Table 1. The modeled theoretical maximum 12-month annual impact is 0.080 $\mu g/m^3$, and exceeds the DEEP ASIL value of 0.0033 $\mu g/m^3$. The location of the maximum annual-average DEEP impact is shown on Figure 3.

Therefore, a draft second-tier risk assessment for DEEP has been prepared and submitted to Ecology under separate cover (Landau Associates 2014). The risk assessment demonstrates that the estimated incremental increase in cancer risks over a 70-year period caused by the Project Oxford generators is less than 10 per million at all maximally-impacted receptors. The risk assessment also demonstrates that the hazard quotient for non-cancer risks is less than 1.0. According to Ecology's regulations, no third-tier DEEP analysis is required [WAC 173-460-090(7)].

5.4.4 1-Hour NO_2 Impacts During Facility-Wide Power Outage

As described in this section, the modeled ambient impact for 1-hour NO_2 during an unplanned power outage is less than the ASIL.

A worst-case screening analysis was conducted to demonstrate compliance with the ASIL for NO_2. The AERMOD/PVMRM model was set to assume that the Project Oxford 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 for each of the 5 modeling years. The maximum Project Oxford-only, 1-hour modeled ambient concentration of NO_2 at the project boundary for the full power outage scenario is 388 µg/m^3, which is less than the NO_2 ASIL of 470 µg/m^3. The location of the modeled impact is shown on Figure 3.

Therefore, ASIL compliance for NO_2 is confirmed using the first-tier screening analysis. No second-tier risk assessment for NO_2 is required.

6.0 SIGNATURES

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

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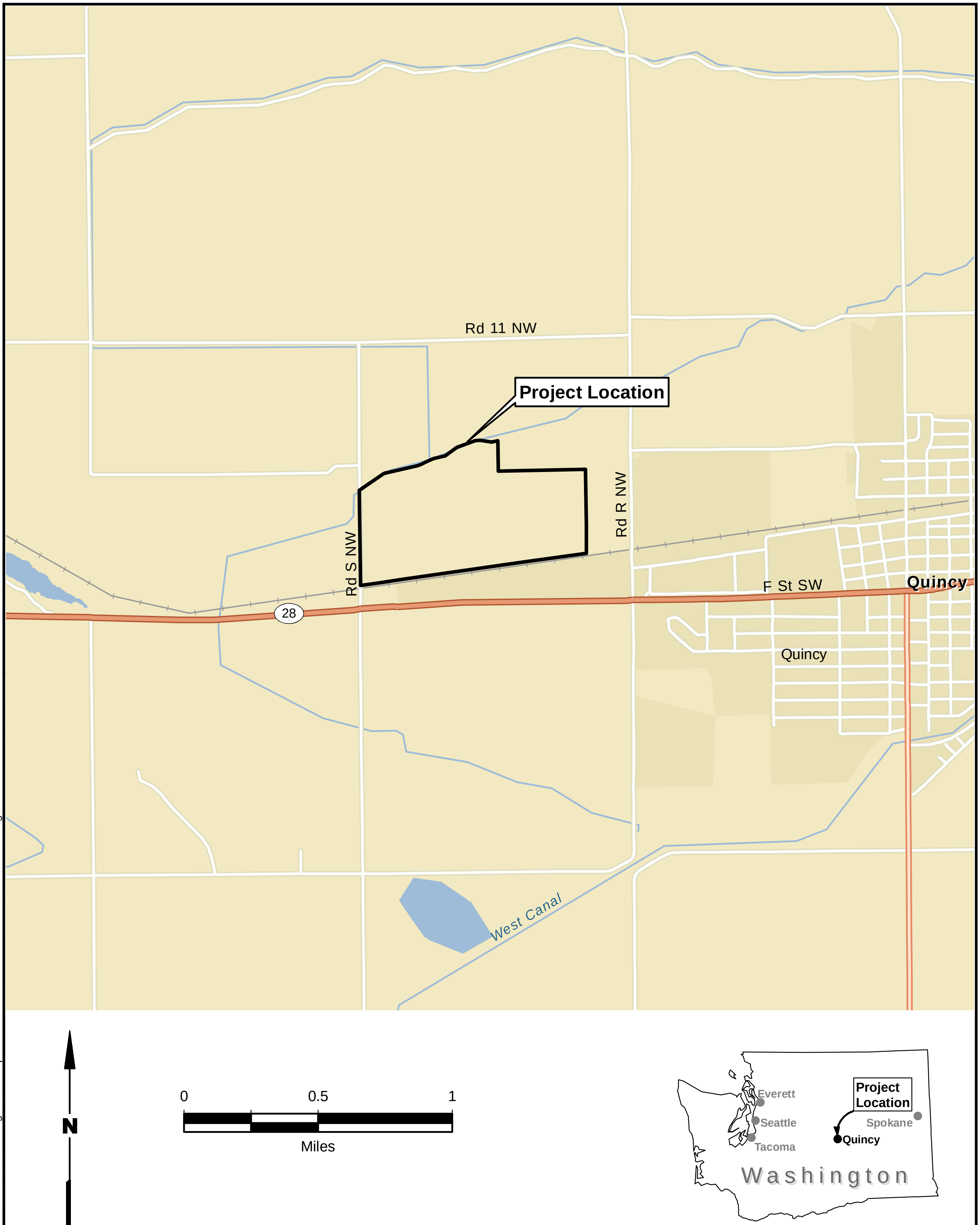

Data Source: Esri 2012.

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Project Oxford Data Center Quincy, Washington	**Vicinity Map**	Figure 1

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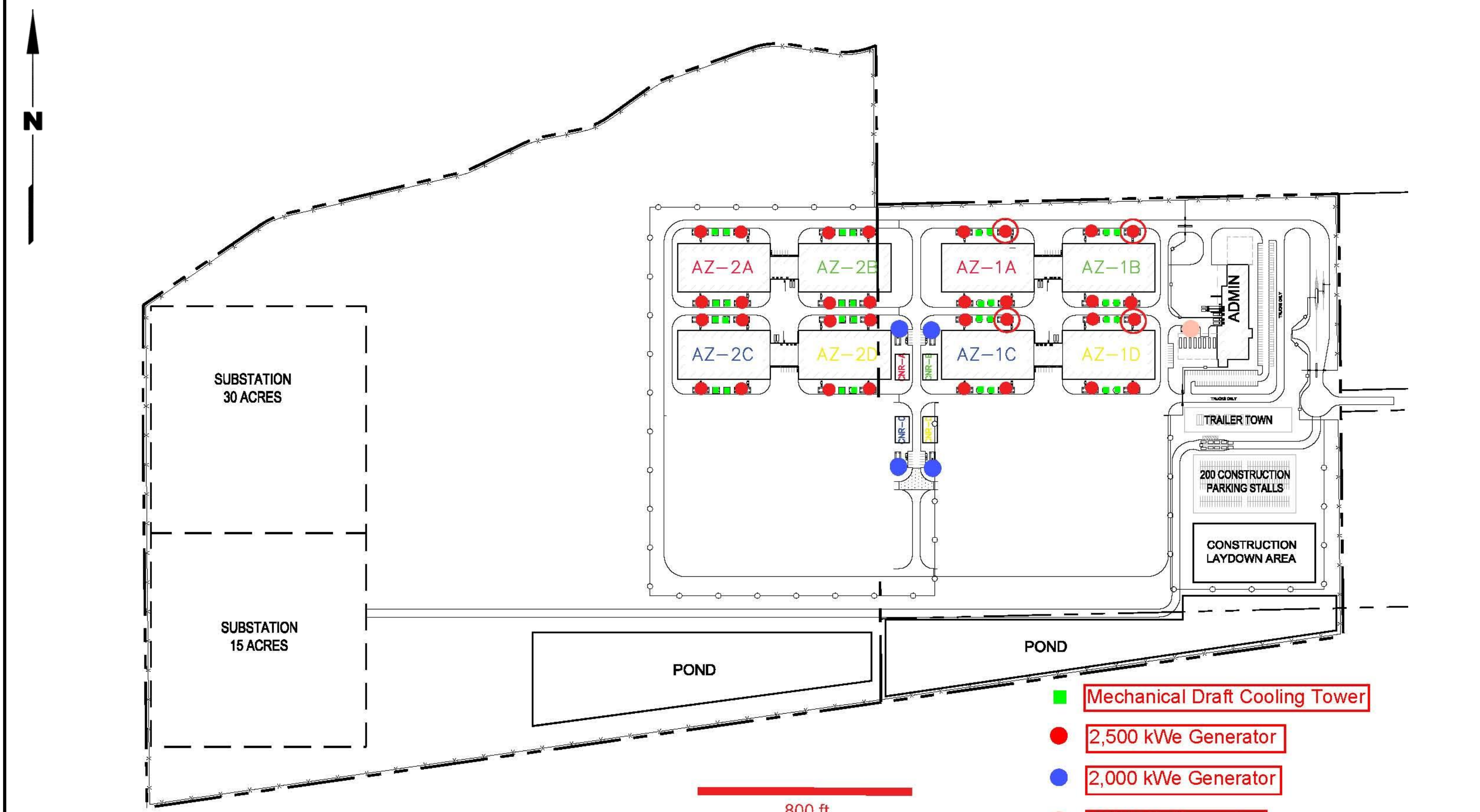

Data Source: Microsoft

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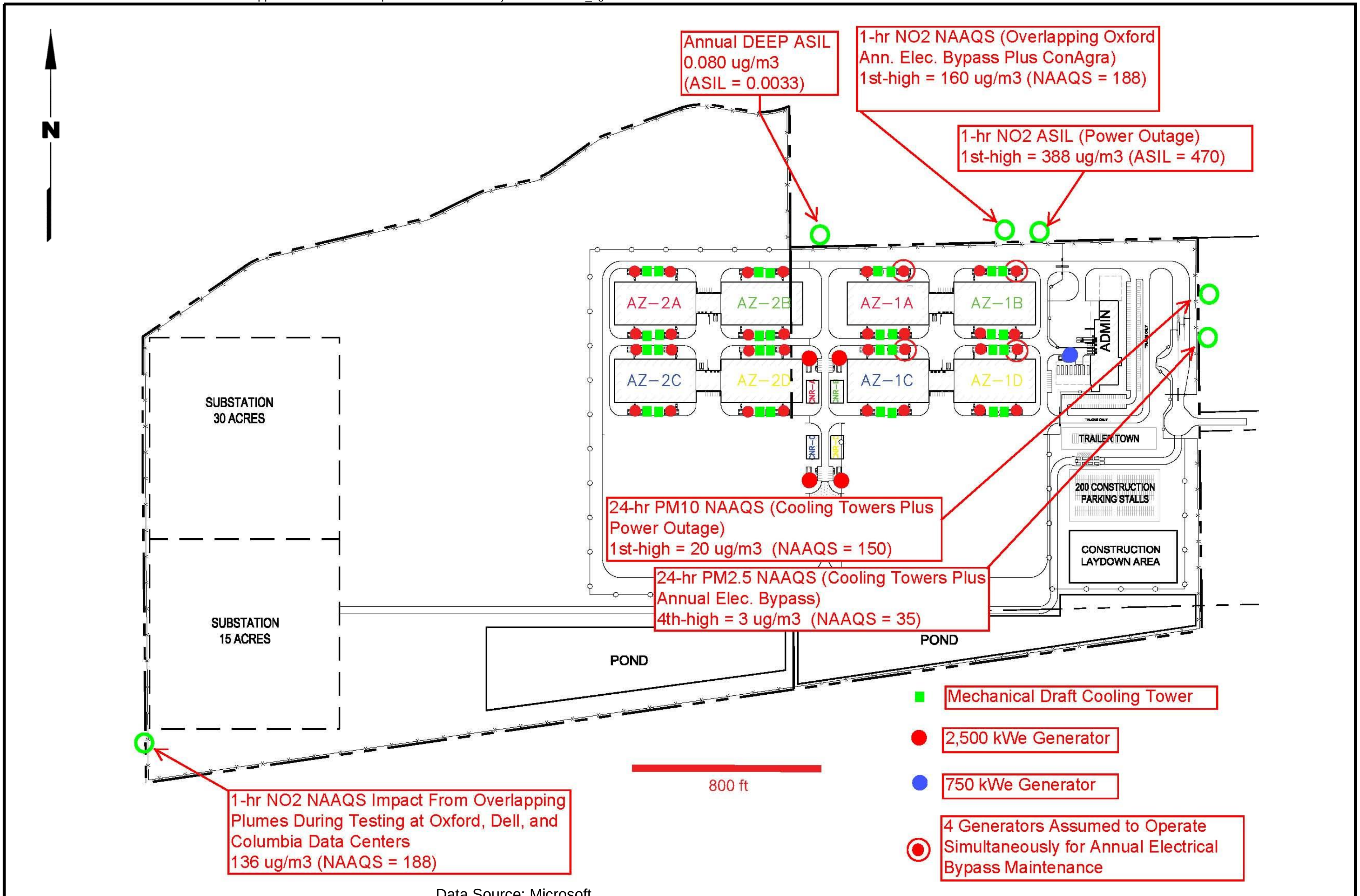
Project Oxford Data Center
Quincy, Washington

Site Plan

Figure 2



Data Source: Microsoft

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Project Oxford Data Center Quincy, Washington	**Maximum AERMOD Impact Locations**	Figure 3

TABLE 1
EMERGENCY GENERATOR RUNTIME SCENARIOS AND PROPOSED RUNTIME LIMITS
MICROSOFT PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

Runtime Event	Per-Generator Annual Hours/Year of Runtime at Indicated Load		
	Idle (10% Load)	80% Load	100% Load
Per-Generator Runtime for Recurring Annual Events			
Total Annual Runtime for Combined Runtime Scenarios	29 hrs/yr for combined weekly testing and generator cooldown. Runtime averaged across all generators in service. Runtime averaged over a 3-year rolling period.	40 hrs/yr for combined emergency power outages and electrical bypass for transformer maintenance. Runtime averaged across all generators in service. Runtime averaged over a 3-year rolling period.	17.5 hrs/yr for combined monthly load bank testing, semiannual load bank testing, and as-needed generator corrective maintenance. Runtime averaged across all generators in service. Runtime averaged over a 3-year rolling period.
Operational Limit To Comply with 1-Hour NO_2 NAAQS	N/A	Up to four 2,500-kW generators operating simultaneously during electrical bypass transformer maintenance, at an average generator load of 80 percent.	Up to three 2,500-kW generators tested simultaneously
Operational Limit To Comply with 24-Hour $PM_{2.5}$ NAAQS	N/A	Maximum daily generator usage during electrical bypass transformer maintenance limited to 192,000 kWe-hours per day.	N/A
One-Time-Only or Infrequent Events Accounted for in 70-Year Average DEEP Risk Assessment			
Initial Generator Commissioning (50 hours per generator, conducted once during the 70-year averaging period)	N/A	Each generator is tested once for 50 hrs over a full range of loads (average load assumed to be 80%). Distributed over 70 years, this is equivalent to 50/70 or 0.7 hrs/yr.	N/A
Periodic Stack Emission Testing on 3-yr cycle (2-3 gensets per year, each genset tested once every 24 years)	N/A	Each generator runs for 30 hrs/test over a range of loads (average load assumed to be 80%). Each generator is tested every 24 years. Distributed over 24 years, this is equivalent to 30/24 or 1.25 hours/year for each generator.	N/A

Note: Detailed breakdown of the daily, weekly, monthly, and annual runtime hours for each operating scenario is provided in Appendix C.

TABLE 2
UNCONTROLLED (EPA TIER 2-COMPLIANT) GENERATOR EMISSION RATES APPLICABLE TO COLD-START CONDITIONS MICROSOFT PROJECT OXFORD DATA CENTER QUINCY, WASHINGTON

Pollutant	Generator Load	Tier 2-Compliant Emission Rates (lbs/hour) 0.75 MW	Tier 2-Compliant Emission Rates (lbs/hour) 2.5 MW
NO_x	10%	5.7	7.02
	80%	22	40.95
	100%	37	61.89
PM (Includes back-half particulate fraction)	10%	0.49	1.19
	80%	0.58	0.46
	100%	0.54	0.53
CO	10%	4	4.62
	80%	6	4.71
	100%	4.1	6.01
VOCs	10%	0.59	0.96
	80%	0.53	1.19
	100%	0.4	1.31

TABLE 3
CONTROLLED [TIER 4 (FINAL)-COMPLIANT] GENERATOR EMISSION RATES FOR WARMED-UP CONDITIONS
MICROSOFT PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

Pollutant	Load	0.75-MW Generators		2.0-MW Generators	2.5-MW Generators	
		Emission Rate (Front Half Only For PM) (lb/hr)	Emission Rate (Front + Back Halves For PM) (lb/hr)	Emission Rate (Including Front Half and Back Half For PM) (lb/hr)	Emission Rate (Front Half Only For PM) (lb/hr)	PM Emission Rate (Front + Back Halves) (lb/hr)
NO_x	10%	5.7	--	0.49	0.5	--
	80%	1.8	--	2.6	3.37	--
	100%	2.6	--	2.2	2.47	--
PM	10%	0.06	0.18	0.48	0.076	0.379
	80%	0.03	0.1	0.21	0.08	0.288
	100%	0.042	0.12	0.148	0.077	0.283
CO	10%	0.8	--	2.6	2.93	--
	80%	0.75	--	10.1	15.04	--
	100%	0.53	--	4.45	7.61	--
Ammonia	10%	0.024	--	0.064	0.080	--
	80%	0.19	--	0.51	0.64	--
	100%	0.24	--	0.64	0.80	--
VOCs	10%	0.2	--	0.14	0.13	--
	80%	0.1	--	0.82	0.8	--
	100%	0.1	--	0.27	0.32	--

Note: The NO_x emission rate at 10% load for the 0.75-MW generators assumes that the exhaust temperature at that load might be so low that the SCR catalyst would not function.

TABLE 4
FACILITY-WIDE EMISSION RATES FOR CRITERIA AIR POLLUTANTS
MICROSOFT PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

Pollutant	Maximum Emission Rates (Combined Phases 1 and 2)		
	(lbs/hr)	(lbs/day)	(tons/year)
NO_x	352	3,641	8.4 (70-yr average) 8.6 (Maximum 12-month period)
DEEP, PM_{10}, $PM_{2.5}$ from diesel exhaust (includes total PM as front-half plus back-half)	11	252	0.531 (70-yr average) 0.536 (Maximum 12-month period)
DEEP (front-half only)	2.6	60	0.126 (70-year average)
CO	593	13,200	15.4 (70-yr average) 15.6 (Maximum 12-month period)
VOCs	30	699	0.80 (Maximum 12-month period)
Ammonia	22.7	545	0.70
SO_2	1.21	29	0.047
Lead	Negligible (a)	Negligible (a)	Negligible (a)
Cooling Tower Drift Total Suspended Particulates	5.25	126	23
Cooling Tower Drift PM_{10}	2.92	70	12.8
Cooling Tower $PM_{2.5}$	0.682	16.4	2.99
Facility-Wide Total Suspended Particulates	16	378	23.5
Facility-Wide PM_{10}	14	322	13.3
Facility-Wide $PM_{2.5}$	11.7	268	3.53

(a) The EPA's AP-42 document gives no emission factor for lead emissions from diesel-powered engines (EPA 1995), so the lead emissions are assumed to be negligible.

TABLE 5
FACILITY-WIDE EMISSION RATES FOR TOXIC AIR POLLUTANTS
MICROSOFT PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

Pollutant	CAS No.	SQER		Facility Emissions		SQER Ratio	SQER Exceeded?
Diesel Generator TAPs							
$PM_{2.5}$/DEEP	None	0.639	lbs/yr	1,072	lbs/yr	1,668	**Yes**
CO	630-08-0	50.2	lbs/1-hour	593	lbs/1-hour	12	**Yes**
SO_2		1.45	lbs/1-hour	1.2	lbs/hour	0.80	No
NO_2	10102-44	1.03	lbs/1-hour	35.2	lbs/hour	34	**Yes**
Ammonia	7664-41-7	9.3	lbs/day	545	lbs/day	59	**Yes**
Benzene	71-43-2	6.68	lbs/yr	4.48	lbs/yr	0.69	No
Toluene	108-88-3	*657*	lbs/day	0.511	lbs/day	0.00078	No
Xylenes	95-47-6	58	lbs/day	0.351	lbs/yr	0.0061	No
1,3-Butadiene	106-99-0	1.13	lbs/yr	0.24	lbs/yr	0.212	No
Formaldehyde	50-00-0	32	lbs/yr	0.48	lbs/yr	0.015	No
Acetaldehyde	75-07-0	71	lbs/yr	0.15	lbs/yr	0.0022	No
Acrolein	107-02-8	0.0079	lbs/day	0.015	lbs/day	1.82	**Yes**
Benzo(a)pyrene	50-32-8	0.174	lbs/yr	0.0016	lbs/yr	0.0090	No
Benzo(a)anthracene	56-55-3	1.74	lbs/yr	0.0038	lbs/yr	0.0022	No
Chrysene	218-01-9	17.4	lbs/yr	0.0094	lbs/yr	0.0005	No
Benzo(b)fluoranthene	205-99-2	1.74	lbs/yr	0.0068	lbs/yr	0.004	No
Benzo(k)fluoranthene	207-08-9	1.74	lbs/yr	0.0013	lbs/yr	0.0008	No
Dibenz(a,h)anthracene	53-70-3	0.16	lbs/yr	0.0021	lbs/yr	0.013	No
Ideno(1,2,3-cd)pyrene	193-39-5	1.74	lbs/yr	0.0025	lbs/yr	0.0015	No
Naphthalene	91-20-3	5.64	lbs/yr	0.80	lbs/yr	0.14	No
Propylene	115-07-1	394	lbs/day	5.35	lbs/yr	0.014	No
Cooling Tower TAPs							
Fluoride	---	1.71	lbs/day	0.026	lbs/day	0.015	No
Manganese	---	0.0053	lbs/day	0.0025	lbs/day	0.48	No
Copper	---	0.219	lbs/1-hour	3.5E-05	lbs/1-hour	0.00015	No
Chloroform	67-66-3	8.35	lbs/year	0.526	lbs/year	0.063	No
Bromodichloromethane	75-27-4	5.18	lbs/year	0.526	lbs/year	0.102	No
Bromoform	75-25-2	174	lbs/year	13.8	lbs/year	0.079	No

TABLE 6
RANKING OF TECHNICALLY FEASIBLE CONTROL TECHNOLOGIES
MICROSOFT PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

	Percent Removal Efficiency For Each Pollutant			
Technology and Runtime Condition	**$PM_{2.5}$/DEEP**	**CO**	**VOCS**	**NO_x**
Tier-4F Capable Integrated System (Cold-Start, Catalyst-Delay Average Efficiency)	54%	90%	80%	84%
Urea-SCR for NO_x Control (Steady-State, Warmed-Up Removal Efficiency)	Ineffective	Ineffective	Ineffective	89%
Catalyzed DPF By Itself (Steady-State, Warmed-Up Removal Efficiency)	85%	90%	80%	Ineffective
Diesel Oxidation Catalyst By Itself (Steady-State, Warmed-Up Removal Efficiency)	20%	90%	80%	Ineffective

TABLE 7
SUMMARY OF COST-EFFECTIVENESS ANALYSES FOR INDIVIDUAL CRITERIA AIR POLLUTANTS
MICROSOFT PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

	Cost-Effectiveness ($/ton)				
Control Device	**PM**	**CO**	**VOCs**	**NO_X**	**Combined Pollutants**
Tier-4F Capable Integrated Control System (Catalyzed DPF + SCR)	$2,260,000	$199,000	$1,420,000	$34,400	$28,400
Urea-SCR Alone	Ineffective	Ineffective	Ineffective	$19,100	$19,100
Catalyzed DPF Alone	$595,000	$84,000	$432,000	Ineffective	$62,800
Diesel Oxidation Catalyst Alone	$1,090,000	$34,000	$175,000	Ineffective	$27,700

TABLE 8
SUMMARY OF TBACT COST EFFECTIVENESS FOR TOXIC AIR POLLUTANTS
MICROSOFT PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

	Cost-Effectiveness ($/ton)				
Control Device	**PM-TAPs**	**CO**	**Acrolein**	**NO_2**	**Combined TAPs**
Tier-4F Capable Integrated Control System (Catalyzed DPF + SCR)	$2,260,000	$119,000	$7.5 Billion	$343,000	$118,000
Urea-SCR Alone	Ineffective	Ineffective	Ineffective	$191,000	$191,000
Catalyzed DPF Alone	$630,000	$84,000	$3.5 Billion	Ineffective	$73,000
Diesel Oxidation Catalyst Alone	$1,090,000	$34,000	$1.4 Billion	Ineffective	$33,000

TABLE 9
AERMET MODEL INPUT PARAMETERS
MICROSOFT PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

Data Type	Source (a)	Source IDs	Station Type	Latitude	Longitude
Hourly Surface Observations 2001-2005	Grant County International Airport Moses Lake, WA	72782 24111	ASOS-FAA	47.19N	119.31W
Twice-Daily Upper Air Soundings 2001-2005	Spokane, WA	72785 4106	NEXRAD	47.67N	117.62W
Site-Specific Data	AERMET User's guide AERSURFACE	N/A	N/A	47.19N	119.31W

Notes:

(a) Surface and upper air data purchased from the National Climatic Data Center.

ASOS-FAA = Automated Surface Observation System.

NEXRAD = Next Generation Radar.

N/A = Not applicable.

TABLE 10
AIR DISPERSION MODELING RESULTS
MICROSOFT PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

Criteria Pollutant	Standards in μg/m³ – National Standards – Primary	Standards in μg/m³ – National Standards – Secondary	Standards in μg/m³ – Washington State Standards	Maximum Ambient Impact Concentration (μg/m³)	AERMOD Filename	Background Concentrations (μg/m³) (a)	Maximum Ambient Impact Concentration Added to Background (μg/m³) (If Available)
Total Suspended Particulates							
Annual average	--	--	60	0.08 + 1.079 = 1.16	PM10-121313a	6.5 (Regional)	7.65
1st-Highest 24-hour average during power outage with cooling towers	--	--	150	15.7 + 11.3 = 27.0	PM10-121313b	81 (Regional)	108
Particulate Matter (PM_{10})							
Annual average	--	--	50	0.08 + 1.079 = 1.16	PM10-121313a	6.5 (Regional)	7.7
1st-Highest 24-hour average during power outage with cooling towers	150	150	150	8.7 + 11.3 = 20	PM10-121313b	81(Regional)	101
Particulate Matter ($PM_{2.5}$)							
Annual average	12	15	--	0.08 + 0.25 = 0.33	PM10-121313a	6.5 (Regional)	6.8
4th-highest 24-hour average for cooling towers and electrical bypass	35	35	--	0.69 + 2.37 = 3.1	PM25-120613a-e, f	21 (Regional) + 0.021 (Local)	24.4
Carbon Monoxide (CO)							
8-hour average	10,000	--	10,000	873	CO-112713a	482	1,355
1-hour average	40,000	--	40,000	1507	CO-112713a	842	2,349
Nitrogen Oxides (NO_2)							
Annual average (b)	100	100	100	1.1	NOx-120413a	2.8	3.9
1-hour average	188	--	--	160	NOx-112413b thru f	15.6 (Regional), 0.28 (local)	176
Sulfur Dioxide (SO_2)							
Annual arithmetic mean	--	--	80	0.0066	(c)	0.26	0.27
24-hour average	--	--	365	1.2	SO2-120413a	1.0	2.2
3-hour average	--	1,300	--	2.3	SO2-120413a	2.1	4.4
1-hour average	195	--	319	3.1	SO2-120413a	2.6	5.7

TABLE 10
AIR DISPERSION MODELING RESULTS
MICROSOFT PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

Toxic Air Pollutant	ASIL (µg/m^3)	Averaging Period	1st-Highest Ambient Concentration (µg/m^3)	AERMOD Filename
DEEP	0.00333	Annual average	0.080	DEEP-121613a
NO_2	470	1-hour average	388	NOx-112413a
CO	23,000	1-hour average	1,599	CO-112713a
Ammonia	70.8	24-hour average	21.8	(d)
Acrolein	0.06	24-hour average	0.0006	(d)

Notes:

µg/m^3 = Micrograms per cubic meter.

ppm = Parts per million.

ASIL = Acceptable source impact level.

DEEP = Diesel engine exhaust particulate matter

(a) Sum of "regional background" plus "local background" values. Regional background concentrations obtained from WSU NW Airquest website. Local background concentrations derived from AERMOD modeling.

(b) For the purpose of determining the 3-year average, five separate models were run (one for each year of meteorological data) to determine the 98th percentile concentration for each year based on the NAAQS.

(c) A dispersion factor was used to calculate the annual average concentration of SO_2 in ambient air based on the annual average DEEP model.

(d) A dispersion factor was used to calculate the 24-hour average concentration of ammonia and acrolein in ambient air based on the 1st-highest PM 24-hour average model.

TABLE 11
24-HOUR PM_{10} COMPLIANCE MODELING RESULTS
MICROSOFT PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

Modeling Year	**1st-Highest 24-Hour PM_{10} Concentration (µg/m^3)**
1st-Highest 24-Hr Cooling Tower Drift (Assuming 56% PM_{10} fraction)	8.7
1st-Highest Project Oxford-Generators	11.2
Regional Background	81
Local Background	Negligible
Total PM_{10} Impact	101
NAAQS Limit	150

TABLE 12
24-HOUR $PM_{2.5}$ NAAQS COMPLIANCE MODELING RESULTS
MICROSOFT PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

Modeling Year	4th-Highest 24-Hour $PM_{2.5}$ Concentration ($\mu g/m^3$)
4th-Highest 3-year Cooling Tower Drift (Assuming 13% $PM_{2.5}$ fraction)	0.69
4th-Highest 3-Year Average Project Oxford Generators, Assuming 4 generators operating for 24 hrs/day during electrical bypass maintenance	2.37
Regional Background	21
Local Background (Columbia Data Center, Dell Data Center, and ConAgra Fryers)	0.02
Total $PM_{2.5}$ Impact	24.1
NAAQS Limit	35

TABLE 13
1-HOUR NO_2 NAAQS COMPLIANCE MODELING RESULTS
MICROSOFT PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

Modeling Year	1st-Highest 1-Hour NO_2 Concentration ($\mu g/m^3$)
2001-2003 Project Oxford-Only (1st-Highest 1-hour)	160
2002-2004 Project Oxford-Only (1st-Highest 1-hour)	160
2003-2005 Project Oxford-Only (1st-Highest 1-hour)	160
1st-Highest 3-Year Average Project Oxford-Only Impact	160
Regional Background	15.6
Local Background (Columbia Data Center, Dell Data Center, and ConAgra Boilers)	0.28
Total NO_2 Impact	176
NAAQS Limit	188

APPENDIX A

Generator Specifications

DIESEL GENERATOR SET

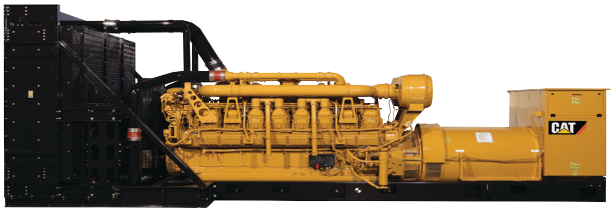

Image shown may not reflect actual package.

Mission Critical Standby
2500 ekW 3125 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.

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

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^SM program cost effectively detects internal engine component condition, even the presence of unwanted fluids and combustion by-products

CAT® 3516C-HD TA 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

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 OSHPD and carries an OSP-0084-10 for use in healthcare projects in California

Mission Critical Standby 2500 ekW 3125 kVA

60 Hz 1800 rpm 480 Volts

FACTORY INSTALLED STANDARD & OPTIONAL EQUIPMENT

System	Standard	Optional
Air Inlet	• Single element canister type air cleaner • Service indicator	[ ] Dual element & heavy duty air cleaners [ ] Air inlet adapters & shut-off
Cooling	• Radiator with guard • Coolant drain line with valve • Fan and belt guards • Cat® Extended Life Coolant	[ ] Radiator duct flange
Exhaust	• Dry exhaust manifold • Flanged faced outlets	[ ] Mufflers and Silencers [ ] Stainless steel exhaust flex fittings [ ] Elbows, flanges, expanders & Y adapters
Fuel	• Secondary fuel filters • Fuel priming pump • Flexible fuel lines • Fuel cooler*	[ ] Water separator [ ] Duplex fuel filter
Generator	• Cat digital voltage regulator (CDVR) with kVAR/PF control, 3-phase sensing • Winding temperature detectors • Anti-condensation heaters	[ ] Oversize & premium generators [ ] Bearing temperature detectors
Power Termination	• Bus bar (NEMA or IEC mechanical lug holes)- right side standard • Top and bottom cable entry	[ ] Circuit breakers, UL listed, 3 pole with shunt trip,100% rated, manual or electrically operated [ ] Circuit breakers, IEC compliant, 3 or 4 pole with shunt trip, manual or electrically operated [ ] Bottom cable entry [ ] Power terminations can be located on the right, left and/or rear as an option.
Governor	• ADEM™ 3	[ ] Load share module
Control Panels	• EMCP 4.2 Genset controller	[ ] Digital I/O Module [ ] Generator temperature monitoring & protection
Lube	• Lubricating oil and filter • Oil drain line with valves • Fumes disposal • Gear type lube oil pump	[ ] Oil level regulator [ ] Deep sump oil pan [ ] Electric & air prelube pumps [ ] Manual prelube with sump pump [ ] Duplex oil filter
Mounting	• Rails - engine / generator / radiator mounting • Rubber anti-vibration mounts (shipped loose)	[ ] Spring-type vibration isolator [ ] IBC Isolators
Starting/Charging	• 24 volt starting motor(s) • Batteries with rack and cables • Battery disconnect switch	[ ] Battery chargers [ ] Charging alternator [ ] Oversize batteries [ ] Ether starting aid [ ] Heavy duty starting motors [ ] Barring device (manual) [ ] Air starting motor with control & silencer [ ] Jacket water heater
General	• Right-hand service • Paint - Caterpillar Yellow except rails and radiators are gloss black • SAE standard rotation • Flywheel and flywheel housing - SAE No. 00	[ ] UL 2200 [ ] CSA certification [ ] CE Certificate of Conformance [ ] Seismic Certification per Applicable Building Codes: IBC 2000, IBC 2003, IBC 2006, IBC 2009, CBC 2007
Note	Standard and optional equipment may vary for UL 2200 Listed Packages. UL 2200 Listed packages may have oversized generators with a different temperature rise and motor starting characteristics.	

SPECIFICATIONS

CAT GENERATOR

Cat Generator
Frame size.. 1842
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)........................... 003.00
Voltage regulator............. 3 Phase sensing with selectible volts/Hz
Voltage regulation............Less than +/- 1/2% (steady state)
Less than +/- 1/2% (w/3% speed change)

CAT DIESEL ENGINE

3516C-HD ATAAC, V-16, 4-Stroke Water-cooled Diesel
Bore... 170.00 mm (6.69 in)
Stroke.. 215.00 mm (8.46 in)
Displacement..78.08 L (4764.73 in³)
Compression Ratio... 14.7:1
Aspiration..TA
Fuel System.................................... Electronic unit injection
Governor Type... ADEM3

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

Mission Critical Standby 2500 ekW 3125 kVA

60 Hz 1800 rpm 480 Volts

TECHNICAL DATA

Open Generator Set - - 1800 rpm/60 Hz/480 Volts	DM9228	
EPA Certified for Stationary Emergency Application (EPA Tier 2 emissions levels)		
Generator Set Package Performance		
Genset Power rating @ 0.8 pf	3125 kVA	
Genset Power rating with fan	2500 ekW	
Fuel Consumption		
100% load with fan	656.8 L/hr	173.5 Gal/hr
75% load with fan	510.8 L/hr	134.9 Gal/hr
50% load with fan	372.4 L/hr	98.4 Gal/hr
Cooling System[1]		
Air flow restriction (system)	0.12 kPa	0.48 in. water
Engine Coolant capacity with radiator/exp. tank	504.0 L	133.1 gal
Engine coolant capacity	233.0 L	61.6 gal
Radiator coolant capacity	271.0 L	71.6 gal
Inlet Air		
Combustion air inlet flow rate	204.2 m³/min	7211.3 cfm
Exhaust System		
Exhaust stack gas temperature	490.7 ° C	915.3 ° F
Exhaust gas flow rate	554.5 m³/min	19582.0 cfm
Exhaust flange size (internal diameter)	203.2 mm	8.0 in
Exhaust system backpressure (maximum allowable)	6.7 kPa	26.9 in. water
Heat Rejection		
Heat rejection to coolant (total)	826 kW	46975 Btu/min
Heat rejection to exhaust (total)	2502 kW	142288 Btu/min
Heat rejection to aftercooler	786 kW	44700 Btu/min
Heat rejection to atmosphere from engine	161 kW	9156 Btu/min
Heat rejection to atmosphere from generator	101.5 kW	5772.3 Btu/min
Alternator[2]		
Motor starting capability @ 30% voltage dip	6559 skVA	
Frame	1842	
Temperature Rise	150 ° C	270 ° F
Lube System		
Sump refill with filter	466.0 L	123.1 gal
Emissions (Nominal)[3]		
NOx g/hp-hr	5.32 g/hp-hr	
CO g/hp-hr	.42 g/hp-hr	
HC g/hp-hr	.1 g/hp-hr	
PM g/hp-hr	.037 g/hp-hr	

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

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

[3] Emissions data measurement procedures are consistent with those described in EPA CFR 40 Part 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

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. 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 35° API [16° C (60° F)] gravity having an LHV of 42 780 kJ/kg (18,390 Btu/lb) when used at 29° C (85° 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.

Mission Critical Standby 2500 ekW 3125 kVA

60 Hz 1800 rpm 480 Volts

DIMENSIONS

Package Dimensions		
Length	**6982.5 mm**	**274.9 in**
Width	**2569.2 mm**	**101.15 in**
Height	**3009.3 mm**	**118.48 in**

NOTE: For reference only - do not use for installation design. Please contact your local dealer for exact weight and dimensions. (General Dimension Drawing #3292332).

Performance No.: DM9228

Feature Code: 516DE6P

Gen. Arr. Number: 2523944

Source: U.S. Sourced

November 06 2012 20937329

www.Cat-ElectricPower.com

CAT® SCR PROPOSAL

Friday, April 18, 2014 Quotation Number: **13102801RW-E** Revision: **4**

SCR & DPF units in a 409L Stainless Steel Double Wall Critical Grade Silencer Housing

Project Description:	**Microsoft Quincy MWH01 - Cat 3516C HD 2500 ekW Generators**

NC Power Systems
Brant Briody
Sales Representative
17900 W. Valley Highway
Tukwila, WA 98188

Email: bbriody@ncpowersystems.com
Telephone: **(425) 656-4587**
Mobile: **(206) 510-3491**

Application Specifications:

Site Location (Address):	**Quincy Washingtion**		
Environment (Alt,Temp,RH):	**1300 ft, 10 deg to 90 deg F**		
Mounting Location:	**Over Generator**		
Regulation Requirement:	**BACT targeting non-certified Tier 4 Final Levels**		
Average Running Load (%):	**?**	Runtime (hr/yr):	**100**
Minimal Operating Load (%):	**30%**	Minimal Exhaust Temp:	**300 deg C**

Engine Specifications: *Quantity 16* *CAT, reference # DM8266*

Engine Model Number:	**3516C HD, Tier 2**			Engine S/N:	**SBK00251**
Generator Power Rating (ekW):	**2,500**	**Standby**		EPA Family #:	**CCPXL78.1NZS**
Engine Displacement (liters):	**78**			Model Name:	**Generator**
Max Fuel Sulfur Content (ppm):	**< 50**				
Engine Power Output (bhp):	**3,633**	or	***2710***	***bkW @ 1800 RPM***	
Exhaust Flow Rate (ACFM):	**19,579**	or	***554.4***	***m^3/min***	
Exhaust Stack Temp (deg F):	**915**	or	***490.6***	***deg C***	
Max Exhaust Pressure(" H_2O):	**27**	or	***6.7***	***kPa***	

Estimated Engine Emissions Data:

Requirement	**Emissions Source:**	***Potential Site Variation***	
BACT		***Pre Catalyst***	***Post Catalyst Estimates*****
g/bkW-hr		**g/bkW-hr**	**g/bkW-hr**
0.67	**NOx***	**5.93**	**0.67**
3.50	**CO**	**1.61**	**3.50**
0.19	**HC**	**0.47**	**0.19**
0.03	**PM**	**0.14**	**0.03**

**NOx Reductions will be validated by a calibrated gas analyzer during Dealer Site Commissioning of the CAT SCR System at defined load points and steady-state conditions.*

***Post Catalyst Emissions Reduction based on 100% Load, ISO conditions and exhaust temperatures above 300 deg C through the SCR Catalyst*

DPF Specifications:

Material:	**Platinum Group Catalyzed Cordierite Ceramic wall-flow filter substrates**	
Number of Filters:	**12**	**FDA221**
Typical Regeneration using ULSD:	Above 350 deg C (662 deg F) for 30% of engine operating time & greater than 40% engine load	
Max Number of Cold Starts:	**12 consecutive 10 minute idle sessions followed by 2 hrs regeneration**	

CATERPILLAR®

SCR Specifications:

Material:	**Extruded Vanadia Substrates**		# T6 Modules:	**30**
Total Amount of Catalyst (cubic ft):	**54 (15.3 cubic meters)**		# T2 Modules:	**60**
Number of Catalyst Layers:	**3 layers @ 80 blocks/layer**	***8 wide by 10 high***	# T4 Modules:	
Injection Lance:	**36 inches (914 mm)**			
Approximate DEF Consumption:	**7 gal/hr or 26.6 liters/hr of 32.5% Technical Grade Urea**			
Recommended Reductant:	***32.5% DEF (Diesel Exhaust Fluid), Please reference Cat document PELJ1160***			
Maximum Ammonia Slip:	***Not Specified***			

Dosing Control Cabinet: ***Nema 12 Enclosure (36" high x 32" wide x 12" deep)***

*Touch Screen Display & Dual NOx Sensors for a True Closed-Loop System
*Controller, Pressure Sensor, Temperature Sensor, Dosing Pump, Pressure Regulator, Secondary Urea Filter
*Power requirement: 240/120 volts AC, 10/20 amps, 50 or 60 Hertz
*Records NOx levels pre and post, Temperature and Pressure, Time and Date
*ModBus Communications Enabled
*Auto Start, Stop and Purge Cycle

Tube Bundle: ***Dosing Control Cabinet to Injection Lance***

*1/4" Heat Traced Stainless Steel tubing for DEF Flow
*1/2" Stainless Steel or Poly tubing for Compressed Air

Injection and Mixing Section: ***Integrated within the E-POD housing***

*Air & Urea Injection with Static Mixers internal to the SCR Silencer Housing
*Compressed Air requirement to be Oil Free, 10 SCFM @ 100 PSIG with a refrigerated dryer

Silencer Housing Specifications:

Material:	**409L Stainless Steel, Double Wall, Welded Surface Finish**				
Approximate Dimensions L x W x H (inches):	**197**	**x**	**94**	**x**	**71**
Approximate Dimensions L x W x H (mm):	**5,004**	**x**	**2,388**	**x**	**1,803**
Estimated Weight (pounds / kilograms):	**10,000**	**/ 4550**			
Silencer Sound Reduction (dBa):	**27-35**	**Critical Grade Silencing**			
Est. Pressure Drop Silencer+SCR+DPF ("H_2O):	**21.8**	*as configured at rated load or (kPa):*			***5.4***
Inlet Size inches (mm):	**24 (610)**		**Flange**	# of Inlets:	**1**
Outlet Size inches (mm):	**24 (610)**		**Flange**		

This System Includes:

SILENCER - Stainless Steel:	**Yes**	INTERNAL Mixing and DEF Injection:	**Yes**
SCR Catalyst:	**Yes**	Dosing Control Cabinet:	**Yes**
DPF Units:	**Yes**	Operation & Maintenance Manual:	**Yes**
		Start-up Commissioning:	**No**

Notes:

Recommended minimum engine load of 20% and 360 degrees C through the particulate filters to ensure filter regeneration and prevent wet stacking the catalyst. If this is not possible then following 4 hours of cumulative runtime at low loads the engines should be run with at least 50% load for 2 hours to regenerate the filter media.

Terms & Conditions:	***Incoterms:***	**FCA**	**Santa Fe**
Warranty:	**24 months or 8,000 hours of operation, whichever comes first, from date of commissioning**		

Pricing:

	Closed-Loop System Ref/Cat #	Description	Quantity	Unit Price	Dealer Net Total (USD)
1	**12041601AE**	CAT® SCR w/ SCR & DPF in a 409L Stainless Steel Double Wall Critical Grade Silencer			
2	**12041601AE-IB**	Custom Insulating Blanket			
				Estimated Freight:	
				Total:	

	Recommended Equipment: Ref/Cat #	Description	Quantity	Unit Price	Dealer Net Total (USD)
1	**376-8483**	Atlas Copco SF-4 Air Compressor (typically 460 Volt/ 3 phase, call for options)	**16**		

M310P28768A88160E8459

Cat 3516C HD 2500 ekW Tier 2 Generator, DM8266

SCR Operation Status*	TMI Potential Site Variation Data						Estimated Reduction at % Load							
	Engine Load	Exhaust Temp	NOx	CO	HC	PM	NOx		CO		HC		PM	
	%	deg C	g/bkW-hr	g/bkW-hr	g/bkW-hr	g/bkW-hr	Reduction %	g/bkW-hr	Reduction %	g/bkW-hr	Reduction %	g/bkW-hr	Reduction %	g/bkW-hr
On	**100%**	491	8.55	1.02	0.19	0.07	85%	1.28	80%	0.20	85%	0.03	85%	0.01
On	**75%**	459	6.90	0.64	0.24	0.07	90%	0.69	80%	0.13	80%	0.05	85%	0.01
On	**50%**	455	5.01	0.78	0.39	0.09	90%	0.50	80%	0.16	80%	0.08	85%	0.01
On	**25%**	444	4.69	1.97	0.54	0.19	90%	0.47	80%	0.39	80%	0.11	85%	0.03
On	**10%**	342	8.67	5.71	1.19	0.39	85%	1.30	80%	1.14	70%	0.36	85%	0.06

**SCR in operation above 330 deg C*

Estimated EPA D2 Cycle 5 Mode Weighted Average									
Engine Load	D2 Cycle Weight	NOx		CO		HC		PM	
%	%	Pre g/bkW-hr	Post g/bkW-hr	Pre g/bkW-hr	Post g/bkW-hr	Pre g/bkW-hr	Post g/bkW-hr	Pre g/bkW-hr	Post g/bkW-hr
100%	**5%**	0.428	0.064	0.051	0.010	0.009	0.001	0.003	0.001
75%	**25%**	1.726	0.173	0.161	0.032	0.060	0.012	0.017	0.003
50%	**30%**	1.504	0.150	0.233	0.047	0.117	0.023	0.028	0.004
25%	**30%**	1.408	0.141	0.591	0.118	0.161	0.032	0.056	0.008
10%	**10%**	0.867	0.130	0.571	0.114	0.119	0.036	0.039	0.006
D2 Average:		**5.932**	**0.658**	**1.607**	**0.321**	**0.466**	**0.105**	**0.143**	**0.022**
EPA Tier 4 Final:			**0.670**		**3.500**		**0.190**		**0.030**

PERFORMANCE DATA[DM9228]

November 27, 2013

Performance Number: DM9228

Change Level: 01

SALES MODEL:	3516C	**COMBUSTION:**	DI
ENGINE POWER (BHP):	3,634	**ENGINE SPEED (RPM):**	1,800
GEN POWER WITH FAN (EKW):	2,500.0	**HERTZ:**	60
COMPRESSION RATIO:	14.7	**FAN POWER (HP):**	130.1
APPLICATION:	PACKAGED GENSET	**ASPIRATION:**	TA
RATING LEVEL:	MISSION CRITICAL STANDBY	**AFTERCOOLER TYPE:**	ATAAC
SUB APPLICATION:	STANDARD	**AFTERCOOLER CIRCUIT TYPE:**	JW+OC, ATAAC
PUMP QUANTITY:	2	**INLET MANIFOLD AIR TEMP (F):**	122
FUEL TYPE:	DIESEL	**JACKET WATER TEMP (F):**	210.2
MANIFOLD TYPE:	DRY	**TURBO CONFIGURATION:**	PARALLEL
GOVERNOR TYPE:	ADEM3	**TURBO QUANTITY:**	4
ELECTRONICS TYPE:	ADEM3	**TURBOCHARGER MODEL:**	GT6041BN-48T-1.10
CAMSHAFT TYPE:	STANDARD	**CERTIFICATION YEAR:**	2010
IGNITION TYPE:	CI	**CRANKCASE BLOWBY RATE (FT3/HR):**	3,619.4
INJECTOR TYPE:	EUI	**FUEL RATE (RATED RPM) NO LOAD (GAL/HR):**	16.2
FUEL INJECTOR:	2501368	**PISTON SPD @ RATED ENG SPD (FT/MIN):**	2,539.4
REF EXH STACK DIAMETER (IN):	12		
MAX OPERATING ALTITUDE (FT):	2,953		

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
2,500.0	100	3,633	336	0.334	173.5	78.1	121.9	1,235.6	67.6	915.2
2,250.0	90	3,283	303	0.335	157.1	71.3	119.4	1,190.0	61.3	881.2
2,000.0	80	2,935	271	0.339	142.3	64.3	116.9	1,158.9	55.3	864.0
1,875.0	75	2,760	255	0.342	134.9	60.7	115.8	1,145.6	52.3	858.5
1,750.0	70	2,586	239	0.346	127.6	57.0	114.7	1,133.3	49.3	854.6
1,500.0	60	2,237	207	0.354	113.0	49.5	112.7	1,112.4	43.2	851.2
1,250.0	50	1,889	174	0.365	98.4	41.3	111.0	1,091.8	36.8	850.7
1,000.0	40	1,547	143	0.373	82.5	31.4	109.4	1,061.5	29.3	856.6
750.0	30	1,203	111	0.385	66.2	21.7	107.9	1,010.3	22.1	848.2
625.0	25	1,029	95	0.394	57.9	17.2	107.2	968.3	18.7	831.1
500.0	20	854	79	0.403	49.2	12.7	106.4	902.0	15.5	796.1
250.0	10	497	46	0.441	31.3	4.8	104.1	700.7	9.8	647.3

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
2,500.0	100	3,633	85	466.7	7,212.2	19,578.8	32,046.3	33,260.4	7,001.7	6,362.4
2,250.0	90	3,283	78	443.0	6,831.8	17,980.7	30,219.3	31,318.8	6,593.0	6,013.7
2,000.0	80	2,935	70	417.8	6,404.5	16,560.6	28,284.6	29,277.2	6,151.5	5,625.4
1,875.0	75	2,760	66	404.7	6,173.3	15,893.2	27,261.3	28,202.4	5,928.1	5,427.1
1,750.0	70	2,586	63	391.2	5,929.9	15,232.6	26,196.0	27,086.8	5,698.4	5,222.0
1,500.0	60	2,237	55	363.5	5,411.9	13,879.0	23,947.5	24,739.5	5,205.5	4,779.1
1,250.0	50	1,889	46	334.6	4,843.3	12,413.0	21,444.3	22,133.2	4,657.5	4,283.2
1,000.0	40	1,547	36	297.5	4,121.4	10,609.5	18,262.0	18,840.0	3,963.0	3,647.2
750.0	30	1,203	25	249.8	3,423.0	8,763.8	15,175.3	15,640.3	3,294.6	3,037.8
625.0	25	1,029	21	223.4	3,104.6	7,844.6	13,765.1	14,171.8	2,988.1	2,760.8
500.0	20	854	16	197.2	2,791.2	6,823.5	12,376.2	12,722.2	2,671.7	2,476.1
250.0	10	497	7	152.3	2,237.9	4,800.2	9,917.6	10,136.8	2,132.0	1,999.8

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
2,500.0	100	3,633	46,992	9,146	142,265	79,907	19,835	44,723	154,077	372,403	396,702
2,250.0	90	3,283	44,242	8,557	127,929	70,449	17,960	39,380	139,243	337,204	359,207
2,000.0	80	2,935	41,477	8,162	116,879	63,561	16,262	34,167	124,444	305,311	325,233
1,875.0	75	2,760	40,076	8,007	111,588	60,518	15,425	31,612	117,053	289,608	308,505
1,750.0	70	2,586	38,657	7,874	106,293	57,637	14,588	29,085	109,651	273,881	291,752
1,500.0	60	2,237	35,755	7,684	95,729	52,220	12,915	24,201	94,874	242,485	258,307
1,250.0	50	1,889	32,626	7,527	85,184	46,626	11,245	19,401	80,109	211,118	224,893
1,000.0	40	1,547	29,235	7,262	72,693	40,153	9,427	13,873	65,583	176,995	188,544
750.0	30	1,203	25,476	6,784	59,425	32,726	7,565	8,706	51,005	142,037	151,305
625.0	25	1,029	23,394	6,435	52,542	28,568	6,621	6,496	43,653	124,317	132,429
500.0	20	854	21,006	5,995	44,739	23,683	5,624	4,534	36,223	105,594	112,484
250.0	10	497	15,737	5,026	27,795	12,371	3,578	1,916	21,071	67,181	71,564

Emissions Data

RATED SPEED POTENTIAL SITE VARIATION: 1800 RPM

GENSET POWER WITH FAN		EKW	2,500.0	1,875.0	1,250.0	625.0	250.0
PERCENT LOAD		%	100	75	50	25	10
ENGINE POWER		BHP	3,633	2,760	1,889	1,029	497
TOTAL NOX (AS NO2)		G/HR	22,948	14,101	7,004	3,568	3,185
TOTAL CO		G/HR	2,726	1,304	1,092	1,496	2,098
TOTAL HC		G/HR	500	499	543	408	437
PART MATTER		G/HR	185.5	123.7	132.1	139.5	141.0
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	2,818.9	2,229.5	1,544.3	1,352.7	2,230.2
TOTAL CO	(CORR 5% O2)	MG/NM3	351.8	213.9	252.3	594.6	1,552.7
TOTAL HC	(CORR 5% O2)	MG/NM3	55.9	72.8	108.8	140.7	282.4
PART MATTER	(CORR 5% O2)	MG/NM3	19.7	16.5	25.8	48.5	88.2
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,373	1,086	752	659	1,086
TOTAL CO	(CORR 5% O2)	PPM	281	171	202	476	1,242
TOTAL HC	(CORR 5% O2)	PPM	104	136	203	263	527
TOTAL NOX (AS NO2)		G/HP-HR	6.38	5.15	3.74	3.50	6.47
TOTAL CO		G/HP-HR	0.76	0.48	0.58	1.47	4.26
TOTAL HC		G/HP-HR	0.14	0.18	0.29	0.40	0.89
PART MATTER		G/HP-HR	0.05	0.05	0.07	0.14	0.29
TOTAL NOX (AS NO2)		LB/HR	50.59	31.09	15.44	7.87	7.02
TOTAL CO		LB/HR	6.01	2.88	2.41	3.30	4.62
TOTAL HC		LB/HR	1.10	1.10	1.20	0.90	0.96
PART MATTER		LB/HR	0.41	0.27	0.29	0.31	0.31

RATED SPEED NOMINAL DATA: 1800 RPM

GENSET POWER WITH FAN		EKW	2,500.0	1,875.0	1,250.0	625.0	250.0
PERCENT LOAD		%	100	75	50	25	10
ENGINE POWER		BHP	3,633	2,760	1,889	1,029	497
TOTAL NOX (AS NO2)		G/HR	19,123	11,751	5,837	2,974	2,654
TOTAL CO		G/HR	1,515	725	607	831	1,165
TOTAL HC		G/HR	376	375	408	307	329
TOTAL CO2		KG/HR	1,740	1,340	966	559	296
PART MATTER		G/HR	132.5	88.4	94.3	99.6	100.7
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	2,349.1	1,857.9	1,286.9	1,127.3	1,858.5
TOTAL CO	(CORR 5% O2)	MG/NM3	195.4	118.8	140.1	330.3	862.6
TOTAL HC	(CORR 5% O2)	MG/NM3	42.1	54.8	81.8	105.8	212.3
PART MATTER	(CORR 5% O2)	MG/NM3	14.1	11.8	18.4	34.7	63.0
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,144	905	627	549	905
TOTAL CO	(CORR 5% O2)	PPM	156	95	112	264	690
TOTAL HC	(CORR 5% O2)	PPM	79	102	153	197	396
TOTAL NOX (AS NO2)		G/HP-HR	5.32	4.30	3.12	2.92	5.39
TOTAL CO		G/HP-HR	0.42	0.26	0.32	0.82	2.37
TOTAL HC		G/HP-HR	0.10	0.14	0.22	0.30	0.67
PART MATTER		G/HP-HR	0.04	0.03	0.05	0.10	0.20
TOTAL NOX (AS NO2)		LB/HR	42.16	25.91	12.87	6.56	5.85
TOTAL CO		LB/HR	3.34	1.60	1.34	1.83	2.57
TOTAL HC		LB/HR	0.83	0.83	0.90	0.68	0.72
TOTAL CO2		LB/HR	3,836	2,955	2,130	1,233	654
PART MATTER		LB/HR	0.29	0.19	0.21	0.22	0.22
OXYGEN IN EXH		%	9.4	10.4	11.3	12.2	14.4
DRY SMOKE OPACITY		%	1.7	1.4	1.9	2.5	3.8
BOSCH SMOKE NUMBER			0.58	0.49	0.62	0.92	1.27

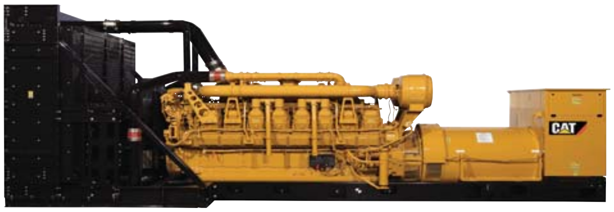

Image shown may not reflect actual package.

Mission Critical Standby
2000 ekW 2500 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.

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

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® 3516C TA 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

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 OSHPD and carries an OSP-0084-10 for use in healthcare projects in California

FACTORY INSTALLED STANDARD & OPTIONAL EQUIPMENT

System	Standard	Optional
Air Inlet	• Air cleaner	
Cooling	• Package mounted radiator	
Exhaust	• Exhaust flange outlet	[ ] Exhaust mufflers (except Tier 4)
Fuel	• Primary fuel filter with integral water separator • Secondary fuel filters • Fuel priming pump	
Generator	• Matched to the performance and output characteristics of Cat engines • Load adjustment module provides engine relief upon load impact and improves laod acceptance and recovery time • IP23 protection	[ ] Oversize and premium generators [ ] Permanent magnet excitation (PMG) [ ] Internal excited (IE) [ ] Anti-condensation space heaters
Power Termination	• Bus bar	[ ] Circuit breakers, UL listed [ ] Circuit breakers, IEC compliant
Control Panel	• EMCP 4 Genset Controller	[ ] EMCP 4.2 [ ] EMCP 4.3 [ ] EMCP 4.4 [ ] Generator temperature monitoring and protection [ ] Load share module [ ] Digital I/O module [ ] Remote monitoring software
Mounting		[ ] Rubber vibration isolators
Starting/Charging		[ ] Battery chargers [ ] Oversize batteries [ ] Jacket water heater [ ] Heavy duty starting system [ ] Charging alternator [ ] Air starting motor with control and silencer (3500 & C175 models only)
General	• Paint - Caterpillar Yellow except rails and radiators gloss black	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 [ ] EU Certificate of Conformance (CE) [ ] UL 2200 package [ ] 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

SPECIFICATIONS

CAT GENERATOR

Cat Generator
Frame size.. 825
Excitation... Permanent Magnet
Pitch.. 0.6667
Number of poles... 4
Number of bearings..................................... Single bearing
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... Pilot Shaft
Overspeed capability... 150
Wave form Deviation (Line to Line).......................... 003.00
Voltage regulator............. 3 Phase sensing with selectible volts/Hz
Voltage regulation...........Less than +/- 1/2% (steady state)
Less than +/- 1/2% (w/3% speed change)

CAT DIESEL ENGINE

3516C ATAAC, V-16, 4-Stroke Water-cooled Diesel
Bore... 170.00 mm (6.69 in)
Stroke.. 190.00 mm (7.48 in)
Displacement..69.00 L (4210.64 in^3)
Compression Ratio.. 14.7:1
Aspiration... TA
Fuel System.................................. Electronic unit injection
Governor Type... ADEM3

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	DM9168	
EPA Certified for Stationary Emergency Application (EPA Tier 2 emissions levels)		
Generator Set Package Performance		
Genset Power rating @ 0.8 pf	2500 kVA	
Genset Power rating with fan	2000 ekW	
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	77.6 Gal/hr
Cooling System[1]		
Air flow restriction (system)	0.12 kPa	0.48 in. water
Engine Coolant capacity with radiator/exp. tank	475.0 L	125.5 gal
Engine coolant capacity	233.0 L	61.6 gal
Radiator coolant capacity	242.0 L	63.9 gal
Inlet Air		
Combustion air inlet flow rate	185.5 m^3/min	6550.9 cfm
Exhaust System		
Exhaust stack gas temperature	400.1 ° C	752.2 ° F
Exhaust gas flow rate	433.1 m^3/min	15294.8 cfm
Exhaust flange size (internal diameter)	203.2 mm	8.0 in
Exhaust system backpressure (maximum allowable)	6.7 kPa	26.9 in. water
Heat Rejection		
Heat rejection to coolant (total)	759 kW	43164 Btu/min
Heat rejection to exhaust (total)	1788 kW	101683 Btu/min
Heat rejection to aftercooler	672 kW	38217 Btu/min
Heat rejection to atmosphere from engine	133 kW	7564 Btu/min
Heat rejection to atmosphere from generator	107.5 kW	6113.5 Btu/min
Alternator[2]		
Motor starting capability @ 30% voltage dip	4647 skVA	
Frame	825	
Temperature Rise	130 ° C	234 ° F
Lube System		
Sump refill with filter	466.0 L	123.1 gal
Emissions (Nominal)[3]		
NOx g/hp-hr	5.45 g/hp-hr	
CO g/hp-hr	.3 g/hp-hr	
HC g/hp-hr	.11 g/hp-hr	
PM g/hp-hr	.025 g/hp-hr	

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

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

[3] Emissions data measurement procedures are consistent with those described in EPA CFR 40 Part 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

Applicable Codes and Standards: AS1359, CSA C22.2 No 100-04, UL142, UL489, UL601, UL869, UL2200, NFPA 37, NFPA 70, NFPA 99, NFPA 110, IBC, IEC60034-1, ISO3046, ISO8528, NEMA MG 1-22, NEMA MG 1-33, 72/23/EEC, 98/37/EC, 2004/108/EC

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 35° API (16° C or 60° F) gravity having an LHV of 42 780 kJ/kg (18,390 Btu/lb) when used at 29° C (85° F) and weighing 838.9 g/liter (7.001 lbs/U.S. gal.).

Additional Ratings may be available for specific customer requirements. Consult your Cat representative for details.

DIMENSIONS

Package Dimensions		
Length	6434.6 mm	253.33 in
Width	2378.7 mm	93.65 in
Height	2958.4 mm	116.47 in

NOTE: For reference only - do not use for installation design. Please contact your local dealer for exact weight and dimensions. (General Dimension Drawing #2846051).

Performance No.: DM9168

Feature Code: 516DE7F

Gen. Arr. Number: 2628106

Source: U.S. Sourced

February 27 2013 21376178

www.Cat-ElectricPower.com

CATERPILLAR

Cat 3516C 2000 ekW Tier 2 Generator, DM8263

SCR Operation Status*	TMI Potential Site Variation Data						Estimated Reduction at % Load							
	Engine Load	Exhaust Temp	NOx	CO	HC	PM	NOx		CO		HC		PM	
	%	deg C	g/bkW-hr	g/bkW-hr	g/bkW-hr	g/bkW-hr	Reduction %	g/bkW-hr	Reduction %	g/bkW-hr	Reduction %	g/bkW-hr	Reduction %	g/bkW-hr
On	**100%**	400	8.77	0.72	0.20	0.05	92%	0.70	80%	0.14	85%	0.03	85%	0.01
On	**75%**	363	6.22	0.51	0.31	0.07	93%	0.44	80%	0.10	80%	0.06	85%	0.01
On	**50%**	346	5.12	0.80	0.46	0.11	93%	0.36	80%	0.16	80%	0.09	85%	0.02
On	**25%**	339	6.76	2.84	0.66	0.42	90%	0.68	80%	0.57	80%	0.13	85%	0.06
OFF	**10%**	289	9.56	5.84	1.45	0.66	80%	1.91	80%	1.17	70%	0.43	85%	0.10

**SCR in operation above 330 deg C*

Using 80% NOx Reduction @ 10% load for D2 Calculations

Estimated EPA D2 Cycle 5 Mode Weighted Average									
Engine Load	D2 Cycle Weight	NOx		CO		HC		PM	
%	%	Pre g/bkW-hr	Post g/bkW-hr	Pre g/bkW-hr	Post g/bkW-hr	Pre g/bkW-hr	Post g/bkW-hr	Pre g/bkW-hr	Post g/bkW-hr
100%	**5%**	0.438	0.035	0.036	0.007	0.010	0.002	0.003	0.000
75%	**25%**	1.555	0.109	0.127	0.025	0.077	0.015	0.017	0.003
50%	**30%**	1.536	0.108	0.241	0.048	0.137	0.027	0.032	0.005
25%	**30%**	2.027	0.203	0.853	0.171	0.197	0.039	0.125	0.019
10%	**10%**	0.956	0.191	0.584	0.117	0.145	0.043	0.066	0.010
D2 Average:		**6.512**	**0.645**	**1.842**	**0.368**	**0.566**	**0.127**	**0.242**	**0.036**
EPA Tier 4 Final:			**0.670**		**3.500**		**0.190**		**0.030**

CAT® SCR PROPOSAL

Friday, April 18, 2014 Quotation Number: **14022801RW-E** Revision:

SCR & DPF units in a 409L Stainless Steel Double Wall Critical Grade Silencer Housing

Project Description:	**Microsoft Quincy MWH01 - Cat 3516C 2000 ekW Generators**

NC Power Systems
Brant Briody
Sales Representative
17900 W. Valley Highway
Tukwila, WA 98188

Email: bbriody@ncpowersystems.com
Telephone: **(425) 656-4587**
Mobile: **(206) 510-3491**

Application Specifications:

Site Location (Address):	**Quincy Washingtion**		
Environment (Alt,Temp,RH):	**1300 ft, 10 deg to 90 deg F**		
Mounting Location:	**Over Generator**		
Regulation Requirement:	**BACT targeting non-certified Tier 4 Final Levels**		
Average Running Load (%):		Runtime (hr/yr):	**100**
Minimal Operating Load (%):	**30%**	Minimal Exhaust Temp:	**350 deg C**

Engine Specifications: *Quantity 4 CAT, reference # DM8263*

Engine Model Number:	**3516C , Tier 2**			Engine S/N:	**516DE5B**
Generator Power Rating (ekW):	**2,000**	**Standby**		EPA Family #:	
Engine Displacement (liters):	**69**			Model Name:	**Generator**
Max Fuel Sulfur Content (ppm):	**< 50**				
Engine Power Output (bhp):	**2,937**	or	***2191***	***bkW @ 1800 RPM***	
Exhaust Flow Rate (ACFM):	**15,293**	or	***433.0***	***m^3/min***	
Exhaust Stack Temp (deg F):	**752**	or	***400.0***	***deg C***	
Max Exhaust Pressure(" H_2O):	**27**	or	***6.7***	***kPa***	

Estimated Engine Emissions Data:

Requirement	Emissions Source:		Potential Site Variation
BACT		***Pre Catalyst***	***Post Catalyst Estimates****
g/bkW-hr		**g/bkW-hr**	**g/bkW-hr**
0.67	**NOx***	**8.77**	**0.67**
3.50	**CO**	**0.72**	**3.50**
0.19	**HC**	**0.20**	**0.19**
0.03	**PM**	**0.05**	**0.03**

**NOx Reductions will be validated by a calibrated gas analyzer during Dealer Site Commissioning of the CAT SCR System at defined load points and steady-state conditions.*

***Post Catalyst Emissions Reduction based on 100% Load & Engine Rating obtained and presented in accordance with ISO 3046/1 and SAE J1995 JAN90 Standard Reference Conditions*

DPF Specifications:

Material:	**Platinum Group Catalyzed Cordierite Ceramic wall-flow filter substrates**	
Number of Filters:	**9**	**FDA221**
Typical Regeneration using ULSD:	Above 350 deg C (662 deg F) for 30% of engine operating time & greater than 40% engine load	
Max Number of Cold Starts:	**12 consecutive 10 minute idle sessions followed by 2 hrs regeneration**	

CATERPILLAR

SCR Specifications:				
Material:	**Extruded Vanadia Substrates**		# T6 Modules:	**24**
Total Amount of Catalyst (cubic ft):	**43 (12.2 cubic meters)**		# T2 Modules:	**48**
Number of Catalyst Layers:	**3 layers @ 64 blocks/layer**	***8 wide by 8 high***	# T4 Modules:	
Injection Lance:	**36 inches (914 mm)**			
Approximate DEF Consumption:	**8.4 gal/hr or 31.8 liters/hr of 32.5% Technical Grade Urea**			
Recommended Reductant:	***32.5% DEF (Diesel Exhaust Fluid), Please reference Cat document PELJ1160***			
Maximum Ammonia Slip:	***Not Specified***			

Dosing Control Cabinet: ***Nema 12 Enclosure (36" high x 32" wide x 12" deep)***

*Touch Screen Display & Dual NOx Sensors for a True Closed-Loop System
*Controller, Pressure Sensor, Temperature Sensor, Dosing Pump, Pressure Regulator, Secondary Urea Filter
*Power requirement: 240/120 volts AC, 10/20 amps, 50 or 60 Hertz
*Records NOx levels pre and post, Temperature and Pressure, Time and Date
*ModBus Communications Enabled
*Auto Start, Stop and Purge Cycle

Tube Bundle: ***Dosing Control Cabinet to Injection Lance***

*1/4" Heat Traced Stainless Steel tubing for DEF Flow
*1/2" Stainless Steel or Poly tubing for Compressed Air

Injection and Mixing Section: ***Integrated within the E-POD housing***

*Air & Urea Injection with Static Mixers internal to the SCR Silencer Housing
*Compressed Air requirement to be Oil Free, 10 SCFM @ 100 PSIG with a refrigerated dryer

Silencer Housing Specifications:						
Material:	**409L Stainless Steel, Double Wall, Welded Surface Finish**					
Approximate Dimensions L x W x H (inches):	**182**	**x**	**94**	**x**	**58**	
Approximate Dimensions L x W x H (mm):	**4,623**	**x**	**2,388**	**x**	**1,473**	
Estimated Weight (pounds / kilograms):	**10,000**	**/ 4550**				
Silencer Sound Reduction (dBa):	**27-35**	**Critical Grade Silencing**				
Est. Pressure Drop Silencer+SCR+DPF ("H_2O):	**20.6**	*as configured at rated load or (kPa):*			***5.1***	
Inlet Size inches (mm):	**20 (508)**		**Flange**	# of Inlets:	**1**	
Outlet Size inches (mm):	**24 (610)**		**Flange**			

This System Includes:			
SILENCER - Stainless Steel:	**Yes**	INTERNAL Mixing and DEF Injection:	**Yes**
SCR Catalyst:	**Yes**	Dosing Control Cabinet:	**Yes**
DPF Units:	**Yes**	Operation & Maintenance Manual:	**Yes**
		Start-up Commissioning:	**No**

Notes:

Engine should be run with a Load Bank during normal operation to provide minimum of 40% load in order to regenerate the DPF units.

Recommended minimum engine load of 40% and 360 degrees C through the particulate filters to ensure filter regeneration and prevent wet stacking the catalyst. If this is not possible then following 4 hours of cumulative runtime at low loads the engines should be run with at least 60% load for 2 hours to regenerate the filter media.

Terms & Conditions:	***Incoterms:***	**FCA**	**Santa Fe**
Warranty:	**24 months or 8,000 hours of operation, whichever comes first, from date of commissioning**		

Pricing:

		Closed-Loop System			**Dealer Net**
	Ref/Cat #	**Description**	**Quantity**	**Unit Price**	**Total (USD)**
1	**12080201AE**	CAT® SCR w/ SCR & DPF in a 409L Stainless Steel Double Wall Critical Grade Silencer			
2	**12080201AE-IB**	Custom Insulating Blanket			
				Estimated Freight:	
				Total:	

	Recommended Equipment:				**Dealer Net**
	Ref/Cat #	**Description**	**Quantity**	**Unit Price**	**Total (USD)**
1	**376-8483**	Atlas Copco SF-4 Air Compressor (typically 460 Volt/ 3 phase, call for options)			

M312P33992A93752E9370

PERFORMANCE DATA[DM8263]

March 17, 2014

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
APPLICATION:	PACKAGED GENSET	**ASPIRATION:**	TA
RATING LEVEL:	STANDBY	**AFTERCOOLER TYPE:**	ATAAC
SUB APPLICATION:	STANDARD	**AFTERCOOLER CIRCUIT TYPE:**	JW+OC, ATAAC
PUMP QUANTITY:	2	**INLET MANIFOLD AIR TEMP (F):**	122
FUEL TYPE:	DIESEL	**JACKET WATER TEMP (F):**	210.2
MANIFOLD TYPE:	DRY	**TURBO CONFIGURATION:**	PARALLEL
GOVERNOR TYPE:	ADEM3	**TURBO QUANTITY:**	4
ELECTRONICS TYPE:	ADEM3	**TURBOCHARGER MODEL:**	GTA5518BN-56T-1.12
CAMSHAFT TYPE:	STANDARD	**CERTIFICATION YEAR:**	2006
IGNITION TYPE:	CI	**CRANKCASE BLOWBY RATE (FT3/HR):**	2,937.9
INJECTOR TYPE:	EUI	**FUEL RATE (RATED RPM) NO LOAD (GAL/HR):**	13.7
FUEL INJECTOR:	2664387	**PISTON SPD @ RATED ENG SPD (FT/MIN):**	2,244.1
REF EXH STACK DIAMETER (IN):	12		
MAX OPERATING ALTITUDE (FT):	3,117		

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

PERFORMANCE DATA[DM8263]

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

Regulatory Information

EPA TIER 2		2006 - 2010		
GASEOUS EMISSIONS DATA MEASUREMENTS ARE CONSISTENT WITH THOSE DESCRIBED IN EPA 40 CFR PART 89 SUBPART D AND ISO 8178 FOR MEASURING HC, CO, PM, AND NOX. GASEOUS EMISSIONS VALUES ARE WEIGHTED CYCLE AVERAGES AND ARE IN COMPLIANCE WITH THE NON-ROAD REGULATIONS.				
Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max Limits - G/BKW - HR**
U.S. (INCL CALIF)	EPA	NON-ROAD	TIER 2	CO: 3.5 NOx + HC: 6.4 PM: 0.20

EPA EMERGENCY STATIONARY		2011 - ----		
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. GASEOUS EMISSIONS LIMIT VALUES ARE WEIGHTED CYCLE AVERAGES AND ARE IN COMPLIANCE WITH THE NON-ROAD REGULATIONS.				
Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max Limits - G/BKW - HR**
U.S. (INCL CALIF)	EPA	STATIONARY	EMERGENCY STATIONARY	CO: 3.5 NOx + HC: 6.4 PM: 0.20

DIESEL GENERATOR SET

Image shown may not reflect actual package.

MISSION CRITICAL
750 ekW 938 kVA
60 Hz 1800rpm 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.

UL 2200/ CSA - Optional

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

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[SM] program cost effectively detects internal engine component condition, even the presence of unwanted fluids and combustion by-products

CAT C27 ATAAC DIESEL ENGINE

- Utilizes ACERT™ Technology
- Reliable, rugged, durable design
- Four-cycle diesel engine combines consistent performance and excellent fuel economy with minimum weight
- Electronic engine control

CAT GENERATOR

- Designed to match the performance and output characteristics of Cat diesel engines
- Single point access to accessory connections
- UL 1446 recognized Class H insulation

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 OSHPD and carries an OSP-0084-10 for use in healthcare projects in California

FACTORY INSTALLED STANDARD & OPTIONAL EQUIPMENT

System	Standard	Optional
Air Inlet	• Air cleaner	
Cooling	• Package mounted radiator	
Exhaust	• Exhaust flange outlet	[ ] Exhaust mufflers
Fuel	• Primary fuel filter with integral water separator • Secondary fuel filters • Fuel priming pump	
Generator	• Matched to the performance and output characteristics of Cat engines	[ ] Oversize and premium generators [ ] Permanent magnet excitation (PMG) [ ] Internal excited (IE) [ ] Anti-condensation space heaters
Power Termination	• Bus bar	[ ] Circuit breakers, UL listed [ ] Circuit breakers, IEC compliant
Control Panel	• EMCP 4 Genset Controller	[ ] EMCP 4.2 [ ] EMCP 4.3 [ ] EMCP 4.4 [ ] Generator temperature monitoring and protection [ ] Load share module [ ] Digital I/O module [ ] Remote monitoring software
Mounting		[ ] Rubber vibration isolators
Starting/Charging		[ ] Battery chargers [ ] Oversize batteries [ ] Jacket water heater [ ] Heavy duty starting system [ ] Charging alternator
General	• Paint - Caterpillar Yellow except rails and radiators gloss black	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 [ ] EU Certificate of Conformance (CE) [ ] UL 2200 package [ ] 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

SPECIFICATIONS

CAT GENERATOR

Frame size 1296
Excitation .... Permanent Magnet
Pitch 0.6667
Number of poles 4
Number of bearings .... Single bearing
Number of Leads 012
Insulation .... UL 1446 Recognized Class H with tropicalization and antiabrasion
- Consult your Caterpillar dealer for available voltages
IP Rating ....Drip Proof IP23
Alignment .... Pilot Shaft
Overspeed capability 150
Wave form Deviation (Line to Line) ....Less than 5% deviation
Voltage regulator.................. 3 Phase sensing with selectible volts/Hz
Voltage regulation ....Less than +/- 1/2% (steady state)
Less than +/- 1% (no load to full load)

CAT DIESEL ENGINE

C27 TA, V-12, 4-Stroke Water-cooled Diesel
Bore .... 137.20 mm (5.4 in)
Stroke .... 152.40 mm (6.0 in)
Displacement ....27.03 L (1649.47 in³)
Compression Ratio 16.5:1
Aspiration .... TA
Fuel System .... MEUI
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 - - 1800rpm/60 Hz/480 Volts	DM9071	
EPA Certified for Stationary Emergency Application (EPA Tier 2 emissions levels)		
Generator Set Package Performance		
Genset Power rating @ 0.8 pf	937.5 kVA	
Genset Power rating with fan	750 ekW	
Fuel Consumption		
100% load with fan	202.9 L/hr	53.6 Gal/hr
75% load with fan	162.4 L/hr	42.9 Gal/hr
50% load with fan	116.2 L/hr	30.7 Gal/hr
Cooling System [1]		
Air flow restriction (system)	0.12 kPa	0.48 in. water
Engine coolant capacity	55.0 L	14.5 gal
Inlet Air		
Combustion air inlet flow rate	58.7 m^3/min	2073.0 cfm
Exhaust System		
Exhaust stack gas temperature	509.3 °C	948.7 °F
Exhaust gas flow rate	158.9 m^3/min	5611.5 cfm
Exhaust flange size (internal diameter)	203 mm	8 in
Exhaust system backpressure (maximum allowable)	10.0 kPa	40.2 in. water
Heat Rejection		
Heat rejection to coolant (total)	324 kW	18426 Btu/min
Heat rejection to exhaust (total)	742 kW	42197 Btu/min
Heat rejection to aftercooler	138 kW	7848 Btu/min
Heat rejection to atmosphere from engine	100 kW	5687 Btu/min
Heat rejection to atmosphere from generator	56.5 kW	3216.0 Btu/min
Alternator [2]		
Motor starting capability @ 30% voltage dip	2117 skVA	
Frame	1296	
Temperature Rise	150 °C	270 °F
Lube System		
Sump refill with filter	68.0 L	18.0 gal
Emissions (Nominal) [3]		
NOx g/hp-hr	5.25 g/hp-hr	
CO g/hp-hr	.25 g/hp-hr	
HC g/hp-hr	.03 g/hp-hr	
PM g/hp-hr	.021 g/hp-hr	

[1] For ambient and altitude capabilities consult your Cat dealer. Air flow restriction (system) is added to existing restriction from factory.
[2] Generator temperature rise is based on a 40°C ambient per NEMA MG1-32. UL 2200 Listed packages may have oversized generators with a different temperature rise and motor starting characteristics.
[3] Emissions data measurement procedures are consistent with those described in EPA CFR 40 Part 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.

Cat C27 750 ekW Tier 2 Generator, DM9071

SCR Operation Status*	TMI Potential Site Variation Data						Estimated Reduction at % Load							
	Engine Load	Exhaust Temp	NOx	CO	HC	PM	NOx		CO		HC		PM	
	%	deg C	g/bkW-hr	g/bkW-hr	g/bkW-hr	g/bkW-hr	Reduction %	g/bkW-hr	Reduction %	g/bkW-hr	Reduction %	g/bkW-hr	Reduction %	g/bkW-hr
On	**100%**	509	8.51	0.62	0.07	0.05	93%	0.60	80%	0.12	80%	0.01	85%	0.01
On	**75%**	489	6.38	1.05	0.12	0.09	92%	0.51	80%	0.21	80%	0.02	85%	0.01
On	**50%**	452	5.75	1.43	0.21	0.32	92%	0.46	80%	0.29	80%	0.04	85%	0.05
On	**25%**	366	6.78	2.01	0.32	0.43	90%	0.68	80%	0.40	70%	0.10	85%	0.06
OFF	**10%**	278	8.74	3.70	0.67	0.52	80%	1.75	70%	1.11	60%	0.27	85%	0.08

**SCR in operation above 330 deg C*

***80% NOx Reduction used for 10% load D2 Calculation as per bid spec*

Estimated EPA D2 Cycle 5 Mode Weighted Average									
Engine Load	D2 Cycle Weight	NOx		CO		HC		PM	
%	%	Pre g/bkW-hr	Post g/bkW-hr	Pre g/bkW-hr	Post g/bkW-hr	Pre g/bkW-hr	Post g/bkW-hr	Pre g/bkW-hr	Post g/bkW-hr
100%	**5%**	0.43	0.03	0.03	0.01	0.00	0.00	0.00	0.00
75%	**25%**	1.60	0.13	0.26	0.05	0.03	0.01	0.02	0.00
50%	**30%**	1.73	0.14	0.43	0.09	0.06	0.01	0.10	0.01
25%	**30%**	2.03	0.20	0.60	0.12	0.10	0.03	0.13	0.02
10%	**10%**	0.87	0.17	0.37	0.11	0.07	0.03	0.05	0.01
D2 Average:		**6.65**	**0.67**	**1.70**	**0.38**	**0.26**	**0.08**	**0.30**	**0.05**
EPA Tier 4 Final:			**0.67**		**3.50**		**0.19**		**0.03**

CATERPILLAR®

CAT® SCR PROPOSAL

Friday, April 18, 2014 Quotation Number: **13112201RW-E** Revision: **1**

SCR & DPF units in a 409L Stainless Steel Double Wall Critical Grade Silencer Housing

Project Description:	**Microsoft Quincy MWH01- C27 750 ekW Generator**

NC Power Systems
Brant Briody *Email:* bbriody@ncpowersystems.com
Sales Representative *Telephone:* (425) 656-4587
17900 W. Valley Highway *Mobile:* (206) 510-3491
Tukwila, WA 98188

Application Specifications:

Site Location (Address):	**Quincy Washingtion**		
Environment (Alt,Temp,RH):	**1300 ft, 10 deg to 90 deg F**		
Mounting Location:	**Over Generator**		
Regulation Requirement:	**BACT targeting non-certified Tier 4 Final Levels**		
Average Running Load (%):	**?**	Runtime (hr/yr):	**100**
Minimal Operating Load (%):	**30%**	Minimal Exhaust Temp:	**375 deg C**

Engine Specifications: *Quantity 1 CAT, reference # DM9071*

Engine Model Number:	**C27, Tier 2**			Engine S/N:	**MJE02012**
Generator Power Rating (ekW):	**750**	**Standby**		EPA Family #:	**ACPXL27.0ESW**
Engine Displacement (liters):	**27**			Model Name:	**Generator**
Max Fuel Sulfur Content (ppm):	**< 50**				
Engine Power Output (bhp):	**1,141**	or	***851***	***bkW @ 1800 RPM***	
Exhaust Flow Rate (ACFM):	**5,610**	or	***158.9***	***m^3/min***	
Exhaust Stack Temp (deg F):	**949**	or	***509.4***	***deg C***	
Max Exhaust Pressure(" H_2O):	**40**	or	***10.0***	***kPa***	

Estimated Engine Emissions Data:

Requirement	**Emissions Source:**	***Potential Site Variation***	
BACT		***Pre Catalyst***	***Post Catalyst Estimates*****
g/bkW-hr		**g/bkW-hr**	**g/bkW-hr**
0.67	**NOx***	**6.65**	**0.67**
3.50	**CO**	**1.70**	**3.50**
0.19	**HC**	**0.26**	**0.19**
0.03	**PM**	**0.30**	**0.03**

**NOx Reductions will be validated by a calibrated gas analyzer during Dealer Site Commissioning of the CAT SCR System at defined load points and steady-state conditions.*

***Post Catalyst Emissions Reduction based on 100% Load, ISO conditions*

DPF Specifications:

Material:	**Platinum Group Catalyzed Cordierite Ceramic wall-flow filter substrates**	
Number of Filters:	**3**	**FDA221**
Typical Regeneration using ULSD:	Above 375 deg C (707 deg F) for 30% of engine operating time & greater than 40% engine load	
Max Number of Cold Starts:	**12 consecutive 10 minute idle sessions followed by 2 hrs regeneration**	

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SCR Specifications:

Material:	**Iron Zeolite Catalyzed Cordierite Ceramic Substrates**		# T6 Modules:	**36**
Total Amount of Catalyst (cubic ft):	**17 (4.8 cubic meters)**		# T2 Modules:	
Number of Catalyst Layers:	**3 layers @ 24 blocks/layer**	***4 wide by 6 high***	# T4 Modules:	
Injection Lance:	**36 inches (914 mm)**			
Approximate DEF Consumption:	**2.5 gal/hr or 9.4 liters/hr of 32.5% Technical Grade Urea**			
Recommended Reductant:	***32.5% DEF (Diesel Exhaust Fluid), Please reference Cat document PELJ1160***			
Maximum Ammonia Slip:	***Not Specified***			

Dosing Control Cabinet: *Nema 12 Enclosure (36" high x 32" wide x 12" deep)*

*Touch Screen Display & Dual NOx Sensors for a True Closed-Loop System
*Controller, Pressure Sensor, Temperature Sensor, Dosing Pump, Pressure Regulator, Secondary Urea Filter
*Power requirement: 240/120 volts AC, 10/20 amps, 50 or 60 Hertz
*Records NOx levels pre and post, Temperature and Pressure, Time and Date
*ModBus Communications Enabled
*Auto Start, Stop and Purge Cycle

Tube Bundle: *Dosing Control Cabinet to Injection Lance*

*1/4" Heat Traced Stainless Steel tubing for DEF Flow
*1/2" Stainless Steel or Poly tubing for Compressed Air

Injection and Mixing Section: *Integrated within the E-POD housing*

*Air & Urea Injection with Static Mixers internal to the SCR Silencer Housing
*Compressed Air requirement to be Oil Free, 10 SCFM @ 100 PSIG with a refrigerated dryer

Silencer Housing Specifications:

Material:	**409L Stainless Steel, Double Wall, Welded Surface Finish**					
Approximate Dimensions L x W x H (inches):	**120**	**x**	**80**	**x**	**45**	
Approximate Dimensions L x W x H (mm):	**3,048**	**x**	**2,032**	**x**	**1,143**	
Estimated Weight (pounds / kilograms):	**4,400**	**/ 2000**				
Silencer Sound Reduction (dBa):	**27-35**	**Critical Grade Silencing**				
Est. Pressure Drop Silencer+SCR+DPF ("H_2O):	**20.9**	*as configured at rated load or (kPa):*			***5.2***	
Inlet Size inches (mm):	**12 (305)**		**Flange**	# of Inlets:	**1**	
Outlet Size inches (mm):	**12 (305)**		**Flange**			

This System Includes:

SILENCER - Stainless Steel:	**Yes**	INTERNAL Mixing and DEF Injection:	**Yes**
SCR Catalyst:	**Yes**	Dosing Control Cabinet:	**Yes**
DPF Units:	**Yes**	Operation & Maintenance Manual:	**Yes**
		Start-up Commissioning:	**No**

This System Excludes:

Delivery/Freight Expenses, Consumables and Utilities
Installation and supply of interconnecting power, control cables, conduit, reductant tanks, plumbing, supply pumps, etc.
Installation, Commissioning of the Proposed System and any required permitting
Exhaust piping insulation *(Recommend insulating the exhaust from the engine to the inlet of the emissions control system)*

Notes:

Recommended minimum engine load of 30% and 375 degrees C through the particulate filters to ensure filter regeneration and prevent wet stacking the catalyst. If this is not possible then following 4 hours of cumulative runtime at low loads the engines should be run with at least 50% load for 2 hours to regenerate the filter media.

Terms & Conditions:	***Incoterms:***	**FCA**	**Santa Fe**
Warranty:	**24 months or 8,000 hours of operation, whichever comes first, from date of commissioning**		

Pricing:

	Closed-Loop System				**Dealer Net**
	Ref/Cat #	**Description**	**Quantity**	**Unit Price**	**Total (USD)**
1	**12031201AE**	**CAT® SCR w/ SCR & DPF in a 409L Stainless Steel Double Wall Critical Grade Silencer**			
2	**12031201AE-IB**	**Custom Insulating Blanket**			
				Estimated Freight:	
				Total:	

	Recommended Equipment:				**Dealer Net**
	Ref/Cat #	**Description**	**Quantity**	**Unit Price**	**Total (USD)**
1	**376-8483**	Atlas Copco SF-4 Air Compressor (typically 460 Volt/ 3 phase, call for options)			

M315P32175A73952E7759

PERFORMANCE DATA[DM9071]

November 26, 2013

Performance Number: DM9071

Change Level: 02

SALES MODEL:	C27	**COMBUSTION:**	DI
ENGINE POWER (BHP):	1,141	**ENGINE SPEED (RPM):**	1,800
GEN POWER WITH FAN (EKW):	750.0	**HERTZ:**	60
COMPRESSION RATIO:	16.5	**FAN POWER (HP):**	37.5
APPLICATION:	PACKAGED GENSET	**ADDITIONAL PARASITICS (HP):**	52.7
RATING LEVEL:	STANDBY	**ASPIRATION:**	TA
SUB APPLICATION:	STANDARD	**AFTERCOOLER TYPE:**	ATAAC
PUMP QUANTITY:	1	**AFTERCOOLER CIRCUIT TYPE:**	JW+OC, ATAAC
FUEL TYPE:	DIESEL	**INLET MANIFOLD AIR TEMP (F):**	120
MANIFOLD TYPE:	DRY	**JACKET WATER TEMP (F):**	210.2
GOVERNOR TYPE:	ADEM4	**TURBO CONFIGURATION:**	PARALLEL
ELECTRONICS TYPE:	ADEM4	**TURBO QUANTITY:**	2
IGNITION TYPE:	CI	**TURBOCHARGER MODEL:**	GTA5008BS-56T-1.60
INJECTOR TYPE:	EUI	**CERTIFICATION YEAR:**	2006
REF EXH STACK DIAMETER (IN):	10	**PISTON SPD @ RATED ENG SPD (FT/MIN):**	1,800.0
MAX OPERATING ALTITUDE (FT):	10,000		

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
750.0	100	1,141	305	0.329	53.6	52.6	120.7	1,210.7	36.7	948.7
675.0	90	1,036	276	0.333	49.3	48.2	117.3	1,184.5	33.3	935.9
600.0	80	931	248	0.339	45.0	43.6	114.3	1,157.5	30.1	920.5
562.5	75	878	234	0.342	42.9	41.2	112.8	1,143.4	28.5	911.5
525.0	70	826	220	0.344	40.6	38.3	110.7	1,127.0	26.5	902.0
450.0	60	722	193	0.346	35.7	31.9	105.8	1,084.0	22.3	877.6
375.0	50	618	165	0.348	30.7	25.3	100.8	1,028.5	18.0	845.1
300.0	40	516	138	0.350	25.8	19.1	97.6	957.6	14.1	798.9
225.0	30	413	110	0.356	21.0	13.6	95.6	866.3	10.9	731.9
187.5	25	361	96	0.361	18.7	11.0	94.8	813.1	9.5	691.2
150.0	20	309	82	0.368	16.3	8.6	94.0	754.4	8.2	645.3
75.0	10	201	54	0.403	11.6	4.9	92.4	617.0	6.1	532.3

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
750.0	100	1,141	55	340.2	2,073.6	5,610.2	8,929.7	9,304.9	1,958.6	1,773.7
675.0	90	1,036	51	321.4	1,972.9	5,269.2	8,478.1	8,823.2	1,856.4	1,685.5
600.0	80	931	46	304.2	1,874.4	4,932.9	8,053.0	8,368.4	1,757.3	1,600.2
562.5	75	878	43	295.1	1,825.8	4,766.3	7,827.5	8,127.9	1,709.1	1,558.8
525.0	70	826	40	282.3	1,763.3	4,540.6	7,544.0	7,828.2	1,639.5	1,497.3
450.0	60	722	34	253.9	1,610.3	4,039.0	6,871.8	7,121.9	1,485.0	1,359.5
375.0	50	618	27	225.6	1,444.6	3,541.1	6,147.8	6,362.8	1,334.4	1,225.1
300.0	40	516	21	197.9	1,288.0	3,054.4	5,467.1	5,647.9	1,193.2	1,099.5
225.0	30	413	15	170.0	1,143.5	2,567.6	4,844.7	4,992.1	1,059.4	981.2
187.5	25	361	12	155.9	1,073.8	2,322.4	4,546.8	4,677.5	992.1	921.8
150.0	20	309	10	141.7	1,005.3	2,074.6	4,256.4	4,370.3	923.1	860.8
75.0	10	201	6	120.2	905.7	1,659.5	3,831.9	3,913.1	822.6	775.2

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
750.0	100	1,141	18,420	5,664	42,192	23,831	6,126	7,849	48,396	115,016	122,520
675.0	90	1,036	17,400	5,193	39,249	22,066	5,635	6,930	43,919	105,788	112,691
600.0	80	931	16,092	4,896	36,354	20,327	5,147	6,123	39,470	96,630	102,935
562.5	75	878	15,154	5,120	34,836	19,404	4,904	5,715	37,253	92,070	98,078
525.0	70	826	14,494	5,043	33,095	18,346	4,642	5,184	35,034	87,162	92,850
450.0	60	722	13,468	4,399	29,123	15,903	4,084	4,077	30,613	76,677	81,680
375.0	50	618	11,700	4,303	24,895	13,283	3,509	3,072	26,205	65,876	70,174
300.0	40	516	10,463	3,778	20,710	10,638	2,951	2,194	21,876	55,406	59,021
225.0	30	413	9,817	2,772	16,546	7,940	2,405	1,443	17,528	45,159	48,105
187.5	25	361	9,420	2,280	14,506	6,617	2,133	1,114	15,330	40,038	42,651
150.0	20	309	8,879	1,864	12,505	5,323	1,858	813	13,103	34,888	37,164
75.0	10	201	6,965	1,736	8,856	2,900	1,326	427	8,541	24,901	26,525

Emissions Data

RATED SPEED POTENTIAL SITE VARIATION: 1800 RPM

GENSET POWER WITH FAN		EKW	750.0	562.5	375.0	187.5	75.0
PERCENT LOAD		%	100	75	50	25	10
ENGINE POWER		BHP	1,141	878	618	361	201
TOTAL NOX (AS NO2)		G/HR	7,181	4,159	2,639	1,824	1,310
TOTAL CO		G/HR	520	683	655	540	554
TOTAL HC		G/HR	55	82	96	88	101
PART MATTER		G/HR	47.2	59.4	150.5	116.9	78.8
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	3,190.9	2,326.7	2,078.5	2,424.5	2,904.0
TOTAL CO	(CORR 5% O2)	MG/NM3	231.7	383.5	519.6	772.5	1,347.1
TOTAL HC	(CORR 5% O2)	MG/NM3	21.1	40.7	65.9	111.3	214.7
PART MATTER	(CORR 5% O2)	MG/NM3	17.2	27.7	103.8	128.4	160.0
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,554	1,133	1,012	1,181	1,414
TOTAL CO	(CORR 5% O2)	PPM	185	307	416	618	1,078
TOTAL HC	(CORR 5% O2)	PPM	39	76	123	208	401
TOTAL NOX (AS NO2)		G/HP-HR	6.35	4.76	4.29	5.06	6.52
TOTAL CO		G/HP-HR	0.46	0.78	1.07	1.50	2.76
TOTAL HC		G/HP-HR	0.05	0.09	0.16	0.24	0.50
PART MATTER		G/HP-HR	0.04	0.07	0.24	0.32	0.39
TOTAL NOX (AS NO2)		LB/HR	15.83	9.17	5.82	4.02	2.89
TOTAL CO		LB/HR	1.15	1.51	1.45	1.19	1.22
TOTAL HC		LB/HR	0.12	0.18	0.21	0.19	0.22
PART MATTER		LB/HR	0.10	0.13	0.33	0.26	0.17

RATED SPEED NOMINAL DATA: 1800 RPM

GENSET POWER WITH FAN		EKW	750.0	562.5	375.0	187.5	75.0
PERCENT LOAD		%	100	75	50	25	10
ENGINE POWER		BHP	1,141	878	618	361	201
TOTAL NOX (AS NO2)		G/HR	5,935	3,437	2,181	1,507	1,082
TOTAL CO		G/HR	278	365	351	289	296
TOTAL HC		G/HR	29	43	51	47	53
TOTAL CO2		KG/HR	525	419	298	180	112
PART MATTER		G/HR	24.2	30.5	77.2	59.9	40.4
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	2,637.1	1,922.9	1,717.8	2,003.7	2,400.0
TOTAL CO	(CORR 5% O2)	MG/NM3	123.9	205.1	277.9	413.1	720.4
TOTAL HC	(CORR 5% O2)	MG/NM3	11.2	21.5	34.9	58.9	113.6
PART MATTER	(CORR 5% O2)	MG/NM3	8.8	14.2	53.2	65.9	82.0
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,285	937	837	976	1,169
TOTAL CO	(CORR 5% O2)	PPM	99	164	222	330	576
TOTAL HC	(CORR 5% O2)	PPM	21	40	65	110	212
TOTAL NOX (AS NO2)		G/HP-HR	5.25	3.94	3.54	4.18	5.39
TOTAL CO		G/HP-HR	0.25	0.42	0.57	0.80	1.48
TOTAL HC		G/HP-HR	0.03	0.05	0.08	0.13	0.27
PART MATTER		G/HP-HR	0.02	0.03	0.13	0.17	0.20
TOTAL NOX (AS NO2)		LB/HR	13.08	7.58	4.81	3.32	2.39
TOTAL CO		LB/HR	0.61	0.81	0.77	0.64	0.65
TOTAL HC		LB/HR	0.06	0.10	0.11	0.10	0.12
TOTAL CO2		LB/HR	1,157	924	658	397	246
PART MATTER		LB/HR	0.05	0.07	0.17	0.13	0.09
OXYGEN IN EXH		%	8.9	10.1	11.2	13.2	15.4
DRY SMOKE OPACITY		%	0.4	1.4	2.9	4.4	3.8
BOSCH SMOKE NUMBER			0.18	0.48	1.07	1.51	1.40

Regulatory Information

EPA TIER 2		2006 - 2010		
GASEOUS EMISSIONS DATA MEASUREMENTS ARE CONSISTENT WITH THOSE DESCRIBED IN EPA 40 CFR PART 89 SUBPART D AND ISO 8178 FOR MEASURING HC, CO, PM, AND NOX. GASEOUS EMISSIONS VALUES ARE WEIGHTED CYCLE AVERAGES AND ARE IN COMPLIANCE WITH THE NON-ROAD REGULATIONS.				
Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max Limits - G/BKW - HR**
U.S. (INCL CALIF)	EPA	NON-ROAD	TIER 2	CO: 3.5 NOx + HC: 6.4 PM: 0.20

EPA EMERGENCY STATIONARY		2011 - ----		
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. GASEOUS EMISSIONS LIMIT VALUES ARE WEIGHTED CYCLE AVERAGES AND ARE IN COMPLIANCE WITH THE NON-ROAD REGULATIONS.				
Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max Limits - G/BKW - HR**
U.S. (INCL CALIF)	EPA	STATIONARY	EMERGENCY STATIONARY	CO: 3.5 NOx + HC: 6.4 PM: 0.20

APPENDIX B

Mechanical Draft Cooling Tower Technical Information

May 14, 2014

Microsoft DC 2015 Project Team

Re: Cooling Tower Drift
RFP No. DC2015-13
Tower Model MD5008PAF2

To Whom It May Concern:

SPX Thermal Performance and Ratings department has reviewed the subject tower selection. Our data indicates the subject model will conform to 0.0005% of the circulating water flow rate as drift.

Please do not hesitate to contact us should you require any further information.

Sincerely,

Corey Baker, P.E.
Senior Engineer II
Thermal Performance and Ratings
SPX Cooling Technologies, Inc.

SPX COOLING TECHNOLOGIES, INC.
7401 WEST 129 STREET
OVERLAND PARK, KANSAS 66213
UNITED STATES

TEL | 913 | 664 | 7400
FAX | 913 | 664 | 7439

spxcooling.com

Jim Wilder

From: Jim Wilder
Sent: Tuesday, June 03, 2014 8:05 AM
To: gary.huitsing@ecy.wa.gov; gregory.flibbert@ecy.wa.gov
Cc: Jim Wilder; Ray Cheng; John Radick; Kevin Williams (DCS); Cohen, Matthew
Subject: FW: Microsoft Oxford: Flowrate-specific Cooling tower specs for winning bidder (SPX-Marley)

Hello Gary - The preceding email messages confirm that the SPX-Marley cooling towers at Microsoft Project Oxford are certified for the 0.0005% drift rate at the design water and air flowrates. This information is provided based on your request of May 21.

We trust this information will allow you to proceed briskly with the public comment period.
Please call me to discuss the upcoming schedule.
Thanks!

From: Bougher, Doug [mailto:doug.bougher@spx.com]
Sent: Tuesday, June 03, 2014 6:26 AM
To: Ray Cheng; Jim Wilder
Cc: Paul Boege
Subject: RE: Microsoft Project Oxford: Cooling tower specs for winning bidder (SPX-Marley)

Ray, Mike,

SPX certifies that the drift rate is 0.0005% at Microsoft's design water flow rate of 950 gpm and an air flow rate 143,600cfm for the 4 cell cooling towers used in Project Oxford.

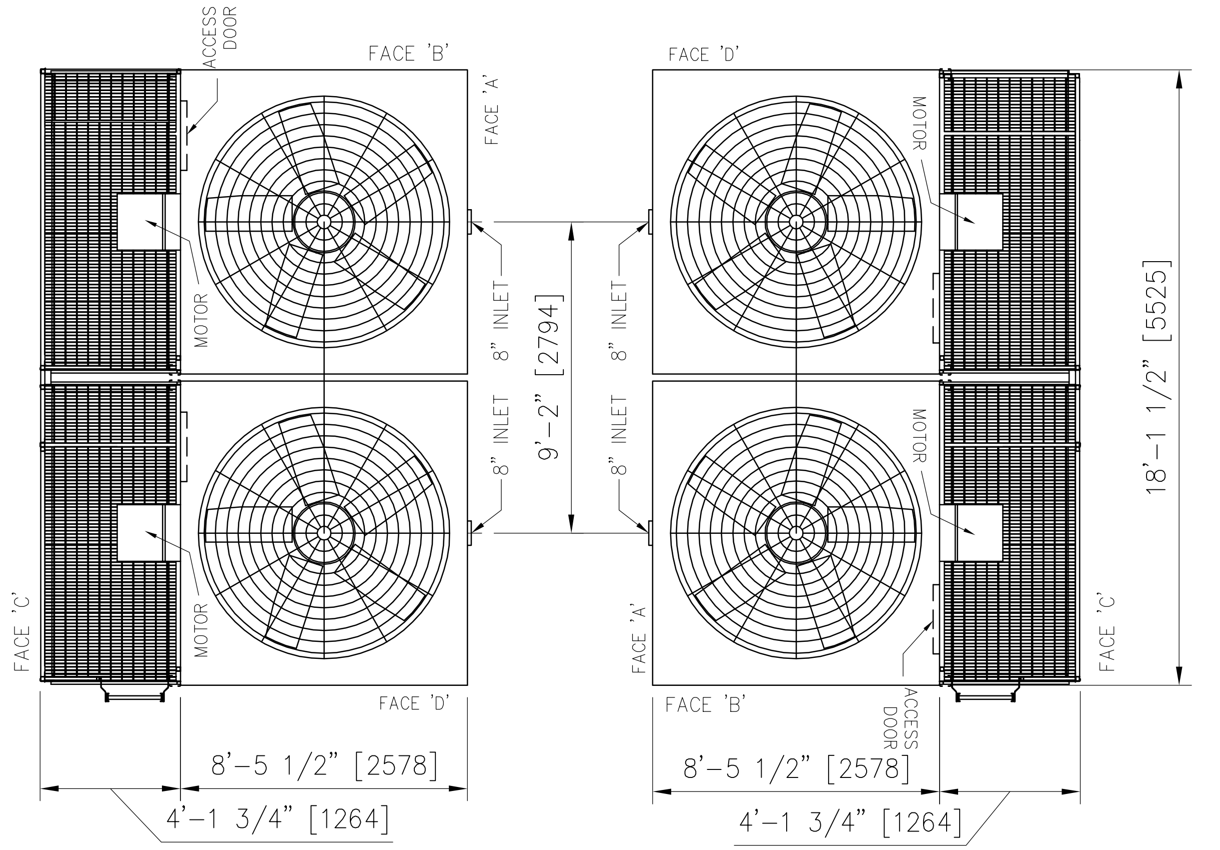
-Doug

SPX

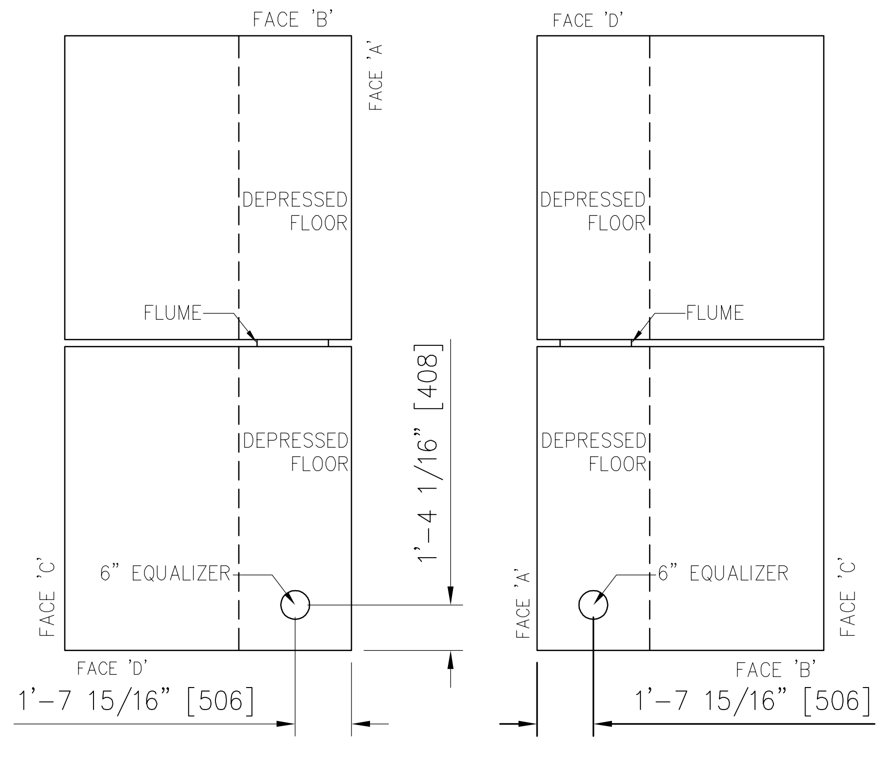
Doug Bougher
Director HVAC & Refrigeration Sales
Evaporative Cooling
SPX Cooling Technologies, Inc.

7401 West 129th Street
Overland Park, Kansas 66213
TEL +1 913-664-7540
MOB +1 913-827-7573
FAX +1 913-693-9506
doug.bougher@spx.com
www.spx.com

From: Ray Cheng [mailto:raycheng@microsoft.com]
Sent: Thursday, May 29, 2014 1:22 PM



PLAN VIEW

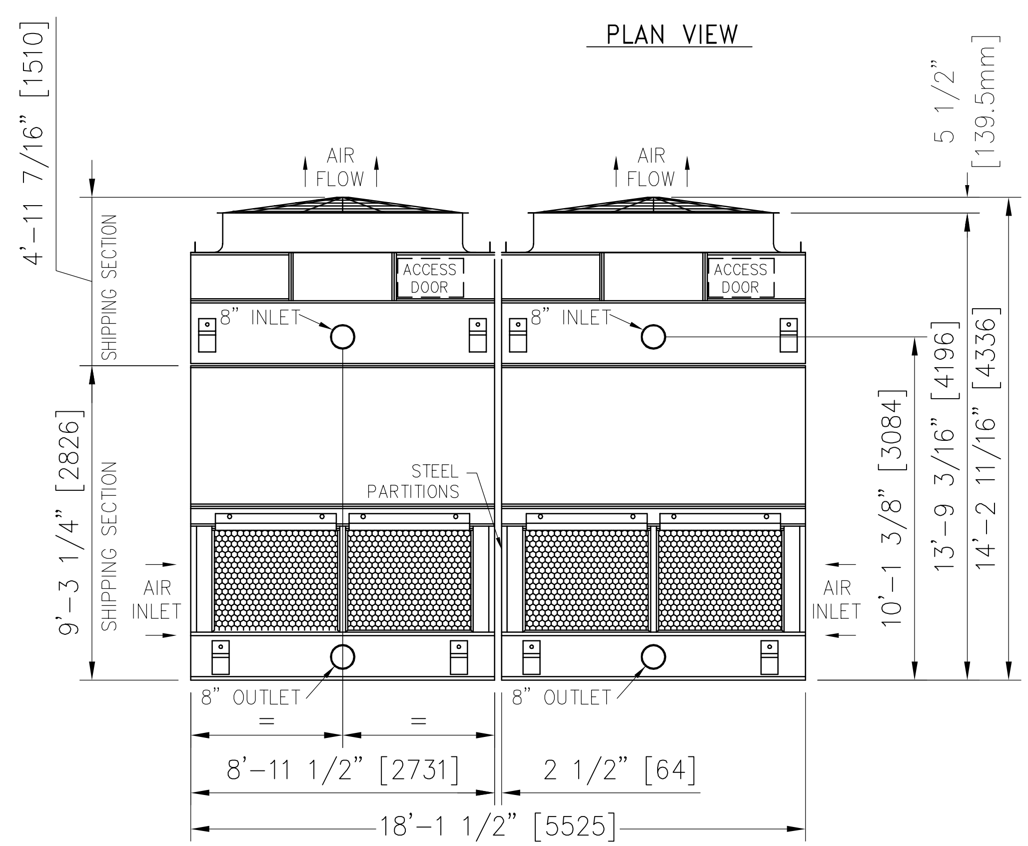


PLAN VIEW
OF COLD WATER BASIN

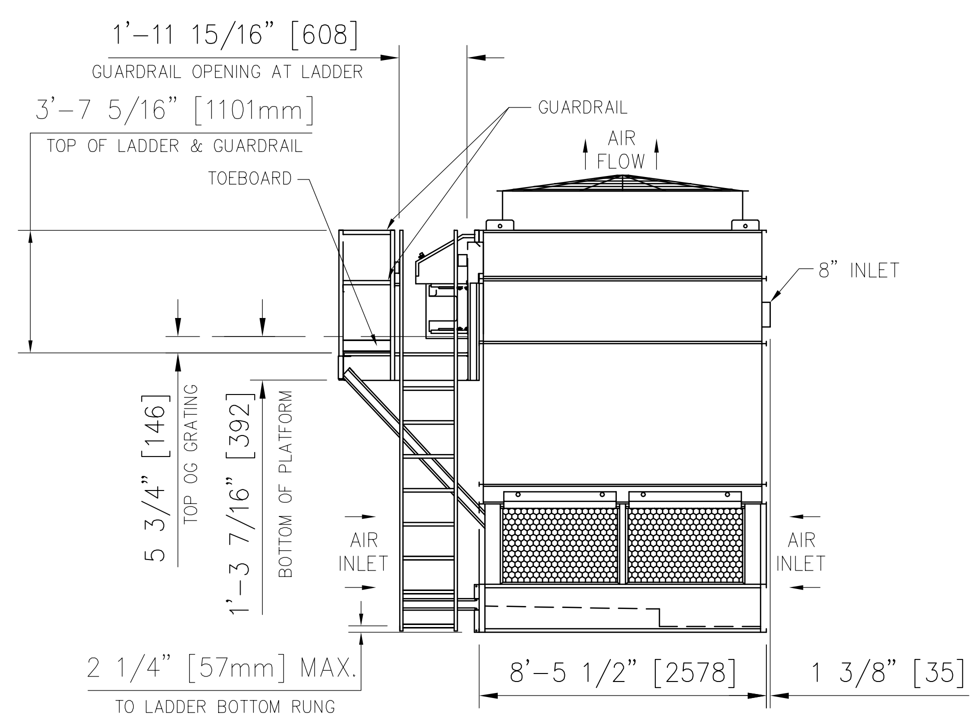
NOTES

1. THE EQUIPMENT MUST BE INSTALLED LEVEL TO INSURE MAXIMUM THERMAL PERFORMANCE AND TO AVOID RACKING.
2. AIR INLET FACES MUST HAVE AN ADEQUATE AIR SUPPLY. IF OBSTRUCTIONS EXIST, CONSULT YOUR SPX-CT REPRESENTATIVE.
3. FOR TOWER SUPPORT REQUIREMENTS, WEIGHTS AND LOADS, REFER TO THE "SUGGESTED SUPPORTING STEEL ARRANGEMENT" DRAWING.
4. REFERENCE "OUTLET PIPING ARRANGEMENT" DRAWINGS FOR AVAILABLE CONFIGURATIONS.
5. PIPING MUST NOT BE SUPPORTED BY THE TOWER STRUCTURE, INLET, OR OUTLET CONNECTIONS.
6. INLET PIPE CONNECTION IS GROOVED TO SUIT A MECHANICAL COUPLING AND BEVELED FOR WELDING.
7. FAN MOTOR MUST BE LOCKED OUT AND INOPERABLE BEFORE ENTERING TOWER.
8. ADD PLATFORM WEIGHT TO TOWER OPERATING WEIGHT SHOWN ON THE SUGGESTED SUPPORTING STEEL DRAWING FOR TOTAL LOAD.
9. PLATFORM & LADDER ARE FIELD INSTALLED BY OTHERS.
10. ASSEMBLY TOLERANCE IS ±1/8" [±3mm]. CONSULT SUPPLIERS OF SUPPORTING STRUCTURE FOR CONSTRUCTION TOLERANCE.

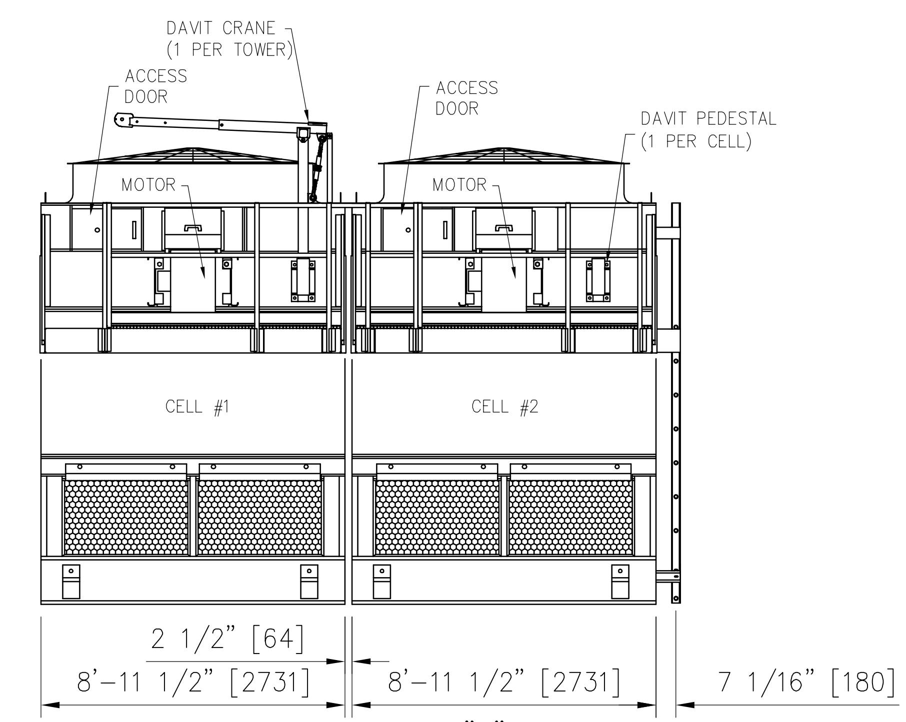
PLATFORM WEIGHT (per cell)
550 lbs. [249 kgf.]



ELEVATION - FACE "A"
(LADDER NOT SHOWN FOR CLARITY)



ELEVATION - FACE "D"
(TOWER 1 IS SHOWN
TOWER 2 IS OPPOSITE HAND)



ELEVATION - FACE "C"
(TOWER 1 IS SHOWN
TOWER 2 IS OPPOSITE HAND)
DAVIT ONLY SHOWN IN THIS VIEW TO INDICATE LOCATION

ECO NUMBER	SD SCHEMATIC DETAILS MD5008##F MULTI-CEL DC 2015 POR Data Center				SPX.			
REV. BY / CHECKED								
REV. DATE	DRAWN BY	DATE	CHECKED	APPROVED	ORDER NUMBER	PLOT	DRAWING NUMBER	REV.
01/30/2014	JENNESS_STD	01/27/2014	DMJ	DMJ	— / —	1=70	Z0870572	A

SPX- Marley

Jim Wilder

From: Bougher, Doug [doug.bougher@spx.com]
Sent: Wednesday, April 23, 2014 12:13 AM
To: James Boyce
Cc: raycheng@microsoft.com; paboeg@microsoft.com; Neil L. Doyle; PETERSON, BART; Gorman, Rob
Subject: RE: DC2015_Cooling Towers_Additional Request

James,

Here are the answers to your questions. Feel free to call me on my cell to discuss more.

1. A drift rate of 0.0003% is not a commercially available proven product. It would be custom for us, but as we have mentioned, that drift rate is below field measurement capabilities so it could not be proven.
2. Drift is inversely proportional to the L/G (liquid flow rate to gas flow rate) in the tower. This means lowering the water flow rate actually increases the drift. Lowering the air flow rate will improve drift, but would require a significant reduction in fan speed to get to the levels requested. This would also require an increase in water temperatures or decrease in wet bulb. A review of the annual average ambient conditions and heat load for each site would be needed to make a calculated estimate and potentially recommend tower changes.

Please let me know if you would like to have a more in depth technical discussion with our team.

Thanks,

-Doug

SPX

Doug Bougher
Director HVAC & Refrigeration Sales
Evaporative Cooling
SPX Cooling Technologies, Inc.

7401 West 129th Street
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TEL +1 913-664-7540
MOB +1 913-827-7573
FAX +1 913-693-9506
doug.bougher@spx.com
www.spx.com

From: James Boyce [mailto:James.Boyce@bruceshaw.com]
Sent: Tuesday, April 22, 2014 4:07 AM
To: Bougher, Doug
Cc: raycheng@microsoft.com; paboeg@microsoft.com; neil.l.doyle@bruceshaw.com
Subject: DC2015_Cooling Towers_Additional Request

Dear Doug,

EVA PCO

Jim Wilder

From: Troy Reineck [treineck@evapco.com]
Sent: Wednesday, April 23, 2014 1:28 PM
To: James Boyce
Cc: raycheng@microsoft.com; paboeg@microsoft.com; Neil L. Doyle; Jamie Facius
Subject: RE: DC2015_Cooling Towers_Additional Request
Attachments: Exhibit 1-1A - Cooling Towers - DRB1 - Add Alternate_EVAPCO 042314 TJR.xlsx

Dear James,

Thank you for the request.
Please see Evapco's response attached.

Thank you,
Troy J. Reineck
410-756-2600
treineck@evapco.com

From: James Boyce [mailto:James.Boyce@bruceshaw.com]
Sent: Tuesday, April 22, 2014 5:07 AM
To: Troy Reineck
Cc: raycheng@microsoft.com; paboeg@microsoft.com; neil.l.doyle@bruceshaw.com
Subject: DC2015_Cooling Towers_Additional Request

Hi Troy,

Further to the request below please respond asap with comment to the following:

- At our current cooling tower size, is the 0.0003% drift rate tower a commercially available proven product or a custom made product?
- Since we are oversizing our cooling towers (with 0.0005% drift rate), will selected towers operate with our current flow rate (reduced flow rate) will satisfy 0.0003% drift rate performance? If yes, please provide a formal letter of confirmation.

Thanks in advance,

James.

MICROSOFT DATA CENTER - DC2015 US REGIONAL BID
COOLING TOWERS PACKAGE

Bidder: EVAPCO **Status:** Final BAFO Bid

		DC2015 US REGIONAL BID				
		Des Moines, Iowa		Quincy, Washington		
	Alternates / Options (do not include any applicable taxes unless noted). All alternates shall be valid for the duration of the Regional Purchase Order Agreement (3 years) and will be subject to the volume discount and escalation rate provisions listed below.					
	Alternate / Options:					
1	Additional cost to upgrade Coolong Tower to 0.0003% drift rate	Exception	#VALUE!	Exception	#VALUE!	No upgrade is available to reduce the drift rate to 0.0003%. There is no commercially av ailable proven product with a guaranteed 0.0003% drift rate. The minimum guaranteed drift rate Evapco can provide is 0.0005%. This exceeds the specified limit of 0.001% as noted in spec section 23 6500 1.4A 7. P er previous bid documents there is no cost add for Ev apco to acheive the 0.0005% drift rate.
2	*Vendor to complete*		$ -		$ -	
3	*Vendor to complete*		$ -		$ -	
4	*Vendor to complete*		$ -		$ -	
5	*Vendor to complete*		$ -		$ -	

ENGINEERING DATA
AND SPECIFICATIONS

Marley MD 5000

COUNTERFLOW COOLING TOWER

MD towers are galvanized steel, factory assembled, counterflow cooling towers, designed to serve air conditioning and refrigeration systems as well as light to medium industrial process loads on clean water. The Marley MD evolved from a factory-assembled concept of towers pioneered by Marley some 75 years ago, and incorporates all of the design advancements that our customers have found valuable. MD towers represent the current state of the art in this cooling tower category.

The specifications portion of this publication not only relates the language to use in describing an appropriate MD cooling tower—but also defines why certain items and features are important enough to specify with the intention of insisting upon compliance by all bidders. The left hand column of pages 40 thru 53 provides appropriate text for the various specification paragraphs, whereas the right hand column comments on the meaning of the subject matter and explains its value.

Pages 40 through 44 indicate those paragraphs which will result in the purchase of a basic cooling tower—one that accomplishes the specified thermal performance, but which will lack many operation—and maintenance-enhancing accessories and features that are usually desired by those persons who are responsible for the continuing operation of the system of which the cooling tower is part. It will also incorporate those standard materials which testing and experience has proven to provide acceptable longevity in normal operating conditions.

Pages 45 through 53 provide paragraphs intended to add those features, components, and materials that will customize the cooling tower to meet the user's requirements.

AIR MOVEMENT PACKAGE

- High efficiency fan—wide-chord design for maximum efficiency at low fan tip speeds
- Eased inlet fan cylinder—ensures full area, low turbulent airflow through the cylinder
- Spherical roller bearings are rated at an L_{10} life of 100,000 hours
- TEFC Fan Motor—1.15 service factor, variable torque, and specially insulated for cooling tower duty
- The MD Series air movement package including the structural support—guaranteed against failure for a period of five full years.

WATER DISTRIBUTION SYSTEM

- Pressurized spray system distributes water evenly over the fill
- Low-clog polypropylene nozzles—deliver precise distribution of water over the fill area
- Marley MC thermoformed PVC film fill assembled into packs for ease of removal and cleaning
- Marley XCEL drift eliminators—limit drift losses to no more than .001% of the design flow rate

STRUCTURE

- Induced-draft, counterflow design may require less plan area than crossflow towers typically use
- Series 300 stainless steel, 316 stainless steel or heavy mill galvanized steel construction
- Factory assembled—ensures final field installation will be hassle-free
- Triple-pass PVC inlet louvers—limit splash-out and eliminate sunlight from entering the collection basin

SYSTEM CLEANLINESS

Cooling towers are very effective air washers. Atmospheric dust able to pass through the relatively small louver openings will enter the circulating water system. Increased concentrations can intensify system maintenance by clogging screens and strainers—and smaller particulates can coat system heat transfer surfaces. In areas of low flow velocity—such as the cold water basin—sedimentary deposits can provide a breeding ground for bacteria.

In areas prone to dust and sedimentation, you should consider installing some means for keeping the cold water basin clean. Typical devices include side stream filters and a variety of filtration media.

WATER TREATMENT

To control the buildup of dissolved solids resulting from water evaporation, as well as airborne impurities and biological contaminants including Legionella, an effective consistent water treatment program is required. Simple blowdown may be adequate to control corrosion and scale, but biological contamination can only be controlled with biocides.

An acceptable water treatment program must be compatible with the variety of materials incorporated in a cooling tower—ideally the pH of the circulating water should fall between 6.5 and 9.0. Batch feeding of chemicals directly into the cooling tower is not a good practice since localized damage to the tower is possible. Specific startup instructions and additional water quality recommendations can be found in the MD User Manual which accompanies the tower and also is available from your local Marley sales representative. For complete water treatment recommendations, consult a competent, qualified water treatment supplier.

⚠ **CAUTION**

The cooling tower must be located at such distance and direction to avoid the possibility of contaminated discharge air being drawn into building fresh air intake ducts. The purchaser should obtain the services of a Licensed Professional Engineer or Registered Architect to certify that the location of the cooling tower is in compliance with applicable air pollution, fire and clean air codes.

TYPICAL APPLICATIONS

The MD tower is an excellent choice for normal applications requiring cold water for the dissipation of heat. This includes condenser water cooling for air conditioning, refrigeration, and thermal storage systems, as well as their utilization for free-cooling in all of those systems. The MD can also be used in the cooling of jacket water for engines and air compressors, and are widely applied to dissipate waste heat in a variety of industrial, power and manufacturing processes.

Choosing the all stainless steel construction option, the MD can be confidently applied in unusually corrosive processes and operating environments. However, no single product line can answer all problems, and selective judgement should be exercised in the following situations

APPLICATIONS REQUIRING ALTERNATIVE COOLING TOWER SELECTIONS

Certain types of applications are incompatible with any cooling tower with film fill—whether MD or a competitive tower of similar manufacture. Film fill is subject to distortion in high water temperatures, and the narrow passages are easily clogged by turbid or debris-laden water. Some of the applications, which call for alternative tower designs are:

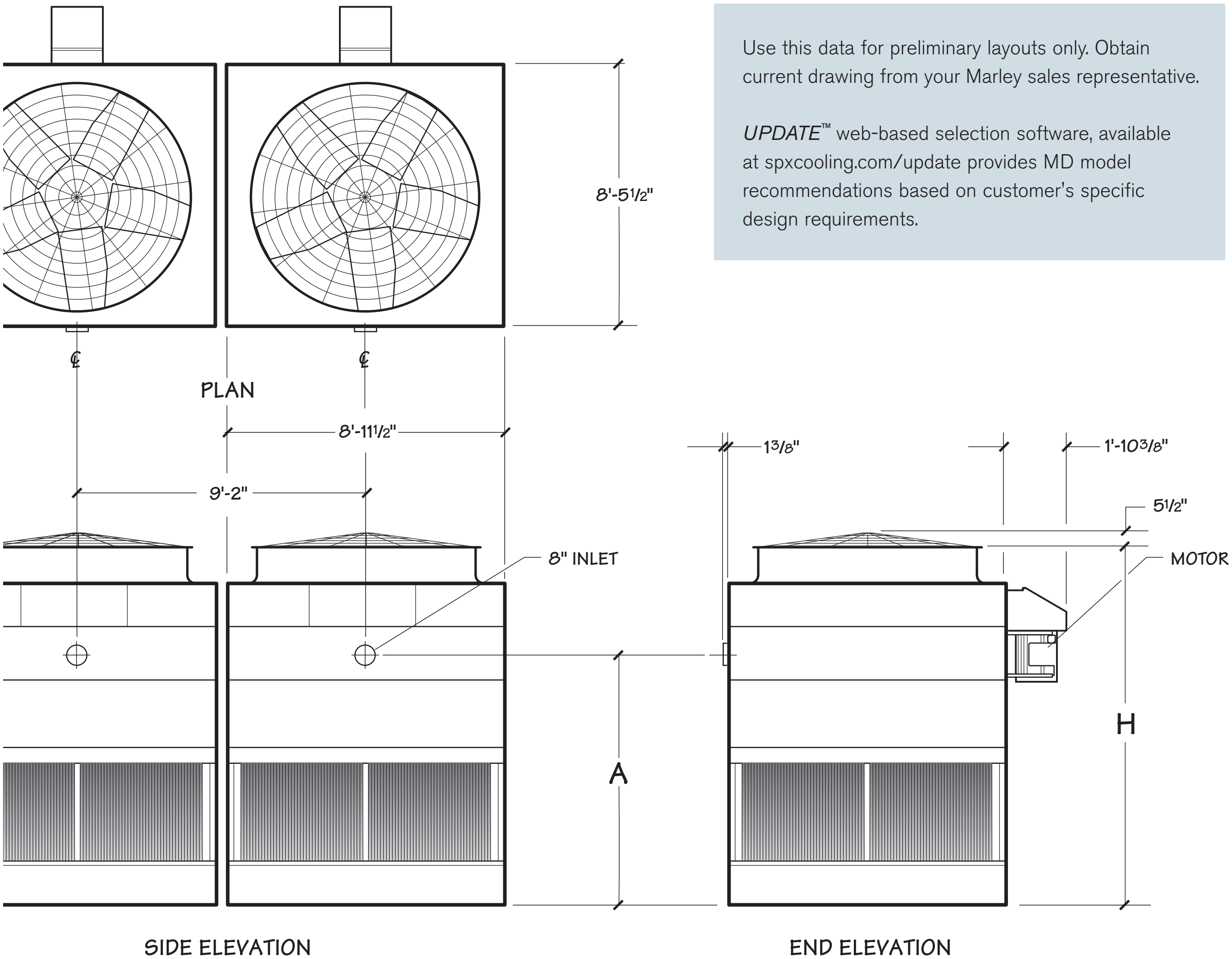
- Water temperatures exceeding 135°F—adversely affects the service life and performance of normal counterflow PVC fill. Higher temperature fill materials are available.
- Ethylene glycol content—can plug fill passages as slime and algae accumulate to feed on the available organic materials.
- Fatty acid content—found in processes such as soap and detergent manufacturing and some food processing—fatty acids pose a serious threat for plugging fill passages.
- Particulate carry over—often found in steel mills and cement plants—can both cause fill plugging, and can build up to potentially damaging levels on tower structure.
- Pulp carry over—typical of the paper industry and food processing where vacuum pumps or barometric condensers are used. Causes fill plugging which may be intensified by algae.

ALTERNATIVE SELECTIONS

In addition to the MD, SPX Cooling Technologies offers a full scope of products in various designs and capacities to meet the special demands of specific applications.

spxcooling.com—visit us on the web for a complete list of products, services, publications and to find your nearest sales representative.

MD5008 MULTICELL



Use this data for preliminary layouts only. Obtain current drawing from your Marley sales representative.

UPDATE™ web-based selection software, available at spxcooling.com/update provides MD model recommendations based on customer's specific design requirements.

MD5008 MULTICELL

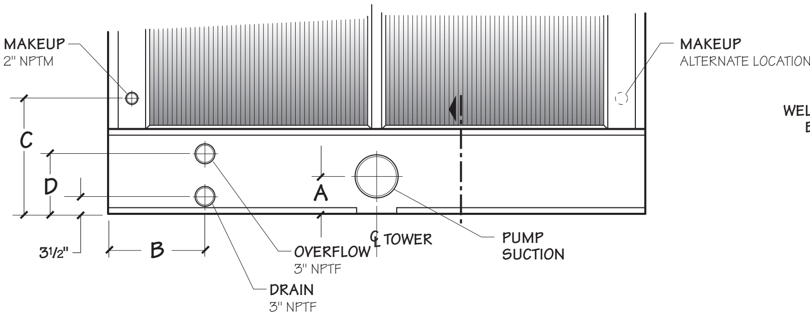
Model note 2	Nominal Tons note 3	Motor hp	dBA 5'-0" from air inlet face	dBA 5'-0" above fan outlet	Dimensions		Design Operating Weight lb	Shipping Weight lb	
					H note 5	A		Weight/Cell	Heaviest Section
MD5008KLC2L	149	5	79	76	11'-6 13/16"	7'-11"	6772	3798	1965
MD5008MAC2L	165	7.5	80	80					
MD5008NAC2L	179	10	81	81					
MD5008PAC2L	202	15	81	84					
MD5008QAC2L	216	20	81	85					
MD5008KLD2L	161	5	79	76	12'-6 13/16"	8'-11"	7049	4075	2110
MD5008MAD2L	180	7.5	80	80					
MD5008NAD2L	197	10	81	81					
MD5008PAD2L	223	15	81	84					
MD5008QAD2L	239	20	81	85					
MD5008KLF2L	166	5	79	76	13'-6 13/16"	9'-11"	7326	4352	2387
MD5008MAF2L	189	7.5	80	80					
MD5008NAF2L	207	10	81	81					
MD5008PAF2L	234	15	81	84					
MD5008QAF2L	255	20	81	85					

A Sound dBA Approach

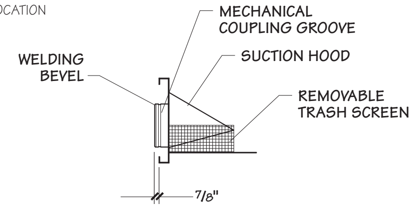
Various low sound options are available for up to 16 dB reduction from the standard dBA options in the schematic data table. Consult *UPDATE* selection software for performance, sound levels and dimensions.

NOTE

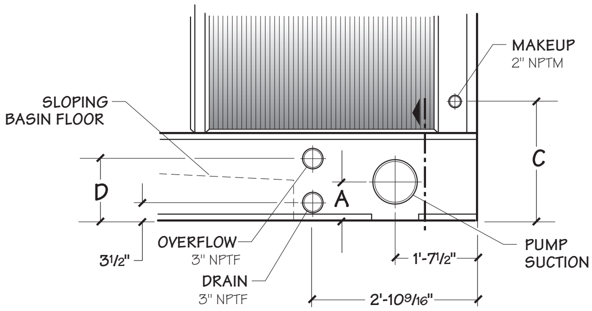
1. **Use this bulletin for preliminary layouts only.** Obtain current drawings from your Marley sales representative. All table data is per cell.
2. Last two characters of the model number indicate number of cells and cell configuration.
3. Nominal tons are based upon 95°F HW, 85°F CW, 78°F WB and 3 GPM/ton. The Marley ***UPDATE*** web-based selection software provides MD model recommendations based on specific design requirements.
4. Standard overflow is a 3" dia. FPT connection located on the side of the collection basin. Makeup water connection is 2" dia. MPT connection located on the side of the tower. A 3" FPT drain connection is located on the side of the collection basin.
5. Models with an Ultra Quiet Fan option require a taller fan cylinder, add 1'-11½" to this dimension for correct height.



SIDE-OUTLET SUCTION CONNECTION

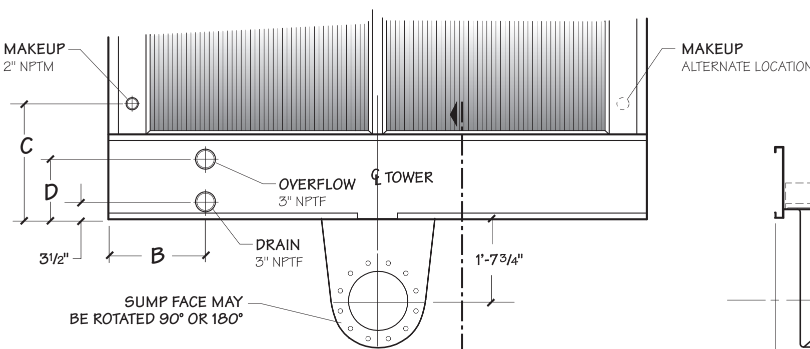


SUCTION SECTION

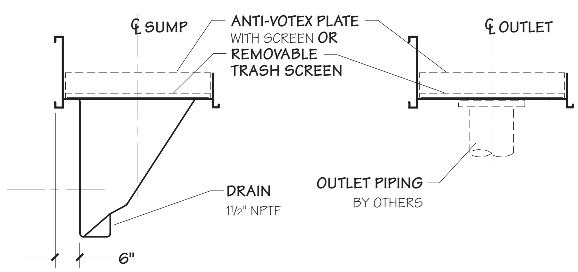


END-OUTLET SUCTION CONNECTION

Model	Dimensions				
	Suction Diameter	A	B	C	D
MD5006	4"	–	1'-7 ⅜"	1'-11 ⅛"	1'-0"
	6"	7 ½"	1'-7 ⅜"	1'-11 ⅛"	1'-0"
	8"	–	1'-7 ⅜"	1'-11 ⅛"	1'-0"
MD5008	6"	–	1'-7 ⅜"	1'-11 ⅛"	1'-0"
	8"	7 ½"	1'-7 ⅜"	1'-11 ⅛"	1'-0"
	10"	–	1'-7 ⅜"	1'-11 ⅛"	1'-0"
MD5010	6"	–	1'-6 ¾"	1'-11 ⅛"	1'-0"
	8"	7 ½"	1'-6 ¾"	1'-11 ⅛"	1'-0"
	10"	–	1'-6 ¾"	1'-11 ⅛"	1'-0"
MD5016	6"	–	1'-6 ¾"	2'-1 ⅛"	1'-1"
	8"	7 ½"	1'-6 ¾"	2'-1 ⅛"	1'-1"
	10"	8 ½"	1'-6 ¾"	2'-1 ⅛"	1'-1"
	12"	–	1'-6 ¾"	2'-1 ⅛"	1'-1"
MD5018	6"	–	1'-6 ¾"	2'-1 ⅛"	1'-1"
	8"	7 ½"	1'-6 ¾"	2'-1 ⅛"	1'-1"
	10"	8 ½"	1'-6 ¾"	2'-1 ⅛"	1'-1"
	12"	9 ½"	1'-6 ¾"	2'-1 ⅛"	1'-1"
	14"	–	1'-6 ¾"	2'-1 ⅛"	1'-1"

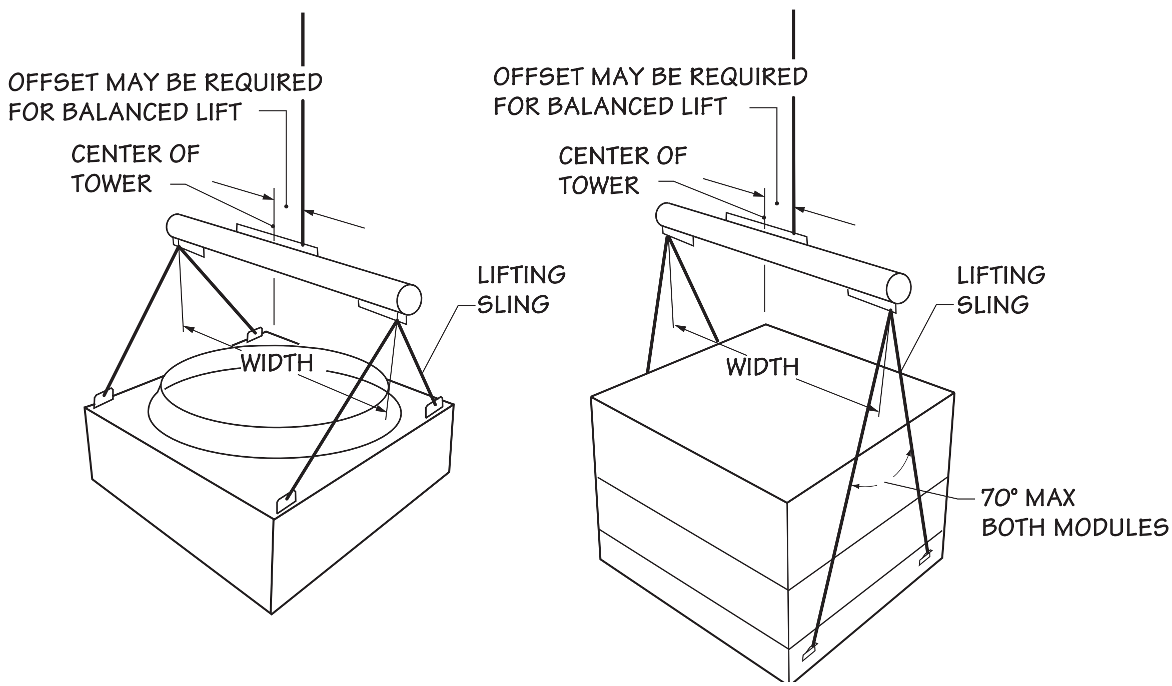


SIDE-OUTLET SUMP CONNECTION



SUMP SECTION

Outlet Diameter	Maximum GPM per Outlet																								
	Side or End Suction pump flow					Sump pump flow without anti-vortex plate					Sump pump flow with anti-vortex plate or gravity flow with or without anti-vortex plate					Bottom Outlet pump flow without anti-vortex plate					Bottom Outlet pump flow with anti-vortex plate or gravity flow with or without anti-vortex plate				
	MD 5006	MD 5008	MD 5010	MD 5016	MD 5018	MD 5006	MD 5008	MD 5010	MD 5016	MD 5018	MD 5006	MD 5008	MD 5010	MD 5016	MD 5018	MD 5006	MD 5008	MD 5010	MD 5016	MD 5018	MD 5006	MD 5008	MD 5010	MD 5016	MD 5018
6"	815					630	630	630			815	900	900	900	900						345				
8"		1174	1369	1559	1559	815	1091	1091	1091	1091	815	1174	1369	1559	1559	281					598	598	598		
10"				2347	2458		1174	1369	1720	1720		1174	1369	2347	2458	442	442	442			815	943	943	943	943
12"					3012				2347	2443				2347	3012	628	628	628			815	1174	1338	1338	1338
14"										2954						760	760	760	760		815	1174	1369	1618	1618
16"										3012						815	991	991	991	991	815	1174	1369	2112	2112
18"																	1174	1256	1256	1256		1174	1369	2347	2636
20"																		1369	1559	1559			1369	2347	2937
24"																			2257	2257				2347	3012



Model	Base Module			Top Module		
	Width	Sling Length Minimum	Weight lb	Width	Sling Length Minimum	Weight lb
MD5006	6'-0"	9'-0"	1700	8'-6"	5'-0"	1800
MD5008	8'-6"	10'-0"	2400	9'-0"	8'-0"	2000
MD5010	8'-6"	12'-0"	3100	8'-6"	10'-0"	2400
MD5016	12'-0"	12'-0"	3900	12'-0"	10'-0"	4700
MD5018	12'-0"	15'-0"	8700	12'-0"	15'-0"	4000

NOTE

1 Hoisting operations can be dangerous and suitable safety precautions should be taken to protect personnel and the equipment being hoisted.
2 All hoisting equipment should be certified and comply with local and national safety regulations.
3 Ensure that slings are of sufficient length so not to impose bending loads onto the casing—use of spreader bars is essential.
4 For overhead lifts or where additional safety is required, add slings beneath the tower unit

When the ambient air temperature falls below 32°F, the water in a cooling tower can freeze. *Marley Technical Report #H-003* "Operating Cooling Towers in Freezing Weather" describes how to prevent freezing during operation. Available at spxcooling.com or ask your Marley sales representative for a copy.

During shutdown, water collects in the cold water basin and may freeze solid. You can prevent freezing by adding heat to the water left in the tower—or, you can drain the tower and all exposed pipework at shutdown.

ELECTRIC BASIN HEATERS

An automatic basin water heater system is available consisting of the following components:

- Stainless steel electric immersion heater(s).

  —Threaded couplings are provided in the side of the collection basin.
- NEMA 4 enclosure containing:

  —Magnetic contactor to energize heater.

  —Transformer to convert power supply to 24 volts for control circuit.

  —Solid state circuit board for temperature and low-water cutoff.

  Enclosure may be mounted on the side of the tower.
- Control probe in the collection basin to monitor water temperature and level.

Heater components are normally shipped separately for installation by others.

Note: any exposed piping that is still filled with water at shutdown—including the makeup water line—should be electrically traced and insulated (by others).

INDOOR STORAGE TANK

With this type of system, water flows from an indoor tank, through the load system, and back to the tower, where it is cooled. The cooled water flows by gravity from the tower to the tank located in a heated space. At shutdown, all exposed water drains into the tank, where it is safe from freezing.

The amount of water needed to successfully operate the system depends on the tower size and GPM and on the volume of water contained in the piping system to and from the tower. You must select a tank large enough to contain those combined volumes—plus a level sufficient to maintain a flooded suction on your pump. Control makeup water according to the level where the tank stabilizes during operation.

The MD cooling tower can be a very effective air washer. Atmospheric dust able to pass through the relatively small louver openings will enter the recirculating water system. Increased concentrations can intensify systems maintenance by clogging screens and strainers—and smaller particulates can coat system heat transfer surfaces. In areas of low flow velocity—such as the collection basin—sedimentary deposits can provide a breeding ground for bacteria.

In areas prone to dust and sedimentation, you should consider installing some means for keeping the collection basin clean. Typical devices include side stream filters and a variety of filtration media.

BLOWDOWN

Blowdown or Bleedoff is the continuous removal of a small portion of the water from the open recirculating system. Blowdown is used to prevent the dissolved solids from concentrating to the point where they will form scale. The amount of blowdown required depends on the cooling range—the difference between the hot and cold water temperatures of the closed circuit— and the composition of the makeup water.

⚠ **CAUTION**

The cooling tower must be located at such distance and direction to avoid the possibility of contaminated discharge air being drawn into building fresh air intake ducts. The purchaser should obtain the services of a Licensed Professional Engineer or Registered Architect to certify that the location of the cooling tower is in compliance with applicable air pollution, fire and clean air codes.

WATER TREATMENT

To control the buildup of dissolved solids resulting from water evaporation, as well as airborne impurities and biological contaminants including Legionella, an effective consistent water treatment program is required. Simple blowdown may be adequate to control corrosion and scale, but biological contamination can only be controlled with biocides.

An acceptable water treatment program must be compatible with the variety of materials incorporated in a cooling tower—ideally the pH of the recirculating water should fall between 6.5 and 9.0. Batch feeding of the chemicals directly into the cooling tower is not a good practice since localized damage to the cooling tower is possible. Specific startup instructions and additional water quality recommendations can be found in the *MD Cooling Tower User Manual* which accompanies the cooling tower and also is available at spxcooling.com.

Specifications	Specification Value

1.0 **Base:**

1.1 Furnish and install an induced-draft, counterflow-type, factory assembled, film fill, industrial duty, cooling tower. Unit shall consist of _____ cell(s), as shown on plans. The limiting overall dimensions of the tower shall be _____ wide, _____ long, and _____ high. Total operating power of all fans shall not exceed _____ hp, consisting of_____ @ _____ hp motor(s). Tower shall be similar and equal in all aspects to Marley Model ____________________.

- Your specification base establishes the type, configuration, base material, and physical limitations of the cooling tower to be quoted. During the planning and layout stages of your project, you will have focused your attention on a cooling tower selection that fits your space allotment, and whose power usage is acceptable. Limitations on physical size and total operating horsepower avoid the introduction of unforeseen operational and site-related influences. Specifying the number of cells, and the maximum fan hp/cell will work to your advantage.
You are specifying a counterflow tower, which is a type noted—and often specified—for its economical use of plan area. It effectively replaces most makes of older towers—both forced-draft and induced-draft—usually without major redesign of the existing site.

2.0 **Thermal Performance:**

2.1 The tower shall be capable of cooling _____ GPM of water from ____ °F to _____ °F at a design entering air wet-bulb temperature of _____ °F. The thermal performance rating shall be Certified by the Cooling Technology Institute.

- CTI Certification means that the cooling tower has been tested under operating conditions and found to perform as rated by the manufacturer under those circumstances. It assures the buyer that the tower is not intentionally or inadvertently undersized by the manufacturer. A list of CTI certified cooling towers can be found at ***cti.org***.

2.2 The tower shall be capable of minimum _____ GPM/hp efficiency at 95°F-85°F-75°F, per ASHRAE Standard 90.1.

- The minimum efficiency per ASHRAE Standard 90.1 for induced draft open cooling towers applied to comfort cooling is 38.2 GPM/hp @ 95/85/75. There are no efficiency requirements for non-comfort cooling applications. If you want greater efficiency you can require it by specifying a higher ASHRAE Standard 90.1 GPM/hp.

Each model's ASHRAE Standard 90.1 rating can be viewed in our online sizing and selection software at spxcooling.com/update.

3.0 **Performance Warranty:**

3.1 CTI Certification notwithstanding, the cooling tower manufacturer shall guarantee that the cooling tower supplied will meet the specified performance conditions when the tower is installed as shown on the plans. If, because of a suspected thermal performance deficiency, the owner chooses to conduct an on-site thermal performance test under the supervision of a qualified, disinterested third party in accordance with CTI or ASME standards during the first year of operation; and if the tower fails to perform within the limits of test tolerance; then the cooling tower manufacturer will pay for the cost of the test and will make such corrections as are appropriate and agreeable to the owner to compensate for the performance deficiency.

- CTI certification alone is not sufficient to assure you that the cooling tower will perform satisfactorily in your situation. Certification is established under relatively controlled conditions, and cooling towers seldom operate under such ideal circumstances. They are affected by nearby structures, machinery, enclosures, effluent from other sources, etc. Responsible and knowledgeable bidders will take such site-specific effects into consideration in selecting the cooling tower—but the specifier must insist by the written specification that the designer/manufacturer guarantee this “real world” performance. Any reluctance on the part of the bidder should cause you some concern.

Specifications	Specification Value

4.0 **Design Loading:**

4.1 The tower structure, anchorage and all its components shall be designed by licensed professional engineers, employed by the manufacturer, per the International Building Code to withstand a wind load of 30 psf, as well as a .3g seismic load. Maintenance platforms and guardrails, where specified shall be capable of withstanding a 200 lb concentrated live load in any direction and shall be designed in accordance with OSHA guidelines.

■ It is important to understand the distinction between ***structure*** and ***anchorage***. Specifying that only the ***anchorage*** meet these requirements means the tower can become non-functional, even fall down, yet remain attached to the foundation. Specifying ***structure*** will require the tower to remain operational. The indicated design values are the minimums allowed under accepted design standards. They give you assurance that the tower can be shipped, handled, hoisted—and ultimately operated in a normal cooling tower environment. Most MD models will withstand significantly higher wind and seismic loads. If your geographic location dictates higher wind load or seismic load values, please make the appropriate changes, after discussion with your Marley sales representative.

Some countries and states, like Florida, require structure and anchorage to meet a given loading. Check with your local officials.

30 psf windload, .3g seismic load—applicable for most applications but consult the local code official for actual requirements.
60 psf live load, 200 lb concentrated load—ensures the tower can be safely accessed for routine maintenance when a guardrail is installed as well ensuring the end user complies with government safety laws.

5.0 **Construction:**

5.1 Except where otherwise specified, all components of the cooling tower shall be fabricated of heavy-gauge steel, protected against corrosion by G-235 galvanizing. After passivation of the galvanized steel (8 weeks at pH 7-8, and calcium hardness and alkalinity at 100-300 ppm each), the cooling tower shall be capable of withstanding water having a pH of 6.5 to 9.0; a chloride content up to 500 ppm as NaCl (300 ppm as Cl-); a sulfate content (as SO_4) up to 250 ppm; a calcium content (as $CaCO_3$) up to 500 ppm; silica (as SiO_2) up to 150 ppm; and design hot water temperatures up to 130°F. The circulating water shall contain no oil, grease, fatty acids, or organic solvents. Fiberglass casing, polyurethane barriers, and thermosetting hybrids and the components they are adhered to shall be considered non-recyclable and not allowed.

■ In the history of cooling towers, no other coating for carbon steel has exhibited the success and longevity of galvanization in exposure to the normal cooling tower water quality defined at left. No paints or electrostatically-applied coatings, however exotic they may be, can approach galvanization's history of success.

If extended longevity of the cooling tower is required—or unusually harsh operating conditions are expected—consider specifying stainless steel as either the base construction material, or the material utilized for specific components of your choice. See Stainless Steel Options on page 45.

5.2 The specifications, as written, are intended to indicate those materials that will be capable of withstanding the above water quality in continuing service, as well as the loads described in paragraph 4.1. They are to be regarded as minimum requirements. Where component materials unique to individual tower designs are not specified, the manufacturers shall take the above water quality and load carrying capabilities into account in the selection of their materials of manufacture.

Specifications

6.0 **Mechanical Equipment**:

6.1 Fan(s) shall be propeller-type, incorporating aluminum alloy blades attached to galvanized hubs with U-bolts. Blades shall be individually adjustable Fan(s) shall be driven through a one-piece multi-groove, solid back V-type belt, sheaves (pulleys), and tapered roller bearings. Bearings shall be rated at an L10 life of 100,000 hours, or greater. Both motor and fan sheaves (pulleys) shall be all cast aluminum to prevent premature corrosion.

6.1 (alternate)* Fan(s) shall be propeller-type, incorporating aluminum alloy blades attached to galvanized hubs with U-bolts. Blades shall be individually adjustable. Maximum fan tip speed shall be 13,000 ft/min. Fan(s) shall be driven through a right angle, industrial duty, oil lubricated, geared speed reducer that requires no oil changes for the first five (5) years of operation. All gearbox bearings shall be rated at an L_{10A} service life of 100,000 hours or greater and the gear sets shall have AGMA Quality Class of 9 or greater. The gearbox shall include any modifications to enable operation down to 10% of full speed.
**Currently available on MD5016 and MD5018 models only.*

6.2 Motor(s) shall be ____ hp maximum, NEMA Premium Efficiency, TEFC, 1.15 service factor, variable torque, inverter duty and insulated for cooling tower duty. Speed and electrical characteristics shall be ______ RPM, single-winding, 3 phase, ____ hertz, ____ volts. Motor shall operate shaft-down position for belt drive towers and in the shaft-horizontal position for geardrive towers. Nameplate power shall not be exceeded at design operation. TEAO motors are not acceptable.

6.3 The complete mechanical equipment assembly for each cell shall be supported by a rigid, hot-dip galvanized steel structural support that resists misalignment between the motor and sheaves (pulleys). For belt-drive towers with motors mounted outside the airstream, a protective cover shall be mounted over the motor and sheave to protect it from the weather and prevent inadvertent contact. The mechanical equipment assembly shall

Specification Value

- Propeller-type fans require only half the operating hp of blower-type fans. However, they should be readily adjustable to permit compensation for jobsite conditions.

The Marley Power Belt drive system features all-aluminum sheaves, power band belts and long-life bearings for dependable service.

TEFC motors offer additional benefits over TEAO motors whose only source of cooling is the flow of air produced by the cooling tower fan. This air rate is not always ideal due to motor position, blockage, variable speed operation, etc. TEFC ensures the motor will always be cooled properly.

Unless otherwise specified, motor speed will be 1800 RPM in 60 Hertz areas and 1500 RPM in 50 Hertz areas on standard models. Low sound models will use motor speeds appropriate for the specific model.

The value of a 5 year mechanical equipment warranty speaks for itself. Except for the motor, virtually all of the mechanical equipment on a Marley tower is designed and manufactured by SPX Cooling Technologies. Cooling tower vendors who purchase commercial fans, driveshafts, etc. may require that you deal directly with those commercial suppliers for warranty satisfaction.

Specifications | **Specification Value**

be warranted against any failure caused by defects in materials and workmanship for no less than five (5) years following the date of tower shipment. This warranty shall cover the fan(s), premium efficiency motor(s), speed reducer(s), drive shaft(s) and coupling(s), and the mechanical equipment support. The bearing assemblies and V-belts shall be warranted for 18 months.

7.0 **Fill, Louvers and Drift Eliminators:**

7.1 Fill shall be cross-corrugated, counterflow film type, thermoformed from 15 mil thick PVC. Fill shall be supported on channel sections supported from the tower structure and have a flame spread rating less than 25.

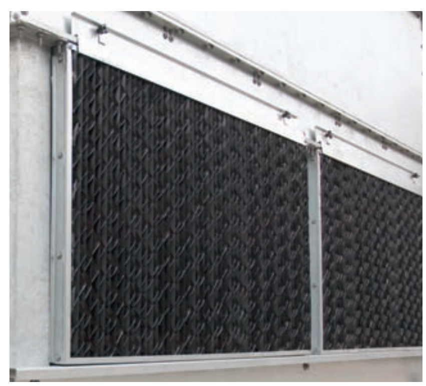
- Fill modules can be removed for inspection and cleaning in accordance with local anti legioinella guidelines.

7.2 Drift eliminators shall be 17 mil thick PVC with a minimum of three changes in air direction, and shall limit drift losses to 0.005% or less of the design water flow rate.

- Drift rate varies with design water loading and air rate, as well as drift eliminator depth and number of directional changes. A drift rate of 0.001% is readily available on many standard models. If a lower rate is required, please discuss with your Marley sales representative.

7.3 Air inlet louvers shall be a minimum of 5" air travel, triple pass PVC to limit water splashout and prevent direct sunlight from entering the collection basin. For ease of service and long life of louvers, PVC louvers shall be enclosed in a removable frame that attaches to the air inlet without tools. Louvers with less than three changes in air direction are unacceptable.

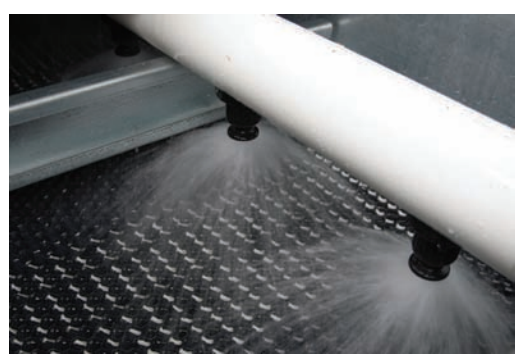
- Triple-pass inlet louvers



8.0 **Hot Water Distribution System:**

8.1 A pressured spray system shall distribute water evenly over the fill. The branch arms shall be corrosion resistant PVC with polypropylene spray nozzles attached to the branch arms with a rubber socket connection for ease of removal and cleaning. To ensure proper spray system operation, nozzles shall seat in branch arms without regard for direction or alignment.

- The combination of PVC piping and polypropylene nozzles is very resistant to the build-up of scale and slime.



Specifications	Specification Value
9.0 **Casing and Fan Guard:**	
9.1 The casing shall be heavy gauge G-235 galvanized steel and shall be capable of withstanding the loads described in paragraph 4.1. Casing panels shall encase the fill on all four sides of the tower. The top of the fan cylinder shall be equipped with a conical, non-sagging, removable fan guard, fabricated of welded 5/16" and 7 gauge rods, and hot dip galvanized after fabrication.	
10.0 **Access:**	
10.1 A large rectangular access door shall be located in the plenum on the motor side of the tower.	
11.0 **Cold Water Collection Basin**:	
11.1 The collection basin shall be heavy-gauge galvanized steel and shall include the number and type of suction connections required to accommodate the outflow piping system shown on the plans. Suction connections shall be equipped with debris screens. A factory installed, float operated, mechanical make-up valve shall be included. An overflow and drain connection shall be provided in each cell of the tower. The basin floor shall slope toward the drain to allow complete flush out of debris and silt which may accumulate. Towers of more than one cell shall include steel flumes for flow and equalization between cells.	■ The MD tower design offers side-suction as standard. Bottom outlets may be supplied to accommodate a variety of piping schemes. Unless so specified, the tower you may be asked to approve may only be available with one type of suction connection requiring you to redesign your piping layout. The sloping floor and low-level drain is valuable because it provides a way to achieve flush-out cleanability.
13.0 **Warranty**:	
13.1 The MD cooling tower shall be free from defects in materials and workmanship for a period of eighteen (18) months from the date of shipment.	

Specifications	Specification Value

Stainless Steel Options

Stainless Steel Collection Basin:

11.1 *Replace paragraph 11.1 with the following:* The collection basin shall be welded 301L stainless steel construction. Only low-carbon stainless steel alloys will be accepted in order to minimize the risk of intergranular corrosion in the weld zones. The basin shall include the number and type of suction connections required to accommodate the out-flow piping system shown on the plans. Basin suction connections shall be equipped with debris screens. A factory installed, float operated, mechanical make-up valve shall be included. An overflow and drain connection shall be provided in each cell of the tower. The basin floor shall slope toward the drain to allow complete flush out of debris and silt which may accumulate.

- The cold water basin is the only part of the tower that is subject to periods of stagnant water, concentrated with treatment chemicals and customary contaminants. It is also the most expensive and difficult part of any tower to repair or replace. For these reasons, many customers–particularly those who are replacing older towers–choose to specify stainless steel cold water basins.

- The 316 alloy was designed to increase resistance to chlorides. Generally, cooling towers in HVAC service utilize water sources, which do not approach the limits of 300 series stainless, even up to several cycles of concentration. Industrial cooling towers, generally circulating more aggressive water, use 300 series stainless as standard metallurgy, upgrading to 316 for situations such as estuary water or other significant source of chlorides. The vast majority of cooling tower water sources result in an acceptable environment for 300 series stainless steel, with HVAC systems typically being on the mild end of the spectrum. If you have one of the rare instances where water quality exceeds 900 ppm Cl, talk to you Marley sales representative about 316SS.

All Stainless Cooling Tower:

5.1 *Replace paragraph 5.1 with the following:* Except where otherwise specified, all components of the cooling tower shall be fabricated of heavy-gauge, series 301L stainless steel. Only low-carbon stainless steel alloys will be accepted in order to minimize the risk of intergranular corrosion in the weld zones. The tower shall be capable of withstanding water having a chloride content (NaCl) up to 750 ppm; a sulfate content (SO_4) up to 1200 ppm; a calcium content ($CaCO_3$) up to 800 ppm; silica (SiO_2) up to 150 ppm; and design hot water temperatures up to 135°F. The circulating water shall contain no oil, grease, fatty acids, or organic solvents.

- Where water quality falls outside the limits indicated in Paragraph 5.1, an all-stainless tower is worthy of your consideration. For pure resistance to corrosion–coupled with the capability to meet stringent fire and building codes–there is no substitute for stainless steel. No paints or electostatically-applied coatings, however exotic they may be, can match stainless steel's ability to withstand adverse operating conditions.

Specifications	Specification Value
Convenience and Safety Options	
Mechanical Access Platform: 10.2 *Add the following paragraph in the Access section:* There shall be a mechanical access platform at the mechanical access door allowing access to the mechanical system, drift eliminators, distribution system and fill. The platform shall be galvanized steel bar grating, supported by galvanized steel framework attached to the tower. The platform shall be surrounded by a guardrail, kneerail, and toeboard designed according to OSHA guidelines and shall be capable of withstanding a 200 lb concentrated live load in any direction. A ladder shall be permanently attached to the platform and to the casing of the tower, rising from the base of the tower to the top of the handrail.	■ Periodic inspection and maintenance of a cooling tower distribution system is fundamental to preserving maximum cooling system efficiency. All cooling towers—crossflow or counterflow—are subject to clogging to varying degrees by waterborne contaminants such as pipe scale and sediment. Therefore, safe and easy access to these components is of significant value to the operator. Access can be provided in a number of ways, including portable ladders or scaffolding, but for maximum safety and convenience, a field installed Marley access platform with guardrails is available to make this task as safe and user-friendly as possible. Further, its location on the side of the tower does not add to the height of the unit, preserving architectural integrity. It also saves the owner time and money, in that maintenance personnel may devote their time to inspection rather than searching for ladders or erection of portable scaffolding.
Ladder Extension: 10.2 *Add the following to the end of paragraph 10.2:* Provide a ladder extension for connection to the foot of the ladder. This extension shall be long enough to rise from the roof (grade) level to the base of the cooling tower. The installing contractor shall be responsible for cutting the ladder to length; attaching it to the foot of the cooling tower ladder; and anchoring it at its base.	■ Many cooling towers are installed such that the base of the unit is 2'-0" or more above the roof or grade level. This makes it difficult to get up to the foot of the attached ladder. The ladder extension alleviates this problem. Marley ladder extensions are available in standard 5'-0" and 11'-0" lengths.
Ladder Safety Cage: 10.2 *Add the following to the end of paragraph 10.2:* A welded aluminum safety cage shall surround the ladder, extending from a point approximately 7'-0" above the foot of the ladder to the top of the handrail. Maximum weight of welded subassemblies shall not exceed 20 lb for ease of installation.	
Ladder Safety Gate: 10.2 *Add the following to the end of paragraph 10.2:* A steel, self-closing gate shall be provided at the guardrail level of the ladder.	■ A galvanized steel self-closing gate located at the guardrail level of the fan deck, exterior motor access platform and access door platform. Stainless steel is available with the stainless guardrail option.

Specifications	Specification Value

Motor Davit:

10.4 *Add the following paragraph in the Access section:* A powder coated davit crane with hot dipped galvanized mounting base shall be field installed on the motor face of the cooling tower and shall have a maximum capacity of 500 lb.

- Simplify the removal of the fan motor when required. If you would prefer stainless steel construction change powder coated and hot dipped galvanized to stainless steel in the description. Available with this option is a zinc plated hand crank winch with 45'-0 of 3/16" diameter galvanized aircraft cable with swivel hook with swaged ball fitting.

Motor and Fan Davit:

10.4 *Add the following paragraph in the Access section:* A powder coated davit crane with hot dipped galvanized mounting base shall be field installed on the motor face of the cooling tower. The davit shall have maximum capacity of 500 lbs at a 5"-6 boom extension and 1000 lbs at a 3'-0 boom extension.

- Simplify the removal of the fan motor or fan assemble when required. If you would prefer stainless steel construction change powder coated and hot dipped galvanized to stainless steel in the description. Available with this option is a zinc plated hand crank winch with 60'-0 of 1/4" diameter galvanized aircraft cable with swivel hook and swaged ball fitting.

  Also available with this options is a 115V electric winch with a 6'-0 pendant control. Includes 60'-0 of 1/4" diameter galvanized aircraft cable with swivel hook with swaged ball fitting.

Control Options

Fan Motor Starter Control Panel:

6.4 *Add the following paragraph in the Mechanical Equipment section:* Each cell of the cooling tower shall be equipped with a UL / CUL 508 listed control panel in a NEMA 3R or 4X outdoor enclosure capable of controlling single-speed or two-speed motors as required, and designed specifically for cooling tower applications. The panel shall include a main circuit breaker or main fused disconnect with an external operating handle, lockable in the off position for safety. Full voltage non-reversing magnetic starter shall be controlled with a thermostatic or solid-state temperature controller. Door mounted selector switches shall be provided to enable automatic or manual control and wired for 120VAC control. Control circuit to be wired out to terminal blocks for field connection to a remote vibration switch, overload trip alarms and remote temperature control devices. The temperature controller shall be adjustable for the required cold-water temperature. If a thermostatic controller is used it shall be mounted on the side of the tower with the temperature sensing bulb installed in the cold water basin using a suspension mounting bracket. If a solid-state temperature controller is used the controller will be door mounted on the control panel. The solid-state temperature controller will

- If it is your opinion that the control system for the cooling tower be part of the cooling tower manufacturer's responsibility, we are in wholehearted agreement with you. Who better to determine the most efficient mode and manner of a cooling tower's operation—and to apply a system most compatible with it—than the designer and manufacturer of the cooling tower?

  Marley variable speed drives are also available for the ultimate in temperature control, energy management, and mechanical equipment longevity.

Specifications	Specification Value

display two temperatures, one for outgoing water and the other for set point. Water temperature input shall be obtained using a three-wire RTD with dry well in the outlet water piping and wired back to the solid-state temperature controller in the control panel.

Vibration Limit Switch:

6.5 *Add the following paragraph in the Mechanical Equipment section:* A vibration limit switch in a NEMA 4 housing shall be installed on the mechanical equipment support and wired to the shutdown circuit of the fan motor starter or VFD. The purpose of this switch will be to interrupt control power voltage to a safety circuit in the event of excessive vibration causing the starter or VFD equipment to de-energize the motor. It shall be adjustable for sensitivity, and include a means to reset the switch.

- Unless specified otherwise, a Marley M-5 vibration switch will be provided. The requirement for manual reset assures that the cooling tower will be visited to determine the cause of excessive vibration.

Basin Heater:

11.2 *Add the following paragraph in the Cold Water Basin section:* Provide a system of electric immersion heaters and controls for each cell of the tower to prevent freezing of water in the collection basin during periods of shutdown. The system shall consist of one or more stainless steel electric immersion heaters installed in threaded couplings provided in the side of the basin. A NEMA 4 enclosure shall house a magnetic contactor to energize heaters; a transformer to provide 24-volt control circuit power; and a solid-state circuit board for temperature and low water cut-off. A control probe shall be located in the basin to monitor water level and temperature. The system shall be capable of maintaining 40°F water temperature at an ambient air temperature of _____ °F.

- The Marley basin heater components described at left represent our recommendation for a reliable automatic system for the prevention of basin freezing. They are normally shipped separately for installation at the jobsite by the installing contractor. When purchased in conjunction with the enhanced Control System option, however, they are customarily factory-mounted and tested.

Submerged in basin water, in which zinc ions are present, copper immersion heaters must not be used. Insist upon stainless steel.

The ambient air temperature that you insert in the specifications should be the lowest 1% level of winter temperature prevalent at site.

Water Level Control System:

11.2 *Add the following paragraph to the Cold Water Basin section:* Provide a water level control system including a NEMA 4X control panel, water level probes and probe stilling chamber. The control system shall monitor the water level in the cold-water basin to determine level events used for cold-water make-up, high and low alarms or pump shut down. The

- Solid-state liquid level controls provide you with state of the art systems to control and monitor the water level in your cooling tower collection basin. Relays operating in conjunction with suspended stainless steel electrode probes monitor basin water levels, providing simple solenoid-valve water makeup or discrete on/off signals to more sophisticated automation controls. Optional configurations might include makeup along with high and low water level alarm and cutoff, or pump cutoff. Packaged systems including any of these variations are available. Consult you Marley sales representative or download a copy of ACC-NC-9D from spxcooling.com for additional information.

Specifications | **Specification Value**

control panel shall use electromechanical relays providing power for the make-up solenoid and electrical contacts for alarm and pump shutdown control circuits. Probes shall be contained in a vertical stilling chamber to stabilize the water in the cold-water basin. Probes shall have replaceable stainless steel tips and level height shall be field adjustable.

Fan Motor Variable Speed Drive:

Marley All Weather ACH550 System

6.4 *Add the following paragraph in the Mechanical Equipment section when VFD is used with customers Building Management System:* A complete UL listed Variable Speed Drive system in a NEMA 1 indoor, NEMA 12 indoor or NEMA 3R outdoor enclosure shall be provided. The VFD shall use PWM technology with IGBT switching and integrated bypass design. The VFD shall catch a fan spinning in the reverse direction without tripping. The panel shall include a main disconnect with short circuit protection and external operating handle, lockable in the off position for safety. The VFD system shall receive a speed reference signal from the Building Management System monitoring the tower cold-water temperature. As an option to receiving the speed reference signal from a building management system, the drive must have the capability to receive a 4-20 ma temperature signal from an RTD transmitter. The VFD shall have an internal PI regulator to modulate fan speed maintaining set point temperature. The drive's panel display shall be able to display the set-point temperature and cold-water temperature on two separate lines. The bypass shall include a complete magnetic bypass circuit and with capability to isolate the VFD when in the bypass mode. Transfer to the bypass mode shall be manual in the event of VFD failure. Once the motor is transferred to the by-pass circuit the fan motor will run at constant full speed. The bypass circuit will not modulate ON and OFF based on cold-water temperature. The application must be able to handle very cold water while VFD is in a by-pass mode. Operator controls shall be mounted on the front of

- Marley VFD drive systems are designed to combine absolute temperature control with ideal energy management. The cooling tower user selects a cold water temperature and the drive system will vary the fan speed to maintain that temperature. Precise temperature control is accomplished with far less stress to the mechanical equipment components. The improved energy management provides fast payback.

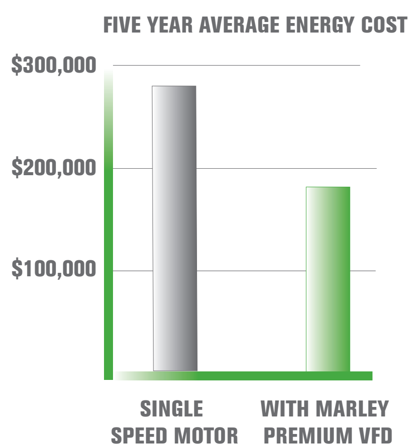
  Motors operated on a VFD shall carry a service factor of 1.0. When operating on a VFD, the drive parameters should be programmed to limit the current to motor nameplate hp. Adjust the Motor specification accordingly.

Specifications	Specification Value

the enclosure and shall consist of start and stop control, bypass/VFD selection, Auto/Manual selections, manual speed control. To prevent heating problems in the cooling tower fan motor, the VFD system shall de energize the motor once 25% motor speed is reached and cooling is no longer required. The cooling tower manufacturer shall supply VFD start-up assistance. Tower vibration testing throughout the speed range is required to identify and lockout any natural frequency vibration levels which may exceed CTI guidelines.

Marley Premium VFD System:

6.4 *Add the following paragraph in the Mechanical Equipment section when VFD is used as a stand alone system:* A complete UL listed Variable Speed Drive system in a NEMA 12 indoor or NEMA 3R outdoor enclosure shall be provided. The VFD shall use PWM technology with IGBT switching and integrated bypass design. The VFD shall catch a fan spinning in the reverse direction without tripping. The panel shall include a main disconnect with short circuit protection and external operating handle, lockable in the off position for safety. The system shall include a solid state, PI temperature controller to adjust frequency output of the drive in response to the tower cold-water temperature. The temperature of the cold water and set point shall be displayed on the door of the control panel. The bypass shall include a complete magnetic bypass circuit with capability to isolate the VFD when in the bypass mode. Transfer to the bypass mode shall be automatic in the event of VFD failure or for specific trip conditions allowing safe transfer of utility voltage to the motor. Automatic bypass with an earth ground condition is not allowed. The bypass contactor shall be cycled on and off while operating in bypass, to maintain the set-point temperature of the cold water. The drive design shall be operated as a stand- alone system without the need for a BMS system. Operator controls shall be mounted on the front of the enclosure and shall consist of start and stop control, bypass/VFD selector switch, Auto/Manual selector switch, manual speed control, and solid-state temperature controller. An emer-



20% reduction in fan speed will typically save 50% of electrical energy

Specifications	Specification Value

gency bypass selector switch internal to the panel allowing the cooling tower fan motor to be run at full speed shall be furnished. To prevent heating problems in the cooling tower fan motor, the VFD system shall de energize the motor once 25% motor speed is reached and cooling is no longer required. The VFD shall include de-icing logic with auto canceling and adjustable time. Speed in De-Ice mode shall not exceed 50 % motor speed. The cooling tower manufacturer shall supply VFD start-up assistance. Tower vibration testing throughout the speed range is required to identify and lockout any natural frequency vibration levels which may exceed CTI guidelines.

Miscellaneous Options

Equalizer Flume Weir Gates:

11.2 *Add the following paragraph under Cold Water Collection Basin:* The interconnecting flume between cells shall be equipped with a removable cover plate to permit the shutdown of one cell for maintenance purposes, or to permit independent cell operation.

- Where it is your intention to be able to operate both cells of the tower while the flume cover plate is installed, separate outlet connections, float valves and overflows must be provided for each cell. Likewise, this would require separate sensors and controls for basin heater systems, if installed.

Fan Cylinder Extensions:

9.1 *Insert the following before the last sentence:* Fan cylinder extensions shall be provided to elevate the fan discharge to a height of ___ ft above the fan deck level.

- Extensions are available in nominal 1'-0" increments to a maximum height that varies by model. Such extensions may be considered necessary in order to elevate the discharge beyond the bounds of an enclosure. Discuss applicability with your local Marley sales representative.

Basin Sweeper Piping:

11.2 *Add the following paragraph to the Cold Water Collection Basin section:* The cold water basin shall be equipped with factory installed corrosion resistant PVC sweeper piping with plastic nozzles. The sweeper piping system shall be designed to force dirt and debris towards a dedicated drain in the depressed section of the collection basin.

Specifications	Specification Value

Sound Control:

1.2 *Add the following paragraph to the Base section:* The cooling tower shall be designed for quiet operation, and shall produce an overall level of sound not higher than _______ dB(A) measured at _______ ft from the locations in the following table. Sound levels shall be measured with a Type 1 (precision) system and in full conformance with ATC-128 test code published by the Cooling Technology Institute (CTI). The measurement system shall have a real-time frequency analyzer and separate microphones with an overall tolerance +/- 3 dB. All low sound options shall be CTI Certified for thermal performance.

Location	63	125	250	500	1000
Air Inlet Side SPL					
Air Inlet End SPL					
Fan Discharge SPL					

Location	2000	4000	8000	Overall dB(A)
Air Inlet Side SPL				
Air Inlet End SPL				
Fan Discharge SPL				

■ Sound produced by a standard MD tower operating in an unobstructed environment will meet all but the most restrictive noise limitations–and will react favorably to natural attenuation. Where the tower has been sized to operate within an enclosure, the enclosure itself will have a damping effect on sound. Sound also declines with distance–by about 5 or 6 dB(A) each time the distance doubles. Where noise at a critical point is likely to exceed an acceptable limit, you have several options–listed below in ascending order of cost impact:

- In many cases, noise concerns are limited to night time, when ambient noise levels are lower and neighbors are trying to sleep. You can usually resolve these situations by using variable speed drives, and operating the fans at reduced speed "after hours". The natural night time reduction in wet-bulb temperature makes this a very feasible solution in most areas of the world. Variable speed drives automatically minimize the tower's noise level during periods of reduced load and/or reduced ambient without sacrificing the system's ability to maintain a constant cold water temperature. This is a relatively inexpensive solution, and can pay for itself quickly in reduced energy costs.
- In counterflow towers, the water falling from the fill media into the collection basin creates high-frequency splash noise at the air inlets that may be objectionable. Splash attenuation media installed in the collection basin may be the most economical way to significantly reduce sound levels at this critical location.
- Where noise is a concern at all times (for example, near a hospital), one possible solution is to oversize the tower so it can operate continuously at reduced (⅔ or ½) motor speed even at the highest design wet-bulb temperature. Typical sound reductions are 7 dB(A) at ⅔ fan speed or 10 dB(A) at ½ fan speed, but larger reductions are often possible.
- The most extreme cases may require discharge sound attenuator sections–however, the static pressure loss imposed by discharge attenuators may necessitate an increase in tower size. Your Marley sales representative will be able to help you meet your sound requirements.

Splash Attenuation:

1.3 *Insert the following paragraph in the Base section:* The cooling tower shall be equipped with polypropylene splash attenuation media factory installed in the collection basin to reduce falling water noise.

Outlet Sound Attenuation:

1.3 *Add the following paragraph to the Base section:* The cooling tower shall be equipped with outlet sound attenuation baffles positioned and spaced horizontally across the entire fan opening. The baffles shall be constructed of perforated sheet metal filled with sound absorbing material, and contained within a steel box that is self-supporting.

Specifications	Specification Value

Ultra Quiet Fan:

6.1 *Replace paragraph 6.1 with the following:* Fan(s) shall be propeller-type, incorporating wide-chord acoustic geometry, corrosion and fire resistant marine grade aluminum blades and aluminum hubs. Blades shall be resiliently mounted to fan hub and individually adjustable. Maximum fan tip speed shall be 10,000 ft/min. Fan(s) shall be driven through a one-piece multi-groove, solid back V-type belt, sheaves (pulleys), and tapered roller bearings. Bearings shall be rated at an L_{10} life of 100,000 hours, or greater. Both motor and fan sheaves (pulleys) shall be all cast aluminum to prevent premature corrosion.

6.1 (alternate)* *Replace paragraph 6.1 with the following:* Fan(s) shall be propeller-type, incorporating wide-chord acoustic geometry, corrosion and fire resistant marine grade aluminum blades and aluminum hubs. Blades shall be resiliently mounted to fan hub and individually adjustable. Maximum fan tip speed shall be 10,000 ft/min. Fan(s) shall be driven through a right angle, industrial duty, oil lubricated, geared speed reducer that requires no oil changes for the first five (5) years of operation. The gearbox bearings shall be rated at an L_{10A} service life of 100,000 hours or greater. The gear sets to have AGMA Quality Class of 9 or greater.

**Currently available on MD5016 and MD5018 models only.*

- For more severe cases requiring the lowest possible fan sound levels the Marley "Ultra Quiet" fan option is now available on all MD models. Tower height may increase slightly—obtain current sales drawings from your Marley sales representative for accurate dimensions. If your requirement calls for outlet attenuation, you might consider the Ultra Quiet fan in lieu of attenuation. Outlet attenuators are not available with the Ultra Quiet Fan option.

Marley "Ultra Quiet" fan

PROJECT OXFORD COOLING TOWER PARTICULATE MATTER AND TOXIC AIR POLLUTANT EMISSIONS
COMBINED 32 CTs AT COMBINED PHASES 1+2
Feedwater = Treated Recycled Wastewater

No of Towers	32	towers		
Recirc Water TDS	69,000	mg/L		
Feedwater TDS	1,500	mg/L		
Cycles of Concentration (Well Water)	46.0	cycles		
Recirc Water Flow Each Tower	950	gpm		
Drift Rate	0.0005	percent of recirc flow		
Liquid Drift Droplet Emissions	76	lbs/hour	2.38	lbs/hr/tower
Evaporated Solid TSP Emissions	5.25	lbs/hour	0.164	lbs/hr/tower
Combined Make Up Water for 32 towers	300	gallons/minute		
Basis for droplet size distribution	SPX/Marley, based on 0.0005% drift rate			

Non-Volatile Particulate Matter and TAPs Emitted As Evaporated Solid Drift Droplets

Toxic Air Pollutant in Industrial Wastewater	Conc. In CT Feedwater, mg/L	Hourly Emission (lbs/hr)	Daily Emission (lbs/day)	Annual Emission (lbs/yr)	Small Quantity Emission Rate	
Fluoride	0.31	0.0011	0.0260	9.50	1.71	lbs/day
Manganese	0.03	0.0001	0.0025	0.92	0.0053	lbs/day
Copper	0.01	0.0000350	0.000840	0.31	0.219	lbs/1-hour
Total Suspended Particulate	1,500	5.25	126.0	45,974	TSP Fraction =	100%
PM10 Based on Droplet Size Distribution	1,500	2.92	70.03	25,562	PM10 Fraction =	56%
PM2.5 Based on Droplet Size Distribution	1,500	0.682	16.374	5,977	PM2.5 Fraction =	13%

Volatile Chlorine Disinfection TAPs (Assume 100% of VOC content of makeup water stream is evaporated)

Toxic Air Pollutant	Conc. In CT Makeup Water, mg/L	Annual Emission (lbs/yr)	Small Quantity Emission Rate	
Chloroform	0.0004	0.526	8.35	lbs/yr
Bromo Dichloromethane	0.0004	0.526	5.18	lbs/yr
Bromoform	0.0105	13.8	174	lbs/yr

Table E3: IWTP Effluent Analysis. One twenty-four hour composite sample was taken each day on seven separate days.

Parameter	1/23/2008	1/24/2008	1/25/2008	1/28/2008	1/29/2008	1/30/2008	1/31/2008	Average	Units	PQL	Method
Alkalinity	571	569	568	570	571	569	567	**569.29**	mg/L	10	SM2320B
Aluminum	0.0138	0.0148	0.0149	0.0201	0.0166	0.0135	0.0134	**0.02**	mg/L	0.01	EPA 200.8
NH3-N	0.401	0.577	0.397	0.467	0.433	0.442	0.572	**0.47**	mg/L	0.05	SM4500NH3G
Fecal Coliform	13	1600	220	220	140	500	500	**456.14**	MPN/100mL	2	SM9221E
Total Coliform	80	1600	300	500	500	500	500	**568.57**	MPN/100mL	2	SM9221B
Barium	0.0199	0.0226	0.0213	0.0238	0.0249	0.0245	0.0248	**0.02**	mg/L	0.001	EPA 200.8
Bicarbonate	571	569	568	570	571	569	567	**569.29**	mg/L	10	SM2320B
BOD	5.1	5.45	5.09	4.02	4.22	4.57	3.9	**4.62**	mg/L	2	SM5210B
Boron	0.0295	0.0331	0.034	0.0356	0.0448	0.0462	0.0451	**0.04**	mg/L	0.01	EPA 200.8
Bromide	ND	ND	ND	ND	ND	ND	ND		mg/L	0.1	EPA 300.0
Cadmium	ND	ND	ND	ND	ND	ND	ND		mg/L	0.001	EPA 200.8
Calcium	43.3	47.3	42.6	43.4	46	46.1	44.5	**44.74**	mg/L	0.01	EPA 200.8
Carbonate	ND	ND	ND	ND	ND	ND	ND		mg/L	10	SM2320B
Chloride	286	296	273	274	291	289	261	**281.43**	mg/L	2	EPA 300.0
Chromium	ND	ND	ND	ND	ND	ND	ND		mg/L	0.001	EPA 200.8
COD	38.1	12.1	32	39.3	29	39.4	34	**31.99**	mg/L	5	EPA 410.4
Conductivity	2080	2160	2130	2160	2173	2153	2194	**2,150.00**	µmhos/cm	10	SM2510B
Copper	0.00256	0.00313	0.00276	0.00288	0.00926	0.00715	0.012	**0.01**	mg/L	0.001	EPA 200.8
Fluoride	0.371	0.34	0.352	0.221	0.319	0.22	0.323	**0.31**	mg/L	0.1	EPA 300.0
Hardness	209	227	206	213	218	223	215	**215.86**	mg/L	1	EPA 200.8
Magnesium	24.4	26.3	24.1	25.4	25.1	26.1	25.1	**25.21**	mg/L	0.1	EPA 200.8
Iron	0.0479	0.0606	0.0594	0.061	0.0704	0.0591	0.0453	**0.06**	mg/L	0.01	EPA 200.8
Lead	ND	ND	ND	ND	ND	ND	ND		mg/L	0.001	EPA 200.8
Lithium	ND	ND	ND	ND	ND	ND	ND		mg/L	0.001	EPA 200.8
Manganese	0.0142	0.0257	0.0254	0.0296	0.0421	0.0378	0.0369	**0.03**	mg/L	0.001	EPA 200.8
Molybdenum	0.00128	0.00116	0.0011	0.00109	ND	ND	ND		mg/L	0.001	EPA 200.8
Nickel	ND	ND	ND	ND	ND	ND	ND		mg/L	0.001	EPA 200.8
NO3/N	4.67	1.65	0.975	0.95	0.305	0.206	0.482	**1.32**	mg/L	0.1	EPA 300.0
NO2/N	ND	ND	ND	ND	ND	ND	ND		mg/L	0.1	EPA 300.0
pH	7.91	7.86	7.87	7.98	7.76	7.95	7.94	**7.90**	ph Units		EPA 150.1
PO4/P	4.95	1.89	5.2	1.11	1.85	2.79	1.22	**2.72**	mg/L	0.05	EPA 300.0
Potassium	249	279	246	274	315	362	353	**296.86**	mg/L	0.01	EPA 200.8
Silica (as SiO2)	25.8	27.2	24.8	25.9	25.7	25.9	25	**25.76**	mg/L	1	EPA 200.8
Silica (Molybdate)*	38.5	42.1	31.7	39	43.2	57.6	57.1	**44.17**	mg/L	10	SM 4500 SIO2C
Sodium	247	250	221	228	216	249	234	**235.00**	mg/L	0.1	EPA 200.8
TDS (measured)	1353	1370	1328	1253	1392	1325	1343	**1,337.71**	mg/L	10	EPA 160.1
TSS	5	228	0	6	6	7	7	**37.00**	mg/L	5	EPA 160.2
TVS	277	276	249	989	741	640	380	**507.43**	mg/L	5	SM2540E
Strontium	0.221	0.223	0.213	0.227	0.204	0.211	0.208	**0.22**	mg/L	0.01	EPA 200.8
Sulfate	80.4	83.1	82.6	83.1	82.1	85.5	83.5	**82.90**	mg/L	2	EPA 300.0
Sulfide	0.0826	0.0885	0.0671	0.0667	0.0831	0.0819	0.0814	**0.08**	mg/L	0.05	SM4500S2F
Sulfite	ND	ND	ND	ND	ND	ND	ND		mg/L	0.5	SM 4500 SO3B
TKN	2.48	2.49	2.61	2.39	1.66	1.05	1.15	**1.98**	mg/L	0.1	SM4500NORGC
TOC	9.07	9.52	8.7	8.64	9.07	8.73	8.54	**8.90**	mg/L	1	SM5310C
Total P	5.08	3.82	5.63	3.55	2.09	3.08	1.45	**3.53**	mg/L	0.01	SM4500PF
Total Residual Chlorine	0.28	0.07	0.07	0.1	0.08	0.14	0.08	**0.12**	mg/L	0.01	SM 4500CL-G
Vanadium	0.0273	0.0251	0.0238	0.025	0.0158	0.0162	0.0201	**0.02**	mg/L	0.001	EPA 200.8
Zinc	0.0159	0.0181	0.0178	0.0238	0.0235	0.0229	0.0222	**0.02**	mg/L	0.001	EPA 200.8

Equivalence values		
Monovalent cations:	17.84	meq
Divalent cations:	4.31	meq
M:R ratio;	4.14	

Charge balance verification		
Cations:	22.1	meq
Anions:	19.1	meq
Variance from average:	7.5%	
City water comparison		
Cations:	6.1	meq
Anions:	5.3	meq
Variance from average:	7.0%	

Total Anions	**938.26**	Major: bicarbonate, chloride, sulfate
Total Cations	**602.01**	Major: Ca, Mg, Na, K
TDS - summed	**1,540.27**	

Per Higgins and Novak, 1997a and b, typical M:D of <2:1 is indicative of good settling sludge.

WATER MANAGEMENT LABORATORIES INC.
1515 80th St. E.
Tacoma, WA 98404
(253) 531-3121

DRINKING WATER VOLATILE ORGANIC CHEMICALS (VOC's) ANALYSIS REPORT
EPA TEST METHOD - EPA 524.2/TTHM's
WA DOH TEST PANEL: TTHM

System ID No.: 704501		DOH Source No*: S92	Lab Sample No: SEE BELOW
System Name: City of Quincy			Group: A
Multiple Source Nos.: N/A		Date Collected: 09/12/11	Date Received: 09/14/11
Sample Type: A	Purpose: C	Date Analyzed: 09/16/11	Analyst: LHL
County: Grant		Date Reported: 09/18/11	Supervisor: [signature]
Specific Sample Location: SEE BELOW			
Send To: Cascade Analytical Inc. 3019 G.S. Center Road Wenatchee, WA 98801			Comments: **11C-18577 thru 18581** **PO# 158150091311**

* Generally S92 for Distribution Sample

DOH #	27	28	29	30	31
SRL	0.25 µg/L	0.5 µg/L	0.5 µg/L	0.5 µg/L	0.5 µg/L
MCL	-	-	-	-	80 µg/L

All results are in micrograms per Liter (ppB)

Lab Sample No:	Collect Date	Analysis Date	Site / Location	0.40 ug/L Chloroform	0.40 ug/L Bromo dichloro methane	Chloro dibromo methane	10.5 ug/L Bromoform	Total Trihalo-methanes
08970948	09/12/11	09/16/11	1010 Yahoo Way	0.7	0.9	4.5	14.8	20.9
08970949	09/12/11	09/16/11	1400 13th Ave. SW (Monument & Elem)	0.9	ND	2.2	11.2	14.3
08970950	09/12/11	09/16/11	1801 F Street SW (Double Diamond) - TP1	ND	0.6	3.4	8.7	12.7
08970951	09/12/11	09/16/11	Rd "Q" NW & Martin Road - TP5	ND	ND	2.4	11.0	13.4
08970952	09/12/11	09/16/11	1720 Central Ave. S. (QCBid) - TP3	ND	ND	2.5	7.1	9.6
			SQER	8.35#/yr	5.18 #/yr	—	174 #/yr	
			De-min	0.417#/yr	0.259#/yr	—	8.72#/yr	

NOTES:

SRL (State Reporting Level): Indicates the minimum reporting level required by the Washington Department of Health (DOH).

MCL (Maximum Contaminant Level): If the contaminant amount exceeds the MCL, immediately contact your regional DOH office.

NA (Not Analyzed): In the RESULTS column indicates this compound was not included in the current analysis.

ND (Not Detected): In the RESULTS column indicates this compound was analyzed and not detected at a level greater than or equal to the SRL.

< : Indicates less than.

Comments: A maximum contaminant level of 80ug/L Total Trihalomethanes (Compounds 27-30) is allowed

TECHNICAL MEMORANDUM

TO: File 1409 001.010
Project Oxford Data Center Notice of Construction Permit

FROM: Jim Wilder, P.E.

DATE: January 15, 2014

RE: DRIFT PARTICULATE SIZE DISTRIBUTIONS FOR MECHANICAL DRAFT COOLING TOWERS WITH HIGH CONCENTRATIONS OF TOTAL DISSOLVED SOLIDS WATER CONSERVATION TECHNOLOGIES, INC WATER TREATMENT SYSTEM PROJECT OXFORD DATA CENTER QUINCY, WASHINGTON

INTRODUCTION

This technical memorandum presents the calculations for the emission rates of cooling tower drift particles at the Project Oxford Data Center in Quincy, Washington, focusing on determining the fraction of emitted solid drift particulate matter with an aerodynamic diameter less than or equal to 2.5 microns ($PM_{2.5}$) and less than or equal to 10 microns (PM_{10}). This issue is important for the Project Oxford Data Center because Microsoft will be using the Water Conservation Technologies, Inc. cooling tower water pretreatment system to increase the total dissolved solids (TDS) concentration in the recirculation stream to an unusually high value of 69,000 milligrams per liter (mg/L). Therefore, it is important to provide a realistic estimate of PM_{10} and $PM_{2.5}$ emission rates for the purpose of modeling the ambient air quality impacts downwind of the cooling towers.

KEY FINDINGS

The key result of these calculations are as follows:

- For a high-performance drift eliminator with a 0.0005 percent performance and a recirculation water TDS concentration of 69,000 mg/L, the calculated $PM_{2.5}$ fraction for the evaporated solid drift particles is only 13 percent.
- The $PM_{2.5}$ fraction decreases to only 6 percent for conventional drift eliminators (0.005 percent performance).

CALCULATION PROCEDURE

The Project Oxford Data Center will use mechanical-draft cooling towers with high-TDS recirculation water (TDS concentrations of up to 69,000 mg/L). The cooling towers will be configured with a drift efficiency of between 0.005 percent and 0.0005 percent of the recirculation water flowrate. The key issue is to determine the fraction of the emitted solid particles that will be smaller than 2.5 microns ($PM_{2.5}$). We used the calculation procedures developed by Joel Reisman and Gordon Frisbie of

Graystone Environmental Industries (see Attachment 1) to calculate the particle size distribution for the evaporated solid particles.

There is already a regulatory precedent for conducting realistic estimates of the particle sizes for cooling tower drift emissions. As shown by the regulatory citations in Attachment 2, this cooling tower drift calculation methodology has been accepted by at least two air quality agencies (Texas Commission for Environmental Quality, and the State of Mississippi) for the purpose of allowing applicants to forecast the $PM_{2.5}$ and PM_{10} fractions of drift emissions for air quality permit applications.

For any given diameter of a liquid drift droplet emitted from a cooling tower, the diameter of the evaporated solid particle is forecast using the following equation:

$$D_p = D_d [(TDS)(d_w/d_p)]^{1/3}$$, where

D_p is the diameter of the evaporated solid particle (microns)

D_d is the diameter of the liquid droplet

TDS is the TDS concentration within the cooling tower recirculation stream (weight fraction)

d_w is the specific gravity of water (1.0)

d_p is the specific gravity of the evaporated salt particle (2.2 for sodium chloride particles).

This calculation is performed for liquid droplets in each size category of the known droplet size distribution. The resulting size distribution for the evaporated solid particles is then inspected to determine the cumulative fractions of particles smaller than 10 microns and 2.5 microns.

DRIFT DROPLET SIZE DISTRIBUTIONS FOR VARIOUS DRIFT ELIMINATOR CONFIGURATIONS

One of the cooling tower manufacturers that is bidding to provide the cooling towers at the Project Oxford Data Center (SPX/Marley) has published droplet size distributions for various configurations. Droplet size distributions for two tower configurations are shown in Attachment 3:

- Conventional drift rate of 0.005 percent, which exhibits a large droplet size distribution (mass median diameter of approximately 50 microns)
- High-efficiency drift rate of 0.0005 percent, which exhibits a smaller droplet size distribution (mass median diameter of approximately 30 microns).

CALCULATED $PM_{2.5}$ FRACTION AND $PM_{2.5}$ EMISSION RATES

The solid particle fractions for total suspended particulates, PM_{10}, and $PM_{2.5}$ emitted from the Project Oxford mechanical draft cooling towers were estimated from the droplet size distributions shown in Attachment 3 using the Reisman and Frisbie method (Attachment 1). In all cases, the cooling tower feedwater was assumed to be chlorinated, pre-treated industrial re-use wastewater received from the City of Quincy system. The assumptions were as follows:

- TDS in recirculation water = 69,000 mg/L
- SPX/Marley drift droplet size distributions for drift performance of 0.005 percent and 0.0005 percent.

Calculation spreadsheets displaying the calculated evaporated particle size distributions for total suspended particulates, PM_{10}, and $PM_{2.5}$ are presented in Attachment 4. The calculated particle size fractions are summarized in Table 1 below.

TABLE 1
CALCULATED SIZE DISTRIBUTION FOR EVAPORATED SOLID DRIFT PARTICLES
PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

	Fraction of Evaporated Solid Particle Emissions Smaller Than Stated Size	
Drift Performance	**PM_{10}**	**$PM_{2.5}$**
High Efficiency, 0.0005%	56%	13%
Standard Efficiency, 0.005%	32%	6%

ATTACHMENTS

Attachment 1: Reisman and Frisbie Article on Cooling Tower Droplet Size Distributions
Attachment 2: Regulatory Agency Examples for Consideration of Droplet Size Distribution for Calculation of PM_{10} and $PM_{2.5}$ Emissions from Cooling Towers
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ATTACHMENT 1

Reisman and Frisbie Article on Cooling Tower Droplet Size Distributions

Calculating Realistic PM_{10} Emissions from Cooling Towers

Abstract No. 216 Session No. AM-1b

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ABSTRACT

Particulate matter less than 10 micrometers in diameter (PM_{10}) emissions from wet cooling towers may be calculated using the methodology presented in EPA's AP-42[1] , which assumes that all total dissolved solids (TDS) emitted in "drift" particles (liquid water entrained in the air stream and carried out of the tower through the induced draft fan stack.) are PM_{10}. However, for wet cooling towers with medium to high TDS levels, this method is overly conservative, and predicts significantly higher PM_{10} emissions than would actually occur, even for towers equipped with very high efficiency drift eliminators (e.g., 0.0006% drift rate). Such over-prediction may result in unrealistically high PM_{10} modeled concentrations and/or the need to purchase expensive Emission Reduction Credits (ERCs) in PM_{10} non-attainment areas. Since these towers have fairly low emission points (10 to 15 m above ground), over-predicting PM_{10} emission rates can easily result in exceeding federal Prevention of Significant Deterioration (PSD) significance levels at a project's fenceline. This paper presents a method for computing realistic PM_{10} emissions from cooling towers with medium to high TDS levels.

INTRODUCTION

Cooling towers are heat exchangers that are used to dissipate large heat loads to the atmosphere. Wet, or evaporative, cooling towers rely on the latent heat of water evaporation to exchange heat between the process and the air passing through the cooling tower. The cooling water may be an integral part of the process or may provide cooling via heat exchangers, for example, steam condensers. Wet cooling towers provide direct contact between the cooling water and air passing through the tower, and as part of normal operation, a very small amount of the circulating water may be entrained in the air stream and be carried out of the tower as "drift" droplets. Because the drift droplets contain the same chemical impurities as the water circulating through the tower, the particulate matter constituent of the drift droplets may be classified as an emission. The magnitude of the drift loss is influenced by the number and size of droplets produced within the tower, which are determined by the tower fill design, tower design, the air and water patterns, and design of the drift eliminators.

AP-42 METHOD OF CALCULATING DRIFT PARTICULATE

EPA's AP-42[1] provides available particulate emission factors for wet cooling towers, however, these values only have an emission factor rating of "E" (the lowest level of confidence acceptable). They are also rather high, compared to typical present-day manufacturers' guaranteed drift rates, which are on the order of 0.0006%. (Drift emissions are typically expressed as a percentage of the cooling tower water circulation rate). AP-42 states that "a *conservatively high* PM_{10} emission factor can be obtained by (a) multiplying the total liquid drift factor by the TDS fraction in the circulating water, and (b) assuming that once the water evaporates, all remaining solid particles are within the PM_{10} range." (Italics per EPA).

If TDS data for the cooling tower are not available, a source-specific TDS content can be estimated by obtaining the TDS for the make-up water and multiplying it by the cooling tower cycles of concentration. [The cycles of concentration is the ratio of a measured parameter for the cooling tower water (such as conductivity, calcium, chlorides, or phosphate) to that parameter for the make-up water.]

Using AP-42 guidance, the total particulate emissions (PM) (after the pure water has evaporated) can be expressed as:

PM = Water Circulation Rate x Drift Rate x TDS [1]

For example, for a typical power plant wet cooling tower with a water circulation rate of 146.000 gallons per minute (gpm), drift rate of 0.0006%, and TDS of 7,700 parts per million by weight (ppmw):

PM = 146,000 gpm x 8.34 lb water/gal x 0.0006/100 x 7,700 lb solids/10^6 lb water x 60 min/hr = <u>3.38 lb/hr</u>

On an annual basis, this is equivalent to almost 15 tons per year (tpy). Even for a state-of-the-art drift eliminator system, this is not a small number, especially if assumed to all be equal to PM_{10}, a regulated criteria pollutant. However, as the following analysis demonstrates, only a very small fraction is actually PM_{10}.

COMPUTING THE PM_{10} FRACTION

Based on a representative drift droplet size distribution and TDS in the water, the amount of solid mass in each drop size can be calculated. That is, for a given initial droplet size, assuming that the mass of dissolved solids condenses to a spherical particle after all the water evaporates, and assuming the density of the TDS is equivalent to a representative salt (e.g., sodium chloride), the diameter of the final solid particle can be calculated. Thus, using the drift droplet size distribution, the percentage of drift mass containing particles small enough to produce PM_{10} can be calculated. This method is conservative as the final particle is assumed to be perfectly spherical; hence as small a particle as can exist.

The droplet size distribution of the drift emitted from the tower is critical to performing the analysis. Brentwood Industries, a drift eliminator manufacturer, was contacted and agreed to provide drift eliminator test data from a test conducted by Environmental Systems Corporation (ESC) at the Electric Power Research Institute (EPRI) test facility in Houston, Texas in 1988 (Aull[2], 1999). The data consist of water droplet size distributions for a drift eliminator that achieved a tested drift rate of 0.0003 percent. As we are using a 0.0006 percent drift rate, it is reasonable to expect that the 0.0003 percent drift rate would produce smaller droplets, therefore, this size distribution data can be assumed to be conservative for predicting the fraction of PM_{10} in the total cooling tower PM emissions.

In calculating PM_{10} emissions the following assumptions were made:

- Each water droplet was assumed to evaporate shortly after being emitted into ambient air, into a single, solid, spherical particle.
- Drift water droplets have a density (ρ_w) of water; 1.0 g/cm^3 or $1.0*10^{-6}\ \mu g/\mu m^3$.
- The solid particles were assumed to have the same density (ρ_{TDS}) as sodium chloride, (i.e., 2.2 g/cm^3).

Using the formula for the volume of a sphere, $V = 4\pi r^3/3$, and the density of pure water, $\rho_w = 1.0\ g/cm^3$, the following equations can be used to derive the solid particulate diameter, D_p, as a function of the TDS, the density of the solids, and the initial drift droplet diameter, D_d :

$$\text{Volume of drift droplet} = (4/3)\pi(D_d/2)^3 \qquad [2]$$

$$\text{Mass of solids in drift droplet} = (TDS)(\rho_w)(\text{Volume of drift droplet}) \qquad [3]$$

substituting,

$$\text{Mass of solids in drift} = (TDS)(\rho_w)(4/3)\pi(D_d/2)^3 \qquad [4]$$

Assuming the solids remain and coalesce after the water evaporates, the mass of solids can also be expressed as:

$$\text{Mass of solids} = (\rho_{TDS})\ (\text{solid particle volume}) = (\rho_{TDS})(4/3)\pi(D_p/2)^3 \qquad [5]$$

Equations [4] and [5] are equivalent:

$$(\rho_{TDS})(4/3)\pi(D_p/2)^3 = (TDS)(\rho_w)(4/3)\pi(D_d/2)^3 \qquad [6]$$

Solving for D_p:

$$D_p = D_d\ [(TDS)(\rho_w/\rho_{TDS})]^{1/3} \qquad [7]$$

Where,

TDS is in units of ppmw
D_p = diameter of solid particle, micrometers (μm)
D_d = diameter of drift droplet, μm

Using formulas [2] – [7] and the particle size distribution test data, Table 1 can be constructed for drift from a wet cooling tower having the same characteristics as our example; 7,700 ppmw TDS and a 0.0006% drift rate. The first and last columns of this table are the particle size distribution derived from test results provided by Brentwood Industries. Using straight-line interpolation for a solid particle size 10 μm in diameter, we conclude that approximately 14.9 percent of the mass emissions are equal to or smaller than PM_{10}. The balance of the solid particulate are particulate greater than 10 μm. Hence, PM_{10} emissions from this tower would be equal to PM emissions x 0.149, or 3.38 lb/hr x 0.149 = 0.50 lb/hr. The process is repeated in Table 2, with all parameters equal except that the TDS is 11,000 ppmw. The result is that approximately 5.11 percent are smaller at 11,000 ppm. Thus, while total PM emissions are larger by virtue of a higher TDS, overall PM_{10} emissions are actually lower, because more of the solid particles are larger than 10 μm.

Table 1. Resultant Solid Particulate Size Distribution (TDS = 7700 ppmw)

EPRI Droplet Diameter (μm)	Droplet Volume (μm³) [2][1]	Droplet Mass (μg) [3]	Particle Mass (Solids) (μg) [4]	Solid Particle Volume (μm³)	Solid Particle Diameter (μm) [7]	EPRI % Mass Smaller
10	524	5.24E-04	4.03E-06	1.83	1.518	0.000
20	4189	4.19E-03	3.23E-05	14.66	3.037	0.196
30	14137	1.41E-02	1.09E-04	49.48	4.555	0.226
40	33510	3.35E-02	2.58E-04	117.29	6.073	0.514
50	65450	6.54E-02	5.04E-04	229.07	7.591	1.816
60	113097	1.13E-01	8.71E-04	395.84	9.110	5.702
70	179594	1.80E-01	1.38E-03	628.58	10.628	21.348
90	381704	3.82E-01	2.94E-03	1335.96	13.665	49.812
110	696910	6.97E-01	5.37E-03	2439.18	16.701	70.509
130	1150347	1.15E+00	8.86E-03	4026.21	19.738	82.023
150	1767146	1.77E+00	1.36E-02	6185.01	22.774	88.012
180	3053628	3.05E+00	2.35E-02	10687.70	27.329	91.032
210	4849048	4.85E+00	3.73E-02	16971.67	31.884	92.468
240	7238229	7.24E+00	5.57E-02	25333.80	36.439	94.091
270	10305995	1.03E+01	7.94E-02	36070.98	40.994	94.689
300	14137167	1.41E+01	1.09E-01	49480.08	45.549	96.288
350	22449298	2.24E+01	1.73E-01	78572.54	53.140	97.011
400	33510322	3.35E+01	2.58E-01	117286.13	60.732	98.340
450	47712938	4.77E+01	3.67E-01	166995.28	68.323	99.071
500	65449847	6.54E+01	5.04E-01	229074.46	75.915	99.071
600	113097336	1.13E+02	8.71E-01	395840.67	91.098	100.000

[1] Bracketed numbers refer to equation number in text.

The percentage of PM_{10}/PM was calculated for cooling tower TDS values from 1000 to 12000 ppmw and the results are plotted in Figure 1. Using these data, Figure 2 presents predicted PM_{10} emission rates for the 146,000 gpm example tower. As shown in this figure, the PM emission rate increases in a straight line as TDS increases, however, the PM_{10} emission rate increases to a maximum at around a TDS of 4000 ppmw, and then begins to decline. The reason is that at higher TDS, the drift droplets contain more solids and therefore, upon evaporation, result in larger solid particles for any given initial droplet size.

CONCLUSION

The emission factors and methodology given in EPA's AP-42[1] Chapter 13.4 *Wet Cooling Towers*, do not account for the droplet size distribution of the drift exiting the tower. This is a critical factor, as more than 85% of the mass of particulate in the drift from most cooling towers will result in solid particles larger than PM_{10} once the water has evaporated. Particles larger than PM_{10} are no longer a regulated air pollutant, because their impact on human health has been shown to be insignificant. Using reasonable, conservative assumptions and a realistic drift droplet size distribution, a method is now available for calculating realistic PM_{10} emission rates from wet mechanical draft cooling towers equipped with modern, high-efficiency drift eliminators and operating at medium to high levels of TDS in the circulating water.

Table 2. Resultant Solid Particulate Size Distribution (TDS = 11000 ppmw)

EPRI Droplet Diameter (μm)	Droplet Volume (μm^3) [2][1]	Droplet Mass (μg) [3]	Particle Mass (Solids) (μg) [4]	Solid Particle Volume (μm^3)	Solid Particle Diameter (μm) [7]	EPRI % Mass Smaller
10	524	5.24E-04	5.76E-06	2.62	1.710	0.000
20	4189	4.19E-03	4.61E-05	20.94	3.420	0.196
30	14137	1.41E-02	1.56E-04	70.69	5.130	0.226
40	33510	3.35E-02	3.69E-04	167.55	6.840	0.514
50	65450	6.54E-02	7.20E-04	327.25	8.550	1.816
60	113097	1.13E-01	1.24E-03	565.49	10.260	5.702
70	179594	1.80E-01	1.98E-03	897.97	11.970	21.348
90	381704	3.82E-01	4.20E-03	1908.52	15.390	49.812
110	696910	6.97E-01	7.67E-03	3484.55	18.810	70.509
130	1150347	1.15E+00	1.27E-02	5751.73	22.230	82.023
150	1767146	1.77E+00	1.94E-02	8835.73	25.650	88.012
180	3053628	3.05E+00	3.36E-02	15268.14	30.780	91.032
210	4849048	4.85E+00	5.33E-02	24245.24	35.909	92.468
240	7238229	7.24E+00	7.96E-02	36191.15	41.039	94.091
270	10305995	1.03E+01	1.13E-01	51529.97	46.169	94.689
300	14137167	1.41E+01	1.56E-01	70685.83	51.299	96.288
350	22449298	2.24E+01	2.47E-01	112246.49	59.849	97.011
400	33510322	3.35E+01	3.69E-01	167551.61	68.399	98.340
450	47712938	4.77E+01	5.25E-01	238564.69	76.949	99.071
500	65449847	6.54E+01	7.20E-01	327249.23	85.499	99.071
600	113097336	1.13E+02	1.24E+00	565486.68	102.599	100.000

Figure 1: Percentage of Drift PM that Evaporates to PM10

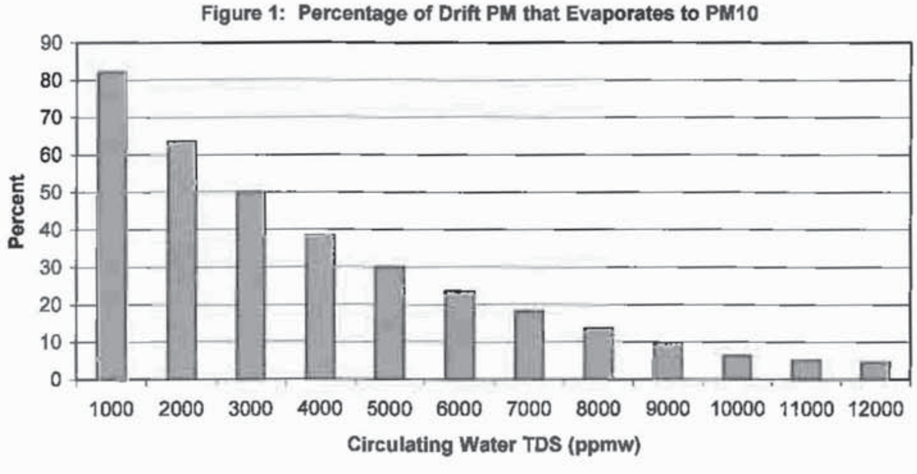
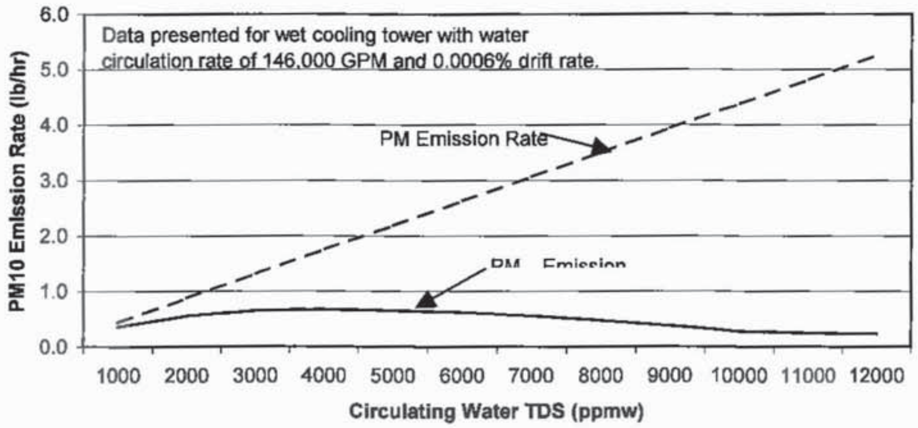


Figure 2: PM_{10} Emission Rate vs. TDS



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1. EPA, 1995. Compilation of Air pollutant Emission Factors, AP-42 Fifth edition, Volume I: *Stationary Point and Area Sources*, Chapter 13.4 Wet Cooling Towers, http://www.epa.gov/ttn/chief/ap42/, United States Environmental Protection Agency, Office of Air Quality Planning and Standards, January.

2. Aull, 1999. Memorandum from R. Aull, Brentwood Industries to J. Reisman, Greystone, December 7, 1999.

KEY WORDS

Drift
Drift eliminators
Cooling tower
PM_{10} emissions
TDS

ATTACHMENT 2

Regulatory Agency Examples for Consideration of Droplet Size Distribution for Calculation of PM_{10} and $PM_{2.5}$ Emissions from Cooling Towers

Texas Commission on Environmental Quality

INTEROFFICE MEMORANDUM

To: Chemical Section Permit Reviewers **Date:** February 9, 2009

Thru: Dana Poppa Vermillion, PE; Manager, Chemical Section

From: Kurt Kind, PhD PE, Technical Specialist, Chemical Section

Subject: Particulate Emissions from Cooling Towers

For all permit applications received after March 1, Chemical section will require PM emissions be quantified and authorized from cooling towers that are subject to review (including renewals). This review should be performed as follows:

New or modified sources

Perform the review as for any other new or modified facility (BACT, NAAQS, etc). PM emissions from cooling tower drift (droplets of cooling water that are entrained in ambient air rather than returning to the cooling tower basin) must be quantified (Tier 1 BACT for drift is no more than 0.001% of cooling water to the tower). The drift and total dissolved solids (TDS) concentration in the cooling water are used to estimate total PM emissions.

For new cooling towers, a particle size distribution should be provided for drift from the proposed cooling tower which can be used to determine the fraction of drift that will result in PM10 emissions. Note that the particle size distribution must be specific to the tower proposed because the limited information available indicates that the particle size distribution can vary significantly from tower to tower. If a particle size distribution is not available, all PM emissions must be treated as PM10.

At renewal

Estimate the cooling tower PM emissions based on manufacturer's data or operating experience. Only use the AP-42 factor (0.02%) if neither of these options are available. Assume all PM is emitted as PM10 unless there is a particle size distribution available for the cooling tower.

If the cooling tower PM emissions to be added to the permit are not significant (<15 tpy PM10 and <25 tpy PM) add them to the MAERT with the boilerplate cooling tower PM monitoring condition per the March 10, 1997 memo from Victoria Hsu, P.E., Director, New Source Review Permitting Division, entitled "Permit Renewal Requirements."

If the emissions are significant, a permit amendment will be necessary and should be reviewed as described above. If the emission increase is still significant following the application of BACT, PSD review may apply. The permit holder may do a retrospective PSD applicability analysis to demonstrate that the additional PM emissions from the cooling tower(s) would not have made the original construction project subject to PSD review. Another option available would be to treat the authorization of cooling tower PM emissions as a project occurring today. In either case, PSD review would be required unless the net emission increase is not significant.

This topic and the emission calculations associated with it will be discussed in detail at the next Chemical section meeting.

From a Mississippi permit approval:

- Cooling Towers – The drift emissions from the cooling towers are limited to the particulate associated with dissolved solids in liquid droplets that become entrained in the air stream exiting the cooling tower. The particle size distribution is dependent on several factors including the design of the cooling tower, the drift eliminators, and the concentration of dissolved solids in the recirculating water (e.g., higher concentrations of dissolved solids may result in fewer particles below 2.5 microns aerodynamic diameter). Based on the Reisman and Frisbie method, "Calculating Realistic PM_{10} Emissions from Cooling Towers" (Reisman and Frisbie, 2002), $PM_{2.5}$ emissions would be less than 2% of the PM_{10} emissions at the assumed TDS concentration. This ratio would hold despite variance in circulation rates or expected TDS concentrations of the cooling tower. Accordingly, this represents a reliable statistical relationship over the operating range of the cooling towers. Therefore, 2% of the PM_{10} represents a reasonable and conservative proxy and surrogate for $PM_{2.5}$ from the cooling towers.

Pre-Construction Review and Preliminary Determination of Approval for Mississippi Power Company, Kemper IGCC Facility Facility No. 1380-00017, Technical Review by Krystal Rudolph; Air Quality Analysis By Bruce Ferguson, December 17, 2009

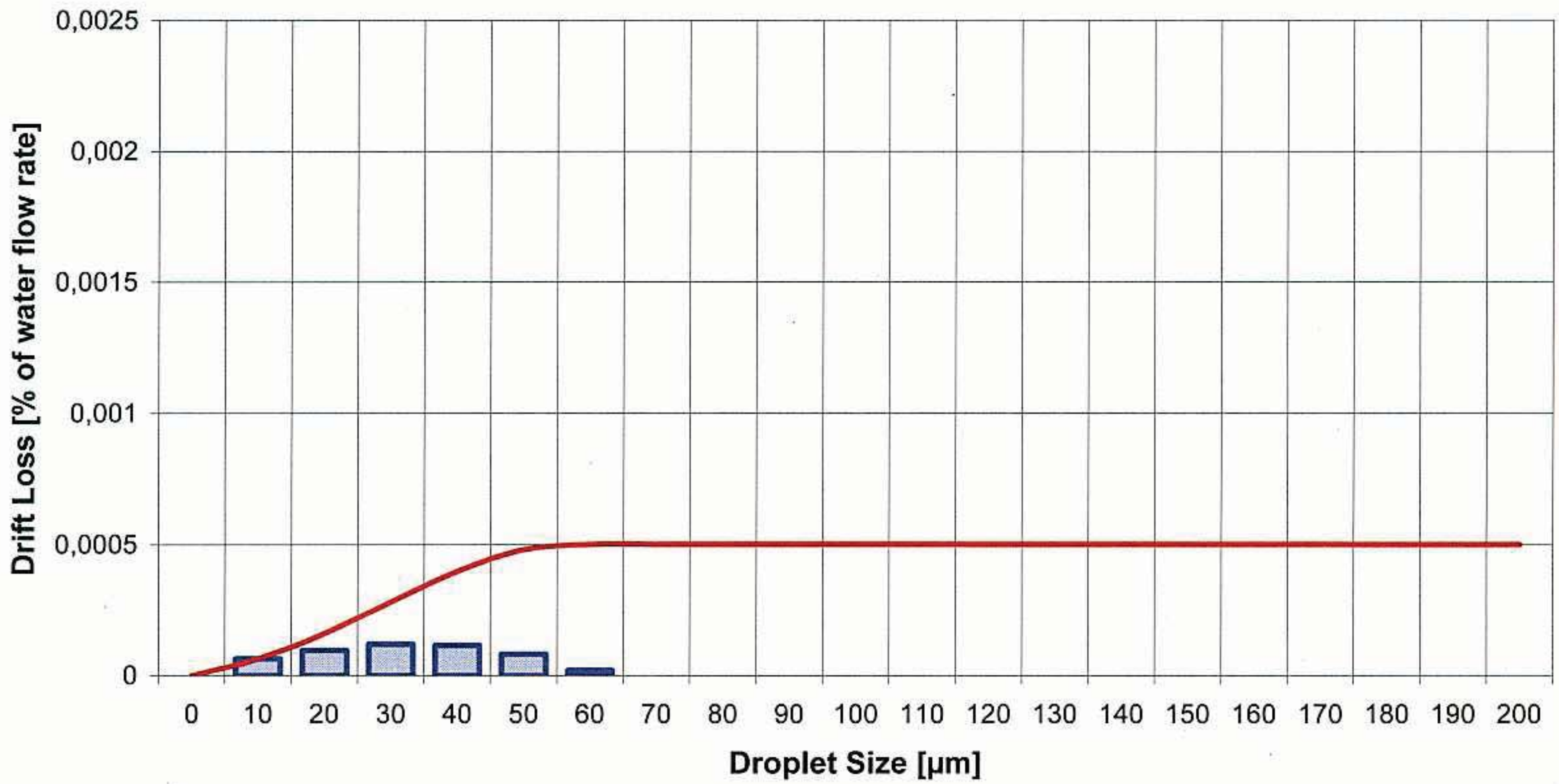
ATTACHMENT 3

Droplet Size Distributions for Industrial Cooling Towers Equipped with Drift Eliminators

Cooling Tower Drift Loss (Standard Data)

SPX Cooling Technologies
Balcke | Hamon Dry Cooling | Marley

Drift Loss as a Function of the Droplet Size
(Total Drift Loss = 0.0005% of water flow rate)



ATTACHMENT 4

Calculation Spreadsheets for Calculation of $PM_{2.5}$ Fraction and PM_{10} Fraction in Cooling Tower Drift Particulate Emissions

Cooling Tower Drift Droplet and Evaporated Particle Size Distributions
High-Efficiency Drift Configuration = 0.0005%

Methodology for calculating the evaporated solid particle size distribution based on the droplet size distribution is taken from "Calculating Realistic PM10 Emissions from Cooling Towers", Reisman and Frisbie, Environmental Progress, July 2002.

Cooling Tower	SPX Cooling Technology for 0.0005% drift eliminator
Drift Efficiency	0.0005%
Recirc. Water TDS Conc., mg/L	69,000
Drift Droplet Density, g/cc	1.0
Evaporated salt particle density, g/cc	2.2

Diameter of Drift Droplets or Evaporated Particles (microns)	Liquid Droplet Size Distribution (percent)	Percent Smaller Size Distribution	Evaporated Solid Particle Diameter (microns)		
10	13	13	3.2	PM2.5 Fraction	13%
20	18.5	31.5	6.3		
30	24.1	55.6	9.5	PM10 Fraction	56%
40	22.2	77.8	12.6		
50	16.7	94.5	15.8		
60	5.6	100.1	18.9		
70					
80					
90					
100					
110					
120					
Total	100.1				

P:\1409\001\010\WIP\T\Emission Calcs\Preliminary Emissions Provided to Ecology & URS\[DRAFT WORK-IN-PROGRESS MWH01 Emission Calculations.xlsx]Extra high effcy 0.0005%

APPENDIX C

Derivation of Theoretical Maximum 12-Month Emission Rates

TECHNICAL MEMORANDUM

LANDAU ASSOCIATES
ENVIRONMENTAL | GEOTECHNICAL | NATURAL RESOURCES

TO: Gary Huitsing, Washington State Department of Ecology

FROM: Jim Wilder, P.E.

DATE: March 12, 2014

RE: DERIVATION OF THEORETICAL MAXIMUM 12-MONTH EMISSION RATES
PROPOSED PROJECT OXFORD DATA CENTER
QUINCY, WASHINGTON

INTRODUCTION AND SUMMARY

This technical memorandum describes how the 70-year average emission rates calculated for the Microsoft Project Oxford Data Center in Quincy, Washington were adjusted upward to correspond to the maximum theoretical 12-month emission rates. The calculated theoretical maximum 12-month emission rates are only slightly higher than the 70-year average emission rates that were presented in Landau Associates' original permit application (Landau Associates 2014a,b), because the 70-year average calculations already accounted for commissioning testing and stack emission testing. The small "adjustment factors" to adjust the 70-year average emission rates upward to the theoretical maximum 12-month period are as follows:

- Particulate matter: 1.008
- Nitrogen oxides: 1.02
- Carbon monoxide:1.01
- Fuel consumption: 1.009.

DERIVATION OF THEORETICAL 12-MONTH MAXIMUM EMISSION RATES

Because human health risk factors for carcinogens such as diesel engine exhaust particulate matter (DEEP) assume that the receptor is exposed for a 70-year period, the DEEP risk assessment was conducted based on the 70-year average emission rates, with the initial emissions during generator commissioning and the periodic stack emission testing distributed over the 70-year exposure period. The calculation of the 70-year average emission rates for all regulated air pollutants is described in detail in the January 2014 Notice of Construction Supporting Information Report (Landau Associates 2014a), and the cancer risks caused by those 70-year average emissions were presented in the January 2014 Second-Tier Risk Analysis for Diesel Engine Exhaust Particulate Matter (Landau Associates 2014b). Microsoft believed that the 70-year average emission rates presented in those reports were conservatively high. However, the Washington State Department of Ecology (Ecology) has determined that emission rates used for modeling compliance with the annual-average National Ambient Air Quality Standards

(NAAQS) and the annual-average Acceptable Source Impact Levels (ASILs) must be based on the theoretical maximum emission rates for any 12-month rolling period, rather than the 70-year average. This document describes how the theoretical maximum 12-month emission rates were derived.

Generator usage during the theoretical maximum 12-month period would include a combination of generator commissioning, fully operational data center activity, and periodic stack emission testing. For this assessment, we considered the following 12-month operating scenarios:

- Scenario 1:70-year average as used for the DEEP risk assessment, distributing the generator commissioning and periodic stack testing over the 70-year exposure period
- Scenario 2: Commissioning of 21 Phase 1 generators, followed by installation of the Phase 1 data center servers, followed by a partial year of full operation of Phase 1
- Scenario 3: Full year of operation for Phase 1, plus commissioning of 16 Phase 2 generators, followed by installation of the Phase 2 data center servers, followed by a partial year of full operation of Phase 2, including stack emission testing of two generators for Phase 1
- Scenario 4: 12 months of full operation of combined Phases 1+2, including stack emission testing of two generators for either Phase 1 or Phase 2.

The anticipated sequence of events and the schedule for commissioning of Phase 1 and Phase 2 generators were provided by Microsoft. Based on those anticipated sequences, for each scenario we compiled the maximum theoretical combination of generator runtime that could occur during any 12-month period. The maximum theoretical 12-month generator usage for Scenario 2 is derived in Table 1. The maximum theoretical runtime for Scenario 3 is derived in Table 2. The maximum theoretical runtime for Scenario 4 is derived in Table 3.

The theoretical maximum diesel usage rates and the annual emission rates for DEEP, nitrogen oxides (NO_x), carbon monoxide (CO) and volatile organic compounds (VOC) corresponding to each 12-month scenario were calculated using the same methods that were used to calculate the 70-year average emissions. A screen shot of the emission calculation spreadsheet that was provided to Ecology is shown in Attachment 1.

Table 4 lists the "menu" of annual emissions caused by each subset of activity. The 12-month emission rates for each scenario were then calculated by summing the individual subset activities relevant for that scenario. The calculated 12-month emission rates for Scenario 1, Scenario 2, Scenario 3, and Scenario 4 are shown in Tables 5 through 8, respectively. The last line in Tables 5 through 8 shows the "adjustment factor" for that scenario, which is the ratio of that scenario's theoretical maximum 12-month emissions compared to the 70-year average emission rates presented in the January 2014 permit application.

Depending on the pollutant being considered, the calculated 12-month emissions are highest for either Scenario 3 or Scenario 4. To provide a conservatively high estimate, for each pollutant the higher value from either of those scenarios was selected, and the values for each pollutant were combined to create a composite worst-case scenario. Table 9 shows the overall emission rates and the 70-year average adjustment factors for the composite worst-case 12-month period. The worst-case composite 12-month emissions are only slightly higher than the 70-year average values presented in the DEEP risk assessment report (the adjustment factors range from only 1.008 to 1.02).

The composite worst-case adjustment factors listed in Table 9 were used to scale up the 70-year average annual emission rates and the 70-year average ambient concentrations used to demonstrate compliance with the annual-average NAAQS for all pollutants, the annual-average ASILs for all pollutants, and for the annual-average chronic non-cancer DEEP hazard quotient. No adjustments were made to 1-hour average or 24-hour average emission rates or ambient concentrations.

REFERENCES

Landau Associates. 2014a. *Notice of Construction Supporting Information Report, Proposed Microsoft Project Oxford Data Center, Quincy, Washington*. Prepared for The Microsoft Corporation. January 23.

Landau Associates. 2014b. *Second-Tier Risk Analysis for Diesel Engine Exhaust Particulate Matter, Proposed Microsoft Project Oxford Data Center, Quincy, Washington*. Prepared for The Microsoft Corporation. January 22.

TABLE 1
SEQUENCE FOR SCENARIO 2:
PHASE 1 COMMISSIONING FOLLOWED BY PARTIAL YEAR OF PHASE 1 OPERATION

Month	Activity
0	Begin commissioning first 5 generators
4	Finish commissioning first 5 generators
4-8	Commission generators 6-21 (16 generators)
8-12	Install servers
12+	Phase 1 fully operational
The maximum 12-month activity for this scenario includes the following: Commission 16 Phase 1 generators + 4 months full operation of Phase 1	

TABLE 2
SEQUENCE FOR SCENARIO 3:
FULL YEAR OF PHASE 1 OPERATION, PHASE 2 COMMISSIONING, FOLLOWED BY PARTIAL YEAR OF PHASE 2 OPERATION, WITH STACK EMISSION TESTING OF PHASE 1

Month	Activity
0	Begin commissioning 16 Phase 2 generators
4	Finish commissioning 16 Phase 2 generators
4-7	Install servers for 8 MW (first Phase 2 AZ Building with 4 generators)
7-12	First Phase 2 AZ Building (4 generators) fully operational
7-10	Install servers for final 3 Phase 2 AZ Buildings (12 generators)
10-12	Final three Phase 2 AZ buildings operational (12 generators)
12+	Stack testing at Phase 1
The maximum 12-month activity for this scenario includes the following: 21 Phase 1 generators fully operational + Commission 16 Phase 2 generators + 5 months operation of 4 Phase 2 generators + 2 months operation of 12 Phase 2 generators + Stack testing of 2 Phase 1 generators	

TABLE 3
SEQUENCE FOR SCENARIO 4:
FULL OPERATION OF COMBINED PHASES 1+2, PLUS STACK TESTING OF TWO GENERATORS

Month	Activity
1-12	Full operation of Phase 1
1-12	Full operation of Phase 2
1-12	Stack testing of 2 generators
The maximum 12-month activity for this scenario includes the following: 12 months full operation of Phase 1 + 12 months full operation of Phase 2 + Stack testing of 2 generators	

TABLE 4
MENU OF SUBSET RUNTIME ACTIVITIES

Scenario	Fuel (gallons/year)	Facility-Wide Emissions (tons/year)			
		DEEP	NO_x	CO	VOCs
70-Year Average Including Commissioning + Stack Testing	442,878	0.531	8.57	15.9	0.79
Phases 1+2 Routine Runtime, w/out Commissioning or Stack Tests	432,360	0.522	8.45	15.43	0.77
Phases 1+2 Routine Plus 2-Generator Stack Testing	446,659	0.535	8.61	16.11	0.8
Phase 1 Only Routine (No Commissioning or Stack Tests)	245,166	0.298	5.7	8.7	0.44
Phase 2 Commissioning of 16 Generators for 40 hours Each	101,683	0.094	2.28	5.08	0.26
Phase 2, 12 months of Routine Runtime	187,194	0.224	2.75	6.73	0.33
Net Emissions for 2-Generator Stack Tests	14,299	0.013	0.16	0.68	0.03

TABLE 5
SCENARIO 1: 70-YEAR ANNUAL AVERAGE

Activity	Fuel (gallons/year)	Facility-Wide Emissions (tons/year)			
		DEEP	NO_x	CO	VOCs
70-Year Average Including Commissioning + Stack Testing	442,878	0.531	8.57	15.9	0.79

TABLE 6
SCENARIO 2: 12-MONTH EMISSIONS, COMMISSIONING OF PHASE 1, FOLLOWED BY OPERATION OF PHASE 1

Activity	Fuel (gallons/year)	Facility-Wide Emissions (tons/year)			
		DEEP	NO_x	CO	VOCs
Commissioning of 21 Phase 1 Generators	127,104	0.1175	2.85	6.35	0.325
4 Months of Operation of Phase 1 Generators	81,722	0.099	1.9	2.9	0.15
12-Month Total Emissions	208,826	0.217	4.75	9.25	0.47
Adjustment Factor Compared to 70-Year Average	0.47	0.41	0.55	0.58	0.60

TABLE 7
SCENARIO 3: 12-MONTH EMISSIONS, COMMISSIONING OF PHASE 2, FOLLOWED BY OPERATION OF COMBINED PHASES 1+2

Activity	Fuel (gallons/year)	Facility-Wide Emissions (tons/year)			
		DEEP	NO_x	CO	VOCs
12 months Routine Operation of Phase 1	245,166	0.298	5.7	8.7	0.44
Commissioning of 16 Phase 2 Generators	101,683	0.094	2.28	5.08	0.26
5 Months of Operation of 4 Phase 2 Generators	19,499	0.023	0.286	0.701	0.034
2 months Operation of 12 Phase 2 Generators	23,399	0.028	0.344	0.841	0.041
Emission Testing of 2 Phase 1 Generators	14,299	0.013	0.16	0.68	0.03
12-Month Total Emissions	404,047	0.46	8.77	16.00	0.81
Adjustment Factor Compared to 70-Year Average	0.91	0.86	1.023	1.01	1.02

TABLE 8
SCENARIO 4: 12-MONTH EMISSIONS, FULL OPERATION OF COMBINED PHASES 1+2, PLUS STACK TESTING OF TWO GENERATORS

Activity	Fuel (gallons/year)	Facility-Wide Emissions (tons/year)			
		DEEP	NO_x	CO	VOCs
12 months Routine Operation of Phase 1	245,166	0.298	5.7	8.7	0.44
Routine Operation of Phase 2	187,194	0.224	2.75	6.73	0.33
Stack Testing of 2 Generators	14,299	0.013	0.16	0.68	0.03
12-Month Total Emissions	446,659	0.535	8.61	16.1	0.8
Adjustment Factor Compared to 70-Year Average	1.009	1.008	1.005	1.013	1.013

TABLE 9
OVERALL EMISSION RATES FOR COMPOSITE WORST-CASE 12-MONTH PERIOD

Activity	Fuel (gallons/year)	Facility-Wide Emissions (tons/year)			
		DEEP	NO_x	CO	VOCs
Composite Maximum of Any Value for Any Scenario	446,659	0.535	8.77	16.1	0.81
Composite Maximum of Any Adjustment Factor for Any Scenario	1.009	1.008	1.02	1.01	1.02

ATTACHMENT 1

Screen Shot of Excel Spreadsheet Calculations

Worst-Case Annual Emission Scenarios Compared to 70-Year Average

Menu of Runtime Scenarios

Scenario	uel, gal/yea	Facility-Wide Emissions, tons/year			
		DEEP	Nox	CO	HC
70-Year Average Including Commissioning + Stack Testi	442,878	0.531	8.57	15.9	0.79
Phases 1+2 Routine Runtime, W/out Commissioning or	432,360	0.522	8.45	15.43	0.77
Phases 1+2 Routine Plus 3-Generator Stack Testing	446,659	0.535	8.61	16.11	0.8
Phase 1 Only Routine (No Commissioning or Stack Tests	245,166	0.298	5.7	8.7	0.44
Phase 2 Commisioning of 16 Gens for 40 hrs Each	101,683	0.094	2.28	5.08	0.26
Phase 2, 12 months of Routine Runtime	187,194	0.224	2.75	6.73	0.33
Net Emissions for 3-Gen Stack Tests	14,299	0.013	0.16	0.68	0.03

Scenario 1. 70-Year Annual Average

Activity	Fuel, gal/year	Facility-Wide Emissions, tons/year			
		DEEP	Nox	CO	HC
70-Year Average Including Commissioning + Stack Testi	442,878	0.531	8.57	15.9	0.79

Scenario 2. Commissioning of Phase 1, Followed By Operation of Phase 1

Activity	Fuel, gal/year	Facility-Wide Emissions, tons/year			
		DEEP	Nox	CO	HC
Commissioning of 20 Phase 1 Generators	127,104	0.1175	2.85	6.35	0.325
4 Months of Operation of Phase 1 Generators	81,722	0.099	1.9	2.9	0.15
12-Month Total Emissions	208,826	0.217	4.75	9.25	0.47
Ajustment Factor Compared to 70-Year Average	0.47	0.41	0.55	0.58	0.60

Scenario 3. Commissioning of Phase 2, Followed By Operation of Combined Phases 1 +2

Activity	Fuel, gal/year	Facility-Wide Emissions, tons/year			
		DEEP	Nox	CO	HC
12 months Routine Operation of Phase 1	245,166	0.298	5.7	8.7	0.44
Commissioning of 16 Phase 1 Generators	101,683	0.094	2.28	5.08	0.26
5 Months of Operation of 4 Phase 2 Generators	19,499	0.023	0.286	0.701	0.034
2 months Operation of 12 Phase 2 Generators	23,399	0.028	0.344	0.841	0.041
Emission Testing of 3 Phase 1 Generators	14,299	0.013	0.16	0.68	0.03
12-Month Total Emissions	404,047	0.46	8.77	16.00	0.81
Ajustment Factor Compared to 70-Year Average	0.91	0.86	1.023	1.01	1.02

Scenario 4. Full Operation of Combined Phases 1+2, Plus Stack Testing of 3 Generators

Activity	Fuel, gal/year	Facility-Wide Emissions, tons/year			
		DEEP	Nox	CO	HC
12 months Routine Operation of Phase 1	245,166	0.298	5.7	8.7	0.44
Routine Operation of Phase 2	187,194	0.224	2.75	6.73	0.33
Stack Testing of 3 Generators	14,299	0.013	0.16	0.68	0.03
12-Month Total Emissions	446,659	0.535	8.61	16.11	0.8
Ajustment Factor Compared to 70-Year Average	1.009	1.008	1.005	1.013	1.013

Overall Adjustment Factors for Worst-Case Annual Compared to 70-Year Annual Average

Activity	Fuel, gal/year	Facility-Wide Emissions, tons/year			
		DEEP	Nox	CO	HC
Maximum of Any Value for Any Scenario	446,659	0.535	8.77	16.1	0.81
Maximum of Any Adjustment Factor for Any Scenario	1.009	1.008	1.02	1.01	1.02

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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 15-minute averaging period.

Example: Cold Start Spike Factor for VOC, First 15 Minutes After Cold Start at Low Load

The triangular area under the "VOC spike" is 6,300 ppm-sec. The steady-state VOC concentration is 30 ppm. For the 15-minute steady state period the area under the steady-state concentration-vs-time curve is 30 ppm x 15 minutes x 60 seconds or 27,000 ppm-sec.

The "VOC cold start spike factor" is the area of the spike divided by the area under the warmed up steady state curve. :

VOC cold start spike ratio = (6300 ppm-sec) / (6300+27,000 ppm-sec) = 0.189

So the VOC Cold Start Spike Factor = 1.189 for the initial 15-minute period.

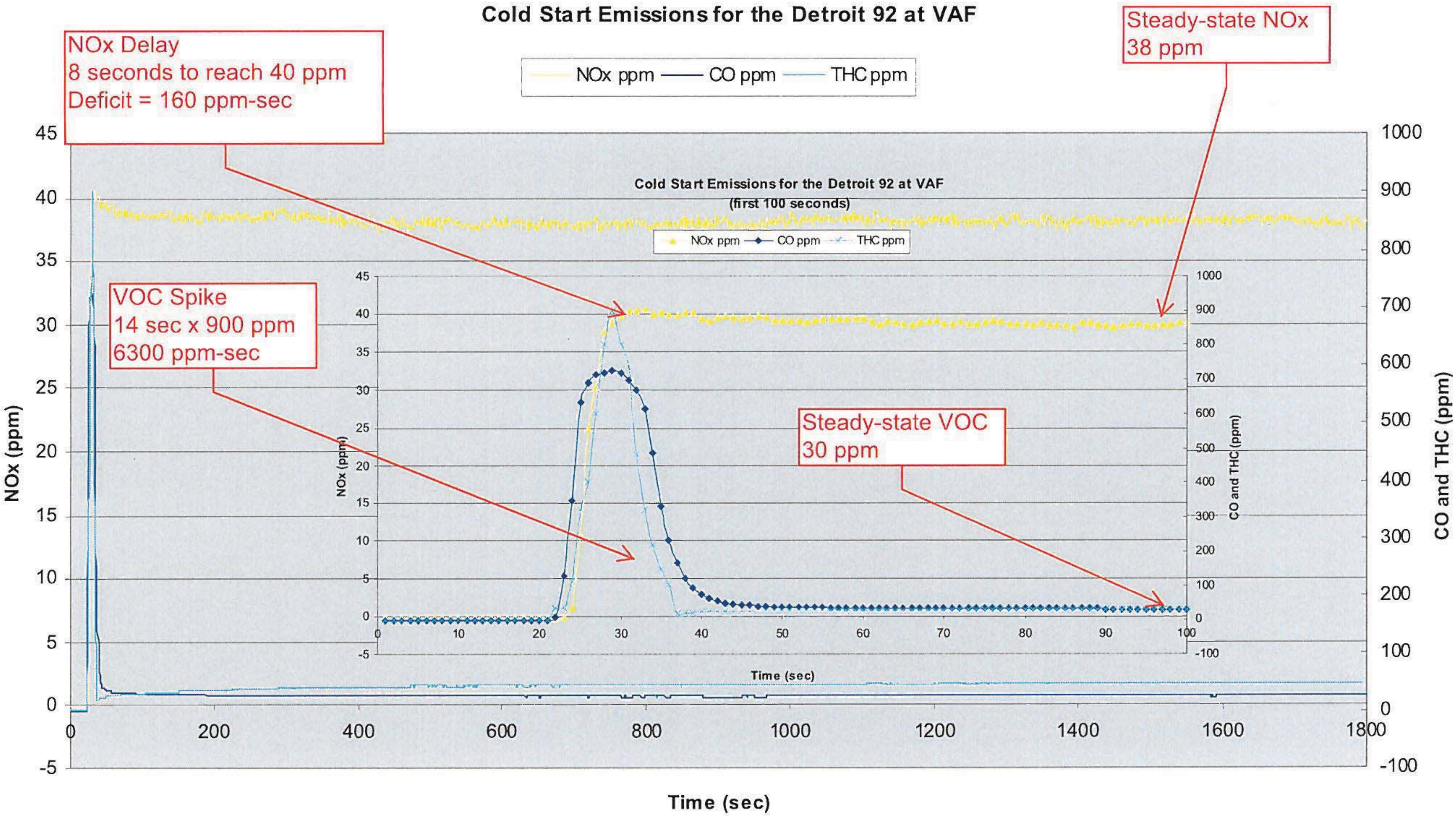

Figure 19. Cold-start emissions for CO and NO_X as a function of time

Cold-Start Spike Adjustment Factors for CO, VOC, PM

VOC/PM Black Puff Cold-Start Spike Adjustment Factors

Load	Spike Area (ppm-sec)	Steady-State Area (ppm-sec)	Total Area (ppm-sec)	Black Puff Factor
10% (15 min)	6300	27000	33300	1.189
80% (10 min)	6300	18000	24300	1.259
100% (10 min)	6300	18000	24300	1.259

CO Black Puff Cold-Start Spike Adjustment Factors

Load	Spike Area (ppm-sec)	Steady-State Area (ppm-sec)	Total Area (ppm-sec)	Black Puff Factor
10% (15 min)	15000	18000	33000	1.455
80% (10 min)	15000	12000	27000	1.556
100% (10 min)	15000	12000	27000	1.556

APPENDIX E

Ammonia Emission Rates and Ambient Impact Calculations

(Calculation spreadsheet was provided to the Washington State Department of Ecology under separate cover)

Ammonia Emission Rates and Ambient Risk Assessment
Microsoft MWH-01 Data Center

Emission Factor from Vantage Data Center: 0.32 (lbs/hr NH3)/(Mwe)

70-Year Average Emission Rates Including All Activity

Gen #	Load Condition	No. Gens	Hrs/Yr Warmed Up With Ammonia Slip	Mwe, Warmed Up With Ammonia Slip	Mwe-Hrs/Year Warmed Up Condition With Ammonia Slip	NH3 Emission Factor, lbs/Mwe	Annual Ammonia Emissions, tons/yr
2.5 MW @ 100% load	Cold start	32	2.67	0	0	0	0
2.5 MW @ 100% load	Warmed up	32	14.83	2.5	1,186	0.32	0.19
2.5 MW @ 80% load	Cold start	32	0.67	0	0	0	0
2.5 MW @ 80% load	Warmed up	32	41.27	2	2,641	0.32	0.42
2.5 MW @ 10% load	Cold start	32	13.00	0	0	0	0
2.5 MW @ 10% load	Warmed up	32	16.01	0.25	128	0.32	0.02
2 MW @ 100% load	Cold start	4	2.67	0	0	0	0
2 MW @ 100% load	Warmed up	4	14.83	2	119	0.32	0.02
2.MW @ 80% load	Cold start	4	0.67	0	0	0	0
2 MW @ 80% load	Warmed up	4	41.27	1.6	264	0.32	0.042
2 MW @ 10% load	Cold start	4	13.00	0	0	0	0
2 MW @ 10% load	Warmed up	4	16.01	0.2	13	0.32	0.0020
0.75 MW @ 100% load	Cold start	1	2.67	0	0	0	0
0.75 MW @ 100% load	Warmed up	1	14.83	0.75	11	0.32	0.0018
0.75 MW @ 80% load	Cold start	1	0.67	0	0	0	0
0.75 MW @ 80% load	Warmed up	1	41.27	0.6	25	0.32	0.0040
0.75 MW @ 10% load	Cold start	1	13.00	0	0	0	0
0.75 MW @ 10% load	Warmed up	1	16.00	0.075	1.2	0.32	0.0002
					Facility-Wide Total Ammonia Emissions, tons/year		0.702

Facility-Wide Daily NH3 Emission Rate During a 24-hour Power Outage

Generators	No. Gens	Rated Mwe	Load	Daily Runtime, hours	MW-hrs/day	NH3 Emission Factor, lbs/MW-hr	Daily NH3 Emissions, lbs/day
2.5 MW AZ Generators	32	2.5	0.8	24	1,536	0.32	492
2.0 MW CNR Generators	4	2	0.8	24	154	0.32	49
0.75 Admin building	1	0.75	0.8	24	14	0.32	5
			Facility-Wide Daily NH3 Emission Rate During a 24-hour Power Outage, lbs/day				545
			Facility-Wide 1-Hour NH3 Emission Rate During a Power Outage, lbs/day				22.7

24-Hour Ambient Air Quality Impact Assessment for Tier-1 ASIL Comparison (Use AERMOD for Acrolein to develop dispersion factor

Acrolein emission rate	0.015	lbs/day	
Acrolein ambient conc.	0.0006	ug/m3	
Acrolein dipsersion factor	0.040	(ug/m3)/(lbs/day)	
Facility-wide NH3 emissions during 24-hour power outage	545	lbs/day	
Maximum 24-hour NH3 ambient impact at property line	21.8	ug/m3	
24-hr ASIL for ammonia	70.8	ug/m3	

Hazard Quotient Assessment at Key Risk Assessment Receptors

Receptor	MIBR		MICR		MIRR		School		Hospital	
Averaging Period	1-hour	Annual	1-hour	Annual	1-hour	Annual	1-hour	Annual	1-hour	Annual
Acrolein 1-hr Impact, ug/m3	0.001	--	0.0006	--	0.00072	--	0.00069	--	0.0007	--
Acrolein 1-hr Emission, lbs/hr	5.97E-04	--	5.97E-04	--	5.97E-04	--	5.97E-04	--	5.97E-04	--
Acrolein Dispersion Factor, ug/m3/(lbs/hr)	1.68E+00	--	1.01E+00	--	1.21E+00	--	1.16E+00	--	1.17E+00	--
Ammonia Hourly Emission Rate, lbs/hour	22.7	--	22.7	--	22.7	--	22.7	--	22.7	--
Ammonia 1-hr Impact, ug/m3	38.1	--	22.8	--	27.4	--	26.3	--	26.6	--
Ammonia 1-hr Acute REL, ug/m3	3,200	--	3,200	--	3,200	--	3,200	--	3,200	--
Ammonia Acute HQ	0.012	--	0.007	--	0.009	--	0.008	--	0.008	--
DEEP annual, ug/m3	--	0.08	--	0.028	--	0.014	--	0.007	--	0.003
DEEP emissions, tons/yr	--	0.536	--	0.536	--	0.536	--	0.536	--	0.536
DEEP Dispersion Factor, ug/m3/(tpy)	--	0.149	--	0.052	--	0.026	--	0.013	--	0.006
Ammonia Annual Emission Rate, tons/yr	--	0.702	--	0.702	--	0.702	--	0.702	--	0.702
Ammonia Annual Impact, ug/m3	--	0.105	--	0.037	--	0.018	--	0.009	--	0.004
Ammonia Annual chronic REL, ug/m3	--	200	--	200	--	200	--	200	--	200
Ammonia Acute HQ	--	0.00052	--	0.00018	--	0.00009	--	0.00005	--	0.00002

Hourly Stack Test Limits

		Mwe at indicated load			NH3 Emiss (lbs/hr) at indicated load		
		0.75 Mwe	2.0 MWE	2.5 Mwe	0.75 Mwe	2.0 MWE	2.5 Mwe
Ammonia	10%	0.08	0.20	0.25	0.024	0.064	0.080
	80%	0.60	1.60	2.00	0.19	0.51	0.64
	100%	0.75	2.00	2.50	0.24	0.64	0.80

APPENDIX F

Best Available Control Technology Cost Spreadsheets

Table X. BACT Capital Cost for "Tier-4F Capable" System (SCR and Catalyzed DPF)

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
2500 kWe emission control package	ROM cost estimate by Caterpillar		32	$308,450	$9,870,400
2000 kWe system	"0.6 rule" scaled from Caterpillar estimate for 2500 kWe		4	$269,798	$1,079,192
750 kWe system	"0.6 rule" scaled from Caterpillar estimate for 2500 kWe system		1	$149,781	$149,781
Combined systems FOB cost					$11,099,373
Instrumentation	Assume no cost	Assume no cost	0	0	0
Sales Tax	WA state tax	WA state tax	6.5%	--	$721,459
Shipping	0.05A	EPA Cost Manual	5.0%	--	$554,969
Subtotal Purchased Equipment Cost, PEC					$12,375,801
Direct Installation Costs					
Enclosure structural supports	Assume no cost	Assume no cost	0	$0	$0
Installation	1/2 of EPA Cost Manual	1/2 of EPA Cost Manual	2.5%	--	$309,395
Electrical	Assume no cost	Assume no cost	0	0	0
Piping	Assume no cost	Assume no cost	0	0	0
Insulation	Assume no cost	Assume no cost	0	0	0
Painting	Assume no cost	Assume no cost	0	0	0
Subtotal Direct Installation Costs					$309,395
Site Preparation and Buildings (SP)	Assume no cost	Assume no cost	0	0	0
Total Direct Costs, DC (PEC + Direct Installation + Site Prep)					$12,685,196
Indirect Costs (Installation)					
Engineering	0.025*PEC	1/4 of EPA Cost Manual	2.5%	--	$309,395
Construction and field expenses	0.025*PEC	1/2 of EPA Cost Manual	2.5%	--	$309,395
Contractor Fees	From DIS data center	From DIS data center	6.8%	--	$857,186
Startup	0.02*PEC	EPA Cost Manual	2.0%	--	$247,516
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$123,758
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$371,274
Subtotal Indirect Costs, IC					$2,218,524
Total Capital Investment (TCI = DC+IC)					$14,903,720
					TCI per gen $451,628

TCI/PEC
1.20

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Table X. BACT Cost-Effectiveness for "Tier-4F Capable" System

Item	Quantity	Units	Unit cost	Subtotal
Annualized Capital Recovery				
Total Capital Cost				$14,903,720
Capital Recovery Factor, 25 yrs, 4% discount rate				0.06401
Subtotal Annualized 25-year Capital Recovery Cost				$953,987
Direct Annual Costs				
Annual Admin charges	2% of TCI (EPA Manual)		0.02	$298,074
Annual Property tax	1% of TCI (EPA Manual)		0.01	$149,037
Annual Insurance	1% of TCI (EPA Manual)		0.01	$149,037
Annual operation/labor/maintenance costs: Upperbound estimate would assume CARB's value of $3.00/hp/year and would result in $423,000/year. Lower bound estimate would assume zero annual O&M. Mid-range value would account for urea, 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				$596,149
Total Annual Cost (Capital Recovery + Direct Annual Costs)				**$1,550,136**
Uncontrolled emissions (Combined Pollutants)				65.3
Annual Tons Removed (Combined Pollutants)				54.64
Cost Effectiveness ($ per tons combined pollutant destroyed)				**$28,373**

Annual O&M Cost Based on CARB Factors

Annual operation + maintenance (lowermost CARB estimate)	131,552	Installed hp	$3.00	$394,656

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)	
NOX	$10,000	45.10	$451,019	per year
CO	$5,000	7.76	$38,790	per year
VOC	$9,999	1.09	$10,881	per year
PM (FH+BH)	$23,200	0.69	$15,935	per year
Other				
Total Reasonable Annual Control Cost for Combined Pollutants			**$516,626**	**per year**
Actual Annual Control Cost			**$1,550,136**	**per year**
Is The Control Device Reasonable?			**NO (Actual >> Acceptable)**	

Criteria Pollutants Removal Tonnages (Nominal-Controlled)

Pollutant	PM (FH+BH)	CO	VOC	NOX	Other
Tier-2 Uncontrolled TPY	**1.21**	**8.62**	**1.881**	**53.5**	
Controlled TPY	**0.527**	**0.862**	**0.793**	**8.44**	
Tons Removed/Year	**0.69**	**7.76**	**1.088**	**45.1**	
Combined Uncontrolled Tons/yr	65.26				
Combined tons/yr Removed	54.64				
Overall Cold-Start Removal Effcy	57%	90%	58%	84%	
Annualized Cost ($/yr)	$1,550,136	$1,550,136	$1,550,136	$1,550,136	$1,550,136
Indiv Poll $/Ton Removed	$2,256,844	$199,809	$1,424,500	$34,370	

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)	
NO2	$20,000	4.51	$90,204	per year
CO	$5,000	7.76	$38,790	per year
Carcinogen VOC	$9,999	0.0269	$269	per year
DEEP (FH+BH)	$23,200	0.687	$15,935	per year
Non-carcinogen VOC	$5,000	0.0855	$427	per year
Total Reasonable Annual Control Cost for Combined Pollutants			**$145,626**	**per year**
Actual Annual Control Cost			**$1,550,136**	**per year**
Is The Control Device Reasonable?			**NO (Actual >> Acceptable)**	

TAPs Removal Tonnages (Nominal-Controlled)

Pollutant	DEEP (FH+BH)	CO	Carcinogen VOC	NO2	Non Carcinogen VOC	Acrolein
Tier-2 Uncontrolled TPY	**1.21**	**8.62**	**0.0299**	**5.35**	**0.0950**	**0.00023**
Controlled TPY	**0.527**	**0.862**	**0.00299**	**0.84**	**0.00950**	**0.00002**
Tons Removed/Year	**0.687**	**7.76**	**0.0269**	**4.51**	**0.0855**	**0.000206**
Combined Uncontrolled Tons/yr	15.31					
Combined tons/yr Removed	13.07					
Overall Cold-Start Removal Effcy	57%	90%	90%	84%	90%	90%
Annualized Cost ($/yr)	$1,550,136	$1,550,136	$1,550,136	$1,550,136	$1,550,136	$1,550,136
Indiv Poll $/Ton Removed	$2,256,844	$199,809	$57,693,311	$343,696	$18,135,567	$7,530,126,622
Combined TAPs $/Ton Removed	$118,624					

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Table X. BACT Capital Cost for Catalyzed DPF

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
2500 kWe emission control package	ROM cost estimate by Caterpillar		32	$129,200	$4,134,400
2000 kWe system	"0.6 rule" scaled from Caterpillar estimate for 2500 kWe		4	$113,010	$452,040
750 kWe system	"0.6 rule" scaled from Caterpillar estimate for 2500 kWe system		1	$62,739	$62,739
Combined systems FOB cost					$4,649,178
Instrumentation	Assume no cost	Assume no cost	0	0	0
Sales Tax	WA state tax	WA state tax	6.5%	--	$302,197
Shipping	0.05A	EPA Cost Manual	5.0%	--	$232,459
Subtotal Purchased Equipment Cost, PEC					$5,183,834
Direct Installation Costs					
Enclosure structural supports	Assume no cost	Assume no cost	0	$0	$0
Installation	1/2 of EPA Cost Manual	1/2 of EPA Cost Manual	2.5%	--	$129,596
Electrical	Assume no cost	Assume no cost	0	0	0
Piping	Assume no cost	Assume no cost	0	0	0
Insulation	Assume no cost	Assume no cost	0	0	0
Painting	Assume no cost	Assume no cost	0	0	0
Subtotal Direct Installation Costs					$129,596
Site Preparation and Buildings (SP)	Assume no cost	Assume no cost	0	0	0
Total Direct Costs, DC (PEC + Direct Installation + Site Prep)					$5,313,430
Indirect Costs (Installation)					
Engineering	0.025*PEC	1/4 of EPA Cost Manual	2.5%	--	$129,596
Construction and field expenses	0.025*PEC	1/2 of EPA Cost Manual	2.5%	--	$129,596
Contractor Fees	From DIS data center	From DIS data center	6.8%	--	$370,290
Startup	0.02*PEC	EPA Cost Manual	2.0%	--	$103,677
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$51,838
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$155,515
Subtotal Indirect Costs, IC					$940,511
Total Capital Investment (TCI = DC+IC)					$6,253,941
					TCI per gen #DIV/0!

TCI/PEC
1.21

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Table X. BACT Cost-Effectiveness for Catalyzed DPF

Item	Quantity	Units	Unit cost	Subtotal
Annualized Capital Recovery				
Total Capital Cost				$6,253,941
Capital Recovery Factor, 25 yrs, 4% discount rate				0.06401
Subtotal Annualized 25-year Capital Recovery Cost				$400,315
Direct Annual Costs				
Annual Admin charges	2% of TCI (EPA Manual)		0.02	$125,079
Annual Property tax	1% of TCI (EPA Manual)		0.01	$62,539
Annual Insurance	1% of TCI (EPA Manual)		0.01	$62,539
Annual operation/labor/maintenance costs: Upperbound estimate would assume CARB's value of $2.00/hp/year and would result in $282,000/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				$250,158
Total Annual Cost (Capital Recovery + Direct Annual Costs)				**$650,472**
Uncontrolled emissions (Combined Pollutants)				65.3
Annual Tons Removed (Combined Pollutants)				10.36
Cost Effectiveness ($ per tons combined pollutant destroyed)				**$62,816**

Annual O&M Cost Based on CARB Factors

Annual operation + maintenance (lowermost CARB estimate)	131,552	Installed hp	$2.00	$263,104

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)	
NOX	$10,000	0.00	$0	per year
CO	$5,000	7.76	$38,790	per year
VOC	$9,999	1.50	$15,045	per year
PM (FH+BH)	$23,200	1.09	$25,344	per year
Other				
Total Reasonable Annual Control Cost for Combined Pollutants			**$79,179**	**per year**
Actual Annual Control Cost			**$650,472**	**per year**
Is The Control Device Reasonable?			**NO (Actual >> Acceptable)**	

Criteria Pollutants Removal Tonnages (Nominal-Controlled)

Pollutant	PM (FH+BH)	CO	VOC	NOX	Other
Tier-2 Uncontrolled TPY	**1.21**	**8.62**	**1.881**	**53.5**	
Controlled TPY	**0.121**	**0.862**	**0.376**	**53.5**	
Tons Removed/Year	**1.09**	**7.76**	**1.505**	**0.0**	
Combined Uncontrolled Tons/yr	65.3				
Combined tons/yr Removed	10.36				
Quoted Removal Effcy	90%	90%	80%	0%	
Annualized Cost ($/yr)	$650,472	$650,472	$650,472	$650,472	$650,472
Indiv Poll $/Ton Removed	$595,455	$83,844	$432,297	#DIV/0!	

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)	
NO2	$20,000	0.00	$0	per year
CO	$5,000	7.76	$38,790	per year
Carcinogen VOC	$9,999	0.0239	$239	per year
DEEP (FH+BH)	$23,200	1.032	$23,936	per year
Non-carcinogen VOC	$5,000	0.0760	$380	per year
Total Reasonable Annual Control Cost for Combined Pollutants			**$63,345**	**per year**
Actual Annual Control Cost			**$650,472**	**per year**
Is The Control Device Reasonable?			**NO (Actual >> Acceptable)**	

TAPs Removal Tonnages (Nominal-Controlled)

Pollutant	DEEP (FH+BH)	CO	Carcinogen VOC	NO2	Non Carcinogen VOC	Acrolein
Tier-2 Uncontrolled TPY	**1.21**	**8.62**	**0.0299**	**5.35**	**0.0950**	**0.0002287**
Controlled TPY	**0.182**	**0.862**	**0.006**	**5.35**	**0.019**	**0.000046**
Tons Removed/Year	**1.032**	**7.76**	**0.0239**	**0.00**	**0.0760**	**0.000183**
Combined Uncontrolled Tons/yr	15.31					
Combined tons/yr Removed	8.89					
Overall Cold-Start Removal Effcy	85%	90%	80%	0%	80%	80%
Annualized Cost ($/yr)	$650,472	$650,472	$650,472	$650,472	$650,472	$650,472
Indiv Poll $/Ton Removed	$630,482	$83,844	$27,235,608	#DIV/0!	$8,561,360	$3,554,789,460
Combined TAPs $/Ton Removed	$73,170					

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Table X. BACT Capital Cost for Urea-SCR By Itself

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
2500 kWe emission control package	ROM cost estimate by Caterpillar		32	$200,600	$6,419,200
2000 kWe system	"0.6 rule" scaled from Caterpillar estimate for 2500 kWe		4	$175,463	$701,851
750 kWe system	"0.6 rule" scaled from Caterpillar estimate for 2500 kWe system		1	$97,410	$97,410
Combined systems FOB cost					$6,516,610
Instrumentation	Assume no cost	Assume no cost	0	0	0
Sales Tax	WA state tax	WA state tax	6.5%	--	$423,580
Shipping	0.05A	EPA Cost Manual	5.0%	--	$325,831
Subtotal Purchased Equipment Cost, PEC					$7,266,020
Direct Installation Costs					
Enclosure structural supports	Assume no cost	Assume no cost	0	$0	$0
Installation	1/2 of EPA Cost Manual	1/2 of EPA Cost Manual	2.5%	--	$181,651
Electrical	Assume no cost	Assume no cost	0	0	0
Piping	Assume no cost	Assume no cost	0	0	0
Insulation	Assume no cost	Assume no cost	0	0	0
Painting	Assume no cost	Assume no cost	0	0	0
Subtotal Direct Installation Costs					$181,651
Site Preparation and Buildings (SP)	Assume no cost	Assume no cost	0	0	0
Total Direct Costs, DC (PEC + Direct Installation + Site Prep)					$7,447,671
Indirect Costs (Installation)					
Engineering	0.025*PEC	1/4 of EPA Cost Manual	2.5%	--	$181,651
Construction and field expenses	0.025*PEC	1/2 of EPA Cost Manual	2.5%	--	$181,651
Contractor Fees	From DIS data center	From DIS data center	6.8%	--	$511,254
Startup	0.02*PEC	EPA Cost Manual	2.0%	--	$145,320
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$72,660
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$217,981
Subtotal Indirect Costs, IC					$1,310,516
Total Capital Investment (TCI = DC+IC)					$8,758,186
					TCI per gen #DIV/0!

TCI/PEC
1.21

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Table X. BACT Cost-Effectiveness for Urea-SCR By Itself

Item	Quantity	Units	Unit cost	Subtotal
Annualized Capital Recovery				
Total Capital Cost				$8,758,186
Capital Recovery Factor, 25 yrs, 4% discount rate				0.06401
Subtotal Annualized 25-year Capital Recovery Cost				$560,612
Direct Annual Costs				
Annual Admin charges	2% of TCI (EPA Manual)		0.02	$175,164
Annual Property tax	1% of TCI (EPA Manual)		0.01	$87,582
Annual Insurance	1% of TCI (EPA Manual)		0.01	$87,582
Annual operation/labor/maintenance costs: Upperbound estimate would assume CARB's value of $3.00/hp/year and would result in $423,000/year. Lower bound estimate would assume zero annual O&M. Mid-range value would account for urea, 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				$350,327
Total Annual Cost (Capital Recovery + Direct Annual Costs)				**$910,939**
Uncontrolled emissions (Combined Pollutants)				65.3
Annual Tons Removed (Combined Pollutants)				47.65
Cost Effectiveness ($ per tons combined pollutant destroyed)				**$19,115**

Annual O&M Cost Based on CARB Factors

Annual operation + maintenance (lowermost CARB estimate)	131,552	Installed hp	$3.00	$394,656

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)	
NOX	$10,000	47.65	$476,545	per year
CO	$5,000	0.00	$0	per year
VOC	$9,999	0.00	$0	per year
PM (FH+BH)	$23,200	0.00	$0	per year
Other				
Total Reasonable Annual Control Cost for Combined Pollutants			**$476,545**	**per year**
Actual Annual Control Cost			**$910,939**	**per year**
Is The Control Device Reasonable?			**NO (Actual >> Acceptable)**	

Criteria Pollutants Removal Tonnages (Nominal-Controlled)

Pollutant	PM (FH+BH)	CO	VOC	NOX	Other
Tier-2 Uncontrolled TPY	**1.21**	**8.62**	**1.881**	**53.5**	
Controlled TPY	**1.214**	**8.620**	**1.881**	**5.9**	
Tons Removed/Year	**0.00**	**0.00**	**0.000**	**47.7**	
Combined Uncontrolled Tons/yr	65.3				
Combined tons/yr Removed	47.65				
Quoted Removal Effcy	0%	0%	0%	89%	
Annualized Cost ($/yr)	$910,939	$910,939	$910,939	$910,939	$910,939
Indiv Poll $/Ton Removed	#DIV/0!	#DIV/0!	#DIV/0!	$19,115	

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)	
NO2	$20,000	4.77	$95,309	per year
CO	$5,000	0.00	$0	per year
Carcinogen VOC	$9,999	0.0000	$0	per year
DEEP (FH+BH)	$23,200	0.000	$0	per year
Non-carcinogen VOC	$5,000	0.0000	$0	per year
Total Reasonable Annual Control Cost for Combined Pollutants			**$95,309**	**per year**
Actual Annual Control Cost			**$910,939**	**per year**
Is The Control Device Reasonable?			**NO (Actual >> Acceptable)**	

TAPs Removal Tonnages (Nominal-Controlled)

Pollutant	DEEP (FH+BH)	CO	Carcinogen VOC	NO2	Non Carcinogen VOC	Acrolein
Tier-2 Uncontrolled TPY	**1.21**	**8.62**	**0.0299**	**5.35**	**0.0950**	**0.0002287**
Controlled TPY	**1.214**	**8.620**	**0.030**	**0.59**	**0.095**	**0.000229**
Tons Removed/Year	**0.000**	**0.00**	**0.0000**	**4.77**	**0.0000**	**0.000000**
Combined Uncontrolled Tons/yr	15.31					
Combined tons/yr Removed	4.77					
Overall Cold-Start Removal Effcy	0%	0%	0%	89%	0%	0%
Annualized Cost ($/yr)	$910,939	$910,939	$910,939	$910,939	$910,939	$910,939
Indiv Poll $/Ton Removed	#DIV/0!	#DIV/0!	#DIV/0!	$191,155	#DIV/0!	#DIV/0!
Combined TAPs $/Ton Removed	$191,155					

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Table X. BACT Capital Cost for DOC By Itself

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
2500 kWe emission control package	ROM cost estimate by Caterpillar		32	$52,100	$1,667,200
2000 kWe system	"0.6 rule" scaled from Caterpillar estimate for 2500 kWe		4	$45,571	$182,285
750 kWe system	"0.6 rule" scaled from Caterpillar estimate for 2500 kWe system		1	$25,299	$25,299
Combined systems FOB cost					$1,874,785
Instrumentation	Assume no cost	Assume no cost	0	0	0
Sales Tax	WA state tax	WA state tax	6.5%	--	$121,861
Shipping	0.05A	EPA Cost Manual	5.0%	--	$93,739
Subtotal Purchased Equipment Cost, PEC					$2,090,385
Direct Installation Costs					
Enclosure structural supports	Assume no cost	Assume no cost	0	$0	$0
Installation	1/2 of EPA Cost Manual	1/2 of EPA Cost Manual	2.5%	--	$52,260
Electrical	Assume no cost	Assume no cost	0	0	0
Piping	Assume no cost	Assume no cost	0	0	0
Insulation	Assume no cost	Assume no cost	0	0	0
Painting	Assume no cost	Assume no cost	0	0	0
Subtotal Direct Installation Costs					$52,260
Site Preparation and Buildings (SP)	Assume no cost	Assume no cost	0	0	0
Total Direct Costs, DC (PEC + Direct Installation + Site Prep)					$2,142,645
Indirect Costs (Installation)					
Engineering	0.025*PEC	1/4 of EPA Cost Manual	2.5%	--	$52,260
Construction and field expenses	0.025*PEC	1/2 of EPA Cost Manual	2.5%	--	$52,260
Contractor Fees	From DIS data center	From DIS data center	6.8%	--	$160,863
Startup	0.02*PEC	EPA Cost Manual	2.0%	--	$41,808
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$20,904
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$62,712
Subtotal Indirect Costs, IC					$390,805
Total Capital Investment (TCI = DC+IC)					$2,533,450
					TCI per gen #DIV/0!

TCI/PEC
1.21

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Table X. BACT Cost-Effectiveness for DOC By Itself

Item	Quantity	Units	Unit cost	Subtotal
Annualized Capital Recovery				
Total Capital Cost				$2,533,450
Capital Recovery Factor, 25 yrs, 4% discount rate				0.06401
Subtotal Annualized 25-year Capital Recovery Cost				$162,166
Direct Annual Costs				
Annual Admin charges	2% of TCI (EPA Manual)		0.02	$50,669
Annual Property tax	1% of TCI (EPA Manual)		0.01	$25,335
Annual Insurance	1% of TCI (EPA Manual)		0.01	$25,335
Annual operation/labor/maintenance costs: Upperbound 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				$101,338
Total Annual Cost (Capital Recovery + Direct Annual Costs)				**$263,504**
Uncontrolled emissions (Combined Pollutants)				65.3
Annual Tons Removed (Combined Pollutants)				9.51
Cost Effectiveness ($ per tons combined pollutant destroyed)				**$27,721**

Annual O&M Cost Based on CARB Factors

Annual operation + maintenance (lowermost CARB estimate)	131,552	Installed hp	$0.20	$26,310

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)	
NOX	$10,000	0.00	$0	per year
CO	$5,000	7.76	$38,790	per year
VOC	$9,999	1.50	$15,045	per year
PM (FH+BH)	$23,200	0.24	$5,632	per year
Other				
Total Reasonable Annual Control Cost for Combined Pollutants			**$59,468**	**per year**
Actual Annual Control Cost			**$263,504**	**per year**
Is The Control Device Reasonable?			**NO (Actual >> Acceptable)**	

Criteria Pollutants Removal Tonnages (Nominal-Controlled)

Pollutant	PM (FH+BH)	CO	VOC	NOX	Other
Tier-2 Uncontrolled TPY	**1.21**	**8.62**	**1.881**	**53.5**	
Controlled TPY	**0.971**	**0.862**	**0.376**	**53.5**	
Tons Removed/Year	**0.24**	**7.76**	**1.505**	**0.0**	
Combined Uncontrolled Tons/yr	65.3				
Combined tons/yr Removed	9.51				
Quoted Removal Effcy	20%	90%	80%	0%	
Annualized Cost ($/yr)	$263,504	$263,504	$263,504	$263,504	$263,504
Indiv Poll $/Ton Removed	$1,085,476	$33,965	$175,122	#DIV/0!	

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)	
NO2	$20,000	0.00	$0	per year
CO	$5,000	7.76	$38,790	per year
Carcinogen VOC	$9,999	0.0239	$239	per year
DEEP (FH+BH)	$23,200	0.243	$5,632	per year
Non-carcinogen VOC	$5,000	0.0760	$380	per year
Total Reasonable Annual Control Cost for Combined Pollutants			**$45,041**	**per year**
Actual Annual Control Cost			**$263,504**	**per year**
Is The Control Device Reasonable?			**NO (Actual >> Acceptable)**	

TAPs Removal Tonnages (Nominal-Controlled)

Pollutant	DEEP (FH+BH)	CO	Carcinogen VOC	NO2	Non Carcinogen VOC	Acrolein
Tier-2 Uncontrolled TPY	**1.21**	**8.62**	**0.0299**	**5.35**	**0.0950**	**0.0002287**
Controlled TPY	**0.971**	**0.862**	**0.006**	**5.35**	**0.019**	**0.000046**
Tons Removed/Year	**0.243**	**7.76**	**0.0239**	**0.00**	**0.0760**	**0.000183**
Combined Uncontrolled Tons/yr	15.31					
Combined tons/yr Removed	8.10					
Overall Cold-Start Removal Effcy	20%	90%	80%	0%	80%	80%
Annualized Cost ($/yr)	$263,504	$263,504	$263,504	$263,504	$263,504	$263,504
Indiv Poll $/Ton Removed	$1,085,476	$33,965	$11,033,051	#DIV/0!	$3,468,177	$1,440,033,028
Combined TAPs $/Ton Removed	$32,528					

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APPENDIX G

Ambient Air Quality Modeling

APPENDIX G
AERMOD INPUTS

	DEEP Annual Avg		PM Annual		NOx Annual Avg		NOx 1-hr Avg (NAAQS)		NOx 1-hr Avg (ASIL)		CO 1-hr & 8-hr Avg		PM 24-hr Avg		PM2.5 24-hr Avg		SO2 1-hr, 3-hr, 24-hr, Annual Avg		Acrolein 24-hr Avg	
Parameter	1.5 MW	2.5 MW	Cooling Towers		1.5 MW	2.5 MW	1.5 MW	2.5 MW	1.5 MW	2.5 MW	1.5 MW	2.5 MW	1.5 MW	2.5 MW	1.5 MW	2.5 MW	1.5 MW	2.5 MW	1.5 MW	2.5 MW
Emission Rate per Genset (lbs/yr)	20	29	20	29	345	467	--	--	--	--	--	--	--	--	--	--	1.31	2.6	--	--
Emission Rate per Genset (lbs/hr)	0.0023	0.0033	0.0023	0.0033	0.039	0.053	--	9.6	4.7	9.6	6.6	16.4	0.21	0.30	--	0.19	0.019	0.033	0.000010	0.000017
Emission Rate per Genset (g/sec)	0.00028	0.00042	0.00028	0.00042	0.0050	0.0067	--	1.2	0.59	1.2	0.83	2.1	0.026	0.038	--	0.024	0.0024	0.0042	0.0000012	0.0000022
No. of Gen Operationg Concurrently	5	32	5	32	5	32	0	4	5	32	5	32	5	32	0	4	5	32	5	32
Gen Exhaust Temp (F)	266	415	266	415	266	415	--	742	589	742	589	742	589	742	--	742	589	742	--	--
Gen Exhaust Temp (K)	403	486	403	486	403	486	--	668	582	668	582	668	582	668	--	668	582	668	--	--
Gen Stack Diameter (in)	14	18	14	18	14	18	--	18	14	18	14	18	14	18	--	18	14	18	--	--
Gen Stack Diameter (m)	0.36	0.46	0.36	0.46	0.36	0.46	--	0.46	0.36	0.46	0.36	0.46	0.36	0.46	--	0.46	0.36	0.46	--	--
Gen Flow Rate (ACFM)	2712	5090	2712	5090	2712	5090	--	16639	10557	16639	10557	16639	10557	16639	--	16639	10557	16639	--	--
Gen Exit Velocity (m/s)	13	15	13	15	13	15	--	48	50	48	50	48	50	48	--	48	50	48	--	--
Gen NO2:NOx Ratio	--	--	--	--	0.1	0.1	--	0.1	0.1	0.1	--	--	--	--	--	--	--	--	--	--
PVMRM O3 Concentration (ppb)	--	--	--	--	49	49	--	49	49	49	--	--	--	--	--	--	--	--	--	--
Emission Rate per CT (lbs/hr)	--	--	0.33		--	--	--	--	--	--	--	--	0.33		0.39		--	--	--	--
Emission Rate per CT (g/sec)	--	--	0.042		--	--	--	--	--	--	--	--	0.042		0.049		--	--	--	--
No. of CTs Operating Concurrently			32										32		32					
CT Exhaust Temp (F)	--	--	80		--	--	--	--	--	--	--	--	80		80		--	--	--	--
CT Exhaust Temp (K)	--	--	300		--	--	--	--	--	--	--	--	300		300		--	--	--	--
CT Stack Diameter (in)	--	--	100		--	--	--	--	--	--	--	--	100		100		--	--	--	--
CT Stack Diameter (m)	--	--	2.5		--	--	--	--	--	--	--	--	2.5		2.5		--	--	--	--
CT Flow Rate (ACFM)	--	--	280100		--	--	--	--	--	--	--	--	280100		280100		--	--	--	--
CT Exit Velocity (m/s)	--	--	26		--	--	--	--	--	--	--	--	26		26		--	--	--	--

Adjusted AERMOD Dispersion Factors

Original AERMOD Configuration: CNR Gensets = 1500 kW; Admin Genset = 1500 kW

Revised Configuration: CNR Gensets = 2500 kW; Admin Genset = 750 kW

Pollutant and Averaging Period	Operating Scenario	Original Gnerator Ambient Impact (ug/m3) with CNR Gens = 1500 kWe	Original Facility-Wide Emission Rate for CNR Gens = 1500 kWe	Emission Rate Units	Adjusted Facility-Wide Emission Rate for CNR Gens = 2500 kW	Emission Rate Adjustment Factor for CNR Gens = 2500 kWe	Revised Generator Ambient Impact (ug/m3) for CNR Gens = 2500 kWe
24-hr PM10 NAAQS	Facility Wide Power Outage	11	246	lbs/day DEEP	252	1.024	11.3
1-hr NO2 ASIL	Facility Wide Power Outage	366	332	lbs/hr Nox	352	1.060	388
1-hr CO NAAQS	Facility Wide Power Outage	1507	559	lbs/hr CO	593	1.061	1599
8-hr CO NAAQS	Facility Wide Power Outage	873	559	lbs/hr CO	593	1.061	926
Annual NO2	Combined Annual Operations	1.1	8.33	tons/year NOX	8.57	1.029	1.1
Annual DEEP at MIBR	Combined Annual Operations	0.077	0.516	tons/year DEEP	0.531	1.029	0.079

P:\1409\001\010\WIP\T\Emission Calcs\Preliminary Emissions Provided to Ecology & URS\[CNR 2500 Emission Calculations.xlsx]Adjusted Dispersion Factors

AERMOD RESULTS FOR MICROSOFT MWH-01

Updated 2/7/2014 to adjust generator runtime to 24 hrs/day during electrical bypass

PM2.5 - 24 hr NAAQS

Proposed Project (4th high):

Year	Total Concentration (ug/m3)	Generators	CT (ug/m3)	Receptor	Date	Filename
2001	13.53	1.36	12.17	5000 52358	1072824	PM25-120613a
2002	14.02	1.55	12.47	5000 52358	2062724	PM25-120613b
2003	14.43	1.44	12.99	25000 52358	3/23/2003	PM25-120613c
2004	14.27	1.75	12.52	5000 52358	4070724	PM25-120613d
2005	13.45	1.55	11.90	5000 52358	5061224	PM25-120613e

	2001-2003	2002-2004	2003-2005
Rolling 3-yr Average (4th high) - 4 Gens @ 16 hrs/day	1.45	1.58	1.58
Rolling 3-yr Average (4th high) - CTs	12.54	12.66	12.47

To scale up to 4 gens @ 24 hrs, calculated value = 1.58 * (24/16) = 2.37 ug/m3

Background:

Year	Concentration (ug/m3)	Filename
2001		
2002		
2003	0.021	PM25-120613g
2004		
2005		

	2001-2003	2002-2004	2003-2005
Rolling 3-yr Average	0.02	0.02	0.02

Year	Concentration (ug/m3)	Receptor	Date	Filename

Emission Source	Concentration (ug/m3)
24-hr PM 2.5 NAAQS	
MWH-01	14.2
Local Background (Dell, Microsoft, ConAgra)	0.021
Regional Background	21.0
Total PM 2.5 Concentration	35.3

Info not used

P:\1409\001\010\WIP\T\Air Modeling\[Model Runtime Log.xlsx]PM2.5 Results (4th high)

SCALING OF COOLING TOWER AERMOD RUNS BASED ON ORIGINAL DISPERSION FACTORS AND BASED ON WCTI EMISSION RATES WITH DROPLET SIZE DISTRIBUTION

		Original AERMOD Dispersion Factor			Manually-Adjusted AERMOD for With WCTI and Droplet Size Dist	
Pollutant and Avg. Time	Model ID	Emission Rate Each of 32 towers (lb/hr)	Original AERMOD Concentration (ug/m3)		WCTI Emission Rate Each of 32 towers (lb/hr)	Adjusted Concentration (ug/m3)
PM10 - annual	PM10-121313a	0.33	3.90		0.0913	1.079
PM10 - 24 hr	PM10-121313b	0.33	31.56	1st high	0.0913	8.73
PM2.5 annual	PM10-121313a	0.33	3.90		0.0213	0.25
PM2.5 24-hr 2001	PM25-120613b	0.39	12.17		0.0213	0.66
PM2.5 24-hr 2002	PM25-120613c	0.39	12.47		0.0213	0.68
PM2.5 24-hr 2003	PM25-120613d	0.39	12.66		0.0213	0.69
PM2.5 24-hr 2004	PM25-120613e	0.39	12.52		0.0213	0.68
PM2.5 24-hr 2005		0.39	Unsuccessful AERMOD			
TSP-24 hr	PM10-121313b	0.33	31.56	1st high	0.164	15.7
TSP-Annual	PM10-121313a	0.33	3.9		0.164	1.9

P:\1409\001\010\WIP\T\Air Modeling\[Model Runtime Log.xlsx]PM2.5 Results (4th high)

APPENDIX H

AERMOD Files

(Provided under separate cover)