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## **ARB LPG Fuel Blends Evaluation Project April 1999 Progress Report**

submitted to:

### **LPG Fuel Blends Evaluation Project Task Group and Co-Sponsors**

*American Automobile Manufacturers Association, ARCO Products Co., California Air Resources Board, Cummins Engine Co., Engine Manufacturers Association, Equilon, Ford Motor Co., GFI, IMPCO, National Propane Gas Association, National Renewable Energy Laboratory, Natural Resources Canada, Propane Education and Research Council, Railroad Commission of Texas Alternative Fuels Research & Education Division, South Coast Air Quality Management District, Tosco Refining Co., and Western Propane Gas Association*

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### **I. Executive Summary**

Medium and Light-duty emissions tests were completed in 1998. Southwest Research Institute's (SwRI) Final Report for Performance/Combustion tests was sent to the Task Group. Preparations continued for Durability tests at Bodycote ORTECH (ORTECH). Project fundraising and management continued.

### **II. Test Program Work Performed**

#### **A. Fuel Properties and Octane Tests**

The fuel composition test results from Maxxam Analytics Inc. (Maxxam) on the initial blends of LPG fuel for Durability tests are in Table 1 (see attached results). These tests were conducted to verify fuel blending expectations and to develop a reliable, local fuel composition analysis lab. For a number of reasons (i.e. cost, time, redundancy) it is desirable to have a gas chromatograph capability next to the laboratory where the fuels are under test.

A blend composition test from Dixie Services Inc. (Dixie) for Durability fuel was also ordered. Throughout the project ADEPT has used Dixie's analytical services for fuel composition determination. ADEPT has found Dixie's services to be reliable.

Other fuel composition test data for Emissions and Performance/Combustion tests can be accessed in prior monthly reports at ARB's website:

<http://www.arb.ca.gov/altfuels/lpg/mvlpge/mvlpge.htm>

**Table 1: Maxxam's Fuel Composition Results of Durability Fuel Blends**

Sample I.D.	Components	Date
		Results (mole %)
<b>HD-5/n-Butane Dosage</b>		April 26, 1999
	Methane	0.18
	Ethane and Ethylene	4.68
	Propane	93.71
	Propylene	0.00
	i-Butane	0.60
	n-Butane	0.83
<b>HD-5/n-Butane Dosage</b>		April 26, 1999
	Methane	0.21
	Ethane and Ethylene	4.52
	Propane	93.93
	Propylene	0.00
	i-Butane	0.56
	n-Butane	0.78
<b>HD-5/n-Butane/Propylene Dosage</b>		April 30, 1999
	Methane	0.29
	Ethane and Ethylene	4.49
	Propane	85.26
	Propylene	8.76
	i-Butane	0.48
	n-Butane	0.72

***B. Medium-Duty Engine (Cummins B5.9LPG) Emissions Tests at Bodycote ORTECH.***

Tests were completed in August 1998. Final Report was submitted on November 18, 1998. Prior monthly reports and the Final Report can be accessed on ARB's website: <http://www.arb.ca.gov/altfuels/lpg/mvlpge/mvlpge.htm>.

***C. Light-Duty Truck (F150 Bi-Fuel) Emissions Tests at ARB Haagen Smit Laboratory.***

Tests ended in September 1998. ARB's final report was requested.

***D. Performance/Combustion Tests at Southwest Research Institute.***

Tests were completed in January in 1999. The Final Report was sent to Task Group.

Test program protocol and previous reports can be accessed at ARB's website: <http://www.arb.ca.gov/altfuels/lpg/mvlpge/mvlpge.htm>.

***E. Durability Tests at Bodycote ORTECH.***

The Project Agreement with ORTECH was signed.

After exploring the possibility to use the Performance/Combustion tests engine, it was decided to use the existing Medium-Duty Emissions engine already at ORTECH. The decision was heavily based on budget constraints.

Air Liquide declined to provide the LPG fuel for Durability tests. ADEPT decided that it would manage fuel purchasing, mixing, testing, and delivery to ORTECH. This procedural change will delay the start of the Durability tests program.

Accordingly, Mr. Jared Meyer, ADEPT Project Engineer, traveled to Mississauga, Ontario, CANADA on April 19, 1999. He managed the fuel procurement, mixing, testing, and delivery process until April 30, 1999. The companies involved in this blending process were:

- Primemax Energy Inc.
  - Subcontractor Kinetic Resources Inc. (see attached production specifications)
- NOVA Chemicals [CANADA], Ltd. (see attached production specifications)
- Maxxam Analytics Inc. (fuel composition analysis)
- Dixie Services Inc. (fuel composition analysis)

Cummins chose not to provide the HD-5 baseline wear tolerances for the B5.9 LPG engine.

To compensate for the absence of Cummins data, the Hertz Engineering contract was approved and signed for the tribological oil analysis work (see attached protocol). This analysis will: (1) act as a safety measure against catastrophic engine failure; (2) properly document durability test progress; and (3) be a reliable scientific backup to complement the anticipated Cummins review.

The below durability test cycle was chosen:

- Engine runs at 60% rated power, for the 10-hour run-in period;
- Engine stabilization period at 60% rated power for 25 hours;
- Engine runs at 100% rated power for the remainder of the test period;
- Engine is to run idle during final 15 minutes of the hour prior to sampling/measuring.

This cycle closely complies with the cycle suggested by Cummins.

ORTECH estimated a Durability test timeline (see attached).

### III. Project Management Support and Administrative Work Performed

#### A. Project Fundraising

California Energy Commission (CEC) funds are still being solicited and subject to CEC Committee approval. On April 27, 1999, the Texas State Energy Office and Texas Alternative Fuels Committee (TAFC) informed ADEPT that the TAFC Grant continues to be suspended under the moratorium with no change anticipated until late May/early June 1999. The TAFC budget is under negotiation in the Appropriations Committee of the Texas legislature. There is a possibility that this grant may be deleted during this process.

#### B. Project Expenditures

Table 2 shows April expenditures and total expenditures to date.<sup>1</sup>

**Table 2: April Expenditures and Total Expenditures to Date**

Item	Funds Expended In April	Funds Expended to Date
Fuel (Air Liquide, Phillips)	\$2,685.23	\$26,422.22
Emissions Tests (ORTECH)	\$0.00	\$176,351.07 <sup>2</sup>
Perf./Comb. Tests (SwRI)	\$3,275.81	\$81,895.51
Fuel Properties (Dixie)	\$0.00	\$12,107.25
Engine	\$0.00	\$17,063.47
Raw Durability Tests (ORECH, Hertz)	\$15,000.00	\$15,000.00
Project Management	\$1,589.75	\$56,518.36
Attorney Fees	\$0.00	\$2,250.00
Subcontractor	\$0.00	\$2,273.29
Miscellaneous	\$0.00	\$687.66
<b>Total</b>	<b>\$22,550.79</b>	<b>\$390,568.83</b>

Project Account Balance at month's end: **\$46,214.39**

Table 3 shows total funds received to date, by respective funder.

<sup>1</sup> All outlays above \$1,000 are pre-approved by the LPG Task Group and/or the TAC.

<sup>2</sup> Total includes \$23,422.55 (CAN\$35,931.02), paid directly to ORTECH by PGAC.

**Table 3: Total Funds Received to Date**

<b>Funder</b>	<b>Amount</b>
ARB (ULTRAMAR)	\$85,000.00
ARCO	\$45,000.00
EMA	\$1,000.00
NPGA	\$8,920.00
NRCan	\$119,500.95 <sup>3</sup>
PERC	\$25,000.00 <sup>4</sup>
SCAQMD	\$82,876.64
Shell/Equilon	\$36,000.00
Tosco	\$22,500.00
WPGA	\$10,800.00
<b>Total</b>	<b>\$436,597.59</b>

Table 4 summarizes the in-kind services received to date, by respective funder.

**Table 4: In-Kind Services Received to Date**

<b>Funder</b>	<b>Item</b>	<b>Estimated Value</b>
ARB	ARB-El Monte Light-Duty Emissions Tests	\$90,000
Cummins	Test Support	\$8,000
Ford	Vehicle and Test Support	\$23,500
NREL	Cummins B5.9LPG Engine	\$15,000
<b>TOTAL</b>		<b>\$136,500</b>

**C. Project Contracts and Other Documents**

1. The final October and November 1998 Progress Reports were submitted to Task Group.
2. The U.S. Department of Justice approved ARCO's antitrust filing on behalf of the project.
3. Durability Tests Project Agreement was signed.
4. Hertz Engineering Contract was signed.
5. October and November monthly reports were distributed.

**Travel associated with effort described:**

April 19 – May 1, 1999: ADEPT travel to Mississauga, Ontario, CANADA, for Durability tests fuel preparation.

<sup>3</sup> Total of three payments: one at US\$61,356.48 (conversion ratio of 0.6817), one at US\$34,721.92 (conversion ratio of 0.6518), and one at US\$23,422.55 (conversion ratio of 0.6519). Please note that this figure was incorrectly reported in prior monthly reports due to an ADEPT accounting error.

<sup>4</sup> The total PERC award was for \$30,000. Five thousand was directly allotted to PVC for their costs associated with the project.

#### **IV. Work planned for the next reporting period (May 1 - 31, 1999)**

##### **Project Management-ADEPT**

1. Continue general project management.
2. Prepare and complete funding contracts for co-sponsors.
3. Continue fundraising.
4. Continue Durability tests.

##### **Test Program**

1. ARB-El Monte will finalize results and submit a draft Final Report.
2. ORTECH will continue durability tests.

#### **V. Attachments:**

- Hertz Engineering Oil Analysis protocol.
- Kinetic Resources production specifications for typical propane and n-butane.
- Maxxam Analytics blend composition results.
- NOVA Chemicals production specifications for typical propylene.
- ORTECH's Durability tests timeline.

#### **VI. Disclaimer**

This report was prepared by ADEPT as result of work co-sponsored by the SCAQMD and Task Group members. Opinions, findings, conclusions, and recommendations within are those of the author and do not necessarily represent SCAQMD's views. SCAQMD, their officers, employees, contractors, and subcontractors make no warranty, expressed or implied, and assumes no legal liability for the information in this report. SCAQMD has not approved or disapproved this report, nor have they passed upon the accuracy or adequacy of the information contained herein.

## VII. Glossary of Acronyms

AFRED	Alternative Fuels Research and Education Division
ARB	California Air Resources Board
ARB-El Monte	ARB Haagen Smit Laboratory in El Monte, CA
CEC	California Energy Commission
Dixie	Dixie Services Inc.
EMA	Engine Manufacturers Association
HD5	Certification Fuel
Hertz	Hertz Engineering
LPG	liquefied petroleum gases
Maxxam	Maxxam Analytics Inc.
NPGA	National Propane Gas Association
NRCan	Natural Resources Canada
NREL	National Renewable Energy Laboratory
ORTECH	Bodycote ORTECH
PERC	Propane Education and Research Council
PVC	Propane Vehicle Council
SCAQMD	South Coast Air Quality Management District
SwRI	Southwest Research Institute
TAFC	Texas Alternative Fuels Commission
Tosco	Tosco Refining Company
WPGA	Western Propane Gas Association