Converting Diesel Engines to *Natural Gas Bi-Fuel*

Existing and new diesel engines can be retrofitted to run on Bi-Fuel (often called *DUAL FUEL*) Natural Gas and Diesel with the ability to operate on 100% Diesel Fuel if Natural Gas is interrupted. The system is used to lower exhaust emissions, extend diesel fuel tank run-time, reduce fuel expenses and prolong engine life and maintenance.

Applications: ***Peak shaving, prime power, co-generation, distributed generation*** **diesel powered electric generators. Sources of gas can be from standard pipelines, oil fields, offshore platforms, landfills, digester or other sources of methane gas.**

Technology: Ring Power's GTI® bi-fuel (dual fuel) system is based on a fumigation principle first observed by Mr. Rudolph Diesel, the inventor of the Diesel engine. Natural gas enters the engine with normal combustion air through the air filter, before the turbo charger. A significantly reduced amount of diesel fuel continues into the engine, which serves as a pilot ignition source for the natural gas. Our control system maintains the proper balance of natural gas, diesel and air to meet the engine's BTU power requirements. Applications using controls for dual-fuel fumigation technologies are subject to U.S. patent, with foreign patents pending.

Results: The Ring Power GTI® fumigation system does not add spark plugs or change other specifications within the engine, so factory warranties remain in effect. Engines maintain full rated horsepower/kw at factory recommended operating temperatures. Emissions such as NOx can be lowered by as much as 60%. Oil changes can be extended approximately 3 times normal. Black exhaust smoke (particulates) can become clear.

THE SYSTEM

The Ring Power GTI® Bi-Fuel System operates by blending diesel fuel and natural gas in the combustion chamber. This is achieved using a pilot-ignition, fumigated gas-charge design, whereby natural gas is pre-mixed with engine intake-air and delivered to the combustion chamber via the air-intake valve. The air-gas mixture is ignited when the diesel injector sprays a reduced quantity of diesel fuel into the chamber. This diesel "pilot" acts as the ignition source for the primary air-gas combustible. Because of the high auto-ignition temperature of natural gas, the air-gas mixture will not ignite during the compression stroke, as there is not enough heat present to facilitate combustion.

Because the OEM air-intake and diesel injection systems are utilized by the Bi-Fuel System, no engine modifications are required for installation.

The various components of the Bi-Fuel System are installed externally of the engine, and at no time is the engine disassembled during installation. All OEM engine specifications for injection timing, valve timing, compression ratio, etc., remain unchanged after installation of the Bi-Fuel System. The Bi-Fuel System requires a low pressure natural gas supply (approximately 2 - 5 psi) with a flow rate of approximately 8 scfh/kW (i.e. 500 kW=5,000 scfh).

INSTALLATION

The Ring Power GTI® Bi-Fuel System is applied by trained technicians, with the installation normally taking anywhere from a few hours to a few days depending on the size of the generator. During nearly all of the installation process, the generator can be utilized for emergency power with little or no starting delay if the system is applied at the customers job site. Actual downtime of the generator is limited to only a few minutes, and rental back-up power is normally not required during installation of the System.

After installation of the Ring Power GTI® Bi-Fuel System hardware, the generator is then operated under various load settings (normally with the use of a resistive load bank) while the System is checked and calibrated. After this "tune-in" process is completed, the generator is fully tested in Bi-Fuel mode to assure proper operation of the Bi-Fuel System and generator during light, medium, heavy and transient loads. Finally, the generator is tested in 100% diesel mode to verify that its 100% diesel performance has not been effected by installation of the Bi-Fuel System.

PERFORMANCE

Installation of the Ring Power GTI® Bi-Fuel System in no way compromises the performance of the generator relative to the rated load of the machine. A generator with a 1000 kW stand-by rating which has been retrofitted to Ring Power GTI® Bi-Fuel System will still provide 1000 kW of power in both 100% diesel and Bi-Fuel modes. In other words, the generator is not de-rated after installation of the Bi-Fuel System. Similarly, there is no decrease in generator load response or stability while operating in either fuel mode.

SAFETY & CONTROLS

The Ring Power GTI® Bi-Fuel System incorporates a sophisticated, electronic control system, which controls both natural gas and diesel fuel during operation. In addition, the GTI Electronic Control System (ECS) acts as an engine safety device, by monitoring up to 24 critical data channels including:

- Exhaust Gas Temperature-Stack
- Exhaust Gas Temperature-Cylinder
- High engine manifold air pressure (MAP)
- Low natural gas supply pressure
- High natural gas supply pressure
- High engine vacuum

The various data channels are displayed on the ECS via an LCD display in either text or graphical format. The ECS notifies the user locally (via an LED general fault light) or remotely via modem, in the event of a fault.

If a fault is detected, the ECS will automatically switch the generator to 100% diesel operation and data-log the fault. The ECS fault set points are field adjustable and allow installation technicians to customize the Bi-Fuel System to the specific requirements of the customer and/or the operational limitations set-forth by the engine manufacturer. Once programmed, the fault settings are protected by a keypad lockout code, which prevents unauthorized personnel from altering the set points.

The ECS guarantees that in the unlikely event of either a Bi-Fuel System malfunction, or a disruption in natural gas supply pressure (either low or high pressure faults), the generator drive-engine will be protected from damage. Most of the monitored channels are latching type faults, i.e. if the Bi-Fuel System is deactivated by the ECS, the generator cannot be returned to Bi-Fuel operation until the ECS panel is manually reset. Lastly, the ECS also incorporates a built-in time delay function, which prevents initiation of Bi-Fuel operation after generator start-up, for a period of up to 300 seconds. This feature is used when the converted generator is used in paralleling operations, and allows the generator to start-up and synchronize on 100% diesel fuel before automatically switching to Bi-Fuel operation.

Ring Power GTI® AIR-GAS MIXER

SAVINGS

Savings derived from the use of Ring Power's GTI® Bi-Fuel System are the result of either:

❶

the differential between the cost per kWh charged by the utility and the cost per kWh to produce power with a Bi-Fuel generator or,

❷

in the case of existing diesel prime power operations, the differential in the cost of diesel fuel and natural gas.

Utility Supplied Power:

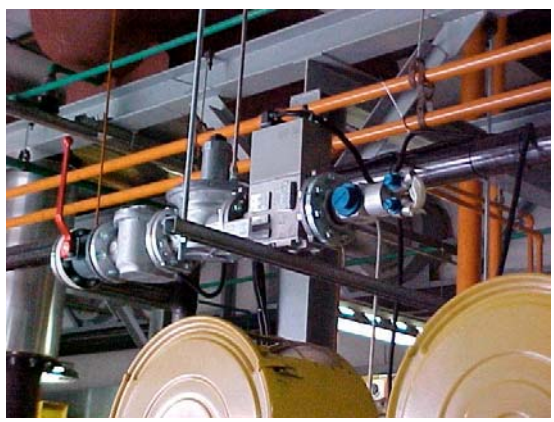
Due to the premium prices which utility companies usually charge for on-peak electricity, it is often most viable to operate the Bi-Fuel generator as a peak-shaver, whereby power is produced on-site only during those hours when electricity is at it's highest price from the utility. In order to determine the cost of producing power with a Bi-Fuel generator, several factors must be considered including:

➡ Cost of natural gas

➡ Cost of diesel fuel

➡ Cost of maintenance program for generator

➡ Cost of future engine overhauls



Summary of Dual-Fuel Benefits

>> Convert any Diesel Engine
>> Generators, Ind. Engines, Marine
>> Extend Oil Changes, Engine Life
>> Full Power, normal Temperatures
>> Run Bi-Fuel *or* 100% Diesel
>> Lower Emissions – C.A.R.B.
>> Smaller Diesel Fuel Tanks Needed
>> Costs much less than Gas Engines

FREQUENT ASKED QUESTIONS

What does "Bi-Fuel" mean?

In simple terms, Bi-Fuel can be defined as the simultaneous combustion of two fuels. In the case of **Ring Power's GTI®** Bi-Fuel System, natural gas is utilized in conjunction with diesel fuel to operate the engine. After conversion, the engine is able to operate on either 100% diesel fuel, or alternately, on a mixture of diesel fuel and natural gas (or other methane based fuels). At no time is the engine able to operate on natural gas exclusively.

Will my engine have to be modified to operate on GTI Bi-Fuel?

No. **Ring Power's GTI®** conversion technology has been designed to allow for in-field retrofit of diesel engines without the need to change or modify the design of the engine. **Ring Power's GTI®** conversion hardware is mounted externally on the engine and does not require modification of the engine or alteration of any critical engine parameter.

What about my engine warranty?

Most OEM engine warranty programs do not prohibit the use of aftermarket parts or Technologies. In brief, the policy of OEM's is that they neither recommend nor endorse aftermarket technologies, however, the use of these products does not automatically void the validity of the engine warranty. In practice, if a converted engine has a failure under warranty, the OEM, in conjunction with **Ring Power's GTI®** technical personnel, make a determination as to the cause of the failure. If the cause is obviously unrelated to Bi-Fuel, the OEM's have historically honored the warranty and repaired the engine. If the cause is determined to be Bi-Fuel related, **Ring Power's GTI®** team will cover repair costs under it's warranty program.

Why can't the engine use 100% natural gas?

Because of the very High ignition temperature of natural gas (approximately 1300T), sufficient heat is not generated during the diesel compression stroke to ignite 100% natural gas. As such, dedicated gas engines employ spark plugs and an ignition system to facilitate combustion of the air-natural gas mixture. In contrast, during Bi-Fuel operation, a reduced quantity of diesel fuel acts as the ignition source for the air-gas mixture; this process is often referred to as pilot ignition.

Will my engine lose power after conversion to Bi-Fuel?

Under normal circumstances, engines converted to **Ring Power's GTI®** Bi-Fuel do not suffer any horsepower/kW losses while operating in Bi-Fuel Mode. Because the System maintains OEM compression ratio values and does not incorporate an air-throttling device, peak horsepower and efficiency levels of the converted engine remain on par with 100% diesel operation. In some circumstances, the engine may be de-rated in Bi-Fuel mode due to shortcomings in gas supply composition and/or quality.

Will my engine run hotter on Bi-Fuel?

Ring Power's GTI® Bi-Fuel technology has been designed to maintain OEM specifications for all engine temperatures including engine coolant temperature, oil temperature, exhaust gas temperature and intake air temperature. The Bi-Fuel System replaces diesel fuel normally consumed by the engine with an equivalent quantity of natural gas, relative to the heat value of each fuel. As such, engine air-fuel ratios during Bi-Fuel operation remain largely equivalent to 100% diesel operation, resulting in normal peak exhaust gas temperatures and associated peak engine thermal loads.

What about efficiency?

As explained above, **Ring Power's GTI®** Bi-Fuel System replaces diesel fuel with an equivalent quantity of natural gas. This process results in the same net fuel burn vs. load as would be experienced during 100% diesel operation. For each gallon of diesel fuel displaced during Bi-Fuel operation, there is a corresponding consumption of approximately 140 cubic feet of pipeline quality natural gas (based on 129,000 btu/gallon # 2 diesel & 930 btu/scf natural gas). Thus, for each gallon of diesel fuel displaced during Bi-Fuel operation, an "equivalent gallon7 of natural gas is consumed resulting in similar engine fuel efficiencies. Note: 1 d of natural gas = I liter # 2 diesel.

What effect will Ring Power's GTI® System have on the durability of my engine?

Generally speaking, operation in Bi-Fuel mode has no negative effects on engine wear rates and durability. As explained above, because engine thermal loads are equivalent to 100% diesel operation, no excess wear of combustion chamber components (pistons, rings, valves, injectors, etc.) occurs. In addition, many users of Bi-Fuel have reported positive benefits relative to engine wear including extended oil change intervals and extended time between overhauls. This is primarily the result of the cleaner burning characteristics of natural gas compared to diesel fuel.

What are the economic benefits to operating on Bi-Fuel?

Fuel cost savings resulting from operation in Bi-Fuel mode win vary according to the respective cost of each of the fuels. If there is a significant cost differential between the cost of diesel fuel (per gallon, liter, etc.) and the equivalent quantity of natural gas (heat value basis) in favor of the natural gas, significant fuel cost savings would result. The closer the fuels are in price, the lower the fuel cost savings will be during Bi-Fuel mode. In addition to fuel cost savings, engine maintenance savings (as explained above) may also contribute to the economic benefit of Bi-Fuel operation.

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(Next Page,.. OEM Confirmation Letters)

Your Original Equipment Warranty is still valid !!

Caterpillar Inc.
Engine Division
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Mossville IL 61552-0610

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The use of these conversions, in and of themselves, will not void Caterpillar's warranty. This does not imply, however, that failures which result from the use of these conversions will be covered under the Caterpillar warranty, which is limited to defects in Caterpillar's workmanship and material for the warranty period.

Marketing Development

Cummins Engine Company Inc.
Box 8005
Columbus IN 47202

Cummins Engine Company's warranty covers defects in workmanship and/or material as manufactured and sold by Cummins: therefore, any product sold in the marketplace not manufactured by Cummins does not affect our warranty. However, any engine performance problem or failure caused by products not manufactured or sold by Cummins is not considered a warrantable type of failure.

Carl Koontz
Service Engineering Director

Failure to follow our recommendations will not void our product warranty: however, product failures resulting from add on equipment would not be of a warrantable nature and would not be covered by DDC.

R.R. Fogoros
Manager, Technical Service