

**ATTACHMENT D-1  
SUPPORTING DOCUMENTS**

**VENDOR DATA**

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**COMPRESSOR ENGINES**

- 1,380 bhp CAT G3616B (4SLB) Compressor Engine Specifications
  - Miratech OxCat Specifications

**TEG DEHYDRATOR**

- 40.0 MMscfd Frederick Logan TEG Dehydrator Specifications

# G3516B

GAS COMPRESSION APPLICATION

## ATTACHMENT D - 1380 bhp G3516B GAS ENGINE SITE SPECIFIC TECHNICAL DATA

CATERPILLAR®

ENGINE SPEED (rpm): 1400  
COMPRESSION RATIO: 8:1  
AFTERCOOLER - STAGE 2 INLET (°F): 130  
AFTERCOOLER - STAGE 1 INLET (°F): 201  
JACKET WATER OUTLET (°F): 210  
ASPIRATION: TA  
COOLING SYSTEM: JW+OC+1AC, 2AC  
IGNITION SYSTEM: ADEM3  
EXHAUST MANIFOLD: DRY  
COMBUSTION: Ultra Lean Burn  
NOx EMISSION LEVEL (g/bhp-hr NOx): 0.5  
SET POINT TIMING: 30

FUEL SYSTEM:

### SITE CONDITIONS:

FUEL:  
FUEL PRESSURE RANGE(psig):  
FUEL METHANE NUMBER:  
FUEL LHV (Btu/scf):  
ALTITUDE(ft):  
MAXIMUM INLET AIR TEMPERATURE(°F):  
STANDARD RATED POWER:

CAT WIDE RANGE  
WITH AIR FUEL RATIO CONTROL

Gas Analysis  
7.0-50.0  
89.4  
929  
1500  
77

1380 bhp@1400rpm

RATING		NOTES	LOAD	MAXIMUM RATING	SITE RATING AT MAXIMUM INLET AIR TEMPERATURE			
				100%	100%	75%	50%	
ENGINE POWER		(1)	bhp	1380	1380	1035	690	
INLET AIR TEMPERATURE			°F	77	77	77	77	

ENGINE DATA								
FUEL CONSUMPTION (LHV)	(2)	Btu/bhp-hr	7442	7442	7971	8561		
FUEL CONSUMPTION (HHV)	(2)	Btu/bhp-hr	8262	8262	8849	9505		
AIR FLOW (77°F, 14.7 psia)	(3)(4)	scfm	3126	3126	2452	1714		
AIR FLOW	(3)(4)	lb/hr	13860	13860	10873	7601		
INLET MANIFOLD PRESSURE	(5)	in Hg(abs)	94.6	94.6	76.8	54.0		
EXHAUST TEMPERATURE - ENGINE OUTLET	(6)	°F	992	992	986	1006		
EXHAUST GAS FLOW (@engine outlet temp, 14.5 psia)	(7)(4)	ft3/min	9107	9107	7123	5054		
EXHAUST GAS MASS FLOW	(7)(4)	lb/hr	14342	14342	11259	7878		

EMISSIONS DATA - ENGINE OUT								
NOx (as NO2)	(8)(9)	g/bhp-hr	0.50	0.50	0.50	0.50		
CO	(8)(9)	g/bhp-hr	2.43	2.43	2.60	2.55		
THC (mol. wt. of 15.84)	(8)(9)	g/bhp-hr	4.75	4.75	5.09	5.17		
NMHC (mol. wt. of 15.84)	(8)(9)	g/bhp-hr	0.71	0.71	0.76	0.78		
NMNEHC (VOCs) (mol. wt. of 15.84)	(8)(9)(10)	g/bhp-hr	0.48	0.48	0.51	0.52		
HCHO (Formaldehyde)	(8)(9)	g/bhp-hr	0.43	0.43	0.43	0.42		
CO2	(8)(9)	g/bhp-hr	472	472	504	548		
EXHAUST OXYGEN	(8)(11)	% DRY	9.0	9.0	8.7	8.3		

HEAT REJECTION								
HEAT REJ. TO JACKET WATER (JW)	(12)	Btu/min	23602	23602	21682	20031		
HEAT REJ. TO ATMOSPHERE	(12)	Btu/min	6110	6110	5092	4074		
HEAT REJ. TO LUBE OIL (OC)	(12)	Btu/min	4475	4475	3978	3363		
HEAT REJ. TO A/C - STAGE 1 (1AC)	(12)(13)	Btu/min	10613	10613	8804	3043		
HEAT REJ. TO A/C - STAGE 2 (2AC)	(12)(13)	Btu/min	5411	5411	5109	3354		

COOLING SYSTEM SIZING CRITERIA			
TOTAL JACKET WATER CIRCUIT (JW+OC+1AC)	(13)(14)	Btu/min	42475
TOTAL AFTERCOOLER CIRCUIT (2AC)	(13)(14)	Btu/min	5681
A cooling system safety factor of 0% has been added to the cooling system sizing criteria.			

### CONDITIONS AND DEFINITIONS

Engine rating obtained and presented in accordance with ISO 3046/1, adjusted for fuel, site altitude and site inlet air temperature. 100% rating at maximum inlet air temperature is the maximum engine capability for the specified fuel at site altitude and maximum site inlet air temperature. Max. rating is the maximum capability for the specified fuel at site altitude and reduced inlet air temperature. Lowest load point is the lowest continuous duty operating load allowed. No overload permitted at rating shown.

For notes information consult page three.

Pre-Controlled  
VOC Emissions:  
= NMNEHC + HCHO  
= 0.48 + 0.43  
= 0.91 g/bhp-hr

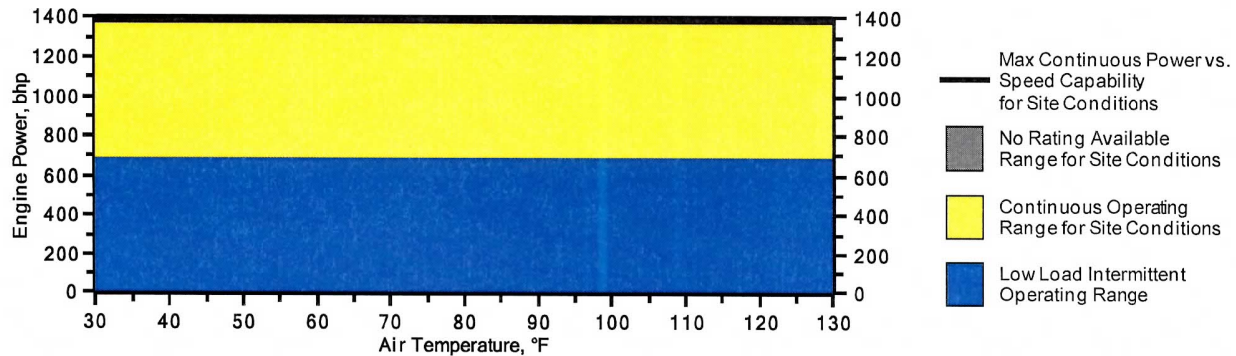
Un-Controlled  
CH4 Emissions:  
= THC - NMHC  
= 4.75 - 0.71  
= 4.04 g/bhp-hr

### Controlled w/ Miratech OxCat:

CO = 93.0% CE = 0.17 g/bhp-hr  
NMNEHC = 48.0% CE = 0.25 g/bhp-hr  
HCHO = 93.0% CE = 0.03 g/bhp-hr  
VOC = 69.3% CE = 0.30 g/bhp-hr

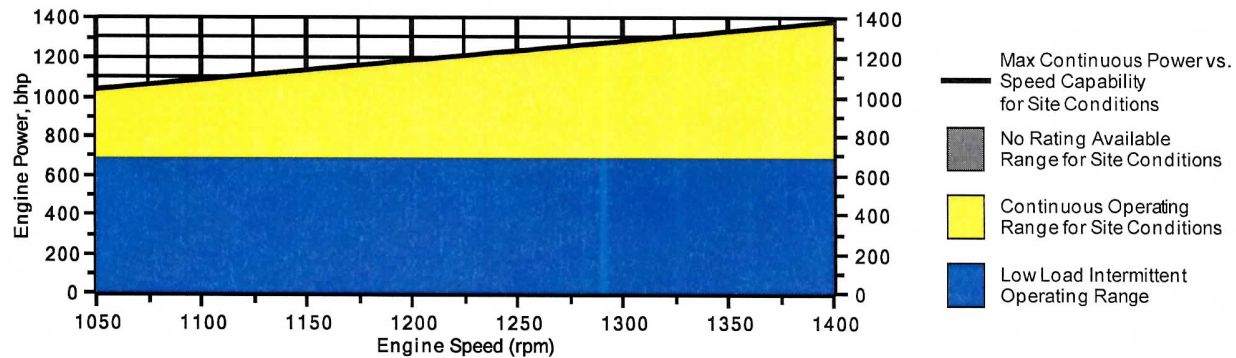
## Engine Power vs. Inlet Air Temperature

Data represents temperature sweep at 1500 ft and 1400 rpm



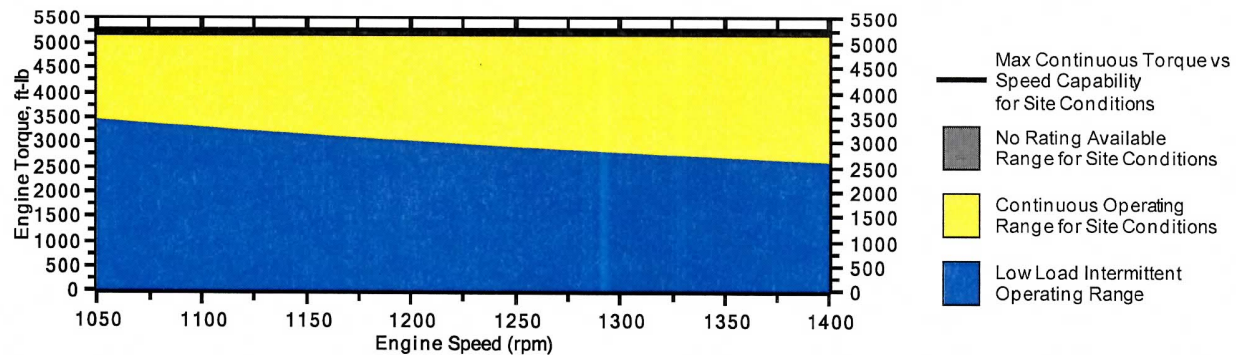
## Engine Power vs. Engine Speed

Data represents speed sweep at 1500 ft and 77 °F



## Engine Torque vs. Engine Speed

Data represents speed sweep at 1500 ft and 77 °F



Note: At site conditions of 1500 ft and 77°F inlet air temp., constant torque can be maintained down to 1050 rpm. The minimum speed for loading at these conditions is 1050 rpm.

# G3516B

GAS COMPRESSION APPLICATION

## ATTACHMENT D - 1380 bhp G3516B GAS ENGINE SITE SPECIFIC TECHNICAL DATA



### NOTES

1. Engine rating is with two engine driven water pumps. Tolerance is  $\pm 3\%$  of full load.
2. Fuel consumption tolerance is  $\pm 3.0\%$  of full load data.
3. Air flow value is on a 'wet' basis. Flow is a nominal value with a tolerance of  $\pm 5\%$ .
4. Inlet and Exhaust Restrictions must not exceed A&I limits based on full load flow rates from the standard technical data sheet.
5. Inlet manifold pressure is a nominal value with a tolerance of  $\pm 5\%$ .
6. Exhaust temperature is a nominal value with a tolerance of  $(+63^{\circ}\text{F}, -54^{\circ}\text{F})$ .
7. Exhaust flow value is on a "wet" basis. Flow is a nominal value with a tolerance of  $\pm 6\%$ .
8. Emissions data is at engine exhaust flange prior to any after treatment.
9. Emission values are based on engine operating at steady state conditions. Fuel methane number cannot vary more than  $\pm 3$ . Values listed are higher than nominal levels to allow for instrumentation, measurement, and engine-to-engine variations. They indicate "Not to Exceed" values. THC, NMHC, and NMNEHC do not include aldehydes. An oxidation catalyst may be required to meet Federal, State or local CO or HC requirements.
10. VOCs - Volatile organic compounds as defined in US EPA 40 CFR 60, subpart JJJJ
11. Exhaust Oxygen level is the result of adjusting the engine to operate at the specified NOx level. Tolerance is  $\pm 0.5$ .
12. Heat rejection values are nominal. Tolerances, based on treated water, are  $\pm 10\%$  for jacket water circuit,  $\pm 50\%$  for radiation,  $\pm 20\%$  for lube oil circuit, and  $\pm 5\%$  for aftercooler circuit.
13. Aftercooler heat rejection includes an aftercooler heat rejection factor for the site elevation and inlet air temperature specified. Aftercooler heat rejection values at part load are for reference only. Do not use part load data for heat exchanger sizing.
14. Cooling system sizing criteria are maximum circuit heat rejection for the site, with applied tolerances.



Constituent	Abbrev	Mole %	Norm
Water Vapor	H2O	0.0000	0.0000
Methane	CH4	96.5400	96.5535
Ethane	C2H6	2.5590	2.5594
Propane	C3H8	0.2300	0.2300
Isobutane	iso-C4H10	0.0210	0.0210
Norbutane	nor-C4H10	0.0350	0.0350
Isopentane	iso-C5H12	0.0090	0.0090
Norpentane	nor-C5H12	0.0080	0.0080
Hexane	C6H14	0.0050	0.0050
Heptane	C7H16	0.0020	0.0020
Nitrogen	N2	0.3340	0.3340
Carbon Dioxide	CO2	0.2430	0.2430
Hydrogen Sulfide	H2S	0.0000	0.0000
Carbon Monoxide	CO	0.0000	0.0000
Hydrogen	H2	0.0000	0.0000
Oxygen	O2	0.0000	0.0000
Helium	HE	0.0000	0.0000
Neopentane	neo-C5H12	0.0000	0.0000
Octane	C8H18	0.0000	0.0000
Nonane	C9H20	0.0000	0.0000
Ethylene	C2H4	0.0000	0.0000
Propylene	C3H6	0.0000	0.0000
TOTAL (Volume %)		99.9860	99.9999

## ATTACHMENT D - 1380 bhp G3516B

Fuel Makeup:	Gas Analysis
Unit of Measure:	English
<b>Calculated Fuel Properties</b>	
Caterpillar Methane Number:	89.4
Lower Heating Value (Btu/scf):	929
Higher Heating Value (Btu/scf):	1031
WOBBE Index (Btu/scf):	1227
THC: Free Inert Ratio:	172.31
Total % Inerts (% N2, CO2, He):	0.58%
RPC (%) (To 905 Btu/scf Fuel):	100%
Compressibility Factor:	0.998
Stoich A/F Ratio (Vol/Vol):	9.71
Stoich A/F Ratio (Mass/Mass):	16.93
Specific Gravity (Relative to Air):	0.574
Specific Heat Constant (K):	1.311

### CONDITIONS AND DEFINITIONS

Caterpillar Methane Number represents the knock resistance of a gaseous fuel. It should be used with the Caterpillar Fuel Usage Guide for the engine and rating to determine the rating for the fuel specified. A Fuel Usage Guide for each rating is included on page 2 of its standard technical data sheet.

RPC always applies to naturally aspirated (NA) engines, and turbocharged (TA or LE) engines only when they are derated for altitude and ambient site conditions.

Project specific technical data sheets generated by the Caterpillar Gas Engine Rating Pro program take the Caterpillar Methane Number and RPC into account when generating a site rating.

Fuel properties for Btu/scf calculations are at 60F and 14.696 psia.

Caterpillar shall have no liability in law or equity, for damages, consequently or otherwise, arising from use of program and related material or any part thereof.

### FUEL LIQUIDS

Field gases, well head gases, and associated gases typically contain liquid water and heavy hydrocarbons entrained in the gas. To prevent detonation and severe damage to the engine, hydrocarbon liquids must not be allowed to enter the engine fuel system. To remove liquids, a liquid separator and coalescing filter are recommended, with an automatic drain and collection tank to prevent contamination of the ground in accordance with local codes and standards.

To avoid water condensation in the engine or fuel lines, limit the relative humidity of water in the fuel to 80% at the minimum fuel operating temperature.

# CATERPILLAR®

## G3516B LE Gas Petroleum Engine

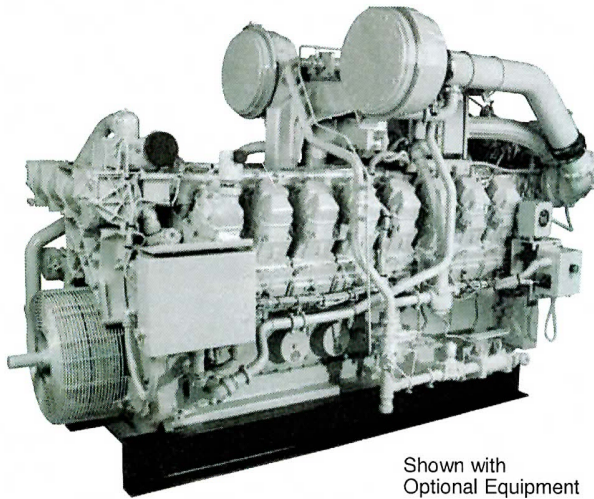
1029 kW (1380 bhp)  
1400 rpm

0.5 g/bhp-hr NOx or 1.0 g/bhp-hr NOx (NTE)

### CAT® ENGINE SPECIFICATIONS

#### V-16, 4-Stroke-Cycle

Bore .....	170 mm (6.7 in.)
Stroke .....	190 mm (7.5 in.)
Displacement .....	69.3 L (4230 cu. in.)
Aspiration .....	Turbocharged-2 Stage Aftercooled
Digital Engine Management	
Governor and Protection .....	Electronic (ADEM™ A3)
Combustion .....	Low Emission (Lean Burn)
Engine Weight, net dry (approx) .....	8401 kg (18,520 lb)
Power Density .....	8.2 kg/kW (13.4 lb/hp)
Power per Displacement .....	19.9 bhp/L
Total Cooling System Capacity .....	221.5 L (58.5 gal)
Jacket Water .....	204.4 L (54 gal)
SCAC .....	17 L (4.5 gal)
Lube Oil System (refill) .....	424 L (112 gal)
Oil Change Interval .....	1000 hour
Rotation (from flywheel end) .....	Counterclockwise
Flywheel and Flywheel Housing .....	SAE No. 00
Flywheel Teeth .....	183



Shown with  
Optional Equipment

### FEATURES

#### Engine Design

- Built on G3500 LE proven reliability and durability
- Ability to burn a wide spectrum of gaseous fuels
- Robust diesel strength design prolongs life and lowers owning and operating costs
- Broad operating speed range at lower site air densities (high altitude/hot ambient temperatures)
- Higher power density improves fleet management
- Quality engine diagnostics
- Detonation-sensitive timing control for individual cylinders

#### Ultra Lean Burn Technology (ULB)

ULB technology uses an advanced control system, a better turbo match, improved air and fuel mixing, and a more sophisticated combustion recipe to provide:

- Lowest engine-out emissions
- Highest fuel efficiency
- Improved altitude and speed turndown
- Stable load acceptance and load rejection

#### Emissions

- Meets U.S. EPA Spark Ignited Stationary NSPS emissions for 2010
- Lean air/fuel mixture provides best available emissions and fuel efficiency for engines of this bore size

#### Advanced Digital Engine Management

ADEM A3 engine management system integrates speed control, air/fuel ratio control, and ignition/detonation controls into a complete engine management system. ADEM A3 has improved: user interface, display system, shutdown controls, and system diagnostics.

#### Full Range of Attachments

Large variety of factory-installed engine attachments reduces packaging time.

#### Testing

Every engine is full-load tested to ensure proper engine performance.

#### Gas Engine Rating Pro

GERP is a PC-based program designed to provide site performance capabilities for Cat® natural gas engines for the gas compression industry. GERP provides engine data for your site's altitude, ambient temperature, fuel, engine coolant heat rejection, performance data, installation drawings, spec sheets, and pump curves.

#### Product Support Offered Through Global Cat Dealer Network

More than 2,200 dealer outlets

Cat factory-trained dealer technicians service every aspect of your petroleum engine

Cat parts and labor warranty

Preventive maintenance agreements available for repair-before-failure options

S•O•S<sup>SM</sup> program matches your oil and coolant samples against Caterpillar set standards to determine:

- Internal engine component condition
- Presence of unwanted fluids
- Presence of combustion by-products
- Site-specific oil change interval

#### Over 80 Years of Engine Manufacturing Experience

Over 60 years of natural gas engine production

Ownership of these manufacturing processes enables Caterpillar to produce high quality, dependable products

- Cast engine blocks, heads, cylinder liners, and flywheel housings
- Machine critical components
- Assemble complete engine

#### Web Site

For all your petroleum power requirements, visit [www.catoilandgas.cat.com](http://www.catoilandgas.cat.com).

**G3516B LE****GAS PETROLEUM ENGINE**

1029 kW (1380 bhp)

**TECHNICAL DATA****G3516B LE Gas Petroleum Engine — 1400 rpm\*\*\***

<b>Fuel System</b>		<b>0.5 g NOx NTE Rating DM8800-03</b>	<b>1.0 g NOx NTE Rating DM8850-02</b>
<b>Engine Power</b>			
@ 100% Load	bkW (bhp)	1029 (1380)	1029 (1380)
<b>Engine Speed</b>		<b>1400</b>	<b>1400</b>
Max Altitude @ Rated Torque and 38°C (100°F)	m (ft)	1219.2 (4000)	1828.8 (6000)
Speed Turndown @ Max Altitude, Rated Torque, and 38°C (100°F)	%	25	25
<b>Aftercooler Temperature</b>			
Stage 1 (JW)	°C (°F)	98.9 (210)	98.9 (210)
Stage 2 (SCAC)	°C (°F)	54 (130)	54 (130)
<b>Emissions*</b>			
NOx	g/bkW-hr (g/bhp-hr)	0.67 (0.50)	1.34 (1.00)
CO	g/bkW-hr (g/bhp-hr)	3.26 (2.43)	3.75 (2.80)
CO <sub>2</sub>	g/bkW-hr (g/bhp-hr)	635 (474)	603 (449)
VOC**	g/bkW-hr (g/bhp-hr)	0.64 (0.48)	0.51 (0.38)
<b>Fuel Consumption***</b>			
@ 100% Load	MJ/bkW-hr (Btu/bhp-hr)	10.33 (7301)	9.97 (7050)
<b>Heat Balance</b>			
Heat Rejection to Jacket Water			
@ 100% Load			
JW	bkW (Btu/mn)	412.37 (23,451)	418.9 (23,820)
OC	bkW (Btu/mn)	78.2 (4449)	78.2 (4449)
Heat Rejection to Aftercooler			
@ 100% Load			
1st Stage AC	bkW (Btu/mn)	94.23 (5359)	78.55 (4467)
2nd Stage AC	bkW (Btu/mn)	176.7 (10,047)	157.9 (8984)
Heat Rejection to Exhaust			
@ 100% Load LHV to 25° C (77° F)	bkW (Btu/mn)	1098 (62,428)	1021.9 (58,113)
Heat Rejection to Atmosphere			
@ 100% Load	bkW (Btu/mn)	107.34 (6110)	107.34 (6110)
<b>Exhaust System</b>			
<b>Exhaust Gas Flow Rate</b>			
@ 100% Load	m <sup>3</sup> /min (cfm)	258.4 (9126)	246.8 (8716)
<b>Exhaust Stack Temperature</b>			
@ 100% Load	°C (°F)	533.33 (992)	532.22 (990)
<b>Intake System</b>			
Air Inlet Flow Rate			
@ 100% Load	m <sup>3</sup> /min (scfm)	88.52 (3126)	84.70 (2991)
<b>Gas Pressure</b>		48-345 (7-50)	48-345 (7-50)

\*at 100% load and speed, all values are listed as not to exceed

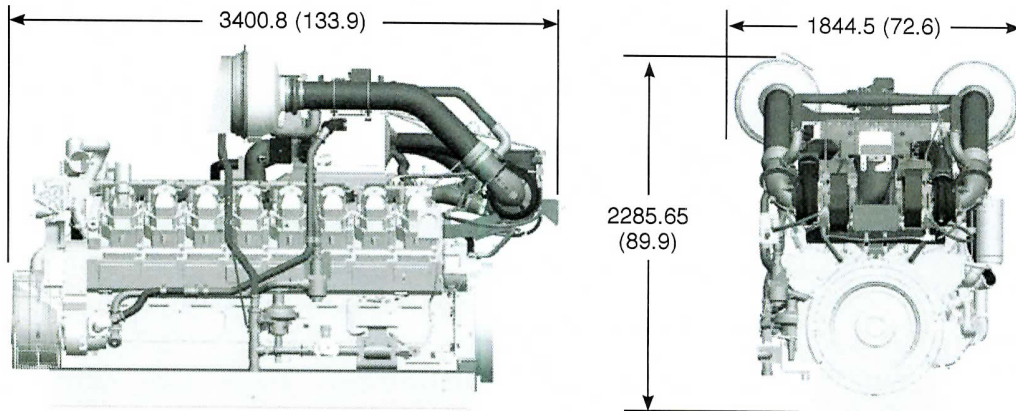
\*\*Volatile organic compounds as defined in U.S. EPA 40 CFR 60, subpart JJJJ

\*\*\*ISO 3046/1



**G3516B LE****GAS PETROLEUM ENGINE**

1029 kW (1380 bhp)

**DIMENSIONS**

DIMENSIONS		
Length	mm (in.)	3400.8 (133.9)
Width	mm (in.)	1844.55 (72.6)
Height	mm (in.)	2285.65 (89.9)
Shipping Weight	kg (lb)	8401 (18,520)

Note: General configuration not to be used for installation.

Dimensions are in mm (inches).

**RATING DEFINITIONS AND CONDITIONS**

Engine performance is obtained in accordance with SAE J1995, ISO3046/1, BS5514/1, and DIN6271/1 standards.

Transient response data is acquired from an engine/generator combination at normal operating temperature and in accordance with ISO3046/1 standard ambient conditions. Also in accordance with SAE J1995, BS5514/1, and DIN6271/1 standard reference conditions.

**Conditions:** Power for gas engines is based on fuel having an LHV of 33.74 kJ/L (905 Btu/cu ft) at 101 kPa (29.91 in. Hg) and 15° C (59° F). Fuel rate is based on a cubic meter at 100 kPa (29.61 in. Hg) and 15.6° C (60.1° F). Air flow is based on a cubic foot at 100 kPa (29.61 in. Hg) and 25° C (77° F). Exhaust flow is based on a cubic foot at 100 kPa (29.61 in. Hg) and stack temperature.

Materials and specifications are subject to change without notice. The International System of Units (SI) is used in this publication. CAT, CATERPILLAR, their respective logos, ADEM, "Caterpillar Yellow" and the "Power Edge" trade dress, as well as corporate and product identity used herein, are trademarks of Caterpillar and may not be used without permission.

Performance Numbers: DM8800-03, DM8850-02  
LEHW0037-00 (11-09)  
Supersedes LEHW0002-02

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