Nahid Zoueshtiagh/R9/USEPA/US
03/08/2006 11:25 AM

To Joseph Lapka/R9/USEPA/US@EPA
cc
bcc
Subject Fw: can you please resend 6/10/05 email

fyi

----- Forwarded by Nahid Zoueshtiagh/R9/USEPA/US on 03/08/2006 11:25 AM -----

KWright@entrix.com
06/17/2005 03:06 PM

To Nahid Zoueshtiagh/R9/USEPA/US@EPA
cc
Subject Re: can you please resend 6/10/05 email

Nahid:

Per your request, attached below is a copy of the information I sent you on 6/10/05:

Per our telephone conference of Monday June 6, 2005, you requested the following in order to finalize your review of the Cabrillo Port Emissions estimates:

- An updated Hazardous Air Pollutant (HAPS) Emissions Inventory
- Comparison Chart of PSD Permit Submittals
- Example Emission Calculations for FSRU Equipment and Vessels

The attached files provide our responses to these requests. Should you have any questions concerning these responses to your requests, please contact me.

Kevin Wright
Air Resources
ENTRIX, Inc.
TEL 702-413-1020, Ext. 224
FAX 702-413-1721

Cabrillo Port Applic Compare_ Final.doc FSRU HAP Emissions.xls

Cabrillo Port Equipment EETs.doc

Equipment Category & Parameters		Dec. 2003 PSD Application	August 2004 Supplemental	May 9, 2005 Supplemental	May 24, 2005 Supplemental
Wartsila Main Generators:					
Engine Type		20V34SG	9L50DF	9L50DF	9L50DF
Engine Specifications		Wartsila Emissions Study Report (4/7/03)			Wartsila Specification 00470507S504 (5/13/05)
Engine Operating Scenario		2 Engines	3 Engines	3 Engines	3 Engines
Emissions Controls		SCR and Oxidation Catalyst	SCR and Oxidation Catalyst	SCR and Oxidation Catalyst	SCR and Oxidation Catalyst
Emission Limits (ppm)	NO_x	15	9	9	9
	VOC	43	48	48	40
	CO	32.8	33	33	20
Annual Emissions (tons/yr)	NO_x	21	13.82	13.1	13.3
	VOC	21	25.91	24.6	20.6
	CO	28	31.09	29.5	18
Wartsila Main Generators (Diesel Back-up):					
Engine Type		18V32DF	9L50DF	9L50DF	9L50DF
Engine Specifications		Wartsila Emissions Study Report (4/7/03), Engineering Estimates			Wartsila Specification 00470507S504 (5/13/05)
Engine Operating Scenario		100 hrs/yr (Diesel) 100 hrs/yr (Gas)	100 hrs/yr (Diesel)	100 hrs/yr (Diesel)	100 hrs/yr (Diesel)
Emissions Controls		Current Tier I Standards	Current Tier I Standards	2006 Tier II Standards	2006 Tier II, SCR and Oxidation Catalyst
Annual Emissions (tons/yr)	NO_x	6.3	5.09	4.0	1.9
	VOC	0.5	0.73	0.2	0.3
	CO	0.7	3.18	0.2	0.2
Freefall Lifeboats					
Engine Operating Scenario		One (1) boat engine limited to 50 hours per year		Three (3) identical boat engines limited to a total of 50 hours per year	
Emissions Controls		Tier II standards	Tier II standards	Tier II standards	Tier II standards

Equipment Category & Parameters		Dec. 2003 PSD Application	August 2004 Supplemental	May 9, 2005 Supplemental	May 24, 2005 Supplemental
Emergency Diesel Engines					
Operating Scenario		200 hrs/yr	100 hrs/yr	100 hrs/yr	100 hrs/yr
Emissions Controls		Current Tier II Standard	Current Tier II Standard	2006 Tier II Standards	2006 Tier II Standards
Annual Emissions (tons/yr)	NO_x	9.86	2.96	3.0	3.0
	VOC	1.40	0.42	0.40	0.40
	CO	12.11	1.85	1.90	1.90
Submerged Combustion Vaporizers (SCVs)					
Specifications		COSTAIN Study Report, AP-42 EFs	COSTAIN Study Report, AP-42 EFs	Selas Specification Sub-X LE (2/18/05), COSTAIN Study Report, AP-42 EFs	
Operating Scenarios		8 total SCVs, 5 SCVs operating at any one time		8 total SCVs, 4 SCVs operating at any one time	
Annual Fuel Gas Burned		1571 MMCF/yr	1665 MMCF/yr	3999 MMCF/yr	3999 MMCF/yr
Emissions Controls		Water Bath only	Water Bath, Low-NO_x Burners		
Emission Limits (ppm)	NO_x	40	20	20	20
	VOC	4.1	4.1	4.1	4.1
	CO	50	50	100	100
Annual Emissions (tons/yr)	NO_x	38.6	20.46	48.9	48.9
	VOC	1.4	1.46	3.5	3.5
	CO	29.4	31.14	148.9	148.9

Equipment Category & Parameters		Dec. 2003 PSD Application	August 2004 Supplemental	May 9, 2005 Supplemental	May 24, 2005 Supplemental
Supply Boats/Tugs (District Waters)					
Operating Scenario		Tug and supply boat activity separate; No Federal and District Waters delineation	Tug and Supply Boat activity separate; District Waters emissions delineation; Tug Boats: 120 hrs/yr; Supply Boats: 104 hrs/yr	Tug and Supply Boat activity combined; District Waters emissions delineation; Tug/Supply Boat: 52 hrs/yr	
Emissions Controls		AP-42 EFs, CA Diesel	2006 Tier II standards, CA diesel	LNG/CA Diesel Dual Fuel	
Annual Emissions (tons/yr) (District Waters)	NO_x	N/A	3.71	0.73	
	VOC	N/A	0.53	0.10	
	CO	N/A	2.32	0.48	
Crew Boats (District Waters)					
Operating Scenario		364 hrs/yr	52 hrs/yr	172 hrs/yr	
Emissions Controls		AP-42 EFs, CA Diesel	2006 Tier II Standards; CA Diesel	LNG Fuel	
Annual Emissions (tons/yr) (District Waters)	NO_x	N/A	0.10	0.41	
	VOC	N/A	0.01	0.06	
	CO	N/A	0.06	0.27	

FSRU HAP Emissions

HAP EMITTENT NAME	Emission Rates (Controlled)						
	Main Gens	Backup Gen	Vaporizers	Emergency	Life Boat	Diesel Tank	Total
	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	tons/yr
Acetaldehyde	2,013	0.05	12	0.11	0.02		1.01
Acrolein	1,238	0.02	11	0.03	0.00		0.62
Benzene	230	3.35	8	3.23	0.03	0.1	0.12
Butadiene -1,3	139	0.17	-	0.16	0.00		0.07
Ethyl Benzene	21	-	28	-	-		0.02
Formaldehyde	12,717	0.16	300	0.33	0.04		6.51
Hexane	579	-	18	-	-		0.30
Naphthalene	39	0.56	2	0.54	0.00		0.02
PAHs	14	0.35	0	0.34	0.00		0.01
Propylene	-	12.03	2,120	11.63	0.08		1.07
Toluene	213	1.21	14	1.17	0.01	0.3	0.11
Xylenes	96	0.83	79	0.80	0.01	0.3	0.09
Facility Total HAPS							**9.96**

Device Notes:

FSRU throughput 800 mmcf/day, 365 days/yr, 292 mmmcf/yr total

Three 9L50DF main generators (8.25 MW each) operating at 100% load for hourly max, 110,903 MW-hr annual total, 99.4% gas fuel, 0.006% diesel pilot fuel (heat input)

Backup 9L50DF generator operating at 100% load for 100 machine hours per year, diesel fuel, 2006 Tier 2 standards

Four SCVs operating at 100% capacity factor for 8,760 hrs/yr, low-NOx burners

Emergency fire pump and generator operating at 100% load for 100 machine hours each per year, diesel fuel, 2006 Tier 2 standards

Three Life Boats exercising at 100% load for 50 machine hours per year total, diesel fuel, 2006 Tier 2 standards

Diesel Storage Tank, 145,000 gallon capacity, throughput based on diesel fuel usage defined above for applicable devices

Cabrillo Port Emission Calculation Methodology

1.0 Wartsila 9L50DF Dual Fuel Main Generators (3)

Heat Rate = 7196 BTU/kw-hr gas + 43 BTU/kw-hr diesel = 7239 BTU/kw-hr (99.4% gas, 0.6% diesel)

Conversion Efficiency = 3413/7239 = 47.1%

Power Output = (3)(8.25 mw) = 24.75 mw = 24,750 kw

Generation = 110,903 mw-hrs/year (BHP engineering estimate)

Heat Input = (24,750 kw)(7,239 BTU/kw-hr)/1e6 = 179.17 mmBTU/hr

Stack Flowrate @ 15% O_2 = (179.17 mmBTU/hr) (8713 dscf/mmBTU) (20.9/5.9) / 1e6 = 5.53 mmdscf/hr

NO_X = 9 ppm, 0.109 g/kw-hr (Wartsila Spec 0047057-S504, 13 May 05)

VOC = 40 ppm, 0.168 g/kw-hr (Wartsila Spec 0047057-S504, 13 May 05)

CO = 20 ppm, 0.147 g/kw-hr (Wartsila Spec 0047057-S504, 13 May 05)

PM_{10} = 10 mg/m^3, 0.0633 g/kw-hr (Wartsila Spec 0047057-S504, 13 May 05)

CO_2 = 444 g/kw-hr (Wartsila Report 4 July 2003)

NH_3 = 10 ppm, 0.045 g/kw-hr (BACT)

1.1 Wartsila 9L50DF Dual Fuel Constants

USEPA Method 19 standard molar volume = (22.414 l/g-mole) (293.16 / 273.16) (453.59) / (28.317) = 385.3 lb/lb-mole @ 68F (20C), 760 mmHg

USEPA Method 19 Dry Fd factor = (0.994)(8710) + (0.006)(9190) = 8713 dscf/mmBTU

Scarborough LNG (fuel gas) sulfur content = 1 ppm S by volume

Scarborough LNG (fuel gas) higher heating value = 1007.6 BTU/cf

California ultra-low sulfur diesel fuel sulfur content = 15 ppm S by weight

SO_2 correction factor (1% diesel, 99% gas by weight, to correct for dual fuel SO_2 emissions from gas-only emissions) = 1.0654

NO_X = 46 lb/lb-mole as NO_2

VOC = 16 lb/lb-mole as CH_4

CO = 28 lb/lb-mole

SO_2 = 64 lb/lb-mole

CO_2 = 44 lb/lb-mole

NH_3 = 17 lb/lb-mole

1.2 Wartsila 9L50DF Dual Fuel Emission Factors

NO_X = (9e-6) (46 lb / 385.3 dscf) (8713 dscf/mmBTU) (20.9/5.9) (7239 BTU/kw-hr) / 1000 = 0.2401 lb/mw-hr

VOC = (40e-6) (16 lb / 385.3 dscf (8713 dscf/mmBTU) (20.9/5.9) (7239 BTU/kw-hr) / 1000 = 0.3711 lb/mw-hr

CO = (20e-6) (28 lb / 385.3 dscf) (8713 dscf/mmBTU) (20.9/5.9) (7239 BTU/kw-hr) / 1000 = 0.3247 lb/mw-hr

SO_2 = (1e-6) (64 lb / 385.3 cf) / (1007.6 BTU/cf) (7239 BTU/kw-hr) (1000 kw/mw) (1.0654) = 0.0013 lb/mw-hr

PM_{10} = (10 mg/m^3) / (453,590 mg/lb) / (35.3147 cf/m^3) (8713 dscf/mmBTU) (20.9/5.9) (7239 BTU/kw-hr) / 1000 = 0.1395 lb/mw-hr

CO_2 = 444 g/kw-hr (1000 kw/mw) / 453.59 g/lb = 978.8576 lb/mw-hr

NH_3 = (10e-6) (17 lb / 385.3 dscf) (8713 dscf) (20.9/5.9 dscf/mmBTU) (7239 BTU/kw-hr) / 1000 = 0.0985 lb/mw-hr

1.3 Wartsila 9L50DF Dual Fuel Emissions

NO_X = (0.2401 lb/mw-hr) (110,903 mw-hrs/yr) / 2000 = 13.31 tons/yr

VOC = (0.3711 lb/mw-hr) (110,903 mw-hrs/yr) / 2000 = 20.58 tons/yr

CO = (0.3247 lb/mw-hr) (110,903 mw-hrs/yr) / 2000 = 18.01 tons/yr

SO_2 = (0.0013 lb/mw-hr) (110,903 mw-hrs/yr) / 2000 = 0.07 tons/yr

PM_{10} = (0.1395 lb/mw-hr) (110,903 mw-hrs/yr) / 2000 = 7.73 tons/yr

CO_2 = (978.8576 lb/mw-hr) (110,903 mw-hrs/yr) / 2000 = 54,279 tons/yr

NH_3 = (0.0985 lb/mw-hr) (110,903 mw-hrs/yr) / 2000 = 5.46 tons/yr

NO_X = (0.2401 lb/mw-hr) (24.75 mw) = 5.94 lb/hr

VOC = (0.3711 lb/mw-hr) (24.75 mw) = 9.19 lb/hr

CO = (0.3247 lb/mw-hr) (24.75 mw) = 8.04 lb/hr

SO_2 = (0.0013 lb/mw-hr) (24.75 mw) = 0.03 lb/hr

Cabrillo Port Emission Calculation Methodology

PM_{10} = (0.1395 lb/mw-hr) (24.75 mw) = 3.45 lb/hr

CO_2 = (978.8576 lb/mw-hr) (24.75 mw) = 24,227 lb/hr

NH_3 = (0.0985 lb/mw-hr) (24.75 mw) = 2.44 lb/hr

2.0 Wartsila 9L50DF Diesel Backup Generator (1)

Heat Rate = 8042 BTU/kw-hr (diesel)

Conversion Efficiency = 3413/8042 = 42.4%

Power Output = 8.25 mw = 8250 kw

Generation = (100 hrs) (8.25 mw) = 825 mw-hrs/year

Heat Input = (8250 kw)(8042 BTU/kw-hr)/1e6 = 66.35 mmBTU/hr

Stack Flowrate @ 15% O_2 = (66.35 mmBTU/hr) (9190 dscf/mmBTU) (20.9/5.9) / 1e6 = 2.16 mmdscf/hr

NO_X = 150 ppm, 2.127 g/kw-hr (Wartsila Spec 0047057-S504, 13 May 05)

VOC = 60 ppm, 0.296 g/kw-hr (Wartsila Spec 0047057-S504, 13 May 05)

CO = 25 ppm, 0.216 g/kw-hr (Wartsila Spec 0047057-S504, 13 May 05)

PM_{10} = 21 mg/m^3, 0.156 g/kw-hr (Wartsila Spec 0047057-S504, 13 May 05)

CO_2 = 520 g/kw-hr (Wartsila Report 4 July 2003)

NH_3 = 10 ppm, 0.052 g/kw-hr (BACT)

2.1 Wartsila 9L50DF Diesel Constants

USEPA Method 19 standard molar volume = (22.414 l/g-mole) (293.16 / 273.16) (453.59) / (28.317) = 385.3 lb/lb-mole @ 68F (20C), 760 mmHg

USEPA Method 19 Dry Fd factor = 9190 dscf/mmBTU

California ultra-low sulfur diesel fuel higher heating value = (19,300 BTU/lb) (7.1 lb/gal) = 137,030 BTU/gallon (AP-42)

California ultra-low sulfur diesel fuel sulfur content = 15 ppm S by weight

NO_X = 46 lb/lb-mole as NO_2

VOC = 16 lb/lb-mole as CH_4

CO = 28 lb/lb-mole

SO_2 = 64 lb/lb-mole

CO_2 = 44 lb/lb-mole

NH_3 = 17 lb/lb-mole

2.2 Wartsila 9L50DF Diesel Emission Factors

NO_X = (150e-6) (46 lb / 385.3 dscf) (9190 dscf/mmBTU) (20.9/5.9) (8042 BTU/kw-hr) / 1000 = 4.6884 lb/mw-hr

VOC = (60e-6) (16 lb / 385.3 dscf (9190 dscf/mmBTU) (20.9/5.9) (8042 BTU/kw-hr) / 1000 = 0.6523 lb/mw-hr

CO = (25e-6) (28 lb / 385.3 dscf) (9190 dscf/mmBTU) (20.9/5.9) (8042 BTU/kw-hr) / 1000 = 0.4756 lb/mw-hr

SO_2 = (15e-6) (64 lb / 32 lb) (7.1 lb/gal) / (137,030 BTU/gal) (8042 BTU/kw-hr) (1000 kw/mw) = 0.013 lb/mw-hr

PM_{10} = (21 mg/m^3) / (453,590 mg/lb) / (35.3147 cf/m^3) (9190 dscf/mmBTU) (20.9/5.9) (8042 BTU/kw-hr) / 1000 = 0.3432 lb/mw-hr

CO_2 = 520 g/kw-hr (1000 kw/mw) / 453.59 g/lb = 1146.4098 lb/mw-hr

NH_3 = (10e-6) (17 lb / 385.3 dscf) (9190 dscf) (20.9/5.9 dscf/mmBTU) (8042 BTU/kw-hr) / 1000 = 0.1155 lb/mw-hr

2.3 Wartsila 9L50DF Diesel Emissions

NO_X = (4.6884 lb/mw-hr) (825 mw-hrs/yr) / 2000 = 1.93 tons/yr

VOC = (0.6523 lb/mw-hr) (825 mw-hrs/yr) / 2000 = 0.27 tons/yr

CO = (0.4756 lb/mw-hr) (825 mw-hrs/yr) / 2000 = 0.20 tons/yr

SO_2 = (0.013 lb/mw-hr) (825 mw-hrs/yr) / 2000 = 0.01 tons/yr

PM_{10} = (0.3432 lb/mw-hr) (825 mw-hrs/yr) / 2000 = 0.14 tons/yr

CO_2 = (1146.4098 lb/mw-hr) (825 mw-hrs/yr) / 2000 = 473 tons/yr

NH_3 = (0.1155 lb/mw-hr) (825 mw-hrs/yr) / 2000 = 0.05 tons/yr

NO_X = (4.6884 lb/mw-hr) (8.25 mw) = 38.68 lb/hr

VOC = (0.6523 lb/mw-hr) (8.25 mw) = 5.38 lb/hr

CO = (0.4756 lb/mw-hr) (8.25 mw) = 3.92 lb/hr

SO_2 = (0.013 lb/mw-hr) (8.25 mw) = 0.10 lb/hr

PM_{10} = (0.3432 lb/mw-hr) (8.25 mw) = 2.83 lb/hr

CO_2 = (1146.4098 lb/mw-hr) (8.25 mw) = 9458 lb/hr

NH_3 = (0.1155 lb/mw-hr) (8.25 mw) = 0.95 lb/hr

3.0 Emergency Generator Diesel (1)

Heat Rate = 8533 BTU/kw-hr (diesel)

Conversion Efficiency = 3413/8533 = 40%

Power Output = 4.2 mw = 4200 kw

Generation = (100 hrs) (4.2 mw) = 420 mw-hrs/year

Heat Input = (4200 kw) (8533 BTU/kw-hr)/1e6 = 35.84 mmBTU/hr

Stack Flowrate @ 15% O_2 = (35.84 mmBTU/hr) (9190 dscf/mmBTU) (20.9/5.9) / 1e6 = 1.17 mmdscf/hr

3.1 USEPA Tier 2 Standards (>560 kw):

NO_X + VOC = 6.4 g/kw-hr (5.6 g/kw-hr NO_X + 0.8 g/kw-hr VOC)

CO = 3.5 g/kw-hr

PM_{10} = 0.2 g/kw-hr

CO_2 = 700 g/kw-hr (AP-42, Table 3.3-1)

3.2 Emergency Diesel Constants

USEPA Method 19 standard molar volume = (22.414 l/g-mole) (293.16 / 273.16) (453.59) / (28.317) = 385.3 lb/lb-mole @ 68F (20C), 760 mmHg

USEPA Method 19 Dry Fd factor = 9190 dscf/mmBTU

California ultra-low sulfur diesel fuel higher heating value = (19,300 BTU/lb) (7.1 lb/gal) = 137,030 BTU/gallon (AP-42)

California ultra-low sulfur diesel fuel sulfur content = 15 ppm S by weight

NO_X = 46 lb/lb-mole as NO_2

VOC = 16 lb/lb-mole as CH_4

CO = 28 lb/lb-mole

SO_2 = 64 lb/lb-mole

CO_2 = 44 lb/lb-mole

3.3 Emergency Diesel Emission Factors

NO_X = (5.6 g/kw-hr) (1000 kw/mw) / 453.59 g/lb = 12.3460 lb/mw-hr

VOC = (0.8 g/kw-hr) (1000 kw/mw) / 453.59 g/lb = 1.7637 lb/mw-hr

CO = (3.5 g/kw-hr) (1000 kw/mw) / 453.59 g/lb = 7.7162 lb/mw-hr

SO_2 = (15e-6) (64 lb / 32 lb) (7.1 lb/gal) / (137,030 BTU/gal) (8042 BTU/kw-hr) (1000 kw/mw) = 0.013 lb/mw-hr

PM_{10} = (0.2 g/kw-hr) (1000 kw/mw) / 453.59 g/lb = 0.4409 lb/mw-hr

CO_2 = 700 g/kw-hr (1000 kw/mw) / 453.59 g/lb = 1543.2439 lb/mw-hr

3.4 Emergency Diesel Emissions

NO_X = (12.346 lb/mw-hr) (420 mw-hrs/yr) / 2000 = 2.59 tons/yr

VOC = (1.7637 lb/mw-hr) (420 mw-hrs/yr) / 2000 = 0.37 tons/yr

CO = (7.7162 lb/mw-hr) (420 mw-hrs/yr) / 2000 = 1.62 tons/yr

SO_2 = (0.013 lb/mw-hr) (420 mw-hrs/yr) / 2000 = 0.003 tons/yr

PM_{10} = (0.4409 lb/mw-hr) (420 mw-hrs/yr) / 2000 = 0.09 tons/yr

CO_2 = (1543.2439 lb/mw-hr) (420 mw-hrs/yr) / 2000 = 324 tons/yr

NO_X = (12.3460 lb/mw-hr) (4.2 mw) = 51.85 lb/hr

VOC = (1.7637 lb/mw-hr) (4.2 mw) = 7.41 lb/hr

CO = (7.7162 lb/mw-hr) (4.2 mw) = 32.41 lb/hr

SO_2 = (0.013 lb/mw-hr) (4.2 mw) = 0.056 lb/hr

PM_{10} = (0.4409 lb/mw-hr) (4.2 mw) = 1.85 lb/hr

CO_2 = (1543.2439 lb/mw-hr) (4.2 mw) = 6482 lb/hr

4.0 Emergency Firepump Diesel (1)

Heat Rate = 9751 BTU/kw-hr (diesel)

Conversion Efficiency = 3413/9751 = 35%

Power Output = 0.6 mw = 600 kw

Generation = (100 hrs) (0.6 mw) = 60 mw-hrs/year

Heat Input = (600 kw) (9751 BTU/kw-hr)/1e6 = 5.85 mmBTU/hr

Stack Flowrate @ 15% O_2 = (5.85 mmBTU/hr) (9190 dscf/mmBTU) (20.9/5.9) / 1e6 = 0.19 mmdscf/hr

4.1 USEPA Tier 2 Standards (>560 kw):

NO_X + VOC = 6.4 g/kw-hr (5.6 g/kw-hr NO_X + 0.8 g/kw-hr VOC)

CO = 3.5 g/kw-hr

PM_{10} = 0.2 g/kw-hr

CO_2 = 700 g/kw-hr (AP-42, Table 3.3-1)

4.2 Same calculation methodology as Emergency Generator.

5.0 Freefall Lifeboat Diesel (3)

Heat Rate = 11,377 BTU/kw-hr (diesel)

Conversion Efficiency = 3413/11,377 = 30%

Power Output = 0.056 mw = 56 kw

Generation = (50 hrs) (0.056 mw) = 2.8 mw-hrs/year

Heat Input = (56 kw) (11377 BTU/kw-hr)/1e6 = 0.64 mmBTU/hr

Stack Flowrate @ 15% O_2 = (0.64 mmBTU/hr) (9190 dscf/mmBTU) (20.9/5.9) / 1e6 = 0.02 mmdscf/hr

5.1 USEPA Tier 2 Standards (>37 kw, <75 kw)

NO_X + VOC = 7.5 g/kw-hr (6.5 g/kw-hr NO_X + 1.0 g/kw-hr VOC)

CO = 5.0 g/kw-hr

PM_{10} = 0.4 g/kw-hr

CO_2 = 700 g/kw-hr (AP-42, Table 3.3-1)

5.2 Same calculation methodology as Emergency Generator.

6.0 Tug Supply Dual Fuel Main Generators (District Waters)

Heat Rate = 9751 BTU/kw-hr

Conversion Efficiency = 3413/9751 = 35%

Load Factor = 30% (from activity profile)

Power Output = (15,000 BHP) (0.3) / 1.341 BHP/kw = 3360 kw = 3.36 mw

Generation = (52 hrs/yr) (3.36 mw) = 174 mw-hrs/year

Heat Input = (3360 kw)(9751 BTU/kw-hr)/1e6 = 32.72 mmBTU/hr

Stack Flowrate @ 15% O_2 = (32.72 mmBTU/hr) (8710 dscf/mmBTU) (20.9/5.9) / 1e6 = 1.01 mmdscf/hr

6.1 Tug Supply Dual Fuel Constants

USEPA Method 19 standard molar volume = (22.414 l/g-mole) (293.16 / 273.16) (453.59) / (28.317) = 385.3 lb/lb-mole @ 68F (20C), 760 mmHg

USEPA Method 19 Dry Fd factor = 8710 dscf/mmBTU

Scarborough LNG (fuel gas) sulfur content = 1 ppm S by volume

Scarborough LNG (fuel gas) higher heating value = 1007.6 BTU/cf

California ultra-low sulfur diesel fuel sulfur content = 15 ppm S by weight

SO_2 correction factor (1% diesel, 99% gas by weight, to correct for dual fuel SO_2 emissions from gas-only emissions) = 1.0654

PM_{10} correction factor (1% diesel, 99% gas by weight, to correct for dual fuel PM_{10} emissions from gas-only emissions) = 1.0744

NO_X = 46 lb/lb-mole as NO_2

VOC = 16 lb/lb-mole as CH_4

CO = 28 lb/lb-mole

SO_2 = 64 lb/lb-mole

CO_2 = 44 lb/lb-mole

6.2 Gas Fuel ICE Emission Factors (AP-42 Table 3.2-2)

NO_X = 0.847 lb/mmBTU

VOC = 0.118 lb/mmBTU

CO = 0.557 lb/mmBTU

SO_2 = 1.65 E-4 lb/mmBTU (for 1 ppm S)

PM_{10} = 0.010 lb/mmBTU

CO_2 = 110 lb/mmBTU

6.3 Tug Supply Dual Fuel Emission Factors

NO_X = (0.847 lb/mmBTU) (9751 BTU/kw-hr) / 1000 = 8.2595 lb/mw-hr

VOC = (0.118 lb/mmBTU) (9751 BTU/kw-hr) / 1000 = 1.1507 lb/mw-hr

CO = (0.557 lb/mmBTU) (9751 BTU/kw-hr) / 1000 = 5.4315 lb/mw-hr

SO_2 = (1.65e-4 lb/mmBTU) (9751 BTU/kw-hr) (1.0654) / 1000 = 0.0017 lb/mw-hr

PM_{10} = (0.010 lb/mmBTU) (9751 BTU/kw-hr) (1.0744) / 1000 = 0.1048 lb/mw-hr

CO_2 = (110 lb/mmBTU) (9751 BTU/kw-hr) / 1000 = 1072.6571 lb/mw-hr

6.4 Tug Supply Dual Fuel Emissions

NO_X = (8.2595 lb/mw-hr) (174 mw-hrs/yr) / 2000 = 0.721 tons/yr

VOC = (1.1507 lb/mw-hr) (174 mw-hrs/yr) / 2000 = 0.100 tons/yr

CO = (5.4315 lb/mw-hr) (174 mw-hrs/yr) / 2000 = 0.474 tons/yr

SO_2 = (0.0017 lb/mw-hr) (174 mw-hrs/yr) / 2000 = 0.0001 tons/yr

PM_{10} = (0.1048 lb/mw-hr) (174 mw-hrs/yr) / 2000 = 0.009 tons/yr

CO_2 = (1072.6571 lb/mw-hr) (174 mw-hrs/yr) / 2000 = 93.588 tons/yr

NO_X = (8.2595 lb/mw-hr) (3.36 mw) = 27.716 lb/hr

VOC = (1.1507 lb/mw-hr) (3.36 mw) = 3.861 lb/hr

CO = (5.4315 lb/mw-hr) (3.36 mw) = 18.227 lb/hr

SO_2 = (0.0017 lb/mw-hr) (3.36 mw) = 0.006 lb/hr

Cabrillo Port Emission Calculation Methodology

PM_{10} = (0.1048 lb/mw-hr) (3.36 mw) = 0.352 lb/hr

CO_2 = (1072.6571 lb/mw-hr) (3.36 mw) = 3599.521 lb/hr

7.0 Crew Boat Main Gas Fuel Generators (District Waters)

Heat Rate = 9751 BTU/kw-hr

Conversion Efficiency = 3413/9751 = 35%

Load Factor = 47% (from activity profile)

Power Output = (1500 BHP) (0.47) / 1.341 BHP/kw = 530 kw = 0.53 mw

Generation = (172 hrs/yr) (0.53 mw) = 90 mw-hrs/year

Heat Input = (530 kw)(9751 BTU/kw-hr)/1e6 = 5.13 mmBTU/hr

Stack Flowrate @ 15% O_2 = (5.13 mmBTU/hr) (8710 dscf/mmBTU) (20.9/5.9) / 1e6 = 0.158 mmdscf/hr

7.1 Crew Boat Gas Fuel Constants

USEPA Method 19 standard molar volume = (22.414 l/g-mole) (293.16 / 273.16) (453.59) / (28.317) = 385.3 lb/lb-mole @ 68F (20C), 760 mmHg

USEPA Method 19 Dry Fd factor = 8710 dscf/mmBTU

Scarborough LNG (fuel gas) sulfur content = 1 ppm S by volume

Scarborough LNG (fuel gas) higher heating value = 1007.6 BTU/cf

NO_X = 46 lb/lb-mole as NO_2

VOC = 16 lb/lb-mole as CH_4

CO = 28 lb/lb-mole

SO_2 = 64 lb/lb-mole

CO_2 = 44 lb/lb-mole

7.2 Gas Fuel ICE Emission Factors (AP-42 Table 3.2-2)

NO_X = 0.847 lb/mmBTU

VOC = 0.118 lb/mmBTU

CO = 0.557 lb/mmBTU

SO_2 = 1.65 E-4 lb/mmBTU (for 1 ppm S)

PM_{10} = 0.010 lb/mmBTU

CO_2 = 110 lb/mmBTU

7.3 Crew Boat Dual Fuel Emission Factors

NO_X = (0.847 lb/mmBTU) (9751 BTU/kw-hr) / 1000 = 8.2595 lb/mw-hr

VOC = (0.118 lb/mmBTU) (9751 BTU/kw-hr) / 1000 = 1.1507 lb/mw-hr

CO = (0.557 lb/mmBTU) (9751 BTU/kw-hr) / 1000 = 5.4315 lb/mw-hr

SO_2 = (1.65e-4 lb/mmBTU) (9751 BTU/kw-hr) (1.0654) / 1000 = 0.0017 lb/mw-hr

PM_{10} = (0.010 lb/mmBTU) (9751 BTU/kw-hr) (1.0744) / 1000 = 0.1048 lb/mw-hr

CO_2 = (110 lb/mmBTU) (9751 BTU/kw-hr) / 1000 = 1072.6571 lb/mw-hr

7.4 Crew Boat Gas Fuel Emissions

NO_X = (8.2595 lb/mw-hr) (90 mw-hrs/yr) / 2000 = 0.373 tons/yr

VOC = (1.1507 lb/mw-hr) (90 mw-hrs/yr) / 2000 = 0.052 tons/yr

CO = (5.4315 lb/mw-hr) (90 mw-hrs/yr) / 2000 = 0.246 tons/yr

SO_2 = (0.0017 lb/mw-hr) (90 mw-hrs/yr) / 2000 = 0.0001 tons/yr

PM_{10} = (0.1048 lb/mw-hr) (90 mw-hrs/yr) / 2000 = 0.004 tons/yr

CO_2 = (1072.6571 lb/mw-hr) (90 mw-hrs/yr) / 2000 = 48.498 tons/yr

NO_X = (8.2595 lb/mw-hr) (0.53 mw) = 4.432 lb/hr

VOC = (1.1507 lb/mw-hr) (0.53 mw) = 0.605 lb/hr

CO = (5.4315 lb/mw-hr) (0.53 mw) = 2.856 lb/hr

SO_2 = (0.0017 lb/mw-hr) (0.53 mw) = 0.001 lb/hr

PM_{10} = (0.1048 lb/mw-hr) (0.53 mw) = 0.051 lb/hr

CO_2 = (1072.6571 lb/mw-hr) (0.53 mw) = 563.925 lb/hr

8.0 Selas Sub-X LE SCVs (4)

Heat Input = (4) (115 mmBTU/hr) = 460 mmBTU/hr

Throughput = (460 mmBTU/hr) / (1007.6 mmBTU/mmcf) = 0.45653 mmcf/hr

Annual Fuel Gas Throughput = (0.45653 mmcf/hr) (8760 hrs/yr) = 3999.206 mmcf/yr

Stack Flowrate @ 3% O_2 = (460 mmBTU/hr) (8710 dscf/mmBTU) (20.9/17.9) / 1e6 = 4.68 mmdscf/hr

8.1 Emission Factors @ 3% oxygen

NO_X = 20 ppmv (Selas Specification)

ROC = 4.1 ppmv (Costain Report)

CO = 100 ppmv (Selas Specification)

PM_{10} = 1.9 lb/mmcf (AP-42 Table 1.4-2, non-condensible filterable fraction, condensibles remain in 70 F water solution)

CO_2 = 9.2% (Selas Specification, 6.6% @ 8% oxygen)

8.2 Selas Sub-X LE SCV Constants

USEPA Method 19 standard molar volume = (22.414 l/g-mole) (293.16 / 273.16) (453.59) / (28.317) = 385.3 lb/lb-mole @ 68F (20C), 760 mmHg

USEPA Method 19 Dry Fd factor = 8710 dscf/mmBTU

Scarborough LNG (fuel gas) sulfur content = 1 ppm S by volume

Scarborough LNG (fuel gas) higher heating value = 1007.6 BTU/cf

NO_X = 46 lb/lb-mole as NO_2

VOC = 16 lb/lb-mole as CH_4

CO = 28 lb/lb-mole

SO_2 = 64 lb/lb-mole

CO_2 = 44 lb/lb-mole

8.3 Selas Sub-X LE SCV Emission Factors

NO_X = (20e-6) (46 lb / 385.3 dscf) (8710 dscf/mmBTU) (20.9/17.9) (1007.6 BTU/cf) = 24.467 lb/mmcf

VOC = (4.1e-6) (16 lb / 385.3 dscf (8710 dscf/mmBTU) (20.9/17.9) (1007.6 BTU/cf) = 1.745 lb/mmcf

CO = (100e-6) (28 lb / 385.3 dscf) (8710 dscf/mmBTU) (20.9/17.9) (1007.6 BTU/cf) = 74.466 lb/mmcf

SO_2 = (1) (64 lb / 385.3 cf) = 0.166 lb/mmcf

PM_{10} = 1.9 lb/mmcf

CO_2 = (0.092) (44 lb / 385.3 dscf) (8710 dscf/mmBTU) (20.9/17.9) (1007.6 BTU/cf) = 107656.700 lb/mmcf

8.4 Selas Sub-X LE SCV Emissions

NO_X = (24.467 lb/mmcf) (3999.206 mmcf/yr) / 2000 = 48.93 tons/yr

VOC = (1.745 lb/mmcf) (3999.206 mmcf/yr) / 2000 = 3.49 tons/yr

CO = (74.466 lb/mmcf) (3999.206 mmcf/yr) / 2000 = 148.90 tons/yr

SO_2 = (0.166 lb/mmcf) (3999.206 mmcf/yr) / 2000 = 0.33 tons/yr

PM_{10} = (1.9 lb/mmcf) (3999.206 mmcf/yr) / 2000 = 3.80 tons/yr

CO_2 = (107656.700 lb/mmcf) (3999.206 mmcf/yr) / 2000 = 215270.66 tons/yr

NO_X = (24.467 lb/mmcf) (0.45653 mmcf/hr) = 11.17 lbs/hr

VOC = (1.745 lb/mmcf) (0.45653 mmcf/hr) = 0.80 lbs/hr

CO = (74.466 lb/mmcf) (0.45653 mmcf/hr) = 34.00 lbs/hr

SO_2 = (0.166 lb/mmcf) (0.45653 mmcf/hr) = 0.08 lbs/hr

PM_{10} = (1.9 lb/mmcf) (0.45653 mmcf/hr) = 0.87 lbs/hr

CO_2 = (107656.700 lb/mmcf) (0.45653 mmcf/hr) = 49148.55 lbs/hr