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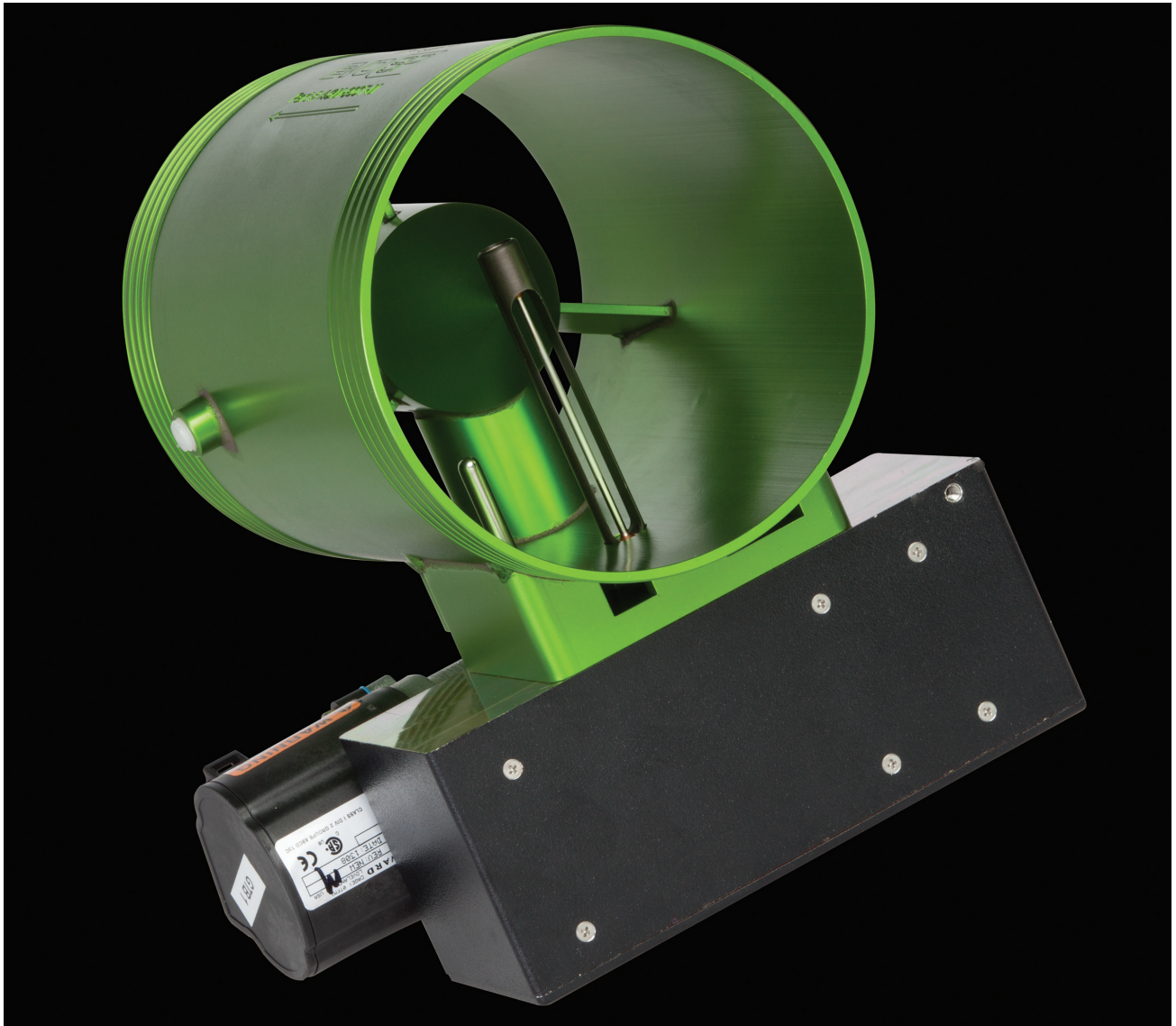
Bi-Fuel Systems For
Cat Mine Haulers

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GFS Corp.'s bi-fuel conversion system is now designed for Caterpillar's 793D mine haul truck. The new EVO-MT 7930 system incorporates an air/gas mixer with an integrated throttle body and mass airflow sensor, shown here.

BEING MINE-FUL OF BI-FUEL

GFS Corp. expands bi-fuel conversion systems for mine haul trucks

BY JACK BURKE

GFS Corp. has expanded its line of bi-fuel conversion systems designed for high-horsepower diesel engines on haul trucks used primarily in mining operations.

The new EVO-MT 7930 system is designed for Caterpillar's 793D haul truck and joins the company's EVO-

MT systems designed for Komatsu's 830AC, 830DC and 930E as well as Caterpillar's 777B, 777C, 793B and 793C haul truck models.

The new system incorporates much of the same design as the previous Caterpillar conversion systems and gives mine operators the option

of using more sustainable and less expensive liquid natural gas (LNG) as a substitute for diesel fuel in their haul trucks, said Kerry Hackney, vice president of operations for the Weston, Fla.-based company. The first of these new systems has been installed on a Caterpillar 793D working in a coal mine in the Powder River Basin of northeast Wyoming.

The EVO-MT system incorporates an electronic control unit (ECU) that monitors critical engine, chassis and system data and uses this information to dynamically control the operating fuel mode of the engine. The ECU

The EVO-MT bi-fuel conversion systems from GFS Corp. are designed for Komatsu's 830AC, 830DC and 930E as well as Caterpillar's 777B, 777C, 793B and 793C haul truck models. The company's newest model, the EVO-MT 7930, is designed for Caterpillar's 793D mine haul truck.



also provides sophisticated engine protection and monitoring functionality with pre-alarm, alarm and shut-down logic that enables the engine to be switched from LNG and diesel mode to diesel-only operation seamlessly and automatically, GFS said.

These protective systems and control algorithms are designed to ensure continued engine reliability and uptime when operating on LNG. The ECU monitors critical engine parameters, including exhaust gas temperature, manifold air temperature, knock, engine coolant temperature, engine speed and manifold air pressure, Hackney said. Each ECU data channel is sampled 50 times per second (50 Hz), ensuring rapid detection and correction of anomalies, according to the company.

In the EVO-MT system, engine coolant passes through a heat exchanger to convert the LNG from a liquid to gaseous state. That vaporized gas then runs through a gas train where the pressure is controlled, Hackney said. The gas then goes through a series of low-pressure hoses to air/gas mixers installed just ahead of the

turbochargers. These mixers incorporate fast-acting throttle bodies that are controlled by the ECU.

"There's no modification to the engine itself," Hackney said. "We do install the air/gas mixers ahead of the turbos, but that's just in the air intake."

The harsh conditions common to mining applications were a key challenge in developing a robust product, he said.

"If you haven't been around the mining environment, it would shock you the duty cycle those trucks go through," Hackney said. "Any equipment installed on these trucks must be able to withstand a harsh, high G-load environment."

GFS sizes the LNG fuel storage for any given truck model assuming a 50% substitution rate with a typical refueling schedule of every 12 hours, Hackney said. The system is designed to substitute LNG for diesel fuel at a rate up to between 60 and 70%, depending on the engine load at any given moment. The weighted average substitution rate over the total duty cycle of the truck will vary depending on several factors, including — but not limited to — engine

age and maintenance condition and duty cycle of the truck, he said.

The user interface is designed to enable quick and simple access to both real time and logged system data using a proprietary, password-protected, graphical user interface (GUI) program. The GUI program is PC-compatible, and technical personnel can access system data using a USB interface located in the operator cab. In addition, the GUI program is utilized during haul truck setup and commissioning to create or load fuel-mapping algorithms and to program various system control, pre-alarm and alarm set points, the company said.

Plug-and-play wiring harnesses are intended to simplify installation of the EVO-MT 7930 system. GFS pre-assembles and tests all components as a system at the company's factory prior to shipping for installation on site, Hackney said, and an installation usually takes about two days per vehicle.

"As big as these trucks are, our biggest challenge is finding adequate space for the LNG fuel storage," he said. According to Hackney, the LNG

on the Cat 793D is stored in three tanks that are contained in a fuel storage module located on the truck's upper deck. That module also contains the system's gas train and vaporizer. The system draws from all three tanks at the same time, he said. They are filled through a remote fill port mounted on the side of the diesel tank, allowing convenient, simultaneous refueling of both fuels, Hackney said.

If problems develop within the system or if the vehicle runs out of LNG, the engine seamlessly and automatically reverts to using diesel alone. "The driver doesn't even notice — he just keeps going," Hackney said. "Red and green indicator lights mounted on the fuel storage module show the state of the system. A red light would notify maintenance personnel that the system needs service and is not using gas."

The ability to be able to operate on 100% diesel is an important consideration in mines that are often remotely located, Hackney said, as the LNG supply could be interrupted.

Hackney said the price differential between diesel and LNG has dramatically shrunk since 2013 in the United States, but the company doesn't expect that situation to continue long-term. The price differential still remains in other countries around the world, he said.

"When diesel prices are back where they were, there's a great price differential between LNG and diesel on

a Btu-to-Btu basis," Hackney said. "In the mining business, you can offer quite a large fuel savings based on that delta."

As an added benefit, he said that some mining customers look at bi-fuel systems from an emissions improvement point of view, especially diesel particulate release. Currently, GFS doesn't use emissions as a marketing point for its equipment, but Hackney said the benefits are significant, with a typical reduction in greenhouse gases at the tailpipe of approximately 50%.

According to Hackney, when the well-to-wheel numbers are analyzed, the percentage number would be greater. Nitrogen oxide (NO_x) will typically be reduced by approximately 30 to 50%. Diesel particulates will drop between 30 to 50% in direct proportion to the diesel substitution rate — or even slightly more in stationary applications. GFS also sells an integrated diesel oxidation catalyst (DOC) for those customers interested in further improvements in emissions.

"When someone contacts us and are serious about the conversion systems, the first questions we ask are, 'How many trucks do you have? What kind are they? What engines are in them?' and then the key point, 'What's your duty cycle?'" Hackney said. "How long do you spend climbing loaded? How much do you spend running level loaded and level unloaded? How long do you spend going downhill?" From that data, we can have a fairly good

idea of the savings that we can offer."

Larger mines that have the highest fuel burn are the best targets for the bi-fuel system, Hackney said. The cost of the required LNG infrastructure, like on-site fuel storage and dispensing equipment, prohibits smaller operations like quarries from benefiting from the system, he said.

Hackney said GFS currently sells its equipment in North America, with systems installed in the United States and Canada, but distributors recently were named in Chile and Peru. The company believes Australia, Colombia, Mexico, Indonesia and China are potential markets down the road, Hackney said, and the company plans to offer systems for other haul truck models as demand warrants.

GFS also offers its EVO-SP bi-fuel system for stationary applications, such as standby or primary power applications, but the system is particularly designed for oil rigs, fracking pumps and other demanding, dynamic load applications, Hackney said. The GFS EVO-SP system is applicable to all high-speed, four-stroke diesel engines ranging from 150 kW to 3.5 MW.

GFS has also successfully tested its EVO-LT system for locomotives, Hackney said, and the company recently announced the availability of the EVO-LT4400 System for GE 7FDL powered locomotives. **dp**

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