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Responses to Questions Regarding HBRP Emission Calculations

January 17, 2007

1. ***What is the maximum continuous brake horsepower for the Wärtsilä engines?***

The maximum continuous brake horsepower for the Wärtsilä engines is 22,931 bhp (see Tables 8.1A-2 and 8.1A-3, Case 5).

2. ***What is the exhaust temperature at the catalyst?***

Exhaust temperatures at the entrance to the catalyst module will vary by fuel and load, as follows:

Fuel	Exhaust Temperature at Catalyst Module Entrance, °F					
	1) Hot Base	2) Hot Low	3) Hot Mid	4) Cold Mid	5) Cold Base	6) Cold Low
Natural Gas	760	840	819	808	748	840
Liquid Fuel	705	732	685	615	635	663

3. ***How many cylinders are in the Wärtsilä engines?***

Each engine has 18 cylinders.

4. ***Please provide the references for the fuel analyses in Tables 8.1-11A and 8.1-11B.***

Natural gas fuel: PG&E design fuel specification (attached).

CARB Diesel fuel: CARB specification for sulfur and aromatics content; Wärtsilä data for higher heating value; Chevron Products Company Exchange Specifications for Diesel fuels in the Western Region, Ultra Low Sulfur S15 (attached) for API gravity, cetane number and ash content. Flash point is typical for Diesel fuel. Please note that the values provided for API gravity, cetane number, ash content and flash point are nominal and were not used in any calculations. The value provided for the aromatics content is a fuel specification limit, but was not used in any calculations.

5. ***Please identify the exhaust flow rates associated with the heat input rates for each fuel shown in Table 8.1-14.***

The hourly, daily and annual heat input rates shown in Table 8.1-14 correspond to the maximum heat input operating cases, which occur under full load conditions. The exhaust gas flow rates for these conditions are shown as Case 5 in Table 8.1A-2 (natural gas firing with diesel pilot injection) and Case 1 in Table 8.1A-3 (Backup diesel fuel firing).

6. *Please submit detailed calculations for Table 8.1-15.*

All mass emission rates shown reflect maximum hourly heat input (Case 5 from Table 8.1A-2 for natural gas firing and Case 1 from Table 8.1A-3 for liquid fuel firing).

Natural gas firing, NOx

Convert NOx concentration at 15% O_2 to actual oxygen concentration at full load (from Table 8.1A-2, Case 5):

$$6.0 \text{ ppmvd @ } 15\% \ O_2 \times \frac{(20.95 - 11.564)}{(20.95 - 15)} = 9.465 \text{ ppmvd @ } 11.56\% \ O_2$$

NOx (as NO_2) mass emission rate for Case 5 is therefore

$$\frac{9.465 \text{ ppmvd}}{10^6} \left| \frac{45{,}533 \text{ dscf}}{\text{Min}} \right| \frac{60 \text{ min}}{1 \text{ hr}} \left| \frac{1 \text{ lb-mol}}{385.3 \text{ dscf}} \right| \frac{46.01 \text{ lb NOx}}{\text{lb-mol}} = 3.13 \text{ lb NOx/hr}$$

Hourly heat input rate for Case 5 is 143.9 MMBtu/hr, so

$$\frac{3.13 \text{ lb NOx/hr}}{143.9 \text{ MMBtu/hr}} = 0.022 \text{ lb NOx/MMBtu}$$

Natural gas firing, SOx

Maximum sulfur content of natural gas is assumed to be 1 grain per 100 dscf of natural gas.

$$\frac{1 \text{ grain}}{100 \text{ dscf}} \left| \frac{1 \text{ lb}}{7000 \text{ grains}} \right| \frac{1 \text{ scf}}{1021.1 \text{ Btu}} \left| \frac{10^6 \text{ Btu}}{\text{MMBtu}} \right| \frac{64.06 \text{ lb } SO_2}{32.06 \text{ lb S}} = 0.0028 \text{ lb } SO_2\text{/MMBtu}$$

Hourly heat input rate for Case 5 is 143.9 MMBtu/hr, so

$$0.0028 \text{ lb } SO_2\text{/MMBtu} * 143.9 \text{ MMBtu/hr} = 0.4 \text{ lb } SO_2\text{/hr}$$

$$0.4 \text{ lb } SO_2\text{/hr} \left| \frac{1 \text{ hr}}{60 \text{ min}} \right| \frac{1 \text{ min}}{45{,}533 \text{ dscf}} \left| \frac{385.3 \text{ dscf}}{1 \text{ lb-mol}} \right| \frac{1 \text{ lb-mol}}{64.06 \text{ lb } SO_2} \left| \frac{10^6}{} \right. = 0.886 \text{ ppmvd @ } 11.56\% \ O_2$$

Converting to 15% O_2,

$$0.886 \text{ ppmvd @ } 11.56\% \ O_2 \times \frac{(20.95 - 15)}{(20.95 - 11.564)} = 0.55 \text{ ppmvd @ } 15\% \ O_2$$

Natural gas firing, CO

Convert CO concentration at 15% O_2 to actual oxygen concentration at full load (from Table 8.1A-2, Case 5):

$$13.0 \text{ ppmvd @ } 15\% \ O_2 \times \frac{(20.95 - 11.564)}{(20.95 - 15)} = 20.507 \text{ ppmvd @ } 11.56\% \ O_2$$

CO mass emission rate for Case 5 is therefore

20.507 ppmvd	45,533 dscf	60 min	1 lb-mol	28.01 lb CO	= 4.13 lb CO/hr
10^6	min	1 hr	385.3 dscf	lb-mol	

Hourly heat input rate for Case 5 is 143.9 MMBtu/hr, so

$$\frac{4.13 \text{ lb CO/hr}}{143.9 \text{ MMBtu/hr}} = 0.029 \text{ lb CO/MMBtu}$$

Natural gas firing, ROG

Convert ROG concentration at 15% O_2 to actual oxygen concentration at full load (from Table 8.1A-2, Case 5):

$$28.0 \text{ ppmvd @ } 15\% \ O_2 \times \frac{(20.95 - 11.564)}{(20.95 - 15)} = 44.170 \text{ ppmvd @ } 11.56\% \ O_2$$

ROG (as CH_4) mass emission rate for Case 5 is therefore

44.170 ppmvd	45,533 dscf	60 min	1 lb-mol	16.04 lb CH_4	= 5.10 lb ROG/hr
10^6	Min	1 hr	385.3 dscf	lb-mol	

Hourly heat input rate for Case 5 is 143.9 MMBtu/hr, so

$$\frac{5.10 \text{ lb ROG/hr}}{143.9 \text{ MMBtu/hr}} = 0.035 \text{ lb ROG/MMBtu}$$

Natural gas firing, PM_{10}

PM_{10} emission rate was provided by the manufacturer.

CARB Diesel firing, NOx

Convert NOx concentration at 15% O_2 to actual oxygen concentration at full load (from Table 8.1A-3, Case 1):

$$35.0 \text{ ppmvd @ } 15\% \ O_2 \times \frac{(20.95 - 12.34)}{(20.95 - 15)} = 50.66 \text{ ppmvd @ } 12.34\% \ O_2$$

NOx (as NO_2) mass emission rate for Case 5 is therefore

$$\frac{50.66 \text{ ppmvd}}{10^6} \times \frac{54{,}078 \text{ dscf}}{\text{min}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{1 \text{ lb-mol}}{385.3 \text{ dscf}} \times \frac{46.01 \text{ lb NOx}}{\text{lb-mol}} = 19.92 \text{ lb NOx/hr}$$ [1]

Hourly heat input rate for Case 5 is 148.6 MMBtu/hr, so

$$\frac{19.92 \text{ lb NOx/hr}}{148.9 \text{ MMBtu/hr}} = 0.134 \text{ lb NOx/MMBtu}$$

CARB Diesel firing, SOx

Maximum sulfur content of liquid fuel is limited by regulation to 15 ppmw.

$$\frac{15 \text{ lb S}}{10^6 \text{ lb fuel}} \times \frac{1 \text{ lb}}{19{,}692 \text{ Btu}} \times \frac{10^6 \text{ Btu}}{\text{MMBtu}} \times \frac{64.06 \text{ lb } SO_2}{32.06 \text{ lb S}} = 0.0015 \text{ lb } SO_2\text{/MMBtu}$$

Hourly heat input rate for Case 1 is 148.9 MMBtu/hr, so

$$0.0015 \text{ lb } SO_2\text{/MMBtu} * 148.9 \text{ MMBtu/hr} = 0.22 \text{ lb } SO_2\text{/hr}$$

$$0.22 \text{ lb } SO_2\text{/hr} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{1 \text{ min}}{54{,}078 \text{ dscf}} \times \frac{385.3 \text{ dscf}}{1 \text{ lb-mol}} \times \frac{1 \text{ lb-mol}}{64.06 \text{ lb } SO_2} \times 10^6 = 0.40 \text{ ppmvd @ } 12.34\% \ O_2$$

Converting to 15% O_2,

$$0.\ 40 \text{ ppmvd @ } 12.34\% \ O_2 \times \frac{(20.95 - 15)}{(20.95 - 12.34)} = 0.27 \text{ ppmvd @ } 15\% \ O_2$$ [2]

[1] Value of 19.2 lb/hr in Table 8.1-15 is a typographical error. 19.92 lb/hr was used in calculating maximum daily and annual emissions; see Table 8.1A-6.

[2] Value of 0.40 ppmc in Table 8.1-15 is actually SO_2 concentration at actual O_2, not reference O_2. This concentration was shown only for information and was not used in any emissions calculations.

CARB Diesel firing, CO

Convert CO concentration at 15% O_2 to actual oxygen concentration at full load (from Table 8.1A-3, Case 1):

$$20.0 \text{ ppmvd @ } 15\%\ O_2 \times \frac{(20.95 - 12.34)}{(20.95 - 15)} = 28.95 \text{ ppmvd @ } 12.34\%\ O_2$$

CO mass emission rate for Case 1 is therefore

$$\frac{28.95 \text{ ppmvd}}{10^6} \left| \frac{54{,}078 \text{ dscf}}{\text{min}} \right| \frac{60 \text{ min}}{1 \text{ hr}} \left| \frac{1 \text{ lb-mol}}{385.3 \text{ dscf}} \right| \frac{28.01 \text{ lb CO}}{\text{lb-mol}} = 6.93 \text{ lb CO/hr}$$

Hourly heat input rate for Case 1 is 148.9 MMBtu/hr, so

$$\frac{6.93 \text{ lb CO/hr}}{148.9 \text{ MMBtu/hr}} = 0.047 \text{ lb CO/MMBtu}$$

CARB Diesel firing, ROG

Convert ROG concentration at 15% O_2 to actual oxygen concentration at full load (from Table 8.1A-3, Case 1):

$$40.0 \text{ ppmvd @ } 15\%\ O_2 \times \frac{(20.95 - 12.34)}{(20.95 - 15)} = 57.90 \text{ ppmvd @ } 12.34\%\ O_2$$

ROG (as CH_4) mass emission rate for Case 5 is therefore

$$\frac{57.90 \text{ ppmvd}}{10^6} \left| \frac{54{,}078 \text{ dscf}}{\text{Min}} \right| \frac{60 \text{ min}}{1 \text{ hr}} \left| \frac{1 \text{ lb-mol}}{385.3 \text{ dscf}} \right| \frac{16.04 \text{ lb } CH_4}{\text{lb-mol}} = 7.94 \text{ lb ROG/hr}$$

Hourly heat input rate for Case 1 is 148.9 MMBtu/hr, so

$$\frac{7.94 \text{ lb ROG/hr}}{148.9 \text{ MMBtu/hr}} = 0.053 \text{ lb ROG/MMBtu}$$

CARB Diesel firing, PM_{10}

PM_{10} emission rate was provided by the manufacturer.

Exhibit E, Attachment 6

Fuel Specifications

This Attachment 6 provides the fuel specifications for the project, which shall be in accordance with tariff Rule 21, Section C, Transportation of Natural Gas, located at PG&E's website http://www.pge.com/tariffs/doc/GR21.doc. The guarantees shall be based on the design values of the fuel properties. The Project shall be capable of operating over the full range of fuel properties indicated below.

1. Natural Gas

	Design Value*	**Range***
Hexane (C6)	0.014	0 – 0.03
Propane (C3)	0.246	0.10 – 0.50
I Butane (C4)	0.030	0 – 0.06
N Butane (C4)	0.036	0 – 0.06
Iso Pent (C5)	0.010	0 – 0.03
N Pent (C5)	0.007	0 – 0.03
Nitrogen	1.030	0.90 – 1.20
Methane (C1)	95.642	94.5 – 96.5
CO2	0.671	0.50 – 1.00
Ethane (C2)	2.315	1.8 – 3.0
Total	100.00	
Hydrogen (% volume)		Max. 2
Water and hydrocarbons condensates before engine		Not allowed
Ammonia (mg/m^3_N)		Max. 25
Chlorine + fluorine (mg/m^3_N)		Max. 50
Particles and solids (mg/m^3_N)		Max. 50
Particles and solids size (um)		Max. 5
Pressure delivered to interconnection point (psig)		170 – 320 psig at the revenue meter

Temperature delivered to interconnection point (^oF)	60	60 – 100 at the revenue meter
Temperature delivered to interconnection point relative to hydrocarbon dewpoint,		See Tariff Rule 21, Section C, "Quality of Gas"
Heating Value, HHV **	1021.1	1010 – 1030
Compressibility Factor	1.0021	1.0021
Real Relative Density	0.581	0.57 - 0.59
Methane Number	90	Approximately 86 - 93

* % Mole at 14.730 psia and uncorrected for compressibility

** HHV is in Dry Btu at 14.730 psia and 60ºF and corrected for compressibility

Additional notes:

- The sum of other hydrocarbons besides those specified above (C1 through C6 compounds) shall not to exceed 0.05 mass-%.
- Aromatic hydrocarbons, or silicon based compounds or impurities resulting from the operating and maintenance of the gas delivery systems are not allowed.
- Total sulfur not to exceed 5 ppm on a mass basis.
- It is understood that variations in the gas composition inside the specification will occur and are permitted; however sudden extreme changes in gas temperature, pressure or composition are not allowed.

2. Distillate Fuel

Per California regulations, the liquid distillate fuel for the Project shall meet the specifications set by the California Air Resources Board (CARB) for Ultra Low Sulfur Diesel fuel. The fuel shall have a sulfur content of less than or equal to 15 ppm by weight and comply with the following Sections in California Code of Regulations:

Title 13, Sections 2281 through 2285
Title 17, Section 93114

3. Bio Diesel Fuel

The units shall be capable of continuous operation on Bio Diesel fuel. This fuel shall be of the B20 blend, and comply with industry standard ASTM D6751.

CHEVRON PRODUCTS COMPANY
EXCHANGE SPECIFICATIONS
ASTM DIESEL GRADE HS NO. 2D, LS NO. 2D AND CARB VEHICULAR DIESEL
WESTERN REGION

SPECIFICATION TEST	Methods	High Sulfur S5000	Low Sulfur S500	Ultra Low Sulfur S15	CARB Vehicle S15
Color	(1) Visual	Red	See Note 1	See Note 1	See Note 1
Appearance at 70°F	(1) D 4176	Bright and Clear	Bright and Clear	Bright and Clear	Bright and Clear
API Gravity, Min.	(2 D 1298 or D 4052(2)	30	30	30	30
Flash Point, PM °F, Min.	(3) D 93	125	125	125	125
Aromatics, Mass %, Max.	D 5186				10
Cetane Number, Min.	(5) D 613	40	40	40	40
Cetane Index, Min.	D 4737	40	40	40	40
Cetane Index, Min.	(6) D 976		40	40	
Sulfur, Mass %, Max.	D 2622 or D 4294 or D 5453 or D 7039 or D5453	0.5	0.05 (7)	0.0015	0.0015
Distillation, °F, 90% Recovery	D 86	540 - 640	540 - 640	540 - 640	540 - 640
Viscosity, Kin., cSt @ 40 °F	D 445	1.9 - 4.1	1.9 - 4.1	1.9 - 4.1	1.9 - 4.1
Carbon Resid. Rams. 10% Bottoms, Mas %.	D 524 or D 4530	0.35	0.35	0.35	0.35
Ash, Mass %, Max.	D 482	0.01	0.01	0.01	0.01
Sediment and Water, Vol. %, Max.	D 2709	0.05	0.05	0.05	0.05
Copper Corrosion, Max. 3 Hours at 122°F	D 130	3	3	3	3
Thermal Stability, 90 Minutes % Reflectance, Min.	(8) D 6468	80	80	80	80
Cloud Point, °F, Max.	(9) D 2500	See Notes	See Notes	See Notes	See Notes
Pour Point, °F, Max.	D 97	See Notes	See Notes	See Notes	See Notes

NOTES:

1. High sulfur diesel must be dyed at the refinery (EPA regulations) to a visible pink color. According to IRS this fuel must contain Dye Solvent 164 at a concentration spectrally equivalent to 3.9 pounds per thousand barrels (PTB) (11.13 mg/liter) of solid dye Standard Solvent red 26. Low sulfur, ultra low sulfur and CARB diesel are generally on road diesels and consequently not dyed. However, if they are sold as non-taxable diesel or heating fuel they must be dyed to 3.9 PTB.

2. The Kinder Morgan Pipelines and the Chevron Pipelines have a minimum 30 API gravity specification.
3. 125 ºF flash point minimum is for vehicles. Some marine fuels and utility companies require a 140 ºF flash point.
4. CARB regulation limits the aromatics to 10 volume % maximum. CARB also permits the use of a CARB "alternate diesel" formulation. CARB alternate formulations specify the sulfur, cetane number, aromatics, nitrogen and poly nuclear aromatics levels. The supplier must certify that the diesel is per Title 13, California Code of Regulations, Sections 2281 and 2282. Aromatics content method D1319 has poor reproducibility with diesels. CARB allows the use of the more precise D5168. CARB "alternate diesel formulas" must report aromatics in mass %.
5. D4737 may be used in lieu of D613 however; D613 shall be run at intervals to assure compliance. CARB approved "alternate diesel formulas" must be tested by D613 and meet the minimum cetane designated by the CARB certification formula for that fuel. D4737, procedure A is applicable to high sulfur diesel and procedure B is applicable to low sulfur and ultra low sulfur diesel.
6. D976 is a substitute allowed by EPA in place of testing for aromatics. It is not a substitute for D613. For cetane index, D4737 must be used.
7. Both low sulfur (S500) and ultra low sulfur diesel (S15) are legal on-highway fuels through June 1, 2010 outside of California. Inside California only CARB ultra low sulfur diesel is allowed for al l vehicle diesel (on and off road) and stationary equipment. Also see note 4 for California diesel.
8. If the supplier uses a different test method for determining stability, the fuel must meet an equivalent specification. We reserve the right to reject fuel as not "fit for purpose" that does not meet this specification.
9. During the winter, field blending of with number one grades may be necessary to reach the desired cloud point in a certain location. When the cloud point is less than 10 ºF, the minimum flash point can be 100 ºF, the minimum viscosity 1.7cSt, and the minimum 90% recovered is waived.

Cloud Point and Pour Point Requirements:

AREA	**DATE**	**CLOUD POINT °F MAX.**	**POUR POINT °F MAX.**
El Segundo Distribution Area	September 1 - March 31	+ 24	+20
	April 1 - August 31	+36	+25
El Paso Distribution Area			
Albuquerque (Chevron PL)	September 1 - October 31	+20	0
	November 1 - February 15	+10	-10
	February 16 - February 28	+16	-5
	March 1 - March 15	+20	+5
	March 16 - April 15	+24	+5
	April 16 - August 31	+36	+20
El Paso, Tucson (KMEP)	September 1 - November 30	+24	+5
	December 1 - January 31	+18	0
	February 1 - April 15	+24	+5
	April 16 - August 31	+36	+20
Western Washington (Olympic Pipeline)	November 1 - February 28	+14	+0
	March 1 - August 31	+24	+15

Salt Lake City/ Pocatello/Boise/Idaho (CPL) and Spokane	September 1 - September 30	+24	+15
	October 1 - February 29	+26	-20
	March 1 - March 31	+24	+15
	April 1 - August 31	+32	+20
Pasco (CPL)	September 1 - October 30	+24	+15
	November 1 - February 28	+14	+0
	March 1 - March 31	+24	+15
	April 1 - July 31	+32	+20
Willbridge Distribution Area	September 1 - February 29	+18	+15
	March 1 - March 31	+30	+20
	April 1 - August 31	+36	+20
Hawaii	January 1 - December 31	+50	Report

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