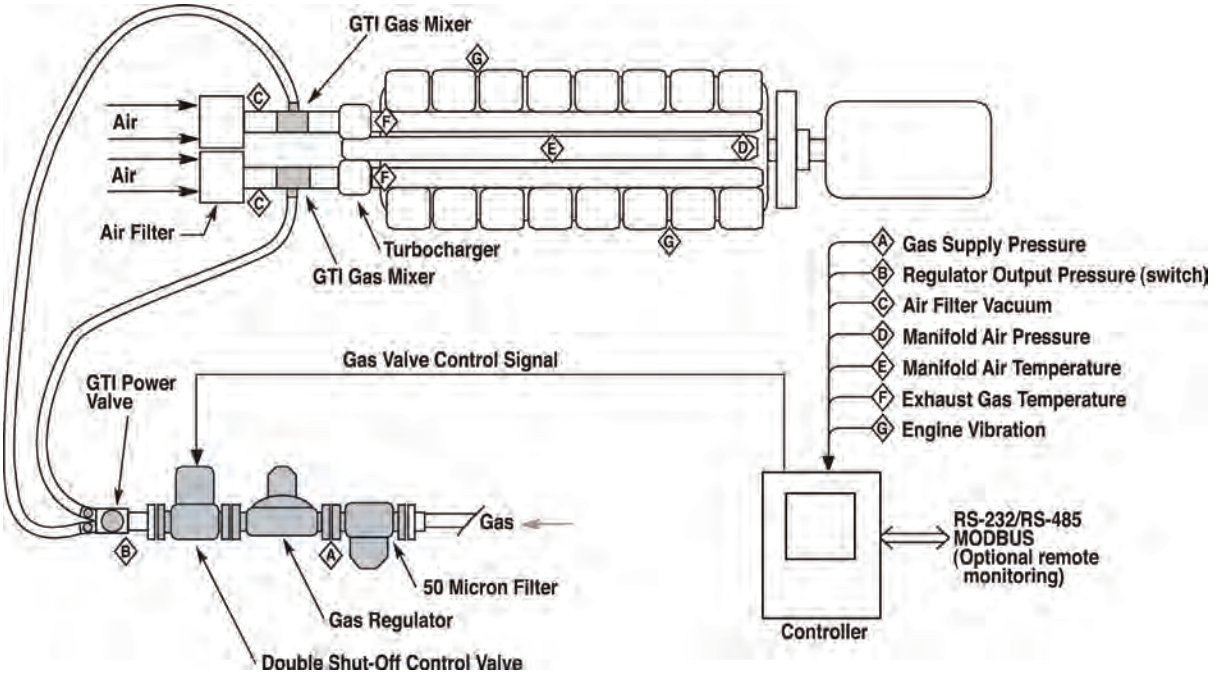
GTI Bi-Fuel®

for heavy-duty diesel engines

altronic

Bi-Fuel® System Operation and Performance



NOTE: REQUIRES ISOCHRONOUS DIESEL GOVERNOR

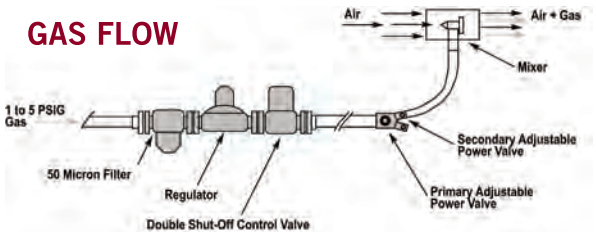
Typically, gas is introduced downstream of the engine air cleaner and upstream of the turbocharger. The gas is supplied at approximately atmospheric pressure using a proprietary air-fuel mixer that allows for a high level of gas mixing with the least possible air restriction. The air-gas mixture is compressed 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. 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 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.

GAS FLOW



Operate Your Diesel Engine on Natural Gas

The GTI Bi-Fuel® System from ALTRONIC, LLC 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 Step Control System (STEPCON) 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.

Cost Savings

Displacing a percentage of diesel fuel with methane-based gas provides an immediate economic benefit based on the cost difference between the fuels and the amount of run time of the genset. In high usage gensets, the GTI system can pay for itself in a short period of time. Simple Excel-based spread sheets are available to assist in modeling the economic benefits of converting your diesel genset to GTI Bi-Fuel®.

Increased Run Time

Reducing the amount of diesel fuel used extends the run time in proportion to the substitution rate. This provides extra hours of operation for critical applications during extended power outages.

Simplified Logistics

The frequency of refueling is reduced, thereby lessening the costs—and risks—associated with hauling diesel fuel, especially to locations that make such logistics awkward.

Reduced Liquid Fuel Storage

As environmental concerns about liquid fuel storage increases pressure on operators, using the GTI Bi-Fuel® system offers some relief by reducing the volume of above-ground diesel fuel storage.

Flare Gas Reduction

Around the world, governments and environmental concerns are increasing pressure to reduce the flaring of unwanted gases into the atmosphere. The GTI-Bi-Fuel® system allows these waste gases to be used as fuel for the generation of electrical power.

Flexible Fuel Rates

Many gas suppliers offer discounted rates to customers who can tolerate supply interruptions in times of high demand/inadequate supply. GTI Bi-Fuel® offers this kind of flexibility since the genset can operate on 100% diesel at any time.

Reduced Capital Costs

Due to the higher power density of diesel engines relative to pure spark-ignited gas engines, the cost per kW produced of a diesel engine can be significantly less compared to the same output gas engine. The use of the GTI Bi-Fuel® system allows the user to enjoy many of the benefits of gas engine operation coupled with the lower capital cost of the initial purchase.

*Substitution rates can vary from 25% to 70%, subject to gas quality and other application conditions.

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.

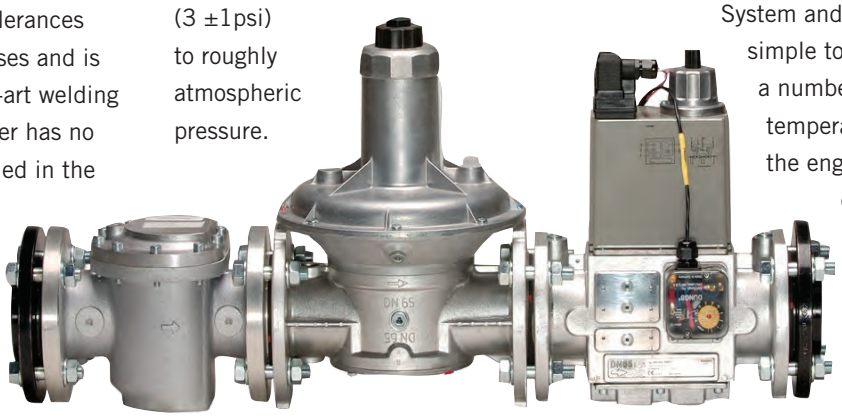
Gas Power Valve

The Bi-Fuel® System employs an adjustable gas flow metering device that is installed 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.

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.

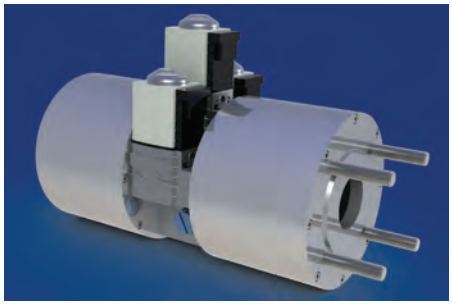


With a negative outlet pressure, the design allows the system to use a "demand" control scheme whereby engine intake airflow determines the gas flow of the engine. As engine load changes, corresponding changes in intake air volume automatically draw additional fuel into the mixer.

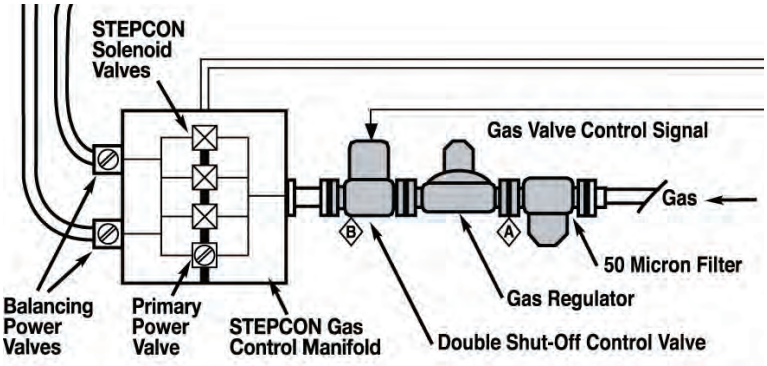
Engine Control System

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. It monitors a number of pressure and temperature points 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.

GTI Step Control System (STEPCON®)



The STEPCON® system is an option to the basic GTI Bi-Fuel® system. STEPCON® retains all of the components of the basic fumigation system with the addition of a Gas Control Manifold (GCM), kW sensor, and a panel upgrade with customized firmware and outputs.



The STEPCON® enhances the bi-fuel system, allowing its application over a wider load range, adjusting the optimal substitution rate based on load with the capability to make substitution level adjustments in response to rapid load changes.

The design requires no modifications to the diesel engine, controls, or sensors, and uses all of the same basic safety systems to protect the engine. The STEPCON® system incorporates a kW sensor to enhance its ability to sense engine load, and a gas control manifold (GCM) assembly, installed directly on the outlet side of the gas train. The GCM incorporates a standard manual power valve in parallel with three single-solenoid fuel control valves, each of which has a manually set, fully adjustable orifice that is set by the commissioning technician.

A standard GTI Bi-Fuel® commissioning procedure is performed for the load window where the lowest level of substitution will take place, with all three solenoid valves electrically closed, using only the manual power valve to set this lowest (initial) level of substitution. The commissioning procedure is repeated for the second, third, and fourth stepped levels of substitution, each time setting the percent of substitution for its corresponding load window by adjusting the variable orifice of each solenoid valve. Customized software is used to create ON/OFF combinations of the three solenoid valves in the gas control manifold to "shape" the gas substitution curve to follow the engines tolerance to gas as engine load is varied across a wide range, providing optimized substitution over a wide load band. The result is a load map that allows the GTI control panel to rapidly transition to the selected valve combinations based on engine load, thus maximizing the benefits of the bi-fuel application.

STEPCON® Applications

The STEPCON® system is intended for use in applications where there is a need to accommodate adjustments in the optimal substitution rate as a result of changes in conditions that would normally require a limitation to the maximum possible substitution over a given load window; or a limitation to the maximum possible load window with a given rate of substitution. An example would be an installation where high operating temperatures (either time-of-day or load related) limit the substitution at elevated loads. Another example is a genset that spends a large percentage of its time at light load, below the point where a standard bi-fuel system—optimized to operate in the engine's moderate-to-heavy load region—would be in the bi-fuel OFF condition (such as on a drill rig).

STEPCON® Sizing

The STEPCON® system is available in a number of models to accommodate various engine configurations.

GCM	Inlet Flange	Outlet Size	Outlets
STEP65215	DN65	1.5" JIC	2
STEP65415	DN65	1.5" JIC	4
STEP80120	DN80	2.0" JIC	1
STEP80220	DN80	2.0" JIC	2
STEP80420	DN80	2.0" JIC	4

STEPCON Fuel Control Manifold Size Chart

Bi-Fuel® Kit Application and Contents

GTI Series	Engine Power Rating	Engine Type	Gas Train Kit	Gas Mixers	GTI Series No.	Vibration Sensor(s)	STEPCON Option	CSA Certified**
25*	Up to 75 kWe	In-line engine	1" NPT	1 x 3"	2513-0E	NA	NA	No
	75-150 kWe	In-line engine	1" NPT	1 x 4"	2514-1E	NA	NA	No
					2514-1A	Opt. (1)	NA	No
50	75-150 kWe	In-line engine	1" NPT	1 x 4"	5014-0E	NA	NA	No
					5014-1A	Opt. (1)	NA	Yes
	150-300 kWe	In-line engine	DN50 / 2" NPT	1 x 5"	5015-0E	NA	NA	No
					5015-1A	Opt. (1)	NA	Yes
65	300-600 kWe	In-line or V-engine, com. manifold	DN65 / 2.5" NPT	1 x 6"	6516-1B	Std. (2)	Optional	Yes
		V-engine	DN65 / 2.5" NPT	2 x 6"	6526-1B			
	600-1200 kWe	V-engine, common manifold	DN65 / 2.5" NPT	2 x 6"	6526-2B	Std. (2)	Optional	Yes
				4 x 6"	6546-2B			
		V-engine, dual manifold	DN65 / 2.5" NPT	2 x 6"	6526-2C			
				4 x 6"	6546-2C			
		V-engine, quad manifold	DN65 / 2.5" NPT	2 x 6"	6526-2D			
				4 x 6"	6546-2D			
80	1200-3000 kWe	V-engine, common manifold	DN80 / 3" NPT	2 x 7"	8027-2B	Std. (2)	Optional	Yes
				4 x 6"	8046-2B			
				4 x 7"	8047-2B			
		V-engine, dual manifold	DN80 / 3" NPT	2 x 7"	8027-2C			
				4 x 6"	8046-2C			
				4 x 7"	8047-2C			
		V-engine, quad manifold	DN80 / 3" NPT	2 x 7"	8027-2D			
				4 x 6"	8046-2D			
				4 x 7"	8047-2D			

* Series 25 kits require 12Vdc Power; all other Series require 24Vdc power.
** CSA CERTIFIED CLASS I, DIV. 2, GROUP D System available — contact Altronic sales office for details.

- 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

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