

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
1a. REPORT SECURITY CLASSIFICATION Unclassified			1b. RESTRICTIVE MARKINGS None		
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.		
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE					
4. PERFORMING ORGANIZATION REPORT NUMBER(S) No. 2468			5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION Belvoir RD&E Center Materials, Fuels and Lubricants Dir.		6b. OFFICE SYMBOL (If applicable) STRBE-VF		7a. NAME OF MONITORING ORGANIZATION	
6c. ADDRESS (City, State, and ZIP Code) Fuels and Lubricants Division Fort Belvoir, VA 22060-5606			7b. ADDRESS (City, State, and ZIP Code)		
8a. NAME OF FUNDING/SPONSORING ORGANIZATION		8b. OFFICE SYMBOL (If applicable)		9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
3c. ADDRESS (City, State, and ZIP Code)			10. SOURCE OF FUNDING NUMBERS		
			PROGRAM ELEMENT NO. 627.33	PROJECT NO. AH 20VM	TASK NO.
11. TITLE (Include Security Classification) Fuel-Related Problems in Vehicles and Equipment (U)					
12. PERSONAL AUTHOR(S) Dr. Madeline Swann					
13a. TYPE OF REPORT Final		13b. TIME COVERED FROM <u>Mar 87</u> TO <u>Dec 87</u>		14. DATE OF REPORT (Year, Month, Day) June 1988	
15. PAGE COUNT 51					
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) Diesel-powered equipment; fuel-related problems; diesel/distillate fuel quality; fuel additives. (IES)		
FIELD	GROUP	SUB-GROUP			
19. ABSTRACT (Continue on reverse if necessary and identify by block number) A field quality survey was distributed in an attempt to define the magnitude of the overall diesel fuels quality issue. This questionnaire was sent to 61 US Army Logistic Assistance Offices and Reserve Components Support Offices, with secondary distribution encouraged. There were 131 responses to the questionnaire. The results of the questionnaire are reported. Also included in the report are conclusions and recommendations resulting from the questionnaire.					
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS REPORT <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION Unclassified		
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PREFACE

The Fuels and Lubricants Division, Materials, Fuels, and Lubricants Directorate, Belvoir Research, Development and Engineering (RD&E) Center distributed a fuel quality survey, "Questionnaire on Fuel-Related Problems in Vehicles and Equipment," on 17 March 1987, in an attempt to define the magnitude of the overall fuels quality issue. This questionnaire was essential because the final results of the Logistics Management Institute report on fuel quality trends could probably have a profound effect on the future technology base resources for supporting mobility fuels research, development, testing, and evaluation (RDTE).

This questionnaire was sent to 61 US Army Logistic Assistance Offices throughout the continental US (CONUS) and outside the continental US (OCONUS) and Reserve Components Support Offices (National Guard Bureau/Office of the Chief Army Reserve), with secondary distribution encouraged. Each Office was told that duplication of this questionnaire was strongly encouraged to broaden the base/source of information available as much as possible. There were 132 responses to the questionnaire. The major results of the fuel quality survey were:

1. Approximately 50% of the respondents had recent or past occurrences of vehicle and/or equipment operational problems that appeared to be related to fuel quality.
2. The majority of responses to the questionnaire were from locations in OCONUS/Germany. The location providing the second largest number of responses was CONUS.
3. There were only minimal responses from: Hawaii, Puerto Rico, Panama, OCONUS/Asia, and OCONUS/Italy.
4. According to the results of this survey, the locations experiencing the most fuel-related operational problems were CONUS and OCONUS/Germany.
5. Approximately 65% of the respondents replied "yes" to the question about whether or not the fuel was suspected of being contaminated in the fuel-related problems. But when those respondents were asked which inspection property was off-specification, 66% stated that no properties were off-specification.
6. A field manual or guide on recognizing fuel contamination problems and recommending preventive measures is both wanted and needed.

As a result of this questionnaire, it is realized that the quality of fuels can have serious consequences on the mission of the Department of Defense (DOD) by degrading vehicles, equipment, and weapons systems performance and by damaging critical vehicles, equipment, and weapons

components. Because DOD's highest priority goal in mobility fuels technology is to achieve the capability of utilizing fuels which are now readily available and are projected to be available from the commercial sector, we must be aware of the problems experienced in the field. Without this knowledge, it would be impossible to determine how effectively vehicles, equipment, and weapons operate on current fuels. From the problems, it can be determined which components of the fuel systems are affected. This will determine what changes and/or modifications are needed and begin research for developing fixes. This is essential because the mission of DOD cannot be unduly influenced by short-term fluctuation in petroleum supplies.

A listing of addressees receiving the questionnaire and a listing of respondents are available from:

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(Keyed) →



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SECTION I. BACKGROUND

In Fiscal Year (FY) 1982, the Office of the Under Secretary of Defense (Research and Engineering) stated that DOD's highest priority goal in mobility fuels technology was to achieve the capability of utilizing fuels which were readily available and projected to be available from the commercial sector. The efforts to achieve this goal must not be unduly influenced by short-term fluctuations in petroleum supplies. Therefore, achieving this goal requires continuing attention to the following:

1. Assessment of properties and availability of future fuels
2. Improved understanding and quantification of effects of fuel properties on equipment
3. Improved fuel qualification procedures
4. Determination of fuel tolerance limits of current equipment
5. Definition of multifuel engine characteristics
6. Development of appropriately modified fuel specifications

In order to coordinate the above efforts, each Military Department has developed a Mobility Fuels Technology Program.

As a result of continuing fuel quality problems, the Office of the Assistant Secretary of Defense (Acquisition and Logistics) initiated a study in FY 1986 to assess the overall quality of DOD fuels. The Logistics Management Institute (LMI) was tasked to conduct a survey to determine the extent and significance of any quality changes, i.e., to identify trends in the quality of fuel procured by DOD, and to generate recommendations to minimize or avoid future fuel quality problems.

The LMI Report indicated that the fuel-related problems in the field (fuel quality problems that cause inadequate performance of DOD weapon systems) have been relatively infrequent.* The problems identified in the report were: fuel deterioration during storage, vehicle filter plugging, excessive filtration times (reduces the efficiency of fuel-pumping equipment), and low jet fuel "lubricity" (shortens fuel pump life).

LMI stated that these types of problems could have serious consequences, but available evidence suggests that they affect only a very small amount of DOD fuel. This is because current DOD quality control procedures detect and avoid (eliminate) almost all problems before the fuel is used.

* W. Salthouse and M. Hoyler, Report AL619R1, *Managing Fuel Quality in the Department of Defense*, Logistics Management Institute, Bethesda, MD, 1987.

According to LMI, the most common diesel fuel problem is deterioration during long-term storage. This is particularly true for war reserve stocks in remote overseas locations, especially in hot climates. Therefore, LMI suggested that strategies devised to improve fuel quality management should focus on long-term storage. The following strategies were recommended to the Defense Logistics Agency (DLA):

1. Buy less severely processed diesel fuels which are more stable for war reserves in remote locations where immediate availability is critical.
2. Unless the cost is prohibitive, construct underground storage facilities in hot climate areas to reduce fuel temperatures and improve fuel stability.
3. As a continuing effort to increase the turnover of fuel stocks in remote locations, contract with commercial firms to store and sell military specification fuels in lieu of their regular fuels.
4. DOD should continue testing fuels in long-term storage every 3 months in the Middle East and every 6 months at all other locations.

LMI examined evidence on crude oil quality and changes in refinery operations to determine the causes of changes in product quality and direction of future fuel quality trends. Crude oils refined in the United States have declined in quality in recent years—they have become heavier and the sulfur content has increased. However, LMI found no evidence that the crude quality was worsening worldwide. In fact, it was concluded that the US crude quality decline had only limited direct effects on product quality. Therefore, LMI concluded that fuel quality was not expected to decline in the future. It was also concluded that the quality of imported crude oil declined as the result of the growth in conversion capacity (conversion processes that convert heavy crude oil products into lighter, more valuable products). Therefore, LMI concluded that a slowdown in conversion capacity growth should also lessen the crude oil quality decline.

For a lasting solution to diesel fuel deterioration, LMI recommended that the services fuels research offices should continue investigating the use of additives for increasing stability of diesel fuels. It was also recommended that a more reliable diesel fuel stability test be developed.

The LMI Report stated that diesel fuel problems have been minimal. This statement was based on the assumption that the US Army has only shown a total of 38 diesel fuel problems have occurred during 1965 through 1985. Although LMI stated that some fuel problems may not be reported to higher levels, the authors stated that this was an accurate estimate of the number of fuel problems. This was based on the hypothesis that there were two major reasons to doubt the occurrence of large-scale underreporting. First, fuels procured by DLA for transportation and storage are subjected to thorough and repetitive testing. LMI interpreted this to mean that it was unlikely

serious bulk fuel quality problems could exist and remain unreported. Secondly, underreporting seemed implausible to LMI because of DOD incentives. Military fuel personnel can (and should) reject fuel shipments from DLA on suspicion that the fuel may lead to poor equipment performance.

After reviewing the LMI Report, the Fuels and Lubricants Division of the Materials, Fuels and Lubricants Directorate, Belvoir RD&E Center, took exception with the following two major findings in the report:

1. Fuel quality is not expected to "worsen" in the future.
2. DOD's fuel quality problems are minimal because of the absence of reported and documented instances.

To address the LMI statement that fuel quality is not expected to "worsen" in the future, the article, "Distillate Stability Ensured by Testing and Treatment" is used as a reference.** The article clearly indicates the effects of increasing process severity (types of precursors present in refining fractions) on future product quality as is anticipated with using heavier crudes and/or upgrading process streams. This is only one of many articles that clearly identifies the projected trend of fuel quality. These articles, written and supported by technologists within the fuels industry, support—as does this Center—the statement that fuel quality IS expected to "worsen."

On the issue of DOD's fuel quality problems being minimal because of the absence of reported and documented instances where problems are either underreported or not reported at all, the evidence (only 38 diesel fuel problems existed in a 20-year period) presented by LMI showed that the authors were not aware of all of the fuel problems. In fact, the above-mentioned data (38 problems) was obtained from a brochure prepared by Belvoir Fuels and Lubricants Research Facility (BFLRF) that only addressed diesel fuel quality and cleanliness. Through the years, the Fuels and Lubricants Division within this Center and BFLRF have provided technical support to specific fuel related vehicle and equipment problems for the US Army, as well as the other services. Based upon this interface with the field, these personnel are more than aware of the occurring fuel quality problems, and they maintain that there have been in excess of the 38 instances cited by LMI.

Upon further review of the statements made by LMI to support the position that DOD's fuel quality problems are minimal, it can be seen that the explanation presented by LMI reflects a lack of understanding of the current overall system within the military for supply and quality assurance. It is well recognized by all personnel involved in fuels utilization and logistic support that many fuel problems which occur are never reported. This is especially true in CONUS operations where diesel fuel is supplied under the posts, camps and stations (PCS) contract bulletin system.

**M. W. Schrepfer, R. J. Arnold, and C. A. Stansky, *Distillate Stability Ensured by Testing and Treatment*, Oil and Gas Journal, (16 January 1984).

Ironically, there is very little complete testing (compared to the full spectrum of tests performed on bulk fuel deliveries) conducted on tank truck deliveries. This is because there is a dependence on the integrity of the contractor/supplier and the lack of adequate quality assurance capability.

SECTION II. RESULTS

A Questionnaire on Fuel-Related Problems in Vehicles and Equipment (Appendix A) was distributed by the Fuels and Lubricants Division to obtain the specific details on fuel-related vehicle and equipment problems occurring within the field environment. In the past, these details have been difficult to obtain because of the existing system's infrastructure.

The returned questionnaires were initially sorted according to the response to Question #1, *Have there been recent or past occurrences of vehicle and/or equipment (V/E) operational problems that appeared to be related to fuel quality?* The responses to this question are shown in Table 1.

Table 1. Total Responses to Question #1

Response	# of Total Responses	% of Total Responses
Yes	65	49.24
No	64	48.49
Do Not Know	3	2.27

The above data indicates that approximately 50% of the personnel responding to the questionnaire experienced some type of vehicle and/or equipment operational problems that appeared to be related to the quality of the fuel.

A detailed examination of all of the data was performed. The data was analyzed in the following specific areas to determine if any patterns were present:

- Geographical location
- Types of fuel-related problems
- Affected engine components
- Types of vehicles and equipment
- CONUS vs. OCONUS problems

- Fuel contamination
- Fuel samples
- Fuel additives

GEOGRAPHICAL LOCATION

Table 2 shows responses to Question #1 grouped by geographical location. The percentages are based on the total number of responses (132 questionnaires returned).

Table 2. Responses to Question #1 by Geographical Location

Geographical Location	# of Responses	% of Total Responses	# of "Yes" Responses	% of Total Responses	# of "No" Responses	% of Total Responses	# of "Do Not Know" Responses	% of Total Responses
CONUS/ Private Industry	1	0.76	1	0.76	0	0.00	0	0.00
Hawaii	3	2.27	1	0.76	2	1.52	0	0.00
Puerto Rico	2	1.52	1	0.76	1	0.76	0	0.00
APO Miami - Panama	1	0.76	0	0.00	0	0.00	0	0.00
OCONUS/APO San Francisco/ Asia	3	2.27	1	0.76	2	1.52	0	0.00
OCONUS/APO New York/Europe/ Italy	1	0.76	1	0.76	0	0.00	0	0.00
OCONUS/APO New York/Europe/ Germany	71	53.79	27	20.46	41	31.06	3	2.27
CONUS	50	37.88	33	25.00	17	12.88	0	0.00

The results indicate that 91.67% (121 of 132) of the responses were from OCONUS/ Germany (71 responses) and within CONUS (50 responses).

In addition, the responses were examined to determine the percentage of fuel-related problems in each location. Table 3 contains Responses to Question #1 in Each Geographical Location. According to this survey, the largest number of vehicles and/or equipment that have experienced operational problems which appear to be related to fuel quality are located in CONUS. This is evident in Table 2 where CONUS "Yes" equals 25.00% of the total 132 responses, and in Table 4 where CONUS "Yes" equals 66.00% of the total CONUS responses. OCONUS/Germany is the area where the second largest number of fuel-related operational problems occurred. This is evident in Table 2 where OCONUS/Germany "Yes" equals 20.46% of the total responses and in Table 3 where OCONUS/Germany equals 28.03% of the total OCONUS responses.

Table 3. Responses to Question #1 in Each Geographical Location

Geographical Location	# of Responses	% of Total Responses	# of "Yes" Responses	% of Total Responses	# of "No" Responses	% of Total Responses	# of "Do Not Know" Responses	% of Total Responses
CONUS/ Private Industry	1	100.00	1	100.00	0	0.00	0	0.00
Hawaii	3	100.00	1	33.33	2	66.67	0	0.00
Puerto Rico	2	100.00	1	50.00	1	50.00	0	0.00
APO Miami - Panama	1	100.00	0	0.00	0	100.00	0	0.00
OCONUS/APO San Francisco/ Asia	3	100.00	1	33.33	2	66.67	0	0.00
OCONUS/APO New York/Europe/ Italy	1	100.00	1	100.00	0	0.00	0	0.00
OCONUS/APO New York/Europe/ Germany	71	100.00	27	38.03	41	57.75	3	4.23
CONUS	50	100.00	33	66.00	17	34.00	0	0.00

TYPES OF FUEL-RELATED PROBLEMS

The respondents were asked if there were operational problems that appeared to be related to fuel quality, how were these problems detected, i.e., engine problems, fuel system starvation, etc. Table 4 indicates the responses. It can be seen from the data in Table 4 that most of the operational problems caused by fuel quality were detected through fuel system starvation. This conclusion is also verified by the fact that there was increased maintenance of fuel systems.

In addition to these fuel-related problems, other isolated problems cited were:

- Water contamination
- Low engine performance
- Sluggish starts, "backfiring," and "bucking"
- Evidence of a black-gray substance found in the equipment fuel lines and filters
- Gelling fuel in winter months in some vehicles

In addition, two respondents noted that all problems listed in Table 4 (a-d) were experienced.

AFFECTED ENGINE COMPONENTS

Based on the fuel-related problems in Table 4 (fuel system starvation and increased maintenance of fuel system), the questionnaire then asked what engine components were affected. Table 5 contains Engine Components Affected by Fuel-Related Problems.

The engine components most often affected were the primary and secondary fuel filters. Because the poor quality fuel causes plugging of the fuel filters, the fuel cannot flow through the fuel system. Even though this is a major problem, it does appear that the fuel filters are performing their function, i.e., preventing poor quality fuel from flowing through the fuel system.

In addition, the following responses were included in Table 5 as other engine components that were affected:

- Burning injector caps
- Malfunctioning of injector pump in extremely cold washer
- "Water in fuel" light on in Commercial Utility Cargo Vehicle (CUCV)
- Plugging pump filters on generators
- Plugging/ruining fuel pumps

Table 4. Types of Fuel-Related Problems

QUESTION #2	PRIVATE INDUSTRY	HAWAII	PUERTO RICO	APO MIAMI PANAMA	OCONUS APO SAN FRANCISCO ASIA	OCONUS APO NEW YORK EUROPE ITALY	OCONUS APO NEW YORK EUROPE GERMANY	CONUS
<i>If the response to Question 1 was Yes, were these primarily problems occurring from:</i>								
a. Engine starting difficulties	0	0	1	0	1	1	13	14
b. Engine stalling	0	0	0	0	1	1	10	9
c. Fuel system starvation	1	0	0	0	1	1	12	22
d. Increased maintenance of fuel system	1	0	0	0	1	1	9	17
e. Other	0	1	0	0	0	0	4	4

If the response to Question 1 was Yes, were these primarily problems occurring from:

Table 5. Engine Components Affected by Fuel-Related Problems

QUESTION #3	PRIVATE INDUSTRY	HAWAII	PUERTO RICO	APO MIAMI PANAMA	OCONUS APO SAN FRANCISCO ASIA	OCONUS APO NEW YORK EUROPE ITALY	OCONUS APO NEW YORK EUROPE GERMANY	CONUS
a. Plugging of primary fuel filters	0	0	0	0	1	1	5	11
b. Plugging of secondary fuel filters	1	0	0	0	1	0	3	7
c. Plugging of both primary/secondary filters	0	0	0	0	0	0	14	17
d. Plugging of water separators	0	1	0	0	1	1	7	5
e. Plugging of fuel injector filters	0	1	0	0	0	0	2	3
f. Sticking injector nozzles	0	1	0	0	1	0	4	4
g. Plugging/fouling injector nozzles	0	0	0	0	0	0	5	5
h. Other	0	0	0	0	0	0	2	12

If the above observed problems (Table 4) were related to either Questions 2c or 2d, were these problems a result of:

TYPES OF VEHICLES AND EQUIPMENT

The questionnaire then asked what specific type of vehicles and equipment have had problems based on evidence seen in fuel filters, water separators, fuel injector filters, and injector nozzles (Table 5). First, the responses were examined to determine the total number of vehicles and equipment cited under each problem by geographical location. (Some questionnaires listed several pieces of equipment under each problem.) The responses can be seen in Table 6. Examination of this table again indicates that there were more vehicle/equipment problems within CONUS while the second largest number of fuel-related operational problems were in OCONUS/Germany.

Table 6. Total Number of Vehicles/Equipment Cited Under Each Problem

GEOGRAPHICAL LOCATION	PROBLEM TYPE*	TOTAL NUMBER
Private Industry	a - c	1
OCONUS/APO San Francisco/Asia	a - c	3
OCONUS/APO New York/Europe/Italy	a - c	1
OCONUS/APO New York/Europe/Germany	a - c	35
CONUS	a - c	75
Hawaii	d	1
OCONUS/APO San Francisco/Asia	d	3
OCONUS/APO New York/Europe/Italy	d	1
OCONUS/APO New York/Europe/Germany	d	9
CONUS	d	16
Hawaii	e - g	1
OCONUS/APO San Francisco/Asia	e - g	2
OCONUS/APO New York/Europe/Italy	e - g	1
OCONUS/APO New York/Europe/Germany	e - g	9
CONUS	e - g	22
OCONUS/APO San Francisco/Asia	b	1
OCONUS/APO New York/Europe/Germany	b	4
CONUS	b	12
CONUS	h	2

* See Table 5.

a - c: Plugging of primary fuel filters, secondary fuel filters, both primary/secondary filters

b: Plugging of secondary fuel filters

d: Plugging of water separators

e - g: Plugging of fuel injector filters, sticking injector nozzles, plugging/fouling injector nozzles

h: Other

This data was then analyzed to determine if any specific types of vehicles/equipment are more prone to experience fuel-related operational problems. The data is in Table 7. (The data was grouped by geographical location and fuel problem).

Table 7. Vehicles/Equipment Experiencing Fuel-Related Problems

GEOGRAPHICAL LOCATION	PROBLEM TYPE*	VEHICLE/ EQUIPMENT AFFECTED	TOTAL NUMBER
Private Industry	a - c	Highway class 8 trucks	1
OCONUS/APO New York/Europe/Italy	a - c	M113	1
		M110	1
		M60	1
OCONUS/APO New York/Europe/Italy	a - c	General	1
OCONUS/APO New York/Europe/Germany	a - c	M113 FOV	4
		30kW Generators	1
		60kW Generators	1
		M35A2	4
		M1A1/M1	1
		M578	3
		M548	2
		CUCV M1008	1
		M577	2
		M818	2
		M110A2	1
		M813	1
		M109	1
		M923	1
		M915	1
		CUCV	1
		M34 Series Trucks	1
		M981	1
		5 Ton Tractors	1
		M931	1
		5 Ton Trucks	1
		M131A5	1
		M131A4C	1
		M923/TPU	1
CONUS	a - c	5 Ton Dumps	1
		M51A2	2
		M817	2
		M929	1
		109A3 Howitzer	6
		M813	2
		M54A1C	1
		M548 Carrier	2
		M113A2	2

Table 7. Continued

GEOGRAPHICAL LOCATION	PROBLEM TYPE*	VEHICLE/ EQUIPMENT AFFECTED	TOTAL NUMBER
CONUS (continued)	a - c	M34 Series Trucks	6
		5 Ton Trucks	5
		M2380 Crane	1
		9M250 Compressor	2
		14M250 Compressor	2
		5kW Generators	1
		M559 GOER	1
		M520 GOER	1
		M35	1
		M60A3	2
		M88	1
		M48A1	1
		M35A2	4
		M185A2	1
		5 Ton M816w/w-M818	1
		Commercial Vehicles	1
		Over-the-road Tractors	1
		M911	1
		15kW thru 60 kW Diesel Generators	1
		Fuel Filters	1
		Tactical Vehicles	1
		M110 Howitzers	2
		M60A1	1
		MHE Equipment	1
		M113 Series/M60 Series	1
		M578	1
		Cummings Detroit GM	1
		MW24 Truck	1
		M2389 Crane	1
		100kW	1
		All diesel powered vehicles	1
		All diesel powered CCE	1
		MW24C	1
		M1010	1
		M1009	1
		M1008	1
		M109A2	1
		155mm SP Howitzer	1
		M60 Tank	1
		TRACS FILS 07	1
		TRACS FILS 08	1
Hawaii	d	Fuel transport system/vehicles	1
OCONUS/APO San Francisco/Asia	d	M5778	1
		GOERS	1
		HEMMTs	1

Table 7. Continued

GEOGRAPHICAL LOCATION	PROBLEM TYPE*	VEHICLE/ EQUIPMENT AFFECTED	TOTAL NUMBER
OCONUS/APO New York/Europe/Italy	d	General	1
OCONUS/APO New York/Europe/Germany	d	M35A2	1
		M1A1/M1	1
		M113	1
		M578	1
		M110 Howitzers	1
		M109 Howitzers	1
		HEMMT	1
		M818	1
		5 Ton Tractors	1
CONUS	d	M109A3	1
		M485 Tank	1
		Wheeled Vehicles	1
		Engineer Equipment	1
		15kW thru 60kW Diesel Generators	1
		M110	1
		M578	1
		M60 Series	1
		Cummings Detroit GM	1
		CUCV	2
		M1008	2
		M1009	2
		M548	1
Hawaii	e - g	Fuel transport systems/vehicles	1
OCONUS/APO San Francisco/Asia	e - g	M34 Series Trucks	1
		5 Ton Trucks	1
OCONUS/APO New York/Europe/Italy	e - g	Low mileage, usage vehicles	1
OCONUS/APO New York/Europe/Germany	e - g	CUCV FOV	1
		Diesel powered generators	1
		M35A2	2
		M1A1/M1	1
		CUCV M1009	1
		M35A2/M818	1
		CUCV series vehicles	1
		M110A2	1
CONUS	e - g	M48A5	1
		M109A3	2
		M5548	1
		Wheeled Vehicles	1
		Engineer Equipment	1
		M34 Series Trucks	2
		15kW thru 60kW Diesel Generators	1

Table 7. Continued

GEOGRAPHICAL LOCATION	PROBLEM TYPE*	VEHICLE/ EQUIPMENT AFFECTED	TOTAL NUMBER
CONUS (continued)	c - g	5 Ton Trucks	1
		Tactical Vehicles	1
		M109 SP Howitzers	1
		M110 SP Howitzer	1
		M60A1 Tanks Construction	1
		MHE Equipment	1
		M113 Series	1
		M109/M578	1
		Cummings Detroit GM	1
		M548	2
		M110A2	1
		Boiler plant equipment (injectors)	1
OCONUS/APO San Francisco/Asia	b	M109	1
OCONUS/APO New York/Europe/Germany	b	M35A2	2
		M1A1/M1	1
		M100A2	1
CONUS	b	Wheeled Vehicles	1
		Engineer Equipment	1
		15kW thru 60kW Diesel Generators	1
		M34 Series Trucks	1
		5 Ton Trucks	1
		Tactical Vehicles	1
		M109 SP Howitzer	1
		M110 SP Howitzer	1
		M60A1 Tanks	1
		MHE Equipment	1
		Cummings Detroit GM	1
		M109A3	1
CONUS	h	30kW Generators	1
		60kW Generators	1

* See Table 5.

After reviewing Table 7, it was determined that specific types of vehicles and equipment were prone to experience more problems than others. These vehicles and equipment experienced problems world-wide. The 15 most frequently cited were:

- M35A2
- M109
- M110
- 5 Ton Trucks

- M34 Series Trucks
- M113
- M60
- M578
- M1008
- M548
- 30kW Generators
- M1009
- 60kW Generators
- M1A1/M1
- M818

The above list was examined to determine if these vehicles and equipment were prone to experience a particular problem. Examination of the responses showed that the vehicles/equipment prone to be affected by plugging of primary and/or secondary fuel filters were:

- M35A2
- M113
- M34 Series Trucks
- M60
- 5 Ton Trucks
- M578
- M548
- M1008
- M1009
- M818

The following vehicles/equipment were prone to be affected by plugging of fuel injector filters, sticking injector nozzles, and plugging/fouling injector nozzles:

- M109
- M110
- 30kW Generators
- 60kW Generators
- M1A1/M1

CONUS vs. OCONUS PROBLEMS

The responses were examined to determine if there were more fuel-related problems and if more vehicles/equipment were affected within CONUS or OCONUS. The responses were also examined to find out if an engine component was affected more frequently within CONUS than OCONUS.

The responses were first reviewed to decide if more fuel-related problems occurred within CONUS or OCONUS. Upon examining the questionnaire, it was determined that more fuel-related problems occurred within CONUS vs OCONUS. The responses also indicated that the engine components most affected by these problems were the primary and secondary fuel filters both within CONUS and OCONUS.

The data was then studied to establish if more vehicles/equipment experienced fuel-related problems within CONUS or OCONUS.

Table 8. CONUS vs OCONUS Problems

PROBLEM TYPE*	TOTAL NUMBER	
	CONUS	OCONUS
a - c	29	18
d	9	9
e - g	10	13
b	5	3
h	1	0

* Refer to Table 5

It can be seen in Table 8 that most of the vehicles/equipment fuel-related problems occurred within CONUS. The most frequently experienced fuel-related operational problems in vehicles/equipment within both CONUS and OCONUS were plugging of primary and secondary fuel filters.

FUEL CONTAMINATION

After determining that fuel-related problems do exist that affect vehicles and equipment, the next steps were to determine if the fuel was contaminated and why contamination was suspected.

5. *In any of the fuel-related problems described in Question 3, was the fuel suspected of being contaminated?*

6. *If the response to Question 5 was Yes, why was this suspected?*

When the responses were reviewed, it was seen that there were approximately the same number of cases of suspected fuel contamination causing fuel-related problems within CONUS as OCONUS. The reasons given most frequently as evidence that fuel contamination was suspected were:

- Water in the fuel and the filters (necessary to replace fuel-related parts before scheduled service)
- Sludge, algae, bacterial growth, fungi, particulates, etc. in the fuel
- Plugged fuel filters (numerous fuel filter changes due to excessive water)
- Water and sludge found in fuel tanks (new filters stopped-up in short time (before scheduled service))
- Discoloration of fuel

Next, Question # 7 asked, *If the response to Question 5 was Yes, was water contamination found?* Based upon the responses, it was established that the problem of water contamination causing fuel-related problems was greater in OCONUS areas than within CONUS.

FUEL SAMPLES

To follow-up the contamination problems, the respondents were asked the following questions:

8. *Was a fuel sample taken?*

9. *If a sample was taken, where was the sample(s) taken from?*
- a. *Vehicle fuel tank*
 - b. *Dispensing pump/tank truck*
 - c. *Central bulk/storage tank*
 - d. *Other*
10. *If fuel samples were taken and analyzed, did the test results show the fuel to be off-specification?*
11. *If the fuel was off-specification, what inspection properties did not meet the requirements of the specification?*
- a. *Distillation*
 - b. *Gravity*
 - c. *Particulates*
 - d. *Appearance*
 - e. *Color Residue*
 - f. *Other*
12. *If the fuel samples were analyzed, can the test results of these analyses be provided to this Center?*

Unfortunately, only 22 respondents had taken fuel samples. One sample was taken by a respondent in private industry, one in OCONUS/Asia, one in OCONUS/Italy, nine in OCONUS/Germany, and ten in CONUS. This only represents 17% of the total responses. Of the fuel samples taken, the samples were from all of the listed locations, i.e., vehicle fuel tank, dispensing pump/tank truck, central bulk/storage tank, and other. It was obvious from the responses that some respondents took more than one fuel sample.

When questioned as to whether the fuel samples were off-specification, the majority (22 responding "No" vs 11 responding "Yes") stated that the fuel samples taken were not off-specification. The requirements of the specification that the fuels were tested against were: distillation, gravity, particulates, appearance, and color residue. When this data was reviewed more closely, it was realized that approximately 65% of the respondents replied "Yes" to the question about whether fuel was suspected of being contaminated in the fuel-related problems. However, when asked if the fuel was off-specification, 66% of those responding to that question stated that the fuel was not off-specification.

Of those responding that the fuel was off-specification, no one requirement in particular seemed to be the problem. In fact, when responses were reviewed, it was noticed that some fuels failed to meet more than one requirement of the specification. Refer to Table 9.

Table 9. Requirement that was Off-Specification in Fuel Sample(s)

PROPERTY	PRIVATE INDUSTRY	HAWAII	PUERTO RICO	APO MIAMI PANAMA	OCONUS		OCONUS		OCONUS	
					APO SAN FRANCISCO ASIA	NEW YORK EUROPE ITALY	APO NEW YORK EUROPE GERMANY	CONUS		
a. Distillation	0	0	0	0	0	0	0	2	0	0
b. Gravity	0	0	0	0	0	0	0	0	0	0
c. Particulates	1	0	0	0	0	0	0	0	2	2
d. Appearance	0	1	0	0	0	0	0	1	3	3
e. Color Residue	0	0	0	0	0	0	0	3	2	2
f. Other	0	0	0	0	0	1	0	0	3	3

The perfect follow-up would have been to have the fuel samples sent to the Fuels and Lubricants Division at this Center. Unfortunately, only six respondents stated that fuel samples could be sent to the Center: one in private industry, two in OCONUS/Germany, and three in CONUS.

FUEL ADDITIVES

Next, the respondents were asked if fuel additives were presently being used or had been used in the past in vehicles/equipment problems described at the beginning of the questionnaire or as general practice. Results are tabulated in Table 10. From the data, it was concluded that most of the fuel does not contain any additives within CONUS or OCONUS.

Then the question was asked if either of the specification prescribed additives—fuel system icing inhibitor (MIL-T-27686) or the diesel fuel stabilizer (MIL-S-53021)—had been used. Results are tabulated in Table 11.

From the data in Tables 10 and 11, 93% (26 of 28) of the respondents replied that the specification-allowed additives, MIL-T-27686 and MIL-S-53021, were used in the fuel.

The respondents were then asked if MIL-T-27686 or MIL-S-53021 were not added, what type(s) of additive(s) were used and what was the intended function; i.e., brand name and what it does. Six locations within OCONUS/Germany and five locations within CONUS responded that some type of additive other than MIL-T-27686 or MIL-S-53021 was used. The additives and their functions are:

Denatured alcohol: Removes water during cold weather months

Biocide and stabilizer: Prevents fungus accumulation and other contaminants from forming in vehicles fuel cells and/or fuel storage tanks

Commercial fuel conditioner: (No purpose given with response)

DE-Z-LENE: Removes water and breaks down sludge

Respondents were asked how the above products (proprietary additives) were obtained. Those replies are shown in Table 12. The data shows that the majority of the proprietary additives used were obtained through military supply systems.

The respondents were then asked if the use of these additives resolved the fuel-related problems. Responses are shown in Table 13.

Table 10. Fuel Additives Used in the Fuel

RESPONSE	PRIVATE INDUSTRY	HAWAII	PUERTO RICO	APO MIAMI PANAMA	OCONUS APO SAN FRANCISCO ASIA	OCONUS APO NEW YORK EUROPE ITALY	OCONUS APO NEW YORK EUROPE GERMANY	CONUS
"Yes"	0	1	0	0	1	0	9	17
"No"	1	2	2	0	1	0	16	15
"Do Not Know"	0	0	0	0	0	0	11	3

Table 11. Fuel Additives (MIL-T-27686 and MIL-S-53021) Used in the Fuel

RESPONSE	PRIVATE INDUSTRY	HAWAII	PUERTO RICO	APO MIAMI PANAMA	OCONUS APO SAN FRANCISCO ASIA	OCONUS APO NEW YORK EUROPE ITALY	OCONUS APO NEW YORK EUROPE GERMANY	CONUS
"Yes"	0	2	0	0	1	0	9	14
"No"	0	1	0	0	0	1	10	6

Table 12. How Proprietary Additives Were Obtained

ADDITIVE SOURCE	PRIVATE INDUSTRY	HAWAII	PUERTO RICO	APO MIAMI PANAMA	OCONUS APO SAN FRANCISCO ASIA	OCONUS APO NEW YORK EUROPE ITALY	OCONUS APO NEW YORK EUROPE GERMANY	CONUS
a. Military supply source	0	0	0	0	0	0	5	2
b. Local purchase requisition	0	0	0	0	0	0	0	0
c. Free sample	0	0	0	0	0	0	1	0
d. Other	0	0	0	0	0	0	1	2

Table 13. Use of Additives Resolve Fuel-Related Problems

RESPONSE	PRIVATE INDUSTRY	HAWAII	PUERTO RICO	APO MIAMI PANAMA	OCONUS APO SAN FRANCISCO ASIA	OCONUS APO NEW YORK EUROPE ITALY	OCONUS APO NEW YORK EUROPE GERMANY	CONUS
"Yes"	0	0	0	0	1	0	6	12
"No"	0	0	0	0	0	0	4	0
"Do Not Know"	0	1	1	0	0	0	6	4

From the data in Table 13, it can be seen that the additives, including fuel system icing inhibitor (MIL-T-27686), diesel fuel stabilizer (MIL-S-53021), and the proprietary products/additives, only had an effect on fuel-related problems in approximately half of the incidents. In other words, there were a total of 37 responses stating that additives (MIL-T-27686, MIL-S-53021, and proprietary) were used. Thirty-five respondents replied to the question whether or not the additives used resolved the fuel-related problems. The additive resolved the problem in only 19 cases (54%). In 4 cases (11%), the additive did not resolve the problem. In 12 cases (34%) the respondents did not know whether or not the additive resolved the problem.

FIELD MANUAL/GUIDE

To conclude the questionnaire, the respondents were asked if a field manual or guide on recognizing fuel contamination problems and recommending preventive measures would be of assistance in their operation. Table 14 summarizes the results.

A total of 82% (108 of 132) of the respondents replied to this question. A total of 78% (84 of 108) replied that a field manual or guide would be helpful, while 22% (24 of 108) said it would not.

When asked what topics should be included in the manual, 82 of the respondents provided topics. The most requested topics are presented in Appendix B.

The respondents were also asked to provide any general comments to this survey that they felt were appropriate. A total of 38% (50 of 132) provided general comments. The most frequently cited comments are contained in Appendix C.

Table 14. Need for Field Manual/Guide

RESPONSE	PRIVATE INDUSTRY	HAWAII	PUERTO RICO	APO MIAMI PANAMA	OCONUS		APO NEW YORK EUROPE ITALY	APO NEW YORK EUROPE GERMANY	CONUS
					APO SAN FRANCISCO ASIA				
"Yes"	1	2	1	0	2	1		40	37
"No"	0	1	1	0	0	0		15	7

SUMMARY OF RESULTS

Geographical Location

When the question was asked if recent or past occurrences of vehicle and equipment operational problems appeared related to fuel quality, the majority of the problems cited occurred in CONUS vs. OCONUS.

Types of Fuel-Related Problems

When asked what was the major fuel quality problem, the response was fuel system starvation. The second most reported problem was increased maintenance of the fuel system. It can be concluded that poor quality fuel is not only not properly flowing through the fuel system but also increasing maintenance of the fuel system.

Affected Engine Components

When asked which engine components were affected most by the above fuel-related problems (fuel system starvation and increased maintenance of fuel system), the response was primary and secondary fuel filters.

Types of Vehicles and Equipment

The survey asked which vehicles and equipment have had problems based on evidence seen in fuel filters, water separators, fuel injector filters, and injector nozzles. There was evidence that some vehicles and equipment experienced more problems than the others. The five most frequently reported were: M35A2, M109, M110, 5 Ton Truck, and M34 Series Truck. In all geographical locations, these vehicles/equipment most often experienced operational problems because of plugging of primary and secondary fuel filters.

CONUS vs. OCONUS Problems

When the data was analyzed to determine if more fuel-related problems occurred CONUS or OCONUS, there were more problems within CONUS. When the responses were examined to find out if more vehicles/equipment experienced problems within CONUS or OCONUS, again it was within CONUS.

Fuel Contamination

When asked if fuel contamination was suspected, approximately the same number of cases of suspected fuel contamination causing fuel-related problems were cited within CONUS as OCONUS. When asked specifically about water contamination, there were more problems OCONUS than CONUS.

Fuel Samples

As a follow-up to the fuel contamination questions, the respondents were asked several questions about taking samples and analyzing the contaminated fuel. Unfortunately, only 17% of the respondents took a fuel sample. These samples were taken from several places, i.e., vehicle fuel tank, dispensing pump/tank truck, central bulk/storage tank, etc. The respondents were asked if the fuels were "off-specification." The majority responded that they were not. The ideal follow-up would have been to have the fuel samples sent to the Fuels and Lubricants Division at this Center. Unfortunately, only six respondents stated that fuel samples could be sent to the Center.

Fuel Additives

The respondents were asked if fuel additives were presently used or had been used in the past in vehicles/equipment problems described at the beginning of the questionnaire or as general practice. Because only 28 respondents said that additives were used, it is concluded that most of the fuel does not contain any additives within CONUS or OCONUS. Of these 28 respondents, 26 replied that the specification prescribed additives, MIL-T-27686 and MIL-S-53021, were added to the fuel. The respondents were asked if the above-named additives were not used, what type(s) of additive(s) were used and what is the intended function (i.e., brand name and what it does). Six locations OCONUS and five locations within CONUS responded that additives other than MIL-T-27686 and MIL-S-53021 were added. These "proprietary" additives were obtained through one of the following: the military supply system (respondents were asked to provide the National Stock Numbers (NSNs), local purchase requisition, free sample. When asked if the use of these additives (specification prescribed and/or "proprietary") resolved the fuel-related problems, the responses indicated that only in approximately half of the cases did the additives have any effect on the fuel-related problems.

SECTION III. CONCLUSIONS

1. Approximately 50% of the respondents had recent or past occurrences of vehicle and/or equipment operational problems that appeared to be related to fuel quality.
2. The majority of responses to the questionnaire were from locations in OCONUS/Germany. The location providing the second largest number of responses was CONUS.
3. There were only minimal responses from: Hawaii, Puerto Rico, Panama, OCONUS/Asia, and OCONUS/Italy.
4. According to the results of this survey, the locations experiencing the most fuel-related operational problems were CONUS and OCONUS/Germany.
5. Approximately 50% of the respondents to the question about whether or not the fuel was suspected of being contaminated in the fuel-related problems responded "Yes." But when those respondents were asked which inspection property was off-specification, 66% stated that no properties were off-specification.
6. A field manual or guide on recognizing fuel contamination problems and recommended preventive measures is wanted and needed.

As a result of this questionnaire, it can be seen that the quality of fuels can have serious consequences on DOD's mission by degrading vehicles, equipment, and weapons systems performance and damaging critical vehicles, equipment, and weapons components. Because DOD's highest priority goal in mobility fuels technology is to achieve the capability of utilizing fuels which are now readily available and are projected to be available from the commercial sector, we must be aware of the problems experienced in the field. Without this knowledge, it would be impossible to determine how effectively vehicles, equipment, and weapons operate on current fuels. From the problems, it can be determined which components of the fuel systems are affected. This will determine what changes and/or modifications are needed and make it possible to begin research for developing fixes. This is essential because the mission of DOD can not be unduly influenced by short-term fluctuation in petroleum supplies.

SECTION IV. RECOMMENDATIONS

1. Another questionnaire should be distributed and guidance should be given as to whom the respondents should be (i.e., direct support units/maintenance shops, Director of Industrial Operations officer, etc.)
2. With the next questionnaire, areas such as Asia, Italy, Panama, etc. need to be targeted because it has been shown in the past that these areas have experienced numerous fuel-related operational problems. There were very few returned questionnaires from these areas.
3. A data base of fuel-related problems experienced by diesel powered vehicles and equipment should be developed. This data base should include all field problems not just major problems where personnel, such as Belvoir Fuels and Lubricants Research Facility personnel, are sent out to investigate.
4. The units in the field should be asked to keep the Fuels and Lubricants Division of Belvoir Research, Development and Engineering Center informed of all fuel testing and test results that resulted from vehicle and/or equipment operational problems that appeared to be related to fuel quality.
5. A test kit needs to be developed for use in the field to monitor the quality of fuel, i.e., in tank truck shipments, in vehicles and equipment, etc. From the results of this questionnaire, it is evident that there is a need for increased capability for field testing of fuels. For example, 65% of the respondents stated that fuel contamination was suspected and the fuel was tested. However, 66% of them stated that when the properties (i.e., distillation, gravity, particulates, appearance, color residue, etc.) of the fuels tested, those properties were not off-specification. The testing procedure needs to be evaluated to determine what properties need to be field tested to detect contamination.
6. A field manual or guide on recognizing fuel contamination problems and preventive measures should be published. Some of the topics that should be included are:
 - How to prevent contamination of fuels
 - How field personnel can detect contaminated fuels
 - How to use fuel additives
 - How to take a fuel sample in the field
 - How to run a field test when contamination is suspected
7. A point-of-contact should be established with "hot lines" for field personnel can call about fuel problems.

APPENDIX A

QUESTIONNAIRE ON FUEL-RELATED PROBLEMS IN VEHICLES AND EQUIPMENT

Over the past several years, the subject of diesel/distillate fuel quality has been highly visible within the industry as evidenced by the numerous articles and publications cited in the open literature and trade journals. A recently initiated effort within the Office of the Secretary of Defense has been tasked to obtain documentation from the military services to confirm the reported decline in fuel quality which has resulted from changing crude feedstocks (i.e., use of heavier crudes, etc.) Obtaining the specific details on fuel-related vehicle and equipment problems occurring within the field environment has been difficult because of the infrastructure of the system which currently exists.

To expedite this data gathering process, a questionnaire has been prepared for surveying the different Army activities. This questionnaire attempts to provide for the major types of information needed with consideration being given to the nature of different operations on-going. Your cooperation is being solicited in responding to this questionnaire. When this survey is completed, a summary of all responses received will be forwarded for your information. The specific details on returning this questionnaire will be found at the end of the questionnaire. Your assistance in participating in this survey will be greatly appreciated.

1. Have there been recent or past occurrences of vehicle and/or equipment (V/E) operational problems that appeared to be related to fuel quality?
 - a. Yes _____
 - b. No _____
 - c. Do not know _____

2. If the response to Question 1 was Yes, were these problems primarily occurring from:
 - a. Engine starting difficulties _____
 - b. Engine stalling _____
 - c. Fuel system starvation _____
 - d. Increased maintenance of fuel system _____
 - e. Other _____

3. If the above observed problems were related to either Questions 2c or 2d, were these problems a result of:

- a. Plugging of primary fuel filters _____
- b. Plugging of secondary fuel filters _____
- c. Plugging of both primary/secondary filters _____
- d. Plugging of water separators _____
- e. Plugging of fuel injector filters _____
- f. Sticking injector nozzles _____
- g. Plugging/fouling injector nozzles _____
- h. Other _____

4. If the types of fuel-related problems as described by either Questions 3a-g were evidenced, what specific type of vehicles and/or equipment were affected?

	Problem Type	Evidenced Primarily In
a.	3a-c	_____ _____ _____
b.	3d	_____ _____ _____ _____ _____
c.	3e-g	_____ _____ _____ _____ _____
d.	3b	_____ _____ _____

5. In any of the fuel-related problems described in Question 3, was the fuel suspected of being contaminated?

- a. Yes _____
- b. No _____
- c. Do not know _____

6. If the response to Question 5 was Yes, why was this suspected?

7. If the response to Question 5 was Yes, was water contamination found?

- a. Yes ☐
- b. No ☐

8. If the response to Question 5 was Yes, was a fuel sample taken?

- a. Yes ☐
- b. No ☐
- c. Do not know ☐

9. If the response to Question 8 was Yes, where was the sample(s) taken from?

- a. Vehicle fuel tank ☐
- b. Dispensing pump/tank truck ☐
- c. Central Bulk/storage tank ☐
- d. Other ☐
-
-
-

10. If fuel samples were taken and analyzed, did the test results show the fuel to be off-specification?

- a. Yes ☐
- b. No ☐

11. If the response to Question 10 was Yes, what inspection properties did not meet the requirements of the specification?

- a. Distillation _____
- b. Gravity _____
- c. Particulates _____
- d. Appearance _____
- e. Color Residue _____
- f. Other _____

12. If the fuel samples were analyzed, can the test results of these analyses be provided to this Center?

- a. Yes _____
- b. No _____

13. In any of these vehicle/equipment problems described in Questions 2 and 3 or as a general practice, have there or are there now fuel additives being used?

- a. Yes _____
- b. No _____
- c. Do not know _____

14. If the response to Question 13 was Yes, have either fuel system icing inhibitor (MIL-I-27686) or the diesel fuel stabilizer (MIL-S-53021) been used?

- a. Yes _____
- b. No _____

15. If the response to Question 14 was No, what are or have been the type(s) of additive(s) used and what is their intended function (i.e., brand name and what it does?)

16. If the response to Question 14 was No and proprietary additives were identified under Question 15, how were these obtained?

- a. Military supply system _____
- b. Local purchase requisition _____
- c. Free sample _____
- d. Other _____

17. If the response to Question 16 was Military Supply System, what is the National Stock Number of the product(s) used?

18. Did the use of additives either identified under Questions 14 or 15 resolve the fuel-related problems?

- a. Yes _____
- b. No _____
- c. Do not know _____

19. Would a field manual or guide on recognizing fuel contamination problems and recommended preventive measures be of any assistance in your operation?

- a. Yes _____
- b. No _____

20. If the response to Question 19 was Yes, what things/topics would you want to see included?

21. Please provide any general comments relative to this survey that you feel appropriate.

This questionnaire was completed by:

Point of Contact:

When completed, please return questionnaire to the following address:

Commander

US Army Belvoir Research, Development and Engineering Center

ATTN: STRBE-VF

Fort Belvoir, VA 22060-5606

APPENDIX B

SUGGESTED FIELD MANUAL TOPICS

When asked what topics should be included in the manual, 82 of the respondents provided topics. The most requested topics were:

1. Types of contamination.
2. A section on how to detect contaminated fuels including: the causes of contamination, the initial signs of contamination with photographs, and the symptoms with photographs showing damage caused by various contaminants.
3. Field test procedures to check the fuel in the field or distribution point for contamination and a method for testing fuel to determine what is contaminating the fuel.
4. A section on prevention of contamination from procurement to user/fuel dispensers to vehicle operators.
5. Information on fuel sampling methods and techniques including: step-by-step guide on how to take a sample (for operators) and when to take fuel samples.
6. A section on how to use fuel additives and the best considered additives for: moisture absorbency, algae inhibitors, icing problems, etc. The National Stock Numbers (NSNs) of the additive must be included.
7. A section on proper maintenance procedures, i.e., housekeeping, storage, fuel handling, etc.
8. A section on what should be done as soon as contamination is noticed, including additives to be used after contamination is found and procedures for clean-up of fuel samples after they have been contaminated.
9. A special section on diesel fuel during cold weather periods including cold weather additives (uses and NSNs) and causes of diesel fuel system gelling and recommended cures.
10. Simpler but specific guidelines on proper mixture of fuel and additives in small quantities (suitable for Field Units to use).
11. How to determine if there is water in the fuel.

12. A section on housekeeping techniques: exactly how to purge tanks and special equipment when purging, procedures for cleaning vehicle fuel systems, procedures for cleaning fuel storage tanks and supply systems, and proper fuel tank maintenance.
13. A section on what to do with fuel stored in vehicles that sit 2 weeks or longer, guidance on how to handle fuel on low density, infrequent use equipment, and how long different types of fuel stay in issued state before they break down.
14. A point-of-contact that field personnel can consult about fuel contamination problems.
15. A list of grades of Army fuels and seasonal fuel identification.
16. A section on the uses of the different grades of fuels.
17. A listing of previously encountered problems with preventive corrective measures.
18. A brief explanation of the fuel system.
19. A test that has a short turn-around time. Many respondents complained that the turn-around time was too long when a fuel sample was sent for analysis.
20. A section on how to interpret laboratory reports.

APPENDIX C

GENERAL COMMENTS

When the respondents were asked to provide any general comments to this survey that they felt were appropriate, 38% (50 of 132) provided general comments. The most frequently cited comments were:

1. A section in the manual concerning diesel fuel properties and their effects on engine performance and emissions would be helpful.
2. Army ground fuel support equipment is old and difficult to support with long lead times. Lack of training is a problem.
3. The aviation fuel user has a critical need for close surveillance of fuel. Ground mobility fuel problems are not of critical nature but there appears to be a need for more timely response to fuel problems from test facilities.
4. Supply support system should require emphasis on maintaining fuel quality and surveillance.
5. Fuels and lubricants should be tested in various geographical locations where at times, drastic changes of temperatures were experienced and should be done under controlled conditions.
6. A field manual on this subject would be of great interest and benefit if it is simple and straightforward. Also, as in all manuals, it must get into the hands of the soldiers who will pump fuel everyday.
7. Since guidelines for fuel problems are either not available or unknown, fuel problems are not normally recognized.
8. The survey needs to be more detailed. It needs to ask where the fuel came from, such as POL point, off-post gas station. It also needs to ask about down time of equipment due to fuel malfunctions.
9. In Europe, very few samples laboratories are available. Turn-around time is 3 to 4 weeks.
10. Every operator should receive training on handling fuel.
11. Several Reserve Units stated that they purchase fuel with credit cards from commercial gas stations. Their vehicles are low mileage and need additives to keep diesel fuels from gelling.

12. Fuel provided by vendors does not meet specifications. (The respondent did not mention what they are doing about off-specification fuel.)

13. Several respondents recommended including fuel sampling procedures into operator manuals for fuel dispensing vehicles, tanks, and pumps. They stated that one source document is needed for fuel personnel in the use of their equipment and product dispensing. This would help the soldiers in the field.

14. a. The biggest problem is water and foreign matter in the fuel, but may be caused by storage tanks or fuel tanks.

b. The biggest contributing factor to contamination accumulation is due to fuel tanks not being drained to get rid of water and moisture accumulation. This happens especially in high humidity and hot climates.

c. Most of the time when units have fuel contamination problems, it is from poor maintenance of the fuel tanks. There is rust and dirt from removing the filter screen during refueling. This practice should be stopped. Fuel tanks left empty over long periods of time will rust. They should be full at all times.

15. Diesel fuel powered vehicles are fairly new to the military. A strong educational program stressing the most critical points to remember when operating a diesel powered vehicle would save money and reduce downtime.

There were detailed comments from a CONUS location that generally summarized all of the comments received.

a. Commercial source/credit cards are used exclusively at this facility. Quality is good. Most stations have visible dispensing pump filters. Any water contamination that we experience is probably from condensation in the equipment tanks.

b. The majority of our fuel problems result from either:

(1) Fuel dispensing from unfiltered pods in the field, or

(2) Low usage equipment with large tanks, i.e., 2380 Crane or 100kW generators. Fuel remains in this equipment for several years before it is used up.

c. A black, gelatinous substance has been detected on the primary filters of multifuel vehicles, even though they were in relatively routine use and filters were drained periodically. (Equipment was still functioning normally; the filters were doing their job.)

d. Over-use of additives is probably more harmful than under-use. Fuel System Icing Inhibitor (FSII) is a very harsh substance which will deteriorate rubber products. The general tendency when water CONTAMINATION is detected or suspected is: to dump in "an extra dose" of inhibitor "to dry out the tank." Another popular misconception is that the diesel inhibitor will "thin-out" the fuel in the tank (lowering pour point, cloud point).

e. I have seen evidence of internal deterioration (cracking, softening, black residue) on fuel return lines (rubber hoses on GM 5.7 liter diesel). This resulted in stalling, loss of power, erratic idling, (Roosa-master pump will shut down when their return lines are restricted.) The only explanation I could reach was that the original equipment fuel lines were incompatible with the various additives that had been in use. Replacement of these lines solved the difficulty. While the return hoses on CUCV (6.2 liter diesel) appear to be more substantial than earlier models, hose deterioration is still a potential problem that bears watching.

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