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## **ARB LPG Fuel Blends Evaluation Project May 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. Performance/Combustion tests were completed in January 1999 at Southwest Research Institute (SwRI). Bodycote ORTECH (ORTECH) took initial engine measurements for Durability tests. Project fundraising and management continued.

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

#### **A. Fuel Composition Tests**

ADEPT received the fuel blend composition test results from Maxxam Analytics Inc. (Maxxam) and Dixie Services Inc. (Dixie) on the same LPG blend for Durability tests (attached). There were variances that greatly impacted the type and amount of components to be added for the final blend. Further tests were performed by Dixie and Maxxam to determine the correct composition (see Table 1). The average of Dixie's results was used to decide the final blending step [required venting part of the 14,000 USWG trailer and adding specific amounts of n-butane and propylene (attached)].

**Table 1: Maxxam Blend Composition Analysis (Durability Test Fuel)**

Sample I.D.	Component/s	Lab - Date	Lab - Date	Difference
Origin		Results (volume %)	Results (volume %)	(vol. %)
# 10121		Maxxam - 4/30/99	Maxxam - 5/18/99	
Maxxam	Methane	0.21	0.09	0.12
	Ethane and Ethylene	4.47	4.56	0.09
	Propane	85.28	85.72	0.44
	Propylene	8.61	7.89	0.72
	i-Butane	0.59	0.73	0.14
	n-Butane	0.85	1.02	0.17
# 051791		Dixie - 5/12/99	Maxxam - 5/18/99	
Dixie	Methane	0.11	0.12	0.01
	Ethane and Ethylene	4.59	4.63	0.04
	Propane	86.06	85.60	0.46
	Propylene	7.69	7.72	0.03
	i-Butane	0.70	0.86	0.16
	n-Butane	0.85	1.07	0.22
# 061291		Dixie - 5/19/99	Maxxam - 5/18/99	
Primemax	Methane	0.07	0.07	0.00
	Ethane and Ethylene	4.22	4.02	0.20
	Propane	86.07	85.80	0.27
	Propylene	8.02	8.19	0.17
	i-Butane	0.71	0.86	0.15
	n-Butane	0.91	1.11	0.20

Other fuel composition data from the 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>

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

Tests were completed in January in 1999. The Final Report was sent to the Task Group. No written comments were received date.

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 engine was shipped to Cummins Ontario, Inc. for disassembly and cleaning. Initial engine measurements were taken (attached).

On May 12, 1999, Dr. Barry Hertz of Hertz Engineering (Hertz), conducted oil sampling training at ORTECH. An oil sampling schedule outlining the 510 hours of Durability tests is attached. A data table for recording oil sampling was provided (attached).

Hertz submitted analysis data on the new oil sample of Mobil Delvac Super GEO 15W-40 motor oil used in the test engine (attached). Analysis verified that the oil is clean of wear metals and falls within the specification range quoted in the Engine Manufacturers Association (EMA) Lubricating Oils Data Book (attached).

With more fuel composition results from Maxxam and Dixie, discrepancies were resolved. Propylene and n-butane were added to prepare the final Durability tests blend.

**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. The Texas Alternative Fuels Committee (TAFC) budget is under negotiation in the Appropriations Committee of the Texas legislature. ADEPT has been advised by AFRED that this grant may be at risk during this process.

Tosco signed the project MOU covering the joint research conducted by the Task Group.

**B. Project Expenditures**

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

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

Item	Funds Expended In May	Funds Expended to Date
Fuel (Air Liquide, Phillips)	\$185.23	\$26,576.01
Emissions Tests (ORTECH)	\$0.00	\$176,351.07 <sup>2</sup>
Perf./Comb. Tests (SwRI)	\$1,899.46	\$83,794.97
Fuel Properties (Dixie)	\$335.00	\$12,288.46
Engine	\$0.00	\$17,063.47
Raw Durability Tests (ORECH, Hertz)	\$4,000.00	\$19,000.00
Project Management	\$20,730.54	\$77,391.20
Attorney Fees	\$0.00	\$2,250.00
Subcontractor	\$1,611.00	\$3,934.29
Miscellaneous	\$0.00	\$697.75
<b>Total</b>	<b>\$28,761.23</b>	<b>\$419,347.22</b>

Project Account Balance at month's end: **\$17,250.37**

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

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

Funder	Amount
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>

<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.

<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). This figure was incorrectly reported in prior monthly reports due to an ADEPT accounting error.

<sup>4</sup> Total PERC award was \$30,000. \$5,000 was allotted to PVC for its project costs.

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 December 1998 and January 1999 Progress Reports were distributed to Task Group.
2. Tosco's MOU was signed.

**Travel associated with effort described:**

No travel was conducted in May.

**IV. Work planned for the next reporting period (June 1-30, 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:**

1. Maxxam fuel blend composition results;
2. Dixie fuel blend composition results;
3. Calculation worksheet for mixing LPG blends;
4. Engine Parts Measurement Record Worksheet;
5. Oil Sampling Schedule;
6. Hertz Engineering Oil Sampling Log;
7. Inductively Coupled Plasma (ICP) Spectrometry and physical characteristics results for engine motor oil from Fluid Life Corporation;
8. EMA Lubricating Oils Data Book Specification.

**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

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## 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
EMA	Engine Manufacturers Association
Hertz	Hertz Engineering Inc.
LPG	liquefied petroleum gases
Maxxam	Maxxam Analytics Inc.
MOU	Memorandum of Understanding
NPGA	National Propane Gas Association
NRCan	Natural Resources Canada
NREL	National Renewable Energy Laboratory
ORTECH	Bodycote ORTECH
PGAC	Propane Gas Association of Canada
PERC	Propane Education and Research Council
PVC	Propane Vehicle Council
SCAQMD	South Coast Air Quality Management District
SwRI	Southwest Research Institute
TAC	Technical Assessment Committee
TAFC	Texas Alternative Fuels Commission
USWG	U.S. water gallons
WPGA	Western Propane Gas Association