



Bi-fuel systems for Diesel Engines in Oil & Gas drilling environments

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SYSTEM OVERVIEW AND DESCRIPTION

The GTI Bi-Fuel System is a retrofit technology that allows diesel engines to operate on a mixture of diesel fuel and natural gas.

This is achieved through the use of proprietary and patented technologies that are installed externally of the engine.

Conversion to GTI bi-fuel requires no major changes or modifications of the engine and allows the engine to operate on gas mixtures ranging from **50% to over 70%** of total fuel consumed.

After conversion to bi-fuel, the engine can still be operated on 100% diesel fuel without loss of power or efficiency.

The Bi-Fuel System has been designed to allow for switching of fuel modes during full or part load conditions, without interruption in engine speed, power or stability.

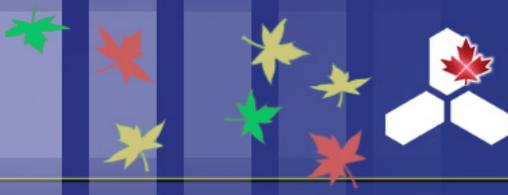
The Bi-Fuel System utilizes a fumigation gas delivery method whereby gas is delivered to the cylinders via the standard engine air-intake system and is then ignited by a diesel “pilot” which acts as an ignition source for the air-gas mixture.



What is Bi-Fuel?

- Bi-Fuel is a “co-firing” of standard diesel fuel and natural gas (methane)
- It is designed for use in conventional, heavy-duty diesel engines
- No engine modifications are required
- The GTI Bi-Fuel Systems can be installed in the field or accomplished as an OEM up-fit
- Natural gas typically substitutes between 50-80% of the diesel fuel required to maintain a given speed and load

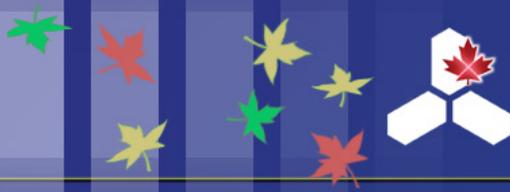




Characteristics of the GTI Bi-Fuel System

- High efficiency
- Compression ignition
- Low gas supply pressure
- Sophisticated Altronic engine protection system
- Auto-switching of fuel modes
- Non-intrusive, simple installation
- Easy to operate

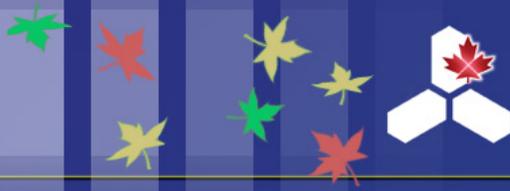




Benefits to the User

- Reduced energy costs
- “Fuel flexibility”
- Reduced exhaust emissions
- Rapid payback
- Extended run-time for emergency operation
- Higher compression engine capability without paying more for a dedicated NG engine alternate.





Bi-Fuel-Equipped Diesel Engines vs. Dedicated Gas Engines

- Lower initial cost for diesel engines
- “Fuel flexibility”
- Higher efficiency
- Reduced O&M costs
- Smaller physical “footprint” vs. output
- Reduced lead-time for diesel engines vs. NG engines.
- You get the best of both worlds when you use a GTI bi-fuel system with your diesel engine!

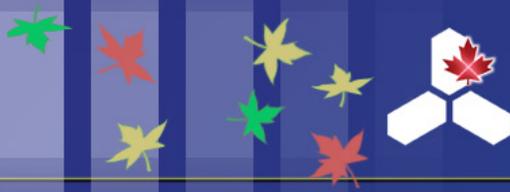




Specific Advantages of Bi-Fuel Operation for Stand-By Service

- Decreased on-site fuel requirements
- Reduced exposure to environmental liabilities (smaller above and below ground diesel storage tanks)
- Extended run-time vs. amount of fuel stored
- Less wet stacking
- Decreased visual emissions during system testing/validation





Fuel Gasses Compatible with the GTI Bi-Fuel System

- Pipeline natural gas
- Well-head gas
- Coal-bed gas
- Bio-gas (landfill, wastewater)
- Liquid natural gas (LNG)
- Compressed natural gas (CNG)





Compatible Fuel Types

The Bi-Fuel System is compatible with methane-based fuels such as natural gas, wellhead gas, landfill gas and digester gas.

Hydrocarbon gases such as propane and butane are not compatible with Bi-Fuel operation (in pure form) due to unfavorable combustion characteristics of these fuels.

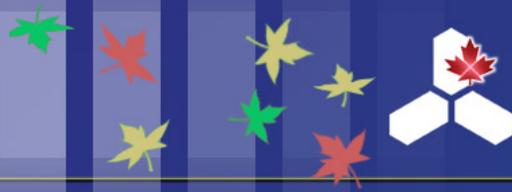
Gas quality and composition are critical factors for bi-fuel operation, as “pipeline quality” natural gas can have drastically different properties from location to location, as well from season to season. Ideally, pipeline supplied gas will have a high concentration of methane and a low overall concentration of heavier hydrocarbon gases (see table).

For lower quality gases (pipeline supplied or other), reductions in engine performance and/or gas substitution rate may be required.



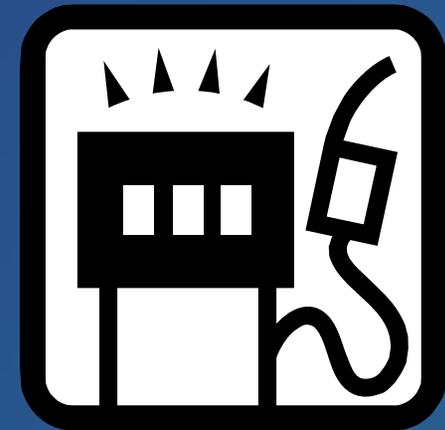
Typical High Quality Pipeline Gas/Composition in Volume%

Methane C₁	Ethane C₂	Propane C₃	Butane C₄	Nitrogen N	Carbon Dioxide CO₂	Oxygen O₂
97.09	0.88	0.26	0.09	1.41	0.12	-



Typical Run-Time without the GTI Bi-Fuel System

- 100% Diesel Run-Time: 800KW Generator
 - Fuel rate: .07 Gallon/KWh
 - Full-load fuel burn: 56 GPH
 - Fuel storage capacity: 1500 Gallons
 - Run-time: Approx. 26 hours





Typical Extended Run-Time with the GTI Bi-Fuel System

- GTI Bi-Fuel Run-Time: 800KW Generator
 - Diesel Fuel rate: .014 Gallon/KWh
 - Full-load diesel fuel burn: 11 GPH
 - Gas usage: 6300 SCFH
 - Fuel storage capacity: 1500 Gallons
 - Gas capacity: unlimited (pipeline NG)
 - Run-time: **Approx. 136 hours**

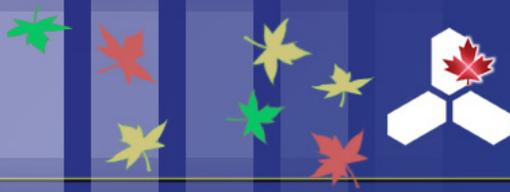




Bi-Fuel Economics

- Typical Savings on Peak Demand Electricity Rates (Peak Shaving)
 - Usage: 1000 kilowatts
 - Peak operating hours: 1500/year
 - “On-peak” cost of electricity: 14.0 cents/kw-hr
 - Bi-Fuel operating cost (fuel): 5.4 cents/kw-hr
 - Other operating costs (depreciation; maintenance): 1.5 cents/kw-hr
- Total Bi-Fuel operating cost: 6.9 cents/kw-hr
- Savings on Bi-Fuel: 7.1 cents/kw-hr
- Annual savings with generator operating on Bi-Fuel: \$106,500.00





Extended Run-Time with the GTI Bi-Fuel System

- 100% Diesel vs. GTI Bi-Fuel Run-Time on a 1000KW load
 - Diesel Fuel Rate: 54 gallons/hour
 - Fuel Storage Capacity: 1500 gallons
 - 100% Diesel Run-Time: 28 hours
 - Bi-Fuel Gas Substitution Rate: 75%
 - 75% Gas Run-Time: 111 hours





Bi-Fuel Combustion Process

The Bi-Fuel combustion process varies somewhat from the normal diesel cycle due to the unique properties of methane, the homogenous nature of the air-gas mixture and the interaction of the diesel pilot with the mixture.

These factors lead to a more rapid combustion process and a steeper rise in cylinder pressure compared to the normal diesel cycle. Peak cylinder pressures reached during Bi-Fuel combustion, however, are equivalent to normal diesel levels.



Bi-Fuel Combustion Process: Delivery

The Bi-Fuel System utilizes a vacuum-based gas control scheme, whereby changes in combustion airflow result in a corresponding change of gas supplied to the engine.

The gas is supplied to the engine at approximately atmospheric pressure, with the use of an air-gas mixing device installed upstream of the turbocharger inlet and downstream of the engine air filter.

The mixer is connected via flexible hose to the GTI “gas train” consisting of a gas filter, regulator, electrically operated solenoid valve and gas power valve.





Bi-Fuel Combustion Process: Intake Valve

After exiting the mixer, the air-gas charge follows the normal path through the turbocharger, charge-air cooling system (where applicable) and intake manifold.

The mixture is delivered to the combustion chamber through the intake valve (s), compressed during the compression cycle and then ignited when the diesel injector is activated.

Due to the high ignition temperature of the air-gas mixture, ignition will not occur until the diesel pilot is introduced, providing the necessary “spark” for combustion.



Bi-Fuel Combustion Process: Governor

As engine vacuum changes according to variations in load, more or less gas is supplied to the engine from the gas train.

This variation in gas flow is achieved with the use of a “zero governor” style of gas regulator, which alters the gas flow rate in order to maintain approximately atmospheric delivery pressure.

The actual outlet pressure of the regulator is slightly negative (about $-.5''$ w.c.) in order to ensure zero flow-rate at one atmosphere of ambient pressure (pressure at mixer with engine not running).





Engine Governing

Comparison of Engine Governing: Bi-Fuel vs. 100% Diesel

Engine Parameter	100% Diesel Mode	Bi-Fuel @ 70% Gas
Power	1000 HP	1000 HP
Speed	1800 RPM	1800 RPM
Diesel Rack Position (%)	90%	27%



Gas Ratios

The quality of the supplied gas, as well as other considerations such as engine condition/design, operating characteristics and ambient conditions will govern the knock limit of the air-gas mixture.

With high quality gas, such as that supplied via pipeline in many areas, up to 60% ~ 80% substitution may be achieved at a given load (typically prime or continuous power rating).

For lower quality fuel gases, the maximum gas substitution may be limited to between 40% and 60%.





Bi-Fuel Emissions

Bi-Fuel operation will typically reduce production of:

- Nitrogen oxides
- Sulfur oxides
- Reactive hydrocarbons
- Carbon dioxide
- Particulates and
- Will also reduce exhaust opacity levels
- Also means that if your company is gas flaring at the site, that gas can now be used to reduce your fuel power operating costs!
 - Along with the added benefit to the environment by not flaring the gas, a definite PR plus!

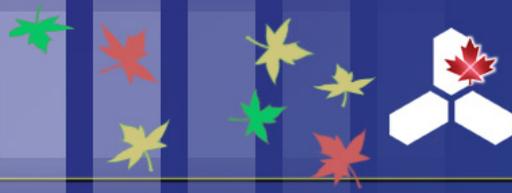
Please contact GTI for detailed information on emissions performance.



Maintenance

- Because the Bi-Fuel System utilizes low restriction air-fuel mixing devices and maintains the lean-burn combustion cycle of the diesel engine, engine operating efficiencies (specific fuel consumption) are typically on par with 100% diesel levels and are often slightly improved due to the unique combustion characteristics of bi-fuel.
- Because natural gas burns with virtually no large particulate residues (unlike diesel which produces carbon particles during combustion), cylinder liner and ring wear are reduced and lubricating oil is kept cleaner during bi-fuel operation.
 - This leads to longer average intervals between engine overhauls.
 - In addition, the clean burn characteristics of natural gas decrease engine wet-stacking at lighter loads and prevent the build-up heavy carbon deposits in the combustion chamber and exhaust system.





Time and Manpower Requirements for Conversion

Conversion time will depend on the size and complexity of the application.

Generally, one to two days will be required for smaller engines, while larger engines might require two to four days.

In either case, manpower required is usually limited to between one and three technicians.



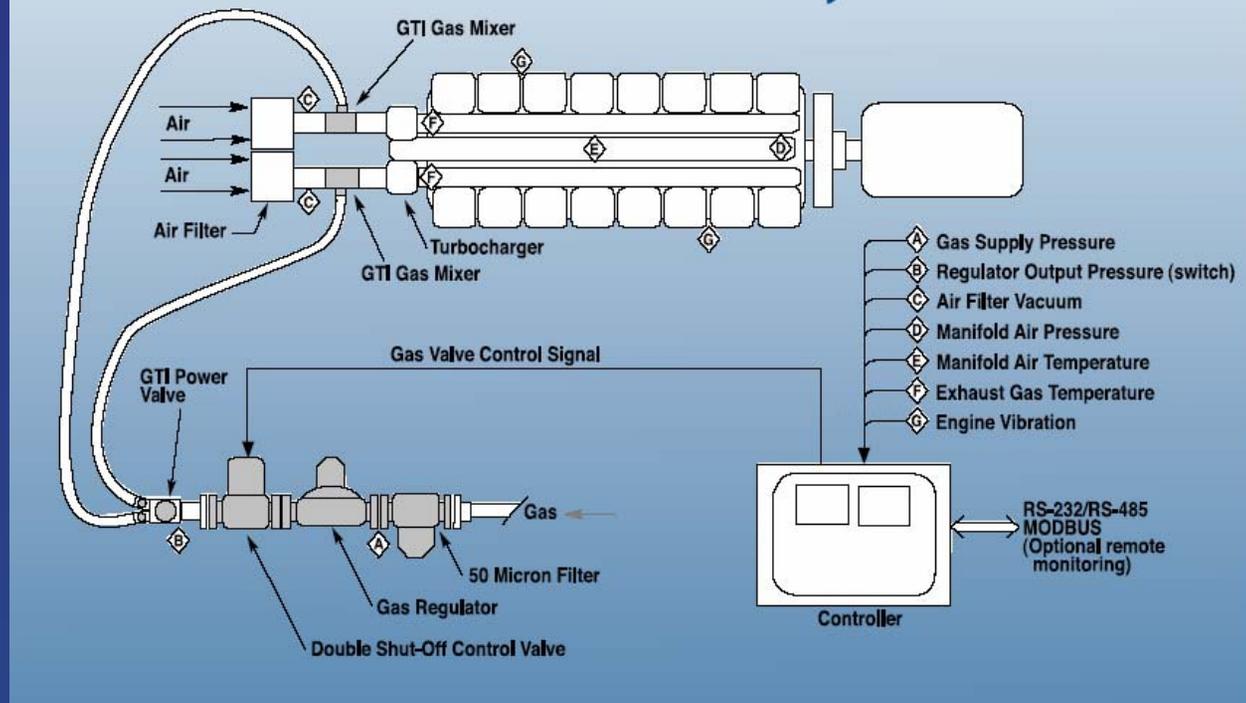
GTI Bi-Fuel Kit Application Chart

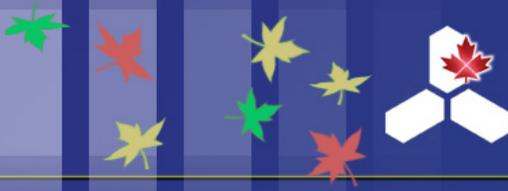
Model	Kilowatt Electric	Engine Horsepower
Series I	Up to 300 kWe	Up to 400 HP
Series II	350 – 600 kWe	450 – 800 HP
Series III	650 – 1100 kWe	850 – 1400 HP
Series IV	1200 – 2000 kWe	1600 – 2700 HP



Bi-Fuel System Overview

The GTI Bi-Fuel System





GTI COMPONENTS

- GAS TRAIN
- 50 MICRON FILTER
- ZERO PSI GOVERNOR
- DUAL SOLENOID VALVE
- INLINE GAS POWER VALVE





GTI Bi-Fuel System Gas Train

- State-of-the-art design
- Carries all major approvals
 - SAA, and Cenelec
- DC-powered
- Valve proving system
- 50 micron gas filtration



Gas Filter

Zero Pressure
Regulator

Gas Solenoid Valve

Gas Power
Valve



OEMs Offering GTI Bi-Fuel Systems

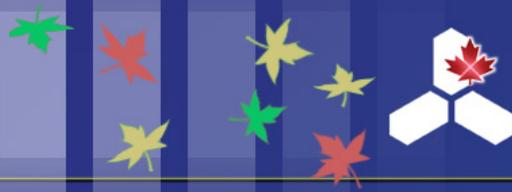
- FG Wilson – Worldwide
- Cummins-Eastern
Canada
- Geveke-Europe
- Finning-Canada & Chile
- Ringpower – Worldwide
- Toromont - Canada
- Enercon - Worldwide



A Selected List of GTI Bi-Fuel System Customers

- Keyspan Energy
- Petrobras Oil Company
- M&M Aerospace
- Marriott Hotels
- Miami Dade Community College
- The University of Evansville
- Simpower

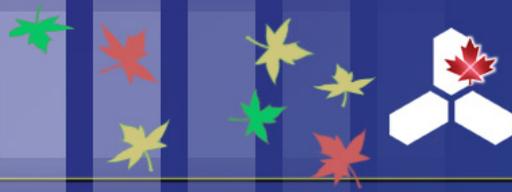




Additional list of GTI Bi-Fuel System Customers

- CHEVRON TEXACO
- CSA
- CUMMINS EASTERN CANADA
- ENCANA
- FG WILSON
- FINNING CATERPILLAR
- M&M AEROSPACE
- MARRIOTT
- MOTOROLA
- PETROBRAS
- POWER SECURE
- PUBLIX
- PRECISION DRILLING
- THOMPSON CATERPILLAR
- TOROMONT CATERPILLAR



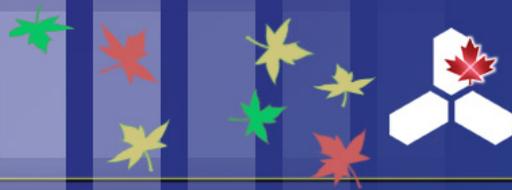


Manufacturer Engine Warranty

Installation of the Bi-Fuel System does not generally impact factory engine warranties.

Because the engine is not modified from the original design, OEM's typically take the position that while they will not be responsible for bi-fuel related failures, the full force and effect of their warranty will remain valid after conversion to bi-fuel.





Bi-Fuel System Warranty

Primary components of the Bi-Fuel System including air-gas mixers, electronic controllers and gas train components are covered by a two year warranty.

Electronic sensors, switches and thermocouples are covered by a one year warranty.



Why Choose GTI?

- Established and reputable market presence
- We have an engine encompassing warranty
- Bi-fuel experience world-wide in many varied market environments
- Our >1000MW installation history has had no engine failure due too a bi-fuel installation
- Our Customer Service is responsive, efficient, and orientated to ensure your satisfaction!





Contact Us



Visit us on the Web at

<http://www.gti-aci.com>

Located in Garland, Texas



Visit us on the Web at

<http://www.fe-ltd.ca>

Located in Calgary, Alberta

