

The Power of Propane

By Brian Feehan

Propane Vehicle Council

With more than 500,000 propane-powered forklifts currently operating in the US, the propane industry maintains 80 percent of the spark-ignition forklift market. In terms of industry impact, the forklift market represents 15 percent of total propane consumption. The Propane Vehicle Council (PVC) is committed to this significant market segment.

The PVC serves as the catalyst for the investigation, examination and resolution to barriers prohibiting the development of the propane forklift market. The PVC will keep fuel composition and air quality issues at the forefront of the propane industry's agenda and will develop specific related projects to meet the needs of the propane forklift industry.

The propane-powered forklift market has grown over the years mainly because of the inherent beneficial characteristics of propane that make it an excellent fuel for industrial trucks. This is proven through both lower economic costs as well as the performance capabilities of propane such as lower initial investment, lower operating costs, consistent power, lift load capacity, superior speed and low greenhouse gas emissions.

In addition to these important performance and environmental benefits, the propane industry and marketers deliver superior customer service. Users should view their propane supplier as a resource to consult with. For example, many propane suppliers offer computerized emissions services to help assess air/fuel mixtures and address equipment efficiency. A propane supplier can also provide resources to keep users up to date on emissions requirements and safety information.

In addition to meeting the forklift segments needs today, we are also looking to the future, which features an ever more stringent regulatory environment in which we all must operate. Some of the critical issues under investigation and examination by the propane industry include

propane fuel quality, air quality and fuel systems technologies. Several research and development projects are currently underway with future projects planned. The propane industry is devoting a substantial amount of resources to ensure propane remains the fuel of choice for the industrial truck market segment. The following is an overview of five current and planned projects for 2003:

1. Fuel Systems Technology Project

At the beginning of the year, the Propane Education & Research Council (the Council) announced the award of a \$1.39 million research grant to the Southwest Research Institute (SwRI) to study propane fuel system technologies and their ability to meet Environmental Protection Agency (EPA) 2007 standards for large spark-ignited (LSI) non-road engines.

New regulations published by the EPA in November 2002 are scheduled to take effect in 2004. In 2007, the regulations will require transient cycle testing for certification and compliance with significantly lower emissions limits. The research grant will investigate three propane engine fuel system technologies to evaluate their ability to meet EPA 2007 standards, with a comprehensive analysis of the effects of propane fuel composition on emissions and engine performance.

The research effort has several objectives:

- Investigate closed-loop carburetion, central fuel injection and port fuel injection technologies and evaluate their ability to meet EPA 2007 LSI engine standards;
- Explore the effects of LPG fuel quality variation on emissions deterioration to establish fuel composition needed to ensure adequate engine and emissions performance in lift truck applications with respect to the EPA 5,000-hour durability requirement;
- Investigate the effect of LPG sulfur levels on forklift catalyst performance;
- Investigate the effectiveness of fuel additives on fuel

system durability and emissions deterioration; and

- Investigate the effectiveness of filters and/or oil separators.

2. Forklift Emissions Data Research

The industrial truck industry has been plagued by misleading and often conflicting reports on the relative emissions of various fuels. In addition, data from outdated emissions studies continue to be disseminated. The result in the marketplace is confusion. The propane industry will soon release a comprehensive literature review that attempts to clarify the issue by offering a review of the key data from emissions studies performed to date.

3. Maintenance Training Program

This multi-phase project is designed to develop and institute a "best practices" propane education program for forklift technicians and end users in proper fuel system maintenance. This "train the trainer" program is slated to become a part of an industry effort to maximize both the emissions and economic benefits of propane as a fuel source for forklift applications. The effort will include:

- A compilation of training materials (i.e., literature, manuals, emissions analyzers) for use in "train-the-trainer" education courses, providing attendees with the information they need to return to their company and educate their co-workers in propane maintenance and safety procedures
- A phase I program participation goal of reaching propane forklift operations in six targeted US cities through local propane distributors

The Forklift Technician Maintenance & Training Program is described in more depth in the sidebar above.

4. Fuel Composition Research

With an understanding of the urgency surrounding the fuel quality issue in light of new 2004 and 2007 indoor emissions standards, the propane industry plans to reinstate a fuel quality research project designed to investigate and define the relationship between propane fuel quality and exhaust emissions issues. The Propane Education & Research Council (PERC) Fuel Quality Task Force is scheduled to lead the project, with the key objectives of the project being as follows:

- Identify propane fuel quality issues requiring immediate investigation
- Establish a research & development process for examining key issues
- Prioritize research needs and set a course of action through fuel quality research project work

5. Forklift Technology Assessment

This project was designed to determine propane industry research and development needs to support the forklift industry's future certification and emissions standards requirements. Data gathering approaches for the project include:

- Identify and quantify today's forklift industry, recent developments in the industry and the forklift market based on product sales and major suppliers
- A literature review of information related to propane use and forklift products
- An evaluation of engines, fuel systems, emission control requirements and refueling practices
- A survey of forklift manufacturer representatives, forklift dealers, fuel system suppliers and emissions control system suppliers

These projects demonstrate both the propane industry's commitment to the forklift market and its proactive effort to ensure that propane continues to be one of the cleanest and most cost-effective fuels for forklifts. As we move forward with the development of these and other projects, we know that it is important to communicate with the forklift industry directly. I am pleased to report that in addition to our renewed industry focus, we are also building and strengthening our relationship with the Industrial Truck Association (ITA).

The US propane industry is witnessing a transition and restructuring of industry organizations representing the multiple markets served by the propane industry. The journey to a well represented, customer driven and unified industry is well underway. The creation of the Propane Education and Research Council (PERC), the relocation of the National Propane Gas Association (NPGA) to Washington, DC and the reorganization of the Propane Vehicle Council (PVC) complete the transition of three organizations working together to represent the interests of the US and North American propane industry. Our goal is to ensure that the propane industry continues to satisfy and exceed your expectations.

Brian Feehan has recently returned to the US after spending the past several years in France as the Projects Director for the World LP Gas Association and is now serving as the Executive Director of the Propane Vehicle Council (PVC). As Projects Director for the WLPGA, he developed marketing tools and implemented strategies promoting the use of LP Gas worldwide. In addition, Mr. Feehan worked to develop the Global Autogas Industry Network (GAIN), the worldwide network within the WLPGA that promotes the use of propane as a motor fuel. He holds a Masters Degree in Public Administration and a BA in Political Science from George Mason University.

Forklift Emission Study:

Propane Delivers Highest Total Energy Efficiency When Compared to Other Engine Fuel Production Life Cycles

The Propane Education and Research Council (PERC) recently released a review of forklift emission studies that compares the emissions data of propane to compressed natural gas (CNG) or gasoline. The review, *Industrial Truck Emission Data Compared by Fuel*, finds that propane delivers the highest energy efficiencies when compared to other fuel production life cycles. It also shows that propane forklifts, when fitted with approved closed loop controls and exhaust catalysts, result in very low emissions that meet and exceed California Air Resource Board Large Spark Ignition (CARB LSI) standards.

“Eighty percent of class 4 and 5 internal combustion forklifts are fueled by propane,” said Roy Willis, PERC president. “Yet the forklift market is plagued by reports that are misleading or contain conflicting data on the rela-

tive emissions benefits of various fuels. We believe this review sets the record straight; when forklift emissions data is compared accurately, propane delivers the highest efficiencies and remains one of the cleanest fuels available for industrial lift trucks.”

Conducted by two independent alternative fuel vehicle (AFV) experts, the review, “Industrial Truck Emission Data Compared by Fuel,” examined research findings from seven forklift emissions studies performed between 1990 and 2002. “Testing conditions are an integral part of research studies,” said William McGlinchey, one of the review’s authors. “Our review has found that previous research studies often did not use the same fuel delivery system and engine, elements that are crucial for accurate comparative studies.”

The authors examined two studies that used Life Cycle Analysis (LCA) emissions models to assess the emissions impact of “upstream” production of a given fuel, and found that propane delivers the highest total energy efficiency relative to other fuels. Regardless of the source of production, petroleum or natural gas, propane delivers the highest overall total efficiency rating, 89.3 percent, as compared to compressed natural gas (87.2 percent), conventional gasoline (81.6 percent), reformulated gasoline (82.6 percent), conventional diesel (85.6 percent) or reformulated diesel (83.6 percent).

The LCA emissions model, developed by Argonne National Laboratory, provides estimates rather than specific emissions quantities. However, in the absence of specific emissions quantities, these estimates are the best available indicators of total emissions contributions for fuel production. The model estimates upstream and total fuel cycle energy consumption, greenhouse gases and emissions for both short-and long-term scenarios. The

**Engine B OPTIMIZED LPG
 Results (g/kW-h)**

Description	HC	NOx	HC+NOx	CO
Baseline	1.3	15.7	16.9	9.9
Closed-Loop/ OEM catalyst	0.5	0.5	0.7	4.0
Closed-loop with new calibration	0.3	0.7	1.0	7.9
Closed-loop with larger catalyst	0.3	0	0.3	5.5

This table illustrates emission test results that are the product of currently accepted lift truck engine technology. The authors of the study concluded that, “Low emission results, meeting CARB LSI standards, could be obtained (on LPG) with a properly operating control system.”

model describes upstream emissions as the emissions emanating from pre-consumer fuel processing from feedstock to the gas station dispenser.

Propane Produces Low Tailpipe Emissions

The review finds that when propane is compared accurately to CNG or gasoline, differences in industrial truck tailpipe emissions are negligible. In addition, the review revealed that:

- The most recent substantive comparison of gasoline and propane, a 2002 study conducted by Southwest Research Institute on behalf of CARB, found that emissions results meeting CARB LSI standards for large spark ignited industrial trucks could be obtained using propane and a properly operating control system and exhaust catalyst.
- Forklift manufacturers and fuel systems technologies manufacturers that have met current CARB LSI requirements, including Ford Power Products, IMPCO, Jasper, MCFA, Mitsubishi, NACCO, Nissan and Toyota, all used propane fuel systems for the certification. Two manufacturers also certified gasoline engines, but none of these manufacturers chose to certify CNG fuel systems in 2001 or 2002.
- Zenith Fuels Systems, Inc., a manufacturer of fuel delivery systems for industrial engine applications, conducted tests using the same fuel system and engine to compare tailpipe emissions. The test found that propane was capable of producing emissions well below CARB regulations.

Maintenance is Key To Performance

The review emphasizes the role that regular maintenance plays in fuel control system performance and emissions reduction. “Our next step is to support the training

FUEL	FUEL-CYCLE STAGE	ENERGY EFF. (%)	TOTAL EFF. (%)^a
Crude Oil	Recovery	98.0 (1)	-----
	Transportation and storage	99.5 (2)	
Conventional Gasoline	Refining	85.0 (3)	81.6
	Transportation, storage and distribution	98.5 (4)	
Reformulated Gasoline	Refining	86.0 (3)	82.6
	Transportation,	98.5 (4)	
LPG	Refining	93.5(3)	89.3
	Transportation, storage and distribution	97.9(4)	
Conventional Diesel	Refining	89.0(3)	85.6
	Transportation, storage and distribution	98.6(4)	
Reformulated Diesel	Refining	87.0(3)	83.6
	Transportation, storage and distribution	98.6(4)	

^a ([1]*[2]*[3]*[4] = Total Efficiency %)

Upstream fuel cycles: Energy efficiencies of natural-gas-based fuel cycle stages

and maintenance needs of propane-powered forklift operators,” said Willis. “PERC has funded programs to ensure that propane-powered forklift operators receive the support they need to comply with emissions standards and achieve greater return on their investments.”

PERC, in its most extensive research project to date, is working with several forklift manufacturers and a private research institution to build and demonstrate the next generation of clean, low emissions forklifts.



For more information, please contact Brian Feehan, executive director of the Propane Vehicle Council, at (202) 530-0479; or contact the Propane Education & Research Council at (202) 452-8975.

Visit us on-line at

www.propanevehicle.org and www.propanecouncil.org.