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Alternative FUELS IN TRUCKING

Cummins' Heavy-Duty Propane Engine Receives 1999 EPA CFFV LEV Certification

On December 2, 1997, Cummins Engine Co., Inc. of Columbus, Indiana, announced that its B5.9LPG is the first dedicated heavy-duty propane gas engine to receive certification to the 1999 Environ-mental Protection Agency (EPA) Clean Fuel Fleet Vehicle (CFFV) Low Emissions Vehicle (LEV) standard. This spark-ignited power plant features advanced electronic engine management, closed-loop air/fuel ratio control, lean-burn technology and integrated subsystems. The technology and subsystem are common with the current Cummins B5.9G, C8.3G and L10G natural gas engines.

The B5.9LPG is the first dedicated heavy-duty propane engine available for bus and truck markets. The engine is rated at 195-horsepower and 420 lb-ft peak torque. Its lean-burn technology gives a thermal efficiency that is much higher than propane stoichiometric gasoline engine conversions. Production began in September at the Rocky Mount, North Carolina manufacturing plant where the B5.9 and C8.3 diesel and natural gas engines are also built.

Like the Cummins B5.9 natural gas engine, the propane version is based on the heavy-duty B5.9 diesel platform and designed for high durability at a low cost. The B5.9G natural gas engine has been in production since 1994 and can be purchased through more than 30 vehicle manufacturers. A few critical parts from the B5.9G engine were optimized for operation with HD-5 LPG vehicle fuel.

The Cummins B5.9LPG engine

Cummins has 7 years of experience with spark-ignition, lean-burn engines for bus and truck fleets. The company's alternative engines currently power more than 2,400 vehicles in various fleet applications with operations covering more than 150 million miles in revenue service.

Cummins received support to develop the B5.9LPG engine from various industry stakeholders including the National Renewable Energy Laboratory/Department of Energy, Natural Resources Canada, Propane Vehicle Council, Propane Gas Association of Canada, South Coast Air Quality Management District and Superior Propane, Inc. Further information on the B5.9LPG is available from Cummins by phone at 1-800-343-7357, by e-mail at powermaster@cummins.com, or on the World Wide Web at www.cummins.com.

INSIDE THIS ISSUE

Gasalarm Systems Introduces Series GS2000 Gas Monitor

Gasalarm Systems has introduced a combustible gas monitoring system that can help advance alternative fuel vehicle use in the trucking industry. The SERIES GS2000 monitor is designed to detect methane, propane, and butane fumes in such areas as the fuel tank, engine compartment, and vehicle cab. With the new system, the trucking industry can safeguard operators while increasing productivity, improving customer service, and conforming to the recommended practices set up by the Society of Automotive Engineers (SAE) in J2343, *Recommended Practices for LNG Powered Heavy Duty Trucks*.

Article 4.9 of SAEJ2343 recommends that trucks have a warning system for potentially dangerous gas fumes in the cab and in the engine compartment. The SERIES GS2000 monitoring system is designed to detect these fumes. The system controller features three alarm settings and a separate diagnostic for detecting faults in the system itself. Because the controller SERIES GS2000 is small (approximately 4 in. long, 1 in. high and 2.5 in. wide), it fits easily into the dashboard. It consumes very little power, and does not require frequent calibration or maintenance. The sensor(s) for the SERIES GS2000 can be mounted in the engine compartment, fuel tank space, or cab, and has mud/splash guards. Each sensor has a miniature 2-20 milli-amp transmitter with a life expectancy of 1 to 2 years in continuous operation.

The system's separate alarms activate at varying levels of gas fumes. At standard factory settings, an alarm goes off if fumes exceed 15% of LEL, causing the yellow A1 LED to light up and the buzzer to beep slowly. Beyond a 30% LEL, the amber A2 LED illuminates and the buzzer beeps slightly faster. After the LEL exceeds 45%, the red A3 LED lights up and the buzzer beeps very quickly. The alarm controller has an auxiliary relay that also can be used to energize beacons or external horns. The relay activates if the LEL exceeds 45%. Users can adjust the alarm systems from 0% to 100% LEL.

For more information on Gasalarm Systems' SERIES GS2000, call Gasalarm Systems Company, Inc. at (281) 364-1988, fax them at (281) 364-1987, or e-mail them at gasalarm@compuserve.com.

Lessons Learned from the Ontario, California, LCNG Station

One major challenge that must be overcome before building an alternative-fuel storage and dispensing station is surmounting all the administrative and legal hurdles. Experience in the city of Ontario, California, where a liquefied and compressed natural gas (LCNG) station was recently built illustrates the importance of meeting these challenges in the planning phase. The building contractors for the site encountered unexpected administrative problems with city officials that caused many delays. They learned that erecting an LCNG fueling station takes very careful planning, not just in design and construction, but in understanding and adhering to regional and local code regulations.

Foremost, all the necessary permits must be obtained and every detail considered before construction can begin. To illustrate, in mid-April of 1997, the city of Ontario approved the foundation plans for the LCNG tank pad. However, the city withheld an operating permit for the liquefied natural gas (LNG) tank and dispenser because more detailed design drawings were necessary. In addition, the drawings had to be signed by a licensed California engineer. After the contractor provided the needed information, there was an additional administrative processing delay, causing the completion date for the station to be pushed back.

The station's compressed natural gas (CNG) dispensers were installed in October. However, coordination difficulties arose with the electrical inspectors which caused delays in obtaining operating approval for CNG service. The engineers working on the LNG service of the station also experienced delays caused by a late shipment of the nitrogen needed to test the pressure and electricity. Once the nitrogen was delivered, the vessel pressure tested well, but one unit experienced electrical problems. Solving these problems caused additional delays that, in turn, caused postponing of scheduled training for the station operators.

Clearly, getting an LCNG station constructed and running is no simple task. Contractors have many legal obstacles to overcome before an LCNG station is operational. They must understand all aspects of the permitting process and obtain all the necessary permits before construction begins. Time should be included in construction planning to allow orderly permitting to occur. A good plan should also include time allotted for the unexpected, such as material delivery delays and debugging of systems. Building in the flexibility to be able to manage the unexpected is a vital component of the planning process.

Warren Gretz\PIX02488

Refueling a compressed natural gas Dodge Caravan SE.

EPA Finalizes Heavy-Duty Diesel Engine Emissions

On October 21, 1997, the U.S. Environmental Protection Agency (EPA) issued new emissions standards for heavy-duty diesel engines. They will take effect in Model Year (MY) 2004. The EPA emphasized further reductions in oxides of nitrogen (NOx), which are key components in tropospheric ozone (smog) formation. On a national level, roughly 50% of NOx emissions come from mobile sources, and the EPA wants to cut these emissions from heavy-duty vehicles.

The new EPA emissions standards cover engines used in urban buses and in highway trucks weighing more than 8,500 pounds and represent a 50% reduction in NOx levels below the standards in force today. These new standards do not apply to off-road vehicles, marine vehicles, or locomotives. Under the new rules, all engines certified during and after MY 2004 must meet either (1) a combined non-methane hydrocarbon (NMHC) plus NOx standard of 2.4 grams per brake-horsepower hour (g/bhp-hr) or (2) a combined NMHC plus NOx standard of 2.5 g/bhp-hr with no more than 0.5 g/bhp-hr of NMHC emissions. The current rules governing particulate matter will remain the same (0.1g/bhp-hr for trucks and 0.05g/bhp-hr for buses). The EPA expects that the diesel engine manufacturers can meet these standards. However, the agency has established backup regulations that can be set up if engine manufacturers have problems adapting to the new standards.

Besides establishing new rules on highway diesel engine emissions, the EPA also modified the averaging, banking, and trading (ABT) programs; clarified responsibilities of parties rebuilding or repowering engines; and adopted new in-use emissions control provisions.

The ABT program modifications are meant to add flexibility and encourage engine manufacturers to make cleaner burning engines before 2004. New trading procedures would eliminate current credit discounting and life limits. Manufacturers can also generate credit for natural gas engines to offset diesel engine emissions.

Although the EPA issued these new regulations for highway diesel engine emissions, they are holding off on issuing new standards for highway Otto-cycle (spark-ignited) engines, most of which use gasoline. The agency is currently reviewing proposals and looking for better technology that could further control emissions from heavy-duty gasoline engine's.

For a summary of EPA emissions standards contact Jennifer Barker, U.S. EPA, Office of Mobile Sources, 2565 Plymouth Road, Ann Arbor, MI, 48105, (313) 668-4510 or visit the World Wide Web site http://www.epa.gov/OMSWWW/nonroad.htm

Heavy-Duty Highway

	Year	CO (g/bhp-hr)	Idle CO (percent exhaust gas flow)
Federal	1990	15.5	0.5*
	1991-93	15.5	0.5*
	1994-97	15.5	0.5*
	1998+	15.5	0.5*
Proposed federal	2004+	15.5	0.5*
European Union	10/96	3.0	
	10/98		
California	1987-90*	15.5	0.5*
	1991-93*	15.5	0.5*
	1994+*	15.5	0.5*
	1994-95*	15.5	0.5*
	1996+*	15.5	0.5*

*This refers to a note concerning this entry. For

Standards

Engines—CI and Urban Buses

HC (g/bhp-hr)	NMHC + NOX (g/bhp-hr)	NOx (g/bhp-hr)	PM (g/bhp-hr)	Smoke* (percentage)	Useful Life	Warranty Period
.3*		6.0 (NCP)	0.60 (NCP)	20/15/50	1990-97+ for HC, CO, and PM: LHDDE: 8years/110,000 miles HHDDE: 8 years/185,000 miles HHDDE: 8 years/290,000 miles 1994+ urban buses for PM only: 10 years/290,000 miles 1998+ for NOx: LHDDE: 10years/110,000 miles HHDDE: 10 years/185,000 miles HHDDE: 10 years/290,000 miles	5years/1000,000 miles (but not less than the basic mechanical warranty for the engine family)
1.3		5.0 (ABT, NCP)	0.25 (ABT, NCP), 0.10*	20/15/50		
1.3		5.0 (ABT, NCP)	0.10 (ABT, NCP), 0.07*, 0.05*	20/15/50		
1.3		4.0 (ABT, NCP)	0.10 (ABT, NCP), 0.05*	20/15/50		
	2.4 or 2.5 with a limit of 0.5 on NMHC (ABT)		0.10 (ABT, NCP), 0.05*	20/15/50	LHDDE: 10years/110,000 miles HHDDE: 10 years/185,000 miles HHDDE and urban buses: 435,000 miles, 13,000 hours, or 10 years (but not less than 290,000 miles)	5years/1000,000 miles (but not less than the basic mechanical warranty for the engine family)
0.8		5.2	0.19 0.11*	42/2.26* 100/1.459* 200/1.065*		
1.3/1.2*		6.0	0.60	20/150/50	LHDDE: 8 years/110,000 miles HHDDE: 8 years/185,000 miles HHDDE: 8 years/290,000 miles	5 years/1000,000 miles. or 3.000 hours (for 1994 and earlier engines greater than 8,500 lbs and for 1995+engines greater than 14,000 lbs)
1.3/1.2*		5.0	0.25*/0.10*			
1.3/1.2*		5.0	0.10			
1.3/1.2*		5.0 (0.5-3.5*)	0.07*			
1.3/1.2*		4.0 (0.5-2.5*)	0.05			

the full text of this chart please see the EPA's *Emissions Standards Reference Guide for Heavy-Duty and Nonroad Engines.*

The Cryenco TADOPTR Program

For any alternative fuel to succeed in today's market, it must be economically competitive with its fossil fuel counterpart. With heavy-duty vehicles, the standard fossil fuel is diesel. The only competitively priced, alternative fuel in today's heavy-duty market is natural gas (LNG). Liquefying rather than compressing the natural gas allows more fuel to be stored on a truck.

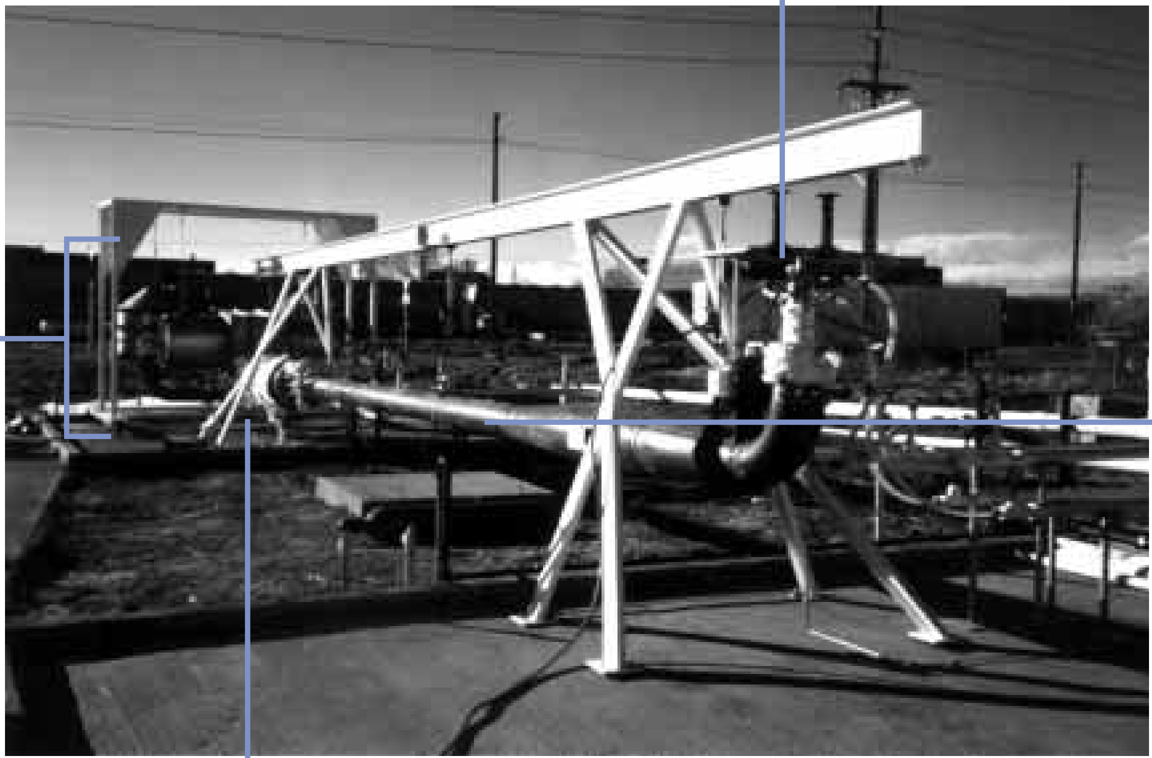
From an operator's point of view, however, the fuel price is only one component of the total cost of using the fuel. Let us use liquefied natural gas (LNG) as an example. LNG is a cryogenic liquid and is stored at about -270°F. As it warms, it begins to boil. This means that if the fuel is not used quickly, some of it may be lost through "boil off." This potential fuel loss increases the cost of LNG and reduces its economic competitiveness.

One solution to the problem is to install a device that could reliquefy boil-off gas. Although the technology to liquefy gases is not new, most systems must convert massive quantities of gas to be cost effective. Using existing technology to liquefy very small amounts of gas is too expensive. Now, technology is emerging which promises to solve the problem.

In 1994, Cryenco obtained the rights to develop a new cryogenic refrigeration technology called thermoacoustically driven orifice pulse tube refrigeration, or TADOPTR. The unique process refrigerates, and thus liquefies, industrial and natural gases for a variety of purposes, including fueling trucks with LNG and compressed natural gas (CNG). The technology is well suited for small liquefaction capacities of roughly 500 to 10,000 gallons per day (GPD).

In 1989, scientists from the Los Alamos National Laboratory (LANL) and the National Institute of Standards and Technology (NIST) first demonstrated TADOPTR. That demonstration was the joining of two separate, but synergistic technologies—the thermoacoustic driver (TAD) and orifice pulse tube refrigeration (OPTR)—neither of which uses any moving parts. LANL patented the TADOPTR system, and in 1993, Cryenco entered a licensing agreement with LANL to further develop the technology for liquefaction of gases.

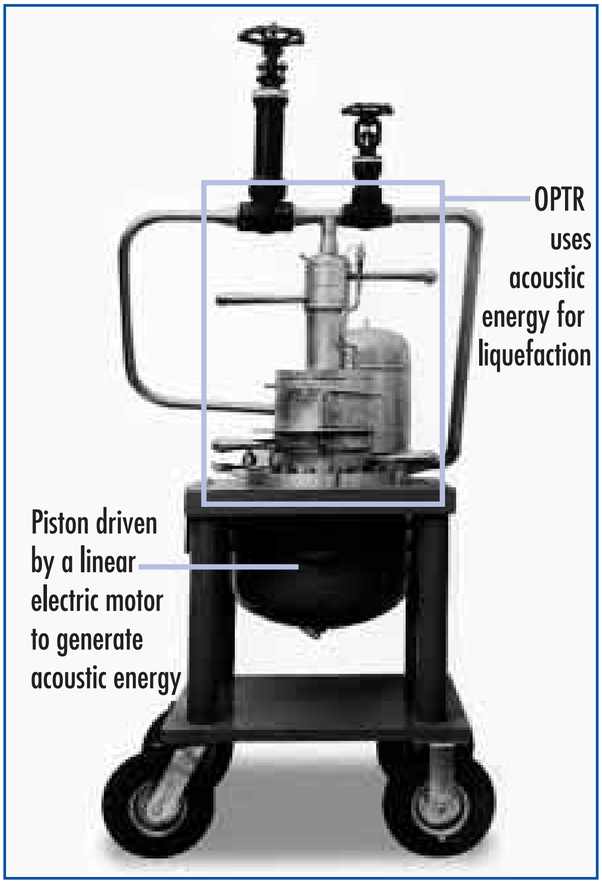
This TADOPTR prototype system currently liquefies about 150 gallons of LNG per day.



Cryenco has divided the TADOPTR project into two phases. Phase I involves developing a system with a liquefaction capacity of approximately 500 GPD. Phase II involves developing a system with a capacity of 5,000-10,000 GPD. Both systems will be designed to fit on a standard, flat bed truck.

The TADOPTR system consists of three major components. The first is its power source, a natural gas burner. Next is the TAD, which is a converter that changes the thermal input power to acoustic power, like a pressure oscillation. The third component is the OPTR, another convertor that changes the acoustic power into heat removal, or thermal extraction power. One end of the TADOPTR is heated to ≥400°F, while the other end gets cooled to ≤240°F. The working gas, typically helium, is the only thing that moves within the system. Creating a large temperature difference across a short section of a pipe filled with a working gas causes the gas to go into spontaneous pressure oscillations. By using the continuous input of heat from a burner to maintain the required temperature difference, the oscillations are sustained.

The OPTR operates on a modified Stirling refrigeration cycle, but the cold displacer in a Stirling system is replaced by a gas column (or pulse tube), an orifice (or opening), and a reservoir. These are all static components that cycle the working gas between a cold, heat-extracting heat exchanger when the TAD cools and expands the working gas, and a warm, heat-rejecting heat exchanger when the TAD compresses and heats the working gas. In this way, the OPTR pumps thermal energy from a cold reservoir to a warm reservoir.



A linear motor driven OPTR

The three components of a TADOPTR each have a characteristic dimension. The OPTR is a 500-GPD unit that has dimensions of only a few feet. The burner is about 5-10 feet long. The TAD is roughly 40 feet long and a couple of feet wide. As the photo above illustrates, the OPTR is the front vertical section, the TAD is the long tube in the middle, and the natural gas burner is at the back. The unit pictured is designed to produce about 100 GPD of LNG.

Cryenco raised private venture capital funds to support the initiation of Phase I of the TADOPTR project and invested considerable internal funds in support of the program. In May 1995, Cryenco received a federal contract from the U.S. Advanced Research Program Agency, most of which also was directed toward supporting Phase I of the project. The U.S. Department of Energy provides funding to LANL to pursue fundamental research on thermal acoustics in parallel with Cryenco's commercialization efforts.

Cryenco is currently investigating several potential markets for the TADOPTR. The potential uses include natural gas liquefaction at remote gas and oil wells, natural gas liquefaction at offshore oil wells, natural or industrial boil-off gas reliquefaction at large scale storage facilities, and others. Each of these markets has its own unique criteria and operating conditions that should be addressed.

For the natural gas liquefaction applications in particular, an attractive feature of the technology is that it uses natural gas as a power source. However, Cryenco has expanded its program to include smaller scale, OPTR-based, refrigeration and liquefaction systems that use an electrical power source. The electrical systems, orifice pulse tube refrigeration liquefiers (LOPTRs), will have liquefaction capabilities from roughly 10 to 500 GPD, although there are no technical limits on going to larger sizes. The LOPTR systems are expected to address markets which require cryogenic liquids.

Cryenco's evolving technology holds great promise for solving the LNG boil-off problem. Work is underway to set up a field experiment to determine if the promise will become a reality.

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The aim of **Alternative Fuels in Trucking** is to inform fleet owners and operators, equipment suppliers, government officials, and other interested parties about important developments in the use of alternative fuels in heavy-duty trucks. Suggestions and comments are welcome and may be directed to the National Alternative Fuels Hotline at 800-423-1DOE. Views expressed by guest authors are their own, and not those of ATAF, DOE, or NREL.

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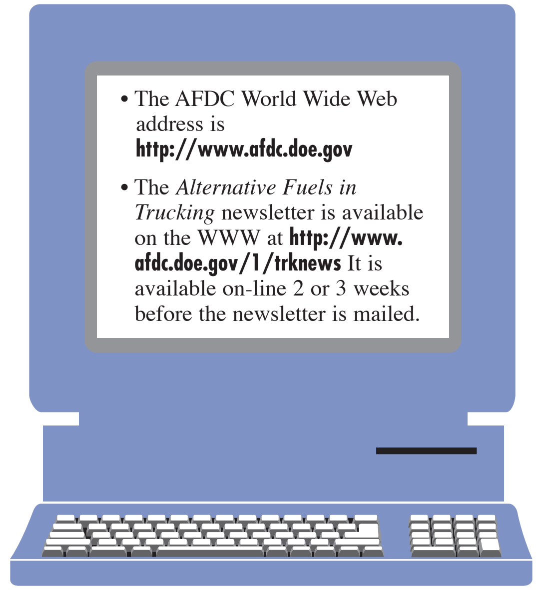

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