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Alternative Fuels Utilization Program Project Office Operating Plan For FY 1985–86

R. L. Graves
R. N. McGill

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ALTERNATIVE FUELS UTILIZATION PROGRAM PROJECT OFFICE OPERATING PLAN FOR FY 1985-86

R. L. Graves
R. N. McGill

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NOTICE: This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

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ALTERNATIVE FUELS UTILIZATION PROGRAM PROJECT OFFICE OPERATING PLAN FOR FY 1985-86

R. L. Graves
R. N. McGill

ABSTRACT

Oak Ridge National Laboratory (ORNL) was assigned the responsibility of being field project office for the DOE Alternative Fuels Utilization Program AFUP in April 1984. This document is the first operating plan developed by ORNL for AFUP and reflects the general program philosophy and goals as described in the DOE Headquarters AFUP program plan. Current efforts in AFUP are largely focused on three fuel areas; new hydrocarbon fuels, synthetic fuels, and alcohol fuels. All projects either underway or planned for the near future are described in this report.

1. INTRODUCTION

1.1 Purpose of this Document

This plan has been developed to document the specific projects, both those underway and those planned for the near future, in the DOE Alternative Fuels Utilization Program (AFUP) for which Oak Ridge National Laboratory (ORNL) serves as the field project office. Whereas a DOE headquarters plan* describes the AFUP goals, overall technical direction, and philosophy, the ORNL Plan deals on a more detailed level with the specific projects underway, procurement plans, contracting and contract monitoring procedures, and in-house work at ORNL. Included in this document are descriptions of AFUP, in brief, and of the technical activities, project management plan, and project funding. This project plan covers activities through FY 1986, with some efforts having been initiated in FY 1984 or earlier.

*Project Planning Document, Transportation Alternative Fuels Utilization Program (AFUP), 1985 Update, DOE Office of Transportation Systems, January 1985.

1.2 AFUP Goals, Purpose, Scope

Dependence on imported petroleum remains a significant threat to the nation's well-being. It is true that petroleum consumption in the United States decreased for a period from 1978 through 1983 but consumption is now increasing and has reached the same level as in 1975, a time when the "oil crisis" was fresh in mind. It is further true that imported petroleum now comes to the United States from more politically stable regions of the world, but international treaties would still make the United States susceptible to disruptions in the middle east. Furthermore, the imported petroleum costs the United States about $150 million per day, enough to buy Exxon, one of the largest companies in the world, in about one year. When coupled with the recognition that proven domestic petroleum reserves have dropped by 30% since 1973, despite a doubling of exploratory drilling, the facts bear out that the oil problem, though temporarily dormant, is still with us. The **primary goal of AFUP** is to assure the availability of technology for, and eliminate barriers to, the use of viable alternative transportation fuel options, so industry can fill temporary and long-term gaps between petroleum supply and demand and reduce the nation's dependence on petroleum imports by using abundant indigenous resources.

The development of processing technologies for production of non-petroleum-derived fuels is certainly important in alleviating dependence on imports but indeed deficiencies in utilization technologies have stymied the adoption of alternative fuels as much as have the technical shortcomings in process technologies. For instance, most current transportation engines require a liquid hydrocarbon fuel with at least 11-12% hydrogen by weight. Hence a great void exists between fuel requirements and abundant resources such as coal, a solid with 4-5% hydrogen.

Attempts to cross this void have typically placed the technical burden on the process technologies and have resulted in fuels that are perceived to be marginally economically viable for the most part. AFUP activities strive to determine if some of the burden could be shifted to the utilization side. As a further example, technical deficiencies on the utilization side have inhibited blanket substitution of methanol for

gasoline due to a number of reasons such as the inability of engines to compensate for minor changes in fuel properties and materials incompatibility. Hence R&D under AFUP is considered to be nationally significant with potentially large payoff.

AFUP currently addresses six classes of fuels: (1) New hydrocarbon fuels, (2) synthetic gasoline and distillate fuel, (3) alcohol fuels, (4) advanced fuels, (5) emergency fuels, and (6) methane and related gaseous fuels. Detailed definitions of these classes are provided in Section 3. Work on advanced fuels (hydrogen) and emergency fuels (including heating oils, residual oils, vegetable oils) is essentially complete to the degree warranted by overall factors, leaving the existing emphasis on the remaining classes.

AFUP activities are problem-oriented and deal with topics such as engine wear due to alcohol fuel use and excessive soot emissions from highly aromatic synthetic diesel fuels. The scope of AFUP work covers alternative fuel distribution, utilization, and emissions, with the focus on utilization. However, the scope of interest, concern, and coordination covers the entire spectrum of topics in alternative fuels from resource through the effects (e.g., environmental) of their use.

In accordance with administration guidelines, AFUP utilizes a decentralized project management. The Project Management is the responsibility of ORNL. In this role, ORNL carries out the detailed planning of R&D projects, procures the projects through subcontracts, manages those efforts, and conducts in-house R&D as well. ORNL serves as an extension of headquarters in many respects and, as such, works very closely with headquarters staff.

2. AFUP ORGANIZATION

2.1 DOE Headquarters

The AFUP is conducted by the Heat Engine Propulsion Division of the Office of Transportation Systems (OTS), Office of Conservation and Renewable Energy. The program manager at Headquarters is E. Eugene Ecklund. This organization is shown in Figure 1.

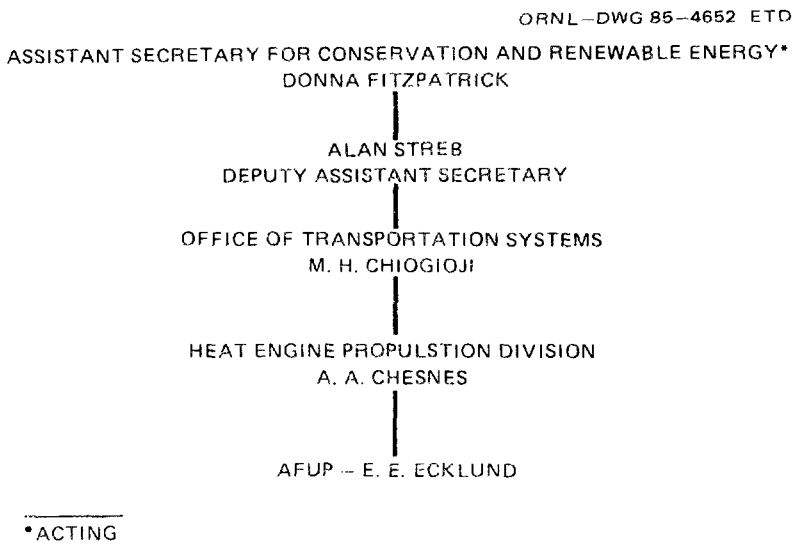


Fig. 1. Organization of AFUP within DOE (as proposed, May 1985).

2.2 DOE Headquarters/Oak Ridge Operations (ORO)/ORNL

The communication channels between Headquarters, ORO, and ORNL is shown in Fig. 2.

The formal program direction and budget guidance are provided to ORO by OTS through program guidance letters. The ORO is responsible for managing the prime contract, currently with Martin Marietta Energy Systems, Inc., for the operation of ORNL. Day-to-day interactions principally involve OTS staff and project management at ORNL. Also, at the request of OTS, ORNL maintains an informal, technical liaison with DOE subcontractors as well as the official channels to ORNL's own subcontractors.

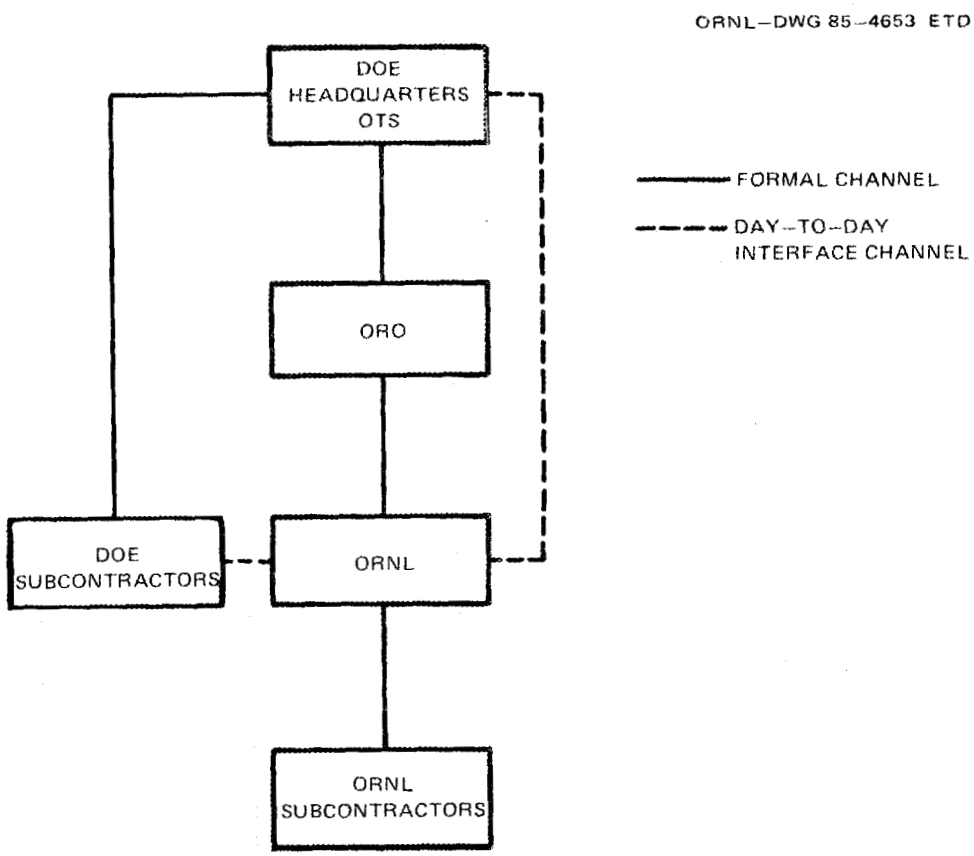


Fig. 2. Channels of Communication for DOE Headquarters, ORO, ORNL.

3. TECHNICAL PLAN

Activities are classified according to the type of fuel under consideration. The six classes of fuels are shown in Table 1 with their definitions.

The types of efforts in these areas include assessments and system studies but the majority of R&D projects are experimental in nature. Fig. 3, adapted from the AFUP program plan, depicts the matrix of activities in the AFUP projects.

Table 1. AFUP activity areas, classified by fuel type

Fuel class	Description
(1) New hydrocarbon fuels	Non-petroleum hydrocarbon fuels which, though perhaps similar to conventional fuels do not meet current fuel specifications.
(2) Synthetic gasoline or distillate fuel	Non-petroleum gasoline or diesel fuel which essentially meet current fuel specifications.
(3) Alcohol fuels	Oxygenated fuels, in general, not limited to ethanol or methanol.
(4) Advanced Fuels	Fuels highly dissimilar to conventional fuels such as hydrogen and carbon slurry fuels.
(5) Emergency Fuels	Finished fuels and various liquid hydrocarbons which might be blended and utilized in an emergency fuel shortage where conventional fuels have become scarce.
(6) Methane and related gaseous fuels	Includes natural gas and liquefied petroleum gas (LPG), that can be substituted for conventional automotive fuels.

ORNL–DWG 85–4655 ETD

FLOW OF WORK EFFORT →

ACTIVITY AREA \ WORK PHASE	PROBLEM DEFINITION	PROBLEM SOLVING	SELECTION & VERIFICATION	PILOT–SCALE PROGRAMS	LARGE–SCALE ADAPTATION
PROCESS TECHNOLOGY ASSESSMENT	DOE FOSSIL AND RENEWABLE ENERGY PROGRAMS AND INDUSTRY LIAISON				
FUEL PROPERTIES & COMPOSITION		SPECIFICATION DEVELOPMENT			
ENGINE–VEHICLE CHARACTERIZATION					
SYSTEMS STUDIES	SOCIOECONOMIC – ENVIRONMENTAL – LEGAL – INSTITUTIONAL FACTORS				

Fig. 3. Matrix of AFUP Activities per DOE Headquarters Project Planning Document.

The following sections discuss the currently perceived R&D needs in each fuel classification and the individual projects, both current and planned.

3.1 New Hydrocarbon Fuels

The long-term objective in this classification is to identify the optimum combination of resource/processing/engine technology in terms of efficiency, environmental acceptability, and marketability. The objective strives to reduce the void between the requirements for fuels usable in modern engines and the characteristics of fuels that can be economically produced from domestic resources. The work breakdown structure (WBS) to achieve the objective is shown in Fig. 4. Most aspects of the WBS are underway with some contracted efforts addressing more than one topic and, in other cases, more than one contract or grant dealing with a single topic.

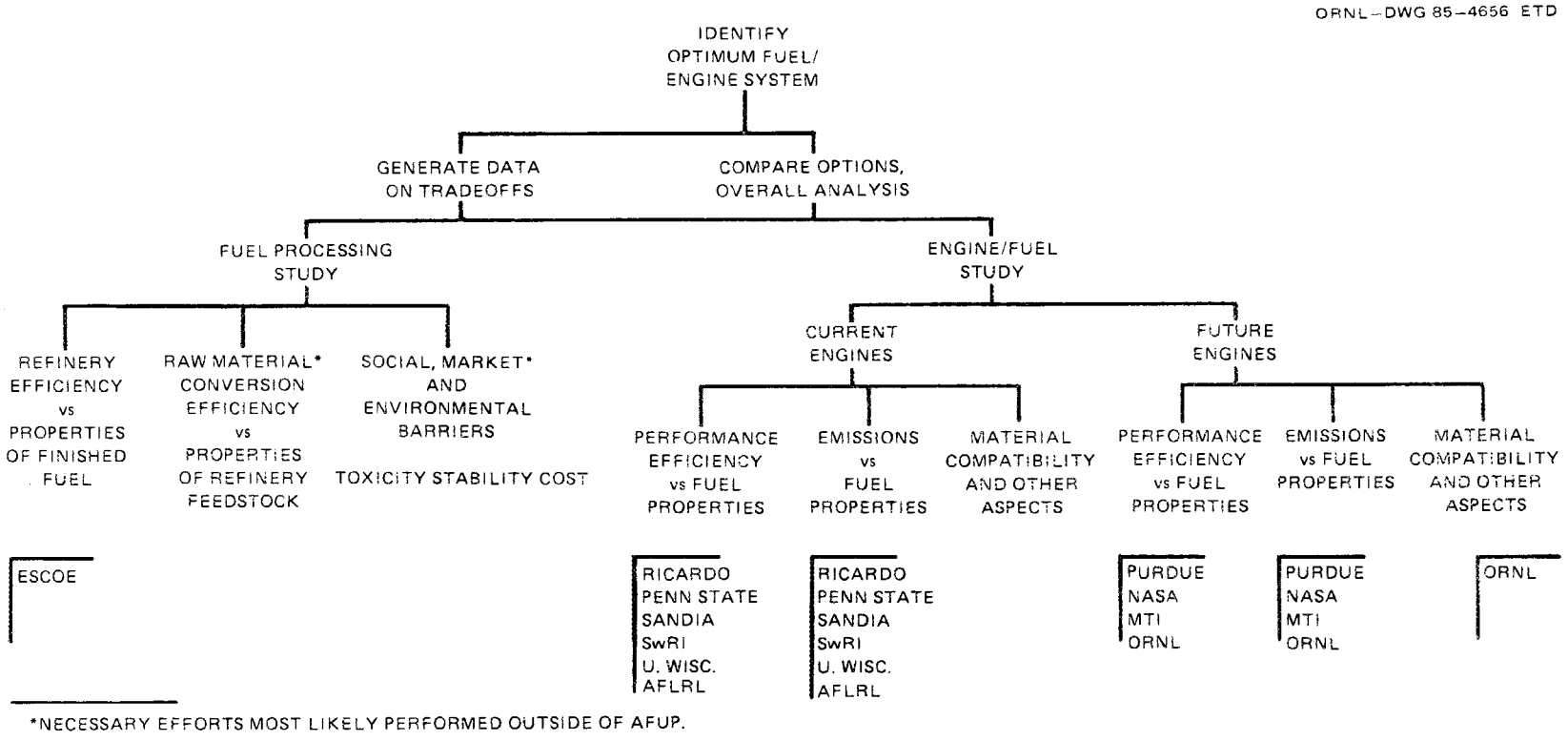


Fig. 4. Work Breakdown Structure for Major Objectives in New Hydrocarbon fuels.

The energy that could be saved in processing syncrudes by relaxing fuel specifications is being addressed by ESCOE. A limited number of syncrudes are being addressed, so additional work will be necessary to determine whether variations in the basic coal liquefaction or shale retorting process could have a significant effect on the overall processing efficiency. Data for this latter activity is expected to be available from non-AFUP projects.

Since new hydrocarbon fuels represent significant departures from conventional fuels, impact studies and engine tolerance evaluations for conventional and advanced engines must be made to determine the overall tradeoff between processing efficiency and end-use efficiency. The large amount of fuel/engine experiments is indicative of a generic technical shortcoming in that

(1) There is no single fuel property characterization that is a reliable indicator of engine performance and emissions

which is the case largely because

(2) There is no apparent reliable correlation between fuel properties, as currently determined, and engine performance and emissions.

Hence, considerable effort is directed to the above. The existing projects are of generic interest in that crude oils coming to U.S. refineries are gradually changing in quality, typically getting worse. For distillate fuels in particular, engines that are more tolerant of low cetane and high aromatic content could conceivably extend the supply of petroleum.

Projects underway or planned for a FY 1985 start are described as follows.

TITLE: **Investigation of Alternative Fuel Rating Techniques**

Contractor: Ricardo Consulting Engineers
Contracting Organization: DOE Headquarters
Contract Amount:
Contract Period: Extended to end 4/30/85
Principal Investigator: J. R. Needham

OBJECTIVE:

To conduct testing of various fuels in DI and IDI engines in order to identify an improved fuel rating technique for predicting combustion behavior of alternative diesel fuels.

PROJECT DESCRIPTION:

Detailed in-cylinder data on the combustion of a wide range of petroleum and non-petroleum fuels in modern indirect injection (IDI) and direct injection (DI) diesel combustion systems is to be developed. Analysis of the data to identify the measurable combustion parameters which best relate fuel chemical and physical characteristics to engine performance, knock, emissions, and starting characteristics.

ACCOMPLISHMENTS:

Thirteen test fuels have been evaluated in both DI and IDI diesel engines. Selected fuels were subjected to cold-chamber engine experiments also. Two types of techniques have been used to determine the start of combustion in these engines.

PLANNED ACTIVITIES:

Data will be analyzed to try to correlate fuel parameters with the performance, emissions, and combustion characteristics of the engine. Final reporting is to be completed by April 30, 1985. A peer review for the project is scheduled for late June 1985.

TITLE: **Synthetic Fuels Center**

Contractor: Southwest Research Institute (SwRI)
Contracting Organization: DOE Headquarters (to be procured by ORNL, 9/85)
Contract Amount: $250,000 per year
Contract Period: to end 9/85, to be renewed and incrementally funded annually.
Principal Investigator: N. R. Sefer

OBJECTIVE:

Store, process, and provide inspection data and analysis of experimental test fuels from oil shale and coal syncrudes for the purpose of providing synfuels for engine test projects within DOE, DOD, and industry.

PROJECT DESCRIPTION:

A continuing problem in AFUP has been the lack of test fuels for utilization research. As such, a pilot-scale hydroprocessor has been constructed to convert synthetic feedstocks to finished test fuels of desired properties. The hydroprocessor, by changing catalysts, can hydrocrack, desulfurize, or reform at a rate of one gallon per hour. A distillation unit also resides with the facility. SwRI provides analysis of test fuels used in most AFUP projects under this contract and provides storage for fuels and feedstocks.

ACCOMPLISHMENTS:

The hydroprocessor construction was largely completed in June 1984 and was brought into operation in January 1985. Analyses for approximately 20 test fuels have been conducted in conjunction with a number of other tasks in AFUP.

PLANNED ACTIVITIES:

The use of the hydroprocessor is planned for FY-85 and into FY-86 for processing fuels for other AFUP projects. Two gasolines of different octane numbers are to be processed from a shale oil naphtha. A turbine fuel is to be processed from a stock of EDS middle distillate. Two gasolines are to be produced from a feedstock of SRC II (coal liquid) naphtha. A coal-derived, low-quality diesel fuel is to be produced by caustic wash of an EDS middle distillate. When conditions permit, fuels will be made for industry and private researchers on a reimbursible basis.

TITLE: **Utilization of Alternative Fuels in Diesel Engines**

Contractor: Pennsylvania State University
Contracting Organization: DOE Headquarters
Contract Amount: $79,000 per year (grant)
Contract Period: 2/84 to 1/31/87
Principal Investigator: S. S. Lestz

OBJECTIVE:

To provide fundamental data on the performance and emissions (including bioassay on particulates) from using candidate fuels from oil shale, coal, and tar sands in conventional diesel engines. Also, to investigate effects of fueling diesel engines with methane and propane via fumigation.

PROJECT DESCRIPTION:

Effects of methane fumigation in a conventional V-6 diesel engine are being investigated. Prior work has shown that introduction of methane in small quantities into an engine combustion system produces some unusual effects. Combustion characteristic of tar sands- and shale-derived fuels are to be conducted in a single-cylinder direct-injection diesel engine.

ACCOMPLISHMENTS:

A method for measuring unburned methane emission has been fabricated. Baseline tests of diesel fuel in the V-6 have been completed. The installation of the single-cylinder diesel engine has been completed.

PLANNED ACTIVITIES:

Experiments with methane fumigation in the V-6 diesel are starting as of January 1985. The first fuel to be evaluated in the single-cylinder engine will be the Canadian hypothetical 1990 diesels fuel which is a blend of tar sand- and petroleum-derived products. A progress report will be given at the joint U.S./Canadian AFUP meeting in June 1985.

TITLE: **Effects of Fuel Composition on Ignition Delay in Homogeneous Charge and Direct Injection Compression Ignition Engines**

Contractor: U. Wisconsin
Contracting Organization: Martin Marietta Energy Systems
Contract Amount: $75,000
Contract Period: 9/15/84-9/14/85
Principal Investigator: Gary Borman
David E. Foster

OBJECTIVE:

To investigate effects of fuel composition on ignition delay and autoignition in both stratified charge (direct injection diesel) and homogeneous charge engines, both in a compression ignition mode of operation.

PROJECT DESCRIPTION:

The research activity consists of two separate, but related projects. In the first project, specially blended fuels are to be run in a single cylinder open chamber diesel engine to determine the relationship between fuel volatility, cetane requirement and exhaust particulates. A two-color pyrometer instrument is to be used as a diagnostic aid. In the second project, prevaporized fuel, air and exhaust products are mixed and ignited by compression in a CFR engine. Results from these tests for pure fuels and binary mixtures of pure fuels are then to be compared to chemical kinetic calculations. Absorption spectroscopy will be used as a diagnostic aid to help understand the differences between theory and experiment. Some real fuels will also be tested to obtain ignition delay data.

ACCOMPLISHMENTS:

A test fuel matrix for the DI engine study has been identified and the fuels are being prepared at the SwRI synfuels center. A test engine is being modified. The homogeneous charge engine has been run on seven pure fuels and three binary mixtures to get data on the conditions for autoignition to occur. Calculations using kinetic data have been started for comparison with the data.

PLANNED ACTIVITIES:

Early tests in the DI engine will be performed with No. 2 diesel fuel blended with n-octane until entire test fuel matrix is prepared. The new test engine should be ready in the near future. Next phase of the homogeneous charge study will include additional comparisons between theory and experiment and the absorption spectroscopy measurements.

TITLE: **Engine Testing for Synfuel Operation**

Contractor: Southwest Research Institute with Deere & Company, Inc.
Contracting Organization: Martin Marietta Energy Systems
Contract Amount: $237,000
Contract Period: 1/31/85 to 6/30/86
Principal Investigator: Shannon Vinyard

OBJECTIVE:

To determine whether practical modifications, from a manufacturers viewpoint, can be made to current heavy duty diesel engines to permit operation on synthetic fuels that differ considerably from No. 2 diesel fuel.

PROJECT DESCRIPTION:

A modern heavy-duty diesel engine will be run on a variety of hydrogen-deficient (relative to conventional fuels) shale- and coal-fuels to establish a baseline. The engine manufacturer will review the data and recommend modifications to restore performance and emissions to their original levels. The test engine will be modified and the experiment will be repeated.

ACCOMPLISHMENTS:

None - new project.

TITLE: **Alternative Fuel Variable Effects on Engine Combustion**

Contractor: Universities, to be determined through competitive procurement
Contracting Organization: Martin Marietta Energy Systems
Contract Amount: To be determined
Contract Period: To be determined
Principal Investigator: To be determined

OBJECTIVE:

To determine influence of fuel properties and/or processing history of fuels on their combustion characteristics in transportation engines while also stimulating eduction of new students in alternative fuels technology.

PROJECT DESCRIPTION:

Proposals have been requested and received as of 1/31/85. Specific topics are to be determined. Multiple awards are probable.

ACCOMPLISHMENTS:

None (new project).

TITLE: **Autoignition and Combustion of Fuel Sprays in a Combustion Bomb**

Contractor: Sandia Laboratories (Livermore)
Contracting Organization: DOE Headquarters direct funding
Contract Amount: $150,000
Contract Period: 10/1/84 to 9/30/85
Principal Investigator: T. M. Dyer

OBJECTIVE:

To perform controlled condition experiments with several non-conventional diesel fuels by using a constant volume combustion bomb to determine the parameters that most influence ignition delay, heat release rate, and emissions.

PROJECT DESCRIPTION:

A well-instrumented combustion bomb at Sandia (donated by Volkswagen) is to be used for this project. Initial conditions in the bomb, such as pressure and temperature, will be varied and the ignition characteristics of fuels will be evaluated. Emissions will be measured also. The test fuels are samples from the Ricardo project and are of significantly different composition than usual. The results will permit added analysis of the results of the Ricardo project.

ACCOMPLISHMENTS:

Work in FY1984 showed that when the air charge in the bomb had an initial temperature in excess of about 1000°K, the ignition delay and rate of heat release became essentially independent of fuel composition due to internal bomb configuration and conditions.

PLANNED ACTIVITIES:

Additional experiments will be performed and measurement of emissions conducted. Vegetable oils, which have displayed unusual combustion properties in engines, will be among the next series of test fuels.

TITLE: **Fuels Tests in a Gas Turbine Combustor**

Contractor: NASA, Lewis Research Center
Contracting Organization: DOE Headquarters (Interagency Agreement)
Contract Amount: $310,000
Contract Period: 6/1/85 to 12/31/85
Principal Investigator: J. Rollbuhler

OBJECTIVE:

To evaluate the combustion characteristics such as emissions, radiant heat release and flame stability, for candidate future fuels in a gas turbine combustor operating at the conditions of the AGT engine under development.

PROJECT DESCRIPTION:

A stationary burner rig will be used for these experiments. There will be no rotating parts, blade cascades, or pin specimens for materials studies. Seven fuels will be evaluated including methanol, No. 2 diesel fuel, gasoline, tar sands fuel, and coal liquids. Combustor exit temperatures will range from 1800-2500°F.

ACCOMPLISHMENTS:

None (new project).

TITLE: **Assessment of Fuel/Engine Tradeoffs**

Contractor: ESCOE
Contracting Organization: DOE Headquarters
Contract Amount: $246,000
Contract Term: 6/20/84 to 9/20/85
Principal Investigator: R. L. Thomas

OBJECTIVE:

To assess the tradeoffs between energy use in refining/upgrading of synthetic fuels and the energy use in engines that can be developed to utilize fuels that are processed to a lesser extent than currently done. To determine overall energy savings that would accrue from an engine fuel system combination that is optimized for minimum energy consumption from resource to end use.

PROJECT DESCRIPTION:

A refinery linear programming (LP) model is being used to determine refining efficiency for various product slates that range from conventional fuels to fuels of very relaxed specifications. Feedstocks to the refinery are representative of a petroleum baseline and a coal syncrude from the latest generation Exxon Donor Solvent (EDS) conversion plant. The efficiency of a coal-to-methanol plant serves as a reference point. The fuel tolerance and efficiency of engines are being addressed in a literature review and by a panel of engine experts from industry and universities.

ACCOMPLISHMENTS:

The refinery model runs, subcontracted by ESCOE to Boeing, were completed during December 1984. Other items completed included a review of coal conversion technologies and a study of the compatibility between current refinery unit operations and syncrude properties.

PLANNED ACTIVITIES:

A draft report being written by ESCOE on the subject of engine/fuel matching will be reviewed by the panel of experts with a subsequent review meeting in March 1985. A final report for the entire project is to be completed by September 1985. All technical work is to be finished by June 1985.

TITLE: **Broad-based Fuels Testing in Stirling Engine Combustor**

Contractor: Mechanical Technology, Inc.
Contracting Organization: DOE Headquarters
Contract Amount: $131,845
Contract Term: 3/28/84 to 5/28/85
Principal Investigator: D. Najewicz

OBJECTIVE:

To test several alternative fuels in a Stirling engine combustor rig and evaluate their performance in terms of combustion efficiency, emissions, soot formation, and effects on combustor temperature distribution.

PROJECT DESCRIPTION:

Several different kinds of light fuels are being testing in a Stirling engine combustor test rig to determine their viability as alternative fuels for future Stirling engine applications. Fuels selected for testing are a baseline unleaded gasoline, methanol, ethanol, diesel fuel #2, Naphtha, and a 50-50 mixture of diesel fuel and Naphtha. This project will test the general belief that external-combustion engines are more tolerant of alternate fuels than internal-combustion engines. Judgements of fuels performances will be based on data such as combustion efficiency, temperature profile, exhaust emissions, and burner wall temperature.

ACCOMPLISHMENTS:

Three of the fuels have been completely tested thus far, though the results have not been completely analyzed. Those fuels tested are unleaded gasoline, diesel fuel #2, and the 50-50 Naphtha-diesel fuel mixture.

PLANNED ACTIVITIES:

Complete testing of the final three fuels, analyze and interpret results from all fuels, and complete final reporting of the project.

TITLE: **Fuel Property Effects on Diesel Combustion**

Contractor: Army Fuels and Lubricants Research Laboratory (SwRI)
Contracting Organization: DOE Headquarters by Interagency Agreement, co-funded with Army
Contract Amount: To be determined - new project
Contract Period: to be initiated in FY1985
Principal Investigator: T. W. Ryan

OBJECTIVE:

To separate the effects on diesel engine combustion due to fuel physical properties and chemical properties.

PROJECT DESCRIPTION:

Experiments using a combustion bomb and an experimental diesel engine will be conducted. The research engine has variable compression ratio and variable injection parameters. Several charging mediums, such as air and nitrogen, will be used in the bomb to help determine the effects of their thermodynamic properties on the combustion data. Optical/radiation measurements will be used to determine the start of significant chemical reaction. Fuels used in both bomb and engine experiments will be blended so as to allow study of chemical composition effect and physical property (mainly viscosity) effects.

ACCOMPLISHMENTS:

The construction of the experimental equipment is underway. The combustion bomb is nearly complete and work has been started on the engine. Test fuels are being collected.

TITLE: **Pollutant Formation in Heterogeneous Stratified Mixtures of Fuel Drops in Air**

Contractor: Purdue University
Contracting Organization: DOE Headquarters (grant)
Contract Amount: $68,000 per year
Contract Period: 4/25/84 to 4/24/86
Principal Investigator: Arthur H. Lefebvre

OBJECTIVE:

To investigate the effects of the chemical characteristics of candidate synthetic fuels on combustion in a continuous combustion engine by use of a special combustion rig which simulates either steady-state or pulsed combustion.

PROJECT DESCRIPTION:

A steady flow burner rig will be modified to permit working pressures of up to 15 atmospheres. Air flows for combustion and dilution are separately controlled. Multiple air blast atomizers are used such that drop size can be made consistent for all fuels tested. Three fuels will be tested and emissions will be the principal data recorded. In a second phase of the project, fuel injection in some nozzles will be made intermittent to determine the effects of stratification of fuel/air ratio.

ACCOMPLISHMENTS:

The combustion test rig for high pressure operation has been completed and the emissions measurement system assembled.

PLANNED ACTIVITIES:

Combustion tests to commence around 2/1/85.

TITLE: **Tolerance of Uncooled Diesel and Its Materials of Construction to New Hydrocarbon Fuels**

Contractor: ORNL (in-house project)
Contracting Organization: DOE Headquarters
Contract Amount: $150,000 for FY1985
Contract Period: 2/25/85 to 12/31/86
Principal Investigator: To be determined

OBJECTIVE:

To evaluate the combustion characteristics of conventional and new hydrocarbon fuels in a low-heat-rejection diesel engine to determine effects of insulation on fuel tolerance. Also, to inspect the response of candidate insulation materials to fuels with non-specification properties.

PROJECT DESCRIPTION:

A low-heat-rejection diesel engine, single cylinder with ceramic inserts, will be established as a research tool. The engine will be equipped with a small instrumented material specimen retainer to permit screening tests on candidate materials. The combustion of fuels of variable key properties (aromatic content, end boiling point, etc.) will be evaluated and compared to results with No. 2 diesel fuel. In a companion project, the baseline will be established in a conventional engine. The materials specimen plug will be used to determine if certain fuel properties prove detrimental to the durability and insulating performance of candidate materials.

ACCOMPLISHMENTS:

An existing single-cylinder Deutz diesel is being reconfigured to accept instrumentation and ceramic coupons. This engine will be used to conduct preliminary experiments and verify instrumentation techniques. A larger, custom-designed single cylinder engine (Cummins) that will accept ceramic inserts is being procured. A test cell for this engine is being refurbished to accomodate the necessary instrumentation and controls.

TITLE: **Combustion Properties vs. Toxicity for Progressively Upgraded Coal Liquids**

Contractor: To be determined
Contracting Organization: Martin Marietta Energy Systems
Contract Amount: To be determined
Contract Period: 4/1/85 to 10/31/85 (subject to revision)
Principal Investigator: To be determined

OBJECTIVE:

To determine the combustion characteristics of synfuels that have been systematically upgraded to reduce their toxicity, and thereby determine the compatibility of minimally processed (with regard to toxicity) fuels with current engines and to establish data relating both the reduction of toxicity and the impmrovement in combination quality to the level of processing.

PROJECT DESCRIPTION:

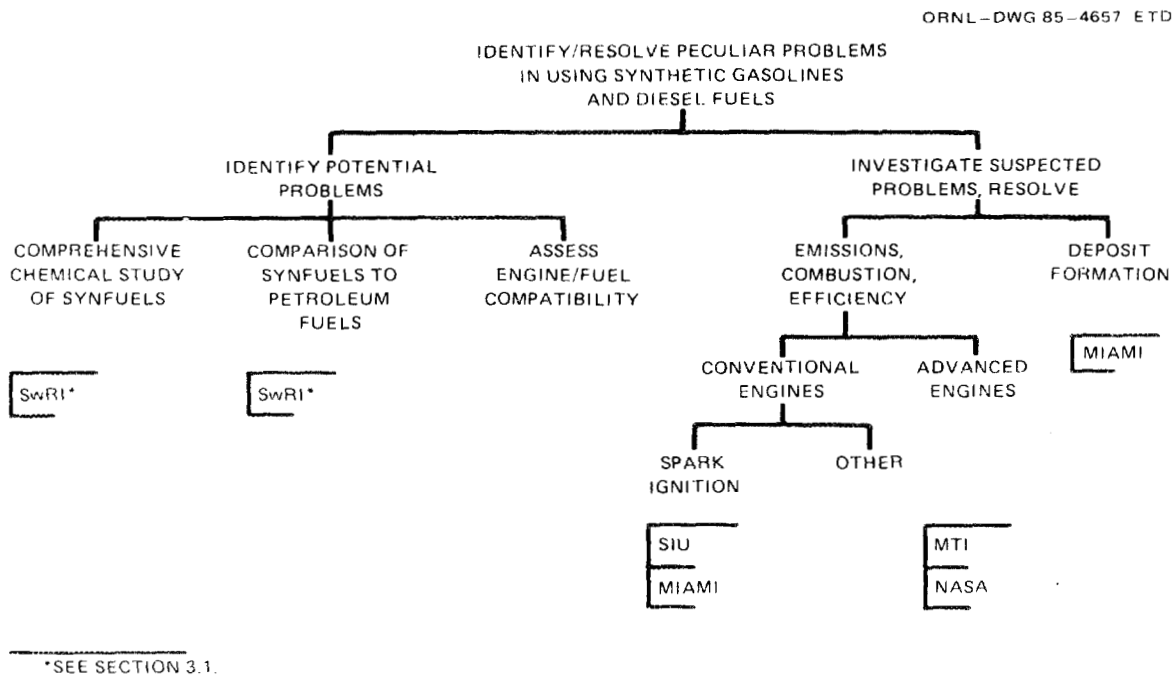
Statement of work for this project not finalized.

ACCOMPLISHMENTS:

None - new project.

3.2 Synthetic Gasoline and Distillate Fuel

The principal objectives of the projects in this classification are to identify, study, and resolve problems of using non-petroleum-derived fuels that essentially meet current fuel specifications. Since fuel specifications can be met by fuels varying widely in chemical makeup, engine experiments are run to uncover fuel-related anomalies that may arise. Such anomalies may include hazardous, non-regulated emissions that historically have not appeared with use of petroleum -derived fuels. The WBS for this classification is shown in Fig. 5, followed by project descriptions.



*SEE SECTION 3.1.

Fig. 5. Work Breakdown Structure for Synthetic Gasolines and Diesel Fuels.

TITLE: **Engine Combustion and Emissions Characteristics of Synthetic Automotive Fuels**

Combustor: Southern Illinois University
Contracting Organization: Martin Marietta Energy Systems
Contract Amount: $63,249
Contract Period: 7/16/84 to 7/15/86
Principal Investigator: Suri Rajan

OBJECTIVE:

To determine how synthetic gasoline combustion characteristics differ in terms of in-cylinder measurements (e.g., flame speed) from petroleum fuels. Emissions to be determined also.

PROJECT DESCRIPTION:

Gasolines from shale- and coal-liquid-naphthas are to be tested in a conventional spark ignition engine. Also a Mobil gasoline manufactured from methanol will be evaluated. Conventional gasoline will be used as baseline fuel.

ACCOMPLISHMENTS:

Instrumentation and data acquisition systems have been set up. New graduate students have been learning to use the test equipment.

PLANNED ACTIVITIES:

The bulk of the project description (above) activities are yet to be conducted. Sufficient data will be generated in time to make presentation at the Contractors Coordination Meeting in November 1985.

TITLE: **Evaluation of Deposits with Synthetic Gasolines**

Contractor: U. Miami
Contracting Organization: DOE Headquarters
Contract Amount: $95,000
Contract Period: 9/1/84 to 12/31/85
Principal Investigator: Mike R. Swain

OBJECTIVE:

To identify problems related to the use of synthetic gasolines in terms of emissions or performance. Particular emphasis is placed on deposit formation and possible increase in octane requirement of the engine.

PROJECT DESCRIPTION:

Shale- and coal-derived gasolines will be evaluated in conventional spark ignition engines and compared to conventional gasolines. Engines will be run on a specific schedule and torn down periodically to inspect deposit formation. Octane requirements for the engine will be evaluated as the tests proceed. Each fuel will be run for 200 hrs. A new engine will be used with each fuel.

ACCOMPLISHMENTS:

A baseline gasoline has been obtained which does not have the anti-deposit additives. Five new gratis GM engines have arrived at the U. Miami and first test engine has been installed.

PLANNED ACTIVITIES:

Bulk of project as described above.

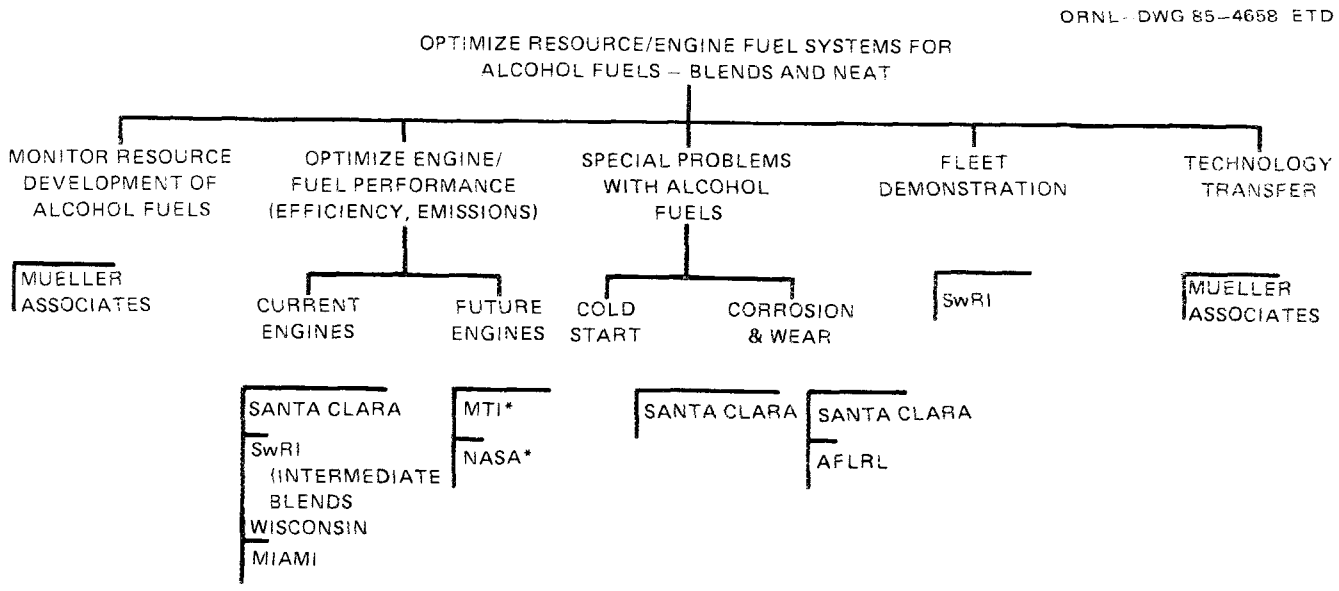
3.3 Alcohol Fuels

Alcohol fuels must necessarily be divided into two subclasses: (1) **extenders** in the form of blends, and (2) **neat** fuels for essentially total substitution. In the AFUP, interest lies in the broad classification of oxygenated hydrocarbons (including ethers), although activities are focused on methanol and ethanol as the principal candidates in this class. AFUP objectives related to alcohol fuels are:

Near-Term Objective. The near-term objective of testing and evaluating alcohol/gasoline blends in commercial and government fleets has been met. Solutions to problems have been verified, and the practicality and reliability of blends in this country have been demonstrated. Currently, commercial blends of ethanol, methanol, higher-order alcohols, and ethers are being marketed.

Longer Term Objective. The longer term objective of defining and evaluating new systems has largely been completed. These efforts focused on optimizing resource/engine/fuel systems based on alcohols, confirming emissions and efficiency improvements in optimized engine, and discovering and solving problems associated with the use of alcohol fuels.

Presently funded projects are, for the most part, directed toward the longer term objective as outlined in the WBS shown in Fig. 6. Project descriptions follow for those projects currently underway, in procurement, or which have been recently completed.



*SEE SECTION 3.1.

Fig. 6. Work Breakdown Structure for Alcohol Fuels — Blends and Neat.

TITLE: **Alcohols in Spark Ignition Engines**

Contractor: University of Santa Clara
Contracting Organization: DOE Headquarters
Contract Amount: $332,500
Contract Term: 1/1/84 to 7/1/85
Principal Investigator: R. K. Pefley

OBJECTIVE:

To carry out research and development in multi-faceted tasks to address remaining problem areas in the adaptation of spark ignition engines to alcohol fuels.

PROJECT DESCRIPTION:

This multi-year project, following development of a fundamental data base, has addressed many of the remaining issues related to the use of alcohol fuels in spark ignition engines. Areas of work have included cold start and warm-up driveability, engine wear and corrosion, photochemical smog research, NO_x suppression research, and vehicle monitoring and data processing. Experiments have included bench tests, engine testing, and vehicle testing.

ACCOMPLISHMENTS:

This project has contributed considerably in its work areas towards bringing alcohol-fueled engines to commercial readiness. Contributions in all of the work areas are too numerous to outline here completely, but the following are selected examples.

A numerical model was developed to investigate methanol evaporation during cold starting and the effects of droplet size (atomization) and manifold heating were among the studies using this model.

Several cold starting aids were experimentally evaluated in a cold-cell. Corrosion and wear mechanisms were investigated.

A photochemical smog chamber was used to study atmospheric reactions of alcohol-vehicle emissions, emphasizing the air quality in the Southern California area.

The work has been fully documented in reports.

PLANNED ACTIVITIES:

Finish final reporting.

TITLE: **Reliability Fleet Testing of Alcohol/Gasoline Blends**

Contractor: Southwest Research Institute
Contracting Organization: DOE Headquarters
Contract Amount: $1,926,000
Contract Term: 7/16/79 to 12/31/84
Principal Investigator: J. D. Tosh

OBJECTIVE:

To demonstrate the commercial readiness of alcohol/gasoline blends including both ethanol and methanol based alcohols.

PROJECT DESCRIPTION:

Fleets of vehicles of various kinds and in various geographical locations were operated on various alcohol/gasoline blends for periods up to four years. Data were gathered on the operation of the fleet vehicles to determine factors such as fuel efficiency, reliability, driver acceptance, and any unforeseen characteristics of the fuel formulations.

ACCOMPLISHMENTS:

A total of 20 fleets were involved at one time or another in the testing. The types of fleets involved ranged from administrative vehicles for city, county, and state governments to vehicles used by the Border Patrol in the Southwest. Various alcohol/gasoline blends were used in the test including gasohol, a formulated gasohol (10% ethanol), Oxinol/gasoline (9.5/90.5) and a methanol/ethanol/TBA/gasoline blend. Results of statistical significance varied from fleet-to-fleet with some yielding enough data to lead to sound conclusions and others yielding too little data upon which to draw conclusions. A number of interim reports dealing with separate fleets have been issued while final reporting is pending.

PLANNED ACTIVITIES:

Final reporting.

TITLE: **Aldehyde Emission Measurements from a Methanol Fueled Stratified Charge Engine**

Contractor: University of Wisconsin
Contract Completed
Principal Investigator: D. E. Foster

OBJECTIVE:

To investigate the origin and mechanisms of unburned fuel and formaldehyde emissions with a Texaco TCCS engine operated with pure methanol.

PROJECT DESCRIPTION:

The Texaco TCCS (Texaco Controlled Combustion System) engine is a lean-burning, direct fuel injected, non-throttled, high compression ratio, spark-ignition engine and, as such, closely resembles the type engine thought by some to be best suited for utilization of pure methanol fuel. However, unburned fuel and aldehyde emissions could be serious problems for methanol fueled stratified charge engines. Therefore, this project addressed the question by running the TCCS engine on methanol at various operating conditions. Continuous and time-resolved exhaust gas sampling methods were used to measure emissions.

ACCOMPLISHMENTS:

Formaldehyde emissions were found to originate in the cylinder gases, especially at low loads. However, formation of aldehyde emissions appears to continue in the exhaust port after combustion products leave the cylinder; this phenomenon becomes more important as the load increases. Fuel impingement on the piston is believed to be responsible for the unburned fuel emissions, and at higher loads it appears to be the primary cause of unburned fuel emissions.

PLANNED ACTIVITIES:

Finalize the final report of the project.

TITLE: **Wear with Methanol Fuels**

Contractor: U.S. Army Fuels and Lubricants Research Laboratory
Contracting Organization: DOE Headquarters
Contract Amount: $75,000
Contract Term: 1/1/84 to 12/31/84
Principal Investigator: E. C. Owens

OBJECTIVE:

To determine the nature of wear mechanisms in spark-ignition engines when operated with neat methanol.

PROJECT DESCRIPTION:

This project continued the wear/lubrication investigation conducted by AFLRL over the previous 5 to 6 years, and which originally revealed the existence of abnormal wear with methanol fuel in cold engines, as well as the reason for it, namely generation of formic acid. The exact nature of the wear mechanisms needed to be defined in order to aid in developing final solutions to the problem of increased wear with methanol fuels. Prior to this project, information was lacking regarding the composition of materials, both liquid and gaseous, that are adjacent to the cylinder walls during the periods of high wear. Therefore, in this project a rapid-acting sampling valve was employed in a CLR engine operating on methanol. Time-resolved sampling of the cylinder surface layer exposed the composition of the surface boundary layer at various times during the engine cycle. From these data, theories were developed regarding the interaction of the chemical species found and the cylinder wall materials so that mechanisms of wear could be identified.

ACCOMPLISHMENTS:

The sampling valve experiments revealed the presence of peroxide in the boundary layer on the cylinder wall after about 20° after top-dead-center and persisting for some time afterwards still in the boundary layer. Separate bench scale experiments revealed that the rate of iron corrosion by formic acid was greatly increased by the presence of peroxide. It was concluded that peroxides play an important role in the corrosion mechanism because residence time of combustion residues on the cylinder walls is brief.

PLANNED ACTIVITIES:

Finish final reporting of the project. (Must be coordinated with reporting to U.S. Army.)

TITLE: **Intermediate Alcohol/Gasoline Blends**

Contractor: Southwest Research Institute
Contracting Organization: DOE Headquarters
Contract Amount: $26,000
Contract Term: 7/23/84 to 12/23/84
Principal Investigator: N. R. Sefer

OBJECTIVE:

(1) Define the properties of methanol-gasoline blends in the 15 to 90 volume percent region, and (2) identify blends which show potential benefits compared to gasoline, to neat methanol, or to low concentration methanol blends.

PROJECT DESCRIPTION:

Methanol-gasoline blends in the intermediate range (15 to 90 volume percent of methanol) have received little attention even though such blends could have benefits relative to gasoline or low concentration blends. Therefore, this project explored the economics and properties of intermediate range blends using available data and limited laboratory testing. Octane numbers, Reid vapor pressure, and distillation curves were measured for pure methanol and for a series of gasoline-methanol blends to determine blending properties. Those properties were then used to formulate a second series of blends using methanol and several gasoline blendstocks, rather than finished gasoline, which were then used to determine contributing characteristics such as octane.

ACCOMPLISHMENTS:

All work and draft final reporting has been completed. It was found that major reductions in fuel costs could be achieved for engines which require expensive, high octane fuel (e.g., light aircraft) by substituting a blend containing 50% methanol and 50% unleaded regular gasoline. Smaller but significant savings could be achieved for automobile engines with compression ratios of 10 or 11 to 1, using blends containing 50 to 70% methanol. The blends containing 50% methanol required only four liquid components and could be produced in a relatively simple refinery.

PLANNED ACTIVITIES:

Finalize draft final report of the project.

TITLE: **Evaluation of Prevaporized and Simulated Decomposed Methanol Fuels**

Contractor: University of Miami
Contracting Organization: Martin Marietta Energy Systems
Contract Amount: $20,000
Contract Term: 2/11/85 to 6/10/85
Principal Investigator: Dr. Michael Swain

OBJECTIVE:

(1) To test a prevaporized methanol fuel in a spark-ignition engine and use the experimental results in a computer program to predict optimum engine performance using liquid methanol as the fuel. (2) To perform the same task using a simulated decomposed methanol (hydrogen/carbon monoxide mixture) as the fuel. (3) To compare the results from the above two cases and draw conclusions regarding the relative benefits versus costs of the two different ways of using methanol.

PROJECT DESCRIPTION:

This project addresses the questions: What are the potential fuel economy gains of decomposed methanol and what is the appropriate baseline of comparison? These are important questions, but insufficient information has existed to answer them conclusively. Therefore, in this project a comparison will be made of the optimized use of decomposed methanol with the optimized use of liquid methanol without decomposition. Engine experiments will provide empirical data on heat release rates, heat transfer during combustion, etc. Then, using the data from the experiments an existing computer program will determine the parameters that define the optimized cases of decomposed methanol versus liquid methanol. This will upgrade a previous analysis based on data which included several assumptions, but which indicated little benefit from decomposed methanol.

ACCOMPLISHMENTS:

None - new project.

PLANNED ACTIVITIES:

All of the statement-of-work.

TITLE: **Documentation of Status of Alcohol Fuels Technology**

Contractor: Mueller Associates, Inc.
Contracting Organization: Martin Marietta Energy Systems
Contract Amount: $75,000
Contract Term: 3/1/85 to 8/31/86
Principal Investigator: To be determined

OBJECTIVE:

To develop several documents which update the technology status of alcohol fuels in transportation utilization. The technology status to be updated ranges from a compendium of major events over the last decade related to alcohol fuels utilization to state-of-technology reports.

PROJECT DESCRIPTION:

After a decade of research and development and evolving commercial activities, considerable changes have occurred in conditions and status related to the utilization of alcohol fuels. Potential gaps or new needs in technology have developed which need to be addressed. Documentation of key technology status and needs are addressed in this project. Specific reports to be prepared by the contractor include: (1) A report on how best to organize and operate fleet demonstrations based on experiences from AFUP and also fleet tests, (2) A compendium of significant events in R&D and commercialization of alcohol fuels, (3) A state-of-technology report on oxygenated fuels, and (4) A report on impacts of growth in production capacity of alcohol fuels.

ACCOMPLISHMENTS:

None - new project.

PLANNED ACTIVITIES:

All of the statement-of-work.

3.4 Advanced Fuels

The long-term objective of this program is to assess advanced fuels for possible use in the highway vehicle systems sector and to assure proper consideration of new developments, inventions, and research programs.

At the present time, two advanced alternative fuels, hydrogen and hybrid fuels (typically, a solid/liquid blend), are of particular interest for application in the highway vehicle sector. The program has provided for consideration of other promising fuels that might be identified, but over the decade in the ten years since the original AFUP feasibility studies were made no others have been shown to warrant attention.

For over a decade, DOE has sponsored a wide variety of R&D projects in the area of hydrogen production, storage, and utilization. Hydrogen production studies and experiments have not identified a cost-competitive source of hydrogen for transportation fuel. Fundamental test data have been developed and published for 19 different configurations of an appropriate light-duty, automotive piston engine. The objective of these tests was to define optimal design and operating conditions for each engine configuration, with particular emphasis on performance and exhaust emissions over the entire load range. This information permits the definition by industry of a first-generation optimized hydrogen engine design. No further work on engine combustion is deemed warranted at this time.

All significant hydrogen storage options have been assessed, including liquid hydrogen (cryogenic storage), reversible and consumable chemical carriers, and metal hydrides. Considerable R&D has been devoted to overcoming the deficiencies of current lightweight magnesium-nickel hydride systems. Although modest improvements have been achieved, the gains are insufficient for application of metal hydrides in the transportation sector without imposing undue cost, performance, and related penalties.

Since hydrogen storage in liquid form has the greatest advantages of all known techniques, a vehicle incorporating such a system was evaluated experimentally. This work was performed with the cooperation of the government of the Federal Republic of Germany, which made available its advanced fuel transfer and cryogenic storage design technology. Although the system tested was not optimized, it provided meaningful reference test data which permitted the projection of potential improvements. Based on current technology, hydrogen systems do not favorably compete with other alternative fuel options and are not a contender for petroleum replacement. No projects in hydrogen fuel utilization area are in progress or planned through FY 1985.

The objectives for hybrid fuels projects include identifying energetic shelf items that could be used as components for formulating hybrid fuels, determining the degree of processing required to produce finished fuels from the various components, and evaluating the performance of candidate formulations of hybrid fuels in existing engines.

In a recent project, seventy different hybrid fuel formulations were considered. These formulations generally consisted of liquid and/or solid components blended with diesel fuel. The fuels were screened in a single-cylinder diesel research engine because they were generally incompatible (not volatile enough) with spark-ignition engine fuel systems. Based on the results of the screening studies, it was concluded that certain types of carbon slurries justified further examination. Further studies were indeed carried out and were completed recently.

Some experimental work has recently been accomplished outside of the AFUP on the use of coal slurries in very large, stationary diesel engines and additional, fundamental studies have been initiated on the combustion of such fuels in gas turbines. In a continuation of work originated under joint sponsorship of DOE and the Federal Railroad Administration, railroad diesel engines are being tested on a variety of degraded petroleum products or non-petroleum products (sometimes blended with diesel fuel) with sponsorship from the rail industry (Association of American Railroads).

In view of these activities, having achieved the near-term objectives, the AFUP has assumed a more passive position pending significant progress by other investigators. Evaluation of new systems to optimize the resource/fuel engine combination, and the assessment of the characteristics of the more appropriate combinations of hybrid fuels and related constituents, will be accomplished if deemed appropriate in the future. Meanwhile, the AFUP role is to monitor the world-wide state-of-the-art hybrid fuel technology pertinent to highway vehicles. There are no projects underway or planned for FY 1985.

3.5 Emergency Fuels

The AFUP objective for this fuel classification is to determine what nonstandard fuels might be compatible with existing engines in order to keep the Nation's highway vehicle system functioning during an emergency situation.

Analytical and experimental R&D efforts were conducted to identify the composition and performance of hydrocarbon materials which could be utilized as emergency fuel constituents for highway transportation systems. Available quantities and properties of key blendstock materials were identified in early projects. Engine/fuel compatibility experiments were performed and a guidebook was assembled to document the data describing the degradation in engine performance, fuel economy, and emissions when nonstandard fuel blends were used in existing engines to permit uninterrupted operation of key vehicle fleets.

Additional projects on emergency fuels are probably not required because considerable progress has been made in stockpiling petroleum (Strategic Petroleum Reserve) and using other options to extend petroleum supplies (e.g., alcohol/gasoline blends, methane, and LPG/propane). Availability of these fuels or components is reasonably good, and the fuels often perform better than conventional fuels. No projects on emergency fuels are underway in FY 1985.

3.6 Methane and Related Gaseous Fuels

The AFUP objectives for gaseous fuels are:

1. To test and evaluate gaseous fuels as substitutes or extenders in current gasoline and diesel engines, permitting determination of performance and emissions characteristics and of the potential for improving engine thermal efficiency.
2. To assess institutional and safety-related issues associated with the use of gaseous fuels.

Since the technology for using gaseous fuels in automotive heat engine/vehicles is well established, DOE's role is focused on studies and/or specific R&D projects which industry could not be expected to accomplish.

Gaseous fuels were added to the AFUP in Fiscal Year 1981 because the Congress of the United States expressed interest in the use of methane (natural gas) as a transportation fuel. The Methane Transportation Research, Development, and Demonstration Act of 1980 (PL 96-512), enacted 12 December 1980, focuses on the expanded use of methane as a fuel for fleet-operated vehicles. Implementation of the Act is the responsibility of DOE's Office of Transportation Systems.

Methane is considered to have application as a vehicle fuel in the form of either compressed natural gas (CNG) or liquefied natural gas (LNG). The Act defines the term "vehicle" to mean any truck, bus, car, station wagon, or van operated on public roads or highways, as well as off-road agricultural vehicles.

Recent projects on the potential efficiency of methane-fueled spark-ignition engines have been completed (shown in the following task descriptions) and further work in this area is not considered a high priority. The most apparent barriers to the widespread use of methane in vehicles are their on-board storage and refueling requirements peculiar to the gaseous fuel. Recent studies of low-pressure storage concepts were conducted with the basis that a viable concept would permit refueling from household gas lines or at least from localized distribution points. These projects were largely experimental in nature

and were concerned with screening candidate sorbent materials and determining their methane storage capacity. The concepts examined would result in a vehicle of limited range, perhaps even inferior to high-pressure on-board storage. Based on this assessment, it appears that no further work by DOE is warranted on this type of storage.

ORNL does plan to co-sponsor a project with other industry and State groups to determine the contaminant levels of pipeline natural gas, including hydrogen sulfide, carbon dioxide, water, oxygen, and other water-soluble sulfides, to assess the need for research into the role of contaminants in corrosion of on-board vehicle storage systems.

A single methane utilization project is planned, dealing with methane as a railroad diesel engine fuel. Over four billion gallons of diesel fuel are used annually for rail transportation. Natural gas offers potential as a less costly, more abundant alternative and its storage and refueling requirements, which hinder methane's acceptance for highway transportation, should present few problems for rail application. The unique aspect of the project is the investigation of high-pressure direct methane injection which should allow more efficient operation of the engine than currently found in conventional dual-fuel engines.

Project descriptions for this fuel classification are as follows.

TITLE: **Effect of Natural Gas Quality on Corrosion in CNG Storage Systems**

Contractor: Southwest Research Institute
Contracting Organization: Martin Marietta Energy Systems with co-funding from New York State Energy Research and Development Agency
Contract Amount: $104,000 from Martin Marietta Energy Systems
Contract Period: To be initiated during FY 1985
Principal Investigator:

OBJECTIVE:

To define natural gas contaminant concentration limits necessary to ensure that internal corrosion of CNG vehicle fuel tanks does not constitute a hazard during the life of the tank.

PROJECT DESCRIPTION:

A literature review and industry survey will be performed to provide data for the formulation of a laboratory corrosion test program. Range of probable contaminants will be identified. A laboratory test program involving accelerated corrosion tests will be conducted using two tank materials, AISI 4130 steel and an aluminum alloy. In addition, metallurgical examination will be conducted on sections of CNG cylinders removed from service. The results of the experiments and inspections will be analyzed to identify critical parameters.

ACCOMPLISHMENTS:

None (new project).

PLANNED ACTIVITIES:

See project description.

TITLE: **Methane Engine Data Base**

Contractor: Southwest Research Institute
Contracting Organization: DOE Headquarters
Contract Amount:
Contract Period: ends 2/10/85
Principal Investigator: Glenn O'Neal

OBJECTIVE:

To develop basic engine data for operation of an SI engine on natural gas with engine parameters optimized for maximum efficiency.

PROJECT DESCRIPTION:

A single cylinder engine will be operated on natural gas over a wide range of operating conditions. Compression ratio of the engine will be varied from a currently common value of 8.4 up to 18.5. Engine efficiency and emissions will be recorded. Two types of combustion chambers, a wedge and a hemi-head, will be used.

ACCOMPLISHMENTS:

All experimental work was completed by November 1984. Using natural gas as fuel decreased maximum power from the engine due to loss in volumetric efficiency, but power was restored by increasing compression ratio to about 15. Due to high octane number of methane, compression ratio of 15 was considered practical. At cruise conditions, the high compression natural gas engine was about 5% more efficient than the baseline gasoline engine. However, NO_x emissions were considerably higher.

PLANNED ACTIVITIES:

Final report to be published by DOE.

TITLE: **Investigation of Liquefied Natural Gas as a Fuel for Railroad Diesel Engines**

Contractor: Southwest Research Institute
Contracting Organization: Martin Marietta Energy Systems
Contract Amount: $180,000 in FY1985, $80,000 in FY1986
Contract Period: To be determined - contract not in place
Principal Investigator: To be determined - contract not in place

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OBJECTIVE:

To establish the feasibility of and basic technology for operating medium-speed rail diesel engines on liquefied natural gas (LNG) fuel. A technology for retrofit to locomotives in service is sought.

PROJECT DESCRIPTION:

An existing test cell and engine at SwRI will be revised to accommodate the storage handling and vaporization of LNG. Two types of fuel injection will be examined, (1) low pressure injection of gas into the engine early in the compression stroke, (current technology), and (2) high-pressure injection late in the compression stroke which is believed to permit more efficient operation.

ACCOMPLISHMENTS:

None (new project).

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4. MANAGEMENT PLAN

The Office of Transportation Systems (OTS) of DOE is responsible for managing this program as well as the advanced heat engines program. OTS is responsible for establishing the program goal and objectives, implementation policies, and funding level. In addition, OTS acts as lead program advocate to obtain adequate resources, coordinates activities with appropriate legislative branches.

In accordance with the DOE policy of decentralizing project management to field sites, OTS has assigned responsibility for the project management of AFUP to ORNL via DOE-ORO. The responsibilities of ORNL include technical project planning, implementation, and control. In general, OTS concurrence is required for initiation of new R&D projects and approval required for project plans.

4.1 ORNL Internal Organization for AFUP

The internal organization is shown in Fig. 7. In addition to overall management responsibilities, Graves leads an additional task for OTS on the adiabatic diesel program. McGill leads a task on the national methanol fleet which falls under the AFUP and OTS umbrella but is considered by OTS to be a separate activity.

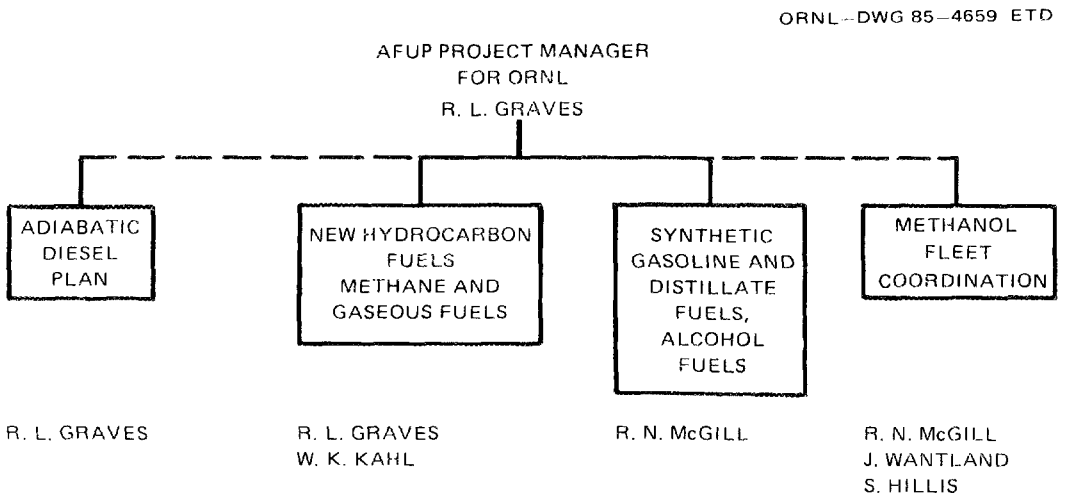

Fig. 7. AFUP Project Staff and Organization at ORNL.

4.2 ORNL/DOE Reporting

ORNL presents monthly reviews of project activities at Headquarters in Washington. Financial status of the project is presented on a frequent basis also. The monthly project review handout is distributed to DOE-ORO and interested parties within ORNL.

4.3 Procurement Procedures

To achieve the objectives of this program cooperative involvement of U.S. industrial, government laboratory, and university research communities is required. The major roles of ORNL in managing this program are to encourage the participation of qualified subcontractors, to coordinate the various R&D activities closely, and to disseminate the results of these activities to the appropriate program participants and government agencies. Because ORNL will be subcontracting most of the program funding, informing potential subcontractors of the current procurement policies is important.

In general, the R&D will be accomplished by Martin Marietta Energy Systems, Inc., subcontracts with industrial research centers and universities and by DOE laboratories and other government research laboratories according to their staff and facility capabilities and their responsiveness to program needs. Regardless of the procurement instrument, all statements of technical scope shall be approved by OTS.

Industrial and university participants may be selected on the basis of research proposals submitted in response to either a request for proposal (RFP) or a program research and development announcement.

In most cases research of a specific nature is required, particularly from an industrial source; therefore, research proposals will be solicited by a Martin Marietta Energy System RFP. Proposals submitted in response to Martin Marietta System RFPs will be evaluated on technical merit by a technical evaluation team chosen by the project manager. This team will include participation by technical experts acting as technical advisors and may include representatives from OTS, ORO, or other government agencies. Any information designated as proprietary

shall be limited to evaluators signing a proprietary agreement. A proposal, based on the results of the technical evaluation, will be selected for a subcontract award by a Martin Marietta Energy System subcontract selection team. The subcontract selection team will be composed of technically and contractually qualified Martin Marietta Energy System personnel, to be chosen by ORNL and the Martin Marietta Energy System Purchasing Division in conformance with DOE-ORO-approved procurement procedures.

For generally defined areas of research interest, program research and development announcement drafts will be developed by ORNL and submitted to ORO for issuance as DOE-ORO program research and development announcements in accordance with DOE procurement regulations. These announcements may provide for the award of Martin Marietta Energy System subcontracts for the proposals selected by DOE-ORO. All proposals will first be reviewed and evaluated by an ORNL technical evaluation team. The ORNL technical manager will advise the DOE-ORO selection panel and provide the results of the ORNL technical evaluation team for the information of the selection panel.

Although most procurements will result from a competitive selection process, sole-source subcontracts will be executed when one source has exclusive capability to perform the work within the time required and at a reasonable price. Any unsolicited proposal should be submitted to DOE for processing and appropriate action, in accordance with DOE procurement regulations.

4.4 Subcontractor/ORNL Relation

Monitoring of each AFUP subcontract is assigned to a particular member of the ORNL project team. Periodic reporting is required of all subcontractors but, in addition, telephone conversations are conducted with the principal investigator at least monthly. Site visits to the subcontractor are made occasionally throughout the duration of the project and more frequently in cases where progress is not meeting that anticipated.

Subcontractors are asked to present reports at one of two AFUP contractor meetings held each year. These presentations are a key means of technology transfer and are considered an extremely important feature of the project.

Distribution of subcontractor periodic reports is the responsibility of ORNL and distribution is typically limited to ORNL and OTS.

A number of R&D activities, as noted in previous sections, are contracted directly from DOE Headquarters. As requested by DOE, ORNL monitors progress on those contracts and maintains a technical liaison on the work. However, any guidance or redirection of the effort must come directly from the designated technical monitor at DOE. Publication of the reports in these contracts is usually carried out at DOE.

For contracts let by Martin Marietta Energy Systems, the ORNL technical manager monitors the project but, in addition, provides official direction of the project and works with Purchasing Division in cases where a change in direction or contract is mandated.

For all research efforts, the ORNL project manager provides the necessary coordinating efforts for related projects and, in particular, must coordinate fuel preparation at the Synthetic Fuel Center with efforts which will require test fuels from that facility.

4.5 Other Project Management Activities

Besides the activities related to contract procurement and management the ORNL Project Management team maintains an awareness of activities in related federal programs (Fossil Energy, Department of Defense, etc.) and also activities published by the private sectors. This awareness is maintained through contact with other investigators, conference attendance, and literature reviews. In addition, the AFUP activities are made known through contractor coordination meetings and dissemination of project plans and annual operating plans.

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