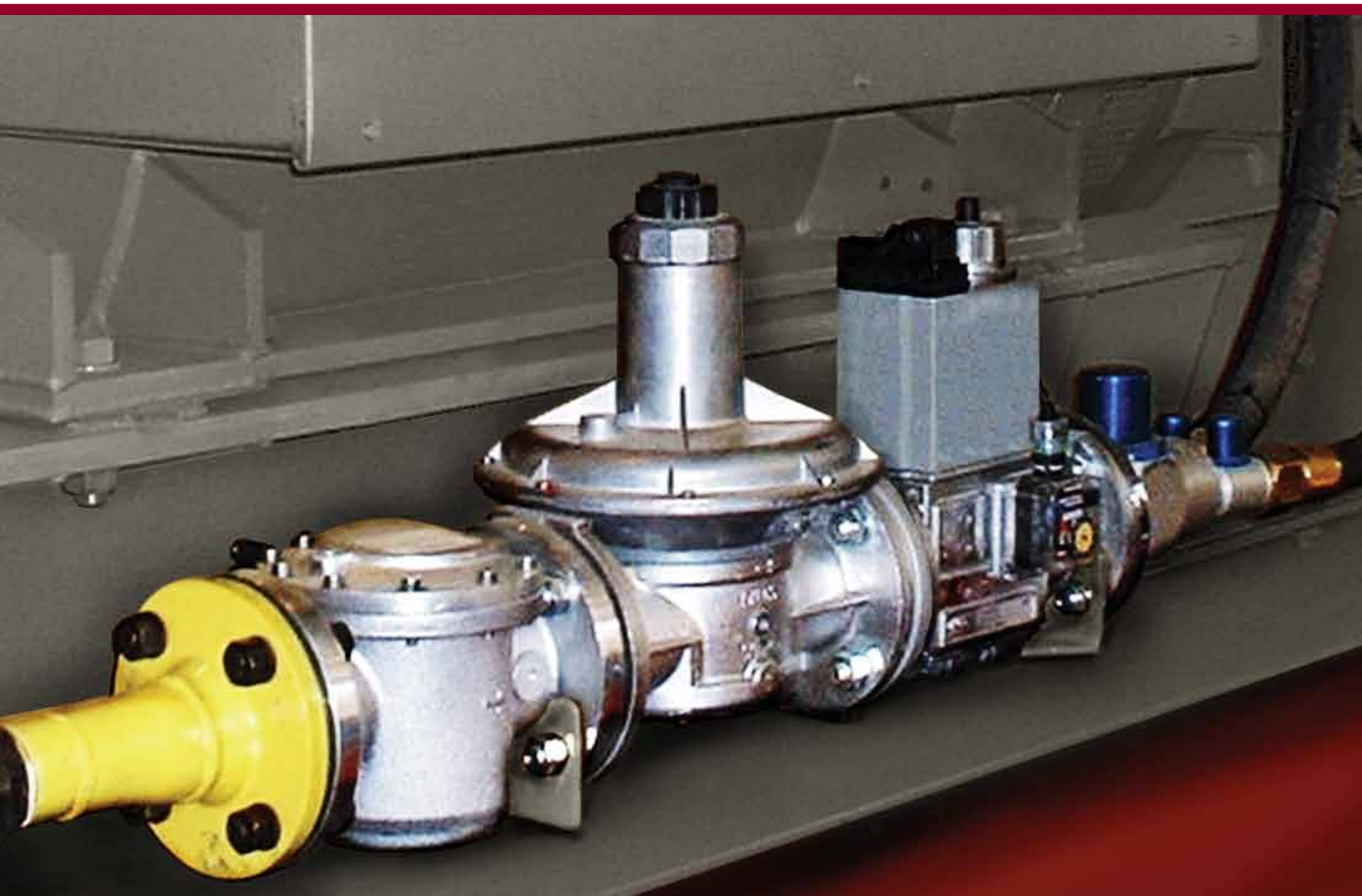
GTI Bi-Fuel® Systems
for heavy-duty diesel engines

altronic



Operate Your Diesel Engine on Natural Gas

- No engine modifications required
- No power or efficiency losses
- Low cost and easy to install
- Reduces operating costs
- Extends run-time of standby engines
- Lowers emissions
- Does not require high-pressure gas supply
- Allows use of interruptible gas
- State-of-the-art controls and monitoring

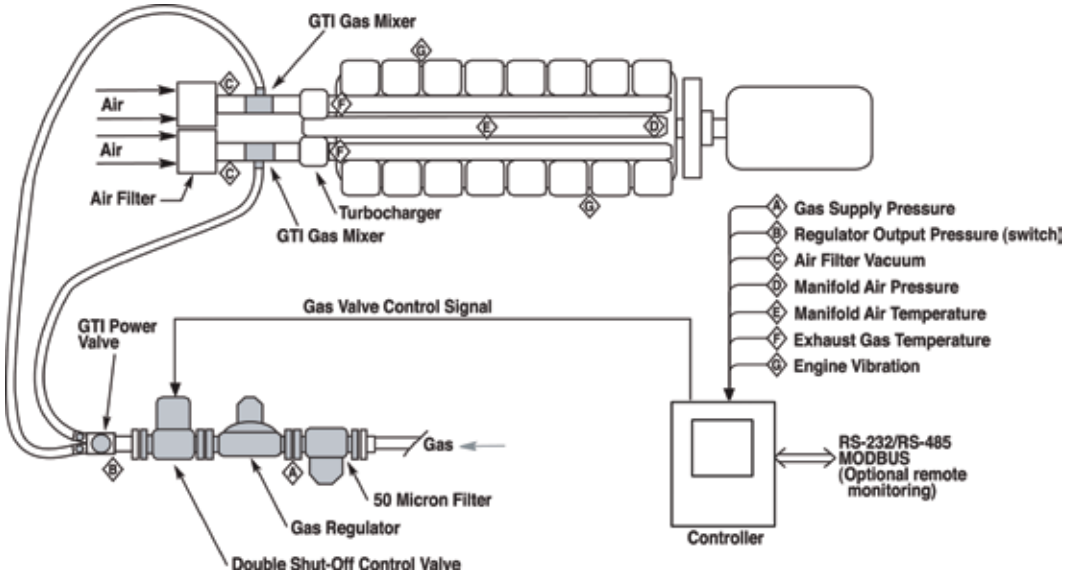
The GTI Bi-Fuel® System from ALTRONIC, INC is an innovative technology that enables operators of heavy-duty diesel engines to substantially reduce operational costs and lower emissions by substituting diesel fuel with lower cost, cleaner-burning natural gas. The Bi-Fuel® System is comprised of patented technologies that allow engines to safely operate on gas percentages up to a maximum of 70%* of the total fuel requirement. Engines converted to GTI Bi-Fuel® exhibit diesel-like performance in such critical areas as efficiency, stability and load acceptance.

A key feature of the Bi-Fuel® System is its ability to switch fuel modes without interruption in engine power output. The engine can be switched between diesel and gas automatically while maintaining speed and load. This feature gives the user the flexibility to choose between gas and diesel modes as dictated by fuel pricing, fuel availability or other operational considerations. An equally important feature of the Bi-Fuel® System is its ability to maintain engine power levels while operating in gas mode between the “continuous” and “prime” ratings of the engine. For operations above the programmed power limit, the engine is automatically switched to 100% diesel mode, thus avoiding the necessity to de-rate the engine. In applications where the load varies substantially, the optional Dynamic Gas Control (DGC) version of the system provides for adjustment of the gas substitution rate according to a map of fuel vs. load.

The Bi-Fuel® System utilizes a state-of-the-art electronic control and monitoring system which monitors critical engine and Bi-Fuel® System parameters and activates or deactivates gas mode according to programmed limits. When a monitored parameter exceeds the allowable limit, the controller switches the engine to 100% diesel mode and electronically logs the fault for diagnostic purposes. The control panel is housed in a NEMA rated weatherproof enclosure and is approved for Class I, Division 2 environments.

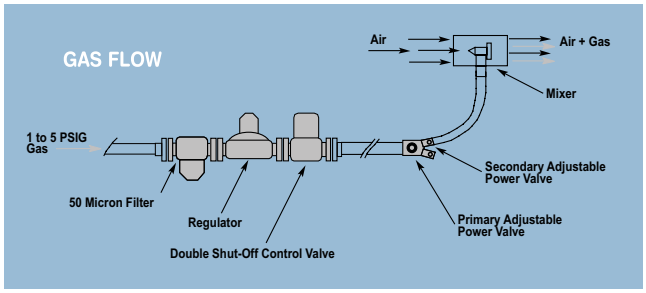
*Subject to gas quality and other application conditions.

Bi-Fuel® System Operation and Performance



NOTE: REQUIRES ISOCHRONOUS DIESEL GOVERNOR

Typically, gas is introduced downstream of the engine air cleaner and upstream of the turbocharger. The gas is supplied at approximately atmospheric pressure using a proprietary air-fuel mixer that allows for a high level of gas mixing with the least possible air restriction. The air-gas mixture is compressed in the turbocharger and distributed to each cylinder by the engine air-intake manifold. The lean air-gas mixture is compressed during the compression stroke of the piston and ignited by the diesel injector. Since the air-gas mixture is maintained in a lean condition, pre-ignition does not occur.



Flow of gas to the engine is load dependent and varies with combustion airflow changes. The Bi-Fuel® System varies gas flow according to changes in engine vacuum level. This allows it to respond to engine fuel requirements while maintaining the integrity of the OEM governing system. The standard Bi-Fuel® System incorporates a manually-adjustable Power Valve to control the gas substitution rate. The optional Dynamic Gas Control (DGC) version automatically optimizes performance across varying load ranges by varying the gas substitution rate as a function of the load. Diesel injection is controlled by the OEM governing system during both gas and diesel modes.

The Altronic DE-based Bi-Fuel® Controller monitors various engine and system parameters such as manifold air pressure and temperature, exhaust gas temperature, intake vacuum, gas pressure and engine vibration. This information allows the controller to determine when to activate or deactivate bi-fuel operation depending on engine performance, load level, ambient temperature, knock limits or gas supply pressure levels. The controller can communicate with remote engine monitoring systems via RS-232/RS-485 connection (ASCII or MODBUS protocol).

Engine performance during Bi-Fuel® operation is typically on par with normal diesel levels. Heat rejection levels to the exhaust and water jacket systems are kept within normal operating parameters. Engine response to load variation is typically equal to—or better than—100% diesel performance due to the unique design of the Bi-Fuel® System and the associated combustion characteristics of the air-gas mixture. Similarly, engine load acceptance (for large block loads) meets or exceeds straight diesel performance.

Bi-Fuel® = Diesel-like Performance

- Operating temperatures
- Stability
- Load acceptance
- Efficiency
- Durability
- Reliability

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Form GTI 8-09

Major System Components and Sub-systems

Air-Fuel Mixer

The Bi-Fuel® System uses a proprietary air-gas mixing device that has been designed for optimum blending of natural gas and engine intake air. Mixing of air and gas is achieved using a sophisticated, fixed-venturi design that avoids the use of an efficiency robbing throttle plate. The low restriction air-gas mixer ensures that adequate air-flow is maintained to the engine and that operating efficiencies are not compromised by installation of the device. The computer-aided-design mixer is built to aerospace tolerances using CNC machining processes and is assembled using state-of-the-art welding techniques. The finished mixer has no moving parts and once installed in the engine air-intake system requires no routine maintenance.

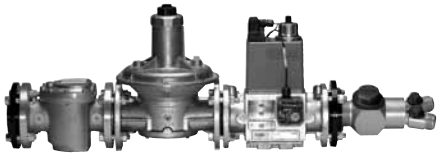
Gas Power Valve

The Bi-Fuel® System employs an adjustable gas flow metering device that is in-stalled up-stream of the air-gas mixer. The gas power valve is a proprietary system component that meters the maximum gas flow rate to the engine for a given load and vacuum level. The power valve works in concert with the air-gas mixer and zero-pressure regulator to supply the required quantity of gas to the engine. Like the air-gas mixer, the gas power valve is built using computer-aided-design and CNC manufacturing and requires no routine maintenance.

Note: The Bi-Fuel® System is also vailable with Dynamic Gas Control (DGC) which replaces the gas power valve with a DC-powered, digitally-controlled flow metering device for precision fuel mapping and non-linear gas control.

Gas Train

Conditioning and regulating the natural gas prior to admission into the engine is a critical part of the GTI Bi-Fuel® System. The system "gas train" includes a 50-micron fuel filter, an electrically-operated solenoid valve, actuated in the event of an emergency



or for system shutdown, and a zero-pressure, demand-type gas pressure regulator. This latter component reduces the inlet gas pressure (3 ±1psi) to roughly atmospheric pressure. With a negative outlet pressure, the design allows the system to use a "demand" control scheme whereby engine intake airflow determines the gas flow of the engine. As engine load changes, corresponding changes in intake air volume automatically draw additional fuel into the mixer.

Engine Control System

The Engine Control System is based on proven Altronic controllers and provides state-of-the-art engine control and safety shutdown monitoring. The system is designed specifically for the GTI Bi-Fuel® System and is straight-forward and simple to operate. The system monitors a number of pressure and temperature points (see opposite page) and returns the engine to 100% diesel operation should any parameter deviate from its normal range. In addition, a hourmeter function tracks the operating hours in Bi-Fuel® mode. Alarms are annunciated in clear message form and the controller maintains an alarm log of the last 100 events.

Dynamic Gas Control (DGC) System

For applications requiring the maximum possible gas substitution, GTI now offers an advanced, "closed-loop" control option. The Dynamic Gas Control system (DGC) utilizes diesel fuel flow meters, kilowatt transducers and a precision Altronic natural gas control valve to dynamically adjust and maximize the rate of natural gas substitution based on real-time variations in engine load. The DGC option is primarily intended for high-use applications such as variably loaded prime power or peak-shaving generator sets requiring the lowest operational fuel costs.

Bi-Fuel® Kit Application and Contents

STANDARD SYSTEM

The gas substitution rate is controlled by the mixer as a function of intake airflow.

DYNAMIC GAS CONTROL (DGC) SYSTEM

The gas substitution rate is adjusted electronically according to map of fuel vs. load.

CSA CERTIFIED CLASS I, DIV. 2, GROUP D

System available — contact Altronic sales office for details.

GTI Series	Engine Power Rating	Engine Type	Gas Train Kit	Gas Mixers	GTI Series No.	Vibration Sensor(s)	DGCS Option	***CSA Certified
A *	Up to 75 kWe	In-line engine	1" NPT	1 x 3"	A-E13	NA	NA	No
	75-150 kWe	In-line engine	1" NPT	1 x 4"	A-E14	NA	NA	No
					A-A14	Opt. (1)	NA	No
I	150-225 kWe	In-line engine	DN50/2" NPT	1 x 5"	I-E15	NA	NA	No
	150-300 kWe	In-line engine	DN50/2" NPT	1 x 5"	I-A15	Opt. (1)	Optional	Yes
II	300-600 kWe	In-line engine	DN65/2.5" NPT	1 x 6"	II-A16	Opt. (1)	Optional	Yes
		V-engine	DN65/2.5" NPT	2 x 6"	II-B26			
III	600-1200 kWe	In-line or V-engine, common manifold	DN65/2.5" NPT	1 x 6"	III-A16	Std. (2)	Optional	Yes
		V-engine, common manifold	DN65/2.5" NPT	2 x 6"	III-B26			
				4 x 6"	III-B46			
		V-engine, dual manifold	DN65/2.5" NPT	2 x 6"	III-C26			
				4 x 6"	III-C46			
		V-engine, quad manifold	DN65/2.5" NPT	2 x 6"	III-D26			
				4 x 6"	III-D46			
IV	1200-3000 kWe	V-engine, common manifold	DN80/3" NPT	2 x 7"	IV-B27	Std. (2)	Optional	Yes
				4 x 6"	IV-B46			
				4 x 7"	IV-B47			
		V-engine, dual manifold	DN80/3" NPT	2 x 7"	IV-C27			
				4 x 6"	IV-C46			
				4 x 7"	IV-C47			
		V-engine, quad manifold	DN80/3" NPT	2 x 7"	IV-D27			
				4 x 6"	IV-D46			
				4 x 7"	IV-D47			
		In-line engine	DN80/3" NPT	1 x 10"	IV-B110 **			

* Series A kits require 12Vdc Power; all other Series require 24Vdc power.
** Contact the GTI sales office for further information.
*** Requires special solenoid valve; contact factory for details.