

Discharge Source # 1

1. Source of waste:

Type: Compressor Turbine (Unit 1 and 2)
Quantity: 2
Make: Solar Turbines Centaur 50-6200LS
Duty: 4498 kW (ISO)
Power Fuel: Natural Gas

2. Proposed treatment of waste:

N/A

3. Quantity of waste discharged:

Maximum rate of waste discharge: 15.54 m³/s @ 20C
Average rate of waste discharge: N/A

4. Operating period:

One unit is expected to operate 8760 hours per year. A second unit may run simultaneously for up to 20% of time (1752 hours per year).

5. Discharge works:

Type: Stack
Elevation at base (ASL): 110 m
Stack Height: 16.65 m
Stack Inside Diameter: 1.156 m
Stack Gas Exit Velocity: 39.6m/s
Stack Gas Discharge Temp: 511 C

6. Characteristics of waste:

SO₂: 0.0097 g/s
NO_x: 0.379 g/s
CO: 0.386 g/s
TP: 0.0707 g/s
UHC = VOCs: 0.2220 g/s

* No additional treatment of waste is proposed for the turbines.

** No additional emission data concerning commissioning, startup and shutdown are available for this discharge source

Discharge Source # 2

1. Source of waste:

Type: Boiler

Quantity: 2

Make: Viessmann – Vitocrossal 200 Series Duty:
440 kW

Power Fuel: Natural Gas

2. Proposed treatment of waste:

N/A

3. Quantity of waste discharged:

Maximum rate of waste discharge: 0.182 m³/s @ 20 C

Average rate of waste discharge: N/A

4. Operating period:

Unit 1 – 8760 hours/year, Unit 2 – Standby

5. Discharge works:

Type: Stack

Elevation at base (ASL): 110 m

Stack Height: 5.78 m

Stack Inside Diameter: 0.152 m

Stack Gas Exit Velocity: 11.7 m/s

Stack Gas Discharge Temp: 68 C

6. Characteristics of waste:

SO₂: 0.0001 g/s

NO_x: 0.0066 g/s

CO: 0.0093 g/s

TP: 0.0014 g/s

UHC = VOCs: 0.0010 g/s

Discharge Source # 3

1. Source of waste:

Type: Generator
Quantity: 1
Make: Waukesha VGG-L36GSI
Duty: 550 kW
Power Fuel: Natural Gas

2. Proposed treatment of waste:

N/A

3. Quantity of waste discharged:

Maximum rate of waste discharge: 0.570 m³/s @ 20 C

Average rate of waste discharge: N/A

4. Operating period:

Non-continuous use – Emergency back-up 876 hours per year

5. Discharge works:

Type: Stack
Elevation at base (ASL): 110 m
Stack Height: 6.0 m
Stack Inside Diameter: 0.254 m
Stack Gas Exit Velocity: 33.6 m/s
Stack Gas Discharge Temp: 602 C

6. Characteristics of waste:

SO₂: 0.000801 g/s
NO_x: 0.1067 g/s
CO: 0.053 g/s
TP: 0.01414 g/s
UHC = VOCs: 0.0107 g/s

* This source is equipped with RAC4-39-10 non-selective 3-way catalyst. Emissions provided above reflect emissions at catalyst outlet flange.

Emission Calculations for Source 1: Compressor Turbine (Unit 1 and 2)

diameter	1.156 m								
Test #	Test Ambient Temperature	Power	Actual Flow		Velocity	Flow @ 15 C		Flow@20 C	Temperature ^[1]
		(hp)	m3/h	m3/s	m/s	m3/h	m3/s	m3/s	C
1	-14	6713	155,299	43.14	41.10	59,550	16.54	16.83	478
2	0	6477	152,855	42.46	40.45	57,036	15.84	16.12	499
3	5	6382	151,955	42.21	40.22	56,151	15.60	15.87	507
4	15	6115	149,550	41.54	39.58	54,250	15.07	15.33	521
5	20	5874	147,072	40.85	38.92	53,009	14.72	14.98	526
6	29	5407	142,399	39.56	37.69	50,655	14.07	14.31	537
	Average				39.7			15.57	511

Test #	Test Ambient Temperature	NOX		CO		UHC=VOC		SO2-based on 43.6ppm fuel		SO2 - 15ppm fuel	PM ^[2]
		lb/hr	g/s	lb/hr	g/s	lb/hr	g/s	lb/hr	g/s	g/s	g/s
1	-14	3.24	0.408	3.29	0.415	1.88	0.24	0.223	0.028		
2	0	3.14	0.396	3.19	0.402	1.83	0.23	0.216	0.027		
3	5	3.11	0.392	3.15	0.397	1.81	0.23	0.214	0.027		
4	15	3.01	0.379	3.06	0.386	1.75	0.22	0.207	0.026		
5	20	2.93	0.369	2.97	0.374	1.7	0.21	0.201	0.025		
6	29	2.76	0.348	2.08	0.262	1.6	0.20	0.19	0.024		
	Average		0.382		0.373		0.2220		0.03	0.0090	0.0451

Source: CENTAUR_50-6200LS-GFS-88664 (Design Gas) + 4.5%.pdf

Calculated

[1] Exit temperature is calculated using the provided actual flow and flow at 15 C.

[2] PM calculations provided below.

PM Calculation	
FG Flow, Sm3/h ^[1]	1627
FG Flow, SCFM	957
HHV, Btu/SCF	1039
lb/MMBtu fuel input (HHV) ^[2]	0.006
PM 10/2.5 emissions, g/s per turbine	0.045

[1] from 4G022-TURB PERF.pdf

[2] from PIL 171 Particulate Matter Emission Estimates.pdf

Emission Calculations for Source 2: Boiler

g/mol, air	28.965
g/m ³ air @20C	1204
diameter	0.152 m

Flow					Velocity	Temperature
lb/hr	g/s	mol/s - air	m3/s @20 C	m3/s -Actual	m/s	C
1351	170.2	5.877	0.141	0.1645	9.1	68

NOX			CO		VOC		PM		SO2	
ppm	mol/s	g/s	lb/hr	g/s	lb/hr	g/s	lb/hr	g/s	lb/hr	g/s
20	1.18E-04	0.0054	0.074	0.0093	0.008	0.0010	0.0111	0.0014	0.0009	0.0001

Source: VITOCROSSAL_200_CI2_BE.pdf

Calculated

Emission Calculations for Source 3: Generator

diameter	0.254 m	10"
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Flow				Velocity	Temperature
acfm	Am3/hr	Am3/s	m3/s @20	m/s	C
3609	6132	1.703	0.571	33.6	602

NOX		CO		VOC		PM		SO2	
lb/hr	g/s	lb/hr	g/s	lb/hr	g/s	lb/hr	g/s	lb/hr	g/s
0.930	0.1172	0.470	0.059	0.090	0.0113	negligible	negligible	negligible	negligible

Source: 'Generator Datasheet (with catalyst) (001).pdf' and '3707-06797-BU-1400A-B23-001.pdf'

Calculated

SOLAR TURBINES INCORPORATED
ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
CUSTOMER: Fortis BC
JOB ID: 4G022

DATE RUN: 14-Feb-23
RUN BY: Edwin A Ventura

--- SUMMARY OF ENGINE EXHAUST ANALYSIS ---
POINT NUMBER 1

HP= 6713, %Full Load=100.0, Elev= 110m , %RH= 60.0, Temperature=-14.0C

GENERAL INPUT SPECIFICATIONS

ENGINE FUEL: CHOICE GAS

100.04 kPa	AMBIENT PRESSURE
60.0 percent	RELATIVE HUMIDITY
0.0008 ---	SP. HUMIDITY (KG H2O/KG DRY AIR)

FUEL GAS COMPOSITION (VOLUME PERCENT)

LHV (kJ/Std.m3) = 34977.7 SG = 0.5840 W.I. @15C (Btu/Scf) = 1226.7

W.I. @15C (kJ/Std.m3) = 45769.5

Gas Fuel Suitability (GFS)# 88664

Methane (CH4)	= 95.3967
Ethane (C2H6)	= 2.8040
Propane (C3H8)	= 0.6040
I-Butane (C4H10)	= 0.0974
N-Butane (C4H10)	= 0.1080
I-Pentane (C5H12)	= 0.0783
N-Pentane (C5H12)	= 0.0149
Hexane (C6H14)	= 0.0059
Heptane (C7H16)	= 0.0038
Octane (C8H18)	= 0.0034
Carbon Dioxide (CO2)	= 0.3263
Water Vapor (H2O)	= 0.0100
Hydrogen Sulfide (H2S)	= 0.0023
Nitrogen (N2)	= 0.5393
N-Nonane (C9H20)	= 0.0015
N-Decane (C10H22)	= 0.0007
MethylCycloHexane (C7H14)	= 0.0016
Benzene (C6H6)	= 0.0009
Toluene (C7H8)	= 0.0005
M-Xylene (C8H10)	= 0.0001
P-Xylene (C8H10)	= 0.0001
3-Methylpentane (C6H14)	= 0.0003

STANDARD CONDITIONS FOR GAS VOLUMES: Temperature: 15 deg C Pressure: 101.3 kPa

NORMAL CONDITIONS FOR GAS VOLUMES: Temperature: 0 deg C Pressure: 101.3 kPa

Solar's turbines are capable of operating over a wide range of fuel blends, however Engineering review is required when methane drops below 80% or other constituents exceed standard boundaries. Performance as modeled here should be accurate, but note that alterations to the combustion and package systems may be necessary.

GENERAL OUTPUT DATA

1163. kg/hr	FUEL FLOW
958.89 Scfm	FUEL FLOW
48916. kJ/kg	LOWER HEATING VALUE
34978. kJ/Std.m3	LOWER HEATING VALUE

59550.	Std.m3/hr	EXHAUST FLOW @ 101.3 KPa & 15C
155299.	m3/hr	ACTUAL EXHAUST FLOW M3/HR
71979.	kg/hr	EXHAUST GAS FLOW
2503.7	deg K	ADIA STOICH FLAME TEMP, CHOICE GAS
2503.4	deg K	ADIA STOICH FLAME TEMP, SDNG
28.60	---	MOLECULAR WEIGHT OF EXHAUST GAS
61.00	---	AIR/FUEL RATIO

EXHAUST GAS ANALYSIS

ARGON	CO2	H2O	N2	O2	
0.91	2.88	5.66	75.82	14.73	VOLUME PERCENT WET
0.96	3.05	0.00	80.37	15.61	VOLUME PERCENT DRY
912.	3189.	2568.	53450.	11858.	kg/hr
0.78	2.74	2.21	45.95	10.19	g/(g FUEL)

SOLAR TURBINES INCORPORATED
 ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
 CUSTOMER: Fortis BC
 JOB ID: 4G022

DATE RUN: 14-Feb-23
 RUN BY: Edwin A Ventura

--- Summary of Emissions for point number 1

CENTAUR 50-6200LS CS/MD 59F MATCH GAS
 EMISSIONS DATA REV. 0.1

ESTIMATED ENGINE EMISSION AT 0.01639 CHOICE NG FUEL/AIR RATIO

0.00 PERCENT OPACITY SMOKE EMISSION			
NOX	CO	UHC	S02
1.26	1.28	0.73	0.087 g/(kg Fuel)
15.00	25.00	25.00	0.741 PPMvd at 15% O2
3.24	3.29	1.88	0.223 lbm/hr
14.19	14.39	8.24	0.976 ton/yr
0.085	0.086	0.050	0.0059 g/GJ
			(GAS TURBINE SHAFT PWR)
0.23	0.23	0.13	0.016 g/(Hp-hr)
			(GAS TURBINE SHAFT PWR)
31.13	31.58	18.09	2.141 mg/Nm3 at 15% O2,
			DRY BASIS (1 ATM, 0 C)
0.060	0.061	0.035	0.0041 lbm/MMBtu (Fuel LHV)
25.81	26.19	15.00	1.775 g/GJ (Fuel LHV)
12.46	20.77	20.77	0.616 PPMv at 16% O2 Dry
0.054	0.055	0.031	0.0037 lbm/MMBtu (Fuel HHV)
0.68	0.69	0.39	0.046 lbm/(MW-hr)
			(GAS TURBINE SHAFT PWR)

S02 EMISSION DEPENDS ON SULFUR CONTENT IN FUEL. THE CURRENT ESTIMATE IS
 BASED ON THE ASSUMPTION OF 100 PERCENT CONVERSION OF FUEL SULFUR TO S02.
 SULFUR CONTENT = 43.6 PPMW

SOLAR TURBINES INCORPORATED
ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
CUSTOMER: Fortis BC
JOB ID: 4G022

DATE RUN: 14-Feb-23
RUN BY: Edwin A Ventura

NEW EQUIPMENT PREDICTED EMISSION PERFORMANCE
DATA FOR POINT NUMBER 1

Fuel: CHOICE GAS Customer: Fortis BC
Water Injection: NO Inquiry Number: OG-CG16-09137
Model: CENTAUR 50-6200LS CS/MD 59F MATCH GAS
Emissions Data: REV. 0.1

The following predicted emissions performance is based on the following specific single point:

HP= 6713, %Full Load=100.0, Elev= 110m , %RH= 60.0, Temperature=-14.0C

NOX	CO	UHC	
15.00	25.00	25.00	PPMvd at 15% O2
14.19	14.39	8.24	ton/yr
0.060	0.061	0.035	lbm/MMBtu (Fuel LHV)
0.68	0.69	0.39	lbm/(MW-hr)
			(gas turbine shaft pwr)
3.24	3.29	1.88	lbm/hr

NOTES:

1. For short-term emission limits such as lbs/hr., Solar recommends using "worst case" anticipated operating conditions specific to the application and the site conditions. Worst case for one pollutant is not necessarily the same for another.
2. Solar's typical SoLoNOx warranty, for ppm values, is available for greater than 0 deg F or -20 deg F, and between 50% and 100% load for gas fuel, and between 65% and 100% load for liquid fuel (except for the Centaur 40). An emission warranty for non-SoLoNOx equipment is available for greater than 0 deg F or -20 deg F and between 80% and 100% load.
3. Fuel must meet Solar standard fuel specification ES 9-98. Emissions are based on the attached fuel composition, or, San Diego natural gas or equivalent.
4. If needed, Solar can provide Product Information Letters to address turbine operation outside typical warranty ranges, as well as non-warranted emissions of SO2, PM10/2.5, VOC, and formaldehyde.
5. Solar can provide factory testing in San Diego to ensure the actual unit(s) meet the above values within the tolerances quoted. Pricing and schedule impact will be provided upon request.
6. Any emissions warranty is applicable only for steady-state conditions and does not apply during start-up, shut-down, malfunction, or transient event.

SOLAR TURBINES INCORPORATED
ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
CUSTOMER: Fortis BC
JOB ID: 4G022

DATE RUN: 14-Feb-23
RUN BY: Edwin A Ventura

--- SUMMARY OF ENGINE EXHAUST ANALYSIS ---
POINT NUMBER 2

HP= 6477, %Full Load=100.0, Elev= 110m , %RH= 60.0, Temperature= 0.0C

GENERAL INPUT SPECIFICATIONS

ENGINE FUEL: CHOICE GAS
100.04 kPa AMBIENT PRESSURE
60.0 percent RELATIVE HUMIDITY
0.0023 --- SP. HUMIDITY (KG H2O/KG DRY AIR)

FUEL GAS COMPOSITION (VOLUME PERCENT)

LHV (kJ/Std.m3) = 34977.7 SG = 0.5840 W.I. @15C (Btu/Scf) = 1226.7
W.I. @15C (kJ/Std.m3) = 45769.5
Gas Fuel Suitability (GFS)# 88664

Methane (CH4)	= 95.3967
Ethane (C2H6)	= 2.8040
Propane (C3H8)	= 0.6040
I-Butane (C4H10)	= 0.0974
N-Butane (C4H10)	= 0.1080
I-Pentane (C5H12)	= 0.0783
N-Pentane (C5H12)	= 0.0149
Hexane (C6H14)	= 0.0059
Heptane (C7H16)	= 0.0038
Octane (C8H18)	= 0.0034
Carbon Dioxide (CO2)	= 0.3263
Water Vapor (H2O)	= 0.0100
Hydrogen Sulfide (H2S)	= 0.0023
Nitrogen (N2)	= 0.5393
N-Nonane (C9H20)	= 0.0015
N-Decane (C10H22)	= 0.0007
MethylCycloHexane (C7H14)	= 0.0016
Benzene (C6H6)	= 0.0009
Toluene (C7H8)	= 0.0005
M-Xylene (C8H10)	= 0.0001
P-Xylene (C8H10)	= 0.0001
3-Methylpentane (C6H14)	= 0.0003

STANDARD CONDITIONS FOR GAS VOLUMES: Temperature: 15 deg C Pressure: 101.3 kPa
NORMAL CONDITIONS FOR GAS VOLUMES: Temperature: 0 deg C Pressure: 101.3 kPa

Solar's turbines are capable of operating over a wide range of fuel blends, however Engineering review is required when methane drops below 80% or other constituents exceed standard boundaries. Performance as modeled here should be accurate, but note that alterations to the combustion and package systems may be necessary.

GENERAL OUTPUT DATA

1131.	kg/hr	FUEL FLOW
932.39	Scfm	FUEL FLOW
48916.	kJ/kg	LOWER HEATING VALUE
34978.	kJ/Std.m3	LOWER HEATING VALUE

57036.	Std.m3/hr	EXHAUST FLOW @ 101.3 KPa & 15C
152855.	m3/hr	ACTUAL EXHAUST FLOW M3/HR
68865.	kg/hr	EXHAUST GAS FLOW
2515.4	deg K	ADIA STOICH FLAME TEMP, CHOICE GAS
2515.0	deg K	ADIA STOICH FLAME TEMP, SDNG
28.57	---	MOLECULAR WEIGHT OF EXHAUST GAS
60.01	---	AIR/FUEL RATIO

EXHAUST GAS ANALYSIS

ARGON	CO2	H2O	N2	O2	
0.90	2.92	5.98	75.60	14.59	VOLUME PERCENT WET
0.96	3.10	0.00	80.41	15.52	VOLUME PERCENT DRY
871.	3096.	2596.	51048.	11254.	kg/hr
0.77	2.74	2.29	45.13	9.95	g/(g FUEL)

SOLAR TURBINES INCORPORATED
 ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
 CUSTOMER: Fortis BC
 JOB ID: 4G022

DATE RUN: 14-Feb-23
 RUN BY: Edwin A Ventura

--- Summary of Emissions for point number 2

CENTAUR 50-6200LS CS/MD 59F MATCH GAS
 EMISSIONS DATA REV. 0.1

ESTIMATED ENGINE EMISSION AT 0.01666 CHOICE NG FUEL/AIR RATIO

0.00 PERCENT OPACITY SMOKE EMISSION			
NOX	CO	UHC	S02
1.26	1.28	0.73	0.087 g/(kg Fuel)
15.00	25.00	25.00	0.741 PPMvd at 15% O2
3.14	3.19	1.83	0.216 lbm/hr
13.77	13.98	8.01	0.947 ton/yr
0.086	0.087	0.050	0.0059 g/GJ
			(GAS TURBINE SHAFT PWR)
0.23	0.23	0.13	0.016 g/(Hp-hr)
			(GAS TURBINE SHAFT PWR)
31.16	31.62	18.11	2.143 mg/Nm3 at 15% O2,
			DRY BASIS (1 ATM, 0 C)
0.060	0.061	0.035	0.0041 lbm/MMBtu (Fuel LHV)
25.78	26.16	14.98	1.773 g/GJ (Fuel LHV)
12.46	20.77	20.77	0.615 PPMv at 16% O2 Dry
0.054	0.055	0.031	0.0037 lbm/MMBtu (Fuel HHV)
0.68	0.69	0.40	0.047 lbm/(MW-hr)
			(GAS TURBINE SHAFT PWR)

S02 EMISSION DEPENDS ON SULFUR CONTENT IN FUEL. THE CURRENT ESTIMATE IS
 BASED ON THE ASSUMPTION OF 100 PERCENT CONVERSION OF FUEL SULFUR TO S02.
 SULFUR CONTENT = 43.6 PPMW

SOLAR TURBINES INCORPORATED
ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
CUSTOMER: Fortis BC
JOB ID: 4G022

DATE RUN: 14-Feb-23
RUN BY: Edwin A Ventura

NEW EQUIPMENT PREDICTED EMISSION PERFORMANCE
DATA FOR POINT NUMBER 2

Fuel: CHOICE GAS Customer: Fortis BC
Water Injection: NO Inquiry Number: OG-CG16-09137
Model: CENTAUR 50-6200LS CS/MD 59F MATCH GAS
Emissions Data: REV. 0.1

The following predicted emissions performance is based on the following specific single point:

HP= 6477, %Full Load=100.0, Elev= 110m , %RH= 60.0, Temperature= 0.0C

NOX	CO	UHC	
15.00	25.00	25.00	PPMvd at 15% O2
13.77	13.98	8.01	ton/yr
0.060	0.061	0.035	lbm/MMBtu (Fuel LHV)
0.68	0.69	0.40	lbm/(MW-hr)
			(gas turbine shaft pwr)
3.14	3.19	1.83	lbm/hr

NOTES:

1. For short-term emission limits such as lbs/hr., Solar recommends using "worst case" anticipated operating conditions specific to the application and the site conditions. Worst case for one pollutant is not necessarily the same for another.
2. Solar's typical SoLoNOx warranty, for ppm values, is available for greater than 0 deg F or -20 deg F, and between 50% and 100% load for gas fuel, and between 65% and 100% load for liquid fuel (except for the Centaur 40). An emission warranty for non-SoLoNOx equipment is available for greater than 0 deg F or -20 deg F and between 80% and 100% load.
3. Fuel must meet Solar standard fuel specification ES 9-98. Emissions are based on the attached fuel composition, or, San Diego natural gas or equivalent.
4. If needed, Solar can provide Product Information Letters to address turbine operation outside typical warranty ranges, as well as non-warranted emissions of SO2, PM10/2.5, VOC, and formaldehyde.
5. Solar can provide factory testing in San Diego to ensure the actual unit(s) meet the above values within the tolerances quoted. Pricing and schedule impact will be provided upon request.
6. Any emissions warranty is applicable only for steady-state conditions and does not apply during start-up, shut-down, malfunction, or transient event.

SOLAR TURBINES INCORPORATED
ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
CUSTOMER: Fortis BC
JOB ID: 4G022

DATE RUN: 14-Feb-23
RUN BY: Edwin A Ventura

--- SUMMARY OF ENGINE EXHAUST ANALYSIS ---
POINT NUMBER 3

HP= 6382, %Full Load=100.0, Elev= 110m , %RH= 60.0, Temperature= 5.0C

GENERAL INPUT SPECIFICATIONS

ENGINE FUEL: CHOICE GAS

100.04 kPa	AMBIENT PRESSURE
60.0 percent	RELATIVE HUMIDITY
0.0033 ---	SP. HUMIDITY (KG H2O/KG DRY AIR)

FUEL GAS COMPOSITION (VOLUME PERCENT)

LHV (kJ/Std.m3) = 34977.7 SG = 0.5840 W.I. @15C (Btu/Scf) = 1226.7

W.I. @15C (kJ/Std.m3) = 45769.5

Gas Fuel Suitability (GFS)# 88664

Methane (CH4)	= 95.3967
Ethane (C2H6)	= 2.8040
Propane (C3H8)	= 0.6040
I-Butane (C4H10)	= 0.0974
N-Butane (C4H10)	= 0.1080
I-Pentane (C5H12)	= 0.0783
N-Pentane (C5H12)	= 0.0149
Hexane (C6H14)	= 0.0059
Heptane (C7H16)	= 0.0038
Octane (C8H18)	= 0.0034
Carbon Dioxide (CO2)	= 0.3263
Water Vapor (H2O)	= 0.0100
Hydrogen Sulfide (H2S)	= 0.0023
Nitrogen (N2)	= 0.5393
N-Nonane (C9H20)	= 0.0015
N-Decane (C10H22)	= 0.0007
MethylCycloHexane (C7H14)	= 0.0016
Benzene (C6H6)	= 0.0009
Toluene (C7H8)	= 0.0005
M-Xylene (C8H10)	= 0.0001
P-Xylene (C8H10)	= 0.0001
3-Methylpentane (C6H14)	= 0.0003

STANDARD CONDITIONS FOR GAS VOLUMES: Temperature: 15 deg C Pressure: 101.3 kPa

NORMAL CONDITIONS FOR GAS VOLUMES: Temperature: 0 deg C Pressure: 101.3 kPa

Solar's turbines are capable of operating over a wide range of fuel blends, however Engineering review is required when methane drops below 80% or other constituents exceed standard boundaries. Performance as modeled here should be accurate, but note that alterations to the combustion and package systems may be necessary.

GENERAL OUTPUT DATA

1119. kg/hr	FUEL FLOW
922.44 Scfm	FUEL FLOW
48916. kJ/kg	LOWER HEATING VALUE
34978. kJ/Std.m3	LOWER HEATING VALUE

56151.	Std.m3/hr	EXHAUST FLOW @ 101.3 KPa & 15C
151955.	m3/hr	ACTUAL EXHAUST FLOW M3/HR
67754.	kg/hr	EXHAUST GAS FLOW
2519.5	deg K	ADIA STOICH FLAME TEMP, CHOICE GAS
2519.1	deg K	ADIA STOICH FLAME TEMP, SDNG
28.55	---	MOLECULAR WEIGHT OF EXHAUST GAS
59.67	---	AIR/FUEL RATIO

EXHAUST GAS ANALYSIS

ARGON	CO2	H2O	N2	O2	
0.90	2.93	6.15	75.48	14.53	VOLUME PERCENT WET
0.96	3.12	0.00	80.43	15.49	VOLUME PERCENT DRY
856.	3060.	2631.	50171.	11036.	kg/hr
0.76	2.73	2.35	44.83	9.86	g/(g FUEL)

SOLAR TURBINES INCORPORATED
 ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
 CUSTOMER: Fortis BC
 JOB ID: 4G022

DATE RUN: 14-Feb-23
 RUN BY: Edwin A Ventura

--- Summary of Emissions for point number 3

CENTAUR 50-6200LS CS/MD 59F MATCH GAS
 EMISSIONS DATA REV. 0.1

ESTIMATED ENGINE EMISSION AT 0.01676 CHOICE NG FUEL/AIR RATIO

0.00	PERCENT OPACITY	SMOKE EMISSION	
NOX	CO	UHC	S02
1.26	1.28	0.73	0.087 g/(kg Fuel)
15.00	25.00	25.00	0.741 PPMvd at 15% O2
3.11	3.15	1.81	0.214 lbm/hr
13.62	13.81	7.91	0.936 ton/yr
0.086	0.087	0.050	0.0059 g/GJ
			(GAS TURBINE SHAFT PWR)
0.23	0.23	0.13	0.016 g/(Hp-hr)
			(GAS TURBINE SHAFT PWR)
31.18	31.64	18.12	2.144 mg/Nm3 at 15% O2,
			DRY BASIS (1 ATM, 0 C)
0.060	0.061	0.035	0.0041 lbm/MMBtu (Fuel LHV)
25.75	26.13	14.97	1.771 g/GJ (Fuel LHV)
12.46	20.77	20.77	0.615 PPMv at 16% O2 Dry
0.054	0.055	0.031	0.0037 lbm/MMBtu (Fuel HHV)
0.68	0.69	0.40	0.047 lbm/(MW-hr)
			(GAS TURBINE SHAFT PWR)

S02 EMISSION DEPENDS ON SULFUR CONTENT IN FUEL. THE CURRENT ESTIMATE IS
 BASED ON THE ASSUMPTION OF 100 PERCENT CONVERSION OF FUEL SULFUR TO S02.
 SULFUR CONTENT = 43.6 PPMW

SOLAR TURBINES INCORPORATED
ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
CUSTOMER: Fortis BC
JOB ID: 4G022

DATE RUN: 14-Feb-23
RUN BY: Edwin A Ventura

NEW EQUIPMENT PREDICTED EMISSION PERFORMANCE
DATA FOR POINT NUMBER 3

Fuel: CHOICE GAS Customer: Fortis BC
Water Injection: NO Inquiry Number: OG-CG16-09137
Model: CENTAUR 50-6200LS CS/MD 59F MATCH GAS
Emissions Data: REV. 0.1

The following predicted emissions performance is based on the following specific single point:

HP= 6382, %Full Load=100.0, Elev= 110m , %RH= 60.0, Temperature= 5.0C

NOX	CO	UHC	
15.00	25.00	25.00	PPMvd at 15% O2
13.62	13.81	7.91	ton/yr
0.060	0.061	0.035	lbm/MMBtu (Fuel LHV)
0.68	0.69	0.40	lbm/(MW-hr)
			(gas turbine shaft pwr)
3.11	3.15	1.81	lbm/hr

NOTES:

1. For short-term emission limits such as lbs/hr., Solar recommends using "worst case" anticipated operating conditions specific to the application and the site conditions. Worst case for one pollutant is not necessarily the same for another.
2. Solar's typical SoLoNOx warranty, for ppm values, is available for greater than 0 deg F or -20 deg F, and between 50% and 100% load for gas fuel, and between 65% and 100% load for liquid fuel (except for the Centaur 40). An emission warranty for non-SoLoNOx equipment is available for greater than 0 deg F or -20 deg F and between 80% and 100% load.
3. Fuel must meet Solar standard fuel specification ES 9-98. Emissions are based on the attached fuel composition, or, San Diego natural gas or equivalent.
4. If needed, Solar can provide Product Information Letters to address turbine operation outside typical warranty ranges, as well as non-warranted emissions of SO2, PM10/2.5, VOC, and formaldehyde.
5. Solar can provide factory testing in San Diego to ensure the actual unit(s) meet the above values within the tolerances quoted. Pricing and schedule impact will be provided upon request.
6. Any emissions warranty is applicable only for steady-state conditions and does not apply during start-up, shut-down, malfunction, or transient event.

SOLAR TURBINES INCORPORATED
ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
CUSTOMER: Fortis BC
JOB ID: 4G022

DATE RUN: 14-Feb-23
RUN BY: Edwin A Ventura

--- SUMMARY OF ENGINE EXHAUST ANALYSIS ---
POINT NUMBER 4

HP= 6115, %Full Load=100.0, Elev= 110m , %RH= 60.0, Temperature= 15.0C

GENERAL INPUT SPECIFICATIONS

ENGINE FUEL: CHOICE GAS

100.04 kPa	AMBIENT PRESSURE
60.0 percent	RELATIVE HUMIDITY
0.0065 ---	SP. HUMIDITY (KG H2O/KG DRY AIR)

FUEL GAS COMPOSITION (VOLUME PERCENT)

LHV (kJ/Std.m3) = 34977.7 SG = 0.5840 W.I. @15C (Btu/Scf) = 1226.7

W.I. @15C (kJ/Std.m3) = 45769.5

Gas Fuel Suitability (GFS)# 88664

Methane (CH4)	= 95.3967
Ethane (C2H6)	= 2.8040
Propane (C3H8)	= 0.6040
I-Butane (C4H10)	= 0.0974
N-Butane (C4H10)	= 0.1080
I-Pentane (C5H12)	= 0.0783
N-Pentane (C5H12)	= 0.0149
Hexane (C6H14)	= 0.0059
Heptane (C7H16)	= 0.0038
Octane (C8H18)	= 0.0034
Carbon Dioxide (CO2)	= 0.3263
Water Vapor (H2O)	= 0.0100
Hydrogen Sulfide (H2S)	= 0.0023
Nitrogen (N2)	= 0.5393
N-Nonane (C9H20)	= 0.0015
N-Decane (C10H22)	= 0.0007
MethylCycloHexane (C7H14)	= 0.0016
Benzene (C6H6)	= 0.0009
Toluene (C7H8)	= 0.0005
M-Xylene (C8H10)	= 0.0001
P-Xylene (C8H10)	= 0.0001
3-Methylpentane (C6H14)	= 0.0003

STANDARD CONDITIONS FOR GAS VOLUMES: Temperature: 15 deg C Pressure: 101.3 kPa

NORMAL CONDITIONS FOR GAS VOLUMES: Temperature: 0 deg C Pressure: 101.3 kPa

Solar's turbines are capable of operating over a wide range of fuel blends, however Engineering review is required when methane drops below 80% or other constituents exceed standard boundaries. Performance as modeled here should be accurate, but note that alterations to the combustion and package systems may be necessary.

GENERAL OUTPUT DATA

1088. kg/hr	FUEL FLOW
897.02 Scfm	FUEL FLOW
48916. kJ/kg	LOWER HEATING VALUE
34978. kJ/Std.m3	LOWER HEATING VALUE

54250.	Std.m3/hr	EXHAUST FLOW @ 101.3 KPa & 15C
149550.	m3/hr	ACTUAL EXHAUST FLOW M3/HR
65334.	kg/hr	EXHAUST GAS FLOW
2527.1	deg K	ADIA STOICH FLAME TEMP, CHOICE GAS
2526.7	deg K	ADIA STOICH FLAME TEMP, SDNG
28.50	---	MOLECULAR WEIGHT OF EXHAUST GAS
59.16	---	AIR/FUEL RATIO

EXHAUST GAS ANALYSIS

ARGON	CO2	H2O	N2	O2	
0.90	2.94	6.66	75.09	14.41	VOLUME PERCENT WET
0.96	3.15	0.00	80.45	15.44	VOLUME PERCENT DRY
822.	2966.	2752.	48221.	10571.	kg/hr
0.76	2.73	2.53	44.31	9.71	g/(g FUEL)

SOLAR TURBINES INCORPORATED
 ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
 CUSTOMER: Fortis BC
 JOB ID: 4G022

DATE RUN: 14-Feb-23
 RUN BY: Edwin A Ventura

--- Summary of Emissions for point number 4

CENTAUR 50-6200LS CS/MD 59F MATCH GAS
 EMISSIONS DATA REV. 0.1

ESTIMATED ENGINE EMISSION AT 0.01690 CHOICE NG FUEL/AIR RATIO

0.00 PERCENT OPACITY		SMOKE EMISSION		
NOX	CO	UHC	S02	
1.26	1.27	0.73	0.086	g/(kg Fuel)
15.00	25.00	25.00	0.741	PPMvd at 15% O2
3.01	3.06	1.75	0.207	lbm/hr
13.20	13.39	7.67	0.908	ton/yr
0.087	0.088	0.051	0.0060	g/GJ
				(GAS TURBINE SHAFT PWR)
0.23	0.24	0.14	0.016	g/(Hp-hr)
				(GAS TURBINE SHAFT PWR)
31.24	31.70	18.16	2.148	mg/Nm3 at 15% O2,
				DRY BASIS (1 ATM, 0 C)
0.060	0.061	0.035	0.0041	lbm/MMBtu (Fuel LHV)
25.68	26.05	14.92	1.765	g/GJ (Fuel LHV)
12.46	20.77	20.77	0.615	PPMv at 16% O2 Dry
0.054	0.055	0.031	0.0037	lbm/MMBtu (Fuel HHV)
0.69	0.70	0.40	0.047	lbm/(MW-hr)
				(GAS TURBINE SHAFT PWR)

S02 EMISSION DEPENDS ON SULFUR CONTENT IN FUEL. THE CURRENT ESTIMATE IS
 BASED ON THE ASSUMPTION OF 100 PERCENT CONVERSION OF FUEL SULFUR TO S02.
 SULFUR CONTENT = 43.6 PPMW

SOLAR TURBINES INCORPORATED
ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
CUSTOMER: Fortis BC
JOB ID: 4G022

DATE RUN: 14-Feb-23
RUN BY: Edwin A Ventura

NEW EQUIPMENT PREDICTED EMISSION PERFORMANCE
DATA FOR POINT NUMBER 4

Fuel: CHOICE GAS Customer: Fortis BC
Water Injection: NO Inquiry Number: OG-CG16-09137
Model: CENTAUR 50-6200LS CS/MD 59F MATCH GAS
Emissions Data: REV. 0.1

The following predicted emissions performance is based on the following specific single point:

HP= 6115, %Full Load=100.0, Elev= 110m , %RH= 60.0, Temperature= 15.0C

NOX	CO	UHC	
15.00	25.00	25.00	PPMvd at 15% O2
13.20	13.39	7.67	ton/yr
0.060	0.061	0.035	lbm/MMBtu (Fuel LHV)
0.69	0.70	0.40	lbm/(MW-hr)
			(gas turbine shaft pwr)
3.01	3.06	1.75	lbm/hr

NOTES:

1. For short-term emission limits such as lbs/hr., Solar recommends using "worst case" anticipated operating conditions specific to the application and the site conditions. Worst case for one pollutant is not necessarily the same for another.
2. Solar's typical SoLoNOx warranty, for ppm values, is available for greater than 0 deg F or -20 deg F, and between 50% and 100% load for gas fuel, and between 65% and 100% load for liquid fuel (except for the Centaur 40). An emission warranty for non-SoLoNOx equipment is available for greater than 0 deg F or -20 deg F and between 80% and 100% load.
3. Fuel must meet Solar standard fuel specification ES 9-98. Emissions are based on the attached fuel composition, or, San Diego natural gas or equivalent.
4. If needed, Solar can provide Product Information Letters to address turbine operation outside typical warranty ranges, as well as non-warranted emissions of SO2, PM10/2.5, VOC, and formaldehyde.
5. Solar can provide factory testing in San Diego to ensure the actual unit(s) meet the above values within the tolerances quoted. Pricing and schedule impact will be provided upon request.
6. Any emissions warranty is applicable only for steady-state conditions and does not apply during start-up, shut-down, malfunction, or transient event.

SOLAR TURBINES INCORPORATED
ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
CUSTOMER: Fortis BC
JOB ID: 4G022

DATE RUN: 14-Feb-23
RUN BY: Edwin A Ventura

--- SUMMARY OF ENGINE EXHAUST ANALYSIS ---
POINT NUMBER 5

HP= 5874, %Full Load=100.0, Elev= 110m , %RH= 60.0, Temperature= 20.0C

GENERAL INPUT SPECIFICATIONS

ENGINE FUEL: CHOICE GAS

100.04 kPa	AMBIENT PRESSURE
60.0 percent	RELATIVE HUMIDITY
0.0089 ---	SP. HUMIDITY (KG H2O/KG DRY AIR)

FUEL GAS COMPOSITION (VOLUME PERCENT)

LHV (kJ/Std.m3) = 34977.7 SG = 0.5840 W.I. @15C (Btu/Scf) = 1226.7

W.I. @15C (kJ/Std.m3) = 45769.5

Gas Fuel Suitability (GFS)# 88664

Methane (CH4)	= 95.3967
Ethane (C2H6)	= 2.8040
Propane (C3H8)	= 0.6040
I-Butane (C4H10)	= 0.0974
N-Butane (C4H10)	= 0.1080
I-Pentane (C5H12)	= 0.0783
N-Pentane (C5H12)	= 0.0149
Hexane (C6H14)	= 0.0059
Heptane (C7H16)	= 0.0038
Octane (C8H18)	= 0.0034
Carbon Dioxide (CO2)	= 0.3263
Water Vapor (H2O)	= 0.0100
Hydrogen Sulfide (H2S)	= 0.0023
Nitrogen (N2)	= 0.5393
N-Nonane (C9H20)	= 0.0015
N-Decane (C10H22)	= 0.0007
MethylCycloHexane (C7H14)	= 0.0016
Benzene (C6H6)	= 0.0009
Toluene (C7H8)	= 0.0005
M-Xylene (C8H10)	= 0.0001
P-Xylene (C8H10)	= 0.0001
3-Methylpentane (C6H14)	= 0.0003

STANDARD CONDITIONS FOR GAS VOLUMES: Temperature: 15 deg C Pressure: 101.3 kPa

NORMAL CONDITIONS FOR GAS VOLUMES: Temperature: 0 deg C Pressure: 101.3 kPa

Solar's turbines are capable of operating over a wide range of fuel blends, however Engineering review is required when methane drops below 80% or other constituents exceed standard boundaries. Performance as modeled here should be accurate, but note that alterations to the combustion and package systems may be necessary.

GENERAL OUTPUT DATA

1059. kg/hr	FUEL FLOW
873.17 Scfm	FUEL FLOW
48916. kJ/kg	LOWER HEATING VALUE
34978. kJ/Std.m3	LOWER HEATING VALUE

53009.	Std.m3/hr	EXHAUST FLOW @ 101.3 KPa & 15C
147072.	m3/hr	ACTUAL EXHAUST FLOW M3/HR
63753.	kg/hr	EXHAUST GAS FLOW
2529.6	deg K	ADIA STOICH FLAME TEMP, CHOICE GAS
2529.2	deg K	ADIA STOICH FLAME TEMP, SDNG
28.46	---	MOLECULAR WEIGHT OF EXHAUST GAS
59.31	---	AIR/FUEL RATIO

EXHAUST GAS ANALYSIS

ARGON	CO2	H2O	N2	O2	
0.89	2.92	7.00	74.81	14.37	VOLUME PERCENT WET
0.96	3.14	0.00	80.44	15.45	VOLUME PERCENT DRY
801.	2880.	2825.	46944.	10301.	kg/hr
0.76	2.72	2.67	44.32	9.72	g/(g FUEL)

SOLAR TURBINES INCORPORATED
 ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
 CUSTOMER: Fortis BC
 JOB ID: 4G022

DATE RUN: 14-Feb-23
 RUN BY: Edwin A Ventura

--- Summary of Emissions for point number 5

CENTAUR 50-6200LS CS/MD 59F MATCH GAS
 EMISSIONS DATA REV. 0.1

ESTIMATED ENGINE EMISSION AT 0.01686 CHOICE NG FUEL/AIR RATIO

0.00	PERCENT OPACITY	SMOKE EMISSION	
NOX	CO	UHC	S02
1.25	1.27	0.73	0.086 g/(kg Fuel)
15.00	25.00	25.00	0.741 PPMvd at 15% O2
2.93	2.97	1.70	0.201 lbm/hr
12.82	13.01	7.45	0.881 ton/yr
0.088	0.089	0.051	0.0060 g/GJ
			(GAS TURBINE SHAFT PWR)
0.24	0.24	0.14	0.016 g/(Hp-hr)
			(GAS TURBINE SHAFT PWR)
31.28	31.74	18.18	2.151 mg/Nm3 at 15% O2,
			DRY BASIS (1 ATM, 0 C)
0.060	0.060	0.035	0.0041 lbm/MMBtu (Fuel LHV)
25.61	25.99	14.89	1.761 g/GJ (Fuel LHV)
12.46	20.77	20.77	0.615 PPMv at 16% O2 Dry
0.054	0.055	0.031	0.0037 lbm/MMBtu (Fuel HHV)
0.70	0.71	0.41	0.048 lbm/(MW-hr)
			(GAS TURBINE SHAFT PWR)

S02 EMISSION DEPENDS ON SULFUR CONTENT IN FUEL. THE CURRENT ESTIMATE IS
 BASED ON THE ASSUMPTION OF 100 PERCENT CONVERSION OF FUEL SULFUR TO S02.
 SULFUR CONTENT = 43.6 PPMW

SOLAR TURBINES INCORPORATED
ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
CUSTOMER: Fortis BC
JOB ID: 4G022

DATE RUN: 14-Feb-23
RUN BY: Edwin A Ventura

NEW EQUIPMENT PREDICTED EMISSION PERFORMANCE
DATA FOR POINT NUMBER 5

Fuel: CHOICE GAS Customer: Fortis BC
Water Injection: NO Inquiry Number: OG-CG16-09137
Model: CENTAUR 50-6200LS CS/MD 59F MATCH GAS
Emissions Data: REV. 0.1

The following predicted emissions performance is based on the following specific single point:

HP= 5874, %Full Load=100.0, Elev= 110m , %RH= 60.0, Temperature= 20.0C

NOX	CO	UHC	
15.00	25.00	25.00	PPMvd at 15% O2
12.82	13.01	7.45	ton/yr
0.060	0.060	0.035	lbm/MMBtu (Fuel LHV)
0.70	0.71	0.41	lbm/(MW-hr)
			(gas turbine shaft pwr)
2.93	2.97	1.70	lbm/hr

NOTES:

1. For short-term emission limits such as lbs/hr., Solar recommends using "worst case" anticipated operating conditions specific to the application and the site conditions. Worst case for one pollutant is not necessarily the same for another.
2. Solar's typical SoLoNOx warranty, for ppm values, is available for greater than 0 deg F or -20 deg F, and between 50% and 100% load for gas fuel, and between 65% and 100% load for liquid fuel (except for the Centaur 40). An emission warranty for non-SoLoNOx equipment is available for greater than 0 deg F or -20 deg F and between 80% and 100% load.
3. Fuel must meet Solar standard fuel specification ES 9-98. Emissions are based on the attached fuel composition, or, San Diego natural gas or equivalent.
4. If needed, Solar can provide Product Information Letters to address turbine operation outside typical warranty ranges, as well as non-warranted emissions of SO2, PM10/2.5, VOC, and formaldehyde.
5. Solar can provide factory testing in San Diego to ensure the actual unit(s) meet the above values within the tolerances quoted. Pricing and schedule impact will be provided upon request.
6. Any emissions warranty is applicable only for steady-state conditions and does not apply during start-up, shut-down, malfunction, or transient event.

SOLAR TURBINES INCORPORATED
ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
CUSTOMER: Fortis BC
JOB ID: 4G022

DATE RUN: 14-Feb-23
RUN BY: Edwin A Ventura

--- SUMMARY OF ENGINE EXHAUST ANALYSIS ---
POINT NUMBER 6

HP= 5407, %Full Load=100.0, Elev= 110m , %RH= 60.0, Temperature= 29.0C

GENERAL INPUT SPECIFICATIONS

ENGINE FUEL: CHOICE GAS
100.04 kPa AMBIENT PRESSURE
60.0 percent RELATIVE HUMIDITY
0.0155 --- SP. HUMIDITY (KG H2O/KG DRY AIR)

FUEL GAS COMPOSITION (VOLUME PERCENT)

LHV (kJ/Std.m3) = 34977.7 SG = 0.5840 W.I. @15C (Btu/Scf) = 1226.7
W.I. @15C (kJ/Std.m3) = 45769.5
Gas Fuel Suitability (GFS)# 88664

Methane (CH4)	= 95.3967
Ethane (C2H6)	= 2.8040
Propane (C3H8)	= 0.6040
I-Butane (C4H10)	= 0.0974
N-Butane (C4H10)	= 0.1080
I-Pentane (C5H12)	= 0.0783
N-Pentane (C5H12)	= 0.0149
Hexane (C6H14)	= 0.0059
Heptane (C7H16)	= 0.0038
Octane (C8H18)	= 0.0034
Carbon Dioxide (CO2)	= 0.3263
Water Vapor (H2O)	= 0.0100
Hydrogen Sulfide (H2S)	= 0.0023
Nitrogen (N2)	= 0.5393
N-Nonane (C9H20)	= 0.0015
N-Decane (C10H22)	= 0.0007
MethylCycloHexane (C7H14)	= 0.0016
Benzene (C6H6)	= 0.0009
Toluene (C7H8)	= 0.0005
M-Xylene (C8H10)	= 0.0001
P-Xylene (C8H10)	= 0.0001
3-Methylpentane (C6H14)	= 0.0003

STANDARD CONDITIONS FOR GAS VOLUMES: Temperature: 15 deg C Pressure: 101.3 kPa
NORMAL CONDITIONS FOR GAS VOLUMES: Temperature: 0 deg C Pressure: 101.3 kPa

Solar's turbines are capable of operating over a wide range of fuel blends, however Engineering review is required when methane drops below 80% or other constituents exceed standard boundaries. Performance as modeled here should be accurate, but note that alterations to the combustion and package systems may be necessary.

GENERAL OUTPUT DATA

1006.	kg/hr	FUEL FLOW
829.04	Scfm	FUEL FLOW
48916.	kJ/kg	LOWER HEATING VALUE
34978.	kJ/Std.m3	LOWER HEATING VALUE

50655.	Std.m3/hr	EXHAUST FLOW @ 101.3 KPa & 15C
142399.	m3/hr	ACTUAL EXHAUST FLOW M3/HR
60701.	kg/hr	EXHAUST GAS FLOW
2533.6	deg K	ADIA STOICH FLAME TEMP, CHOICE GAS
2533.3	deg K	ADIA STOICH FLAME TEMP, SDNG
28.36	---	MOLECULAR WEIGHT OF EXHAUST GAS
59.48	---	AIR/FUEL RATIO

EXHAUST GAS ANALYSIS

ARGON	CO2	H2O	N2	O2	
0.89	2.88	7.91	74.07	14.25	VOLUME PERCENT WET
0.96	3.13	0.00	80.43	15.47	VOLUME PERCENT DRY
758.	2717.	3051.	44417.	9758.	kg/hr
0.75	2.70	3.03	44.16	9.70	g/(g FUEL)

SOLAR TURBINES INCORPORATED
 ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
 CUSTOMER: Fortis BC
 JOB ID: 4G022

DATE RUN: 14-Feb-23
 RUN BY: Edwin A Ventura

--- Summary of Emissions for point number 6

CENTAUR 50-6200LS CS/MD 59F MATCH GAS
 EMISSIONS DATA REV. 0.1

ESTIMATED ENGINE EMISSION AT 0.01681 CHOICE NG FUEL/AIR RATIO

0.00	PERCENT OPACITY	SMOKE EMISSION	
NOX	CO	UHC	S02
1.25	1.26	0.72	0.086 g/(kg Fuel)
15.00	25.00	25.00	0.741 PPMvd at 15% O2
2.76	2.80	1.60	0.190 lbm/hr
12.09	12.27	7.03	0.832 ton/yr
0.090	0.092	0.052	0.0062 g/GJ
			(GAS TURBINE SHAFT PWR)
0.24	0.25	0.14	0.017 g/(Hp-hr)
			(GAS TURBINE SHAFT PWR)
31.39	31.86	18.25	2.159 mg/Nm3 at 15% O2,
			DRY BASIS (1 ATM, 0 C)
0.059	0.060	0.034	0.0041 lbm/MMBtu (Fuel LHV)
25.45	25.82	14.79	1.750 g/GJ (Fuel LHV)
12.46	20.77	20.77	0.615 PPMv at 16% O2 Dry
0.053	0.054	0.031	0.0037 lbm/MMBtu (Fuel HHV)
0.72	0.73	0.42	0.049 lbm/(MW-hr)
			(GAS TURBINE SHAFT PWR)

S02 EMISSION DEPENDS ON SULFUR CONTENT IN FUEL. THE CURRENT ESTIMATE IS
 BASED ON THE ASSUMPTION OF 100 PERCENT CONVERSION OF FUEL SULFUR TO S02.
 SULFUR CONTENT = 43.6 PPMW

SOLAR TURBINES INCORPORATED
ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
CUSTOMER: Fortis BC
JOB ID: 4G022

DATE RUN: 14-Feb-23
RUN BY: Edwin A Ventura

NEW EQUIPMENT PREDICTED EMISSION PERFORMANCE
DATA FOR POINT NUMBER 6

Fuel: CHOICE GAS Customer: Fortis BC
Water Injection: NO Inquiry Number: OG-CG16-09137
Model: CENTAUR 50-6200LS CS/MD 59F MATCH GAS
Emissions Data: REV. 0.1

The following predicted emissions performance is based on the following specific single point:

HP= 5407, %Full Load=100.0, Elev= 110m , %RH= 60.0, Temperature= 29.0C

NOX	CO	UHC	
15.00	25.00	25.00	PPMvd at 15% O2
12.09	12.27	7.03	ton/yr
0.059	0.060	0.034	lbm/MMBtu (Fuel LHV)
0.72	0.73	0.42	lbm/(MW-hr)
			(gas turbine shaft pwr)
2.76	2.80	1.60	lbm/hr

NOTES:

1. For short-term emission limits such as lbs/hr., Solar recommends using "worst case" anticipated operating conditions specific to the application and the site conditions. Worst case for one pollutant is not necessarily the same for another.
2. Solar's typical SoLoNOx warranty, for ppm values, is available for greater than 0 deg F or -20 deg F, and between 50% and 100% load for gas fuel, and between 65% and 100% load for liquid fuel (except for the Centaur 40). An emission warranty for non-SoLoNOx equipment is available for greater than 0 deg F or -20 deg F and between 80% and 100% load.
3. Fuel must meet Solar standard fuel specification ES 9-98. Emissions are based on the attached fuel composition, or, San Diego natural gas or equivalent.
4. If needed, Solar can provide Product Information Letters to address turbine operation outside typical warranty ranges, as well as non-warranted emissions of SO2, PM10/2.5, VOC, and formaldehyde.
5. Solar can provide factory testing in San Diego to ensure the actual unit(s) meet the above values within the tolerances quoted. Pricing and schedule impact will be provided upon request.
6. Any emissions warranty is applicable only for steady-state conditions and does not apply during start-up, shut-down, malfunction, or transient event.

SOLAR TURBINES INCORPORATED
 ENGINE PERFORMANCE CODE REV. 4.20.2.27.13
 CUSTOMER: Fortis BC
 JOB ID: 4G022

DATE RUN: 14-Feb-23
 RUN BY: Edwin A Ventura

CENTAUR 50-6200LS
 CS/MD
 59F MATCH
 GAS
 THD-2S REV. 0.1
 ES-2090
 ES-2090

DATA FOR EXPECTED PERFORMANCE

Fuel Type CHOICE GAS

Elevation	metres	110
Inlet Loss	mm H2O	101.6
Exhaust Loss	mm H2O	101.6
Accessory on GP Shaft	HP	15.5

Engine Inlet Temp.	deg C	-14.0	0	5.0	15.0	20.0	29.0
Relative Humidity	%	60.0	60.0	60.0	60.0	60.0	60.0
Elevation Loss	HP	86	83	81	78	75	69
Inlet Loss	HP	111	108	107	104	101	94
Exhaust Loss	HP	46	46	46	45	44	42
Off-Optimum NPT Loss	HP	3	2	2	2	4	9

Driven Equipment Speed	RPM	13522	13522	13522	13522	13522	13522
Optimum Equipment Speed	RPM	13242	13281	13294	13271	13173	12982
Gas Generator Speed	RPM	15000	15000	15000	14963	14883	14752

Specified Load	HP	FULL	FULL	FULL	FULL	FULL	FULL
Net Output Power	HP	6713	6477	6382	6115	5874	5407
Fuel Flow	Sm3/hr	1626.59	1581.64	1564.76	1521.64	1481.17	1406.32
Heat Rate	Btu/HP-hr	8395	8461	8496	8622	8737	9013
Therm Eff	%	30.307	30.073	29.949	29.512	29.124	28.231

Inlet Air Flow	kg/hr	70964	67877	66775	64381	62826	59821
Engine Exhaust Flow	kg/hr	71979	68865	67754	65334	63753	60701
PCD	kPaG	1010.8	974.0	960.6	929.6	905.6	859.6
Compensated PTIT	deg C	721	741	749	760	760	760
PT Exit Temperature	deg C	469	490	497	511	517	527
Exhaust Temperature	deg C	469	490	497	511	517	527

FUEL GAS COMPOSITION (VOLUME PERCENT)

LHV (kJ/Std.m3) = 34977.7 SG = 0.5840 W.I. @15C (Btu/Scf) = 1226.7
 W.I. @15C (kJ/Std.m3) = 45769.5
 Gas Fuel Suitability (GFS)# 88664

Methane (CH4)	= 95.3967
Ethane (C2H6)	= 2.8040
Propane (C3H8)	= 0.6040
I-Butane (C4H10)	= 0.0974
N-Butane (C4H10)	= 0.1080
I-Pentane (C5H12)	= 0.0783
N-Pentane (C5H12)	= 0.0149

Hexane (C6H14)	=	0.0059
Heptane (C7H16)	=	0.0038
Octane (C8H18)	=	0.0034
Carbon Dioxide (CO2)	=	0.3263
Water Vapor (H2O)	=	0.0100
Hydrogen Sulfide (H2S)	=	0.0023
Nitrogen (N2)	=	0.5393
N-Nonane (C9H20)	=	0.0015
N-Decane (C10H22)	=	0.0007
MethylCycloHexane (C7H14)	=	0.0016
Benzene (C6H6)	=	0.0009
Toluene (C7H8)	=	0.0005
M-Xylene (C8H10)	=	0.0001
P-Xylene (C8H10)	=	0.0001
3-Methylpentane (C6H14)	=	0.0003

STANDARD CONDITIONS FOR GAS VOLUMES: Temperature: 15 deg C Pressure: 101.3 kPa
 NORMAL CONDITIONS FOR GAS VOLUMES: Temperature: 0 deg C Pressure: 101.3 kPa

Solar's turbines are capable of operating over a wide range of fuel blends, however Engineering review is required when methane drops below 80% or other constituents exceed standard boundaries. Performance as modeled here should be accurate, but note that alterations to the combustion and package systems may be necessary.

This performance was calculated with a basic inlet and exhaust system. Special equipment such as low noise silencers, special filters, heat recovery systems or cooling devices will affect engine performance. Performance shown is "Expected" performance at the pressure drops stated, not guaranteed.

NOTES

GFS-88664

5.1 GUARANTEED PERFORMANCE

FT19-03707 PO 4800006416-V2
 DOC # 4G022-TURB PERF
 VDD K06-003 SUBMITTAL 1
 REC'D BY SMCI-DC 2022/12/21

5.1.1 GAS TURBINE PERFORMANCE DATA**Performance Conditions** (See Note a)

Elevation	110	meters
Design Ambient Temperature	29	Celsius
Design Relative Humidity	60	%
Inlet Pressure Drop	101.6	mmH2O
Exhaust Pressure Drop	101.6	mmH2O
Turbine Operating Level	100%; Continuous Duty	
Fuel Gas Composition	GFS-88664	
Compressor Suction Pressure (P1)	749.50	psia
Compressor Discharge Pressure (P2)	2184.50	psia
Compressor Gas Suction Temperature (T1)	50	Fahrenheit
Actual Compressor Inlet Gas Flow	840.79	acfm
Process Gas Composition	Molecular Wt. 16.916 Gas Components (Mol.%): 2-C1H4 95.4009 Methane 3- C2H6 2.8041 Ethane 4- C3H8 0.6040 Propane 5- IC4H10 0.0974 I-Butane 6- NC4H10 0.1078 N-Butane 7- IC5H12 0.0783 I-Pentane 8- NC5H12 0.0144 N-Pentane 10-C6H14 0.0055 N-Hexane 46-N2 0.5393 Nitrogen 49-CO2 0.3266 Carbon Dioxide 61-H2O 0.0085 Water	

SOLARIS MANAGEMENT CONSULTANTS INC.

- ☐ 1 - PROCEED
☒ 2 - PROCEED, CHANGE AS NOTED & RESUBMIT
☐ 3 - DO NOT PROCEED, CHANGE AS NOTED & RESUBMIT
☐ 4 - PROCEED & RESUBMIT CERTIFIED
☐ I/O - DATA RECEIVED FOR INFORMATION ONLY

NAME FSMDATE 01/18/2023

ACCEPTANCE OF THIS DOCUMENT BY SOLARIS DOES
 NOT RELIEVE THE VENDOR OF ANY RESPONSIBILITY
 UNDER THE TERMS AND CONDITIONS OF THE
 APPLICABLE CONTRACT OR PURCHASE ORDER

Guaranteed Centaur 50 Gas Turbine Power Output and Heat Rate (See Note b & c)

Gas Fuel	GFS 88664	
Output Power at Power Turbine Shaft (opt PT Speed)	5,416	hp

Power output,
 heat rate,
 emission
 guarantees to be
 included

Notes:

- (a) Performance is guaranteed on the basis of the pressure drops indicated for the inlet and exhaust systems. These are assumed values. Losses through the Turbine Air Inlet System are based on the configuration described and a clean filter, but do not account for additional losses in site ducting -- particularly where the equipment will be installed in an existing building. Deviations from these values will have a corresponding impact on performance observed at the project site. Intake air quality, gas fuel, and liquid fuel shall meet ES 9-98. Natural Gas fuel sulfur content shall be no greater than 0.1%
- (b) Guarantee Performance is demonstrated based on a standard San Diego factory test, corrected to:
- > 0 feet above sea level
 - > 60% Relative Humidity
 - > 0 inlet duct loss; 0 exhaust duct loss

> 59° F, 80° F, or 100° F, depending on the local ambient temperature when the test is conducted

- (c)** All Standard Warranty conditions (i.e. engine warranty) apply.

5.2 EXPECTED PERFORMANCE

5.2.1 GAS TURBINE PERFORMANCE DATA

The following gas turbine package performance is expected, but not guaranteed. The "Run" numbers correspond to different operating points and/or ambient conditions.

Engine Performance Data for Design Gas

Customer Fortis BC		Model CENTAUR 50-6200LS	
Job ID Eagle Mountain V2		Package Type CS/MD	
Run By Alasdair Peter McLean		Match 59F MATCH	
Date Run 16-Nov-21		Fuel System GAS	
Engine Performance Code REV. 4.20.2.27.13		Engine Performance Data REV. 0.1	
		Fuel Type CHOICE GAS	

DATA FOR EXPECTED PERFORMANCE

Elevation	metres	110				
Inlet Loss	mm H2O	101.6				
Exhaust Loss	mm H2O	101.6				
Accessory on GP Shaft	HP	15.5				
			1	2	3	4
Engine Inlet Temperature	deg C	-14.0	0	5.0	15.0	20.0
Relative Humidity	%	60.0	60.0	60.0	60.0	60.0
Driven Equipment Speed	RPM	13522	13522	13522	13522	13522
Specified Load	HP	FULL	FULL	FULL	FULL	FULL
Net Output Power	HP	6713	6477	6382	6115	5874
Fuel Flow	Sm3/hr	1626.59	1581.63	1564.77	1521.64	1406.33
Heat Rate	Btu/HP-hr	8395	8461	8496	8622	8737
Therm Eff	%	30.308	30.073	29.949	29.512	29.123
Engine Exhaust Flow	kg/hr	71979	68865	67754	65334	63752
PT Exit Temperature	deg C	469	490	497	511	517
Exhaust Temperature	deg C	469	490	497	511	517

Fuel Gas Composition (Volume Percent)	Methane (CH4)	95.40
	Ethane (C2H6)	2.80
	Propane (C3H8)	0.60
	I-Butane (C4H10)	0.10
	N-Butane (C4H10)	0.11
	I-Pentane (C5H12)	0.08
	N-Pentane (C5H12)	0.01
	Hexane (C6H14)	0.0059
	Heptane (C7H16)	0.0038
	Octane (C8H18)	0.0034
	Carbon Dioxide (CO2)	0.33
	Water Vapor (H2O)	0.0100
	Hydrogen Sulfide (H2S)	0.0023
	Nitrogen (N2)	0.54
	N-Nonane (C9H20)	0.0015
	N-Decane (C10H22)	0.0007
	MethylCycloHexane (C7H14)	0.0016
	Benzene (C6H6)	0.0009
	Toluene (C7H8)	0.0005
	M-Xylene (C8H10)	0.0001
	P-Xylene (C8H10)	0.0001
	3-Methylpentane (C6H14)	0.0003

Fuel Gas Properties	LHV (kJ/Std.m3)	34977.7	Specific Gravity	0.5840	Wobbe Index at 60F	1226.7
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This performance was calculated with a basic inlet and exhaust system. Special equipment such as low noise silencers, special filters, heat recovery systems or cooling devices will affect engine performance. Performance shown is "Expected" performance at the pressure drops stated, not guaranteed.

Notes

GFS: 88664 (Design Gas)

Customer Fortis BC	Engine Model CENTAUR 50-6200LS
Job ID Eagle Mountain V2	CS/MD 59F MATCH
Inquiry Number CG16-09137	Fuel Type CHOICE GAS
Run By Alasdair Peter McLean	Water Injection NO
Date Run 16-Nov-21	Engine Emissions Data REV. 0.1

	NOx EMISSIONS	CO EMISSIONS	UHC EMISSIONS
1	6713 HP 100.0% Load Elev. 110 m	Rel. Humidity 60.0%	Temperature -14.0 Deg. C
PPMvd at 15% O2	15.00	25.00	25.00
ton/yr	14.19	14.39	8.24
lbm/MMBtu (Fuel LHV)	0.060	0.061	0.035
lbm/(MW-hr)	0.68	0.69	0.39
(gas turbine shaft pwr) lbm/hr	3.24	3.29	1.88
2	6477 HP 100.0% Load Elev. 110 m	Rel. Humidity 60.0%	Temperature 0 Deg. C
PPMvd at 15% O2	15.00	25.00	25.00
ton/yr	13.77	13.98	8.01
lbm/MMBtu (Fuel LHV)	0.060	0.061	0.035
lbm/(MW-hr)	0.68	0.69	0.40
(gas turbine shaft pwr) lbm/hr	3.14	3.19	1.83
3	6382 HP 100.0% Load Elev. 110 m	Rel. Humidity 60.0%	Temperature 5.0 Deg. C
PPMvd at 15% O2	15.00	25.00	25.00
ton/yr	13.62	13.81	7.91
lbm/MMBtu (Fuel LHV)	0.060	0.061	0.035
lbm/(MW-hr)	0.68	0.69	0.40
(gas turbine shaft pwr) lbm/hr	3.11	3.15	1.81

Notes

1. For short-term emission limits such as lbs/hr., Solar recommends using "worst case" anticipated operating conditions specific to the application and the site conditions. Worst case for one pollutant is not necessarily the same for another.
2. Solar's typical SoLoNOx warranty, for ppm values, is available for greater than 0 deg F or -20 deg F, and between 50% and 100% load for gas fuel, and between 65% and 100% load for liquid fuel (except for the Centaur 40). An emission warranty for non-SoLoNOx equipment is available for greater than 0 deg F or -20 deg F and between 80% and 100% load.
3. Fuel must meet Solar standard fuel specification ES 9-98. Emissions are based on the attached fuel composition, or, San Diego natural gas or equivalent.
4. If needed, Solar can provide Product Information Letters to address turbine operation outside typical warranty ranges, as well as non-warranted emissions of SO2, PM10/2.5, VOC, and formaldehyde.
5. Solar can provide factory testing in San Diego to ensure the actual unit(s) meet the above values within the tolerances quoted. Pricing and schedule impact will be provided upon request.
6. Any emissions warranty is applicable only for steady-state conditions and does not apply during start-up, shut-down, malfunction, or transient event.

Customer Fortis BC	Engine Model CENTAUR 50-6200LS
Job ID Eagle Mountain V2	CS/MD 59F MATCH
Inquiry Number CG16-09137	Fuel Type CHOICE GAS
Run By Alasdair Peter McLean	Water Injection NO
Date Run 16-Nov-21	Engine Emissions Data REV. 0.1

NOx EMISSIONS

CO EMISSIONS

UHC EMISSIONS

4	6115 HP	100.0% Load	Elev. 110 m	Rel. Humidity 60.0%	Temperature 15.0 Deg. C
PPMvd at 15% O2	15.00	25.00	25.00		
ton/yr	13.20	13.39	7.67		
lbm/MMBtu (Fuel LHV)	0.060	0.061	0.035		
lbm/(MW-hr)	0.69	0.70	0.40		
(gas turbine shaft pwr) lbm/hr	3.01	3.06	1.75		
5	5874 HP	100.0% Load	Elev. 110 m	Rel. Humidity 60.0%	Temperature 20.0 Deg. C
PPMvd at 15% O2	15.00	25.00	25.00		
ton/yr	12.82	13.01	7.45		
lbm/MMBtu (Fuel LHV)	0.060	0.060	0.035		
lbm/(MW-hr)	0.70	0.71	0.41		
(gas turbine shaft pwr) lbm/hr	2.93	2.97	1.70		
6	5407 HP	100.0% Load	Elev. 110 m	Rel. Humidity 60.0%	Temperature 29.0 Deg. C
PPMvd at 15% O2	15.00	25.00	25.00		
ton/yr	12.09	12.27	7.03		
lbm/MMBtu (Fuel LHV)	0.059	0.060	0.034		
lbm/(MW-hr)	0.72	0.73	0.42		
(gas turbine shaft pwr) lbm/hr	2.76	2.80	1.60		

Notes

1. For short-term emission limits such as lbs/hr., Solar recommends using "worst case" anticipated operating conditions specific to the application and the site conditions. Worst case for one pollutant is not necessarily the same for another.
2. Solar's typical SoLoNOx warranty, for ppm values, is available for greater than 0 deg F or -20 deg F, and between 50% and 100% load for gas fuel, and between 65% and 100% load for liquid fuel (except for the Centaur 40). An emission warranty for non-SoLoNOx equipment is available for greater than 0 deg F or -20 deg F and between 80% and 100% load.
3. Fuel must meet Solar standard fuel specification ES 9-98. Emissions are based on the attached fuel composition, or, San Diego natural gas or equivalent.
4. If needed, Solar can provide Product Information Letters to address turbine operation outside typical warranty ranges, as well as non-warranted emissions of SO2, PM10/2.5, VOC, and formaldehyde.
5. Solar can provide factory testing in San Diego to ensure the actual unit(s) meet the above values within the tolerances quoted. Pricing and schedule impact will be provided upon request.
6. Any emissions warranty is applicable only for steady-state conditions and does not apply during start-up, shut-down, malfunction, or transient event.

Engine Performance Data for Alternate Gas

Customer Fortis BC		Model CENTAUR 50-6200LS	
Job ID Eagle Mountain V2		Package Type CS/MD	
Run By Alasdair Peter McLean		Match 59F MATCH	
Date Run 16-Nov-21		Fuel System GAS	
Engine Performance Code REV. 4.20.2.27.13		Engine Performance Data REV. 0.1	
		Fuel Type CHOICE GAS	

DATA FOR EXPECTED PERFORMANCE

Elevation	metres	110					
Inlet Loss	mm H2O	101.6					
Exhaust Loss	mm H2O	101.6					
Accessory on GP Shaft	HP	15.5					
		1	2	3	4	5	6
Engine Inlet Temperature	deg C	-14.0	0	5.0	15.0	20.0	29.0
Relative Humidity	%	60.0	60.0	60.0	60.0	60.0	60.0
Driven Equipment Speed	RPM	13522	13522	13522	13522	13522	13522
Specified Load	HP	FULL	FULL	FULL	FULL	FULL	FULL
Net Output Power	HP	6714	6478	6383	6104	5862	5393
Fuel Flow	Sm3/hr	1541.11	1498.50	1482.53	1439.37	1400.96	1330.01
Heat Rate	Btu/HP-hr	8398	8463	8499	8628	8744	9023
Therm Eff	%	30.298	30.064	29.939	29.490	29.100	28.200
Engine Exhaust Flow	kg/hr	71977	68864	67752	65293	63712	60649
PT Exit Temperature	deg C	470	490	498	512	517	527
Exhaust Temperature	deg C	470	490	498	512	517	527

Fuel Gas Composition (Volume Percent)	Methane (CH4)	90.38
	Ethane (C2H6)	6.88
	Propane (C3H8)	1.69
	I-Butane (C4H10)	0.22
	N-Butane (C4H10)	0.24
	I-Pentane (C5H12)	0.04
	N-Pentane (C5H12)	0.03
	Hexane (C6H14)	0.02
	Carbon Dioxide (CO2)	0.24
	Nitrogen (N2)	0.25
	Sulfur Dioxide (SO2)	0.0001

Fuel Gas Properties	LHV (kJ/Std.m3)	36932.8	Specific Gravity	0.6155	Wobbe Index at 60F	1261.7
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This performance was calculated with a basic inlet and exhaust system. Special equipment such as low noise silencers, special filters, heat recovery systems or cooling devices will affect engine performance. Performance shown is "Expected" performance at the pressure drops stated, not guaranteed.

Notes

GFS: 88665 (Alternate Gas)

Customer Fortis BC	Engine Model CENTAUR 50-6200LS
Job ID Eagle Mountain V2	CS/MD 59F MATCH
Inquiry Number CG16-09137	Fuel Type CHOICE GAS
Run By Alasdair Peter McLean	Water Injection NO
Date Run 16-Nov-21	Engine Emissions Data REV. 0.1

NOx EMISSIONS				CO EMISSIONS		UHC EMISSIONS	
1	6714 HP	100.0% Load	Elev. 110 m	Rel. Humidity 60.0%	Temperature -14.0 Deg. C		
PPMvd at 15% O2	15.00	25.00	25.00				
ton/yr	14.19	14.39	8.24				
lbm/MMBtu (Fuel LHV)	0.060	0.061	0.035				
lbm/(MW-hr)	0.68	0.69	0.39				
(gas turbine shaft pwr)	3.24	3.29	1.88				
lbm/hr							
2	6478 HP	100.0% Load	Elev. 110 m	Rel. Humidity 60.0%	Temperature 0 Deg. C		
PPMvd at 15% O2	15.00	25.00	25.00				
ton/yr	13.78	13.98	8.01				
lbm/MMBtu (Fuel LHV)	0.060	0.061	0.035				
lbm/(MW-hr)	0.68	0.69	0.40				
(gas turbine shaft pwr)	3.15	3.19	1.83				
lbm/hr							
3	6383 HP	100.0% Load	Elev. 110 m	Rel. Humidity 60.0%	Temperature 5.0 Deg. C		
PPMvd at 15% O2	15.00	25.00	25.00				
ton/yr	13.62	13.82	7.91				
lbm/MMBtu (Fuel LHV)	0.060	0.061	0.035				
lbm/(MW-hr)	0.68	0.69	0.40				
(gas turbine shaft pwr)	3.11	3.15	1.81				
lbm/hr							

Notes

- For short-term emission limits such as lbs/hr., Solar recommends using "worst case" anticipated operating conditions specific to the application and the site conditions. Worst case for one pollutant is not necessarily the same for another.
- Solar's typical SoLoNOx warranty, for ppm values, is available for greater than 0 deg F or -20 deg F, and between 50% and 100% load for gas fuel, and between 65% and 100% load for liquid fuel (except for the Centaur 40). An emission warranty for non-SoLoNOx equipment is available for greater than 0 deg F or -20 deg F and between 80% and 100% load.
- Fuel must meet Solar standard fuel specification ES 9-98. Emissions are based on the attached fuel composition, or, San Diego natural gas or equivalent.
- If needed, Solar can provide Product Information Letters to address turbine operation outside typical warranty ranges, as well as non-warranted emissions of SO2, PM10/2.5, VOC, and formaldehyde.
- Solar can provide factory testing in San Diego to ensure the actual unit(s) meet the above values within the tolerances quoted. Pricing and schedule impact will be provided upon request.
- Any emissions warranty is applicable only for steady-state conditions and does not apply during start-up, shut-down, malfunction, or transient event.

Customer Fortis BC	Engine Model CENTAUR 50-6200LS
Job ID Eagle Mountain V2	CS/MD 59F MATCH
Inquiry Number CG16-09137	Fuel Type CHOICE GAS
Run By Alasdair Peter McLean	Water Injection NO
Date Run 16-Nov-21	Engine Emissions Data REV. 0.1

NOx EMISSIONS

CO EMISSIONS

UHC EMISSIONS

4	6104 HP	100.0% Load	Elev. 110 m	Rel. Humidity 60.0%	Temperature 15.0 Deg. C
PPMvd at 15% O2	15.00	25.00	25.00		
ton/yr	13.18	13.37	7.66		
lbm/MMBtu (Fuel LHV)	0.060	0.061	0.035		
lbm/(MW-hr)	0.69	0.70	0.40		
(gas turbine shaft pwr) lbm/hr	3.01	3.05	1.75		
5	5862 HP	100.0% Load	Elev. 110 m	Rel. Humidity 60.0%	Temperature 20.0 Deg. C
PPMvd at 15% O2	15.00	25.00	25.00		
ton/yr	12.80	12.99	7.44		
lbm/MMBtu (Fuel LHV)	0.060	0.060	0.035		
lbm/(MW-hr)	0.70	0.71	0.41		
(gas turbine shaft pwr) lbm/hr	2.92	2.96	1.70		
6	5393 HP	100.0% Load	Elev. 110 m	Rel. Humidity 60.0%	Temperature 29.0 Deg. C
PPMvd at 15% O2	15.00	25.00	25.00		
ton/yr	12.07	12.25	7.02		
lbm/MMBtu (Fuel LHV)	0.059	0.060	0.034		
lbm/(MW-hr)	0.72	0.73	0.42		
(gas turbine shaft pwr) lbm/hr	2.76	2.80	1.60		

Notes

1. For short-term emission limits such as lbs/hr., Solar recommends using "worst case" anticipated operating conditions specific to the application and the site conditions. Worst case for one pollutant is not necessarily the same for another.
2. Solar's typical SoLoNOx warranty, for ppm values, is available for greater than 0 deg F or -20 deg F, and between 50% and 100% load for gas fuel, and between 65% and 100% load for liquid fuel (except for the Centaur 40). An emission warranty for non-SoLoNOx equipment is available for greater than 0 deg F or -20 deg F and between 80% and 100% load.
3. Fuel must meet Solar standard fuel specification ES 9-98. Emissions are based on the attached fuel composition, or, San Diego natural gas or equivalent.
4. If needed, Solar can provide Product Information Letters to address turbine operation outside typical warranty ranges, as well as non-warranted emissions of SO2, PM10/2.5, VOC, and formaldehyde.
5. Solar can provide factory testing in San Diego to ensure the actual unit(s) meet the above values within the tolerances quoted. Pricing and schedule impact will be provided upon request.
6. Any emissions warranty is applicable only for steady-state conditions and does not apply during start-up, shut-down, malfunction, or transient event.

Particulate Matter Emissions

Travis Domingo and Anthony Pocengal

PURPOSE

This Product Information Letter (PIL) provides guidance and background related to particulate matter (PM) emissions and the test methodologies to quantify PM emissions. This PIL includes Solar's recommended PM_{10/2.5} emissions factors for air permitting.

PARTICULATE MATTER BACKGROUND

The Environmental Protection Agency (EPA) defines PM₁₀ and PM_{2.5} as particles with aerodynamic diameter smaller than 10/2.5 micrometers respectively. The EPA has designated National Ambient Air Quality Standards (NAAQS) for PM_{10/2.5} to which States have implementation plans to meet the standards (i.e. be in "attainment").

Nearly all particulate matter from gas turbines exhaust is less than one micrometer (micron) in diameter. Therefore, the emission rates of PM₁₀ and PM_{2.5} from gas turbines are theoretically equivalent.

TESTING FOR PARTICULATE MATTER

The turbine combustion process has little effect on the particulate matter generated and measured. The largest contributor to particulate matter emissions for gas and liquid fired combustion turbines is measurement technique and error. Other, minor contributing, sources of particulate matter emissions include carbon, ash, fuel-bonded sulfur, artifact sulfate formation, compressor/lubricating oils, and inlet air.

Historical customer particulate matter source test data show that there is significant variability from test to test. The source test results support the common industry argument that particulate matter from natural gas fired combustion sources is difficult to measure accurately. The reference test methods for particulate matter were developed primarily for measuring emissions from coal-fired power plants and other major emitters of particulates. Generally, current turbines are much more efficient and the fuels they combust are subject to strict quality requirements. The test methods were not developed for these cleaner fuels or verified for low emission levels. There are interferences, insignificant at higher exhaust particulate matter concentrations that result in emissions greater than the actual emissions from gas turbines.

Due to measurement and procedural errors, the measured results may be significantly higher and not representative of actual particulate matter emitted. There are many potential error sources in measuring particulate matter. Most of these have to do with contamination of the samples, material from the sampling apparatus getting into the samples, and human error in samples and analysis. Source test firms are gaining experience in measuring particulate matter and are deploying best practices which has lessened the historical variability from test to test and the emissions levels measured have decreased.

RECOMMENDED PARTICULATE MATTER EMISSION FACTORS

When necessary to support the air permitting process Solar recommends the following PM_{10/2.5} emission factors for all models and ratings except for the Mercury™ 50. Please refer to PIL 205 for the Mercury 50. The emission factors below are intended to include both the front half (filterable) and the back half (condensable).

- Pipeline Natural Gas* and Natural Gas/Hydrogen Blends[&]: 0.006 lb/MMBtu fuel input (HHV)
- Landfill/Digester Gas⁺: 0.02 lb/MMBtu fuel input (HHV)
- Liquid Fuel[#]: 0.01 lb/MMBtu fuel input (HHV)

*Pipeline natural gas emissions factor assumes <1 grains of Sulfur per 100 standard cubic feet.

[&]Natural Gas/Hydrogen Blends can utilize the same emission factors as 100% natural gas.

⁺Landfill/digester gas emissions factor assumes <.15lb SO₂/MMBtu heat input

[#]Liquid fuel emission factor assumes fuel Sulfur content is <500 ppm and ash content is <0.005% by wt.

Contact Solar's Environmental Programs group for particulate matter emissions estimates for fuels not listed above.

The conversion of particulate matter emissions request from mg/Nm³ to lb/MMBtu (HHV) units involves several specific turbine parameters. Please contact Solar if you need the calculation performed.

TEST METHOD RECOMMENDATION

Solar recommends utilizing the preferred reference test method(s) required by applicable regulatory agency. When U.S. EPA reference test methods are specified for use, Solar recommends the below:

- EPA Method 201/201A to measure the "front half". The "Front half" represents filterable PM
- EPA Method 202² (with Nitrogen purge and field blanks) should be used to measure the "back half." "Back half" measurements represent the condensable portion of particulate matter.
 - Solar highly recommends utilizing EPA's recommended best practices⁴ until more representative test methods are accepted for widespread use by EPA, State/Local regulatory authorities, or any other applicable regulatory authority.
 - In addition to the best practices for Method 202, Other Test Method (OTM) 59, Method for the Correction of Residual Ammonia in Condensable particulate Matter Samples Collected according to Method 202⁴ must be followed to minimize additional biases from the presence of ammonia or sulfur dioxide
- EPA Method 5⁵, which measures the front and back halves may be substituted (e.g. where exhaust temperatures do not allow the use of Method 202).

The turbine shall have a minimum of 300 operating hours prior to conducting particulate matter source testing. The turbine shall be running for 3-4 hours prior to conducting a particulate matter source test so that the turbine and auxiliary equipment is in a sustained "typical" operating mode prior to gathering samples.

Testing shall include a minimum of three 4-hour test runs.

ALTERNATE TEST METHODS FOR PM QUANTIFICATION

In addition to the EPA and EU standard reference test methods, there are alternate testing methodologies⁶ available which measure PM emissions to higher accuracy levels. These methodologies utilize dilution sampling techniques that may lead to PM emissions ~10x lower than the current EPA reference test method. This method uses specialized equipment and experience in properly conducting these alternate test methods may not be as widespread. Moreover, utilization of these alternate methodologies requires prior approval from air permitting authorities. Contact Solar's Environmental Strategy Team for more information on these alternate methodologies.

REFERENCES

¹EPA Method 201, Determination of PM10 Emissions, Exhaust Gas Recycle Procedure. EPA Method 201A. Determination of PM10 Emissions, Constant Sampling Rate Procedure, 40 CFR 60, Part 60, Appendix A.

²EPA Method 202, Determination of Condensable Particulate Emissions from Station Sources, 40 CFR 60, Part 60. Appendix A.

³EPA Method 202 Best Practices Handbook, January 2016

⁴OTM 59, Method for the Correction of Residual Ammonia in Condensable particulate Matter Samples Collected according to Method 202

⁵EPA Method 5, Determination of Particulate Emissions from Station Sources, 40 CFR 60, Part 60, Appendix A.

⁶EPA Other Test Method (OTM) 37, Measurement of Direct PM2.5 and PM10 Emissions at Low Concentrations by Dilution Sampling (Constant Sampling Rate Procedure). Conditional Test Method (CTM) 39, Measurement of PM2.5 and PM10 Emissions By Dilution Sampling (Constant Sampling Rate Procedures)

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FT19-03707 PO 4800006797-BU-1400C1
 DOC # VITOCROSSAL_200_CI2_BE
 VDD B23-007 SUBMITTAL 2
 REC'D BY SMCI-DC 2023/06/28



Boiler Emissions

Viessmann Cylinder Burner

Vitocrossal 200 - CI2

Working on the equipment:

The installation, adjustment, service and maintenance of this product must be done by a **licensed professional heating contractor** who is qualified and experienced in the installation, service and maintenance of hot water

CAUTION

Factory settings to be verified or changed by qualified heating contractor, depending on field measured combustion results. Field setup and adjustment is required.

Standard Natural Gas At 1020 BTU/SCF

Boiler Series: Vitocrossal CI2

Model: CI2-1500 (1.5 MMBtu input rating)

Emissions	CI2 1500	units
NOx	< 20	ppm
CO ₂ - high fire	8.5	%
CO - high fire	< 20	ppm
	0.074	lbs/hr
		g/hr
SO ₂	0.0009	lbs/hr
		g/hr
Volatile Organic Compounds (VOC)	0.008	lbs/hr
		g/hr
Lead	7×10 ⁻⁷	lbs/hr
		g/hr
Total Organics (TOC)	0.016	lbs/hr
		g/hr
Total Particulates (PM)	0.0111	lbs/hr
		g/hr
Mass flow rate of flue gases at max. input (Excess air of 30 to 35%)	1351	lbs/h

NOTES:

- > AP 42, Fifth Edition, Volume I Chapter 1: External Combustion Sources 1.4 Natural Gas Combustion 7/1998
- > NOx and CO are stated at 3% Oxygen correction
- > All emissions data is typical for standard Natural Gas operation
- > Emissions will vary based on site specific operating conditions
- > CO₂ settings for each application will be installation site specific and emission or efficiency requirements
- > SO₂, PM (Total), TOC, VOC and Lead are based on calculation using the AP 42 method as published by the US EPA
- > Standby losses: 0.35% of output at maximum input rating. At boiler water temperature of 158°F (room temperature of 68°F)



EGP Facilities BU-1400 - - Squamish BC

VGF - L36GSI

Power Generation

ENGINE SPEED (rpm):	1800	COOLING SYSTEM:	JW, IC + OC
DISPLACEMENT (in3):	2193	INTERCOOLER WATER INLET (°F):	130
COMPRESSION RATIO:	8.6:1	JACKET WATER OUTLET (°F):	180
IGNITION SYSTEM:	CEC	JACKET WATER CAPACITY (gal):	44
EXHAUST MANIFOLD:	Water Cooled	AUXILIARY WATER CAPACITY (gal):	14
COMBUSTION:	Rich Burn, Turbocharged	LUBE OIL CAPACITY (gal):	86
ENGINE DRY WEIGHT (lbs):	11200	MAX. EXHAUST BACKPRESSURE (in. H2O):	15
AIR/FUEL RATIO SETTING:	0.35% CO	MAX. AIR INLET RESTRICTION (in. H2O):	15
ENGINE SOUND LEVEL (dBA)	100	EXHAUST SOUND LEVEL (dBA)	113
IGNITION TIMING:	23° BTDC	PHASE:	3
FREQUENCY (Hz):	60	PHASE ROTATION:	T1-T2-T3
GENERATOR TYPE:	Synchronous		

SITE CONDITIONS:

FUEL:	Natural Gas	ALTITUDE (ft):	360
FUEL PRESSURE RANGE (psig):	26 - 50	MAXIMUM INLET AIR TEMPERATURE (°F):	95
FUEL HHV (BTU/ft3):	1,039.2	FUEL W/L:	92.5
FUEL LHV (BTU/ft3):	939.4		

SITE SPECIFIC TECHNICAL DATA

POWER RATING	UNITS	110% OVERLOAD SITE DATA (See note 18)	MAX RATING AT 100 °F AIR TEMP	SITE RATING AT MAXIMUM INLET AIR TEMPERATURE OF 95 °F		
				100%	75%	50%
CONTINUOUS ENGINE POWER	BHP	880	800	800	600	399
OVERLOAD	% 2/24 hr	Note 18	10	10	-	-
ELECTRICAL EFFICIENCY (LHV)	%	32.3	31.7	31.7	29.8	26.4
GENERATOR OUTPUT	kWe	605	548	548	408	266
GENERATOR KVA	kVA	756	685	685	510	333

based on 94.3% generator efficiency at 0.8 PF, 20 HP cooling fan

FUEL CONSUMPTION

FUEL CONSUMPTION (LHV)	BTU/kWe-hr	10581	10786	10785	11458	12922
FUEL CONSUMPTION (HHV)	BTU/kWe-hr	11705	11931	11930	12675	14294
FUEL FLOW	SCFM	114	105	105	83	61

based on fuel analysis LHV

HEAT REJECTION

JACKET WATER (JW)	BTU/hr x 1000	1986	1870	1865	1555	1244
LUBE OIL (OC)	BTU/hr x 1000	306	298	297	274	252
INTERCOOLER (IC)	BTU/hr x 1000	170	150	144	88	40
EXHAUST	BTU/hr x 1000	1678	1530	1537	1179	818
RADIATION	BTU/hr x 1000	146	142	147	143	134

EMISSIONS (ENGINE OUT):

NOx (NO + NO2)	g/bhp-hr	16.0	16.0	16.0	16.0	16.0
CO	g/bhp-hr	8.0	8.0	8.0	8.0	8.0
THC	g/bhp-hr	1.5	1.5	1.5	1.5	1.5
NMHC	g/bhp-hr	0.250	0.250	0.250	0.250	0.250
NM,NEHC (VOC)	g/bhp-hr	0.250	0.042	0.042	0.042	0.042
CO2	g/bhp-hr	443	450	450	474	524
CO2e (Methane GWP: 25)	g/bhp-hr	474	481	481	505	556
CH2O	g/bhp-hr	0.05	0.050	0.050	0.050	0.050
CH4	g/bhp-hr	1.25	1.25	1.25	1.25	1.25

(0.64 to 0.32)

AIR INTAKE / EXHAUST GAS

INDUCTION AIR FLOW	SCFM	1256	1160	1160	917	675
EXHAUST GAS MASS FLOW	lb/hr	5580	5152	5152	4075	2996
EXHAUST GAS FLOW	ACFM	3903	3609	3608	2821	2011
EXHAUST TEMPERATURE	°F	1114	1116	1116	1098	1050

at exhaust temp, 14.5 psia

HEAT EXCHANGER SIZING¹²

TOTAL JACKET WATER CIRCUIT (JW)	BTU/hr x 1000	2252	2121
TOTAL AUXILIARY WATER CIRCUIT (IC + OC)	BTU/hr x 1000	539	507

COOLING SYSTEM WITH ENGINE MOUNTED WATER PUMPS

JACKET WATER PUMP MIN. DESIGN FLOW	GPM	263
JACKET WATER PUMP MAX. EXTERNAL RESTRICTION	psig	31
AUX WATER PUMP MIN. DESIGN FLOW	GPM	62
AUX WATER PUMP MAX. EXTERNAL RESTRICTION	psig	16

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FUEL COMPOSITION

<u>HYDROCARBONS:</u>			<u>Mole or Volume %</u>	FUEL:	Natural Gas
Methane	CH4		95.399	FUEL PRESSURE RANGE (psig):	26 - 50
Ethane	C2H6		2.8	FUEL WKI:	92.5
Propane	C3H8		0.604		
Iso-Butane	I-C4H10		0.0974	FUEL SLHV (BTU/ft3):	923.07
Normal Butane	N-C4H10		0.1078	FUEL SLHV (MJ/Nm3):	36.30
Iso-Pentane	I-C5H12		0.0783		
Normal Pentane	N-C5H12		0.0144	FUEL LHV (BTU/ft3):	939.42
Hexane	C6H14		0	FUEL LHV (MJ/Nm3):	36.94
Heptane	C7H16		0.0179		
Ethene	C2H4		0	FUEL HHV (BTU/ft3):	1039.18
Propene	C3H6		0	FUEL HHV (MJ/Nm3):	40.86
	SUM HYDROCARBONS		99.119	FUEL DENSITY (SG):	0.58
<u>NON-HYDROCARBONS:</u>				Standard Conditions per ASTM D3588-91 [60°F and 14.696psia] and ISO 6976:1996-02-01[25, V(0;101.325)]. Based on the fuel composition, supply pressure and temperature, liquid hydrocarbons may be present in the fuel. No liquid hydrocarbons are allowed in the fuel. The fuel must not contain any liquid water. Waukesha recommends both of the following: 1) Dew point of the fuel gas to be at least 20°F (11°C) below the measured temperature of the gas at the inlet of the engine fuel regulator. 2) A fuel filter separator to be used on all fuels except commercial quality natural gas. Refer to the 'Fuel and Lubrication' section of 'Technical Data' or contact the Waukesha Application Engineering Department for additional information on fuels, or LHV and WKI* calculations. * Trademark of INNIO Waukesha Gas Engines Inc.	
Nitrogen	N2		0.5393		
Oxygen	O2		0		
Helium	He		0		
Carbon Dioxide	CO2		0.3266		
Carbon Monoxide	CO		0		
Hydrogen	H2		0		
Water Vapor	H2O		0		
	TOTAL FUEL		99.985		

FUEL CONTAMINANTS

Total Sulfur Compounds	0	% volume	Total Sulfur Compounds	0	µg/BTU
Total Halogen as Chloride	0	% volume	Total Halogen as Chloric	0	µg/BTU
Total Ammonia	0	% volume	Total Ammonia	0	µg/BTU
<u>Siloxanes</u>			Total Siloxanes (as Si)	0	µg/BTU
Tetramethyl silane	0	% volume			
Trimethyl silanol	0	% volume			
Hexamethyldisiloxane (L2)	0	% volume			
Hexamethylcyclotrisiloxane (D3)	0	% volume			
Octamethyltrisiloxane (L3)	0	% volume			
Octamethylcyclotetrasiloxane (D4)	0	% volume			
Decamethyltetrasiloxane (L4)	0	% volume			
Decamethylcyclopentasiloxane (D5)	0	% volume			
Dodecamethylpentasiloxane (L5)	0	% volume			
Dodecamethylcyclohexasiloxane (D6)	0	% volume			
Others	0	% volume			

Calculated fuel contaminant analysis will depend on the entered fuel composition and selected engine model.

No water or hydrocarbon condensates are allowed in the engine. Requires liquids removal.

NOTES

1. All data is based on engines with standard configurations unless noted otherwise.
2. Power rating is adjusted for fuel, site altitude, and site air inlet temperature, in accordance with ISO 3046/1 with tolerance of $\pm 3\%$.
3. Fuel consumption is presented in accordance with ISO 3046/1 with a tolerance of $-0 / +5\%$ at maximum rating. Fuel flow calculation based on fuel LHV and fuel consumption with a tolerance of $-0/+5\%$. For sizing piping and fuel equipment, it is recommended to include the 5% tolerance.
4. Heat rejection tolerances are $\pm 30\%$ for radiation, and $\pm 8\%$ for jacket water, lube oil, intercooler, and exhaust energy.
5. Emission levels for engines with Waukesha supplied 3-way catalyst are given at catalyst outlet flange. For all other engine models, emission levels are given at engine exhaust outlet flange prior to any after treatment. Values are based on a new engine operating at indicated site conditions, and adjusted to the specified timing and air/fuel ratio at rated load. Catalyst out emission levels represent emission levels the catalyst is sized to achieve. Manual adjustment may be necessary to achieve compliance as catalyst/engine age. Catalyst-out emission levels are valid for the duration of the engine warranty. Emissions are at an absolute humidity of 75 grains H₂O/lb (10.71 g H₂O/kg) of dry air. Emission levels may vary subject to instrumentation, measurement, ambient conditions, fuel quality, and engine variation. Engine may require adjustment on-site to meet emission values, which may affect engine performance and heat output. NO_x, CO, THC, and NMHC emission levels are listed as a not to exceed limit, all other emission levels are estimated. CO₂ emissions based on EPA Federal Register/Vol. 74, No. 209/Friday, October 30, 2009 Rules and Regulations 56398, 56399 (3) Tier 3 Calculation Methodology, Equation C-5.
6. Air flow is based on undried air with a tolerance of $\pm 7\%$.
7. Exhaust temperature given at engine exhaust outlet flange with a tolerance of $\pm 50^{\circ}\text{F}$ (28°C).
8. Exhaust gas mass flow value is based on a "wet basis" with a tolerance of $\pm 7\%$.
9. Inlet air restrictions based on full rated engine load. Exhaust backpressure based on 160 PSI BMEP and 1800 RPM. Refer to the engine specification section of Waukesha's standard technical data for more information.
10. Cooling circuit capacity, lube oil capacity, and engine dry weight values are typical.
11. Fuel must conform to Waukesha's "Gaseous Fuel Specification" S7884-7 or most current version. Fuel may require treatment to meet current fuel specification.
12. Heat exchanger sizing values given as the maximum heat rejection of the circuit, with applied tolerances and an additional 5% reserve factor.
13. Fuel volume flow calculation in english units is based on 100% relative humidity of the fuel gas at standard conditions of 60°F and 14.696 psia (29.92 inches of mercury; 101.325 kPa).
14. Fuel volume flow calculation in metric units is based on 100% relative humidity of the fuel gas at a combustion temperature of 25°C and metering conditions of 0°C and 101.325 kPa (14.696 psia; 29.92 inches of mercury). This is expressed as $[25, V(0;101.325)]$.
15. Engine sound data taken with the microphone at 1 m (3.3 ft) from the side of the engine at the approximate front-to-back centerline. Microphone height was at intake manifold level. Engine sound pressure data may be different at front, back and opposite side locations. Exhaust sound data taken with microphone 1 meter (3.3 ft) away and 1 meter (3.3 ft) to the side of the exhaust outlet.
16. Due to variation between test conditions and final site conditions, such as exhaust configuration and background sound level, sound pressure levels under site conditions may be different than those tabulated above.
17. Cooling system design flow is based on minimum allowable cooling system flow. Cooling system maximum external restriction is defined as the allowable restriction at the minimum cooling system flow.
18. Continuous Power Rating: The highest load and speed that can be applied 24 hours per day, seven days per week, 365 days per year except for normal maintenance at indicated ambient reference conditions and fuel. It is permissible to operate the engine at the indicated overload power, for two hours in every 24 hour period.
19. emPact emission compliance available for entire range of operable fuels; however, fuel system and/or O₂ set point may need to be adjusted in order to maintain compliance.
20. In cold ambient temperatures, heating of the engine jacket water, lube oil and combustion air may be required. See Waukesha Technical Data.
21. Available Turndown Speed Range refers to the constant torque speed range available. Reduced power may be available at speeds outside of this range. Contact application engineering.

SPECIAL REQUIREMENTS

HOSPITAL CATALYTIC SILENCERS

30 to 40 dBA Noise Reduction

FT19-03707 PO 4800006797-BU-1400A
 DOC # 3707-06797-BU-1400A-B23-001
 VDD B23-001 SUBMITTAL 2
 REC'D BY SMCI-DC 2023/10/06

RAC4 OVERVIEW

The RAC4 provides customizable emission reduction combined with Maxim's best silencing technologies. RAC4 delivers hospital grade silencing for noise sensitive applications. The RAC is designed to require one wrench access cover removal for easy servicing of elements. Attenuation rating is with one catalyst element installed. Maxim Silencers are proudly made in the USA.

HIGHLY EFFICIENT EMISSION REDUCTION

- NSCR Three-Way (NO_x, CO, NMHC, HcHo)
- Oxidation (CO, NMHC, HcHo)
- Diesel Oxidation (CO, NMHC, PM)

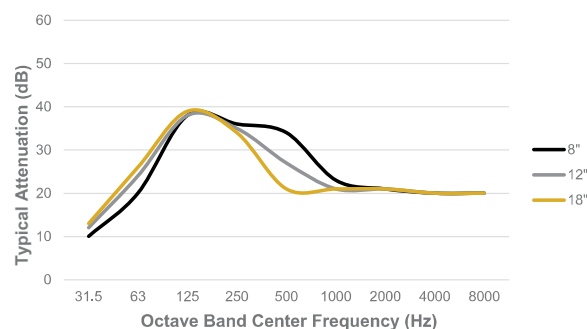
Typical applications: Gas reciprocating internal combustion engines, natural gas compression packages, electrical power generation, and engine driven pumps

FEATURES

- Hinged access cover
- Gasket free seal between catalytic core and housing
- One wrench to remove access cover
- Advanced acoustical design
- Heavy duty, all welded construction and long service life
- High temperature prime coated exterior finish
- Multiple sample ports and separate element monitoring
- Test ports per EPA and TCEQ guidelines

OPTIONS / ACCESSORIES

- Stainless steel construction: 304 or 316
- Flexible connectors
- Companion flanges
- Cleanout openings
- Side inlet and outlet
- Horizontal or vertical support arrangements
- Top or side facing door arrangement
- Custom sizing
- Explosion relief cover
- Special paints and finishes available
- Installs up to two NSCR Three-Way, Oxidation or Diesel Oxidation elements
- Complete range of exhaust accessories



- Listed sound data is based on typical performance and should not be considered absolute.
- *See nomenclature guide for additional information on part number creation.

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MAXIM
 SILENCERS



Emission Control Application Data Sheet

Maxim Silencers

10635 Brighton Lane
Stafford, Texas 77477
Phone: 832 554-0980
Fax: 832 554-0990

May 25, 2016

Customer: **ENERFLEX**

Project: **E004254-01**

Date: **9/11/2023**

Customer Contact: **THOMAS KING**

Maxim Contact: **AARON HUFF/ROBERT GASJENICA**

Engine Data:

Engine Model: **Waukesha L36GS/GSID** Speed: **1800** RPM
Fuel & Operating Type: **Natural Gas Rich Burn** Engine Power: **880** Hp
660 KW
Exhaust Flow Rate: **3609** acfm Exhaust Temperature: **1116** °F
6132 m³/hr **602** °C
5441 lbs/hr

Catalyst Data:

Number of Core layers: **1**
Model: **RAC4-39-10** Inlet Size: **10** in
Grade: **Hospital** Outlet Size: **10** in
Body Diameter: **30** in Body Length: **101** in
Estimated weight: **681** lbs Estimated Back Pressure of the unit: **7.92** in of WC
309 Kg **19.7** mbar
Core Part Number: **PE2-390** Qty **1** Speed through inlet: **6986** ft/min
Cell Density 300 cpsi Back Pressure across Element(s) only 3.01 in of WC
7.5 mbar



Emission:

Min. Temp. at Core Face: **1112** °F **600** °C Catalyst Type: **3-Way**
Max. Temp. at Core Face: **1204** °F **651** °C
O₂ in Exhaust vol %
H₂O in Exhaust vol %
Engine Out / Pre Emission:
Post Emission:

	Pollutant					
	NOx	CO	NMHC/VOC	CH ₂ O/CHCO	ORGANIC PM10	
Engine Out / Pre Emission:	16	8	0.25	0.505	0	g/bhp-hr
Post Emission:	7259.72	3629.86	113.43	229.13	0.00	mg/Nm3
	0.480	0.240	0.048	0.034	0.000	g/bhp-hr
	217.79	108.90	21.68	15.48	0.00	mg/Nm3
	97.0	97.0	80.9	93.2	50.0	% Reduction
	0.93	0.47	0.09	0.07		lb/hr
	4.08	2.04	0.41	0.29		tons/year operation
	107.4	53.7	10.7	7.6		ppmv
						ppmvd @ 15% O2

8760 hr/year

Acoustics:

Frequency Band (Hz):

31.5	63	125	250	500	1000	2000	4000	8000
0	0	0	0	0	0	0	0	0
11	22	38	35	30	21	21	20	20
11	23	40	37	34	26	27	26	25
-11	-23	-40	-37	-34	-26	-27	-26	-25

Raw Noise SPL (dB) at 3.28 ft.: **7** dBA
Estimated Attenuation (dB): **No Element**
Plus: **One Element Layer**
Silenced SPL (dB) at 3.28 ft.: **-19.6** dBA

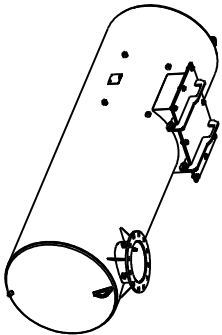
Warranty & Notes:

- If Pre-Emission levels are not as noted above, contact Maxim Silencers for a re-quote.
- To achieve Post Emissions levels detailed above, exhaust temperature and Pre-Emission data must be as specified.
- Maximum allowable exhaust temperature at core face is 1350°F.
- If applicable, the engine will require an air/fuel ratio controller to meet above emission levels. For Rich Burn engines λ must be 0.96 - 0.99.
- Catalyst cleaning/regeneration required, if initial backpressure increases by 2" of WC.
- Engine operation to be stable and reproducible.
- QAC is not designed to withstand a backfire, therefore measures should be taken prior to QAC unit to alleviate backfire pressure.
- Maximum lubrication oil consumption rate to be less than 0.0015 lb/bhp/hr.
- Lube oil sulfate ash contents should not exceed 0.5%.
- Phosphorus and/or Zinc should not exceed 5 ppmv in the exhaust stream.
- A high temperature alarm/shutdown to be maintained at downstream of catalyst at 1300°F.
- Fuel not to contain heavy or transition metals such as Pb, Ar, Zn, Cu, Sn, Fe, Ba, Ni, Cr etc.
- Chlorinated or Silicone containing compounds in the exhaust not to exceed 1 ppmv.
- Sulfur compounds in the exhaust gas stream not to exceed 25 ppmv.
- Performance guarantee is voided should the catalyst become masked or de-activated by any contaminant in the exhaust stream.
- Engine to be maintained and operated in accordance within manufacturer's recommended practice.
- Under no condition will Maxim Silencers assume any contingent liabilities.
- Operating manual is available online at www.maximsilencers.com or contact a Maxim sales representative.
- Nomenclature: QAC4-292-8, 4 is grade (Super Critical), 29 is catalyst block size, 2 is no. of catalyst(s) and 8 is flange diameter.
- Organic PM10 are estimate only and not a guarantee because of the variability in fuels and additives which change PM10.
- Maxim's standard one year warranty applies.

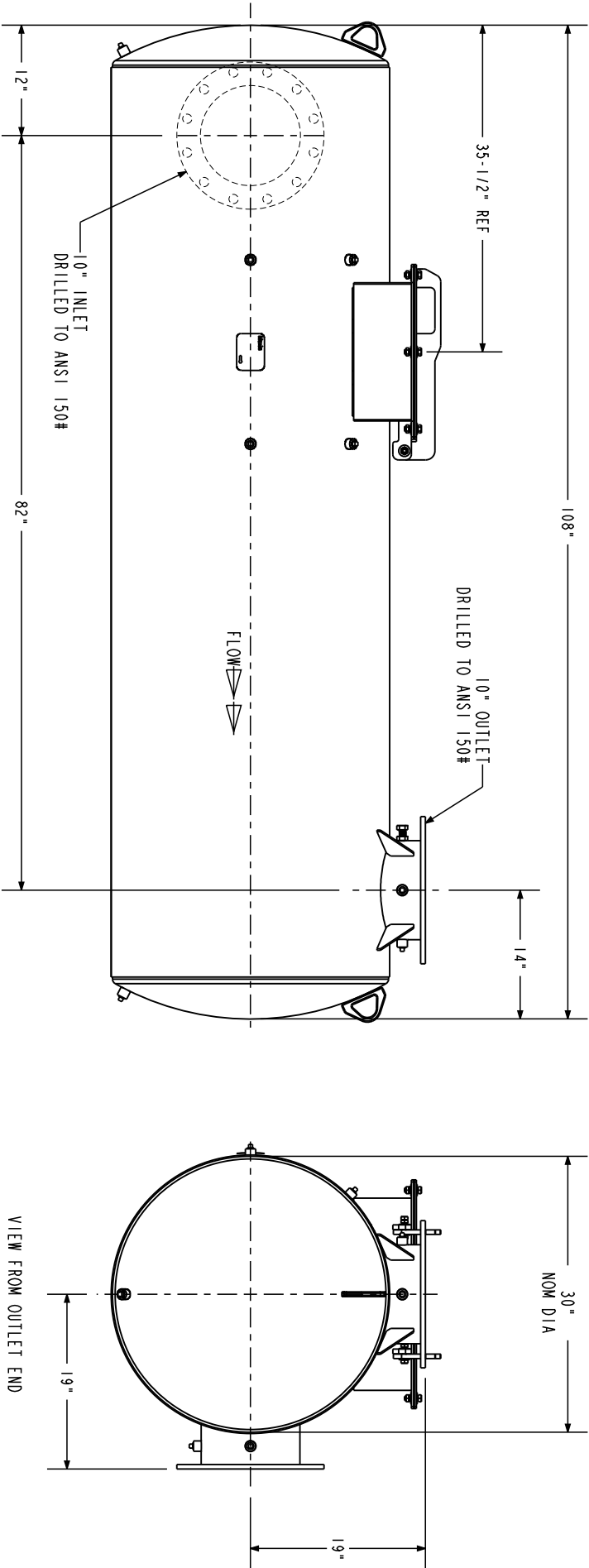
Rev level: 86

9/11/2023

OCTAVE BAND (Hz)	63	125	250	500	1000	2000	4000	8000
ESTIMATED TL (dB)	22	38	35	30	21	21	20	20



SCALE 0.020



- NOTES:
1. MATERIAL CARBON STEEL.
 2. SILENCER IS DESIGNED TO SUPPORT OWN WEIGHT ONLY.
 3. ALL WELDED CONSTRUCTION.
 4. TEST PORTS 1/2" NOM DIA COUPLINGS WITH SQUARE PLUGS.
 5. ONE M18-1.5 NUT WELDED ON INLET & OUTLET.
 6. DRAWING SUBJECT TO CHANGE WITHOUT NOTICE.

ALL DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED. TOLERANCES APPLY ON CRITICAL DIMENSIONS(S) AS SHOWN BELOW: ±.125" FRACTIONAL ±.005" DECIMAL ±.5° ANGLES ±.5° HOLE ANGLES ±.5° HOLE ANGLES ±.5° HOLE ANGLES		DRAWING TYPE:	
		SALES	
		DRAWN BY:	DATE:
		AC:	9/18/23
THE INFORMATION HEREIN IS THE PROPERTY OF MAXI SILENCERS. TRANSMISSION TO OTHERS OR USE EXCEPT THAT FOR WHICH IT IS PROVIDED IS STRICTLY PROHIBITED. DO NOT SCALE DRAWING.		CHECKED BY:	
		DATE:	
		9/18/23	
		TF	
APPROVED BY:		DATE:	
		9/18/23	
		WS	
		9/18/23	
EST. WEIGHT: 843 LBS		MODEL NO.:	
		RAC-39-10CA-18252	
		EXTERNAL FINISH:	
		HT BLACK PAINT	
THIRD ANGLE PROJECTION		SHEET:	
		1 OF 1	
		PH: (713) 682-6777	
		WWW.MAXISILENCERS.COM	
		INFO@MAXISILENCERS.COM	
		TYPE: SUPER CRITICAL HOSPITAL GRADE SILENCER	
		RET: 00	

EGP Facilities BU-1400 - - Squamish BC

VGF - L36GSI

Power Generation

ENGINE SPEED (rpm):	1800	COOLING SYSTEM:	JW, IC + OC
DISPLACEMENT (in3):	2193	INTERCOOLER WATER INLET (°F):	130
COMPRESSION RATIO:	8.6:1	JACKET WATER OUTLET (°F):	180
IGNITION SYSTEM:	CEC	JACKET WATER CAPACITY (gal):	44
EXHAUST MANIFOLD:	Water Cooled	AUXILIARY WATER CAPACITY (gal):	14
COMBUSTION:	Rich Burn, Turbocharged	LUBE OIL CAPACITY (gal):	86
ENGINE DRY WEIGHT (lbs):	11200	MAX. EXHAUST BACKPRESSURE (in. H2O):	15
AIR/FUEL RATIO SETTING:	0.35% CO	MAX. AIR INLET RESTRICTION (in. H2O):	15
ENGINE SOUND LEVEL (dBA)	100	EXHAUST SOUND LEVEL (dBA)	113
IGNITION TIMING:	23° BTDC	PHASE:	3
FREQUENCY (Hz):	60	PHASE ROTATION:	T1-T2-T3
GENERATOR TYPE:	Synchronous		

SITE CONDITIONS:

FUEL:	Natural Gas	ALTITUDE (ft):	360
FUEL PRESSURE RANGE (psig):	26 - 50	MAXIMUM INLET AIR TEMPERATURE (°F):	95
FUEL HHV (BTU/ft3):	1,039.2	FUEL WRI:	92.5
FUEL LHV (BTU/ft3):	939.4		

SITE SPECIFIC TECHNICAL DATA

POWER RATING	UNITS	110% OVERLOAD SITE DATA (See note 18)	MAX RATING AT 100 °F AIR TEMP	SITE RATING AT MAXIMUM INLET AIR TEMPERATURE OF 95 °F		
				100%	75%	50%
CONTINUOUS ENGINE POWER	BHP	880	800	800	600	399
OVERLOAD	% 2/24 hr	Note 18	10	10	-	-
ELECTRICAL EFFICIENCY (LHV)	%	32.3	31.7	31.7	29.8	26.4
GENERATOR OUTPUT	kWe	605	548	548	408	266
GENERATOR KVA	kVA	756	685	685	510	333

based on 94.3% generator efficiency at 0.8 PF, 20 HP cooling fan

FUEL CONSUMPTION

FUEL CONSUMPTION (LHV)	BTU/kWe-hr	10581	10786	10785	11458	12922
FUEL CONSUMPTION (HHV)	BTU/kWe-hr	11705	11931	11930	12675	14294
FUEL FLOW	SCFM	114	105	105	83	61

based on fuel analysis LHV

HEAT REJECTION

JACKET WATER (JW)	BTU/hr x 1000	1986	1870	1865	1555	1244
LUBE OIL (OC)	BTU/hr x 1000	306	298	297	274	252
INTERCOOLER (IC)	BTU/hr x 1000	170	150	144	88	40
EXHAUST	BTU/hr x 1000	1678	1530	1537	1179	818
RADIATION	BTU/hr x 1000	146	142	147	143	134

EMISSIONS (ENGINE OUT):

NOx (NO + NO2)	g/bhp-hr	16.0	16.0	16.0	16.0	16.0
CO	g/bhp-hr	8.0	8.0	8.0	8.0	8.0
THC	g/bhp-hr	1.5	1.5	1.5	1.5	1.5
NMHC	g/bhp-hr	0.250	0.250	0.250	0.250	0.250
NM,NEHC (VOC)	g/bhp-hr	0.250	0.042	0.042	0.042	0.042
CO2	g/bhp-hr	443	450	450	474	524
CO2e (Methane GWP: 25)	g/bhp-hr	474	481	481	505	556
CH2O	g/bhp-hr	0.05	0.050	0.050	0.050	0.050
CH4	g/bhp-hr	1.25	1.25	1.25	1.25	1.25

AIR INTAKE / EXHAUST GAS

INDUCTION AIR FLOW	SCFM	1256	1160	1160	917	675
EXHAUST GAS MASS FLOW	lb/hr	5580	5152	5152	4075	2996
EXHAUST GAS FLOW	ACFM	3903	3609	3608	2821	2011
EXHAUST TEMPERATURE	°F	1114	1116	1116	1098	1050

at exhaust temp, 14.5 psia

HEAT EXCHANGER SIZING¹²

TOTAL JACKET WATER CIRCUIT (JW)	BTU/hr x 1000	2252	2121
TOTAL AUXILIARY WATER CIRCUIT (IC + OC)	BTU/hr x 1000	539	507

COOLING SYSTEM WITH ENGINE MOUNTED WATER PUMPS

JACKET WATER PUMP MIN. DESIGN FLOW	GPM	263
JACKET WATER PUMP MAX. EXTERNAL RESTRICTION	psig	31
AUX WATER PUMP MIN. DESIGN FLOW	GPM	62
AUX WATER PUMP MAX. EXTERNAL RESTRICTION	psig	16

FUEL COMPOSITION

<u>HYDROCARBONS:</u>			<u>Mole or Volume %</u>	FUEL:	Natural Gas
Methane	CH4		95.399	FUEL PRESSURE RANGE (psig):	26 - 50
Ethane	C2H6		2.8	FUEL WKI:	92.5
Propane	C3H8		0.604		
Iso-Butane	I-C4H10		0.0974	FUEL SLHV (BTU/ft3):	923.07
Normal Butane	N-C4H10		0.1078	FUEL SLHV (MJ/Nm3):	36.30
Iso-Pentane	I-C5H12		0.0783		
Normal Pentane	N-C5H12		0.0144	FUEL LHV (BTU/ft3):	939.42
Hexane	C6H14		0	FUEL LHV (MJ/Nm3):	36.94
Heptane	C7H16		0.0179		
Ethene	C2H4		0	FUEL HHV (BTU/ft3):	1039.18
Propene	C3H6		0	FUEL HHV (MJ/Nm3):	40.86
	SUM HYDROCARBONS		99.119	FUEL DENSITY (SG):	0.58
<u>NON-HYDROCARBONS:</u>				Standard Conditions per ASTM D3588-91 [60°F and 14.696psia] and ISO 6976:1996-02-01[25, V(0;101.325)]. Based on the fuel composition, supply pressure and temperature, liquid hydrocarbons may be present in the fuel. No liquid hydrocarbons are allowed in the fuel. The fuel must not contain any liquid water. Waukesha recommends both of the following: 1) Dew point of the fuel gas to be at least 20°F (11°C) below the measured temperature of the gas at the inlet of the engine fuel regulator. 2) A fuel filter separator to be used on all fuels except commercial quality natural gas. Refer to the 'Fuel and Lubrication' section of 'Technical Data' or contact the Waukesha Application Engineering Department for additional information on fuels, or LHV and WKI* calculations. * Trademark of INNIO Waukesha Gas Engines Inc.	
Nitrogen	N2		0.5393		
Oxygen	O2		0		
Helium	He		0		
Carbon Dioxide	CO2		0.3266		
Carbon Monoxide	CO		0		
Hydrogen	H2		0		
Water Vapor	H2O		0		
	TOTAL FUEL		99.985		

FUEL CONTAMINANTS

Total Sulfur Compounds	0	% volume	Total Sulfur Compounds	0	µg/BTU
Total Halogen as Chloride	0	% volume	Total Halogen as Chloric	0	µg/BTU
Total Ammonia	0	% volume	Total Ammonia	0	µg/BTU
<u>Siloxanes</u>			Total Siloxanes (as Si)	0	µg/BTU
Tetramethyl silane	0	% volume			
Trimethyl silanol	0	% volume			
Hexamethyldisiloxane (L2)	0	% volume			
Hexamethylcyclotrisiloxane (D3)	0	% volume			
Octamethyltrisiloxane (L3)	0	% volume			
Octamethylcyclotetrasiloxane (D4)	0	% volume			
Decamethyltetrasiloxane (L4)	0	% volume			
Decamethylcyclopentasiloxane (D5)	0	% volume			
Dodecamethylpentasiloxane (L5)	0	% volume			
Dodecamethylcyclohexasiloxane (D6)	0	% volume			
Others	0	% volume			

Calculated fuel contaminant analysis will depend on the entered fuel composition and selected engine model.

No water or hydrocarbon condensates are allowed in the engine. Requires liquids removal.

NOTES

1. All data is based on engines with standard configurations unless noted otherwise.
2. Power rating is adjusted for fuel, site altitude, and site air inlet temperature, in accordance with ISO 3046/1 with tolerance of $\pm 3\%$.
3. Fuel consumption is presented in accordance with ISO 3046/1 with a tolerance of $-0 / +5\%$ at maximum rating. Fuel flow calculation based on fuel LHV and fuel consumption with a tolerance of $-0/+5\%$. For sizing piping and fuel equipment, it is recommended to include the 5% tolerance.
4. Heat rejection tolerances are $\pm 30\%$ for radiation, and $\pm 8\%$ for jacket water, lube oil, intercooler, and exhaust energy.
5. Emission levels for engines with Waukesha supplied 3-way catalyst are given at catalyst outlet flange. For all other engine models, emission levels are given at engine exhaust outlet flange prior to any after treatment. Values are based on a new engine operating at indicated site conditions, and adjusted to the specified timing and air/fuel ratio at rated load. Catalyst out emission levels represent emission levels the catalyst is sized to achieve. Manual adjustment may be necessary to achieve compliance as catalyst/engine age. Catalyst-out emission levels are valid for the duration of the engine warranty. Emissions are at an absolute humidity of 75 grains H₂O/lb (10.71 g H₂O/kg) of dry air. Emission levels may vary subject to instrumentation, measurement, ambient conditions, fuel quality, and engine variation. Engine may require adjustment on-site to meet emission values, which may affect engine performance and heat output. NO_x, CO, THC, and NMHC emission levels are listed as a not to exceed limit, all other emission levels are estimated. CO₂ emissions based on EPA Federal Register/Vol. 74, No. 209/Friday, October 30, 2009 Rules and Regulations 56398, 56399 (3) Tier 3 Calculation Methodology, Equation C-5.
6. Air flow is based on undried air with a tolerance of $\pm 7\%$.
7. Exhaust temperature given at engine exhaust outlet flange with a tolerance of $\pm 50^{\circ}\text{F}$ (28°C).
8. Exhaust gas mass flow value is based on a "wet basis" with a tolerance of $\pm 7\%$.
9. Inlet air restrictions based on full rated engine load. Exhaust backpressure based on 160 PSI BMEP and 1800 RPM. Refer to the engine specification section of Waukesha's standard technical data for more information.
10. Cooling circuit capacity, lube oil capacity, and engine dry weight values are typical.
11. Fuel must conform to Waukesha's "Gaseous Fuel Specification" S7884-7 or most current version. Fuel may require treatment to meet current fuel specification.
12. Heat exchanger sizing values given as the maximum heat rejection of the circuit, with applied tolerances and an additional 5% reserve factor.
13. Fuel volume flow calculation in english units is based on 100% relative humidity of the fuel gas at standard conditions of 60°F and 14.696 psia (29.92 inches of mercury; 101.325 kPa).
14. Fuel volume flow calculation in metric units is based on 100% relative humidity of the fuel gas at a combustion temperature of 25°C and metering conditions of 0°C and 101.325 kPa (14.696 psia; 29.92 inches of mercury). This is expressed as $[25, V(0;101.325)]$.
15. Engine sound data taken with the microphone at 1 m (3.3 ft) from the side of the engine at the approximate front-to-back centerline. Microphone height was at intake manifold level. Engine sound pressure data may be different at front, back and opposite side locations. Exhaust sound data taken with microphone 1 meter (3.3 ft) away and 1 meter (3.3 ft) to the side of the exhaust outlet.
16. Due to variation between test conditions and final site conditions, such as exhaust configuration and background sound level, sound pressure levels under site conditions may be different than those tabulated above.
17. Cooling system design flow is based on minimum allowable cooling system flow. Cooling system maximum external restriction is defined as the allowable restriction at the minimum cooling system flow.
18. Continuous Power Rating: The highest load and speed that can be applied 24 hours per day, seven days per week, 365 days per year except for normal maintenance at indicated ambient reference conditions and fuel. It is permissible to operate the engine at the indicated overload power, for two hours in every 24 hour period.
19. emPact emission compliance available for entire range of operable fuels; however, fuel system and/or O₂ set point may need to be adjusted in order to maintain compliance.
20. In cold ambient temperatures, heating of the engine jacket water, lube oil and combustion air may be required. See Waukesha Technical Data.
21. Available Turndown Speed Range refers to the constant torque speed range available. Reduced power may be available at speeds outside of this range. Contact application engineering.

SPECIAL REQUIREMENTS