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FIELD DEMONSTRATION OF AVIATION TURBINE FUEL MIL-T-83133C, GRADE JP-8 (NATO CODE F-34) AT FORT BLISS, TX

INTERIM REPORT
BFLRF No. 264

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A JP-8 fuel demonstration was initiated at Ft. Bliss, TX, to demonstrate the impact of using aviation turbine fuel MIL-T-83133C, grade JP-8 (NATO Code F-34) in all military diesel fuel-consuming ground vehicles and equipment. Three major organizations, one ordnance battalion and two activities with a total of 2807 vehicles/equipment (V/E), were identified as participants in the demonstration program, which is authorized to continue through 30 September 1991. JP-8 fuel was first delivered to Ft. Bliss on 31 January 1989. No fuel storage tank or V/E fuel cells were drained and flushed prior to introduction of JP-8 fuel. This procedure resulted in a commingling of JP-8 fuel with existing diesel fuel. As of 31 July 1990, approximately 4,700,000 gallons of JP-8 fuel had been dispensed to user units at Ft. Bliss and at Ft. Irwin National Training Center (NTC) in California. Three prevalent perceived areas of concern arose from the beginning of the program:
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19. ABSTRACT

(1) fuel filter plugging, (2) loss of power, and (3) overheating. The use of JP-8 fuel did not cause or exacerbate any V/E fuel filter plugging. All instances of filter plugging were caused by contaminated or deteriorated diesel fuel remaining in the fuel cells. Where power loss was apparent, generally it was commensurate with the difference in heating values between JP-8 and diesel fuel. No instrumentally measured differences in engine operating temperatures supported any claim of overheating. The V/E at Ft. Bliss operated satisfactorily with the JP-8 fuel with no alterations, mechanical or otherwise, having to be made to any engines or fuel systems. Considering all factors, there were no major differences in fuel procurement costs, V/E fuel consumption, AOAP-directed oil changes, and fuel-wetted component replacements; it was therefore judged that there is no cost penalty associated with use of JP-8 in place of diesel fuel in ground equipment. A widespread acceptance by command, maintenance, and user personnel of JP-8 fuel resulted in Ft. Bliss requesting that it be allowed to continue using JP-8 fuel after the demonstration program ends. The reduced capability of JP-8 to produce smoke in vehicle engine exhaust smoke system (VEESS) is a concern being addressed outside the current JP-8 Demonstration Program.

EXECUTIVE SUMMARY

Problems and Objectives: Cold starts for combat/tactical diesel-burning ground vehicles and equipment (V/E) in NATO have always been an aggravating and expensive problem because of a property possessed by VV-F-800 specification diesel fuels. This property caused diesel fuel at low ambient temperatures to form wax crystals in the fuel. The wax crystals clogged fuel lines and fuel filters to such an extent that engine failures could result. This problem became acute when the Abrams M1 battle tank was introduced into Europe. To alleviate this problem, JP-8 aviation fuel (NATO Code F-34) was mixed with the diesel fuel to lower the cloud point at which wax crystals began forming. This blended fuel, referred to as "M1 fuel mix," has been used by all diesel-fueled V/E in forward areas during November to April annually. Military aircraft in NATO began using JP-8 fuel in 1986 and following agreements reached among U.S. Army, NATO ministers, and DOD representatives, DOD Directive 4140.43 on Fuel Standardization was issued on 11 March 1988 specifying primary fuel support for overseas land-based air and ground forces be accomplished using JP-8. To resolve questions about fuel consumption, hot-starting limitations, nonsmoke capability, inadequate lubricity problems, and safety concerns, an agreement reached between TACOM and TROSCOM representatives resulted in AMC requesting and TRADOC and FORSCOM concurring with a nonimpact demonstration program with Ft. Bliss, TX, as the selected site. This demonstration had as its objectives: (1) to demonstrate acceptability of using JP-8 in all V/E designed to consume diesel fuel; (2) to identify whether use of JP-8 will create user problems in either combat/tactical or combat support vehicles and equipment; (3) to define cost benefits/cost avoidance projections in using JP-8 for diesel-powered ground V/E; (4) to define changes in average fuel consumption; (5) to determine the need for development of a user/operator manual of changeover from diesel to JP-8; and (6) to dispel concerns about safety, which were raised because of the minimum flash point for JP-8 fuel and possible toxicity effects for fuel handlers and crew members.

Importance of Project: Although JP-8 was being used in military aircraft and some engine testing in laboratories had been conducted, no actual field experience using "real world" troops and V/E was available. With European pipelines already nearing completion of conversion to JP-8 fuel and the transition from diesel fuel to JP-8 fuel for NATO V/E getting very close to being implemented, it became imperative that a nonimpact demonstration program be initiated as soon as possible to answer the questions raised, demonstrate that JP-8 fuel is a viable alternate fuel for diesel, and establish guidelines and information for NATO forces in Europe.

Technical Approach: All V/E at Ft. Bliss, TX, were switched to JP-8 fuel by adding JP-8 fuel to existing diesel fuel in dedicated bulk fuel storage tanks and V/E fuel cells. JP-8 fuel was contracted for by DFSC and delivered to Ft. Bliss by tanker trucks and railroad tank cars. A "mixture" of diesel and JP-8 fuel was consumed and replaced by neat JP-8 fuel as the supply of "mixture" fuel became exhausted. Operational and maintenance data along with demands for fuel-wetted components were acquired in order to establish a data base against which future data could be compared. In addition to the objective data, subjective data was also sought to determine command/maintenance/user personnel reactions to using the JP-8 fuel. The nonsmoke capability of JP-8 fuel was not included as a problem to be solved in this demonstration, but was addressed under a separate program.

Accomplishments: The JP-8 fuel demonstration program has been successful in demonstrating that JP-8 fuel can be used in lieu of diesel fuel in V/E. JP-8 is a cleaner burning fuel and a cleaner storing fuel. All problems, real or perceived by maintenance/user personnel, were

resolved by technical consultation or direct comparison tests during which the same or like vehicles or equipment were operated with JP-8 fuel and diesel fuel alternately. The demonstration has served as a source of observation and learning, not only to NATO countries, but other countries throughout the world. Information from the demonstration was very useful in the invasion of Panama, resulted in "lessons learned" and transitional information for NATO, and is now answering many questions being raised by forces in the Middle East.

Military Impact: Use of "one fuel on the battlefield" represents significant advantages in logistics, fuel storage, fuel-handling facilities, and lower costs for all military forces. The enhanced time and tactical benefits resulting from common forward refueling points for ground and air V/E will result in increased operational capabilities and operational readiness for all military units. A negative impact caused by the nonsmoke capability must still be overcome either by mechanical or chemical means.

FOREWORD/ACKNOWLEDGMENTS

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I. BACKGROUND

A proposal to convert to JP-8 (1)* fuel from JP-4 (2) fuel for military aircraft was made within the North Atlantic Treaty Organization (NATO) in 1976 on the beliefs that the results would be greater commercial availability, increased safety, extended operating range, and improved interoperability. The conversion process was slowed in the 1970s because of questions and concerns as to cold startability of helicopters, projected anticipated increased price differential, and availability of JP-8 during sustained wartime operations. NATO ministers agreed to convert from F-40 (JP-4) to F-34 (JP-8) in September 1986 with the agreement ratified on 1 January 1987.

Low-temperature operation of diesel-powered vehicles/equipment (V/E) has always been a problem in Europe. Typical problems include poor startability, reduced fuel flow/pumpability, and fuel waxing. The U.S. Army in Germany adopted the policy of blending equal quantities of DF-2 (F-54) (3) and JP-8 to relieve most of the low-temperature problems. This mixture, which was subsequently used by all diesel-fueled V/E in forward areas during November through April, is now interchanged under NATO Code F-65.

Army Regulation (AR) 703-1 published on 5 January 1987 listed JP-8 as an alternate fuel for diesel-fueled V/E. Then DOD Directive 4140.43 was issued on 11 March 1988, specifying primary fuel support for overseas land-based air and ground forces be accomplished using JP-8. DOD Directive 4140.43 was then paralleled by a draft STANAG 4362, entitled "Fuel Requirements in Future Ground Equipment," which was developed in October 1987 and is now being coordinated. Acceptance of JP-8 as fuel for diesel engines was verified in previous work.(4-6)

* Underscored numbers in parentheses refer to the list of references at the end of this report.

A coordination meeting was held on 8 June 1988 to develop a common language on performance characteristics of JP-8 when used in diesel engines and to agree on the need for a full-scale demonstration program. Representatives from TACOM, PEO CCV/CS, and TROSCOM attended this meeting. Subsequently, AMC proposed a demonstration program be conducted at Ft. Bliss, TX. TRADOC and FORSCOM concurred with the proposal, and Ft. Bliss accepted the invitation to provide cooperation and support for the program.

A "Program Design Plan for JP-8 Demonstration Program at Ft. Bliss, TX" was completed 4 January 1989.(7) Revised versions of the design plan were provided to NATO and other interested parties. On 14 March 1989, a "Standing Operating Procedure (SOP) for the JP-8 Fuel Demonstration Program at Ft. Bliss, TX" (8) was distributed by Belvoir RDE Center. A two-phased plan of action was adopted by Belvoir RDE Center and implemented by BFLRF. Phase I was a limited short-term test, which measured the differences in fuel consumption and vehicle performance between DF-2 and JP-8. The results of Phase I are contained in Interim Report BFLRF No. 257, entitled "Vehicle Acceleration and Fuel Consumption When Operated on JP-8 Fuel," dated February 1989, government accession number AD A216275.(9) Phase II was to be a broad-scale user demonstration of JP-8 as an acceptable alternate fuel in diesel-fuel consuming ground equipment.

II. INTRODUCTION

The JP-8 fuel demonstration program was initially approved for 1 year, 1 February 1989 through 31 January 1990. However, a prolonged time was needed to ensure that a diesel/JP-8 fuel "mixture" was finally consumed so that data could be generated with neat JP-8 operated V/E activities. Consequently, the program was extended through 30 September 1991.

Ft. Bliss was chosen as the demonstration site because it (1) had a proper mix of combat, combat support, and tactical vehicles and equipment most of which had V/E groups, i.e., battle tanks, armored personnel carriers, and trucks, that were in sufficient numbers to represent a statistically significant sample size for each V/E group in the program; (2) has consistently high ambient temperatures during the summer months (provides needed severity); and (3) had previously participated in cooperative-type programs and exhibited outstanding cooperation and willingness to participate.

Liaison/coordination meetings with designated Ft. Bliss personnel were conducted by BFLRF personnel to ensure the preparation, adoption, and smooth implementation of a demonstration program plan. An SOP was prepared in the same manner. The program design plan and the SOP resulted in a Letter of Instructions (LOI) (10) being prepared by the Ft. Bliss Director of Logistics (DOL), now known as the Director of Installation Support (DIS). The LOI formally ratified the design plan and SOP and tasked the appropriate organizations, agencies, and activities at Ft. Bliss for cooperation and support of the overall program. All work at Ft. Bliss connected with demonstration of JP-8 fuel was to be conducted on a noninterference basis having no impact on mission training schedules. Military aviation assets at Ft. Bliss, mostly the aviation squadron of the 3rd Armored Cavalry Regiment (3rd ACR), Prime Power 750-kW standby generators, post engineer construction equipment, and widely scattered materiel-handling equipment belonging to the Ft. Bliss DOL were exempt from using JP-8 fuel. Because of the lack of overhead fueling facilities, the 2/7th Air Defense Artillery Battalion (7th ADA Bn) was also exempted from using JP-8. The 2/7th ADA Bn actually ended up using a permanent DF-2/JP-8 fuel mixture because of circumstances peculiar to its individual situation.

III. OBJECTIVES

The objectives of the JP-8 demonstration program were to:

1. Demonstrate acceptability in using JP-8 in all vehicles and equipment designed to consume diesel fuel.

2. Identify whether use of JP-8 will create user problems in either combat/tactical or combat support vehicles and equipment.

3. Within the scope of the demonstration program:

a. Define changes in average fuel consumption.

b. Define cost benefits/cost avoidance projections in using JP-8 for diesel-powered ground vehicles and equipment.

4. Determine the need for development of a user/operator manual of changeover from diesel to JP-8.

IV. APPROACH

A. Phase I

Phase I was a limited short-term test, which measured the differences in fuel consumption and vehicle performance using DF-2 and then substituting JP-8 fuel. The selected vehicles were the M1009 (CUCV), M928 (5-ton truck), M113A2 (APC), M88A1 (recovery vehicle), M1A1 (Abrams main battle tank), and M60A2 (battle tank). The results of this test were reported in Reference 9.

B. Phase II

Phase II was a broad-scale user demonstration of JP-8 as an acceptable alternate fuel in diesel-fuel consuming ground equipment. This phase was to be conducted on a noninterference basis having no impact on routine mission training schedules. It was not a TEST nor an evaluation of material. This phase is also known as the Ft. Bliss demonstration program.

1. Participating Organizations

The following Ft. Bliss organizations participated in the JP-8 program:

- 3rd Armored Cavalry Regiment (3rd ACR)
- 11th Air Defense Artillery Brigade (11th ADA Bde)
- 6th Air Defense Artillery Brigade (6th ADA Bde)
- 70th Ordnance Battalion (70th Ord Bn)

- Range Command
- Ft. Bliss Transportation Motor Pool (TMP)

2. Vehicles and Equipment

Initially there were approximately 2807 V/E included in the JP-8 demonstration program. Some vehicles were removed from the program during the report period because of normal attrition and due to programmed changes in types of vehicles (i.e., replacement of M113 APCs by Bradley M3 fighting vehicles). Appendix A provides a density listing of V/E participating in the program at Ft. Bliss. It should be noted that only those diesel-consuming V/E enrolled in the Army Oil Analysis Program (AOAP) could be included in the data base and provide operational and maintenance data for comparisons. Unfortunately this eliminated the CUCVs and HMMWVs because of their numbers and because including them in the AOAP program would not be cost effective. The diesel fuel-consuming V/E mix at Ft. Bliss as of 31 March 1990 is shown in the following listing:

Type	Number
Combat Tracked Vehicles	583
Tactical Wheeled Vehicles	1815
TMP Administration Vehicles	60
Construction Equipment	20
Material-Handling Equipment	73
Generator Sets	306
Total	2857

The V/E composite mix showing high-density items as well as the applicable fuel injection system are included in the following listing:

Type	Number	Fuel Injection System
Trucks, 2-1/2 Ton, 5 Ton	823	Rotary-Bosch; PT System
Trucks, 3/4 Ton, 1-1/4 Ton	623	Rotary-Stanadyne
Trucks, 10 Ton, HEMTT	316	Unit Injector
Tracked Carriers	221	Unit Injector
Self-Propelled Howitzers	18	Unit Injector

Type	Number	Fuel Injection System
Gun, Air Defense	47	Unit Injector
Recovery Vehicles	28/9	Rotary-Bosch/Unit Injector
Bradley Fighting Vehicle, M3	116	PT System
Tanks, Combat	129	Turbine System
Generators, 5 kW	39	Rotary-Bendix
Generators, 10 kW	5	Rotary-Bendix
Generators, 15 kW	113	Rotary-Stanadyne
Generators, 30 kW	26	Rotary-Stanadyne
Generators, 60 kW	61/22	Rotary-Roosamaster/PT System
Generators, 150 kW	40	Turbine System

3. Operating Procedures

Operating procedures were established in a "Standing Operating Procedure (SOP) for the JP-8 Fuel Demonstration Program at Ft. Bliss, TX," dated 14 March 1989. The SOP was distributed to Ft. Bliss organizations, agencies, and activities by Headquarters, Air Defense Artillery Center (ADAC), accompanied by a "Letter of Instructions" (LOI) prepared by Headquarters ADAC and Ft. Bliss, dated 28 February 1989. Basically, JP-8 fuel was delivered to the Biggs Army Air Field (BAAF) fuel storage area from which using organizations, agencies, and activities drew fuel. The JP-8 fuel was added to existing DF-2 diesel fuel in bulk fuel storage tanks and individual V/E fuel cells. All participating organizations, agencies, and activities continued normal mission/training activities. Provisions were made to have JP-8 fuel available to the 3rd ACR during its training exercises at the National Training Center, Ft. Irwin, CA.

A BFLRF monitor team was quartered in El Paso, TX, on a monthly rotational basis, to keep abreast of all matters pertaining to the JP-8 program and to provide prompt professional assistance or advice as required. The Logistics Assistance Representatives (LAR) within the U.S. Army Materiel Command Logistics Assistance Office (AMC-LAO) reported all problems, perceived or substantive, to the BFLRF monitor team. Problems were resolved through professional services, consultations, or comparative tests in which the same or like V/E were operated first with one fuel, then the other.

BFLRF monitors visited, on a daily basis, designated points-of-contact who provided data in written form or subjective comments about the use of JP-8 in V/E within their respective organizations. Although little objective data could be obtained from units visiting Ft. Bliss for training, subjective comments from command, maintenance, and user personnel could reveal whether or not any JP-8 related fuel problems arose during their training exercises.

A BFLRF monitor was present at the National Training Center (NTC), Ft. Irwin, CA, during the 3rd ACR training exercises at that post during May and October 1989. Daily visits were made to the training area, and maintenance/user personnel were questioned as to the performance of their respective equipment using JP-8 fuel.

Fuel samples were taken on a selective basis from commercial fuel delivery transports, bulk fuel storage tanks, fuel handling/dispensing equipment and individual V/E fuel cells. Fuel samples were shipped to BFLRF for laboratory analyses. In addition to results from these samples, results of analyses of fuel samples routinely taken by Ft. Bliss personnel and shipped to the General Materiel Petroleum Activity (GMPA) Lab West were provided to BFLRF.

Monthly Reports and Quarterly Executive Summaries were prepared by BFLRF and forwarded to Belvoir RDE Center for review and dissemination to all interested government and military agencies. Also provided were weekly spot reports and special reports covering reported problems and the actions associated with resolving the problems.

An In-Progress Review was held by Belvoir RDE Center, 16 and 17 May 1990, to allow interested government and military agencies to review the program's progress and to allow these agencies to offer suggestions for conducting or improving the program.

4. Fuel and Fuel-Wetted Components

a. Bulk Fuel Logistics

The process of obtaining fuel for the Army begins with the determination of estimated yearly fuel requirements for all activities at a given post/camp/station. These estimates also include fuel required for various training exercises involving visiting units and training at other locations. Based on these requirements, the Defense Fuel Supply Center (DFSC) contracts with appropriate refiners/suppliers to have the required fuel made available at the appropriate Defense Fuel Supply Point (DFSP). At this point, DFSC takes custody of the fuel and is responsible for its quality. Upon receipt of requisitions, DFSC arranges for fuel to be shipped to the user (Ft. Bliss/Ft. Irwin). Once the fuel is off-loaded into the user's tanks, the Army takes custody of the fuel. Fig. 1 is a flow diagram of this entire process at Ft. Bliss, TX.

All JP-8 deliveries to Ft. Bliss were made to the 240,000-gallon storage tank at the Biggs Army Air Field (BAAF). The 240,000-gallon storage tank was cleaned and resealed during December 1988 by a local firm under contract. The lines were flushed and cleaned and filters replaced. GMPA and BFLRF personnel inspected the tank after the work was completed and approval was granted to fill the tank with JP-8 fuel.

For the initial fill, JP-8 fuel was trucked in from 31 January through 3 February 1989. Thirty-two 7,500-gallon tanker trucks were unloaded during this period. The fuel continued to be trucked in until 16 February when the first rail tanker car arrived at BAAF. The fuel continued to be delivered by rail tanker cars with the exception of emergency shipments that occurred when fuel-dispensing volumes increased unexpectedly. The Military Traffic Management Command dedicated 20 rail tanker cars to transport the JP-8 fuel from Houston, TX, to BAAF.

From the BAAF main tank, the JP-8 is taken, using tank trucks/HEMTTs, to underground storage tanks in the individual motor pools. These tanks range in size from 5,000 to 15,000 gallons.

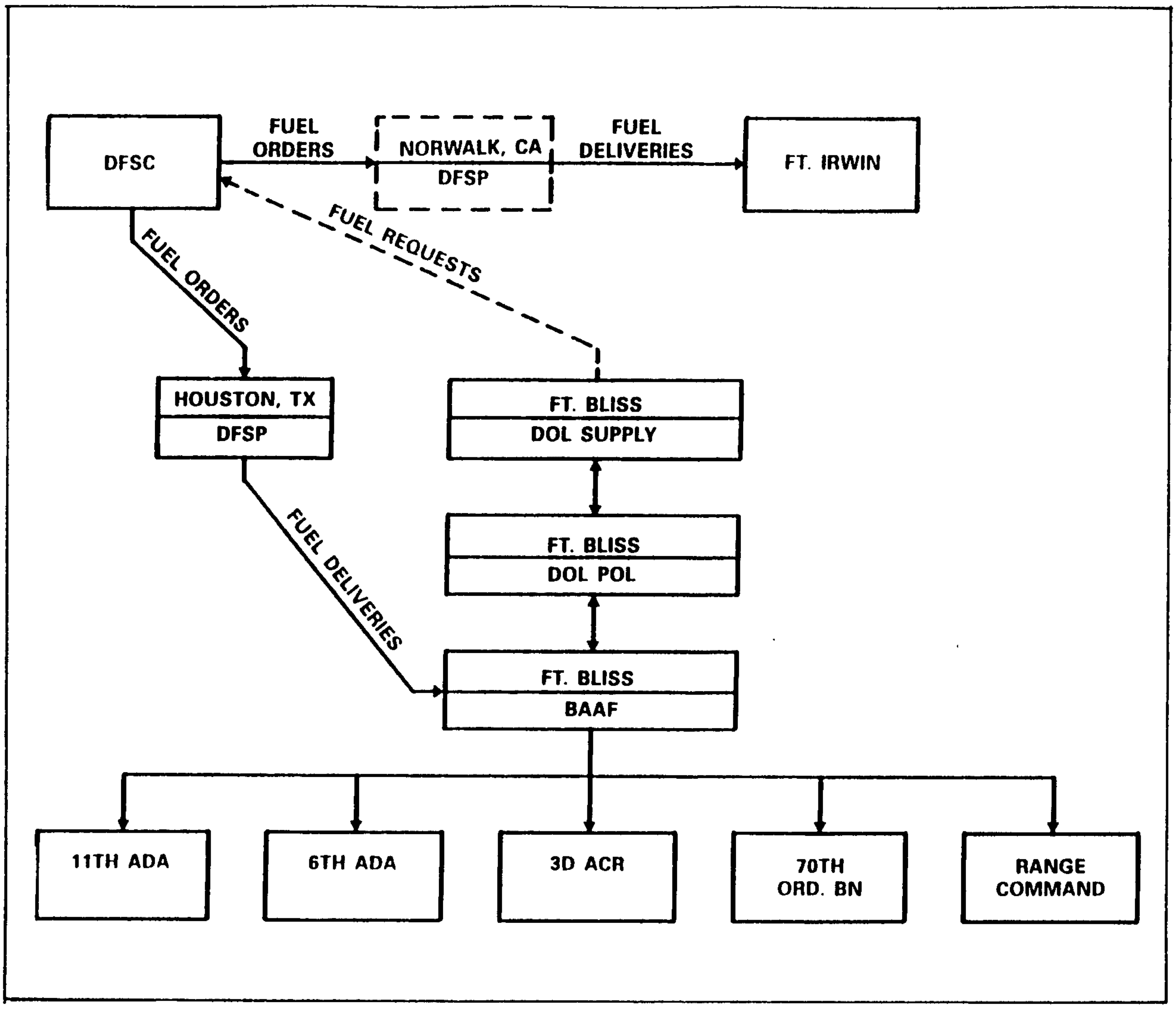


Figure 1. **<u>Flow chart for requisition and delivery of JP-8 fuel during the demonstration program</u>**

While units of the 3rd ACR were training at Ft. Irwin, JP-8 fuel was stored in a precleaned, dedicated storage tank. Individual V/E were fueled from tankers, HEMTTs, and tank and pump units.

b. <u>Fuel Samples and Analyses</u>

Two types of fuel samples were taken during the demonstration program:

- Routine samples, taken to confirm the grade and quality of fuel either being delivered to Ft. Bliss or already in storage at a given site on the post.

- Nonroutine samples, taken to aid in resolving a fuel-related problem or as additional information for a V/E performance test.

All samples were returned to BFLRF for analysis. During the demonstration program, the fuel was to be used for ground vehicles. However, the decision was made at the beginning of the program that, in order to keep with the "One Fuel Forward" concept, and because the fuel was purchased under the JP-8 specification, the fuel must meet aviation fuel standards. This requirement meant that all fuel handling and analyses must be conducted in accordance with JP-8 requirements, as stated in MIL-T-83133C. Analyses conducted on the routine samples included most of those required under MIL-T-83133C, as well as additional analyses normally associated with diesel fuel, such as cetane number, but of special interest to this program because the fuel was to be used in ground vehicles. TABLE 1 presents a list of the routine analyses conducted on each sample. Also presented in TABLE 1 are the requirements for VV-F-800D diesel fuel, grades DF-1 and DF-2 for comparison. The analysis of nonroutine samples was conducted on an individual basis according to the requirements for that situation.

Fuel analysis reports were also received from the General Materiel Petroleum Activity laboratory at Tracey Army Depot. These reports were the results of analysis of samples routinely sent to GMPA for quality assurance/quality conformance testing. GMPA has final jurisdiction over the quality of POL products procured and used by the Army. The data supplied by GMPA were collected, distributed, and were very useful as additional confirmation of fuel quality.

c. Sampling

In general, the method of sampling was determined by the fuel container (i.e., storage tank, fuel cell, etc.), access to the container, and the purpose for taking the sample. All samples were taken into clean, 1-gallon epoxy-lined cans. Many of the railroad tank car samples were taken as dip

TABLE 1. Routine Sample Analysis Protocol

Specification Grade Property	ASTM Method	MIL-T-83133C JP-8	VV-F-800D DF-1	VV-F-800D DF-2 CONUS
Total Acid No., mg KOH/g	D 3242	0.015, max	NR*	NR
Aromatics, vol%	D 1319	25.0, max	NR	NR
Olefins, vol%	D 1319	5.0, max	NR	NR
Sulfur, mass%	D 4294	0.30, max	0.5, max	0.5, max
Hydrogen, mass%	D 3178	13.4, min	NR	NR
Distillation, °C	D 86			
Initial Boiling Point		Report	NR	NR
10% Evaporated		205, max	NR	NR
20% Evaporated		Report	NR	NR
50% Evaporated		Report	Report	Report
90% Evaporated		Report	288, max	338, max
End Point		300, max	330, max	370, max
Residue, vol%		1.5, max	3, max	3, max
Density, kg/L	D 1298	0.840 to 0.775	Report	Report
Cloud Point, °C	D 2500	NR	Regional	Regional
Flash Point, °C	D 93	38, min	38, min	52, min
K. Vis, cSt, at				
40°C	D 445	NR	1.3 to 2.9	1.9 to 4.1
70°C	D 445	NR	NR	NR
Net Heat of Combustion,	D 240			
MJ/kg		42.8, min	Report	Report
Btu/lb		18,400, min		
Btu/gal.		NR		
Cetane Number	D 613	NR	40, min	40, min
Cetane Index	D 976	NR	40, min	40, min
Existent Gum, mg/100 mL	D 381	7.0, max	NR	NR
Particulate Contamination, mg/L	D 2276	1.0, max	10, max	10, max
Accelerated Stability, mg/100 mL	D 2274	NR	1.5, max	1.5, max
FSII, vol%		0.10 to 0.15	NR	NR
Fuel Conductivity, pS/m		150 to 600	NR	NR
Corrosion Inhibitor, mg/L		QPL-25017	NR	NR
Visual Appearance	D 4176	Clean/Bright	Clean/Bright	Clean/Bright
Colonial Pipeline Co. Haze Rating	Proposed	NR	NR	NR
Color	D 156	Report	NR	NR

* NR = No Requirement.

samples. The remaining samples were taken using either a bomb-type thief or a small vacuum pump. Dispensing pump samples were taken only to determine the quality of the fuel being dispensed.

d. Fuel-Wetted Components

Several fuel-wetted components were returned to BFLRF. These components underwent a variety of analyses, which, in most cases, were aimed at determining a probable failure mode. Plugged fuel filters were analyzed to ascertain the nature of the material plugging the filter. Failed injectors were usually disassembled or cut apart to investigate the cause of failure.

A more detailed discussion of the results of analyses of the fuel samples and fuel-wetted components is presented in Section V.C of this report.

e. Fuel Transition Periods

Fuel type was monitored and confirmed by gas chromatographic analysis of samples from individual vehicle fuel tanks and underground storage tanks. The following time periods were established to identify the transition dates from the use of one fuel to another:

- Transportation Motor Pool

Date	Fuel Type
September 1988 to 28 February 1989	DF-2
1 March 1989 to 31 July 1989	Mixture
1 August 1989 to End of Program	JP-8

- All Other Organizations

Date	Fuel Type
1 January 1988 to 31 January 1989	DF-2
1 February 1989 to 30 September 1989	Mixture
1 October 1989 to End of Program	JP-8

5. Operational and Maintenance Data Collection

a. Statistical Approach

(1) Data Collection — Data were collected from nine units assigned to two ADA Brigades (6th and 11th) and one Armored Cavalry Regiment (3rd ACR) at Ft. Bliss, TX. These nine units are 11th ADA (2/1st, 5/62nd, and 3/43rd Battalions); 6th ADA (1/43rd and 2/6th Battalions); and 3rd ACR (1/3rd, 2/3rd, 3/3rd, and Support Squadrons). The types of data collected on each individual vehicle/equipment are detailed in the following subsections b-f of Section IV.B.5.

(2) Quality of Data Collected — The data collected during this study have been examined with the purpose of eliminating obvious erroneous raw data points that may lead to inaccurate average vehicle miles or miles-per-gallon estimates. Therefore, appropriate, but very liberal, guidelines were followed in an attempt to have the data as reliable as possible.

The following are examples of the possible ways in which errors can occur in the data:

- The Army Maintenance Management System (TAMMS) vehicle mileage data, which is compiled through the AOAP samples, do not increase when ordered chronologically by date for an individual vehicle. Often times this was a result of the mileage figure missing a digit, or possibly the addition of an extra digit. TAMMS received the data file, created by the AOAP lab at Ft. Bliss, through magnetic computer media. There is no validation of the accuracy of the data input through the AOAP lab.

- Fuel dispensings recorded on the DA Form 3643 are not verified at the dispensing station. Several different instances occurred where the dispensing data were flawed. A large percentage of the discrepancies resulted from poor penmanship; the USA numbers were not readable. Other times the USA numbers were not assigned to the units reporting the dispensings. Some fuel dispensings recorded bumper number instead of USA number.

- After the merging of the vehicle mileage data from TAMMS and the fuel dispensing data from the Form 3643, individual vehicle miles-per-gallon were computed. Errors in this resultant data base can occur if fuel dispensings are missing between two vehicle mileage recordings; thus, inflating the miles-per-gallon value. The validity of these data were assessed by statistical outlier checks outlined in the next section.

(3) Outlier Checks — The data base created from the merging of TAMMS data and Form 3643 data was submitted to statistical methods for the purpose of identifying outlying observations. Recall that the data base consists of miles-per-gallon (mpg) values for each individual vehicle by fuel period in which mpg could be computed. As was noted in the previous section, some discrepancies in the data (mainly mpg values that were extremely high) were subject to error because of the problems associated with the merging of the two data bases. Since the number of vehicles within a particular vehicle group was large enough, statistical "outlier" checks were made to determine if any of the existing mpg values could be set aside in the comparison of the average mpg readings between the DF-2 and JP-8 fuel periods.

The statistical tests performed checked for outliers in the following five situations:

- highest mpg value
- lowest mpg value
- both highest and lowest mpg values
- two highest mpg values
- two lowest mpg values

These particular tests are described in Reference 11. A total of 46 mpg data values were eliminated from the entire collection of computed mpg points. The eliminated values are summarized in TABLE 2.

TABLE 2. Number of Outliers Removed From mpg Calculations

Unit	Vehicle Group - Group No.*	Fuel	No. of Outliers
6th ADA	Truck, Cargo, 2 1/2 Ton - 10	JP-8	1
	Truck, 5 Ton, 800 Series - 25	DF-2	1
	Truck, 5 Ton, 800 Series - 25	JP-8	1
	Truck, Cargo, 5 Ton - 30	Mixture	1
11th ADA	Truck, Van - 3	JP-8	1
	Gun, Air Defense -6	DF-2	1
	Truck, Cargo, 2 1/2 Ton - 10	DF-2	2
	Truck, Cargo, 2 1/2 Ton - 10	Mixture	1
	Truck, Cargo, 2 1/2 Ton - 10	JP-8	2
	Truck, Cargo - 19	DF-2	1
	Truck, 5 Ton, 800 Series - 25	DF-2	1
	Truck, 5 Ton, 800 Series - 25	Mixture	1
	Truck, 5 Ton, 800 Series - 25	JP-8	1
	Truck, 5 Ton - 30	DF-2	2
	Truck, 5 Ton - 30	Mixture	2
	Truck, 5 Ton - 30	JP-8	1
	Truck, Tractor, 10 Ton - 37	Mixture	1
3rd ACR	Carrier, Mortar - 2	DF-2	2
	Carrier, Mortar - 2	Mixture	2
	Howitzer, S.P. - 4	DF-2	2
	Howitzer, S.P. - 4	JP-8	1
	Tank, Combat - 8	DF-2	1
	Tank, Combat - 8	Mixture	2
	Tank, Combat - 8	JP-8	1
	Cavalry Fighting Vehicle - 9	Mixture	1
	Cavalry Fighting Vehicle - 9	JP-8	2
	Truck, Cargo, 2 1/2 Ton - 10	DF-2	2
	Truck, Cargo, 2 1/2 Ton - 10	Mixture	1
	Truck, Cargo, 2 1/2 Ton - 10	JP-8	1
	Carrier, C.P. - 21	DF-2	2
	Recovery Vehicle - 26	DF-2	1
	Recovery Vehicle - 26	JP-8	1
	Truck, Cargo, 10 Ton - 34	JP-8	2
	Truck, Tanker, 10 Ton - 35	JP-8	1

* For a description of the vehicle groupings and group numbers, see TABLE 21.

(4) Sample Size — For the purposes of comparing the average mpg value of a particular vehicle group between the DF-2 and JP-8 fuel periods, each group must contain enough observations to minimize, within reason, the chance of stating that the average mpg is different between the two fuel periods when it actually is not. Thus, sample size tables (12) were consulted, which resulted in a sample size of at least 17 observations for each group being required in order to detect a difference with probability equal to 0.90. Although average values were computed for all groups that contained at least 2 observations, only those with size greater than or equal to 17 were compared statistically.

(5) Mean Comparisons — In order to determine if the average mpg values were different between the DF-2 and JP-8 fuel periods, a classical statistical method of comparing averages by using the t-test statistic was employed.(13) This same methodology was utilized in the comparisons of the wear metal readings across the two fuel periods.

b. Fuel Consumption Data

The largest data base established during this study involved the collection and archival of fuel dispensings for all nine units monitored. This task involved the development of density listings comprised of each vehicle's USA number and end-item-serial number for all vehicles and equipment assigned to each of the nine units. This information was used as a validation check against the data reported on the unit DA Form 3643 (see Fig. 2). Data taken from the Form 3643 included the dispensing date, USA number, bumper number (if reported), unit to which the vehicle was assigned, and number of gallons of fuel dispensed.

Not surprisingly, these data proved to be the most difficult data base to substantiate for several reasons, e.g., poor penmanship and bumper numbers often being given instead of USA numbers. Also, there were several instances where the USA number recorded on the Form 3643 did not match any of the vehicles compiled in the density listings.

DAILY ISSUES OF PETROLEUM PRODUCTS For use of this form, see AR 703-1; the proponent agency is DCSLOG	PAGE NO.	NO. OF PAGES

VEHICLE USA REGISTRATION NUMBER	TYPE, GRADE AND UNIT OF ISSUES FOR EACH PRODUCT ISSUED						ORGANIZATION AND ADDRESS *(Indicate Service: A, Army; AF, Air Force; N, Navy; M, Marine Corps)*	SIGNATURE, GRADE
	ISSUES			RECEIPTS				
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*
TOTAL RECEIPTS	X	X	X					
TOTAL ISSUES				X	X	X		

POST, CAMP OR STATION	DATE	SIGNATURE OF ATTENDANT

SAMPLE

DA FORM 1 DEC 86 3643 EDITION OF 1 OCT 70 IS OBSOLETE. GPO : 1986 0 - 164-976

Figure 2. Sample DA Form 3643

As a summary of the data collected from this source, there were 66,571 total fuel dispensings collected from the nine units at Ft. Bliss. Of these, 42 percent were found to be in error because of the problems with the USA numbers. The remaining 58 percent of the fuel dispensings represented data collected on 1,764 vehicles.

c. Mileage of Operational Data

In order to compute an individual vehicle's mile-per-gallon value during the DF-2 and JP-8 fuel periods, the number of miles under which the vehicle operated was gathered from the information supplied by the Army Maintenance Management System within the U.S. Army Materiel Readiness Support Activity (MRSA). The fuel dispensings recorded on the Form 3643 did not require odometer or mileage readings at the time of dispensing. Thus, it was necessary to collect mileage data from another source. TAMMS data base was the only means by which the mileage data could be assembled. Using the U.S. Army Oil Analysis Program (AOAP) as the source of the mileage records, the TAMMS organization compiled a data file consisting of the following information for each observation:

- National stock number
- Model description
- Equipment serial number
- USA number
- Unit Identification Code (UIC)
- Date of AOAP sample
- Cumulative mileage reading

Some equipment maintained at Ft. Bliss measured usage in units of hours of operation or kilometers driven. The methodology used within the TAMMS data base converts all the measurement units into miles. Thus, the resulting data base provided a date and cumulative mileage reading for the vehicles at Ft. Bliss, which are enrolled in the AOAP program. This mileage data base was merged with the above-mentioned fuel consumption data base in order to compute miles-per-gallon per vehicle. Mileage readings were reported from 1 March 1988 through 31 July 1990 and were comprised of 2,134 vehicles. Of these, 897 vehicles had at least one corresponding fuel dispensing record from the Form 3643 data base.

d. Operational Data — 1/43rd and 2/6th ADA Battalions, 6th ADA Brigade

An autonomous data base was developed for the operational data supplied by the two battalions in the 6th ADA. Monthly fuel mileage reports were collected by the BFLRF monitors and included the following information:

- Line item number
- Vehicle description
- End item serial number
- USA number
- Bumper number
- Total monthly fuel dispensed (gallons)
- Total monthly miles driven or hours operated

Fuel consumption data were collected from the 1/43rd ADA Battalion for the mixture fuel period (February, April through September 1989) and the JP-8 fuel period (October 1989 through July 1990). The 2/6th ADA Battalion also supplied data for the mixture fuel period (May through July, September 1989) and the JP-8 fuel period (October 1989 through July 1990). There were 294 vehicles and 97 generators reported in the JP-8 period for the 1/43rd ADA Battalion while the 2/6th ADA Battalion recounted 44 vehicles during the same fuel period. No generators were found in the 2/6th ADA Battalion.

e. Operational Data — Ft. Bliss Transportation Motor Pool (TMP)

The Transportation Motor Pool at Ft. Bliss provided an independent source of operational data for those vehicles under their jurisdiction. These data were collected via magnetic tape through the Directorate of Information Management, Computer System Support Branch and by floppy disk through the TMP operations. This data base was comprised of 47 vehicles, which supplied operational data from 1 September 1988 through 30 July 1990.

The monthly vehicle observations included the following information:

- USA number
- Line item number
- National stock number
- Admin number
- Total vehicle miles
- Year-to-date vehicle miles
- Year-to-date diesel fuel dispensed
- In-house maintenance cost
- Commercial maintenance cost

Operational data (gallons dispensed and odometer readings) were available in monthly intervals from the sources at Ft. Bliss. A mile-per-gallon value was computed for each vehicle, where appropriate, for each of the three fuel periods by taking the difference in the first and last odometer reading during the fuel period and dividing it by the total number of gallons dispensed during that period.

f. Oil Degradation Data

Data representing the U.S. Army Oil Analysis Program (AOAP) ongoing at Ft. Bliss were collected via magnetic tape through the U. S. Army Materiel Readiness Support Activity (MRSA) at Lexington, KY. All diesel fuel-burning vehicles and equipment enrolled in AOAP (4,195 individual end items) contributed to the data base developed for the purpose of examining differences in the average wear metal readings across vehicle types and between the DF-2 and JP-8 fuel periods. The total number of observations collected through the AOAP program at MRSA was 38,979. Also included in this data base was a count of AOAP laboratory recommended oil changes noted throughout the program from 1 January 1987 through 31 May 1990.

Each observation in the data base contained the following information:

- Unit Identification Code (UIC) number
- Component serial number
- Component description
- End item serial number
- End item description
- Sample date
- Cumulative end item miles/hours of operation
- Miles/hours since overhaul
- Miles/hours since oil change
- Sample wear metal analysis results
- Lab recommendation codes

V. DISCUSSION OF RESULTS

A. Ambient Temperature History

Ambient temperature history was received from the National Climatic Data Center, Asheville, NC for El Paso, TX (Ft. Bliss) and Barstow, CA (Ft. Irwin). The National Training Center, Ft. Irwin, CA, is located about 30 miles east and north of Barstow, CA. The ambient temperature histories for each site are shown in TABLES 3 and 4. Data provided for 1987 and 1988 are for diesel fuel baseline purposes. It is noted that the Ft. Irwin temperature history includes only those months during which the 3rd ACR was training at the NTC.

TABLE 3. Ambient Temperature (°F) History at El Paso, TX (Ft. Bliss)

Year / Month	Avg. Maximum 1988	1989	1990	Avg. Minimum 1988	1989	1990	Highest 1988	1989	1990	Lowest 1988	1989	1990
January	56.9	58.4	59.3	28.3	28.7	28.9	69	70	73	16	11	20
February	63.7	64.9	64.0	33.1	37.8	34.1	78	82	78	22	21	21
March	70.2	74.9	70.9	36.6	42.5	41.2	87	89	86	22	22	30
April	77.6	85.0	81.0	44.6	49.7	51.8	86	98	92	28	33	42
May	87.4	90.3	87.0	53.2	58.0	59.2	98	101	98	35	47	46
June	94.5	97.7	101.5	63.5	64.8	72.6	101	106	110	46	53	55
July	93.4	95.3	92.4	67.1	68.3	67.9	100	108	99	57	62	62
August	88.5	91.5		66.6	66.6		96	99		60	59	
September	87.4	88.2		57.3	58.6		96	95		78	43	
October (Missing 1988)		79.9			46.5			92			28	
November	69.6	68.9		38.3	37.6		86	77		22	26	
December	56.3	56.9		28.9	27.0		68	73		15	8	

TABLE 4. Ambient Temperature (°F) History at Barstow, CA (Ft. Irwin)

Month	Year/Fuel	Avg. Maximum	Avg. Minimum	Highest	Lowest
October	1987/DF-2	90.1	56.3	105	49
May	1989/JP-8	98.2	60.0	112	42
October	1989/JP-8	87.3	49.5	101	32

B. Fuels Analyses and Results

This section discusses analyses performed by BFLRF and General Materiel Petroleum Activity.

1. BFLRF

Appendix B lists all the fuel samples received at BFLRF during the demonstration program by calendar quarter. Included in this listing is sample date and identification and the purpose for the sample. Not included in this listing are the baseline diesel fuel samples. TABLE B-8, in Appendix B, is a compilation of analytical results for the fuel samples from Ft. Bliss.

a. Baseline Diesel Fuel Samples

TABLE 5 is a listing of the DF-2 samples received for baseline comparison purposes. A total of 11 middle samples and 18 bottom samples were received and analyzed. The results of analyses are presented in TABLES 6 and 7. Note that three of the middle samples (AL-183229-F, AL-18338-F, and AL-18341-F) exceeded the VV-F-800D specification limit of 1.5 mg/100 mL for the accelerated stability test, ASTM D 2274. These three samples also have higher existent gum values than the other samples. Sample AL-18329 also exceeds the specification limit of 10 mg/L for particulate contamination. The results for the bottom samples vary; however, several of the samples had visible water or sediment and dark color.

b. Routine Samples

Routine samples were taken on a regular basis to confirm the quality of the fuel being dispensed at Ft. Bliss, as well as the grade and quality of the fuel in underground storage tanks.

(1) BAAF Main Tank

TABLE 8 is a summary, by quarter, of typical properties of the fuel in the BAAF main tank. As shown by this data, throughout the demonstration program, the fuel in the BAAF main tank met JP-8 specification requirements, with only a few exceptions. Several of the fuel system icing inhibitor (FSII) results are below the specification limit. These results are most likely due to partitioning of the FSII into water bottoms either during delivery or in the storage tank and is not of concern. The low values for fuel conductivity are probably due to differences in testing conditions between point of acceptance of the fuel and the BFLRF laboratory. Conductivity is very sensitive to temperature and water content. The off-specification results for particulates and visual appearance for the fifth quarter sample are due to the fact that this was an all-level sample. The bottom of the tank almost always has a water bottom and a higher particulate contamination because of settling in the tank. These contaminants are expected to settle to the bottom of the tank, and the fuel draw-off line is raised from the bottom of the tank to keep from drawing this

TABLE 5. Ft. Bliss DF-2 Samples (Baseline for JP-8 Comparison)

Lab Code	Sample Location	Tank Code	Sample Source	Sample Date	Date Received at BFLRF
AL-18327-F	3rd SQD, 3rd ACR	2970 T3	Bottom	17 Nov 88	22 Nov 88
AL-18328-F	2nd SQD, 3rd ACR	2990 T6	Bottom	17 Nov 88	22 Nov 88
AL-18329-F	2nd SQD, 3rd ACR	2990 T6	Middle	17 Nov 88	22 Nov 88
AL-18330-F	1st SQD, 3rd ACR	2940 T3	Bottom	17 Nov 88	22 Nov 88
AL-18331-F	2nd SQD, 3rd ACR	2990 OH9	Bottom	17 Nov 88	22 Nov 88
AL-18332-F	1st SQD, 3rd ACR	2940 T2	Bottom	17 Nov 88	22 Nov 88
AL-18333-F	1st SQD, 3rd ACR	2940 T2	Middle	17 Nov 88	22 Nov 88
AL-18334-F	1st SQD, 3rd ACR	2940 OH	Middle	17 Nov 88	22 Nov 88
AL-18335-F	1st SQD, 3rd ACR	2940 OH	Bottom	17 Nov 88	22 Nov 88
AL-18336-F	3rd SQD, 3rd ACR	2970 OH5	Bottom	17 Nov 88	22 Nov 88
AL-18337-F	3rd SQD, 3rd ACR	2970 OH5	Middle	17 Nov 88	22 Nov 88
AL-18338-F	2nd SQD, 3rd ACR	2990 T2	Middle	17 Nov 88	22 Nov 88
AL-18339-F	2nd SQD, 3rd ACR	2990 T2	Bottom	17 Nov 88	22 Nov 88
AL-18340-F	S&T SQD, 3rd ACR	2469 T1	Bottom	18 Nov 88	22 Nov 88
AL-18341-F	S&T SQD, 3rd ACR	2469 T1	Middle	18 Nov 88	22 Nov 88
AL-18342-F	Range Command	9522 T1	Middle	18 Nov 88	22 Nov 88
AL-18343-F	Range Command	9522 T1	Bottom	18 Nov 88	22 Nov 88
AL-18355-F	211th ADA Bn	1037 T2	Bottom	30 Nov 88	05 Dec 88
AL-18356-F	217th ADA Bn	9485 T2	Bottom	29 Nov 88	05 Dec 88
AL-18357-F	217th ADA Bn	9485 T2	Middle	29 Nov 88	05 Dec 88
AL-18358-F	217th ADA Bn	9485 T3	Middle	29 Nov 88	05 Dec 88
AL-18359-F	217th ADA Bn	9485 T3	Bottom	29 Nov 88	05 Dec 88
AL-18360-F	HHB-11th ADA Bn	1050 T2	Bottom	30 Nov 88	05 Dec 88
AL-18361-F	216th ADA Bn (6th)	1046 T2	Bottom	30 Nov 88	05 Dec 88
AL-18362-F	1/43rd ADA Bn	2634 T2	Bottom	30 Nov 88	05 Dec 88
AL-18363-F	1/43rd ADA Bn	2634 T2	Middle	30 Nov 88	05 Dec 88
AL-18364-F	2133 Trans. Co.	2673 T4	Middle	30 Nov 88	05 Dec 88
AL-18365-F	70th ORD, 2133 T.C.	2673 T4	Bottom	30 Nov 88	05 Dec 88
AL-18366-F	70th ORD, 62nd T.C.	MED	Bottom	30 Nov 88	05 Dec 88

TABLE 6. Results of Analyses of DF-2 Middle Samples Taken From Ft. Bliss (Baseline for JP-8 Comparison)

Property	ASTM Method	AL-Code No. 18329-F	18333-F	18334-F	18337-F	18338-F	18341-F	18342-F	18357-F	18358-F	18363-F	18364-F	Averages
TAN, mg KOH/g	D 3242	0.014	0.014	0.018	0.018	0.022	0.018	0.015	0.013	0.011	0.010	0.014	0.015
Aromatics, vol%	D 1319	35.1	32.1	31.9	34.4	36.1	34.3	35.3	ND*	ND	ND	ND	34.2
Olefins, vol%	D 1319	2.4	1.6	2.2	2.4	2.1	2.0	2.3	ND	ND	ND	ND	2.1
Sulfur, mass%	D 4294	0.35	0.31	0.34	0.34	0.45	0.35	0.35	0.35	0.33	0.39	0.40	0.36
Hydrogen, mass%	D 3178	12.5	12.8	12.7	12.6	12.5	12.7	12.6	12.6	12.6	12.5	12.4	12.6
Distillation, °C,													
% Recovery	D 86												
Initial Boiling Point		189	194	188	206	173	188	204	205	194	202	216	196
10%		224	222	212	238	216	225	233	231	223	229	245	227
20%		237	233	222	250	229	237	245	242	234	238	254	238
50%		262	261	249	277	264	267	271	269	259	262	278	265
90%		304	311	298	321	327	319	318	318	307	304	322	314
End Point		337	342	336	345	354	347	343	346	337	333	347	342
Residue, vol%		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Gravity, °API	D 1298	33.1	34.3	35.2	32.9	32.8	33.6	32.9	33.1	34.0	33.3	32.2	33.4
Density, kg/L	D 1298	0.8592	0.8530	0.8484	0.8603	0.8608	0.8566	0.8603	0.8592	0.8545	0.8582	0.8639	0.8577
Cloud Point, °C	D 2500	-23	-21	-26	-17	-16	-18	-18	-13	-16	-14	-8	-17
K. Vis, cSt, at													
40°C	D 445	2.43	2.46	2.15	2.98	2.52	2.53	2.70	2.66	2.36	2.44	3.00	2.57
70°C	D 445	1.50	1.51	1.36	1.77	1.56	1.55	1.64	1.62	1.48	1.50	1.78	1.57
Net Heat of													
Combustion	D 240												
MJ/kg		42.246	42.387	42.463	42.346	42.207	42.320	42.276	42.300	42.344	42.203	42.267	42.305
Btu/lb		18163	18223	18256	18206	18146	18194	18175	18186	18205	18144	18172	18188
Btu/gal.		130011	129493	129033	130482	130125	129851	130260	130175	129601	129711	130802	129959
Cetane Number	D 613	43	46	45	45	43	44	45	44	45	43	46	44
Cetane Index	D 976	43	45	43	46	43	45	45	45	44	43	45	44
Existent Gum,													
mg/100 mL	D 381	12.4	3.5	2.7	1.5	21.4	11.0	2.9	3.2	3.2	4.0	2.3	6.2
Particulate													
Contamination, mg/L	D 2276	14.7	3.6	2.0	6.9	6.9	7.6	4.8	1.7	1.8	1.2	1.5	4.8
Accelerated Stability,													
mg/100 mL	D 2274	2.8	1.3	1.2	1.0	2.7	2.9	1.1	ND	ND	ND	ND	1.9
FSII, vol%		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Conductance, pS/m		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Corrosion Inhibitor,													
mg/L		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Visual	D 4176	Cl/Br**	Sed/Br	Sed/Br	Cl/Br	Cl/Br	Cl/Br	Cl/Br	Sed/Br	Sed/Br	Sed/Br	Sed/Br	--

* ND = Not Determined.
** Cl/Br = Clean/Bright; Sed/Br = Sed/Bright.

(WEB1.B)

TABLE 7. Results of Analyses of DF-2 Bottom of Tank Samples Taken From Ft. Bliss (Baseline for JP-8 Comparison)

AL-Code No.	Color, D 1500	Visual, D 4176	Water and Sediment, vol%	°API Gravity	Density, kg/L
18327-F	5.5	Sed/Dark	0.133	32.7	0.8613
18328-F	4.0	Sed/Dark	0.043	33.1	0.8592
18330-F	2.5	Sed/Bright	<0.005	34.6	0.8515
18331-F	1.5	Clean/Bright	<0.005	32.1	0.8645
18332-F	2.0	Clean/Bright	0.008	34.3	0.8530
18335-F	2.0	Sed/Bright	0.010	35.2	0.8484
18336-F	1.0	Sed/Bright	<0.005	32.9	0.8603
18339-F	4.5	Sed/Bright	0.043	32.8	0.8608
18340-F	3.0	Sed/Bright	0.040	33.6	0.8566
18343-F	1.5	Clean/Bright	0.005	33.0	0.8597
18355-F	3.5	Sed/Cloudy	0.010	32.2	0.8639
18356-F	2.0	Sed/Bright	<0.005	33.1	0.8592
18359-F	2.0	Sed/Bright	0.010	33.3	0.8582
18360-F	5.5	Sed/Cloudy	0.070	33.6	0.8566
18361-F	2.0	Sed/Cloudy	0.010	32.2	0.8639
18362-F	2.5	Sed/Bright	<0.005	33.2	0.8587
18365-F	1.5	Sed/Cloudy	0.070	32.1	0.8645
18366-F	4.5	Sed/Cloudy	0.120	33.0	0.8597

contamination. Since the bottom of the tank was also sampled, the sample contained excess contamination, which would not be dispensed from the tank. As such, these off-specification results are not considered indicative of the condition of the bulk of the fuel in the tank.

TABLE 8. Properties for Fuel in BAAF Main Tank (By Quarter*)

Property	ASTM Method	MIL-T-83133C JP-8 Requirements	1st Quarter	2nd Quarter	4th Quarter	5th Quarter	6th Quarter	7th Quarter	Averages
TAN, mg KOH/g	D 3242	0.015, max	ND (1)	0.003	0.003	0.006	0.006	0.004	0.004
Aromatics, vol%	D 1319	25.0, max	ND	17.8	14.6	16.9	17.1	17.0	16.7
Olefins, vol%	D 1319	5.0, max	ND	2.5	1.2	1.6	1.3	1.4	1.6
Sulfur, mass%	D 4294	0.30, max	0.03	0.03	0.01	0.04	<0.01	0.04	0.03
Hydrogen, mass%	D 3178	13.4, min	13.67	13.69	13.9	13.54	14.09	14.02	13.82
Distillation, °C	D 86								
Initial Boiling Point		Report	181	182	176	174	175	178	178
10% Evaporated		205, max	199	202	191	194	191	190	195
20% Evaporated		Report	ND	207	195	198	194	194	198
50% Evaporated		Report	219	219	206	208	204	207	211
90% Evaporated		Report	245	242	230	233	228	232	235
End Point		300, max	266	266	269	263	265	253	264
Residue, vol%		1.5, max	1.0	1.0	1.0	1.0	0.5	0.5	0.8
Gravity, °API	D 1298	37 to 51	41.9	42	46.6	44.6	46.4	44.2	44.3
Density, kg/L	D 1298	0.840 to 0.775	0.8147	0.8152	0.7941	0.8032	0.7950	0.8050	0.8045
Cloud Point, °C	D 2500	NR (2)	ND	<-60	-50	-53	-53	-54	-54
Flash Point, °C	D 93	38, min	ND	ND	53	60	56	60	57.3
K. Vis, cSt, at									
40°C	D 445	NR	ND	1.55	1.30	1.37	1.30	1.36	1.38
70°C	D 445	NR	ND	1.05	0.90	0.94	0.91	0.95	0.95
Net Heat of Combustion	D 240								
MJ/kg		42.8, min	43.026	43.015	43.294	43.259	43.236	TBD (3)	43.166
Btu/lb		18,400, min	18,498	18,493	18,613	18,598	18,588	TBD	18,558
Btu/gal.		NR	125,791	125,685	123,233	124,532	123,206	TBD	124,489
Cetane Number	D 613	NR	ND	42.8	47.0	46.5	47.6	46.6	46.1
Cetane Index	D 976	Report	45.5	45.9	49.4	46.5	48.5	45.1	46.8
Existent Gum, mg/100 mL	D 381	7.0, max	ND	0.4	0.8	1.5	1.3	1.8	1.2
Particulate Contamination, mg/L	D 2276	1.0, max	ND	0.6	0.6	7.1	0.8	1.0	2.0
Accelerated Stability, mg/100 mL	D 2274	NR	ND	0.2	0.1	0.2	0.1	0.1	0.1
FSII, vol%		0.10 to 0.15	0.07	0.09	0.13	0.09	0.10	0.05	0.09
Fuel Conductivity, pS/m		150 to 600	170	75	120	100	70	90	104
Corrosion Inhibitor, mg/L†		QPL-25017	Trace	19.2	8	ND	9	16.4	13.2
Visual	D 4176	Clean/Bright	ND	Clean/Bright	Clean/Bright	Sed/Hazy	Clean/Bright	Clean/Bright	Clean/Bright
Colonial Pipeline Co. Haze Rating	Proposed	NR	ND	ND	1	2	1	1	1
Color	D 156	Report	+30	ND	+24	+20	+30	TBD	+26

* No 3rd Quarter Data Available.
(1) ND = Not Determined.
(2) NR = No Requirement.
(3) TBD = To Be Determined.
† Based on HITEC E580.

(WEB1.B)

(2) Motor Pool Underground Storage Tanks

Periodically throughout the program, samples were taken from various motor pool underground storage tanks. These samples were analyzed as a means to determine the extent of infiltration of JP-8 into the Ft. Bliss fuel storage and dispensing system. Since not all tanks were sampled each quarter, only average data are presented here. Fig. 3 is a summary of average results for sulfur, density, viscosity, particulates, and accelerated stability. Also, the results presented here are for middle samples only, no bottom sample results are presented. Notice that according to the data presented in Fig. 3, the fuel in the underground tanks seemed to reach an equilibrium somewhere between the third and fourth quarters. This is the point at which the post was declared to be totally on JP-8.

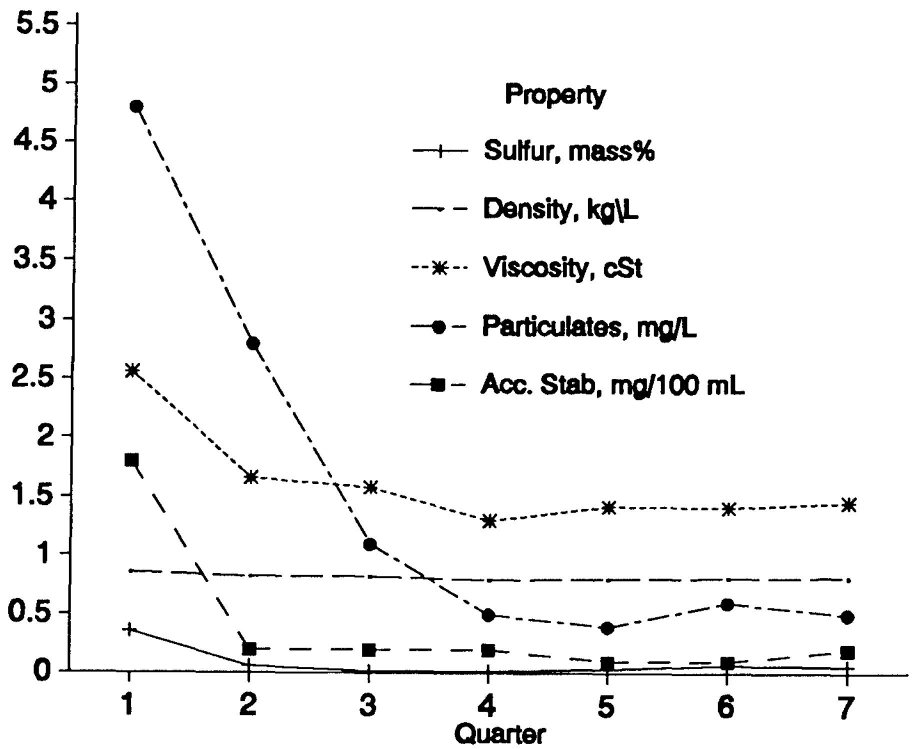


Figure 3. Comparative fuels data
(Underground Storage Tanks)

(3) Ft. Irwin, CA

Sample AL-18737-F is a fuel sample received from Ft. Irwin during the period in which the 3rd ACR was training at the National Training Center. The sample was analyzed for conformance to the JP-8 specifications. The results are given in TABLE 9. The sample meets all JP-8 specifications for which it was tested. Additionally, reports from GMPA Lab West in Tracey, CA, indicated satisfactory tests and analyses results from samples taken from delivery trucks. This fuel was purchased against MIL-T-83133C, and, as such, this was the specification used for determining specification conformance. However, VV-F-800D, OCONUS DF-2 specifications limits are also given in TABLE 9 for information. Notice that the sample met all DF-2 specifications for which it was tested, with the exception of cetane number and cetane index.

c. Nonroutine Samples

Nonroutine samples were taken to either aid in resolution of a fuel-related problem or as additional information for a vehicle/equipment performance test. The results and discussion of the analyses of nonroutine samples are given below, grouped according to the reason for the sample.

(1) Fuel-Related Problems

(a) A BFLRF staff member visited Ft. Bliss during July 1989 and met with the 3rd ACR executive officer, 2/3rd Squadron commander, and the TACOM LAR to discuss preliminary results of analysis of fuel samples (AL-18903 to AL-18908) and fuel filters obtained from the 2/3rd Squadron at Dona Anna Range. This analysis was in response to reported fuel filter plugging in several squadron tracked vehicles. Fuel results are presented in TABLE 10. These data indicate that two of the three front fuel cell samples (18903 and 18907) were diesel fuel. The other front fuel cell was a mixture of DF-2 and JP-8. The rear fuel cells all contained JP-8. One front fuel cell sample, 18903, was very high in particulates. The two DF-2 samples also had very high accelerated stability results. Analysis of the fuel samples and fuel filters indicated that the cause of the filter plugging was fuel degradation products from the deterioration of diesel fuel. Although many of the vehicles in question were operating on JP-8, some of the M1A1 battle tanks still had diesel fuel in their front fuel cells. The results showed no evidence of microbiological contamination. The Regiment's executive officer requested that

TABLE 9. Properties of JP-8 as Compared to Diesel Fuel Specifications

Property	Method	MIL-T-83133C JP-8 Requirements	VV-F-800D DF-2 OCONUS Requirements	Ft. Irwin AL-18737-F
Saybolt Color	D 156	Report	NR (1)	+25
Color	D 1500	NR	NR	0.5
Sulfur, Total, mass%	XRF (2)	0.3, max	0.30, max	<0.01
Distillation, °C	D 86			
Initial Boiling Point		Report	NR	186
10% Recovered		205, max	NR	203
20% Recovered		Report	NR	207
50% Recovered		Report	Report	218
90% Recovered		Report	357, max	247
End Point		300, max	370, max	278
Residue, vol%		1.5, max	3, max	0.5
Loss, vol%		1.5, max	NR	0
Flash Point, °C	D 56	NR	56, min	57
Flash Point, °C	D 93	38, min	NR	ND (3)
Gravity, °API	D 1298	37 to 51	NR	37.9
Density, 15°C, kg/L	D 1298	0.755 to 0.840	0.815 to 0.860	0.834
Kinematic Viscosity, cSt,	D 445			
at -20°C		8.0, max	NR	6.63
at 40°C		NR	1.9 to 4.1	1.68
at 70°C		NR	NR	1.12
Net Heat of Combustion,	D 240			
Btu/lb		18,400 min	NR	18,445
MJ/kg		42.8, min	NR	42.902
Hydrogen, mass%	D 3178	13.4, min	NR	13.7
Particulate Contamination, mg/L	D 2276	1.0, max	10, max	0.6
Fuel System Icing Inhibitor	FED-STD-791, Method 5340	0.10 to 0.15	NR	0.102
Fuel Electrical Conductivity, pS/m	D 2624	150 to 600	NR	300
Cetane Number	D 613	NR	45, min	37.8
Cetane Index	D 976-80	NR	43, min	38.2
Corrosion Inhibitor, mg/L	(4)	Report	NR	NR

(1) NR = No Requirement.
(2) X-Ray Fluorescence.
(3) ND = Not Determined.
(4) Extration/Liquid chromatography method using HITEC E580 as standard.

TABLE 10. Selected M1A1 Front and Rear Fuel Cell Sample Results

Property	ASTM Test Method	Front Fuel Cell AL-18903-F	Rear Fuel Cell AL-18904-F	Front Fuel Cell AL-18905-F	Rear Fuel Cell AL-18906-F	Front Fuel Cell AL-18907-F	Rear Fuel Cell AL-18908-F
Gravity, °API	D 1298	33.3	45.1	39.2	41.7	33.4	41.4
Visual Appearance	D 4176	Sed/Hazy	Sed/Bright	Sed/Hazy	Clean/Bright	Clean/Dark	Sed/Hazy
Color	D 1500	4.0	<0.5	2.5	<0.5	5.0	1.0
Distillation, °C	D 86						
Initial Boiling Point		191	186	189	186	192	187
10% Recovered		224	202	204	202	226	203
20% Recovered		238	207	210	207	243	208
50% Recovered		270	220	230	221	278	221
90% Recovered		322	246	281	246	321	248
End Point		351	282	332	278	356	290
Residue, vol%		1.5	1.0	1.5	1.0	1.5	1.5
Particulate Cont., mg/L	D 2276	19.9	1.1	1.3	1.3	5.4	1.2
Accelerated Stability, mg/100 mL	D 2274	5.0	0.2	0.8	0.1	5.8	0.2

the front fuel cells in M1A1 vehicles in the 1st and 3rd Squadrons be sampled and tested for fuel grade and quality. These vehicles were supposed to contain only JP-8, and he wished to confirm this fact. As a result, 16 samples were obtained from front fuel cells (two vehicles per troop) and mailed to BFLRF for analysis. Gas chromatographic analysis confirmed that the fuel in all of the fuel cells was 90 to 100 percent JP-8.

(b) During July 1989, two fuel samples were taken from the right fuel tank of a 5-ton truck. During routine inspection, this fuel tank, a reserve fuel tank, was found to contain diesel fuel. A sample of this fuel was sent to BFLRF, and the fuel was confirmed to be diesel fuel. The fuel tank was drained and refilled with JP-8, and a sample of this fuel was sent to BFLRF for routine analysis. This fuel was found to be highly contaminated with particulates. The particulate contamination level was 40.1 milligrams per liter.

(c) Two samples of JP-8 were taken during December 1989 directly from the delivering vehicle and forwarded to GMPA for analysis. These samples were reported as not meeting specification requirements due to particulate contamination. The GMPA reported results are given in TABLE 11.

TABLE 11. GMPA Particulate Results for JP-8 From Ft. Bliss

Sample No.	Description	Sample Type	Particulate, D 2276, mg/L
TX-38-01	Biggs POL Point FBT 79916 7500 Gallon	Composite	8.5
TX-38-05	Biggs POL Point FBT 79916 20,000 Gallon	Bottom	2.4

These results raised some concern for these reasons:

- Not all of the receiving (fill) lines at the BAAF main tank have filtration capability, which means that any particulates in the fuel being delivered to BAAF can be pumped into the main tank.

- The GMPA results indicate that the fuel being delivered to BAAF contained unsatisfactory levels of particulates. It is not known if the fuel was dirty prior to being introduced into the delivery vehicles or if the delivery vehicles were dirty. In either case, since the delivery vehicles are completely drained during receipt of shipment, any dirt in the delivery vehicles/fuel was probably pumped into the BAAF main storage tank.

In mid-February 1989, BFLRF monitors obtained two samples from the BAAF main storage tank. One sample was taken from the bottom of the tank, and one sample was taken from the middle of the fuel. A complete discussion of the results of analysis is given below. However, the particulate results were 0.8 mg/L for the middle sample and 32.2 mg/L for the bottom sample.

These results indicate contamination on the bottom of the tank, but the contamination does not seem to be throughout the fuel.

During late February, BFLRF monitor personnel were at BAAF during receipt of a fuel shipment. Samples were taken from several points in an attempt to determine the particulate content of the fuel being delivered, the fuel in the main tank, and the fuel being dispensed. Samples were also taken from various levels near the bottom of the main tank to determine if particulates on the bottom of the tank were being stirred into the fuel during fuel receipt. One sample was also taken 12 inches from the bottom of the main tank, after the fuel had set for one day, to determine if particulates stirred up during fuel receipt are fully settled after 24 hours. A total of seven fuel samples were taken and returned to BFLRF for particulate analysis. The results of these analyses are given in TABLE 12. The delivery truck sample result (AL-19201-F) shows that the fuel delivered in this shipment was clean; however, since this sample was taken from the top of the fuel, it is not known if any dirt was on the bottom of the truck tank. The main tank still has

TABLE 12. BFLRF Particulate Results for JP-8 From Ft. Bliss

Sample No.	Description	Particulate, D 2276, mg/L
AL-19201-F	Delivery Truck Dip Sample	0.5
AL-19200-F	Main Tank Bottom Sample	17.6
AL-19202-F	Main Tank 4 in. From Bottom	1.1
AL-19203-F	Main Tank 12 in. From Bottom	0.6
AL-19199-F	Main Tank Middle Sample	1.1
AL-19204-F	Dispensing Pump After Filter	0.3
AL-19210-F	Main Tank 12 in. From Bottom After 24-Hour Settling	0.9

particulates on the tank bottom (AL-19200-F); this is not surprising since this is where particulates should collect. Some of the bottom particulates were probably introduced with fuel shipments. The bulk of the fuel in the main tank was clean (AL-19210-F), and the fuel being dispensed was very clean (AL-19204-F). The results also showed that filling the tank did not seem to stir up particulates from the bottom of the tank (AL-19199-F, AL-19202-F, and AL-19203-F).

(d) TABLE 13 lists the results of analysis of a diesel fuel sample taken from an underground storage tank at the Ora Grande Range. BFLRF was asked to analyze this fuel and provide comments concerning its quality. This fuel failed to meet VV-F-800D specification limits for particulates and for accelerated stability. BFLRF recommended that this fuel not be used in tracked vehicles.

(2) Vehicle/Equipment Tests

(a) The fuels listed in TABLE 14 are fuel samples from a bus from the Transportation Motor Pool. This bus was involved in a comparative test with diesel fuel and JP-8. The results of analysis of these fuels indicate that sample AL-18991 is diesel fuel, while sample AL-18990 is primarily JP-8.

(b) The fuels in TABLE 15 are samples taken from vehicles used by the 1/85th Regiment (Reserve) for training exercises at Ft. Bliss. Samples were taken prior to the training as well as after the training exercises. The analytical results show that there was some JP-8 in the fuel cells of the vehicles (this was confirmed by gas chromatography). The fuel was still relatively dark in color; 3.0 to 4.0 for the samples versus 0.5 for pure JP-8. However, as shown by the samples from vehicle No. 12, the particulate contamination was decreasing. The quality of the fuel in the vehicles was improving. As JP-8 continued to be used in these vehicles, the quality of the fuel improved even more.

TABLE 13. Results of Analyses of JP-8 Fuel Samples Taken From Ft. Bliss

Property	ASTM Method	MIL-T-83133C JP-8 Requirements	BAAF Main Tank Middle AL-19189-F	BAAF Main Tank Bottom AL-19190-F
TAN, mg KOH/g	D 3242	0.015, max	0.006	0.006
Aromatics, vol%	D 1319	25.0, max	17.1	15.9
Olefins, vol%	D 1319	5.0, max	1.3	1.2
Sulfur, mass%	D 4294	0.30, max	<0.01	0.08
Hydrogen, mass%	D 3178	13.4, min	14.09	13.65
Distillation, °C	D 86			
Initial Boiling Point		Report	175	172
10% Evaporated		205, max	191	192
20% Evaporated		Report	194	196
50% Evaporated		Report	204	208
90% Evaporated		Report	228	238
End Point		300, max	265	274
Residue, vol%		1.5, max	0.5	0.5
Gravity, °API	D 1298	37 to 51	46.4	40.9
Density, kg/L	D 1298	0.840 to 0.775	0.7950	0.8204
Cloud Point, °C	D 2500	NR (1)	-53	-53
Flash Point, °C	D 93	38, min	56	58
K. Vis, cSt, at				
40°C	D 445	NR	1.30	1.43
70°C	D 445	NR	0.91	0.95
Net Heat of Combustion,	D 240			
MJ/kg		42.8, min	43.236	42.819
Btu/lb		18,400, min	18,588	18,409
Btu/gal.		NR	123,206	125,912
Cetane Number	D 613	NR	47.6	45.0
Cetane Index	D 976	Report	48.5	39.5
Existent Gum, mg/100 mL	D 381	7.0, max	1.3	6.8
Particulate Contamination, mg/L	D 2276	1.0, max	0.8	32.2
Accelerated Stability, mg/100 mL	D 2274	NR	0.1	0.1
FSII, vol%		0.10 to 0.15	0.10	0.18
Fuel Conductivity, pS/m		150 to 600	70	60
Corrosion Inhibitor, mg/L*		QPL-25017	9	19
Visual	D 4176	Clean/Bright	Clean/Bright	Sed/Water
Colonial Pipeline Co. Haze Rating	Proposed	NR	1	2
Color	D 156	Report	+30	+2

(1) NR = No Requirement.
* Based on HITEC E580.

TABLE 14. Results of Analyses of JP-8 Fuel Taken From TMP Bus at Ft. Bliss

	USA No. CE6612, Bus, 44 PAX, AL-18990-F	USA No. CE6612, IHC-DT466B, AL-18991-F
Color, D 1500	0.5	2.0
Gravity, °API, D 1298	39.6	37.2
Density, D 1298	0.8266	0.8383
Particulate Contamination, D 2276, mg/L	1.4	10.5
Visual, D 4176	Clean/Bright	Sediment/Hazy

TABLE 15. Results of Analyses of JP-8 Fuel Samples Taken From Vehicles at Ft. Bliss (1/85th Regiment)

	M113, No. 12, AL-18958-F, AL-18995-F	M113, No. 16, AL-18945-F, AL-18993-F	M113, No. 28, AL-18944-F, AL-18994-F	M113, No. 46, AL-18943-F, AL-18992-F
Color, D 1500				
Before	4.0	4.0	5.5	4.5
After	3.0	3.5	4.0	3.5
Gravity, °API, D 1298				
Before	37.7	35.0	34.4	37.0
After	40.0	38.5	38.4	39.6
Density, D 1298				
Before	0.8359	0.8494	0.8525	0.8393
After	0.8247	0.8319	0.8324	0.8266
Particulate Contamination, mg/L, D 2276				
Before	11.9	ND*	ND	ND
After	1.9	5.0	4.9	6.1
Visual, D 4176				
Before	Sed/Hazy**	Sed/Hazy	Sed/Hazy	Sed/Hazy
After	Sed/Hazy	Sed/Hazy	Sed/Hazy	Sed/Hazy

* ND = Not Determined.
** Sed/Hazy = Sediment/Hazy.

(c) The data in TABLE 16 represent four fuel samples of fuel purchased during a convoy from Ft. Bliss, TX, to Ft. Irwin, CA. Each sample was taken from the M915 vehicle fuel tank immediately after fueling. The sample in Can 1 represented fuel obtained from Ft. Bliss and was JP-8 only. Subsequent fuelings were with DF-2. Therefore, the remaining samples were a mixture of JP-8 and diesel. Note that the samples in Cans 2, 3, and 4 had relatively high sulfur levels, although still within specification limits. The visible sediment and water noted in the samples from Cans 2 and 4 were not of great concern, since all samples were taken from the vehicle fuel tank. Also, the sample from Can 1 was below the DF-2 minimum viscosity limit of 1.9 cSt, which is to be expected of JP-8 fuel. This fuel did meet the DF-1 specification limit of 1.3 to 2.9. With the above exceptions, all four samples met the VV-F-800D, CONUS DF-2 specifications.

(d) The four samples listed in TABLE 17 were obtained during a bulldozer test at Ft. Bliss. These samples were analyzed to confirm the grade of fuel. The preliminary distillation results indicated that samples 19400 and 19401 were DF-2 while samples 19402 and 19403 were JP-8. The data for boiling point distribution by gas chromatography found in Figs. 4 through 7 confirm this finding.

2. GMPA Results

Throughout the demonstration program, the GMPA Laboratory (West) at Tracey, CA, provided BFLRF with copies of all analysis reports for samples of JP-8 fuel from Ft. Bliss, TX. TABLE 18 is a compilation of these reported results.

C. Bulk Fuel Consumption

Because of the fact that JP-8 fuel has a lower volumetric net heat of combusion than diesel fuel, it was anticipated that more JP-8 fuel might be required in order to make up for the lower energy content. Based on computations alone, a determination could be made as to how much additional JP-8 fuel would be required to achieve the same energy content as a given amount of

TABLE 16. Results of Analyses of Fuel Tank Samples Taken From Ft. Bliss M915 Convoy Vehicle

Sample Identification:		Can No. 1	Can No. 2	Can No. 3	Can No. 4	VVF-800D Requirements
Property	ASTM Method	AL-19047-F	AL-19048-F	AL-19049-F	AL-19050-F	DF-2 CONUS
TAN, mg KOH/g	D 3242	0.004	0.091	0.102	0.1	NR (1)
Aromatics, vol%	D 1319	17.6	33.7	34.5	34.9	NR
Olefins, vol%	D 1319	1.3	1.3	1.9	1.9	NR
Sulfur, mass%	D 4294	0.02	0.41	0.35	0.34	0.50, max
Hydrogen, mass%	D 3178	14.15	12.76	12.84	12.36	NR
Distillation, °C	D 86					
IBP		179	183	189	109	NR
10% evap		193	226	233	232	NR
20% evap		198	246	251	250	NR
50% evap		211	283	283	283	Report
90% evap		238	333	333	333	338, max
End Point		273	360	361	361	370, max
Residue, vol%		1.0	1.0	1.0	1.0	3.0, max
Gravity, API	D 1298	43.9	32.1	31.7	31.8	NR
Density, kg/L	D 1298	0.8064	0.8654	0.8666	0.866	Report
Cloud Point, °C	D 2500	-52	-11	-11	-11	Local
Flash Point, °C	D 93	57	64	63	64	52, min
K. Vis, cSt, at	D 445					
40°C		1.47	3.11	3.21	3.35	1.9 to 4.4
70°C		0.99	1.91	2.12	2.8	NR
Net Heat of Combustion,						
MJ/kg		42.915	42.087	42.266	42.280	NR
Btu/lb		18,450	18,094	18,171	18,177	NR
Btu/gal.		124,034	130,415	131,291	131,254	NR
Cetane Number	D 613	46.6	46.2	44.4	45.5	40, min
Cetane Index	D 976	46.2	46.0	45.5	45.5	43, min
Existent Gum, mg/100 mL	D 381	1.3	2.1	6.2	6.7	NR
Particulate Contamination, mg/L	D 2276	6.0	7.5	2.2	8.2	10.0, max
Accelerated Stability, mg/100 mL	D 2274	0.1	0.2	0.2	0.3	1.5, max
FSII, vol%		0.09	ND*	ND	ND	NR
Fuel Conductivity, pS/m		100	ND	ND	ND	NR
Corrosion Inhibitor, mg/L**		22	ND	ND	ND	NR
Visual	D 4176	Cl/Br	Sed/Water	Cl/Br	Sed/Water	Cl/Br
Color	D 1500	0.5	0.5	1.0	1.5	NR
Color	D 156	+21	ND	ND	ND	NR

(1) NR = No Requirement.
* ND = Not Determined for Diesel Fuel Sample.
** Based on HITEC E580.

TABLE 17. Results of Analyses of Bulldozer Fuel Samples Taken From Ft. Bliss

Property	ASTM Method	MIL-T-83133C JP-8 Requirements	DF-2 E-53 AL-19400-F	DF-2 E-54 AL-19401-F	JP-8/DF-2 E-54 First Sample AL-19402-F	JP-8/DF-2 E-54 Second Sample AL-19403-F
Gravity, °API	D 1298	37 to 51	33.8	33.5	42.0	41.2
Density, kg/L	D 1298	0.775 to 0.840	0.8556	0.8571	0.8152	0.8189
Color	D 1500	Not Required	1.5	1.0	1.0	0.5
Visual	D 4176	Clean/Bright	Clean/Bright	Sed/Hazy	Clean/Bright	Clean/Bright
Distillation, °C	D 86					
Initial Boiling Point		Report	196	192	178	178
10% Evap		205, max	223	220	194	196
20% Evap		Report	234	232	201	201
50% Evap		Report	259	258	216	216
90% Evap		Report	302	303	254	242
End Point		300, max	327	325	301	276
Residue, vol%		1.5, max	0.5	0.5	0.5	0.5

diesel fuel. In actual operation, this potential difference in amounts of fuel also depends on variation in fuel consumption by different types of V/E, variation in V/E density, and the frequency and extent of major training exercises. It was possible to account for Ft. Bliss fuel consumption by two methods, (1) acquiring total fuel consumption from bulk fuel dispensings at BAAF tank farm, and (2) acquiring fuel dispensings to individual vehicles. Bulk fuel consumption for Ft. Bliss and the 3rd ACR exercises at the National Training Center, Ft. Irwin, CA, are shown in TABLES 19 and 20.

It is believed that the total bulk fuel dispensings are higher with JP-8 than DF-2 for the following reasons:

- M151A1 utility trucks (gasoline) replaced by CUCV and HMMWVs (diesel) in FY89 and FY90
- M113A1 (6V-53) personnel carriers replaced by M3 (VTA-903T) fighting vehicles in FY89
- Introduction of the HEMTT series trucks resulted in the turn-in of several M35A2/M54A2 LD(S) 465-1 trucks in FY89 and FY90
- Intentional drawdown of DF-2 during 1 QTR FY89 and 2 QTR FY89 (Jan) for initial fill of JP-8.

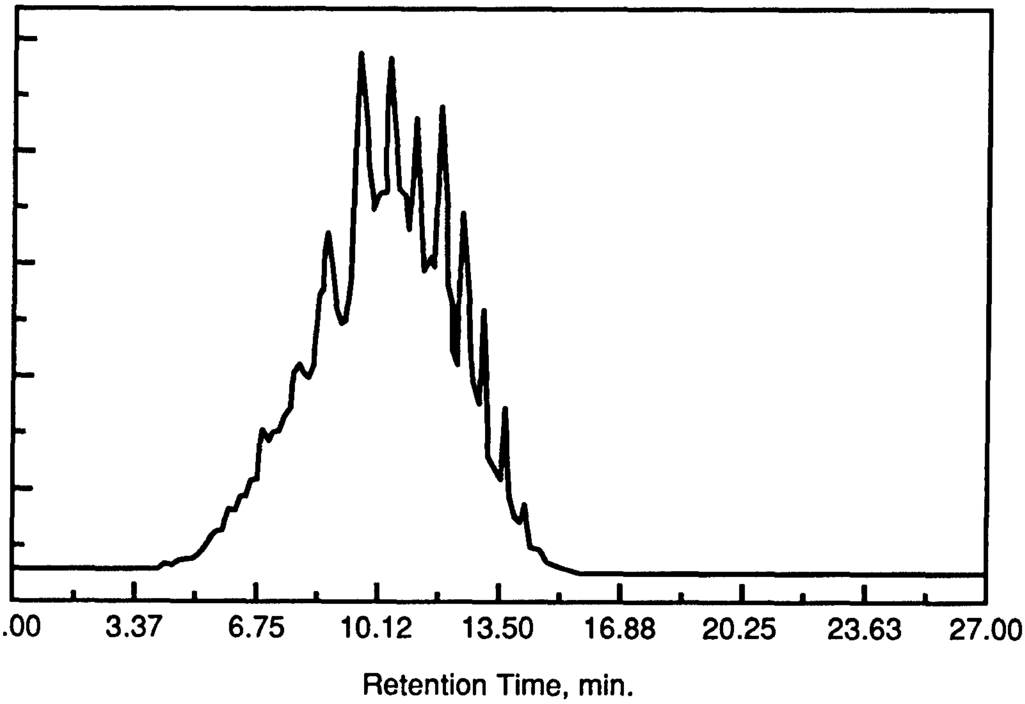


Figure 4. Gas chromatographic boiling point distribution for sample AL-19400-F

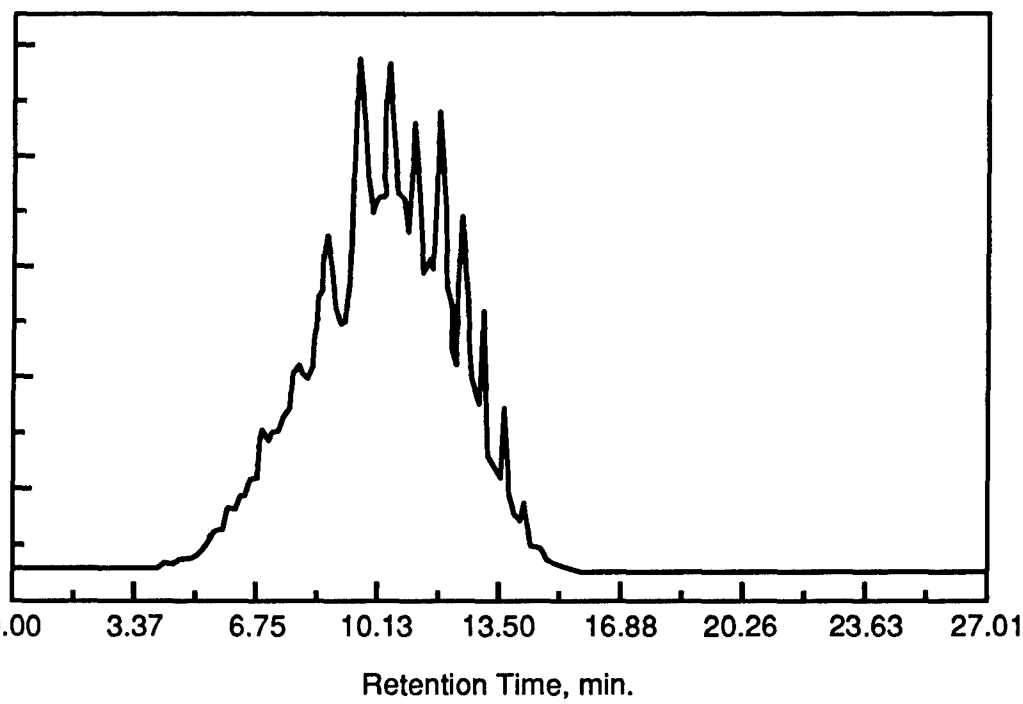


Figure 5. Gas chromatographic boiling point distribution for sample AL-19401-F

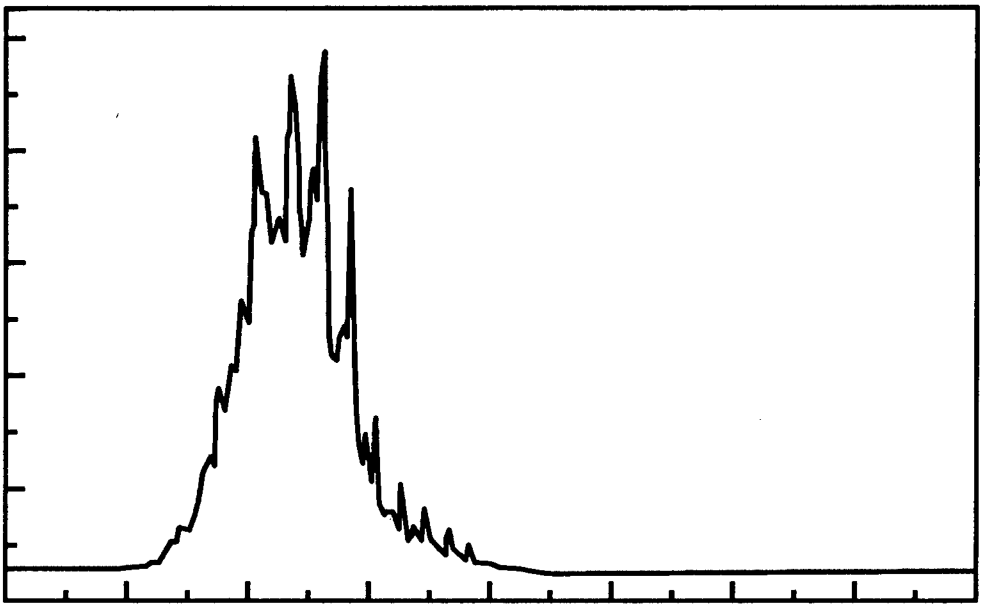


Figure 6. Gas chromatographic boiling point distribution for sample AL-19402-F

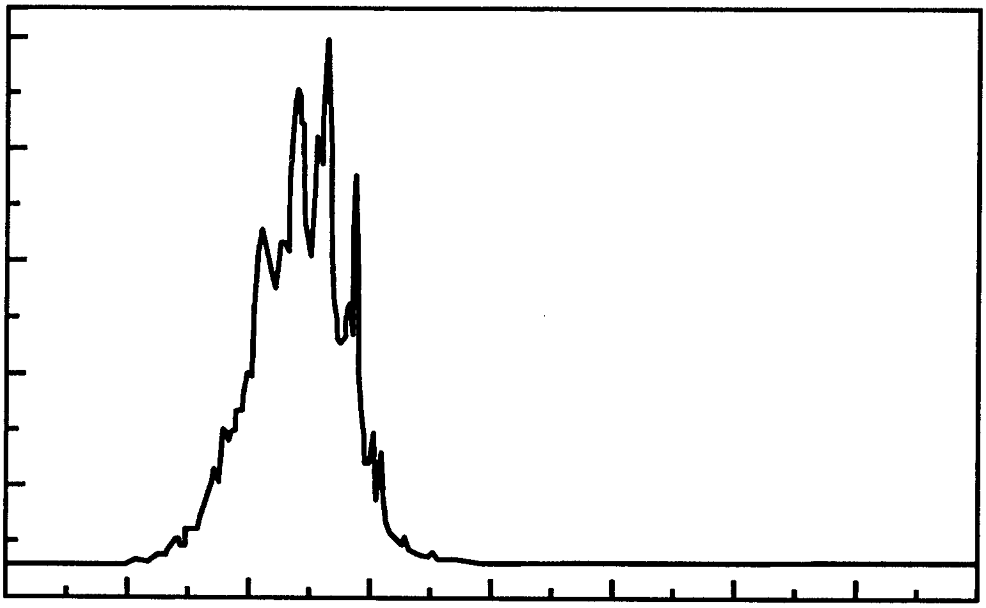


Figure 7. Gas chromatographic boiling point distribution for sample AL-19403-F

TABLE 18. GMPA Laboratory Analyses Results

Lab No.	CA-89-23	TX-38-01	TX-38-05	TX-38-13	TX-38-14	TX-38-17	TX-38-18	TX-38-19	TX-38-22	TX-38-23
Gravity, °API	38.6	46.6	46.2	46.7	46.4	46.2	46.3	42.2	46.2	46.6
Visual Appearance	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B
Distillation, °C										
IBP	175	167	175	173	178	180	180	178	185	176
10%	192	179	188	188	193	184	184	195	190	188
20%	202	193	192	192	198	190	192	200	200	194
50%	216	205	200	204	208	200	210	214	210	203
90%	244	228	220	227	236	225	237	240	238	227
End Point	265	252	253	257	275	248	260	270	270	260
Recovered	98.0	98.0	98.0	97.5	98.5	98.0	98.0	99.0	98.0	98.0
Loss	0.5	1.3	1.0	1.3	0.1	0.9	0.9	0.5	0.9	0.8
Residue	1.0	1.2	1.0	1.2	1.4	1.1	1.1	0.5	1.1	1.2
Cetane Index, D 976	38.5	49.5	46.5	49.0	50.0	47.0	51.0	36.0	43.0	50.5
Existent Gum, mg/100mL	0.8	0.2	0.2	0.8	0.2	1.2	0.8	0.8	0.8	1.0
Copper Corrosion	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A
Flash Point, °C	62	48	56	54	48	53	54	67	60	56
Cloud Point, °C	-50	-42	-43	-49	-47	-43	-43	-50	-43	-43
Water Reaction	1B	1A	1A	1A	1B	1B	1B	1	1B	1B
Icing Inhibitor, vol%	0.15	0.11	0.13	0.13	0.10	0.12	0.12	0.13	0.19	0.11
Particulates, D 2276, mg/L	0.0	8.5	2.4	0.0	0.1	1.5	1.1	0.2	0.5	1.4
K. Vis, 40°C, cSt	1.6	1.3	1.3	1.2	1.3	1.3	1.3	1.6	1.4	1.3
K. Vis, 70°C, cSt	1.1	0.9	0.9	0.9	0.9	0.9	0.9	1.0	0.9	0.9

Lab No.	TX-38-27	TX-38-33	TX-38-37	TX-38-38	TX-38-39	TX-38-40	TX-38-41	TX-38-42	TX-38-43	TX-38-59
Gravity, °API	45.2	40.7	41.1	42.0	40.9	42.9	42.5	42.3	42.8	44.8
Visual Appearance	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B
Distillation, °C										
IBP	175	177	178	178	177	167	178	166	168	182
10%	193	196	197	195	195	188	195	194	195	188
20%	197	198	202	200	215	195	202	202	202	193
50%	207	208	215	217	236	208	215	215	215	205
90%	234	237	235	240	247	234	238	237	240	230
End Point	264	270	260	264	260	258	263	264	265	246
Recovered	98.5	98.5	98.0	98.0	98.0	98.0	98.0	98.0	98.5	98.0
Loss	0.5	0.4	0.9	1.0	1.0	1.5	1.0	1.5	1.0	1.5
Residue	1.0	1.1	1.1	1.0	1.0	0.5	1.0	0.5	0.5	1.5
Cetane Index, D 976	47.0	39.5	42.5	45.0	49.0	42.5	45.0	42.5	42.8	46.0
Existent Gum, mg/100mL	0.0	0.0	0.0	0.0	0.0	0.8	0.4	0.6	0.8	0.0
Copper Corrosion	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A
Flash Point, °C	56	64	60	62	61	60	58	58	58	54
Cloud Point, °C	-50	-49	-47	-45	-43	-45	-45	-45	-45	-54
Water Reaction	1A	1B	1A	1B	1A	1A	1A	1B	1B	1B
Icing Inhibitor, vol%	0.13	0.13	0.14	0.13	0.13	0.14	0.14	0.14	0.14	0.12
Particulates, D 2276, mg/L	0.3	0.3	0.2	0.2	0.2	1.0	0.1	0.4	0.2	0.0
K. Vis, 40°C, cSt	1.3	1.5	1.5	1.6	1.6	1.5	1.5	1.5	1.5	1.3
K. Vis, 70°C, cSt	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9

TABLE 18. GMPA Laboratory Analyses Results (Cont'd)

Lab No.	TX-38-70	TX-38-80	TX-67-29	TX-67-30	TX-67-37	TX-67-38	TX-67-39	TX-67-40	TX-67-90	TX-77-05
Gravity, °API	45.5	45.2	42.1	42.1	42.3	42.3	42.2	41.7	45.3	45.9
Visual Appearance	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B
Distillation, °C										
IBP	175	177	183	182	183	183	182	182	178	184
10%	180	188	194	196	200	198	197	197	188	200
20%	193	192	198	202	205	203	203	204	193	203
50%	205	200	215	214	218	215	215	216	208	215
90%	231	230	242	242	244	243	243	245	235	240
End Point	262	260	257	259	273	268	270	273	284	269
Recovered	98.0	98.0	98.5	98.5	98.0	98.0	98.5	99.0	98.0	98.0
Loss	0.9	1.0	0.1	0.1	1.0	1.0	0.5	0.1	1.0	1.0
Residue	1.1	1.0	1.4	1.4	1.0	1.0	1.0	0.9	1.0	1.0
Cetane Index, D 976	47.5	45.0	45.0	44.0	46.0	45.0	45.0	44.0	48.0	51.5
Existent Gum, mg/100mL	0.4	1.4	0.0	2.2	0.8	1.6	3.6	5.0	1.6	2.2
Copper Corrosion	1B	1A	1A	1A	1A	1A	1A	1A	1A	1A
Flash Point, °C	58	55	63	66	63	61	64	66	58	61
Cloud Point, °C	-45	-47	-54	-52	-50	-54	-50	-48	-50	-50
Water Reaction	1A	1A	1	1	1	1	1	1	1A	1B
Icing Inhibitor, vol%	0.09	0.14	0.15	0.15	0.14	0.14	0.08	0.11	0.12	0.09
Particulates, D 2276, mg/L	0.0	0.2	0.7	2.1	0.8	0.2	1.6	1.3	0.4	0.2
K. Vis, 40°C, cSt	1.3	1.3	1.5	1.6	1.6	1.5	1.6	1.6	1.4	1.5
K. Vis, 70°C, cSt	0.9	0.9	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0

Lab No.	TX-77-07	TX-77-08	TX-77-09	TX-77-10	TX-79-10	TX-79-18	TX-79-19	TX-79-29	TX-79-30	TX-79-31
Gravity, °API	41.8	41.8	--	40.6	46.6	44.2	44.3	45.7	45.7	47.0
Visual Appearance	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B
Distillation, °C										
IBP	183	186	--	179	182	180	174	176	175	176
10%	197	196	193	192	193	192	185	185	185	187
20%	202	202	198	201	197	200	192	195	196	192
50%	213	214	210	212	207	212	205	206	208	203
90%	240	238	--	236	229	236	228	231	232	228
End Point	268	268	260	262	263	265	247	268	266	257
Recovered	98.0	98.0	98.5	98.5	98.0	98.5	98.5	98.0	98.0	98.0
Loss	1.0	1.0	1.0	0.5	1.0	0.5	0.5	0.8	0.8	1.0
Residue	1.0	1.0	0.5	1.0	1.0	1.0	1.0	1.2	1.2	1.0
Cetane Index, D 976	45.0	45.0	41.0	40.5	50.0	47.0	48.5	50.0	50.5	49.0
Existent Gum, mg/100mL	1.4	0.8	4.2	4.0	3.0	1.4	1.0	5.4	1.0	1.6
Copper Corrosion	1A	1A	1A	1A	1B	1A	1A	1A	1A	1A
Flash Point, °C	62	62	55	66	58	48	53	58	58	58
Cloud Point, °C	-46	-46	-49	-45	-47	-47	-45	-43	-43	-45
Water Reaction	1A	1A	1B	1B	1A	1A	1A	1A	1A	1A
Icing Inhibitor, vol%	0.09	0.09	0.09	0.10	0.10	0.12	0.13	0.08	0.11	0.08
Particulates, D 2276, mg/L	0.5	0.1	--	0.2	0.0	0.1	0.2	0.4	0.2	0.5
K. Vis, 40°C, cSt	1.5	1.5	1.6	1.5	1.3	1.4	1.3	1.3	1.3	1.3
K. Vis, 70°C, cSt	1.0	1.0	1.0	1.0	0.9	1.0	0.9	0.9	0.9	0.9

TABLE 18. GMPA Laboratory Analyses Results

Lab No.	TX-79-40	TX-79-47	TX-79-49	TX-79-56	TX-79-58	TX-79-63	TX-79-74	TX-79-78	TX-86-13	TX-86-14
Gravity, °API	33.3	44.8	32.9	41.3	42.3	42.6	45.2	45.4	41.7	41.9
Visual Appearance	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B
Distillation, °C										
IBP	205	178	142	180	180	192	178	180	180	138
10%	227	182	224	186	200	202	184	190	198	158
20%	238	187	236	208	205	212	192	196	205	202
50%	267	207	267	220	218	218	206	210	217	215
90%	213	230	312	245	242	245	234	238	238	238
End Point	338	270	333	277	273	281	250	250	265	203
Recovered	98.5	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.5	98.5
Loss	0.2	1.0	1.4	0.5	0.6	1.0	1.0	1.0	0.5	0.5
Residue	1.3	1.0	0.6	1.5	1.4	1.0	1.0	1.0	1.0	1.0
Cetane Index, D 976	44.5	45.5	44.0	45.0	46.0	47.0	47.0	49.0	44.5	41.5
Existent Gum, mg/100mL	31.8	0.0	34.6	3.4	3.0	1.4	1.8	2.4	0.0	0.4
Copper Corrosion	1A	1A	1A	1A	1A	1B	1A	1A	1A	1A
Flash Point, °C	60	58	82	49	48	59	53	52	62	52
Cloud Point, °C	-18	-48	-13	-46	-47	-51	-47	-49	-47	-45
Water Reaction	1	1B	1B	1B	1B	1A	1A	1B	1	1B
Icing Inhibitor, vol%	0.00	0.12	0.01	0.08	0.08	0.07	0.09	0.07	0.08	0.12
Particulates, D 2276, mg/L	1.0	0.8	0.4	0.4	1.3	0.0	0.9	0.3	0.0	2.0
K. Vis, 40°C, cSt	1.6	1.4	2.6	1.5	1.5	1.6	1.4	1.5	1.6	1.5
K. Vis, 70°C, cSt	1.0	1.4	1.6	1.0	1.0	1.1	1.0	1.0	1.1	1.0

Lab No.	TX-86-17	TX-86-18	TX-91-20	TX-91-21	TX-91-24	TX-91-26	TX-91-42	TX-91-43	TX-91-44	TX-91-45
Gravity, °API	42.0	42.3	44.4	44.0	41.0	40.5	45.3	42.4	44.7	45.3
Visual Appearance	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B	C&B
Distillation, °C										
IBP	182	180	174	184	192	190	186	194	184	182
10%	197	200	192	194	204	201	194	202	192	190
20%	208	205	195	198	208	206	198	206	196	196
50%	215	218	204	212	221	220	211	211	207	208
90%	238	242	228	247	247	248	235	237	230	232
End Point	264	263	264	299	288	294	266	267	258	248
Recovered	--	98.0	98.0	98.0	98.5	98.0	98.0	98.0	98.0	98.0
Loss	0.7	0.5	0.9	0.9	0.1	0.4	1.0	0.5	0.9	0.3
Residue	1.3	1.5	1.1	1.1	0.5	1.5	1.0	1.1	1.1	1.7
Cetane Index, D 976	45.0	46.5	45.0	47.5	43.5	45.0	49.5	43.5	46.5	49.5
Existent Gum, mg/100mL	0.6	1.6	0.4	1.4	11.0	12.0	7.0	0.6	2.6	0.6
Copper Corrosion	--	1A	1A	1A	1A	1A	1A	1B	1A	1A
Flash Point, °C	44	42	52	56	61	64	58	63	54	54
Cloud Point, °C	-45	-45	-43	-38	-49	-54	-47	-47	-47	-47
Water Reaction	1B	1A	1A	1A	1	1	1B	1B	1A	1B
Icing Inhibitor, vol%	0.09	0.10	0.13	0.09	0.15	0.04	0.04	0.09	0.07	0.09
Particulates, D 2276, mg/L	0.4	0.4	0.4	5.6	0.4	1.3	0.0	0.0	0.0	0.8
K. Vis, 40°C, cSt	--	1.5	1.3	1.4	1.6	1.7	1.4	1.6	1.4	1.4
K. Vis, 70°C, cSt	--	1.0	0.9	0.9	1.0	1.0	1.0	1.0	0.9	0.9

TABLE 18. GMPA Laboratory Analyses Results (Cont'd)

Lab No.	TX-91-46	TX-91-47	TX-91-48	TX-91-64	TX-A2-03	TX-A2-04
Gravity, °API	45.4	45.3	45.4	40.9	45.3	39.5
Visual Appearance	C&B	C&B	C&B	C&B	C&B	C&B
Distillation, °C						
IBP	178	188	180	--	175	182
10%	186	190	186	--	188	198
20%	190	196	192	197	194	204
50%	206	205	202	211	204	217
90%	232	232	230	--	229	240
End Point	243	250	248	252	264	263
Recovered	98.0	98.0	98.0	98.0	98.5	98.0
Loss	0.4	0.2	1.0	1.8	0.3	1.0
Residue	1.6	1.8	1.0	--	1.2	1.0
Cetane Index, D 976	48.5	47.0	46.5	40.5	46.5	41.0
Existent Gum, mg/100mL	0.8	1.4	0.8	1.8	4.0	1.0
Copper Corrosion	1A	1A	1A	1A	1A	1A
Flash Point, °C	53	53	54	56	60	58
Cloud Point, °C	-47	-47	-47	-48	-43	-47
Water Reaction	1B	1A	1A	1B	1B	1B
Icing Inhibitor, vol%	0.09	0.07	0.08	0.12	0.07	0.08
Particulates, D 2276, mg/L	0.8	0.6	0.2	0.6	1.2	0.2
K. Vis, 40°C, cSt	1.4	1.5	1.4	1.5	1.4	1.3
K. Vis, 70°C, cSt	0.9	1.0	0.9	1.0	0.9	0.9

TABLE 19. Bulk Fuel Consumption at Ft. Bliss, TX

Period	Bulk Dispensings, gal.		Cost	
	DF-2	JP-8	DF-2	JP-8
1 QTR FY88	461,468		$ 346,101	
2 QTR FY88	588,644		441,483	
3 QTR FY88	599,932		449,949	
4 QTR FY88	339,337		254,503	
1 QTR FY89	370,934		241,107	
2 QTR FY89 (Jan)	257,186		167,171	
2 QTR FY89 (Feb, Mar)		582,630		$ 355,404
3 QTR FY89		478,832		292,088
4 QTR FY89		752,426		458,980
1 QTR FY90		313,761		172,569
2 QTR FY90		813,233		447,278
3 QTR FY90		860,930		473,512
4 QTR FY90 (Jul)		185,052		101,779
Total	2,617,501	3,986,864	$ 1,900,314	$ 2,301,610
Average/Quarter	491,088	664,477	$ 356,532	$ 383,602

TABLE 20. Bulk Fuel Consumption for 3rd ACR at NTC, Ft. Irwin, CA

Period	Bulk Dispensings, gal.		Cost	
	DF-2	JP-8	DF-2	JP-8
October 1987	349,926		$262,445	
May 1989	12,924		8,400	
May 1989		339,747		$207,246
October 1989		348,846		212,796
Total	362,850	688,593	$270,845	$420,042

Since the JP-8 demonstration was to have no impact on user mission requirements (i.e., was to be conducted on a noninterference basis), it was not intended that the V/E fleet would be kept constant as done in a controlled fleet test. Therefore, the difference in average bulk fuel dispensings per quarter for JP-8 versus DF-2 is considered reasonable in view of the major changes in vehicle mix.

Because of the methods used to determine total miles of operation for the different type combat/tactical vehicles, the total gallons shown above cannot be divided into the total miles shown in Section V.D to determine operational miles per gallon.

D. Operational Data Comparisons

1. Data Base Formations

The methods by which individual vehicle fuel dispensings were integrated with mileage data to produce operational data are explained in the following paragraphs:

a. Mileage — Fuel Dispensings Merger — Individual vehicle mile-per-gallon values were computed based on the merging of the TAMMS mileage data base. If chronologically correct sequences of mileage and fuel dispensings resulted, then a miles-per-gallon value was computed for each of the three fuel periods, where applicable. Thus, each individual vehicle contributed at least one mpg figure for each fuel period in which data were collected. Vehicles were then grouped into common group types as described in TABLE 21. All analyses were conducted separately for the 6th ADA Bde, 11th ADA Bde, and 3rd ACR.

In order to assess whether there were significant differences in the average miles-per-gallon value reported during the DF-2 period and the JP-8 period, a statistical methodology using hypothesis testing with the T-test statistic was performed. The average miles-per-gallon values by vehicle group and fuel period were computed for the 6th ADA Bde, 11th ADA Bde, and 3rd ACR and are shown in TABLES 22, 23, and 24, respectively. In the situations where there were at least 15 observations, there was no statistically significant difference in the average mpg values between the DF-2 and JP-8 fuel periods in any of the three units tested. All statistical tests were made at the 5-percent level of significance.

b. 6th ADA Brigade Monthly — Similar comparison tests were made with the data base developed from the 6th ADA monthly fuel reports. Again, average miles-per-gallon values by vehicle group and fuel period were computed and are shown in TABLES 25 and 26 for the 1/43rd and 2/6th ADA Battalions, respectively. No monthly fuel usage reports were gathered for the DF-2 fuel period. However, statistical comparisons were made on the average mpg values between the mixture and JP-8 fuel periods. There were no statistically significant differences (at the 5-percent level of significance) in the average mpg values by vehicle type and fuel period in the two battalions tested.

TABLE 21. Vehicle Groupings

Group No.	Nomenclature	Vehicle Description
1	Carrier, Cargo	M1015
2	Carrier, Mortar	M106A1, M106A2
3	Truck, Van	M109A3
4	Howitzer, S.P.	M109A2, M109A3
5	Carrier, Personnel	M113A1, M113A2
6	Gun, Air Defense	M163A1, M163A2, M42A1
7	Truck, Van	M185A3, M275A2, M292A1
8	Tank, Combat	M1A1
9	Cavalry Fighting Vehicle	M3
10	Truck, Cargo, 2-1/2 Ton	M35A1, M35A2, M35A2C, M36A2
11	Guided Missile Carrier	M48A1
12	Tank, Combat	M48A5, M60, M60A1, M60A1AOS, M60A1R, M60A1RP, M728
13	Truck, F/S	M49A2C
14	Truck, Water	M50A1, M50A2
15	Truck, Dump, 5 Ton	M51A2
16	Truck, Tractor, 5 Ton	M52A1, M52A2
17	Truck, Wrecker, 5 Ton	M543A2
18	Carrier, Cargo	M548, M548A1
19	Truck, Cargo	M54A2W/W, M55A2
20	Truck, Tactical	M561, M792
21	Carrier, C.P.	M577A1, M577A2
22	Recovery Vehicle	M578
23	Carrier, GM	M730, M730A1, TOW
24	Truck, Tractor, HET	M746
25	Truck, 5 Ton, 800 Series	M813, M813A1, M813W/W, M814, M816, M817, M818
26	Recovery Vehicle	M88A1
27	Carrier, Tow	M901
28	Truck, Tractor, HET	M911
29	Truck, Tractor, HET	M915, M916
30	Truck, Cargo, 5 Ton	M923, M923A1, M927, M927A1, M928, M928A1
31	Truck, Tractor, 5 Ton	M931, M31A1, M932
32	Truck, Van, 5 Ton	M934
33	Truck, Wrecker, 5 Ton	M936
34	Truck, Cargo, 10 Ton	M977, M977W/W, M985, M985W/W, M985E1
35	Truck, Tanker, 10 Ton	M978, M978W/W
36	Fire Support Team Vehicle	M981
37	Truck, Tractor, 10 Ton	M983
38	Truck, Wrecker, 10 Ton	M984, M984A1

TABLE 22. Average Miles-per-Gallon by Vehicle Group and Fuel Type — 6th ADA Brigade

Vehicle Group - Group No.	Fuel Type	No. of Vehicles	Average Miles-Per-Gallon
Truck, Van - 3	DF-2	2	4.3
Truck, Van - 3	Mixture	2	3.5
Truck, Van - 3	JP-8	3	3.2
Truck, Cargo, 2-1/2 Ton - 10	DF-2	18	6.1
Truck, Cargo, 2-1/2 Ton - 10	Mixture	29	5.8
Truck, Cargo, 2-1/2 Ton - 10	JP-8	24	7.1
Truck, Tractor, 5 Ton - 16	DF-2	1	6.1
Truck, Tractor, 5 Ton - 16	Mixture	3	1.2
Truck, Tractor, 5 Ton - 16	JP-8	3	4.0
Carrier, C.P. - 21	DF-2	1	2.1
Carrier, C.P. - 21	Mixture	1	1.6
Carrier, C.P. - 21	JP-8	1	0.2
Truck, 5 Ton, 800 Series - 25	DF-2	7	5.0
Truck, 5 Ton, 800 Series - 25	Mixture	6	3.2
Truck, 5 Ton, 800 Series - 25	JP-8	9	3.8
Truck, Cargo, 5 Ton - 30	DF-2	12	9.0
Truck, Cargo, 5 Ton - 30	Mixture	15	4.2
Truck, Cargo, 5 Ton - 30	JP-8	10	4.4
Truck, Van, 5 Ton - 32	DF-2	2	2.9
Truck, Van, 5 Ton - 32	Mixture	2	1.8
Truck, Van, 5 Ton - 32	JP-8	2	3.3
Truck, Cargo, 10 Ton - 34	DF-2	1	5.9
Truck, Cargo, 10 Ton - 34	Mixture	1	2.8
Truck, Cargo, 10 Ton - 34	JP-8	1	1.5
Truck, Tanker, 10 Ton - 35	JP-8	1	0.6
Truck, Tractor, 10 Ton - 37	DF-2	4	5.0
Truck, Tractor, 10 Ton - 37	Mixture	4	1.8
Truck, Tractor, 10 Ton - 37	JP-8	5	1.3
Truck, Wrecker, 10 Ton - 38	JP-8	1	2.3

NOTE: No statistically significant difference in the average mpg values between the DF-2 and JP-8 fuel periods (5-percent level of significance).

TABLE 23. Average Miles-per-Gallon by Vehicle Group and Fuel Type — 11th ADA Brigade

Vehicle Group - Group No.	Fuel Type	No. of Vehicles	Average Miles-Per-Gallon
Truck, Van - 3	DF-2	7	7.5
Truck, Van - 3	Mixture	4	11.6
Truck, Van - 3	JP-8	4	2.5
Gun, Air Defense - 6	DF-2	11	2.2
Gun, Air Defense - 6	Mixture	11	3.6
Gun, Air Defense - 6	JP-8	13	1.6
Truck, Van - 7	Mixture	2	4.2
Truck, Van - 7	JP-8	3	5.5
Truck, Cargo, 2-1/2 Ton - 10	DF-2	115	9.0
Truck, Cargo, 2-1/2 Ton - 10	Mixture	89	7.1
Truck, Cargo, 2-1/2 Ton - 10	JP-8	93	7.6
Truck, Tractor, 5 Ton - 16	DF-2	11	2.1
Truck, Tractor, 5 Ton - 16	Mixture	10	2.6
Truck, Tractor, 5 Ton - 16	JP-8	9	3.7
Truck, Wrecker, 5 Ton - 17	DF-2	2	1.9
Truck, Wrecker, 5 Ton - 17	Mixture	1	1.0
Truck, Cargo - 19	DF-2	5	2.0
Truck, Cargo - 19	Mixture	3	5.1
Truck, Cargo - 19	JP-8	6	2.2
Carrier, C.P. - 21	DF-2	4	4.4
Carrier, C.P. - 21	Mixture	1	1.9
Carrier, C.P. - 21	JP-8	3	1.9
Recovery Vehicle - 22	DF-2	2	1.9
Recovery Vehicle - 22	Mixture	1	3.8
Truck, 5 Ton, 800 Series - 25	DF-2	10	6.4
Truck, 5 Ton, 800 Series - 25	Mixture	8	5.1
Truck, 5 Ton, 800 Series - 25	JP-8	9	4.6
Truck, Cargo, 5 Ton - 30	DF-2	19	3.0
Truck, Cargo, 5 Ton - 30	Mixture	15	4.8
Truck, Cargo, 5 Ton - 30	JP-8	19	2.6
Truck, Tractor, 5 Ton - 31	DF-2	7	3.3
Truck, Tractor, 5 Ton - 31	Mixture	8	5.8
Truck, Tractor, 5 Ton - 31	JP-8	8	3.7
Truck, Van, 5 Ton - 32	DF-2	1	2.0
Truck, Van, 5 Ton - 32	Mixture	1	6.4
Truck, Van, 5 Ton - 32	JP-8	1	4.6
Truck, Cargo, 10 Ton - 34	Mixture	3	1.7
Truck, Cargo, 10 Ton - 34	JP-8	3	1.5
Truck, Tanker, 10 Ton - 35	Mixture	2	3.2
Truck, Tanker, 10 Ton - 35	JP-8	3	2.0
Truck, Tractor, 10 Ton - 37	DF-2	12	2.9
Truck, Tractor, 10 Ton - 37	Mixture	14	2.4
Truck, Tractor, 10 Ton - 37	JP-8	17	2.6

NOTE: No statistically significant difference in the average mpg values between the DF-2 and JP-8 fuel periods (5-percent level of significance).

TABLE 24. Average Miles-per-Gallon by Vehicle Group and Fuel Type — 3rd ACR

Vehicle Group - Group No.	Fuel Type	No. of Vehicles	Average Miles-Per-Gallon
Carrier, Mortar - 2	DF-2	8	3.5
Carrier, Mortar - 2	Mixture	5	1.5
Carrier, Mortar - 2	JP-8	5	3.7
Truck, Van - 3	DF-2	5	3.6
Truck, Van - 3	Mixture	2	1.1
Truck, Van - 3	JP-8	3	2.6
Howitzer, S.P. - 4	DF-2	9	1.2
Howitzer, S.P. - 4	Mixture	7	2.4
Howitzer, S.P. - 4	JP-8	7	1.8
Carrier, Personnel - 5	DF-2	1	3.1
Carrier, Personnel - 5	Mixture	1	1.8
Tank, Combat - 8	DF-2	102	0.4
Tank, Combat - 8	Mixture	86	0.7
Tank, Combat - 8	JP-8	96	0.5
Cavalry Fighting Vehicle - 9	Mixture	71	2.4
Cavalry Fighting Vehicle - 9	JP-8	66	1.4
Truck, Cargo, 2-1/2 Ton - 10	DF-2	33	9.7
Truck, Cargo, 2-1/2 Ton - 10	Mixture	29	13.2
Truck, Cargo, 2-1/2 Ton - 10	JP-8	28	8.8
Tank, Combat - 12	DF-2	2	0.6
Tank, Combat - 12	JP-8	1	<0.1
Truck, Wrecker, 5 Ton - 17	DF-2	1	6.5
Carrier, Cargo - 18	DF-2	6	2.3
Carrier, Cargo - 18	JP-8	4	5.5
Truck, Cargo - 19	DF-2	3	5.5
Truck, Cargo - 19	Mixture	3	4.0
Truck, Cargo - 19	JP-8	2	37.9
Carrier, C.P. - 21	DF-2	27	2.9
Carrier, C.P. - 21	Mixture	16	6.7
Carrier, C.P. - 21	JP-8	19	1.8
Recovery Vehicle - 22	DF-2	1	1.0
Recovery Vehicle - 22	JP-8	1	0.8
Truck, 5 Ton, 800 Series - 25	DF-2	7	6.0
Truck, 5 Ton, 800 Series - 25	Mixture	1	6.4
Truck, 5 Ton, 800 Series - 25	JP-8	1	4.9
Recovery Vehicle - 26	DF-2	12	0.7
Recovery Vehicle - 26	Mixture	10	1.5
Recovery Vehicle - 26	JP-8	10	0.4
Truck, Cargo, 5 Ton - 30	DF-2	1	0.7
Truck, Cargo, 5 Ton - 30	JP-8	2	11.3
Truck, Tractor, 5 Ton - 31	Mixture	2	1.8
Truck, Wrecker, 5 Ton - 33	DF-2	1	5.4
Truck, Wrecker, 5 Ton - 33	JP-8	1	4.8
Truck, Cargo, 10 Ton - 34	JP-8	13	2.6
Truck, Tanker, 10 Ton - 35	JP-8	10	5.9
FISTV (Fire Support Team Vehicle) - 36	DF-2	1	5.2
FISTV (Fire Support Team Vehicle) - 36	Mixture	1	10.8
FISTV (Fire Support Team Vehicle) - 36	JP-8	1	2.3

NOTE: No statistically significant difference in the average mpg values between the DF-2 and JP-8 fuel periods (5-percent level of significance).

TABLE 25. Average mpg Values by Vehicle Group and Fuel Type — 6th ADA Bde, 1/43rd ADA Battalion Monthly Fuel Usage Data Base

Mixture: February, April through September 1989

End Item Description	Number of Vehicles	Average mpg	Total Miles
Truck, Tac, CUCV	84	12.0	71,129
Truck, Amb, CUCV	4	25.0	5,532
Truck, 2-1/2 Ton	42	6.3	13,994
Truck, 5 Ton	55	4.7	11,800
Truck, HEMTT, 10 Ton	45	2.2	11,240

End Item Description	Number of Units	Average gal./hr	Total Hours
Generator Set, 5 kW	6	0.62	644
Generator Set, 10 kW	4	0.94	30
Generator Set, 15 kW	31	1.09	3,390
Generator Set, 30 kW	12	0.41	2,123
Generator Set, 60 kW	1	0.61	87
Generator Set, 150 kW	10	7.49	4,071
Welder, TM	1	0.58	24

JP-8: October 1989 through July 1990

End Item Description	Number of Vehicles	Average mpg	Total Miles
Truck, Tac, CUCV	91	10.7	148,624
Truck, Amb, CUCV	4	16.2	5,315
Truck, 2-1/2 Ton	48	6.0	28,131
Truck, 5 Ton	79	4.3	37,907
Truck, HEMTT, 10 Ton	72	2.5	59,078

End Item Description	Number of Units	Average gal./hr	Total Hours
Generator Set, 5 kW	9	0.69	2,025
Generator Set, 10 kW	4	2.00	4
Generator Set, 15 kW	53	1.32	14,608
Generator Set, 30 kW	13	0.43	2,549
Generator Set, 60 kW	1	1.29	327
Generator Set, 150 kW	16	9.81	7,688
Welder, TM	1	2.00	5

NOTE: No statistically significant difference in the average mpg or gal./hr values between the mixture and JP-8 fuel periods (5-percent level of significance.

TABLE 26. Average mpg Values by Vehicle Group and Fuel Type — 6th ADA Bde, 2/6th ADA Battalion Monthly Fuel Usage Data Base

Mixture: May through July, September 1989

End Item Description	Number of Vehicles	Average mpg	Total Miles
Truck, Tac, CUCV	21	14.0	11,946
Truck, 2-1/2 Ton	10	4.2	2,989
Truck, 5 Ton	8	3.1	1,289
Truck, HEMTT, 10 Ton	4	0.8	422
Tracked Carrier	8	1.9	1,137

JP-8: October 1989 through July 1990

End Item Description	Number of Vehicles	Average mpg	Total Miles
Truck, Tac, CUCV	17	10.8	17,728
Truck, 2-1/2 Ton	8	7.1	3,323
Truck, 5 Ton	3	3.4	2,912
Truck, HEMTT, 10 Ton	4	1.8	1,075
Tracked Carrier	11	2.1	3,975
Truck, 1-1/4 Ton	1	9.9	237

NOTE: No statistically significant difference in the average mpg values between the mixture and JP-8 fuel periods (5-percent level of significance).

c. Ft. Bliss TMP — TABLE 27 summarizes the number of vehicles, total miles driven, and average miles-per-gallon computed from the TMP operational data base collected at Ft. Bliss. There were only two vehicle types (International Harvester 28-passenger bus and International Harvester 44-passenger bus) that contained enough data to test for differences in the average mpg figures. Further, there were no statistically significant differences in the average mpg values between the DF-2 and JP-8 fuel periods for either of the two bus types.

TABLE 27. Ft. Bliss Transportation Motor Pool (TMP) Fuel Consumption Data

Vehicle Type	Fuel Type	No. of Vehicles	Average mpg	Total Miles
International Harvester 28-Passenger Bus	DF-2[1]	10	6.7	55,821
International Harvester 28-Passenger Bus	Mixture[2]	10	6.9	52,160
International Harvester 28-Passenger Bus	JP-8[3]	10	6.4	95,529
International Harvester 44-Passenger Bus	DF-2	25	5.8	104,226
International Harvester 44-Passenger Bus	Mixture	22	5.8	71,680
International Harvester 44-Passenger Bus	JP-8	27	5.7	183,643
Crown Coach 53-Passenger Bus	DF-2	4	5.1	37,441
Crown Coach 53-Passenger Bus	Mixture	4	5.1	30,728
Crown Coach 53-Passenger Bus	JP-8	4	5.0	34,223
International Harvester Truck, Tractor, 10 Ton	DF-2	3	6.5	8,731
International Harvester Truck, Tractor, 10 Ton	Mixture	3	6.3	5,613
International Harvester Truck, Tractor, 10 Ton	JP-8	3	5.4	18,630
International Harvester Truck, Stake, 5 Ton	Mixture	1	5.0	944
International Harvester Truck, Stake, 5 Ton	JP-8	1	6.3	3,031
GMC Truck, Wrecker, 10 Ton	DF-2	1	4.0	911
GMC Truck, Wrecker, 10 Ton	Mixture	1	2.9	430
GMC Truck, Wrecker, 10 Ton	JP-8	1	5.3	3,823
International Harvester Truck, Stake, 3-1/2 Ton	DF-2	2	5.2	5,891
International Harvester Truck, Stake, 3-1/2 Ton	Mixture	1	7.1	1,111
International Harvester Truck, Water, 5 Ton	Mixture	1	7.6	2,127
GMC Truck, Tractor, 10 Ton	DF-2	1	5.9	3,811
GMC Truck, Tractor, 10 Ton	Mixture	1	4.2	397
GMC Truck, Tractor, 10 Ton	JP-8	1	1.4	397
GMC Truck, Van, 5 Ton	DF-2	1	8.0	1,911
GMC Truck, Van, 5 Ton	Mixture	1	7.4	1,971

[1] 1 September 1988 through 28 February 1989.
[2] 1 March 1989 through 31 July 1989.
[3] 1 August 1989 through 31 July 1990.
NOTE: No statistically significant differences in the average mpg values between DF-2 and JP-8 fuel periods (5-percent level of significance) for either the 28-passenger or 44-passenger buses.

2. Average Mileage-per-Vehicle Type

TABLE 28 presents the average mileage-per-vehicle type. These mileages were computed from data submitted by the Army Maintenance Management System based on information received via AOAP oil samples from maintenance and user personnel. The figures shown are the best averages per vehicle type available through 30 June 1990.

3. Mileage Accrued at Ft. Bliss by Unit

TABLE 29 presents total miles, also computed from TAMMS data, for tracked and wheeled vehicles enrolled in the AOAP at Ft. Bliss. The figures represent mileages accumulated through 30 June 1990.

4. Mileage Accumulation for GM 6.2L Powered Vehicles at Ft. Bliss

TABLE 30 presents mileage accumulation for GM 6.2L powered vehicles at Ft. Bliss (CUCV and HMMWV). Of significance is the fact that CUCV and HMMWV vehicles are not enrolled in the Army Oil Analysis Program but still have operated with JP-8 fuel since the beginning of the JP-8 Demonstration Program. Also of importance is the fact that the CUCV/HMMWV family uses a rotary fuel injection system that is more fuel sensitive than other systems (i.e., in-line pumps, unit injectors, oil lubricated rotary pumps, etc.), and this family has the highest vehicle density in the military inventory. No comparisons with prior operations with DF-2 can be made because of lack of data. From actual figures supplied by the 6th ADA Bde, it is possible to determine that, for the CUCV vehicles of that organization, an average 2,337 miles were driven per vehicle. This average extrapolated to the total Ft. Bliss CUCV and HMMWV population (623) results in a conservative estimate of 1,455,951 miles of operation on JP-8.

TABLE 28. Estimated Average Mileage-per-Vehicle Type

Vehicle Type - Group No.	Average Mileage-per-Vehicle Type		
	DF-2	JP-8/DF-2 Mix	JP-8
TRACKED VEHICLES			
3rd ACR			
Carrier, Mortar - 2	507	615	169
Howitzer, S.P. - 4	324	550	246
Tank, Combat - 8	589	652	472
CFV - 9	--*	595	524
Carrier Cargo - 18	195	394	535
Carrier APC - 21	587	628	215
Recovery Vehicle, Light - 22	732	599	116
Recovery Vehicle, Medium - 26	528	490	354
FISTV - 36	428	842	406
Carrier, GM - 23	419	--	--
11th ADA Bde			
Gun, Air Defense - 6	527	634	451
Carrier, APC - 21	439	406	520
Recovery Vehicle, Light - 22	381	346	--
6th ADA Bde			
Carrier, APC - 21	384	194	302
WHEELED VEHICLES			
3rd ACR			
Truck, Van - 3	598	361	148
Truck, Cargo, 2-1/2 Ton - 10	1201	967	615
Truck, Cargo - 19	1138	644	828
Truck, 5-Ton - 25	661	863	258
Truck, Wrecker, 5-Ton - 33	1768	--	835
Truck, Cargo, 10-Ton - 34	--	--	866

* -- = No data recorded on MRSA tape.

TABLE 28. Estimated Average Mileage-per-Vehicle Type (Cont'd)

Vehicle Type - Group No.	Average Mileage-Per-Vehicle Type DF-2	JP-8/DF-2 Mix	JP-8
WHEELED VEHICLES			
3rd ACR			
Truck, Van - 7	922	397	91
Truck, Tractor, 5-Ton - 16	--*	--	136
Truck, Wrecker, 5-Ton - 17	1779	153	--
Truck, Cargo, 5-Ton - 30	310	1318	575
Truck, Tractor, 5-Ton - 31	--	106	113
11th ADA Bde			
Truck, Van - 3	274	547	551
Truck, Cargo, 2-1/2 Ton - 10	541	569	509
Truck, 5-Ton - 25	776	683	519
Truck, Cargo, 5-Ton - 30	505	436	429
Truck, Tractor, 5-Ton - 31	377	805	962
Truck, Van, 5-Ton - 32	279	2380	65
Truck, Cargo, 10-Ton - 34	25	217	112
Truck, Tanker, 10-Ton - 35	--	3241	1977
Truck, Tractor, 10-Ton - 37	599	634	721
Truck, Van - 7	--	233	210
Truck, Tractor, 5-Ton - 16	159	140	140
Truck, Wrecker, 5-Ton - 17	590	39	198
Truck, Cargo - 19	594	545	245
6th ADA Bde			
Truck, Van - 3	199	122	243
Truck, Cargo, 2-1/2 Ton - 10	332	449	541
Truck, Tractor, 5-Ton - 16	157	110	281
Truck, 5-Ton - 25	443	281	245
Truck, Cargo, 5-Ton - 30	540	395	653
Truck, Van, 5-Ton - 32	118	108	133
Truck, Cargo, 10-Ton - 34	714	244	255
Truck, Tanker, 10-Ton - 35	--	--	482
Truck, Tractor, 10-Ton - 37	648	379	403

* -- = No data recorded on MRSA tape.

TABLE 29. Mileage Accrued at Ft. Bliss by Unit

a. 3rd Armored Cavalry Regiment

	Total	Tracked	Wheeled
DF-2	192,232 (13 months)	105,103	87,129
JP-8/DF-2 Mix	222,413 (8 months)	156,136	66,277
JP-8	145,749 (9 months)	95,333	50,416

b. 6th Air Defense Artillery Brigade

	Total	Tracked	Wheeled
DF-2	27,252 (13 months)	384	26,868
JP-8/DF-2 Mix	26,930 (8 months)	194	26,736
JP-8	30,533 (9 months)	302	30,231

c. 11th Air Defense Artillery Brigade

	Total	Tracked	Wheeled
DF-2	121,318 (13 months)	9,751	111,567
JP-8/DF-2 Mix	130,084 (8 months)	9,106	120,978
JP-8	110,812 (9 months)	7,433	103,379
Total Miles (a + b + c) (JP-8 + Mix)		268,504	398,017

d. Transportation Motor Pool

DF-2	218,743 (6 months)
JP-8/DF-2 Mix	167,161 (5 months)
JP-8	326,702 (11 months)
Total TMP Miles (Mix + JP-8)	493,863

All of above mileage values are best estimates from data available through 30 June 1990; **actual** DF-2 values for the combat tactical units would be higher than the values shown due to changes in DA mileage recording practices that occurred after start of the Demonstration Program.

TABLE 30. Mileage Accumulation at Ft. Bliss in GM 6.2L Powered Engines

1/43rd ADA Bn, 6th ADA Bde	
February 1989 through September 1989 (Mix)	Total Miles
Truck, Tactical, CUCV	70,985
Ambulance, Tactical, CUCV	5,532
October 1989 through July 1990 (JP-8)	
Truck, Tactical, CUCV	148,840
Ambulance, Tactical, CUCV	5,171
2/6th ADA Bn, 6th ADA Bde	
May 1989 through September 1989 (Mix)	
Truck, Tactical, CUCV	11,802
October 1989 through July 1990 (JP-8)	
Truck, Tactical, CUCV	17,728
Total Miles	259,407
Average Number of Vehicles	111
Average Miles/Vehicle	2,337

5. Fuel-Wetted Components Usage

Fuel-wetted component usage was tracked for the period 1 January 1988 through 31 July 1990 from DA maintenance request Forms 2407 provided by the maintenance division. Component usage fluctuated between 1988, 1989, and 1990, as shown in TABLE 31. For some vehicle groups, component usage increased, and in others, usage decreased with JP-8 fuel. Further

TABLE 31. Fuel-Wetted Components Replacement

Vehicle/Equipment	Nomenclature	NSN	12 mo 1988	12 mo 1989	7 mo 1990
M561	Fuel Injector Assembly	2910-00-073-3011	0	15	0
M1008/M1009	Fuel Injection Pump	2910-01-160-0613	18	42	47
M998	Fuel Injection Pump	2910-01-171-4636	0	0	5
M35A2	Fuel Metering Pump	2910-00-116-8241	50	70	34
	Fuel Metering Pump	2910-00-759-5410	19	13	6
	Fuel Injector Nozzle Assembly	2910-00-861-1408	250	139	56
M52A2	Fuel Metering Pump	2910-00-908-6320	39	28	14
	Fuel Injector Nozzle Assembly	2910-00-074-8931	469	77	45
M818/936	Fuel Metering Pump	2910-01-104-1446	23	25	10
	Fuel Pump Cam Actuator	2910-01-094-9043	0	3	0
	Fuel Injector Assembly	2910-01-404-3054	71	0	65
M939	Fuel Metering Pump	2910-01-135-1077	9	3	6
M911	Fuel Injector Nozzle Assembly	2910-01-085-8834	29	0	0
M915	Fuel Metering Pump	2910-01-141-9372	0	2	0
	Fuel Metering Pump	2910-01-065-3979	2	6	5
	Fuel Injector Assembly	2910-01-112-7712	39	0	0
	Fuel Injector Assembly	2910-01-145-9403	12	17	6
M978	Fuel Injector Assembly	2910-01-125-3996	0	16	39
M113	Fuel Injector Assembly	2910-00-073-3011	474	439	285
M109A2/M578	Fuel Injector Assembly	2910-00-871-3531	8	0	0
Generator Set, 15 kW	Fuel Metering Pump	2910-00-501-7000	5	5	5
	Injector Assembly	2910-01-035-1355	24	0	0
Generator Set, 30 kW	Fuel Metering Pump	2910-00-499-0818	0	1	7
Generator Set, 60 kW	Fuel Metering Pump	2910-00-228-2799	40	15	36
	Fuel Injector Holder Assembly	2910-00-780-0984	6	0	0
	Fuel Injector Nozzle Assembly	2910-00-110-9692	24	0	0

contributing to this fluctation were equipment gains and losses during 1988 and 1989. It cannot be determined from these data if the use of JP-8 fuel had a statistically significant difference in component usage.

6. AOAP-Directed Oil Changes

The data collected through the AOAP program included standard lab recommendation codes, which identified when vehicles were required to change the oil based on the oil sample analysis. These lab-recommended oil changes were totaled by type of vehicle for each of the three fuel periods. TABLE 32 summarizes the comparisons of AOAP-recommended oil changes from 1 January 1987 through 31 May 1990. Only two vehicle groups demonstrated statistically significant differences in the average number of oil change recommendations between the DF-2 and JP-8 fuel periods. Furthermore, both of these groups (2-1/2 ton truck, 5-ton truck, LD 465-1, and 10-ton truck, DD 8V-92TA) demonstrated lower average AOAP-directed oil changes for the JP-8 fuel period than for the DF-2 fuel period.

7. AOAP Oil Degradation Data

Comparisons were made between average iron (Fe), copper (Cu), and lead (Pb) readings in ppm as computed from the AOAP computer tapes for the period 1 January 1987 through 31 May 1990. The comparisons were made for V/E operations with DF-2 and neat JP-8. The mixture averages are shown as information only. TABLE 33 shows the comparisons of the selected wear metals for each fuel. Figs. 8 through 13 are histogram displays of average wear metals (Fe, Cu, Pb) by vehicle group type and fuel period. Three vehicle groups showed statistically different average lead values between the DF-2 and JP-8 fuel periods. These included: (1) mortar carrier, carrier cargo, and M113APC; (2) M3 Bradley Fighting Vehicle, Cummins 903T; and (3) generator set 30/60 Hz. These groups are identified in TABLE 33 with an asterisk by the average JP-8 lead value. Six vehicle groups showed statistically different average iron values, while five groups demonstrated differences in the average copper readings. These particular groups are also noted with an asterisk in TABLE 33.

TABLE 32. Number of Vehicles and Oil Changes per Vehicle Group per Fuel Period From AOAP Tape: January 1, 1987 - May 31, 1990

Group	Fuel Type	No. of V/E	No. of Oil Change Rec	Avg. No. of Oil Change Rec
AVLB Combat Eng. Veh. & M60A1 Tanks	DF-2	62	87	1.40
AVLB Combat Eng. Veh. & M60A1 Tanks	Mixture	22	27	1.23
AVLB Combat Eng. Veh. & M60A1 Tanks	JP-8	7	11	1.57
M1 & M1A1 Tanks, AGT-1500	DF-2	7	8	1.14
M1 & M1A1 Tanks, AGT-1500	Mixture	2	3	1.50
M1 & M1A1 Tanks, AGT-1500	JP-8	1	1	--
Mortar Carrier; Carrier Cargo; M113APC; Gun	DF-2	171	260	1.52
Mortar Carrier; Carrier Cargo; M113APC; Gun	Mixture	87	131	1.51
Mortar Carrier; Carrier Cargo; M113APC; Gun	JP-8	48	73	1.52
Howitzer, SP; Light Recovery Vehicle, DD 8V-71	DF-2	33	48	1.45
Howitzer, SP; Light Recovery Vehicle, DD 8V-71	Mixture	18	29	1.61
Howitzer, SP; Light Recovery Vehicle, DD 8V-71	JP-8	19	33	1.74
2-1/2 Ton Truck, 5-Ton Truck, LD 465-1	DF-2	52	87	1.67
2-1/2 Ton Truck, 5-Ton Truck, LD 465-1	Mixture	53	66	1.25
2-1/2 Ton Truck, 5-Ton Truck, LD 465-1	JP-8	30	39	1.30*
M3 Bradley Fighting Vehicle, Cummins 903T	DF-2	4	4	1.00
M3 Bradley Fighting Vehicle, Cummins 903T	Mixture	30	43	1.43
M3 Bradley Fighting Vehicle, Cummins 903T	JP-8	30	41	1.37

* Statistically significant difference in the average number of oil change recommendations between the DF-2 and JP-8 fuel periods at the 5-percent level of significance.

TABLE 32. Number of Vehicles and Oil Changes per Vehicle Group per Fuel Period From AOAP Tape: January 1, 1987 - May 31, 1990 (Cont'd)

Group	Fuel Type	No. of V/E	No. of Oil Change Rec	Avg. No. of Oil Change Rec
5-Ton Truck, LDS 465-1	DF-2	31	57	1.84
5-Ton Truck, LDS 465-1	Mixture	36	55	1.53
5-Ton Truck, LDS 465-1	JP-8	34	49	1.44
5-Ton Truck, NHC 250	DF-2	78	105	1.35
5-Ton Truck, NHC 250	Mixture	67	88	1.31
5-Ton Truck, NHC 250	JP-8	34	40	1.18
Truck Tractor, HET 22-1/2 Ton, NHC 400	DF-2	34	55	1.62
Truck Tractor, HET 22-1/2 Ton, NHC 400	Mixture	29	35	1.21
Truck Tractor, HET 22-1/2 Ton, NHC 400	JP-8	14	15	1.07*
HEMTT 10-Ton Truck, DD 8V-92TA	DF-2	88	109	1.24
HEMTT 10-Ton Truck, DD 8V-92TA	Mixture	53	54	1.02
HEMTT 10-Ton Truck, DD 8V-92TA	JP-8	32	38	1.19
Generator Set 15/60 Hz; Generator Set 15/400 Hz	DF-2	29	37	1.28
Generator Set 15/60 Hz; Generator Set 15/400 Hz	Mixture	33	43	1.30
Generator Set 15/60 Hz; Generator Set 15/400 Hz	JP-8	15	20	1.33
Generator Set 30/60 Hz	DF-2	19	22	1.16
Generator Set 30/60 Hz	Mixture	11	14	1.27
Generator Set 30/60 Hz	JP-8	13	15	1.15

* Statistically significant difference in the average number of oil change recommendations between the DF-2 and JP-8 fuel periods at the 5-percent level of significance.

TABLE 33. Average Lead (Pb), Iron (Fe), and Copper (Cu) Metal Readings (in ppm) by Vehicle Group and Fuel Period From AOAP Tape: January 1, 1987 - May 31, 1990

Vehicle Group	Fuel Type	Average Lead	No. of V/E (Pb)	Average Iron	No. of V/E (Fe)	Average Copper	No. of V/E (Cu)
Forklift MHE 222	DF-2	12	3	101	3	33	3
Forklift MHE 222	Mixture	9	2	83	2	38	2
Forklift MHE 222	JP-8	5	2	103	2	43	2
AVLB Combat Eng. Veh. & M60A1 Tanks	DF-2	23	142	135	142	40	142
AVLB Combat Eng. Veh. & M60A1 Tanks	Mixture	24	47	103	47	51	47
AVLB Combat Eng. Veh. & M60A1 Tanks	JP-8	25	40	107	40	51	40
Bulldozer	DF-2	18	4	125	4	92	4
Bulldozer	Mixture	27	2	177	2	103	2
Bulldozer	JP-8	30	2	205	2	114	2
Locomotive	DF-2	5	4	25	4	10	4
Locomotive	Mixture	5	2	31	2	17	2
M1 & M1A1 Tanks, AGT-1500	DF-2	9	35	10	130	5	116
M1 & M1A1 Tanks, AGT-1500	Mixture	4	77	7	123	13	75
M1 & M1A1 Tanks, AGT-1500	JP-8	4	45	8	126	16	48
Mortar Carrier; Carrier Cargo; M113APC; Gun	DF-2	14	376	91	376	34	376
Mortar Carrier; Carrier Cargo; M113APC; Gun	Mixture	17	243	93	244	31	243
Mortar Carrier; Carrier Cargo; M113APC; Gun	JP-8	17*	212	82*	212	27*	211
Howitzer, SP; Light Recovery Vehicle, DD 8V-71	DF-2	24	108	89	108	38	108
Howitzer, SP; Light Recovery Vehicle, DD 8V-71	Mixture	28	93	97	93	45	93
Howitzer, SP; Light Recovery Vehicle, DD 8V-71	JP-8	25	93	84	93	50	93
2-1/2 Ton Truck, 5-Ton Truck, LD 465-1	DF-2	24	599	81	599	35	598
2-1/2 Ton Truck, 5-Ton Truck, LD 465-1	Mixture	23	555	84	555	39	555
2-1/2 Ton Truck, 5-Ton Truck, LD 465-1	JP-8	24	550	90*	550	37	550

* Statistically significant difference in the average metal reading between the DF-2 and JP-8 fuel periods at the 5-percent level of significance.

TABLE 33. Average Lead (Pb), Iron (Fe), and Copper (Cu) Metal Readings (in ppm) by Vehicle Group and Fuel Period From AOAP Tape: January 1, 1987 - May 31, 1990 (Cont'd)

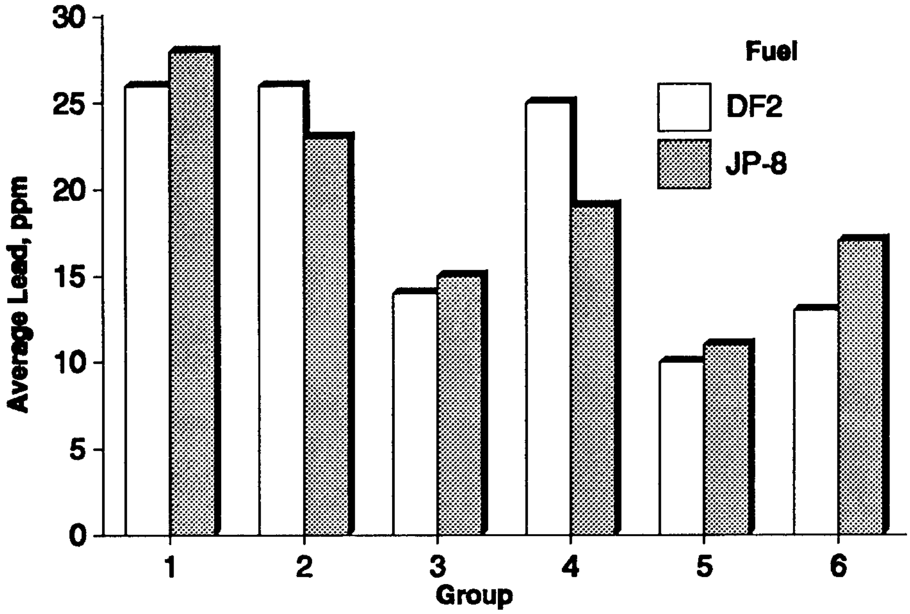
Vehicle Group	Fuel Type	Average Lead	No. of V/E (Pb)	Average Iron	No. of V/E (Fe)	Average Copper	No. of V/E (Cu)
M3 Bradley Fighting Vehicle, Cummins 903T	DF-2	9	25	44	25	22	25
M3 Bradley Fighting Vehicle, Cummins 903T	Mixture	11	138	60	138	26	138
M3 Bradley Fighting Vehicle, Cummins 903T	JP-8	15*	125	87*	125	23	124
Forklift MHE 237	DF-2	36	4	75	4	22	4
Forklift MHE 237	Mixture	24	3	69	3	20	3
Forklift MHE 237	JP-8	22	3	68	3	8	3
5-Ton Truck, LDS 465-1	DF-2	22	144	76	144	32	144
5-Ton Truck, LDS 465-1	Mixture	21	153	76	153	37	153
5-Ton Truck, LDS 465-1	JP-8	20	122	91*	122	32	122
1-1/4 Ton Cargo Truck, DD 353	DF-2	12	31	100	31	36	31
1-1/4 Ton Cargo Truck, DD 353	Mixture	11	8	104	8	42	8
1-1/4 Ton Cargo Truck, DD 353	JP-8	29	8	110	8	47	8
5-Ton Truck, NHC 250	DF-2	26	423	82	422	35	423
5-Ton Truck, NHC 250	Mixture	25	385	83	385	38	385
5-Ton Truck, NHC 250	JP-8	28	412	84	411	41*	412
Truck Tractor, 5 Ton, DD 6V-53T	DF-2	11	1	76	1	30	1
Truck Tractor, 5 Ton, DD 6V-53T	Mixture	10	1	99	1	34	1
Truck Tractor, 5 Ton, DD 6V-53T	JP-8	12	1	255	1	30	1
Truck Tractor, HET 22-1/2 Ton, NHC 400	DF-2	26	74	81	74	52	74
Truck Tractor, HET 22-1/2 Ton, NHC 400	Mixture	21	76	71	76	65	76
Truck Tractor, HET 22-1/2 Ton, NHC 400	JP-8	23	74	63*	74	58	74

* Statistically significant difference in the average metal reading between the DF-2 and JP-8 fuel periods at the 5-percent level of significance.

TABLE 33. Average Lead (Pb), Iron (Fe), and Copper (Cu) Metal Readings (in ppm) by Vehicle Group and Fuel Period From AOAP Tape: January 1, 1987 - May 31, 1990 (Cont'd)

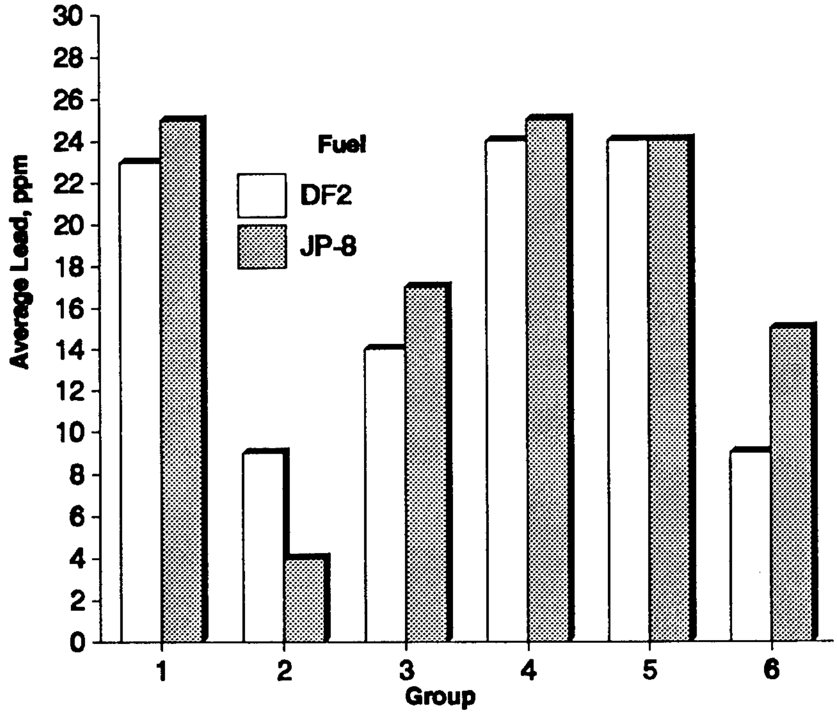
Vehicle Group	Fuel Type	Average Lead	No. of V/E (Pb)	Average Iron	No. of V/E (Fe)	Average Copper	No. of V/E (Cu)
10-Ton Truck, DD 8V-92TA	DF-2	14	312	143	312	35	312
10-Ton Truck, DD 8V-92TA	Mixture	11	312	121	312	33	312
10-Ton Truck, DD 8V-92TA	JP-8	15	300	129*	300	35	300
Generator Set 15/60 Hz; Generator Set 15/400 Hz	DF-2	20	114	52	114	21	114
Generator Set 15/60 Hz; Generator Set 15/400 Hz	Mixture	19	137	51	137	22	137
Generator Set 15/60 Hz; Generator Set 15/400 Hz	JP-8	23	147	55	147	29*	147
Generator Set 30/60 Hz	DF-2	25	78	61	79	21	79
Generator Set 30/60 Hz	Mixture	19	76	58	76	24	76
Generator Set 30/60 Hz	JP-8	19*	74	55	74	14*	74
Generator Set 60/60 Hz	DF-2	10	18	58	18	16	18
Generator Set 60/60 Hz	Mixture	10	20	67	20	21	20
Generator Set 60/60 Hz	JP-8	11	19	78	19	17	19
Generator Set 60/400 Hz	DF-2	13	27	66	27	26	27
Generator Set 60/400 Hz	Mixture	16	42	63	42	24	42
Generator Set 60/400 Hz	JP-8	17	45	70	45	38*	45
Forklift	DF-2	6	1	158	1	17	1
Forklift	Mixture	8	1	71	1	33	1
Forklift	JP-8	11	1	132	1	45	1

* Statistically significant difference in the average metal reading between the DF-2 and JP-8 fuel periods at the 5-percent level of significance.



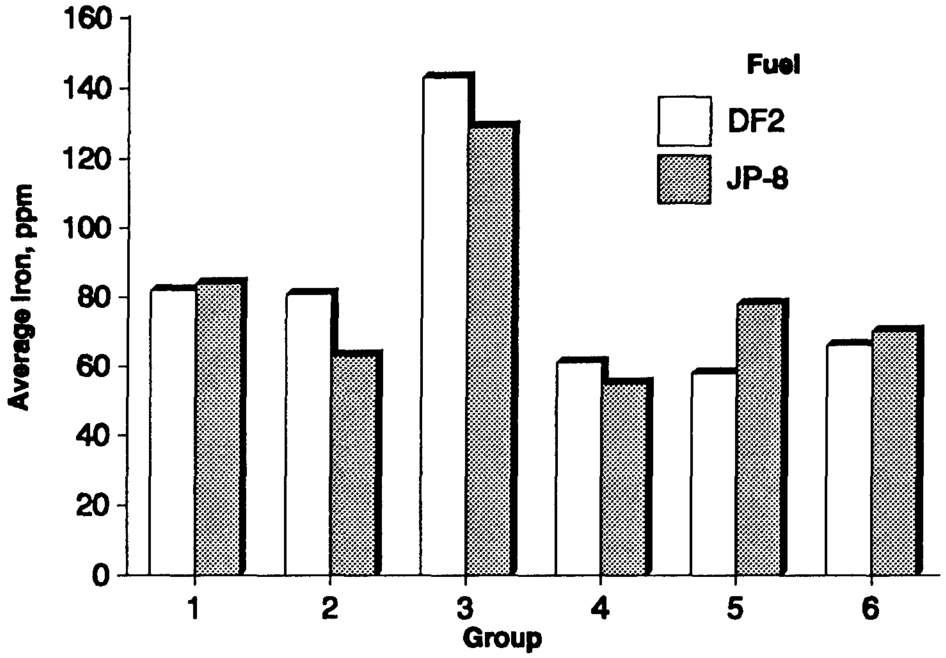
Group Description: 1 = 5-Ton Truck; 2 = Truck, HET 22-1/2 Ton; 3 = 10-Ton Truck; 4 = Gen Set 30/60 Hz; 5 = Gen Set 60/60 Hz; 6 = Gen Set 60/400 Hz

Figure 8. Average lead by vehicle group by fuel period



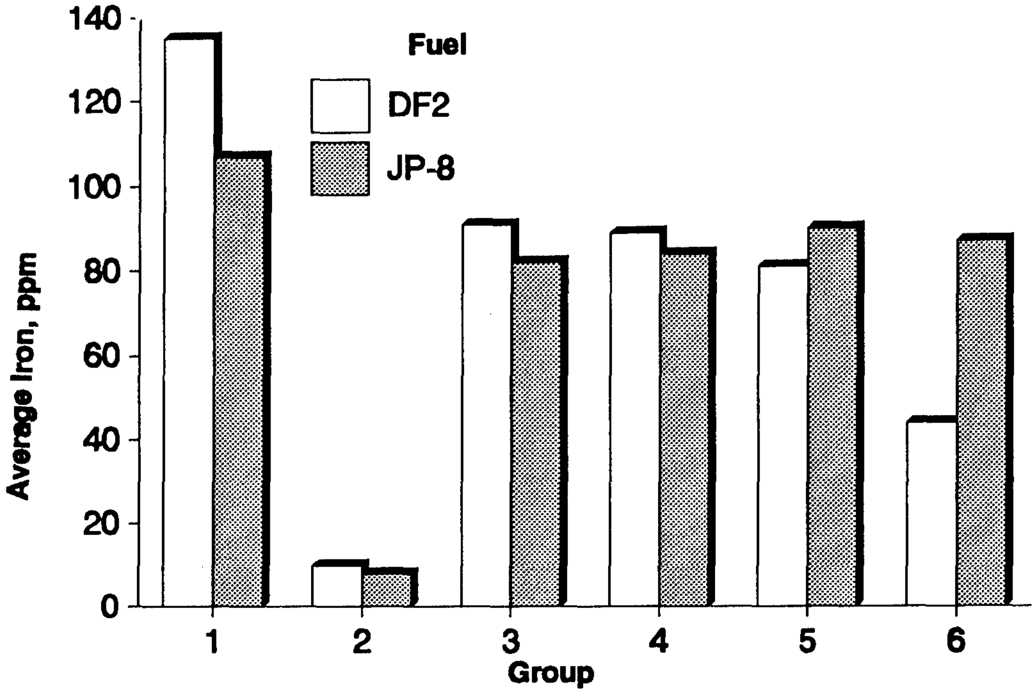
Group Description: 1 = AVLB Combat & M60A1 Tanks; 2 = M1 & M1A1 Tanks; 3 = Carriers & M113APC; 4 = Howitzer & Recovery Vehicle; 5 = 2-1/2 Ton & 5-Ton Trucks; 6 = M3 BFV, Cummins 903T

Figure 9. Average lead by vehicle group by fuel period



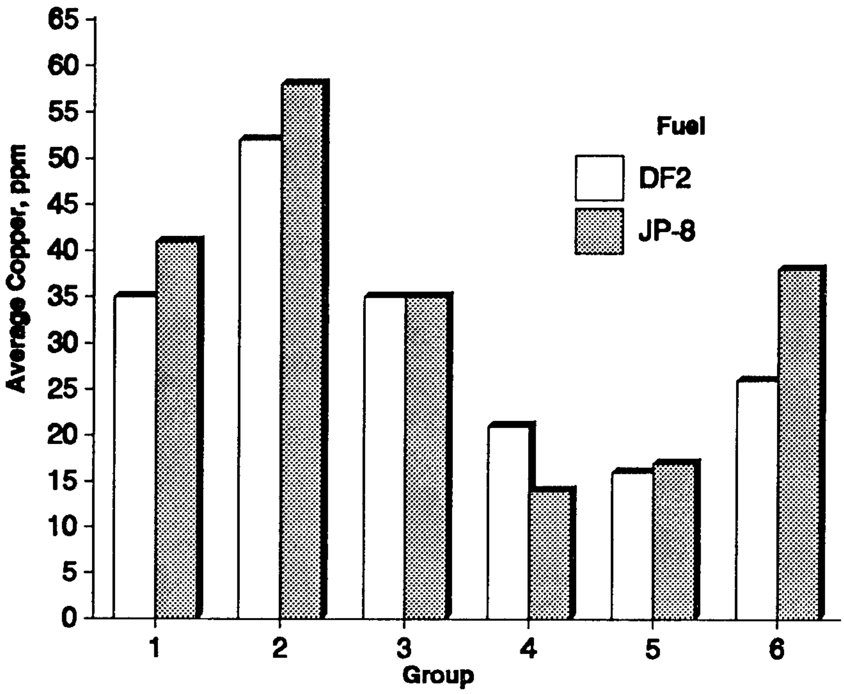
Group Description: 1 = 5-Ton Truck
2 = Truck, HET 22-1/2 Ton
3 = 10-Ton Truck
4 = Gen Set 30/60 Hz
5 = Gen Set 60/60 Hz
6 = Gen Set 60/400 Hz

Figure 10. Average iron by vehicle group by fuel period



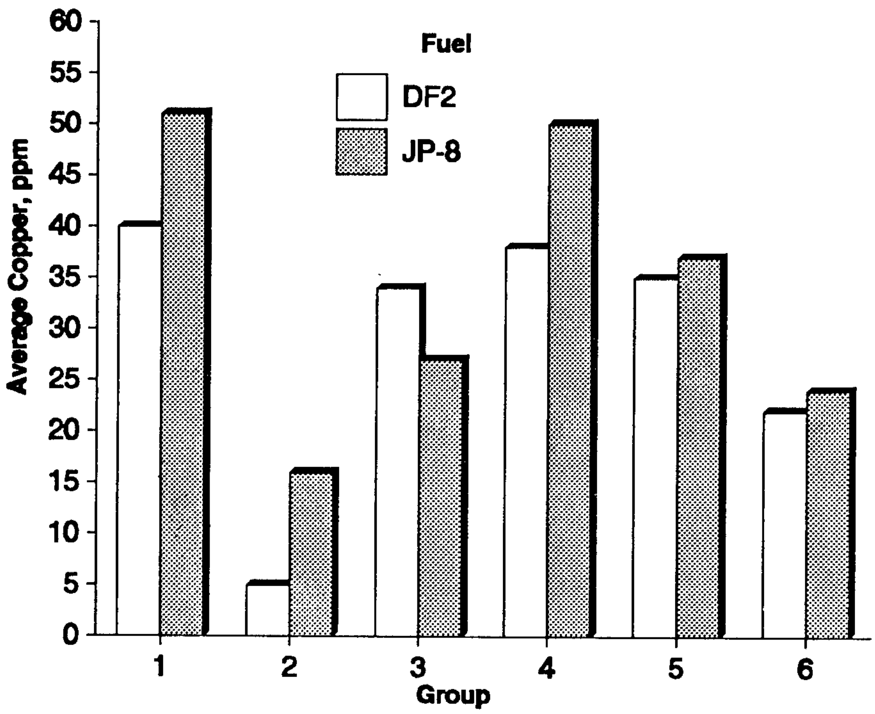
Group Description: 1 = AVLB Combat & M60A1 Tanks
2 = M1 & M1A1 Tanks
3 = Carriers & M113APC
4 = Howitzer & Recovery Vehicle
5 = 2-1/2 Ton & 5-Ton Trucks
6 = M3 BFV, Cummins 903T

Figure 11. Average iron by vehicle group by fuel period



Group Description: 1 = 5-Ton Truck; 2 = Truck, HET 22-1/2 Ton; 3 = 10-Ton Truck; 4 = Gen Set 30/60 Hz; 5 = Gen Set 60/60 Hz; 6 = Gen Set 60/400 Hz

Figure 12. Average copper by vehicle group by fuel period



Group Description: 1 = AVLB Combat & M60A1 Tanks; 2 = M1 & M1A1 Tanks; 3 = Carriers & M113APC; 4 = Howitzer & Recovery Vehicle; 5 = 2-1/2 Ton & 5-Ton Trucks; 6 = M3 BFV, Cummins 903T

Figure 13. Average copper by vehicle group by fuel period

E. Resolution of Maintenance/User Concerns

It was the practice, throughout the demonstration program, to investigate all fuel-related concerns of maintenance/user personnel. Many of the concerns were similar in nature. The following sections discuss the concerns that surfaced during the course of the program. These concerns are summarized in TABLE 34.

TABLE 34. Summary of V/E Operational Concerns Using JP-8 Fuel

Item Number	Subject Concern
1	Safety (vapor/fumes, skin contact)
2	Filter Plugging
3	Fuel Metering Equipment
	a. Electromechanical Fuel System
	b. Fuel Injector Assemblies
	c. NHC-250 Barrel Plunger Assemblies
4	Power Output
	a. Transportation Motor Pool 44-Passenger Buses
	b. M915 Line Haul Tractor
	c. D7E Full-Tracked Bulldozer
	d. Front-End Bucket Loaders
	e. M881A Recovery Vehicle
5	Fuel Consumption - CUCV
6	Vehicle Personnel Heater
7	Vehicle Cooling
8	M911 Fuel Cell Fill Cap Plugs Melting
9	M1A1 Plugged In-Line Check Valves
10	Vehicle Engine Exhaust Smoke System (VEESS)

1. Safety

Two safety concerns were raised by user personnel. People assigned to clean the inside of bulk fuel storage tanks or fuel tankers raised questions about volatility/vapors and toxicity of JP-8 compared with diesel fuel (DF-2). The toxicity issue was investigated by the U.S. Army Environmental Hygiene Agency (USAEHA) and the Office of the Surgeon General (OTSG). These two agencies prepared a Health Hazard Assessment Report (HHAR) for the use of JP-8 fuel in tactical vehicles.(14) This report addressed potential health hazards identified as handling, combustion emissions, and interaction with Halon 1301 during fire suppression. The conclusions stated in this report were that the health hazards identified for JP-8 appear to be equal to or less than those associated with diesel fuel (DF-2). An additional safety matter surfaced that concerned flammability of JP-8 if splashed on hot engine exhaust pipes. This issue was of no consequence and is further discussed under Item E.8, "M911 Filler Cap Alloy Plugs Melting."

2. Filter Plugging

Numerous instances of filter plugging were reported in the first several months of the program. Fuel and fuel filter samples (see Items A through N, P and Q, TABLE 35) were obtained and analyzed at BFLRF. The analyses showed that the filters were plugged by a combination of diesel fuel deterioration products, dirt, dust, and sand. Microbiological contamination was not found to be a largely contributing factor. However, the presence of microbiological growth in the fuel cells could not be entirely ruled out due to the presence of water in several of the fuel cells. The diesel fuel deterioration products were from diesel fuel remaining in the V/E fuel cells at the beginning of the demonstration program. JP-8 did not in any way cause, or contribute to, the filter plugging. The filter plugging problems disappeared as dirty fuel cells and lines were cleaned, scheduled fuel filter changes were made, and the remaining diesel fuel was consumed.

TABLE 35. List of Fuel-Wetted Components Received From Ft. Bliss

Item No.	Date	ID Number	Description	Source	Analyses or Purpose
A	06-09-89	AL-18851	Fuel Filter	Fuel Dispensing Point, Biggs Army Airfield	Identify particulates removed by the filter
B	07-12-89	AL-18892	Fuel Filter	M548A1, HWB-23	Investigate cause of reported fuel filter plugging
C	07-12-89	AL-18893	Fuel Filter	M113A2, HWB-1	Investigate cause of reported fuel filter plugging
D	07-12-89	AL-18894	Fuel Filter	M548A1, HWB-23	Investigate cause of reported fuel filter plugging
E	07-12-89	AL-18895	Fuel Filter	M548A1, HWB-23	Investigate cause of reported fuel filter plugging
F	07-14-89	AL-18899	Filter, Fuel/Water Separator	M1A1, 3/3rd, I-24	Investigate cause of reported fuel filter plugging
G	07-14-89	AL-18900	Final Fuel Filter	M1A1, 3/3rd, I-24	Investigate cause of reported fuel filter plugging
H	07-14-89	AL-18901	Primary Fuel Filter	M1A1, 3/3rd, I-24	Investigate cause of reported fuel filter plugging
I	07-19-89	AL-18915	Primary Fuel Filter	M88A1, 2/3rd, H-63	Investigate cause of reported fuel filter plugging
J	07-19-89	AL-18916	Primary Fuel Filter	M88A1, 2/3rd, H-63	Investigate cause of reported fuel filter plugging
K	07-19-89	AL-18917	Secondary Fuel Filter	M88A1, 2/3rd, H-63	Investigate cause of reported fuel filter plugging
L	07-19-89	AL-18918	Filter, Fuel/Water Separator	M88A1, 2/3rd, H-63	Investigate cause of reported fuel filter plugging
M	07-19-89	AL-18919	Primary Fuel Filter	M577A2, 2/3rd, HHT, HQ-51	Investigate cause of reported fuel filter plugging
N	07-19-89	AL-18920	Secondary Fuel Filter	M577A2, 2/3rd, HHT, HQ-51	Investigate cause of reported fuel filter plugging
O	07-31-89	AL-18983	Electromechanical Fuel System	M1A1, 2/3rd, E-23	Investigate failure of part
P	08-15-89	AL-18988	Primary Fuel Filter	Bus, 44 PAX, IMP No. 706	Retain
Q	08-15-89	AL-18989	Secondary Fuel Filter	Bus, 44 PAX, IMP No. 706	Retain
R	10-20-89	AL-19059	N-50 Fuel Injector	6V-53 Engine DF-2 only	Investigate cause of injector seizure
S	10-20-89	AL-19060	N-50 Fuel Injector	6V-53 Engine DF-2 and JP-8	Investigate cause of injector seizure
T	10-30-89	AL-19075	Fuel Injector Fuel Filter	M817, # E-28 43rd Eng. Co.	Retain
U	02-09-90	AL-19394-X	Barrel Plunger Assy	NHC-250 Fuel Injector	Investigate cause of injector seizure

TABLE 35. List of Fuel-Wetted Components Received From Ft. Bliss (Cont'd)

Item No.	Date	ID Number	Description	Source	Analyses or Purpose
V	02-09-90	AL-19395-X	Barrel Plunger Assy	NHC-250 Fuel Injector	Investigate cause of injector seizure
W	02-09-90	AL-19396-X	Barrel Plunger Assy	NHC-250 Fuel Injector	Investigate cause of injector seizure
X	05-29-90	AL-19382-X	Fuel Injector	DD 6V-53	Investigate cause of injector seizure
Y	06-01-90	AL-19385-X	Barrel/Plunger Assy	DD 6V-53	Investigate cause of injector seizure
Z	06-01-90	AL-19386-X	Barrel/Plunger Assy	DD 6V-53	Investigate cause of injector seizure
AA	06-01-90	AL-19387-X	Barrel/Plunger Assy	DD 6V-53	Investigate cause of injector seizure

3. Fuel Metering Equipment

a. Electromechanical Fuel System

Initial concerns that the electromechanical fuel systems (EMFS) for the M1A1 Abrams tanks were that fuel was not being properly metered to the engine combustor. Discussions with maintenance personnel of the 3rd ACR failed to establish if the failures of the M1A1 vehicle EMFS units were mechanical or electrical. The simplified test equipment (STE) for the M1 vehicle merely diagnosed a faulty unit; it did not isolate an electrical or mechanical fault. The failed units were evacuated to Anniston Army Depot (ANAD) for repair/overhaul. ANAD personnel stated that 60 to 80 percent of the EMFS units turned in for repair were for electrical problems; of the units with mechanical problems, the majority were due to contaminated fuel. No instances of EMFS failure could be directly attributed to the use of JP-8.

b. Fuel Injector Assemblies

(1) Three Barrel and Plunger Assemblies — BFLRF received three DDC 6V-53 barrel and plunger assemblies that had already been removed from their respective unit injector bodies. These injectors were removed from depot-issued engines by Ft. Bliss DIS shop personnel. Typically, depot engines either can be issued to direct support user activity as a replacement for a removed engine, or, in this instance, the engine was issued to the DIS shops for preparation of a power pack. After dynamometer power checks, the engine is shut down to prepare for running a stall check on the transmission. Upon restart of the engine, the fuel injectors were determined to be faulty, possibly seized, and removed from the engine. The three barrel and plunger assemblies were removed from the same engine. Since the three barrels/plungers were received without injector bodies, there is a distinct possibility that the wear surfaces had been distressed by their removal before their examination at BFLRF. With this possibility in mind, three possible seizure mechanisms can be proposed upon examining the surfaces. The first is the "infant mortality" mechanism in which tolerances, surface finish, concentricity, and manufacturing debris can contribute to seizure. This mechanism is demonstrated as relatively uniformly scored surfaces on Items Z and AA in TABLE 35. Another mechanism occurs when small particles are introduced into the injector during assembly or pass through the injector screen filters and become wedged between the barrel and plunger, thus scratching the surfaces. These scratches can increase the amount of asperity contact, which can eventually cause a scored surface, resulting in a seizure. Items Z and AA revealed thin vertical scratches, which would indicate that small particles had been wedged between barrel and plunger. The third mechanism occurs when a particle distresses the sharp shoulder of the plunger helix as it crosses the fill/spill port. Item Y revealed this mechanism, in which significant areas of the plunger helix had been fractured. The debris from the fractured helix then causes seizure when it is wedged between the barrel and plunger surfaces. BFLRF believes these failures are not a JP-8 related issue, but rather a rebuild cleanliness/handling issue.

(2) Complete DDC 6V-53 Unit Injector — BFLRF also received a complete DDC 6V-53 unit injector (Item X, TABLE 35) that had failed under similar circumstances as the aforementioned barrel/plunger assemblies. The injector fuel inlet and outlet

filter screens were rinsed and all particulate trapped. An elemental X-ray analysis of the fuel inlet filter particulate revealed Al, Si, Fe, Ca, Cu, and Zn. It appears Al, Si, and Fe were the most abundant of the elements found. The fuel outlet filter particulate analysis revealed F, Al, Si, Ca, Cu, and Fe, of which the most abundant elements were Al, Si, and Fe. The abundance of Fe was greater on the outlet filter, indicating that scoring had occurred in the barrel/plunger assembly. After a careful disassembly, the barrel/plunger were inspected and revealed a fractured shoulder on the plunger helix. In addition, a small particle was found lodged in a distressed area of the plunger. An elemental analysis of the particle revealed Al, Si, Na, and Cl.

c. NHC-250 Barrel/Plunger Assemblies

Three governor barrel and plunger assemblies (Items U, V, and W, TABLE 35) of PT fuel metering pumps from NHC-250 Cummins engines received from the Ft. Bliss DIS Component Repair Facility were inspected. The service histories of the fuel metering pumps were unknown. Two of the barrel/plunger assemblies were disassembled and revealed no signs of scoring or scuffing, both precursors to seizure. It was noted that the plungers could be inserted into their respective barrels and rotated and translated freely. The third assembly had the plunger seized in the barrel.

The two assemblies that were free arrived in that condition, but had been reported at Ft. Bliss as being seized. Although the plungers did not show any evidence of seizure, an examination of the governor barrel, with a reference to the Cummins PT Fuel Pump Rebuild and Calibration Manual, revealed a possible failure mechanism. The manual states that failure of the plunger can occur due to overheating during extended periods of overspeeding. This occurs when the governor flyweights force the plunger stop collar against the governor barrel face. Although the components are fuel wetted, neither the small bearing area of the plunger stop collar nor the barrel face are designed as thrust washers; therefore, a hydrodynamic fuel film cannot be developed to support the thrust load. This would result in metal-to-metal contact and overheating. The plungers received had their stop collars removed, but the barrel faces were highly polished, indicating extended plunger stop collar/barrel face contact did occur. A PT fuel pump that has seen laboratory dynamometer service was disassembled to examine the governor plunger and barrel. The assembly revealed a dull surface on the barrel face, indicating plunger stop collar/barrel face contact had not occurred in the pump. It is believed the failure of the two Ft. Bliss assemblies can be attributed to overheating due to governor plunger stop collar/barrel face contact and is **not** a JP-8 related problem.

A possible failure mechanism for the third assembly can also be found in the PT fuel pump manual. The manual states that seizure of the governor plunger in the barrel can occur during engine overspeeding due to improper engine speed control caused by improper use of gearing and braking. The manual does indicate this failure mode is more likely to occur in V/VT-903 engines due to their higher engine speeds, but it does not rule out the possibility of occurrence in N/NH/NT series engines. An examination of the governor barrel face indicated that governor plunger stop collar/barrel face contact had not occurred in this assembly. It is believed the plunger/barrel seizure can be attributed to overspeeding.

The Cummins PT Fuel Pump Rebuild and Calibration Manual indicates that governor plunger/barrel assembly failures occur due to overspeed conditions, and is not a fuel-related problem. All facts considered, the conclusion is that governor plunger/barrel assembly failures are **not** a JP-8 related condition.

4. Power Output

a. Transportation Motor Pool 44-Passenger Buses

A performance test was conducted on a fully loaded Transportation Motor Pool (TMP) 44-passenger bus powered by a recently remanufactured IHC-DT466B engine. The vehicle's fuel tank was drained and refilled with JP-8 fuel and new fuel filters installed. The vehicle was loaded to capacity and driven 10 miles on a designated route. Observations were made on acceleration, speeds attained, and overall performance. The following day the vehicle's fuel tank was drained and refilled with DF-2 fuel (fuel filters were not replaced). The vehicle was once again loaded to capacity and driven the same route as the previous day. There were no noticeable differences in performance between the two fuels. A detailed description of the comparative test is contained in Appendix C.

b. M915 Line-Haul Tractor

A BFLRF monitor accompanied a convoy from Ft. Bliss, TX, to Ft. Irwin, CA, as an observer on an M915 line-haul tractor from the 62nd Transportation Company, 70th Ordnance Battalion. The purpose of the trip was to obtain firsthand observations of operator claims of loss of power when operating the M915 on JP-8. A simplified test equipment/internal combustion engines (STE/ICE-R) unit was taken along to monitor fuel pressure at the fuel filter and to monitor engine power of the Cummins NTC-400 engine. The test vehicle fuel tanks were drained and then topped off with JP-8, and the fuel filters were changed. All other vehicles of the convoy topped off their tanks with JP-8, adding it to the fuel existing in their tanks, which was commercial DF-2. The test vehicle carried a cargo of an estimated 26,000 pounds, which was considered to be the heaviest load in the convoy. During the course of the convoy, two refueling stops were made at which all vehicles topped off with commercial DF-2. This refueling allowed the BFLRF monitor to obtain firsthand observations of the M915 operating on JP-8 and DF-2.

The BFLRF monitor and vehicle operator did not observe any performance degradation while the M915 was operating on JP-8. The test vehicle was able to maintain speed on grade and its convoy position in all but two occasions during the trip. The exceptions in which the vehicle could not maintain speed on grade occurred one time with JP-8 and once with DF-2. The inability to maintain position is attributed to the heavier load carried by the test vehicle, as evidenced by the same vehicle response with both fuels. The BFLRF monitor indicated there was no discernible difference in performance of the M915 between the two fuels. The vehicle operator concurred with the monitor's observations.

c. D7E Full-Tracked Bulldozer

(1) Comparative Test No. 1 — A comparative JP-8 versus DF-2 fuel test was conducted on a D7E full-tracked tractor (bulldozer) in response to complaints by operators of power loss and engine overheating while using JP-8 fuel. The tractor is powered by a Caterpillar D 339T/A engine and is assigned to the 43rd Engineer Company, 3rd ACR. The test objectives were to dig two identical combat tank hide positions side-by-side by the same tractor using JP-8 and DF-2 fuels and record start-to-finish times. In preparation for the test, the tractor was thoroughly checked, and the fuel filter was replaced. The tractor was then trucked to a test site selected by the platoon sergeant.

The first position was dug using JP-8 fuel, and the start-to-finish time was 50 minutes. The fuel tank was completely drained of JP-8 fuel and filled with 40 gallons of DF-2 fuel obtained at the Facilities Engineers. The tractor was operated at high idle for 20 minutes to ensure that all the JP-8 fuel was purged from the system. The second hide position was then dug using DF-2 fuel, and the start-to-finish time was 40 minutes. Approximate dimensions for the hide positions were 175 ft long by 13 ft wide. A 5-foot firing platform was placed facing the enemy side followed by a 45-degree cut to a depth of 14 feet, ending with an exit ramp of 30-degree slope.

(2) Comparative Test No. 2 — Two D7E full-tracked tractors (bulldozers) powered with Cat D 339T/A engines were operated by 3rd ACR combat engineers in follow-up comparative fuel evaluations during 13-15 June 1990. Working side-by-side, each dozer sequentially excavated two main battle tank hide emplacements, each operated initially with JP-8 followed by DF-2. There were two engineer operators, one for each tractor, with no operator switching between tractors. After completing the first dig, an HEMTT tanker defueled the JP-8 from each tractor and refueled each tractor with DF-2 that had been obtained from the 2/7th ADA at McGregor Range.

Results of the excavations are as follows:

	Tractor E-53		Tractor E-54	
	JP-8	DF-2	JP-8	DF-2
Elapsed Time, min	90	108	111	74
Total Dig Time, min	74	71	86	60
Ambient Temp, °F	89-90	96-98	89-90	96-98
Max Coolant Temp, °F	230-250	230-250	230-250	230-250

It was noted that the left steering lever of tractor E-54 had a faulty hydraulic control valve that failed to return to the centered position. As a result, the vehicle pushed to the right, scraping the side during the dig. The operator was forced to apply the brake to the left track for steering compensation. Since the operator had not previously operated vehicle E-54, it was felt that the JP-8 dig took a longer time due to lack of operator proficiency in counteracting the sideward pushing tendency of the vehicle. Hence, the dig time with DF-2 was noticeably shorter as the operator became more adept at correcting the vehicle's sideward pushing tendency. Tractor E-53 shows a 4-percent difference in dig time in favor of DF-2; this is more in line with the expected difference due to use of JP-8 fuel than was observed in the previous comparison with JP-8 conducted in December 1989. BFLRF contacted the Engineer Training School, ATSE-CDM-S, to determine the operator/vehicle performance targets used to conduct various engineer tasks. The Engineer Training School representatives indicated that they were not aware of any time limits for site preparations. Operators are taught to do the best they can considering soil composition, moisture, elevation, and temperature conditions at time of operations.

d. Front-End Bucket Loaders

The issue of power loss and overheating on the front bucket loaders reported by 43rd Engineer maintenance section personnel was investigated by the BFLRF monitor. According to the noncommissioned officer in charge (NCOIC) of the heavy equipment section, the front bucket loaders have never experienced power loss and overheating due to JP-8 use. At the beginning of the JP-8 demonstration program, there were complaints of power loss and overheating in one of the bucket loaders. However, the problem was found to be a partially plugged fuel filter and a faulty radiator.

e. M88A1 Recovery Vehicle

The 1/3rd ACR maintenance personnel expressed concern about the lack of power in the M88A1 armored recovery vehicle during operation with JP-8. When towing an M1A1 tank on a straight level road with an M88A1 using DF-2, an average speed of 20 to 22 mph was observed; using JP-8 for the same job produced an average speed of 14 to 15 mph. The problem is compounded because the M88A1 is marginally powered, with DF-2, when recovering M1 vehicles. There is no noticeable difference with JP-8 fuel when the M88A1 is pulling its own weight, or when hoisting power packs or performing other stationary functions.

5. Fuel Consumption

A complaint was received through the TACOM LAR office that a CUCV in the 1/43rd ADA Battalion had a range of 300 miles when using DF-2 and only 150 to 175 miles when operating on JP-8. To investigate this complaint, the BFLRF monitor requested the concerned unit obtain the actual CUCV for a comparative fuel consumption test. The fuel tank of the CUCV was drained, the fuel filter cleaned, and 15 gallons of JP-8 were added. The driver, his NCO, and the BFLRF monitor drove the vehicle over a 69.2-mile route, drained the fuel, and measured the unconsumed JP-8 fuel. Fifteen gallons of DF-2 were added, without a fuel filter change, and the CUCV was operated over the same 69.2-mile route with the same operator and the same number of personnel. At the completion of the run, the DF-2 was drained, and the unconsumed fuel was measured. Fuel consumed and mpg for JP-8 versus DF-2 were 4.34 gal./15.9 mpg and 4.25 gal./16.3 mpg, respectively. This comparison convinced unit operators that the difference in vehicle range with JP-8 when compared with DF-2 was insignificant. A detailed description of the comparative test runs is contained in Appendix C.

6. Vehicle Personnel Heater

A comparative test was scheduled and conducted on a vehicle-mounted personnel heater in which performance with JP-8 fuel was compared against DF-2. With the cooperation of the Ft. Bliss DIS, the test was conducted at the special components repair shop with two TACOM LARs and the BFLRF monitor present as observers. Results showed the difference in air temperature for the two fuels was less than 10°F. Startability was the same for the two fuels, with both reaching the same levels of heat within a few seconds of each other. In two instances, the JP-8 fueled heater reached 8° to 9°F higher air temperature than the DF-2 fueled heater at the same setting. In one instance, DF-2 produced 5°F higher air temperature than the JP-8. The conclusions reached were that there are no significant differences in heater operation using the two fuels. A detailed description of the comparative tests is contained in Appendix C.

7. Vehicle Cooling

Operators of the 3rd ACR M1A1 tanks complained that the tanks were running hotter, but not overheating, with JP-8 fuel than they had with diesel fuel. Similar complaints arose at the National Training Center (NTC) at Ft. Irwin, CA, and at Ft. Bliss, TX. A Textron-Lycoming representative at Ft. Irwin used a testing device on an M1A1 to determine the difference between the temperature attained with JP-8 fuel and a reference temperature attained when the vehicle was operated with DF-2. The temperature attained with JP-8 fuel was 100°F above the DF-2 temperature, but was still well within the M1A1's operating temperature parameters. Similar complaints occurred with D7E bulldozers, M109A3 self-propelled howitzers, front-end bucket loaders, and M3 Bradley fighting vehicles. As the demonstration program progressed, complaints about overheating gradually disappeared.

8. Filler Cap Vent Alloy Plugs Melting

The Ft. Bliss TACOM LARs reported a problem of pressure relief plugs melting in fuel tank caps on the M911 tractors operating in the demonstration program. Initially, it was believed that the JP-8 fuel was producing higher exhaust temperatures and the proximity of the fuel tank filler cap to the exhaust pipe was causing the alloy in the plugs to melt. However, data showed that exhaust port temperatures when using JP-8 fuel are generally ± 50°F when compared to diesel fuel. Of primary concern was the possibility of fire caused by fuel splashing from the vent holes and coming in contact with the hot exhaust pipe.

Investigation (15) revealed that the tractors were equipped with an older design filler cap whose relief plugs were filled with an alloy that had a lower melting point than the new replacement cap. Additionally, upon splashing from the vent holes and exposure to the exhaust pipe, JP-8 fuel offers equal or less fire hazard than would diesel fuel.

9. M1A1 Plugged In-Line Fuel Check Valves

Maintenance personnel at the 1st Squadron, 3rd ACR reported that plugged check valves in the M1A1 tank had caused problems in several of the vehicles. The check valve allows fuel to transfer from front to rear fuel cells and is automatically actuated when the fuel in the rear cells drains down to 1/4 full level. Maintenance personnel stated they had observed plugging of these valves. This phenomena continued even after the front fuel cells were drained and flushed before being refilled with JP-8 fuel. Although annoying to maintenance personnel, the plugged check valves are relatively easy to clean and reinstall. The plugging frequency eased off as remaining contaminants in the fuel cells gradually worked their way through the fuel system. Samples of the plugging debris were not available for analysis, and, hence, composition could not be determined.

10. Ft. Bliss DIS Dynamometer Testing

The DIS Component Repair Facility provided dynamometer test results on rebuild engines from 06 June 1989 through 31 July 1990. BFLRF staff in coordination with the Tank-Automotive Command provided the Component Repair Facility with the minimum acceptable brake horsepower/speed ratings on DF-2 and JP-8 fuel for all engines repaired at Ft. Bliss. As shown below, all engines with the exception of the VTA-903T surpassed the minimum bhp/rpm allowed for JP-8 fuel. The Ft. Bliss facility repaired the first VTA-903T engine in April 1990; consequently, the result depicted for this engine is based on one test only. Additionally, the test was performed before acceptable power limits had been established. The following data are the cumulative average rebuild engine horsepower ratings from 06 June 1989 through 31 July 1990:

Engine Type	Minimum bhp/rpm Allowed DF-2 Fuel	JP-8 Fuel	Dynamometer Test Results With JP-8 Avg. Max Power, bhp
6.2	124 at 3600	112 at 3600	122
6V-53	202 at 2800	182 at 2800	205
NHC-250	210 at 2800	200 at 2800	209
8V-92T	387 at 2100	368 at 2100	380
VTA-903T	480 at 2600	456 at 2600	450
LDT-465-1C	134 at 2600	134 at 2600	136
LDT-465-1A	170 at 2600	170 at 2600	172
AC3500	130 at 2000	120 at 2600	134

11. Vehicle Engine Exhaust Smoke System (VEESS)

The reduced capability of JP-8 to produce smoke when used in onboard vehicle engine exhaust smoke systems (VEESS) was raised as Armor School Issue 17-102-A at a February 1988 review. Because of the nature of the problem, the development of a program to fix the problem was beyond the scope of this demonstration and was addressed by other agencies. Appropriate correspondence on the VEESS/JP-8 issue was brought to the attention of the Ft. Bliss personnel.

F. Major Field Exercises

1. The 194th Armored Brigade from Ft. Knox, KY, completed its "Desert Legion" exercise at Ft. Bliss on 04 March 1989. In response to concerns that fuel consumption would increase significantly when using JP-8 fuel, calculations were made by the 194th Armored Brigade's S-4 section and BFLRF staff. Combined results showed a 2.4-percent increase with JP-8 fuel. This increase was considered insignificant. The 194th Armored Brigade was reportedly pleased with the end of fuel waxing problems when JP-8 was used in 1989 excercises.

2. The 3rd ACR, Ft. Bliss, TX, conducted exercises at the National Training Center, Ft. Irwin, CA, in May 1989 and October 1989. During the first exercise in May 1989, there was reported filter plugging in several combat vehicles, i.e., main battle tanks, personnel carriers, and self-propelled howitzers. However, investigation showed that the problem was caused by deteriorated DF-2 in fuel cells of vehicles being used for the first time since the changeover to

JP-8 fuel. There were no other fuel-related problems reported by units of the 3rd ACR for the remainder of the exercise nor during the October 1989 exercise.

3. The 11th ADA Brigade conducted "Roving Sands" at Ft. Bliss in August 1989 and "Roving Sands 90" in May 1990. The 11th ADA Brigade's "Roving Sands 90" exercise was the largest air defense artillery exercise ever conducted in the United States. More than 8,000 soldiers, airmen, and marines took part in the exercise at Ft. Bliss, TX. No problems were reported due to the use of JP-8.

VI. CONCLUSIONS/RECOMMENDATIONS

The following general conclusions are drawn from the JP-8 Demonstration Program:

- A JP-8 fuel demonstration program was conducted at Ft. Bliss, TX, during the period October 1988 through July 1990 in three major oranizations having a total of over 2,800 vehicles/equipment (V/E).

- Approximately 4,700,000 gallons of JP-8 fuel were dispensed to user units at Ft. Bliss and Ft. Irwin (NTC) during the course of the demonstration program.

- The JP-8 demonstration program verified that JP-8 fuel can be used in diesel fuel-consuming V/E.

- There were no catastrophic failures due to the use of JP-8, nor any insurmountable JP-8 related concerns either during routine or major field training exercises.

- All problems surfaced by maintenance/user personnel were resolved by technical consultation or direct comparison tests with DF-2.

- Widespread acceptance by command, maintenance, and user personnel of JP-8 fuel resulted in Ft. Bliss requesting that they be allowed to continue using JP-8 fuel after the demonstration program ends in September 1991.

Specific conclusions derived from the JP-8 Demonstration Program are:

- No special modifications to current fuels-handling equipment nor changes to current practices are required with the use of JP-8. Normal fuel filter/separator element changes, according to routine procedures, are sufficient.

- The use of JP-8 fuel did not cause or exacerbate any V/E fuel filter plugging. All instance of filter plugging were caused by contaminated or deteriorated diesel fuel remaining in the fuel cells.

- Where power loss was apparent, generally it was commensurate with the difference in heating values between JP-8 and DF-2.

- No instrumentally measured differences in engine operating temperatures supported any claim of overheating.

- For the period 01 February 1989 through 30 June 1990, 268,504 miles were accumulated in tracked vehicles and 398,017 miles in wheeled vehicles for a combined total of 666,521 miles using JP-8 fuel. Total vehicle mileage using JP-8 fuel is increased to approximately 2,122,472 miles when mileage from HMMWV and CUCVs is included. It was estimated that 71,208 hours of operation were accumulated in diesel/turbine engine driven generator sets using JP-8 fuel during the period 01 February 1989 through 31 July 1990. Combined mileage accumulated using JP-8 fuel in transportation motor pool (TMP) vehicles was 493,863 miles.

- For the period 01 January 1988 through 31 July 1990, there were no statistically significant differences observed in average V/E group fuel consumption between JP-8 and DF-2 fuel derived from merger of TAMMS and DA Form 3643 data. Also, there were no statistically significant differences between DF-2/JP-8 mix and JP-8 fuel derived from actual usage data provided by the 6th ADA Brigade.

- Fuel-wetted component replacements were tracked for the period 01 January 1988 through 31 July 1990 from DA maintenance request forms 2407 provided by the maintenance division. Component usage fluctuated between 1988, 1989, and 1990. For some vehicle groups, component usage increased and in others usage decreased with JP-8 fuel. Further contributing to this fluctuation were equipment gains and losses during 1988 and 1989. It cannot be determined from these data if the use of JP-8 fuel had a statistically significant difference in component usage.

- Of eight vehicle groups comprised of 516 vehicles running on DF-2 and 226 on JP-8, two groups showed statistically significant differences in the average number of AOAP-directed oil changes. Both of these groups, 2.5-ton/5-ton truck (LD 465-1), and 10-ton truck (DD 8V-92TA), demonstrated lower average number of AOAP-directed oil changes for the JP-8 fuel period than for DF-2 fuel period.

- Of 42 vehicle groups/wear metal combinations, 28 had no statistically significant differences in the average wear metal reading between JP-8 and DF-2. Fourteen combinations had statistically significant differences in the average wear metal reading. Six combinations showed higher wear metal readings with JP-8, and eight showed lower wear metal readings with JP-8 compared with DF-2.

- Since there were no major differences in fuel procurement cost, V/E fuel consumption, AOAP-directed oil changes, and fuel-wetted component replacements, it is judged that there is no cost penalty associated with the use of JP-8 fuel.

Concerning future changeovers from diesel fuel (DF-2) and subsequent JP-8 transitioning under the single-fuel concept, the following recommendations are made:

- All JP-8 (F-34) POL equipment and procedures for nonaviation use should be operated as required for aviation turbine fuels. All ground vehicles/equipment (V/E) should be refueled with refueler/tankers/dispensing equipment that would be suitable for use with aviation equipment. Any mindset that believes JP-8 intended for ground equipment could be handled as though it were diesel fuel would be contrary to the single-fuel-forward concept. The JP-8 to be used in ground equipment **must** be handled as if it were to be used in aviation equipment.

- NATO F-54 and F-65 (1 to 1 blend F-54/F-34) are, in general, higher quality fuels than CONUS DF-2 and have caused fewer problems in Army mobility ground equipment operated within NATO environment. Therefore, it is expected that individual V/E fuel systems will be cleaner after operation with F-54 and F-65 fuels than with CONUS DF-2.

- Change filter separator elements on all fuel-dispensing equipment previously used for diesel fuel; also change fuel-dispensing pump final filters at above or below ground storage areas that were used with diesel fuel.

- Clean all vehicle refuelers/tankers, change filter separator elements, and ensure that these separator elements are in place and in use for all dispensing operations.

- Draw down all M1 vehicle family **front** and rear fuel cells.

- Change vehicle fuel filters only in accordance with established maintenance schedules; more frequent filter changes should be made only if filter plugging occurs.

- **Older** V/E having had a lengthy period of operation with CONUS DF-2 and recently transferred from CONUS to OCONUS locations would be more prone to fuel system problems.

- Logistic Assistance Representatives should be prepared to field questions/complaints about JP-8 related problems that **in most cases** will be related to **normal** maintenance/fuel-related concerns.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACR	-	Armored Cavalry Regiment
ADA	-	Air Defense Artillery
ADAC	-	Air Defense Artillery Center
AMC	-	Army Materiel Command
ANAD	-	Anniston Army Depot
AOAP	-	Army Oil Analysis Program
APC	-	Armored Personnel Carrier
AR	-	Army Regulation
BAAF	-	Biggs Army Air Field
Bde	-	Brigade
Belvoir RDE Center	-	U.S. Army Belvoir Research, Development and Engineering Center
BFLRF	-	Belvoir Fuels and Lubricants Research Facility (SwRI)
Bn	-	Battalion
CCV/CS	-	Close Combat Vehicle/Combat Support
CUCV	-	Commercial Utility Cargo Vehicle
DFSC	-	Defense Fuel Supply Center
DFSP	-	Defense Fuel Supply Point
DIS	-	Director of Installation Support
DOD	-	Department of Defense
DOL	-	Director of Logistics
EMFS	-	Electromechanical Fuel System
FBT	-	Fuel Bulk Tank
FORSCOM	-	U.S. Armed Forces Command
FSII	-	Fuel System Icing Inhibitor
GMPA	-	General Materiel Petroleum Activity
HEMTT	-	Heavy Expanded Mobility Tactical Truck
HET	-	Heavy Equipment Transport
HHAR	-	Health Hazard Assessment Report
HMMWV	-	High Mobility Multipurpose Wheeled Vehicle

LAO	-	Logistics Assistance Office
LAR	-	Logistics Assistance Representative
LOI	-	Letter of Instructions
mpg	-	Miles-per-gallon
MRSA	-	Materiel Readiness Support Activity
NATO	-	North Atlantic Treaty Organization
NCO	-	Noncommissioned Officer
NCOIC	-	Noncommissioned Officer in Charge
NTC	-	National Training Center
OCONUS	-	Outside Continental United States
ORD	-	Ordnance
OTSG	-	Office of the Surgeon General
PEO	-	Program Executive Office(r)
SOP	-	Standing Operating Procedure
STANAG	-	Standardization Agreement
STE	-	Simplified Test Equipment
TACOM	-	U.S. Army Tank-Automotive Command
TAMMS	-	The Army Maintenance Management System
TMP	-	Transportation Motor Pool
TRADOC	-	Training and Doctrine Command
TROSCOM	-	Troop Support Command
USAEHA	-	U.S. Army Environmental Hygiene Agency
UIC	-	Unit Identification Code
V/E	-	Vehicles/Equipment
VEESS	-	Vehicle Engine Exhaust Smoke System

APPENDIX A

Diesel Fuel-Consuming Vehicles/Equipment Density Listing for Ft. Bliss, TX (as of 31 July 1990)

DIESEL FUEL-CONSUMING VEHICLES/EQUIPMENT DENSITY LISTING FOR FT. BLISS, TEXAS (as of 31 July 1990)

Fuel	Line Item Number	Nomenclature	TRADOC Units	3rd ACR
TACTICAL WHEELED VEHICLES				
Diesel	T38660	Truck Ambulance Tac 1-1/4 Ton M1010	4	5
Diesel	X40009	Truck Cargo 2-1/2 Ton M35 Series	69	77
Diesel	X40146	Truck Cargo 2-1/2 Ton w/w M35 Series	27	46
Diesel	X40283	Truck Cargo 2-1/2 Ton xlwb M36A2	14	9
Diesel	X40420	Truck Cargo 2-1/2 Ton w/w M36A2	10	31
Diesel	X40831	Truck Cargo 5-Ton lwb M54A1	8	28
Diesel	X40968	Truck Cargo 5-Ton lwb M54 Series	8	36
Diesel	X41242	Truck Cargo 5-Ton w/w M55A2	0	2
Diesel	X41105	Truck Cargo 5-Ton xlwb M55A2	13	2
Diesel	X40077	Truck Cargo Dropside 2-1/2 Ton	66	22
Diesel	X40794	Truck Cargo Dropside 5-Ton	43	22
Diesel	X40214	Truck Cargo Dropside 2-1/2 Ton	6	0
Diesel	T59482	Truck Cargo Tactical 5/4-Ton M1008	95	24
Diesel	T59346	Truck Cargo Tactical 5/4-Ton M1008A1	88	21
Diesel	T59414	Truck Cargo Tactical 5/4-Ton M1028	20	10
Diesel	T59278	Truck Cargo Tactical 8x8 HEMTT M977	0	47
Diesel	T39586	Truck Cargo Tactical 8x8 HEMTT M985	1	1
Diesel	T39518	Truck Cargo Tactical 8x8 HEMTT w/w M977	17	8
Diesel	T39654	Truck Cargo Tactical 8x8 HEMTT w/w M985	2	0
Diesel	X43708	Truck Dump 5-Ton	0	5
Diesel	X43845	Truck Dump 5-Ton w/w M51 Series	0	1
Diesel	T87243	Truck Tank FS 2500 gl 8x8 HEMTT M978	3	43
Diesel	T58161	Truck Tank FS 2500 gl 8x8 HEMTT w/w M978	17	16
Diesel	X58367	Truck Tank Water 2-1/2 Ton M50	2	0
Diesel	X59326	Truck Tractor 5-Ton M52	65	40
Diesel	X59463	Truck Tractor 5-Ton M52 w/w	17	25
Diesel	T61035	Truck Tractor HEMTT 2-1/2 Ton w/w M911	0	2
Diesel	T91656	Truck Tractor LET w/w M916	0	2
Diesel	T61103	Truck Tractor Line Haul	48	0
Diesel	T88677	Truck Tractor Tactical HEMTT w/w	129	0
Diesel	T61562	Truck Utility Cgo 1-1/4 Ton HMMWV	32	0
Diesel	T05028	Truck Utility Tactical 3/4-Ton M1009	253	80

DIESEL FUEL-CONSUMING VEHICLES/EQUIPMENT DENSITY LISTING FOR FT. BLISS, TEXAS (CONT'D)
(as of 31 July 1990)

Fuel	Line Item Number	Nomenclature	TRADOC Units	3rd ACR
Diesel	X62237	Truck Van Expansible 5-Ton	13	7
Diesel	X62340	Truck Van Shop 2-1/2 Ton	40	29
Diesel	X62477	Truck Van Shop 2-1/2 Ton	1	1
Diesel	X63299	Truck Wrecker 5-Ton	22	16
Diesel	T63093	Truck Wrecker Tactical HEMTT M984	25	7
COMBAT TRACKED VEHICLES				
Diesel	D10741	Carrier 107 mm Mortar SP M106A2	0	18
Diesel	D11049	Carrier Cargo Tracked 6-Ton M548	0	25
Diesel	D11538	Carrier Command Post M577	1	41
Diesel	D11681	Carrier Gm Equip Less Wpn(tow)	0	18
Diesel	D12087	Carrier Personnel Armored M113	16	90
Diesel	C12155	Carrier Personnel FT Fire Spt M981	0	12
Diesel	E56578	Combat Engineer Vehicle M728	0	3
Diesel	J96694	Gun Air Defense SP 20 M163	47	0
Diesel	K57667	Howitzer Medium SP 155 mm M109	1	17
Diesel	L43644	Launch M60 Tank Series	0	11
Diesel	R50544	Recovery Vehicle Light M578	5	4
Diesel	R50681	Recovery Vehicle Med M88A1	0	28
Diesel	V13101	Tank Combat Low Profile 105 mm M48A5	1	1
Diesel	Z77257	Tank Combat 120 mm M1A1	0	129
Diesel	C76335	Cavalry Fighting Vehicle M3	0	116
CONSTRUCTION EQUIPMENT				
Diesel	F43429	Crane Trk Mtd 25t MT250	1	0
Diesel	L76556	Ldr Scp 645 M	8	2
Diesel	S11711	Rlr Hvs C350BD	1	0
Diesel	W76816	Tractor FT A/C HD-16 M	2	4
Diesel	W83529	Tractor FT A/C HD-16 M	1	0
Diesel	W91074	Tractor Whl Ind w/Loader Backhoe JD410	2	0
GENERATORS				
Diesel	J35813	Generator Set Ded 5 kW 60 HZ MEP002A	26	13
Diesel	J35825	Generator Set Ded 10 kW 60 HZ Libby	1	4

DIESEL FUEL-CONSUMING VEHICLES/EQUIPMENT DENSITY LISTING FOR FT. BLISS, TEXAS (CONT'D)
(as of 31 July 1990)

Fuel	Line Item Number	Nomenclature	TRADOC Units	3rd ACR
Diesel	J36006	Generator Set Ded 15 kW 400 HZ MEP113A	67	0
Diesel	G36074	Generator Set Ded 15 kW 400 HZ PU732/M	23	0
Diesel	J35835	Generator Set Ded 15 kW 60 HZ	9	0
Diesel	J35492	Generator Set Ded 15 kW 60 HZ PU405/M	14	0
Diesel	J36725	Generator Set Ded 30 kW 400 HZ MEP114A	13	0
Diesel	G53871	Generator Set Ded 30 kW 400 HZ PU760/M	2	0
Diesel	J36109	Generator Set Ded 30 kW 60 HZ	2	0
Diesel	J36304	Generator Set Ded 30 kW 60 HZ Holg	2	0
Diesel	J36383	Generator Set Ded 30 kW 60 HZ PU406A/M	4	3
Diesel	J38506	Generator Set Ded 60 kW 400 HZ MEP115A	41	0
Diesel	J35680	Generator Set Ded 60 kW 400 HZ PU707A/M	10	2
Diesel	J38369	Generator Set Ded 60 kW 60 HZ	12	0
Diesel	J38301	Generator Set Ded 60 kW 60 HZ	7	1
Diesel	J35629	Generator Set Ded 60 kW 60 HZ	7	3
Diesel	P42114	Generator Set GT 150 kW 424A	40	0

MATERIAL-HANDLING EQUIPMENT

Diesel	T49119	Truck LF 10000 lb RT M10A	2	5
Diesel	X49051	Truck LF DDA-3520 MHE199	5	0
Diesel	X48914	Truck LF DD MDL MLT6 MHE202	0	3
Diesel	T49255	Truck LF MDL MK4 MHE237	0	4
Diesel	T73645	Truck LF 4000 lb H40-XL	33	0
Diesel	T73645	Truck LF 6000 lb H60-XL	20	0
Diesel	L80632	Locomotive 60-Ton RS-4-TC	1	0

ADMINISTRATIVE VEHICLES (TMP)

Diesel	C39977	Bus Transit 28 Passenger	10	0
Diesel	C39977	Bus Transit 44 Passenger	29	0

APPENDIX B

Fuel Sample Listing and Analytical Results

TABLE B-1. List of Fuel Samples Received From Ft. Bliss During February to April 1989

Item No.	Date	Lab ID No.	Description	Source	Analyses or Purpose
A	02-03-89	AL-18501	JP-8, Delivery	Truck No. T419	Confirm grade and quality
B	02-03-89	AL-18502	JP-8, Delivery	Truck No. T46	Confirm grade and quality
C	02-03-89	AL-18503	JP-8, Delivery	Truck No. T472	Confirm grade and quality
D	02-03-89	AL-18504	JP-8, Delivery	Truck No. T458	Confirm grade and quality
E	02-03-89	AL-18505	JP-8, Delivery	Truck No. T397	Confirm grade and quality
F	02-03-89	AL-18506	JP-8, Delivery	Truck No. T461	Confirm grade and quality
G	02-06-89	AL-18507 to AL-18512	JP-8, Delivery	Several Tank Trucks	Retain
H	02-13-89	AL-18517	JP-8, Delivery	Tank No. 5023	Confirm grade and quality
I	02-13-89	AL-18518	JP-8, Delivery	Tank No. 213	Confirm grade and quality
J	02-13-89	AL-18519	JP-8, Delivery	Truck No. 874	Confirm grade and quality
K	02-13-89	AL-18520	JP-8, Delivery	Truck No. 287	Confirm grade and quality
L	02-13-89	AL-18521	JP-8, Delivery	Truck No. 305	Confirm grade and quality
M	02-13-89	AL-18522	JP-8, Delivery	Truck No. 270	Confirm grade and quality
N	02-21-89	AL-18582	JP-8, Delivery	Rail Car No. 9478	Confirm grade and quality

TABLE B-1. List of Fuel Samples Received From Ft. Bliss During February to April 1989 (Cont'd)

Item No.	Date	Lab ID No.	Description	Source	Analyses or Purpose
O	02-21-89	AL-18583	JP-8, Delivery	Rail Car No. 9400	Confirm grade and quality
P	02-21-89	AL-18584	JP-8, Delivery	Truck No. T177	Confirm grade and quality
Q	02-21-89	AL-18585	JP-8, Delivery	Truck No. T442	Confirm grade and quality
R	02-21-89	AL-18586	JP-8, Delivery	Truck No. 303	Confirm grade and quality
S	02-21-89	AL-18587	JP-8, Delivery	TRL 258	Confirm grade and quality
T	04-06-89	AL-18664	JP-8, Middle	Tank No. 7706	Confirm grade and quality
U	05-03-89	AL-18737	JP-8, Dispensing Nozzle	Tank No. 7706	Confirm grade and quality

TABLE B-2. Summary List of Fuel Samples Received During May to July 1989

Item No.	Date	Lab ID No.	Descrip-tion/Grade	Source	Analyses or Purpose
A	05-03-89	AL-18737	JP-8	Ft. Irwin Bulk Storage	Determine quality, especially cleanli-ness
B	05-16-89	AL-18744 to AL-18749	JP-8	2/3rd ACR Bulk Underground Storage	Compare quality of fuel to baseline samples
C	05-19-89	AL-18753 to AL-18757	JP-8	Rail-Car Delivery Samples	Retain samples
D	05-19-89	AL-18758 to AL-18763	JP-8	Motor Pool Underground Storage Tanks	Compare quality of fuel to baseline samples
E	05-23-89	AL-18772 to AL-18775	JP-8	Motor Pool Underground Storage Tanks	Compare quality of fuel to baseline samples
F	05-23-89	AL-18776 to AL-18777	JP-8	Motor Pool Storage Tanks	Compare quality of fuel to baseline samples
G	06-14-89	AL-18860 to AL-18868	JP-8	3/3rd and 1/3rd Underground Storage Tanks	Compare quality of fuel to baseline samples
H	07-19-89	AL-18903 to AL-18913	JP-8 and DF-2	Vehicle Fuel Cell Samples	Investigate fuel filter plugging and confirm grade and quality of fuel
I	07-27-89	AL-18937 and AL-18938	Unknown	5-Ton Truck, Fuel Tank Samples	Confirm grade and quality of fuel
J	07-27-89	AL-18939 to AL-18953	Unknown	Vehicle Fuel Cell Samples	Confirm grade and quality of fuel
K	07-31-89	AL-18958 to AL-18965	Unknown	Vehicle Fuel Cell Samples	Confirm grade and quality of fuel

TABLE B-3. List of Fuel Samples Received From Ft. Bliss During August to October 1989

Item No.	Date	ID Number	Description	Source	Analyses or Purpose
A	08-15-89	AL-18990	Fuel Tank Sample	Bus, USA No. CE6612, 44 PAX, TMP Vehicle	Confirm identity and quality of fuel
B	08-15-89	AL-18991	Fuel Tank Sample	Bus, USA No. CE6612, 44 PAX, TMP Vehicle	Confirm identity and quality of fuel
C	08-15-89	AL-18992	Fuel Cell Sample, Repeat	M113A1, 1/85th Regt., No. 46	Identify fuel (DF-2 or JP-8)
D	08-15-89	AL-18993	Fuel Cell Sample, Repeat	M113A1, 1/85th Regt., No. 16	Identify fuel (DF-2 or JP-8)
E	08-15-89	AL-18994	Fuel Cell Sample, Repeat	M113A1, 1/85th Regt., No. 28	Identify fuel (DF-2 or JP-8)
F	08-15-89	AL-18995	Fuel Cell Sample, Repeat	M113A1, 1/85th Regt., No. 12	Identify fuel (DF-2 or JP-8)
G	10-12-89	AL-19047	Can 1	M915 Tractor Fuel Tank	Confirm identity and quality of fuel
H	10-12-89	AL-19048	Can 2	M915 Tractor Fuel Tank	Confirm identity and quality of fuel
I	10-12-89	AL-19049	Can 3	M915 Tractor Fuel Tank	Confirm identity and quality of fuel
J	10-12-89	AL-19050	Can 4	M915 Tractor Fuel Tank	Confirm identity and quality of fuel
K	10-20-89	AL-19054	Middle Sample	BAAF Main Tank	Routine analysis
L	10-20-89	AL-19055	Middle Sample	DOL Maint Tank	Routine analysis
M	10-20-89	AL-19056	Bottom Sample	DOL Maint Tank	Routine analysis
N	10-20-89	AL-19057	Bottom Sample	BAAF Main Tank	Routine analysis
O	10-20-89	AL-19058	Sample From 55-Gal. Drum	Component Repair	Confirm identity and quality of fuel
P	10-20-89	AL-19061	Diesel Fuel		Retain
Q	10-24-89	AL-19071	JP-8	Ft. Bliss, Rail Car, No. DODX 9455, Bottom	Routine analysis
R	10-24-89	AL-19072	JP-8	Ft. Irwin, 100,000-Gallon Tank	Routine analysis

TABLE B-4. List of Fuel Samples Received From Fort Bliss During November 1989 to January 1990

No. Item	Date	ID Number	Description	Source	Analyses or Purpose
A	12-11-89	AL-19103	Bldg 2970 Tank No. 1	3/3rd ACR	Confirm identity and quality of fuel
B	12-11-89	AL-19104	Bldg 2970 Tank No. 2	3/3rd ACR	Confirm identity and quality of fuel
C	12-11-89	AL-19105	Tanker Truck Sample No. 103	3/3rd ACR	Confirm identity and quality of fuel
D	12-11-89	AL-19106	Tanker Truck Sample No. 109	3/3rd ACR	Confirm identity and quality of fuel
E	12-18-89	AL-19113	Left Front Fuel Tank	M1A1, H-11	Confirm identity and quality of fuel
F	12-18-89	AL-19114	Right Front Fuel Tank	M1A1, H-11	Confirm identity and quality of fuel
G	12-18-89	AL-19115	Fuel Tank Sample	Dozer No. 43253	Confirm identity and quality of fuel
H	12-18-89	AL-19116	Pump Sample	DEH DF-2 Fuel Tank	Confirm identity and quality of fuel
I	12-18-89	AL-19117	Bldg 2970, Tank No. 3, DF-2	3/3rd ACR	Confirm identity and quality of fuel
J	12-18-89	AL-19118	Bldg 2970, Tank No. 4, DF-2	3/3rd ACR	Confirm identity and quality of fuel
K	01-09-90	AL-19130	Fuel Tank Sample (DF-2)	Gen Set, BMPR No. AE232A	Confirm identity and quality of fuel
L	01-09-90	AL-19131	Fuel Tank Sample	150 kW Gen. Mdl 424A	Confirm identity and quality of fuel
M	01-22-90	AL-19150	Bottom Sample	Rail Tank Car	Confirm identity and quality of fuel
N	01-22-90	AL-19151	Middle Sample	Rail Tank Car	Confirm identity and quality of fuel
O	01-22-90	AL-19152	Bottom Sample	HEMTT-B740	Confirm identity and quality of fuel

TABLE B-5. List of Fuel Samples Received From Ft. Bliss During February to April 1990

Item No.	Date	ID Number	Description	Source	Analyses or Purpose
A	02-16-90	AL-19189-F	JP-8, Middle Sample	BAAF Main Tank	Routine analysis
B	02-16-90	AL-19190-F	JP-8, Bottom Sample	BAAF Main Tank	Routine analysis
C	02-16-90	AL-19191-F	DF-2, Middle Sample	Oro Grande Range	Determine quality of fuel
D	02-23-90	AL-19199-F	JP-8, Middle Sample	BAAF Main Tank	Measure particulates
E	02-23-90	AL-19200-F	JP-8, Bottom Sample	BAAF Main Tank	Measure particulates
F	02-23-90	AL-19201-F	JP-8, Dip Sample	Delivery Truck	Measure particulates
G	02-23-90	AL-19202-F	JP-8, 4 in. From Bottom	BAAF Main Tank	Measure particulates
H	02-23-90	AL-19203-F	JP-8, 12 in. From Bottom	BAAF Main Tank	Measure particulates
I	02-23-90	AL-19204-F	JP-8, Dispensing Pump After Filter	BAAF Main Tank	Measure particulates
J	02-23-90	AL-19205-F	JP-8, Middle Sample	Dona Ana Range	Routine analysis
K	02-23-90	AL-19206-F	JP-8, Bottom Sample	Dona Ana Range	Routine analysis
L	02-23-90	AL-19207-F	JP-8, Middle Sample	3/3rd ACR, Bldg 2970, Tank 1	Routine analysis
M	02-23-90	AL-19208-F	JP-8, Bottom Sample	3/3rd ACR, Bldg 2970, Tank 1	Routine analysis
N	02-23-90	AL-19209-F	JP-8, Bottom Sample	3/3rd ACR, Bldg 2970, Tank 2	Routine analysis
O	02-26-90	AL-19210-F	JP-8, 12 in. From Bottom	BAAF Main Tank	Measure particulates
P	03-26-90	AL-19271-F	JP-8, Middle Sample	Bldg 2970, Tank 1	Routine analysis
Q	03-26-90	AL-19272-F	JP-8, Bottom Sample	Bldg 2970, Tank 1	Routine analysis
R	03-26-90	AL-19273-F	JP-8, Middle Sample	Bldg 2940, Tank 3	Routine analysis
S	03-26-90	AL-19274-F	JP-8, Bottom Sample	Bldg 2940, Tank 3	Routine analysis
T	03-26-90	AL-19275-F	JP-8, Bottom Sample	Bldg 2970, TOH5	Routine analysis
U	03-26-90	AL-19276-F	JP-8, Bottom Sample	Bldg 2990, Tank 6	Routine analysis
V	04-23-90	AL-19309-F	JP-8, Middle Sample	DOL Main Tank	Routine analysis
W	04-23-90	AL-19310-F	JP-8, Bottom Sample	DOL Main Tank	Routine analysis

TABLE B-6. List of Fuel Samples Received From Ft. Bliss During May to July 1990

Item No.	Date	ID Number	Description	Source	Analyses or Purpose
A	04-23-90	AL-19309-F	JP-8, Middle Sample	DOL Main Tank	Routine analysis
B	04-23-90	AL-19310-F	JP-8, Bottom Sample	DOL Main Tank	Routine analysis
C	06-20-90	AL-19400-F	DF-2, Fuel Tank Sample	E-53 Bulldozer	Confirm fuel grade
D	06-20-90	AL-19401-F	DF-2, Fuel Tank Sample	E-54 Bulldozer	Confirm fuel grade
E	06-20-90	AL-19402-F	JP-8, First Sample	E-54 Bulldozer	Confirm fuel grade
F	06-20-90	AL-19403-F	JP-8, Second Sample	HEMTT Tanker	Confirm fuel grade
G	06-20-90	AL-19404-F	JP-8, All-Level Sample	BAAF Main Tank	Routine analysis
H	06-22-90	AL-19406-F	JP-8, 20-ft Sample	BAAF Main Tank	Routine analysis
I	06-22-90	AL-19407-F	JP-8, 4-ft Sample	BAAF Main Tank	Routine analysis
J	06-22-90	AL-19408-F	JP-8, 12-ft Sample	BAAF Main Tank	Routine analysis
K	07-05-90	AL-19422-F	JP-8, Underground Main Tank	233rd Trans. Co.	Routine analysis
L	07-30-90	AL-19456-F	JP-8, Fuel Tank Bottom Sample	Pump No. 2970T3, 3/3rd ACR	Routine analysis
M	07-30-90	AL-19457-F	JP-8, Fuel Tank Bottom Sample	Pump No. 2970T4, 3/3rd ACR	Routine analysis
N	07-30-90	AL-19458-F	JP-8, Fuel Tank Middle Sample	Pump No. 2970T3, 3/3rd ACR	Routine analysis
O	07-30-90	AL-19459-F	JP-8, Fuel Tank Middle Sample	Pump No. 2970T4, 3/3rd ACR	Routine analysis

TABLE B-7. List of Fuel Samples Received From Ft. Bliss During August to October 1990

Item No.	Date	ID Number	Description	Source	Analyses or Purpose
A	08-24-90	AL-19496-F	JP-8	Combat Vehicle Repair Fuel Tank	Retain
B	08-24-90	AL-19497-F	JP-8	Sample From Return Line After Initial Start	Retain
C	08-24-90	AL-19498-F	JP-8	Sample Taken Prior to Engine Start	Retain
D	10-26-90	AL-19550-F	JP-8, 12-in. From Bottom	BAAF Main Fuel Tank	Confirm fuel quality
E	10-26-90	AL-19551-F	JP-8, Middle Sample	BAAF Main Fuel Tank	Confirm fuel quality

APPENDIX C

Resolution of Maintenance/User Concerns

1. TMP Comparative Test (Loaded Bus)

Vehicle:

- Bus, 44 passenger, IHC-DT466B engine, 0 miles on the engine, described by TMP personnel as "brand new."

Method:

- All fuel was drained from the fuel tank and the filters changed. Twenty-five gallons of neat JP-8 were put in the fuel tank from the TMP underground storage tank.
- Forty-four passengers were loaded on the bus, which also carried the driver, the BFLRF monitor, and a TMP representative.
- The bus was operated over a prescribed course chosen because TMP drivers had complained that it was the route over which the alleged loss of power was most evident.
- After the first run, all the JP-8 fuel was drained from the fuel tank and replaced with 55 gallons of neat diesel fuel provided by the TMP. The filters were not changed.
- Thirty-five passengers were loaded on the bus with the driver, the BFLRF monitor, and the TMP representative.
- The bus was operated over the same prescribed route.

Result: There was no discernible loss of power with either fuel.

Conclusions: It was unanimously concluded by the driver, the BFLRF monitor, and the observers that the buses operated the same regardless of the fuel used. The chief, Component Repair Facility, stated that he has noticed no power loss when testing repaired engines on the repair facility's dynamometer.

2. C/1/43rd Comparative Tests

Vehicle: • CUCV, M1008, GM 6.2L engine, 8406.8 miles operation.

Method:

- The fuel tank was drained and the fuel filter cleaned by the vehicle operator. Fifteen measured gallons of neat JP-8 fuel were added to the fuel tank.
- The driver, BFLRF monitor, and an NCO observer then took the vehicle over a prescribed course of 69.2 miles.
- After the first run, all the fuel was drained from the fuel tank and the quantity of fuel measured.
- Fifteen measured gallons of diesel fuel were added to the fuel tank.
- The same personnel from the first run again took the vehicle over the same 69.2-mile course.
- At the end of the run, the fuel was drained from the tank and the quantity of fuel measured.

Results:

	JP-8 Run	Diesel Run
Range	69.2 miles	69.2 miles
Operator	Assigned driver	Assigned driver
Observers	BFLRF monitor, NCO	BFLRF monitor, NCO
Drained Fuel	10 gallons, 2500 mL	10 gallons, 2825 mL
Fuel Consumed (gal.)	4.34	4.25
mpg	15.92	16.28

Conclusion: Based on the data, it appears that the diesel fuel produced an approximate 2.3 percent better gas mileage.

3. Vehicle-Mounted Personnel Heaters, Hard Starting and Running Hot - March 1990

In cooperation with the Ft. Bliss DIS, a comparative test was conducted using a vehicle-mounted HUPP personnel heater. The complaint from field (user) personnel was that the personnel heater appeared to operate as much as 20° to 30°F hotter when using JP-8 fuel as when diesel (DF-2) was used. It was thought that perhaps the difference in viscosity between DF-2 and JP-8 fuel might make a difference in the amount of fuel delivered to the burner of the heater. Also, it was speculated that the JP-8 burned hotter than DF-2 and caused crystallization of the burner plate in the HUPP heaters and the fuel cup in the heating component in the STEWART-WARNER heaters.

A HUPP heater was prepared for operation in the DIS maintenance shop with the TACOM Logistics Assistance Representatives and the BFLRF monitor present as observers. The heater was first operated with JP-8 fuel. A thermometer with an open air sensor on the end of a copper wire was used to determine the output heat emitted by the heater. The heat output as measured by the thermometer went up to about 240°F. It was found that the adjustment screws on the heater had to be adjusted (cleared) so that the fuel flow could be regulated.

The heater was then operated on locally purchased DF-2. The maximum output temperature using the DF-2 was 126°F. The heater was then operated on JP-8 fuel by transferring the fuel inlet hose to JP-8 from the DF-2 container. The output temperature with JP-8 stabilized at 133°F using the same fuel feed setting as with the DF-2.

A further comparison was made by starting the heater with DF-2 and timing its rate of heat increase, then starting the heater with JP-8 and timing its rate of heat increase. Both runs were made with the same fuel feed setting. The results were as follows:

From Start Time to	DF-2	JP-8
Ignition	1 min, 30 sec	1 min, 28 sec
85°F	2 min	
90°F		2 min
130°F	3 min	3 min, 3 sec
136°F	3 min, 40 sec	
135°F		4 min

It was concluded by all in attendance that there was no significant difference between heater operation with either JP-8 or diesel fuel. Most of the heaters in use are using fuel settings for diesel fuel operation. These heaters will be readjusted for JP-8 use as they are turned in for maintenance or repair. The heater repair shop will keep a log on heater repairs to assist in determining time between failures. This issue is considered closed.

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PM ABRAMS, ATTN: AMCPM-ABMS 1
PM BFVS, ATTN: AMCPM-BFVS-S 1
PM 113 FOV, ATTN: AMCPM-M113 1
PM M60 FOV, ATTN: AMCPM-M60 1
APEO SYSTEMS, ATTN: AMCPEO-CCV-S 1
PM LAV, ATTN: AMCPM-LA-E 1
WARREN MI 48397-5000

CDR
US ARMY TANK-AUTOMOTIVE CMD
PROGM EXEC OFF, COMBAT SUPPORT
PM LIGHT TACTICAL VEHICLES
ATTN: AMCPM-TVL 1
PM MEDIUM TACTICAL VEHICLES
ATTN: AMCPM-TVM 1
PM HEAVY TACTICAL VEHICLES
ATTN: AMCPM-TVH 1
WARREN MI 48397-5000

PROJ MGR, LIGHT ARMORED VEHICLES
ATTN: AMCPM-LA-E 1
WARREN MI 48397

CDR, US ARMY TROOP SUPPORT
COMMAND
ATTN: AMSTR-ME 1
AMSTR-MEP 1
AMSTR-WL 1
4300 GOODFELLOW BLVD
ST LOUIS MO 63120-1798

PROGM EXEC OFFICER
ARMORED SYS MODERNIZATION
US ARMY TANK-AUTOMOTIVE CMD
ATTN: SFAE-ASM-S 1
WARREN MI 48397-5000

CDR
US ARMY CECOM
ATTN: AMSEL-LC-SM-IK (DR D HOWE) 1
FT MONMOUTH NJ 07701-5000

CDR
US ARMY LEA
ATTN: LOEA-PL 1
NEW CUMBERLAND ARMY DEPOT
NEW CUMBERLAND PA 17070

HQ, EUROPEAN COMMAND
ATTN: J4/7-LJPO 1
VAIHINGEN, GE
APO NY 09128

CDR
US ARMY GENERAL MATERIAL &
PETROLEUM ACTIVITY
ATTN: STRGP-PW 1
BLDG 247, DEFENSE DEPOT TRACY
TRACY CA 95376-5051

CDR
US ARMY ENGINEER SCHOOL
ATTN: ATSE-CD 1
ATSF-CD 1
FORT LEONARD WOOD MO 65473-5000

HQ, US ARMY T&E COMMAND
ATTN: AMSTE-TE-T 1
ABERDEEN PROVING GROUND MD
21005-5006

CDR
US ARMY ORDNANCE CENTER &
SCHOOL
ATTN: ATSL-CD-CS 1
ABERDEEN PROVING GROUND MD
21005-5006

CDR
US ARMY AIR DEFENSE ARTILLERY CTR
AND FT BLISS
ATTN: ATZC-DPTM-C 5
ATZC-IS 10
AMXLA-C-B-BL 4
ATSA-TP 4
FT BLISS TX 79916-5000

HQ
US ARMY TRAINING & DOCTRINE CMD
ATTN: ATCD-SL 1
FORT MONROE VA 23651-5000

CDR
CONSTRUCTION ENG RSCH LAB
ATTN: CERL-ES 1
P O BOX 4005
CHAMPAIGN IL 61820

CDR
US ARMY TRANSPORTATION SCHOOL
ATTN: ATSP-CD-MS 1
FORT EUSTIS VA 23604-5000

TRADOC SYSTEMS MGR
TACTICAL-WHEELED VEHICLES
ATTN: ATZF-TW 1
FT EUSTIS VA 23604-5361

CDR
US ARMY NATICK RES, DEV & ENGR CTR
ATTN: STRNC-U 1
NATICK MA 01760-5020

CDR
US ARMY QUARTERMASTER SCHOOL
ATTN: ATSM-CDM 1
ATSM-PWD 1
FORT LEE VA 23801

PROJECT MANAGER
PETROLEUM & WATER LOGISTICS
ATTN: AMCPM-PWL (COL WEIMER) 5
4300 GOODFELLOW BLVD
ST LOUIS MO 63120-1798

HQ, US ARMY ARMOR CENTER
ATTN: ATSB-CD-ML 1
ATSB-TSM-T 1
FORT KNOX KY 40121

CDR
COMBINED ARMS COMBAT
DEVELOPMENT ACTIVITY
ATTN: ATZL-CAT-E 1
FORT LEAVENWORTH KS 66027-5300

CDR
US ARMY LOGISTICS CTR
ATTN: ATCL-CD 1
ATCL-MS 1
FORT LEE VA 23801-6000

CDR
US ARMY FIELD ARTILLERY SCHOOL
ATTN: ATSF-CD 1
FORT SILL OK 73503-5600

CDR
NATIONAL TRAINING CENTER
ATTN: AFZJ-DLS-S 2
FT IRWIN CA 92310-5000

CDR
US ARMY INFANTRY SCHOOL
ATTN: ATSH-CD-MIS-M 1
ATSH-TSM-FVS 1
FORT BENNING GA 31905-5400

CDR
US ARMY MEDICAL R&D LABORATORY
ATTN: SGRD-USG-M (MR EATON) 1
FORT DETRICK, MD 21701

CDR
US ARMY AVIATION CTR & FT RUCKER
ATTN: ATZQ-DI 1
FORT RUCKER AL 36362

CDR
US ARMY SAFETY CENTER
ATTN: PESC-SSD 1
FORT RUCKER AL 36362

CDR
USAREUR & 7TH ARMY
ATTN: AEAGD-T 1
APO NY 09403-0104

CDR IN CHIEF, SOUTH (CINCSOUTH)
ATTN: CINCSOUTH/SCJ4-JPO 1
QUARRY HEIGHTS PANAMA
APO MIAMI FL 34003

DEPARTMENT OF THE NAVY

CDR
DAVID TAYLOR RESEARCH CTR
ATTN: CODE 2759 (MR STRUCKO) 1
ANNAPOLIS MD 21402-5067

OFFICE OF THE CHIEF OF NAVAL
RESEARCH
ATTN: OCNR-126 (DR ROBERTS) 1
ARLINGTON VA 22217-5000

PROJ MGR, M60 TANK DEVELOPMENT
ATTN: USMC-LNO 1
US ARMY TANK-AUTOMOTIVE
COMMAND (TACOM)
WARREN MI 48397-5000

DEPARTMENT OF THE NAVY
HQ, US MARINE CORPS
ATTN: LMM/2 1
LPP-2 (MAJ NICHOLS) 1
WASHINGTON DC 20380

CDR
NAVY PETROLEUM OFFICE
ATTN: CODE 43 (MR LONG) 1
CAMERON STATION
ALEXANDRIA VA 22304-6180

CG
USMC RDA COMMAND
ATTN: CODE CBAT 1
QUANTICO VA 22134-5080

DEPARTMENT OF THE AIR FORCE

HQ, USAF
ATTN: LEYSF 1
WASHINGTON DC 20330

CDR
US AIR FORCE WRIGHT AERO LAB
ATTN: AFWAL/POSF (MR DELANEY) 1
WRIGHT-PATTERSON AFB OH
45433-6563

CDR
SAN ANTONIO AIR LOGISTICS CTR
ATTN: SA-ALC/SFT (MR MAKRIS) 1
SA-ALC/MMPRR 1
KELLY AIR FORCE BASE TX 78241

CDR
WARNER ROBINS AIR LOGISTIC CTR
ATTN: WRALC/MMVR-1
(MR PERAZZOLA) 1
ROBINS AFB GA 31098

OTHER GOVERNMENT AGENCIES

ENVIRONMENTAL PROTECTION AGENCY
AIR POLLUTION CONTROL 1
2565 PLYMOUTH ROAD
ANN ARBOR MI 48105

US DEPARTMENT OF ENERGY
ATTN: MR JERRY A ALLSUP 1
MAIL CODE CE-151
FORRESTAL BLDG.
1000 INDEPENDENCE AVE, SW
WASHINGTON DC 20585