

APPENDIX A.1

DETAILED GAS TURBINE EMISSION CALCULATIONS

Appendix A.1 - ESPR

CTG Hourly Emissions - Normal Operations

Data:

Standard Conditions: 29.92 inches Hg and 68 degrees Fahrenheit

Emission Factor (lb/MMBTU) = (ppmvd)*(MW)*(1/SMV)*(20.9/5.9)*(Fd)*(1/1E6)

where,

controlled ppmvd = controlled concentration corrected to 15% O₂

MW = molecular weight (lb/lb-mol)

SMV = specific molar volume at 68 degrees Fahrenheit = 385.3 dscf/lb-mol

Fd = dry oxygen F-factor for natural gas = 8,710 dscf/MMBTU at 68 degrees Fahrenheit

Emission Rate Controlled = Emission Factor Controlled (lb/MMBTU) * Heat Input (MMBTU/hr)

Table A.1.1 - CO Emissions

Operating Condition	Heat Input (MMBTU/hr)	Pollutant Conc. Controlled (ppmvd)	Molecular Weight (lbs/lb-mole)	Specific Molar Volume (dscf/lb-mole)	Dry Fuel Factor (dscf/MMBTU)	Emission Factor Controlled (lb/MMBTU)	Emission Rate Controlled (lb/hr)
Avg. Base	1,881.0	3.0	28	385.3	8,710	0.0067	12.65
Avg. Base (cooler)	1,951.0	3.0	28	385.3	8,710	0.0067	13.12
Avg. Peak	2,096.0	3.0	28	385.3	8,710	0.0067	14.10
Avg. Low	1,155.0	3.0	28	385.3	8,710	0.0067	7.77
Hot Base	1,851.0	3.0	28	385.3	8,710	0.0067	12.45
Hot Base (cooler)	1,930.0	3.0	28	385.3	8,710	0.0067	12.98
Hot Peak	2,073.0	3.0	28	385.3	8,710	0.0067	13.94
Hot Low	1,139.0	3.0	28	385.3	8,710	0.0067	7.66
Mild Base (cooler)	2,004.0	3.0	28	385.3	8,710	0.0067	13.48
Mild Base	1,974.0	3.0	28	385.3	8,710	0.0067	13.28
Mild Low (60%)	1,352.0	3.0	28	385.3	8,710	0.0067	9.09
Mild Low (50%)	1,203.0	3.0	28	385.3	8,710	0.0067	8.09
Cold Base	2,078.0	3.0	28	385.3	8,710	0.0067	13.98
Cold Low (60%)	1,415.0	3.0	28	385.3	8,710	0.0067	9.52
Cold Low (50%)	1,257.0	3.0	28	385.3	8,710	0.0067	8.46
Average	1,690.6						11.37

Appendix A.1 - ESPR

CTG Hourly Emissions - Normal Operations

Table A.1.2 - NOx Emissions

Operating Condition	Heat Input (MMBTU/hr)	Pollutant Conc. Controlled (ppmvd)	Molecular Weight (lb/lb-mol)	Specific Molar Volume (dscf/lb-mole)	Dry Fuel Factor dscf/MMBTU	Emission Factor Controlled (lb/MMBTU)	Emission Rate Controlled (lb/hr)
Avg. Base	1,881.0	2.0	46	385.3	8,710	0.0074	13.86
Avg. Base (cooler)	1,951.0	2.0	46	385.3	8,710	0.0074	14.37
Avg. Peak	2,096.0	2.0	46	385.3	8,710	0.0074	15.44
Avg. Low	1,155.0	2.0	46	385.3	8,710	0.0074	8.51
Hot Base	1,851.0	2.0	46	385.3	8,710	0.0074	13.64
Hot Base (cooler)	1,930.0	2.0	46	385.3	8,710	0.0074	14.22
Hot Peak	2,073.0	2.0	46	385.3	8,710	0.0074	15.27
Hot Low	1,139.0	2.0	46	385.3	8,710	0.0074	8.39
Mild Base (cooler)	2,004.0	2.0	46	385.3	8,710	0.0074	14.76
Mild Base	1,974.0	2.0	46	385.3	8,710	0.0074	14.54
Mild Low (60%)	1,352.0	2.0	46	385.3	8,710	0.0074	9.96
Mild Low (50%)	1,203.0	2.0	46	385.3	8,710	0.0074	8.86
Cold Base	2,078.0	2.0	46	385.3	8,710	0.0074	15.31
Cold Low (60%)	1,415.0	2.0	46	385.3	8,710	0.0074	10.42
Cold Low (50%)	1,257.0	2.0	46	385.3	8,710	0.0074	9.26
Average	1,690.6						12.45

Appendix A.1 - ESPR

CTG Hourly Emissions - Normal Operations

Table A.1.3 - VOC Emissions

Operating Condition	Heat Input (MMBTU/hr)	Pollutant Conc. Controlled (ppmvd)	Molecular Weight (lb/lb-mol)	Specific Molar Volume (dscf/lb-mol)	Dry Fuel Factor dscf/MMBTU	Emission Factor Controlled (lb/MMBTU)	Emission Rate Controlled (lb/hr)
Avg. Base	1,881.0	2.0	16	385.3	8,710	0.0026	4.82
Avg. Base (cooler)	1,951.0	2.0	16	385.3	8,710	0.0026	5.00
Avg. Peak	2,096.0	2.0	16	385.3	8,710	0.0026	5.37
Avg. Low	1,155.0	2.0	16	385.3	8,710	0.0026	2.96
Hot Base	1,851.0	2.0	16	385.3	8,710	0.0026	4.74
Hot Base (cooler)	1,930.0	2.0	16	385.3	8,710	0.0026	4.95
Hot Peak	2,073.0	2.0	16	385.3	8,710	0.0026	5.31
Hot Low	1,139.0	2.0	16	385.3	8,710	0.0026	2.92
Mild Base (cooler)	2,004.0	2.0	16	385.3	8,710	0.0026	5.14
Mild Base	1,974.0	2.0	16	385.3	8,710	0.0026	5.06
Mild Low (60%)	1,352.0	2.0	16	385.3	8,710	0.0026	3.46
Mild Low (50%)	1,203.0	2.0	16	385.3	8,710	0.0026	3.08
Cold Base	2,078.0	2.0	16	385.3	8,710	0.0026	5.32
Cold Low (60%)	1,415.0	2.0	16	385.3	8,710	0.0026	3.63
Cold Low (50%)	1,257.0	2.0	16	385.3	8,710	0.0026	3.22
Average	1,690.6						4.33

Appendix A.1 - ESPR

CTG Hourly Emissions - Normal Operations

Table A.1.4 - PM10 Emissions

Operating Condition	Heat Input (MMBTU/hr)	Emission Factor (lb/MMBTU)	Emission Rate Uncontrolled (lb/hr)	Emission Rate Controlled (lb/hr)
Avg. Base	1,881.0	0.0051	9.50	9.50
Avg. Base (cooler)	1,951.0	0.0049	9.50	9.50
Avg. Peak	2,096.0	0.0045	9.50	9.50
Avg. Low	1,155.0	0.0082	9.50	9.50
Hot Base	1,851.0	0.0051	9.50	9.50
Hot Base (cooler)	1,930.0	0.0049	9.50	9.50
Hot Peak	2,073.0	0.0046	9.50	9.50
Hot Low	1,139.0	0.0083	9.50	9.50
Mild Base (cooler)	2,004.0	0.0047	9.50	9.50
Mild Base	1,974.0	0.0048	9.50	9.50
Mild Low (60%)	1,352.0	0.0070	9.50	9.50
Mild Low (50%)	1,203.0	0.0079	9.50	9.50
Cold Base	2,078.0	0.0046	9.50	9.50
Cold Low (60%)	1,415.0	0.0067	9.50	9.50
Cold Low (50%)	1,257.0	0.0076	9.50	9.50
Average	1,690.6		9.50	9.50

Appendix A.1 - ESPR
CTG Hourly Emissions - Normal Operations

Table A.1.5 - SO_x Emissions

Operating Condition	Heat Input (MMBTU/hr)	Short-Term Emission Factor ¹ (lb/MMBTU)	Long-Term Emission Factor ¹ (lb/MMBTU)	Short-Term Emission Rate Controlled (lb/hr)	Long-Term Emission Rate Controlled (lb/hr)
Avg. Base	1,881.0	0.00209	0.00070	3.92	1.31
Avg. Base (cooler)	1,951.0	0.00209	0.00070	4.07	1.36
Avg. Peak	2,096.0	0.00209	0.00070	4.37	1.46
Avg. Low	1,155.0	0.00209	0.00070	2.41	0.80
Hot Base	1,851.0	0.00209	0.00070	3.86	1.29
Hot Base (cooler)	1,930.0	0.00209	0.00070	4.02	1.34
Hot Peak	2,073.0	0.00209	0.00070	4.32	1.44
Hot Low	1,139.0	0.00209	0.00070	2.37	0.79
Mild Base (cooler)	2,004.0	0.00209	0.00070	4.18	1.39
Mild Base	1,974.0	0.00209	0.00070	4.12	1.37
Mild Low (60%)	1,352.0	0.00209	0.00070	2.82	0.94
Mild Low (50%)	1,203.0	0.00209	0.00070	2.51	0.84
Cold Base	2,078.0	0.00209	0.00070	4.33	1.44
Cold Low (60%)	1,415.0	0.00209	0.00070	2.95	0.98
Cold Low (50%)	1,257.0	0.00209	0.00070	2.62	0.87
Average	1,690.6			3.52	1.17

¹ Based on a maximum long-term sulfur content of 0.25 grains/100 scf fuel; 1,050 BTU/scf natural gas; and 7,000 grains/lb, and 1 mole S for 2 moles SO₂

Based on maximum short-term sulfur content of 0.75 grains/100 scf fuel

SO_x = (0.25 gr/100scf)(1 scf/1,027.7 BTU)(lb/7,000 gr)(2 mol SO₂/1 mol S)(1,000,000 BTU/MMBTU) = 0.00070 lb/MMBTU

SO_x = (0.75 gr/100scf)(1 scf/1,027.7 BTU)(lb/7,000 gr)(2 mol SO₂/1 mol S)(1,000,000 BTU/MMBTU) = 0.00209 lb/MMBTU

APPENDIX A.1 - ESPR
CTG HOURLY STARTUP/SHUTDOWN EMISSIONS

Table A.1.6 CTG - Hourly Startup Emissions (per GT)

	Time (minutes)	NOx Emissions (lbs/hr)	CO Emissions (lbs/hr)	VOC Emissions (lbs/hr)	NOx Emissions (lbs)	CO Emissions (lbs)	VOC Emissions (lbs)
Maximum Startup Emissions	12	N/A	N/A	N/A	25.0	267.0	13.0
Maximum Normal Operation Emissions	48	15.4	14.1	5.4	12.4	11.3	4.3
Sub-total =	60				37.4	278.3	17.3
Adjustment Factor (short term) =					2	2	1
Adjustment Factor (long term) =					1.5	1.5	1
Total (short term) =					74.7	556.6	17.3
Total (long term) =					56.0	417.4	17.3

Table A.1.7 CTG - Hourly Shutdown Emissions (per GT)

	Time (minutes)	NOx Emissions (lbs/hr)	CO Emissions (lbs/hr)	VOC Emissions (lbs/hr)	NOx Emissions (lbs)	CO Emissions (lbs)	VOC Emissions (lbs)
Maximum Shutdown Emissions	7	N/A	N/A	N/A	10.0	135.0	5.0
Maximum Normal Operation Emissions	53	15.4	14.1	5.4	13.6	12.5	4.7
Sub-total =	60				23.6	147.5	9.7
Adjustment Factor (short term) =					2	2	1
Adjustment Factor (long term) =					1.5	1.5	1
Total (short term) =					47.3	294.9	9.7
Total (long term) =					35.5	221.2	9.7

Table A.1.8 CTG - Hourly Startup/Shutdown Emissions (per GT)

	Time (minutes)	NOx Emissions (lbs/hr)	CO Emissions (lbs/hr)	VOC Emissions (lbs/hr)	NOx Emissions (lbs)	CO Emissions (lbs)	VOC Emissions (lbs)
Maximum Startup Emissions	12	N/A	N/A	N/A	25.0	267.0	13.0
Maximum Shutdown Emissions	7	N/A	N/A	N/A	10.0	135.0	5.0
Maximum Normal Operation Emissions	41	15.4	14.1	5.4	10.6	9.6	3.7
Sub-total =	60				45.6	411.6	21.7
Adjustment Factor (short term) =					2	2	1
Adjustment Factor (long term) =					1.5	1.5	1
Total (short term) =					91.1	823.3	21.7
Total (long term) =					68.3	617.5	21.7

Appendix A.1 - ESPR
CTG Daily and Annual Emissions

Table A.1.9 - CTG Cumulative Daily Emissions

	Operating	Cumulative Hourly Emission Rate (lbs/hr)					Cumulative Daily Emissions (lbs/day)				
	Hours per GT	NOx	CO	VOC	SOx	PM10	NOx	CO	VOC	SOx	PM10
Normal Operations	20	30.88	28.20	10.74	2.91	19.00	617.66	563.95	214.84	58.27	380.00
Startup	2	149.41	1113.12	34.59	2.91	19.00	298.83	2226.23	69.19	5.83	38.00
Shutdown	2	94.56	589.82	19.49	2.91	19.00	189.12	1179.63	38.98	5.83	38.00
Total =							1105.61	3969.82	323.00	69.92	456.00

Table A.1.10 - CTG Annual Emissions

Operating Condition 3	Hours per Year	CO (lbs/hr)	NOx (lbs/hr)	VOC (lbs/hr)	PM10 (lbs/hr)	SOx (lbs/hr)	CO (lbs/year)	NOx (lbs/year)	VOC (lbs/year)	PM10 (lbs/year)	SOx (lbs/year)
Unit 5 Start-Up	200	417.42	56.03	17.30	9.50	1.46	83,484	11,206	3,459	1,900	291
Unit 5 Normal Operations	5,056	13.12	14.37	5.00	9.50	1.36	66,352	72,672	25,277	48,032	6,856
Unit 5 Shutdown	200	221.18	35.46	9.74	9.50	1.46	44,236	7,092	1,949	1,900	291
Unit 5 Totals	5,456						194,072	90,970	30,685	51,832	7,439
Unit 7 Start-Up	200	417.42	56.03	17.30	9.50	1.46	83,484	11,206	3,459	1,900	291
Unit 7 Normal Operations	5,056	13.12	14.37	5.00	9.50	1.36	66,352	72,672	25,277	48,032	6,856
Unit 7 Shutdown	200	221.18	35.46	9.74	9.50	1.46	44,236	7,092	1,949	1,900	291
Unit 7 Totals	5,456						194,072	90,970	30,685	51,832	7,439
Total Annual Emissions (lb/year) =							388,145	181,940	61,371	103,664	14,877
Total Annual Emissions (tons/year) =							194.1	91.0	30.7	51.8	7.4