Refinery Equipment of Texas

Bi-Fuel Technology Solution

Bi-Fuel technology combines natural gas and diesel, resulting in an engine that provides the low emissions of natural gas, without giving up the performance and benefits of a diesel engine. In simple terms, Bi-Fuel can be defined as the simultaneous combustion of two fuels. In the case of a Bi-Fuel System, natural gas is utilized in conjunction with diesel fuel to operate the engine. The engine is able to operate on either 100% diesel fuel, or alternately, on a mixture of diesel fuel and natural gas. At no time is the engine able to operate on natural gas exclusively. This innovative, patented system requires no modification to the internal components of the engine. Bi-Fuel technology allows the engine to operate on fuel ratios up to a maximum of 70% natural gas or adjustable ratios necessary to maintain the desired engine speed and load. Benefits of this technology includes reduced exhaust emissions, lower fuel cost, extended diesel fuel tank run-time, prolonged engine life and lower maintenance cost to name a few.

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, digesters or other sources of methane gas.**

Technology: **The bi-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. The Bi-fuel control system maintains the proper balance of natural gas, diesel and air to meet the engine's BTU power requirements. Applications using controls for bi-fuel fumigation technologies are subject to U.S. patent, with foreign patents pending.**

Results: **The 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.**

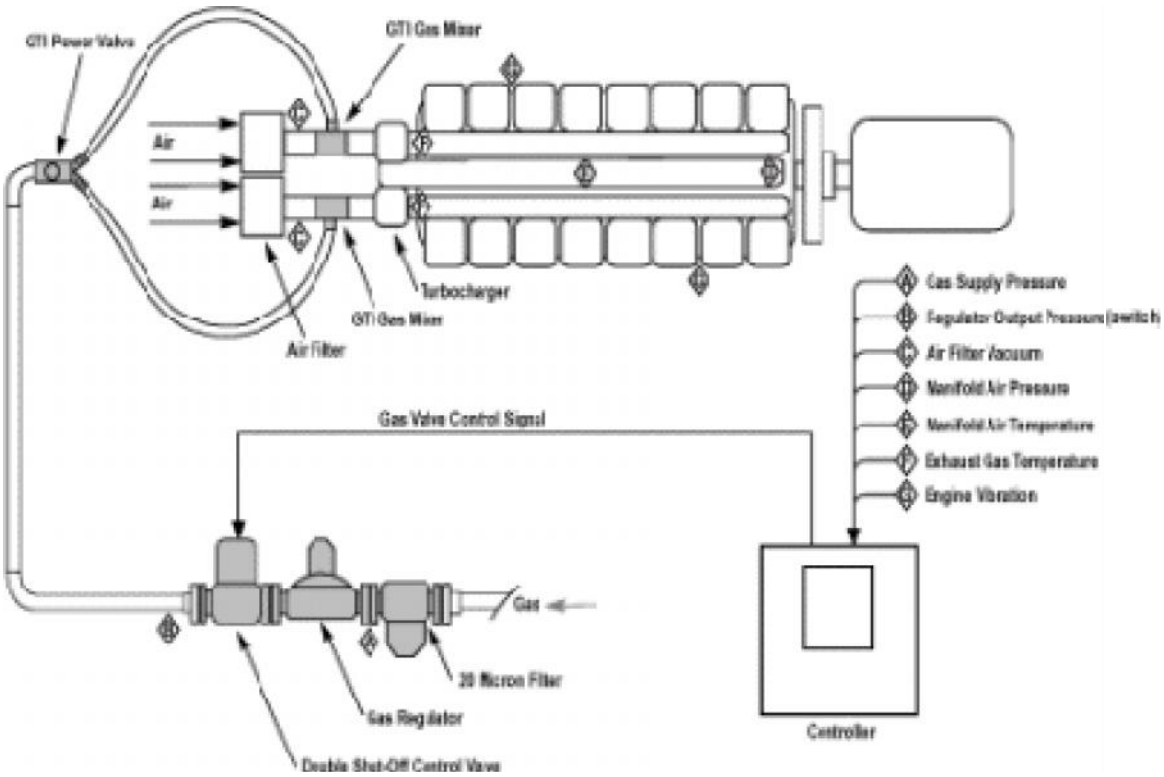
The System

The 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 premixed 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).

Bi-Fuel System Layout



Performance

Installation of the 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 the 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.

The Bi-Fuel System incorporates a sophisticated, "Electronic Control System", which controls both natural gas and diesel fuel during operation. In addition, the 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 start-delay feature is used when the generator is operated in paralleling operations, and allows the generator to start-up and synchronizes on 100% diesel fuel before automatically switching to Bi-Fuel operation.

What are the economic benefits?

Fuel cost savings resulting from operation in Bi-Fuel mode will 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.

Summary of Benefits

- **Convert any Diesel Engine to bi-fuel**
- **Operate on Bi-Fuel or 100% Diesel**
- **Save on Operating Fuel Costs by using cheap Natural Gas.**
- **Substitute up to 70% Natural Gas for Diesel Fuel.**
- **Allows the Use of available Gas Supplies.**
- **No Modification to internal Engine Components is required**
- **Cleaner Burning Natural Gas reduces Exhaust Emissions**
- **Long oil life - extend Oil Change intervals**
- **Extended Engine Life**
- **Smaller engine Fuel Tanks are Needed**
- **Reduces requirements for On-Site Diesel Fuel Storage**
- **Unique, patented Design ensures no Loss of Power or Efficiency**
- **Engine operates at Normal Temperatures**
- **Lower Cost than Gas turbines**
- **Fast delivery**

Additional Advantage - Lower Cost per Kilowatt

Natural gas turbine generators typically cost twice as much as comparable diesel units. With the Bi-Fuel System, you get the power of diesel and most of the benefits of natural gas operation for a price that is competitive with a diesel only unit.

Bi-Fuel Control System Components

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