

Appendix B

Emission Calculations

Individual and combined heat input rate limits for the Gas turbines, HRSGs, and Fuel Heater are given below in **Table B-1**. These are the basis of permit conditions limiting heat input rates.

Table B-1 Maximum Allowable Heat Input Rates

Source	MM Btu/hour-source	MM Btu/day-source	MM Btu/year-source
S-55 and S-57 Gas Turbines, each	1,858	44,592 ^a	16,276,080 ^b
S-55 CTG and S-56 HRSG, each S-57 CTG and S-58 HRSG, each	2,249.1 ^c	53,978 ^d	18,979,304 ^e

^abased upon specified maximum rated heat input of 1,858 MM Btu/hr and 24 hour per day operation

^bbased upon 8,760 hours of operation at full load (1,858 MM Btu/hr)

^cmaximum combined firing rate for gas turbine and HRSG duct burners

^dbased upon maximum duct burner firing of 24 hours per day; calculated as:

$$(24 \text{ hr/day})(2,249.1 \text{ MM Btu/hr}) = 53,978 \text{ MM Btu/day}$$

^ebased upon maximum annual duct burner firing of 7,090 hr/year-HRSG, 1,595 hr/yr gas turbine full load and 75 hr/yr of startup at one-half full load fuel rate (896 MM Btu/hr); calculated as:

$$(7090 \text{ hr/yr})(2,249.1 \text{ MM Btu/hr}) + (1,595 \text{ hr/yr})(1,858 \text{ MM Btu/hr}) + (75 \text{ hr/yr})(929 \text{ MM Btu/day}) = 18,979,304 \text{ MM Btu/year/unit}$$

Table B-2 Maximum Annual Facility Emissions from Permitted Sources (ton/yr)

Source	NO ₂	CO	POC	PM ₁₀	SO ₂
S-55 Gas Turbine and S-56 HRSG ^a	89.2	131.45	24.55	55.25	13.1
S-57 Gas Turbine and S-58 HRSG ^a	89.2	131.45	24.55	55.25	13.1
Total Permitted Emissions	178.4	262.9	49.1	110.5	26.2

^aincludes gas turbine start-up and shutdown emissions

B-1.0 Gas Turbine Start-Up and Shutdown Emission Rate Calculations

The maximum nitrogen oxide, carbon monoxide, and precursor organic compound emission rates from a gas turbine occur during start-up and shutdown periods. The PM₁₀, sulfur dioxide, ammonia, and toxic compound emissions are a function of fuel use rate only and do not exceed typical full load emission rates during start-up.

**Table B-3 Gas Turbine Start-Up Emission Rates
(lb/start-up)**

Pollutant	Cold Start-Up ^a	Hot Start-Up ^b
NO _x (as NO ₂)	452	189
CO	990	291
POC	112	27
PM ₁₀	47	17
SO _x (as SO ₂)	7	2.5

^acold start not to exceed 256 min.

^bhot start not to exceed 90 min.

Shutdown emissions for NO_x, CO, and POC are presented in Table B-4. These emissions have been predicted by General Electric for a shutdown of 23 min. duration.

**Table B-4 Gas Turbine Shutdown Emission Rates
(lb/shutdown)**

Pollutant	Shutdown Emissions
NO _x	59
CO	73
POC	6
PM ₁₀	4
SO _x (as SO ₂)	0.6

Hot Start-Up Emission Rate Calculations

- Maximum duration: 90 min.

NITROGEN OXIDES (as NO₂)

Maximum NO_x emission rate: 164 lb/hr

Total NO₂ = 189 lb/hot start

CARBON MONOXIDE

Maximum CO emission rate: 268 lb/hr

Total CO = 291 lb/hot start

PRECURSOR ORGANIC COMPOUNDS

Total POC = 26.85 lb/hot start

PARTICULATE MATTER (as PM₁₀)

- PM₁₀ emissions are not increased during start-up
- PM₁₀ emission factor based upon full load operation (emission rate of 11 lb/hr)

Total PM₁₀ = 16.5 lb PM₁₀/ hot start

SULFUR DIOXIDE

- SO₂ emissions are not increased during start-up

Total SO₂ = 2.5 lb SO₂/hot start

Cold Start-Up Emission Rate Calculations

- Maximum duration: 256 min.

NITROGEN OXIDES (as NO₂)

Maximum NO_x emission rate: 170 lb/hr

Total NO₂ = 452 lb/cold start

CARBON MONOXIDE

Maximum CO emission rate: 548 lb/hr

Total CO = 990 lb/cold start

PRECURSOR ORGANIC COMPOUNDS

Total POC = 112 lb/cold start

PARTICULATE MATTER (as PM₁₀)

- PM₁₀ emissions are not increased during start-up
- PM₁₀ emission rate during start-up equals maximum baseload emission rate of 11 lb/hr

Total PM₁₀ = 47 lb PM₁₀/cold start

SULFUR DIOXIDE

- SO₂ emissions are not increased during start-up

Total SO₂ = 7 lb SO₂/cold start

B-2.0 Worst-Case Operating Scenarios and Regulated Air Pollutant Emissions for Gas Turbines and HRSGs.

The Gas Turbine/HRSG emission rates shown in **Table B-5** are the basis of permit condition limits and emission offset requirements and were also used as inputs for the ambient air quality impact analysis. To provide maximum operational flexibility, no limitations will be imposed on the type or quantity of turbine start-ups. Instead, the facility must comply with rolling consecutive twelve month mass emission limits at all times. The mass emission limits are based upon the emission estimates calculated for the following power plant operating envelope:

- 1595 hours of baseload (100% load) operation per year for each gas turbine
- 7090 hours of duct burner firing per HRSG per year with steam injection power augmentation at gas turbine combustors
- 6 hot start-ups total per year (90 min. each)
- 14 cold start-ups total per year (256 min. each)
- 20 shutdowns total per year (23 Min. each)

Table B-5 Maximum Annual Regulated Air Pollutant Emissions for Gas Turbines and HRSGs

Source (Operating Mode)	NO ₂ (lb/yr)	CO (lb/yr)	POC (lb/yr)	PM ₁₀ (lb/yr)	SO ₂ (lb/yr)
S-55 & S-57 Gas Turbines (12 total, 90 min. hot start-ups)	2,268	3,492	322	198	29
S-55 & S-57 Gas Turbines (28 total, 256 min. cold start-ups)	12,656	27,720	3136	1,316	196
S-55 & S-57 Gas Turbines (3,190 total hours ^a @ 100% load)	53,274 ^b	77,518 ^b	14,834 ^b	35,090	8007
S-55 & S-57 Gas Turbines and S-56 & S-58 HRSGs (14,180 total hours ^a w/duct burner firing and steam injection power augmentation)	286,436 ^c	414,056 ^c	79,692 ^c	184,340	44171
S-55 & S-57 Gas Turbines (40 total, 23 min. shutdowns)	2,360	2,920	240	160	20
Total Emissions (lb/yr)	356,994	525,706	98,224	221,104	52,423
(ton/yr)	178.4	262.9	49.1	110.5	26.2

^atotal combined firing hours for both turbines

^bbased upon the heat input rate of 1,858 MM Btu/hr for each gas turbine

^cbased upon the maximum combined heat input rate of 2,249.1 MM Btu/hr for each CTG/HRSG power train

B-4.0 Worst-Case Toxic Air Contaminant (TAC) Emissions

The maximum toxic air contaminant emissions resulting from the combustion of natural gas at the S-55 & S-57 Gas Turbines and S-56 & S-57 HRSGs are summarized in **Table B-6**. These emission rates were used as input data for the health risk assessment modeling and are based upon a maximum annual heat input rate of 19,702,116 MM Btu per year (19,128 MM scf/yr based upon a fuel HHV of 1030 Btu/scf) for each gas turbine/HRSG pair. The derivation of the emission factors is detailed in Appendix A.

Table B-6 Potrero Power Plant, Unit 7 – Toxic Emissions

Pollutant	CATEF Emission Factor ^a (lb/MM scf)	Ventura County Emission Factor ^b (lb/MM scf)	Factor Used (lb/MM scf)	Emissions Per Turbine ^c (lb/yr)
Acetaldehyde	6.86E-02		6.86E-02	1.312E+03
Acrolein	2.37E-02		2.37E-02	4.533E+02
Ammonia ^d	6.83E+00		6.83E+0	1.306E+05
Benzene	1.36E-02		1.36E-02	2.601E+02
Butadiene-1,3	1.27E-04		1.27E-04	2.429E+00
Ethylbenzene	1.79E-02		1.79E-02	3.424E+02
Formaldehyde	1.10E-01		1.10E-01	2.104E+03
Hexane ^e	2.59E-01	1.75E+00	N/A	< 1.007E+04
Naphthalene	1.66E-03		1.66E-03	3.175E+01
PAHs	1.06E-04	1.00E-03	1.00E-03	2.028E+01
Propylene	7.71E-01	1.05E+00	1.05E+00	2.008E+04
Propylene Oxide	4.78E-02		4.78E-02	9.143E+02
Toluene	7.10E-02	7.26E-02	7.26E-02	1.389E+03
Xylene	2.61E-02	2.89E-02	2.89E-02	5.528E+02

^a CARB's CATEF Version 1.2 Database emission factors, mean values

^b Ventura County APCD emission factors for gas turbines (1995) reported by the applicant in Appendix I, Public Health Data

^c Based on maximum heat input rate of 249.1 MMBtu/hr operated 8760 hours per year

^d Ammonia emission rate is estimated based on 5 ppm ammonia slip (15% O₂)

^e The Ventura County emission factor represents the detection limit during source testing and therefore may be artificially high. The applicant will accept a permit condition limiting hexane emissions to less than 10,000 pounds per year per unit.

Natural gas heat value used to convert units = 1030 Btu/scf

B-5.0 Maximum Facility Emissions

The maximum annual facility regulated air pollutant emissions for the proposed gas turbines and HRSGs have been shown in **Table B-5**. The total permitted emission rates shown are the basis of permit condition limits and emission offset requirements, if applicable.

Table B-7
Maximum Hourly and Daily Regulated
Air Pollutant Emission Rates for Baseload Operation
(Excluding Gas Turbine Start-up Emissions)

	NO ₂	CO	POC	PM ₁₀	SO ₂
S-55 and S-57 Gas Turbines ^a					
lb/hr-source	16.7	24.3	4.65	11.0	2.51
lb/day-source	401	583	112	264	61
S-55 & S-56 and S-57 & S-58 Gas Turbine/HRSG Power Train ^b					
lb/hr-power train	20.2	29.2	5.62	13.0	3.12
lb/day-power train	484	701	135	312	75

^abased upon maximum heat input rate of 1858 MM Btu/hr for each gas turbine

^bBased upon a maximum combined heat input rate for each gas turbine/HRSG power train of 2,249.1 MM Btu/hr and maximum 24 hours per day duct burner firing

The maximum daily regulated air pollutant emissions per source including gas turbine start-up emissions are shown in **Table B-8**.

Table B-8
Maximum Daily Regulated Air Pollutant Emissions per
Power Train (lb/day)

Source (operating mode)	NO ₂	CO	POC	PM ₁₀	SO ₂
Gas Turbine (Cold Start-up)	452	990	109	47	7
Gas Turbine (Full load w/o Duct Burner Firing)	37	53	10	24	4.5
Gas Turbine & HRSG (Full load w/Duct Burner Firing and steam injection power augmentation)	323	468	90	213	41
Gas Turbine (Hot Start-up)	189	291	27	17	2.5
Total	1,001	1,802	239	301	55

^abased upon one 90 min. hot start-up, one 256 min. cold start-up, 16 hours of full load operation with duct burner firing @ 2,249.1 MMBtu/hr with steam injection power augmentation, and 2.2 hours of full load operation without duct burner firing at 1858 MM Btu/hr over a 24 hour period. These are the basis of permit condition daily mass emission limits.

Table B-9
Air Pollutant Emission Rates for the Commissioning Period^a (lb/day)
For Both Units Operating

Source (operating mode)	NO ₂	CO	POC	PM ₁₀	SO ₂
Gas Turbine (Cold Start-up) ^b	904	1,980	224	94	14
Gas Turbine ^c (Full load w/o Duct Burner Firing)	740	1,060	20	48	9
Gas Turbine & HRSG ^c (Full load w/Duct Burner Firing and steam injection power augmentation)	6460	9,360	180	426	82
Gas Turbine (Hot Start-up) ^b	378	582	54	34	5
Total	8,428	12,982	478	602	110

^abased upon one cold start (4.3 hrs), one hot start (1.5 hrs), full load operation with duct burner and steam augmentation (16 hrs), and full load operation w/o duct burners (2.2 hrs)

^bFrom Table B-3 multiplied by 2 units

^cPOC, PM₁₀, SO₂ emissions are from table B-8 multiplied by two units. NO₂ and CO emissions are multiplied by two units and by 10 to account for non-operational SCR and oxidation catalysts during commissioning.

B-6.0 Modeling Emission Rates

The NO₂ emission rates shown in **Table B-10** were used to model the air quality impacts of the MEC to determine compliance with State and Federal annual ambient air quality standards for NO₂, CO, SO₂ and PM₁₀. A screening impact analysis of gas turbine/HRSG duct burner emission rates and stack gas characteristics revealed that the worst-case impacts occur under the equipment operating scenarios listed.

Table B-10
Emission rates used in modeling analysis (g/s)

Pollutant Source	Max (1-hour)	Commissioning ^a (1-hour) and [8-hour]	Maximum (3-hour)	Maximum (8-hour)	Maximum (24-hour)	Maximum Annual Average
NO _x						
Turbine 1	2.55 ^b	25.5 ^b	n/a	n/a	n/a	2.57
Turbine 2	21.4	21.4				2.57
CO						
Turbine 1	3.73 ^b	37.3 ^b [37.3]	n/a	3.73	n/a	n/a
Turbine 2	69	69.0 ^c [18.3]		18.3		
SO ₂						
Turbine 1	0.777	n/a	0.777	n/a	0.777	0.777
Turbine 2	0.777	n/a	0.777		0.777	0.777
PM ₁₀						
Turbine 1	n/a	n/a	n/a	n/a	1.39	1.59
Turbine 2					1.39	1.59

^aCommissioning is the original startup of the turbines and only occurs during the initial operation of the equipment after installation.

^bTurbine 1 in Cold Startup.

^cCommissioning emissions for SCR and CO Oxidation Systems increased by factor of 10.