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Performance of Fuels, Lubricants, and Associated Products Used During Operation Desert Shield/Storm

by

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Report Date

August 1992

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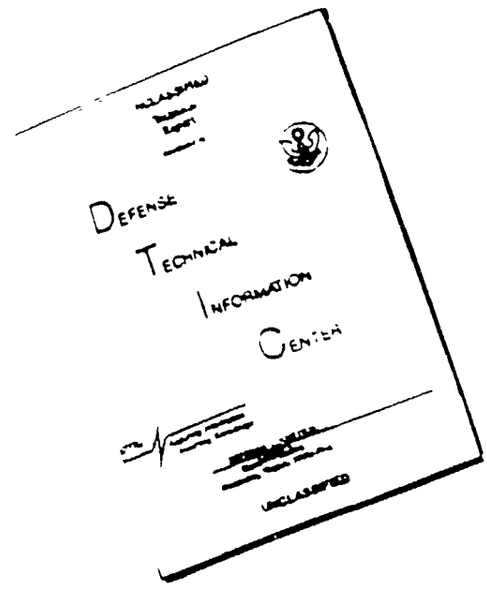

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This report presents all aspects of fuels, lubricants, and associated products used by US forces in Southwest Asia as reported by military organization representatives who were responsible for the procurement, storage, and handling of these products.

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Executive Summary

PROBLEMS AND OBJECTIVES

The designation of Jet A-1 fuel as the primary fuel for use in aviation assets and diesel-burning ground combat/tactical vehicles and equipment during Operation Desert Shield/Storm (ODS) was viewed with concern by some combat commanders, users, and maintenance personnel. Armored commanders, in particular, wanted DF-2 to be used in their Vehicle Engine Exhaust Smoke Systems since aviation jet fuels do not produce a persistent smoke for smoke screens. User/maintenance personnel confronted with wartime demands and schedules, as well as an unfamiliar fuel, complained about the fuel's perceived impact on their vehicles and equipment. A lack of lubricity was reported as a probable cause for failure in Cummins fuel transfer pumps, especially in high ambient temperature operations. An investigation of this lack of lubricity resulted in a Department of the Army (DA) three-man team of experts recommendation that combat commanders be allowed to use the fuel of their choice. Other complaints diminished as the troops became better informed about and more familiar with the fuel. A Belvoir Research, Development and Engineering Center (BRDEC) survey team conducted visits to returned military organizations, including the U.S. Marines, to gather data for review and analysis. These analyses would then lead to recommendations that would shape and direct future research and development efforts and would evaluate the level of funding required to support these efforts.

IMPORTANCE OF PROJECT

Complaints generated by military personnel in the field must be addressed in a timely and efficient manner, especially when their very lives depend on straightforward, accurate answers as they did during ODS. Further, the continued support and approval for designating aviation kerosene base jet fuel as the future "One Fuel on the Battlefield" absolutely depended on a favorable outcome. The results obtained by the use of JP-5 fuel in "Operation Just Cause" and the JP-8 fuel demonstration program at Fort Bliss, TX, were validated on the battlefields of Southwest Asia. The problems with fuels, lubricants, and related Petroleum, Oil and Lubricant (POL) products identified during ODS must be resolved in order to make appropriate changes in fuel storage and handling technical manuals, and to provide the correct information down to user level.

TECHNICAL APPROACH

During ODS, personnel chosen by their respective organizations, agencies, or activities because their position, knowledge, and experience qualified them as experts in the procurement, storage, and handling of fuels, were interviewed by the DA three-man team. In addition, selected operator/maintenance personnel who used or dealt with the results of using POL products were interviewed. After the units

returned to the U.S. from ODS, experts were selected by their respective organizations who were knowledgeable about POL products and who could comment on fuel used in the U.S. as compared to fuel used during ODS. These personnel were interviewed by a survey team formed by BRDEC with the goal of using the results to further define the successes and failures of fuels, lubricants, and associated Class III products during ODS and to determine changes needed in POL equipment, utilization practices, and necessary product research and development.

ACCOMPLISHMENTS

The DA team interviewed personnel of some 16 units/activities including U.S. Army and U.S. Marine Corps personnel as well as some commercial contractors in-country. One of the DA team members was requested by Central Command's (CENTCOM's) JPO to attend a meeting with representatives from Petromin Lubricating Oil Company regarding an agreement wherein Petromin was identified as the company that would be supplying all packaged Class III products to the U.S. at no cost under a host nation support agreement. The DA team member provided guidance as to the acceptability of these commercial packaged products for use in U.S. vehicles and equipment.

The BRDEC survey team interviewed personnel of some 43 different organizations, units, and activities at different posts, plus individuals with special knowledge and insight into POL products and their use in Southwest Asia. Clearly, all evidence pointed to the fact that aviation kerosene base jet fuels could be the one fuel for use by military forces both at home and abroad. Forts Bliss and Hood, TX, have both converted to JP-8. The U.S. Marines have stated that if they are going to fight with aviation jet fuel, they must train with aviation jet fuel as have the 24th Infantry Division (Mech) at Fort Stewart, GA, and the 82nd Airborne Division at Fort Campbell, KY.

MILITARY IMPACT

One fuel for both aviation assets and ground vehicles and equipment can lead to: standardized fuel storage and handling equipment; a drastic reduction in fuel deterioration in storage; reduced hardware and maintenance costs in replacement of fuel-wetted components; a cleaner handling, better smelling product; and easier logistics planning. These improvements will result in increased combat readiness and have a positive direct impact on RAM-D requirements.

Foreword

This study was a cooperative effort between BRDEC, Fort Belvoir, VA, and the Belvoir Fuels and Lubricants Research Facility located at Southwest Research Institute (SwRI), San Antonio, TX. That portion of the work performed by SwRI personnel was funded by BRDEC under Contract No. DAAK70-87-C-0043 Mr. T. C. Bowen, BRDEC, served as the Contracting Office's Representative and Mr. M. E. LePera served as the project technical monitor.

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Section I

Background

The deployment of U.S. forces to Saudi Arabia required that Belvoir Research, Development and Engineering Center (BRDEC) resolve some user concerns about the suitability of specific fuels, lubricants, and associated products for ground vehicles and equipment (V/E) when operated in the harsh desert environment. Further, as ground V/E arrived in Saudi Arabia from locations throughout the world, questions surfaced about how to ensure that the proper fuels and lubricants were in those items, given the high prevailing temperatures. To facilitate the resolution of these immediate concerns, a listing of frequently asked questions and answers was distributed, as well as a list of operational procedures and practices for fuel and lubricant utilization (Appendix A).

Jet A-1[1] fuel had been initially identified as the primary fuel for both aviation and diesel-fueled ground vehicles involved in Operation Desert Shield (ODS).[2] During the two months following first deployment, a series of apparent fuel-related V/E problems surfaced, creating concern among some of the using units as to the acceptability of Jet A-1 in diesel engines. With the scheduled deployment of VII Corps from Germany and the need to project future ground fuel requirements, a team of Army Materiel Command (AMC) personnel requested by Department of the Army (DA) visited Saudi Arabia in December 1990 to thoroughly evaluate all issues related to using Jet A-1 as a ground vehicle fuel in ODS (Appendix B). The summary conclusions that evolved from this DA visit were: insufficient evidence existed to support the conclusion that Jet A-1 was a major factor in fuel system failures; nonfuel-related variables (such as heat, dirt, usage, known defective parts, and questionable maintenance practices) were major contributing factors to system failures; operation of on-board vehicle smoke generation systems would require diesel fuel; and the theater distribution plan could support continued use of both Jet A-1 and diesel fuel.[3]

As a result of these findings, research and development (R&D) efforts were accelerated to establish the lubricity requirements for diesel engine components when using low-viscosity fuels. Because of shortfalls in available packaged products for U.S. Forces, selected commercially available products were evaluated and recommended for use as a temporary fix. Further, agreement was negotiated with a Saudi Arabian manufacturer, Petromin Lubricating Oil, to furnish selected commercial products in lieu of the military specification products to the U.S. ground forces.

Additional support provided a field blending procedure for introducing QPL 25017 corrosion inhibitors into the Jet A-1 fuel; recommended modified engine oil drain intervals for all ground material to counter the adverse effects of the high-sulfur diesel fuel being furnished for some of the ground forces; conducted a flammability hazard assessment of Jet A-1 fuel in ground V/E; and recommended non sand-adhering lubricants for gun systems to reduce potential for malfunctions.

After ODS, when combat personnel had returned to their respective military bases, BRDEC formed a survey team to interview knowledgeable personnel from selected combat organizations, units, and support groups. The purpose of these interviews was to complement the information already received and to provide as comprehensive a view as possible of the actual experiences with fuels, lubricants, and other POL products available to them and the impact on their combat readiness.

Section II

Introduction

Successful operation of diesel-burning ground combat/tactical V/E at Fort Bliss using JP-8 fuel for over 20 months prior to ODS, plus the successful conduct of "Operation Just Cause" in Panama using JP-5[4] led to the designation of another aviation kerosene base jet fuel, Jet A-1, as the primary fuel for aviation assets and V/E used in ODS. Since the only significant difference between JP-8 and Jet A-1 fuel was the additive package mandatory in JP-8, it was believed that Jet A-1 could be used successfully during ODS. However, concerns were expressed by some combat commanders, users, and maintenance personnel about the impact of Jet A-1 on the operations of their V/E. Upon being allowed to use either Jet A-1 or DF-M (diesel fuel provided by Saudi Arabia somewhat equivalent to DF-2), some commanders chose DF-M because of its capability of producing a persistent smoke and because of their unfamiliarity with Jet A-1 fuel. A lack of lubricity was suspected to be the cause of failures in Air Defense 150 kW generators and Cummins NTC-400 engine fuel transfer pumps and, in conjunction with unprecedented usage and high ambient temperatures, was given a degree of credence. Accelerated R&D efforts were established to determine the lubricity requirements for diesel engine components when using low-viscosity fuels.

The other concerns raised in ODS only echoed those that had been noted earlier at Fort Bliss during the JP-8 fuel demonstration program and during "Operation Just Cause." These concerns were well documented in letters, bulletins, and an Interim Report BFLRF No. 264 (AD A233441), entitled "Field Demonstration of Aviation Turbine Fuel MIL-T-83133C, Grade JP-8 (NATO Code F-34) at Fort Bliss, TX," dated December 1990. All these concerns had been resolved by back-to-back tests using JP-8 and DF-2 fuels, respectively, or through technical consultations.[5]

This report presents all aspects of fuels, lubricants, and associated products used by U.S. Forces in Southwest Asia as reported by military organization representatives who were responsible for the procurement, storage, and handling of these products.

The objectives established by BRDEC were to determine—

1. The successes and failures of POL products used during ODS.
2. Changes needed in POL equipment, technical manuals, handbooks, and utilization practices in order to disseminate the information from wholesale level down to user/operator level.
3. The scope and direction of future POL product R&D.
4. The impact on R&D funding priorities and amounts.

Section III

Approach

BRDEC desired to acquire as much information and data as possible about the successes and failures of fuels, lubricants, and associated Class III products used by the U.S. in diesel-fueled ground assets during ODS. This information would complement the information that had already been generated during a DA team visit to Southwest Asia in December 1990 and input from other military and civilian channels. To meet this objective, BRDEC formed an after-action survey team that prepared a data collection plan with an attached questionnaire covering all aspects of fuels, lubricants, and associated Class III products used during ODS. Copies of these plans and questionnaires were forwarded to the AMC's Logistics Assistance Officers (LAO) at Forts Bliss, Hood, Stewart, and Campbell. Copies of the plan and questionnaire were also sent to the Commanding General, Camp Pendleton, CA, and Commanding General, Camp LeJeune, NC (Appendix C). There was insufficient time to visit Fort Campbell, and they were so informed. The questionnaires forwarded to the selected bases were not to be completed ahead of time by units receiving them but were to serve as guides as to the kind and scope of information sought by the survey team.

An itinerary and escort were provided the BRDEC survey team at each post visited. Commanders and their staff were very supportive of the teams' efforts.

Upon completion of the interviews at each post, a letter containing preliminary findings was sent to each respective commander for his information and review. After all relevant responses were documented in a matrix form, copies of these matrices were also provided to the respective commander (Appendix D).

In addition to the interviews, motor pool areas were toured, and some items of interest that had been brought up in the interview sessions were photographed. Fuel samples were taken from tanker trucks and other vehicles that contained fuel that had been drawn in Southwest Asia and returned to CONUS in the individual tanker and vehicle fuel cells. Also, some new and used engine oil samples were acquired, as well as antifreeze and transmission fluid samples. All samples were returned to SwRI for cataloging and then subjected to tests analyses by either BRDEC or SwRI.

Section IV
Discussion

SURVEY RESULTS

Interviews were conducted with POL, maintenance, and user/operator personnel at all levels to ensure as broad a coverage as possible in developing information and encompassing the availability and quality of products needed as well as POL handling and maintenance practices. Also included were the impact of environmental factors such as wind, sand/dirt contamination, and the impact of local (hard) water usage on the operational capabilities of military forces V/E. General information on other subjects of concern to personnel interviewed, including field expedient practices and recommendations, is also addressed in this report (Appendix E).

Responses from all personnel interviewed were first categorized by questions in each area that information was sought. Information that did not pertain specifically to BRDEC areas of responsibility was referred to other AMC or Training and Doctrine Command (TRADOC) agencies. The number of responses for each question was assigned to a "yes," "no" or "no answer" category, which allowed mathematical and statistical calculations and comparisons. Survey participants then met to consider the data in each category, analyze the information, and develop conclusions and recommendations. These recommendations would aid in guidance for future planning in fuels, lubricants, and associated product development with the allocation of required R&D funding.

FUELS

Availability

At the beginning of ODS, it was extremely important that an adequate supply of fuels and lubricants of a satisfactory quality be provided as quickly and conveniently as possible. Saudi Arabia, in its spirit of cooperation with United Nations participants in the operation and recognition of its responsibility for rendering aid to the United Nations Forces, agreed to supply both bulk and packaged petroleum and related products to the Allied Forces under host nation support agreements. Thus, Jet A-1 fuel was the primary fuel used by U.S. Forces in Southwest Asia with DF-M available when requested. Jet A-1 was also reportedly used by French Forces and in German V/E operated in Saudi Arabia. The U.S. Department of Defense (DOD) Directive 4140.43[6] directed the use of

kerosene-base jet fuel in the form of JP-8 (essentially Jet A-1 "with additives") as the fuel of the future (i.e., the Single Fuel on the Battlefield). The JP-8 fuel demonstration program at Fort Bliss had been in process for 20 months by the onset of ODS and had produced data supporting the viability of using aviation grade fuel in U.S. V/E. Since Saudi Arabian refineries reportedly had no downstream capability for injecting the three mandatory additives to the Jet A-1 fuel, it was decided that Jet A-1 fuel would be satisfactory for ground materiel. The U.S. Air Force agreed to furnish additive injection equipment to enable converting the Jet A-1 to JP-8. This conversion was subsequently performed at airfield fueling locations for Air Force aviation assets. There were ample quantities of all fuels made available to U.S. Forces. After the visit of the DA team in December 1990, a decision was made that major commanders (i.e., at the division level) were free to use the fuel of their choice by direction of ARCENT/Deputy Host Nation Support in coordination with U.S. Forces Central Command (CENTCOM). Table 1 illustrates the fuel used by the units interviewed during the survey.

Table 1. Fuel Used by Organizations Interviewed

		Southwest Asia		
Unit	CONUS	Port	Inland	Usage Period
3rd ACR	JP-8	JP-8	Jet A-1	Entire Period
11th ADA Bde	JP-8	JP-8	Jet A-1	Approx. 2 months
			DF-2*	Remainder of war
1st Cav Div	JP-5**	JP-5	Jet A-1	Remainder of war
3rd ACR (Aviation)	JP-4	JP-5	Jet A-1	Remainder of war
6th AIR Cav Bde	JP-4	JP-5	Jet A-1	Remainder of war
1st MEF	DF-2	DF-2	Jet A-1	Entire period
2nd MEF	DF-2	DF-2	Jet A-1	Entire period
24th Inf Div	DF-2	DF-2	Jet A-1	Approx. 2 weeks to 1 month
			DF-2*	Remainder of war

** By request. Also, diesel fuel used was actually a DFM-type (MIL-F-16884) fuel.*

*** Drew 500,000 gallons at Fort Hood and took with them.*

Quality

Fuels provided by Saudi Arabia plus those fuels accompanying U.S. Forces such as those in V/E fuel cells and U.S. Marine Maritime Prepositioning Ships (MPS) were assessed for fuel quality primarily at the bulk fuel storage areas. Bulk fuel storage and

handling personnel relied on the normal practices of accepting refinery and Defense Fuel Supply Center (DFSC) quality assurance personnel tests and analyses to ensure that they received specification qualified products. In the 1st Corps Support Command (COSCOM) area (XVIII Airborne Corps), the HHC, 260th POL Battalion Petroleum Mobile Laboratory was positioned in the 24th ID (M) defense sector and performed the majority of petroleum laboratory testing for the entire XVIII Airborne Corps. When the 260th POL Battalion Mobile Petroleum Laboratory was nonmission-capable, the XVIII Airborne Corps received back-up laboratory testing with the 22nd Petroleum Laboratory at Dhahran International Airport and the Caleb Brett Laboratory at Ras Tanura. No fuel samples were reported taken from ground vehicles and equipment and analyzed by any fuel testing laboratories. In the VII Corps area, only aviation fuel samples were reportedly tested.

The specifications for Jet A-1 met the MIL-T-83133C specification for JP-8 with the exceptions of the mandatory additives, i.e., Corrosion Inhibitor (CI), Fuel System Icing Inhibitor (FSII), and Static Dissipator Additive (SDA). At the beginning of ODS and during the operation, some host nation fuels were delivered in foreign national commercial and military tankers. It was reported that these tankers had no filtering systems and often times contained unknown solid materials as well as other residues. Since these vehicles were not fuel dedicated, they could have contained remains of earlier delivered fuels and oils or other liquid substances. Some vehicles reportedly were observed operating with the fuel tank hatches left open. The DA team observed this during their visit in December 1990. Pink, red, brownish-green, and other colors were attributed to some of the fuel delivered that contained some of these unknown substances. The fuels delivered to units supplied by a higher support group such as a Division or Corps Support Command (DISCOM/COSCOM) and Regimental and Division Maintenance Management Centers (RMMC/DMMC) for the Army or Force Support Service Centers/Groups (FSSC/FSSG) for the Marines were usually superior to fuels delivered to separate units by their own transportation or foreign national tankers. The Army Air Defense Artillery units suffered most from the latter type of delivery vehicles. However, statements made by bulk fuel storage and handling personnel verified that the Jet A-1 fuel delivered to their bladder storage farms was the "cleanest they had ever seen" and contained essentially no water. The majority of all knowledgeable military personnel stated that the quality of the fuel delivered to them was excellent.

The only confirmed firsthand knowledge of DF-M waxing and microbiological growth problems was reported by the 24th Infantry Division from Fort Stewart, GA. Personnel interviewed also stated that these two problems had long been experienced at Fort Stewart prior to any deployment to Southwest Asia. However, after using Jet A-1 for 2 weeks to 1 month in Saudi Arabia, the 24th Infantry Division reverted to DF-M because

of filter clogging in all vehicles. Another more important reason was because they wanted the smoke generation quality of DF-M for the on-board Vehicle Engine Exhaust Smoke Systems (VEESS) of armored vehicles. Although the DF-M fuel provided by the host nation reportedly had a high sulfur content, no reported engine failures were attributed to the use of the diesel fuel.

Analysis

In support of the Operation Desert Storm (ODS) lesson learned program, BFLRF obtained and analyzed several fuel samples from V/E returned to CONUS sites from ODS. Table 2 lists the samples obtained. The samples from Fort Bliss were reported to be Jet A-1; the samples from Fort Stewart were reported to be DF-M; and the samples from Fort Hood were reported to be Jet A-1 or JP-5.

Table 2. Fuel Samples Taken from Operation Desert Storm Vehicles/Equipment

ITEM NO.	DATE	LAB ID NUMBER	DESCRIPTION	SOURCE	P/C/S
A	04/24/91	AL-19697-F	Middle Sample	Fuel Tank Truck	Fort Bliss, TX
B	05/28/91	AL-19711-F	Fuel Cell	M3-600HP-K-13	Fort Bliss, TX
C	05/28/91	AL-19712-F	Front Fuel Cell	M1A1-K-21	Fort Bliss, TX
D	05/28/91	AL-19713-F	Front Fuel Cell	M1A1-K-12	Fort Bliss, TX
E	05/28/91	AL-19714-F	Fuel Cell	M113A1-L-52	Fort Bliss, TX
F	05/28/91	AL-19715-F	Passenger Side Fuel Cell	M35-A2-W/W-L-18	Fort Bliss, TX
G	05/28/91	AL-19716-F	Fuel Cell	M3-K-11	Fort Bliss, TX
H	05/29/91	AL-19717-F	Disp. Hose	Fuel Tank Truck	Fort Stewart, GA
I	05/29/91	AL-19721-F	Disp. Hose	Fuel Tank Truck	Fort Stewart, GA
J	06/19/91	AL-19726-F	Fuel Cell	Tracked Vehicle	Fort Hood, TX
K	06/19/91	AL-19727-F	Fuel Cell	5 kW Generator	Fort Hood, TX

Table 3 lists the results of analysis of sample AL-19697-F. This fuel was taken from a tanker truck brought back with the 3rd ACR from Southwest Asia. The fuel in the tanker was reported to be Jet A-1 and is representative of the fuel used by the 3rd ACR throughout Operations Desert Shield and Desert Storm. This fuel meets all MIL-T-83133C, JP-8, requirements with the exception of icing inhibitor, conductivity (static dissipator additive), and corrosion inhibitor. This failure to meet the specifications is to be expected since this fuel is Jet A-1 and does not require these additives as does JP-8.

Table 3. Results of Analysis of Fuel Sample from Fort Bliss, TX, 3rd ACR Fuel Tanker (Returning from ODS)

Property	ASTM Method	MIL-T-83133C JP-8 Requirements	AL-19697-F
TAN, mg KOH/g	D 3242	0.015, max	0.001
Aromatics, vol%	D 1319	25.0, max	19
Olefins, vol%	D 1319	5.0, max	1.2
Sulfur, mass%	D 4294	0.30, max	< 0.01
Hydrogen, mass%	D 3178	13.4, min	14.1
Carbon, mass%	D 3178	Report	85.86
Distillation,°C	D 86		
Initial Boiling Point		Report	150
10% Evaporation		205, max	171
20% Evaporation		Report	180
50% Evaporation		Report	194
90% Evaporation		Report	231
End Point		300 max	253
Residue, vol%		1.5, max	1
Gravity,°API	D 1298	37 to 51	47.8
Density, kg/L	D 1298	0.840 to 0.775	0.7888
Cloud Point, °C	D 2500	NR*	-55
Flash Point, °C	D 93	38, min	43
K. Vis, cSt, at			
40°C	D 445	NR	1.15
70°C	D 445	NR	1.04
Net Heat of Combustion	D 240		
MJ/kg		42.8, min	43.033
Btu/lb		18,400, min	18,501
Btu/gal.		NR	121,672
Cetane Number	D 613	NR	49.1
Cetane Index	D 976	Report	46.5
Existent Gum, mg/100mL	D 381	7.0, max	0.5
Particulate Contamination,mg/L	D 2276	1.0, max	0.6
Accelerated Stability, mg/100 mL	D 2274	NR	0.14
FSII, vol%		0.10 to 0.15	0.01
Fuel Conductivity, pS/m		150 to 600	31
Corrosion Inhibitor, mg/L***		QPL-25017	ND**
Visual	D 4176	Clean/Bright	Clear/Bright
Colonial Pipeline Co. Haze Rating	Proposed	NR	1
Color	D 156	Report	+4
Copper Corrosion	D 130	NR	1A
Silver Corrosion	IP21	NR	0

** NR = No Requirement.*

*** ND = Not Determined.*

**** Based on HITEC E580.*

Six fuel samples were taken from the fuel cells of selected vehicles of the 3rd ACR in an attempt to obtain samples of Jet A-1 fuel reportedly returned from Southwest Asia to Fort Bliss, TX, in the individual vehicles. These samples were reported to be Jet A-1 fuel, and the results (Table 4) indicate that these samples are Jet A-1. However, all the samples have varying degrees of contamination with what appears to be DF-M, as evidenced by the high gum content of sample AL-19711-F as well as the conductivity, visual appearance, and color results. Since many of these samples are bottom of the fuel cell samples, these results may also indicate the presence of water, dirt, and sludge contamination in the fuel cells.

Table 5 contains the results of analysis of two fuel samples received from Fort Stewart, GA. These samples are from the fuel used by the 24th Infantry Division (Mechanized) during ODS. These two samples were obtained from two separate tankers at Fort Stewart shortly after the 24th returned from Southwest Asia. The analyses indicate that sample AL-19717-F is actually Jet A-1, while sample AL-19721-F is DF-M. Note that AL-19721-F exceeds the VV-F-800C specification maximum allowable levels for sulfur and accelerated stability.

Table 6 lists the results of analysis of the two samples from Fort Hood, TX. The results indicate that both samples are Jet A-1 fuel. The samples meet all applicable JP-8 specification requirements with the exception of visual appearance (both samples) and particulate contamination (AL-19727-F). Since these samples were taken from V/E fuel cells, the slightly increased sediment in the fuel is not of major concern.

Table 7 contains the analysis results of eight Jet A-1 fuel samples taken from vehicle fuel tanks in Southwest Asia during ODS. The fuel meets the specification requirement for JP-8 for the tests performed except for FSII, and two samples (A and C) exceeded the particulate contamination requirement. Sample C was grossly contaminated with sand/dirt.

Table 4. Results of Analyses of Fuel Samples Taken from Vehicle and Equipment Fuel Cells at Fort Bliss, TX (Returning from ODS)

Property	ASTM Method	MIL-T-83133C JP-8 Requirements	AL-19711-F	AL-19712-F	AL-19713-F	AL-19714-F	AL-19715-F	AL-19716-F
TAN, mg KOH/g	D 3242	0.015, max	0 035	0 01	0 001	0 003	0 003	0.006
Aromatics, vol%	D 1319	25 0, max	19 6	18 9	18.9	18.2	19 4	18.9
Olefins, vol%	D 1319	5 0, max	0 8	1	0 9	1.2	1.1	1 2
Sulfur, mass%	D 4294	0 30, max	0 03	0 06	0 02	0.07	0 06	0 06
Hydrogen, mass%	D 3178	13.4, min	14 01	14 01	14 01	14.02	14.18	13.98
Carbon, mass%	D 3178	Report	85 66	85 29	85.89	85 48	85 48	85.52
Distillation, °C								
Initial Boiling Point		Report	149	158	158	154	156	167
10% Evaporation		205, max	170	173	172	170	171	172
20% Evaporation		Report	178	179	177	177	178	181
50% Evaporation		Report	196	195	197	197	196	197
90% Evaporation		Report	231	229	232	233	231	232
End Point		300, max	258	257	251	268	258	259
Residue, vol%		1.5, max	2	2	2	2	2	2
Gravity °API	D 1298	37 to 51	47.4	47.3	47	47 1	47 5	47.3
Density, kg/L	D 1298	0.840 to 0 775	0.7906	0.791	0 7924	0.7919	0.7902	0 7910
Cloud Point, °C	D 2500	NR*	-51	-53	-51	-50	-52	-50
Flash Point, °C	D 93	38, min	44	47	47	47	47	47
K Vis, cSt, at								
40°C	D 445	NR	1 19	1.14	1.15	1 17	1.15	1.18
70°C	D 445	NR	0 86	0.83	0.83	0.85	0 83	0.85
Net Heat of Combustion,	D 240							
MJ/kg		42.8, min	43 012	43.050	42.910	42.894	42 768	42 745
Btu/lb		18,400, min	18,492	18,508	18,448	18,441	18,387	18,377
Btu/gal.		NR	121,885	122,058	121,867	121,753	121,125	121,194
Cetane Number	D 613	NR	46.8	46.8	47	46.9	46 9	49 1
Cetane Index	D 976	Report	46 5	45 5	46	45	46 5	46
Existent Gum, mg/100mL	D 381	7.0, max	86 2	3 3	1.1	2.4	0 7	0 6
Particulate Contamination,mg/L	D 2276	1.0, max	0 9	0.4	0 2	3.3	1 1	0.4
Accelerated Stability, mg/100 mL	D 2274	NR	0.14	0 06	0 09	0 09	0.16	0.11
FSII, vol%		0.10 to 0 15	0.01	0 01	0	0	0	0 14
Fuel Conductivity, pS/m		150 to 600	>1000	50	60	430	140	110
Corrosion Inhibitor, mg/L***		QPL-25017	ND**	17	<1	4	6	5
Visual	D 4176	Clean/Bright	Sed/Bright	Sed/Bright	Sed/Bright	Sed/Bright	Sed/Bright	Sed/Bright
Colonial Pipeline Co. Haze Rating	Proposed	NR	1	1	1	2	1	1
Color	D 156	Report	-1	-1	>-16	>-16	-4	-2

* *NR = No Requirement*

** *ND = Not determined due to the sample forming an emulsion*

*** *Based on HITEC E580*

Table 5. Results of Analyses of Fuel Samples from Fort Stewart, GA, 24th Infantry Division (Mech) Fuel Tankers (Returning from ODS)

Property	ASTM Method	VV-F-800D DF-2 (OCONUS) Requirements	AL-19717	AL-19721
Neutralization No., mg KOH/g	D 974	0.10, max*	0.02	<0.01
Sulfur, mass%	D 4294	0.30, max	0.07	0.75
Hydrogen, mass%	D 3178	NR**	14.15	13.4
Carbon, mass%	D 3178	NR**	84.99	86
Distillation,°C	D 86			
50% Evaporation		Report	196	285
90% Evaporation		357, max	228	348
End Point		370, max	247	371
Residue, vol%		3.0, max	2	3
Gravity,°API	D 1298	NR	47.6	36.7
Density, kg/L	D 1298	0.815 to 0.860	0.7897	0.8408
Cloud Point, °C	D 2500	Local	-54	-1
Pour Point, °C	D 97	Report	-53	-12
Flash Point, °C	D 93	52, min	43	73
K Vis, cSt, at				
40°C	D 445	NR	1.12	2.99
20°C	D 445	1.8 to 9.5	1.48	4.82
Net Heat of Combustion	D 240			
MJ/kg		NR	43.010	42.477
Btu/lb		NR	18,491	18,262
Btu/gal.		NR	121,742	128,026
Cetane Number	D 613	45, min	49	51.4
Cetane Index	D 976	43, min	42.5	54
Particulate				
Contamination,mg/L	D 2276	10.0, max	0.3	1.5
Accelerated Stability,				
mg/100 mL	D 2274	1.5, max	0.1	2
Visual	D 4176	Clean/Bright	Sed/Bright	Sed/Bright
Color	D 1500	NR	0.5	1
Carbon Residue, 10% Btms,				
mass %	D 524	0.20, max	0.06	0.12
Ash, mass %	D 482	0.02, max	<0.01	<0.01
Copper Corrosion,				
3 hours at 50°C	D 130	1, max	1a	1a
Cetane Improver	Appendix B	Report	Negative	Negative
BOCLE, WSD, mm		NR	0.65	0.66

** Specification requirement for OCONUS DF-2.*

*** NR = No Requirement.*

Table 6. Results of Analyses of Fuel Samples from Fort Hood, TX, Vehicle Fuel Cells

Property	ASTM Method	MIL-T-83133C JP-8 Requirements	AL-19726-F	AL-19727-F
TAN, mg KOH/g	D 3242	0 015, max	0.0005	0 011
Aromatics, vol%	D 1319	25 0, max	18 8	19 1
Olefins, vol%	D 1319	5 0, max	2	2
Sulfur, mass%	D 4294	0 30, max	0.06	0 06
Hydrogen, mass%	D 3178	13 4, max	13.91	13 87
Carbon, mass%	D 3178	Report	85.53	85 18
Distillation,°C				
Initial Boiling Point		Report	156	156
10% Evaporation		205, max	172	172
20% Evaporation		Report	178	178
50% Evaporation		Report	194	196
90% Evaporation		Report	234	231
End Point		300, max	276	272
Residue, vol%		1.5, max	1	2
Gravity,°API	D 1298	37 to 51	46.7	47
Density, kg/L	D 1298	0 840 to 0 775	0.7937	0 7924
Cloud Point, °C	D 2500	NR*	<-45	<-45
Flash Point, °C	D 93	38, min	47	47
K Vis, cSt, at				
40°C	D 445	NR	1.21	1.16
70°C	D 445	NR	0 93	0.77
Net Heat of Combustion	D 240			
MJ/kg		42.8, min	42 840	42 887
Btu/lb		18,400, min	18,418	18,438
Btu/gal		NR	121,874	121,80
Cetane Number	D 613	NR	46.4	48
Cetane Index	D 976	Report	45	45.5
Existent Gum, mg/100 mL	D 318	7 0, max	0.2	0.7
Particulate Contamination,mg/L	D 2276	1.0, max	0 8	1.3
Accelerated Stability, mg/100 mL	D 2274	NR	0.13	0.3
FSII, vol%		0.10 to 0.15	0.01	0.14
Fuel Conductivity, pS/m		150 to 600	240	90
Corrosion Inhibitor, mg/L***		QPL-25017	ND**	5
Visual	D 4176	Clean/Bright	Sed/Bright	Sed/Bright
Colonial Pipeline Co., Haze Rating	Proposed	NR	1	1
Color	D 156	Report	-13	-13
BOCLE, WSD, mm		Report	0.54	0.58

* *NR = No Requirement.*

** *ND = Not Determined.*

*** *Based on HITEC E580.*

Table 7. JET A-1 Fuel Sampled In-Country

SAMPLE*	A	B	C	D	E	F	G	H
Test Results								
Gravity, °API	47.0	47.0	47.5	47.5	47 0	47.0	47.0	47.3
Distillation: °C								
IBP	162	158	151	151	156	156	156	159
10% Evaporation	178	179	172	171	172	172	180	175
50% Evaporation	203	202	194	193	216	216	203	199
90% Evaporation	230	230	229	227	250	250	231	228
End Point	256	252	249	254	289	282	254	250
% REC	99	98 5	98.5	99.0	99.5	99.0	98.5	99.0
% Loss	0.5	0 0	0.5	0.0	0.0	0.0	0.5	0 0
% Residue	0.5	1.5	1.0	1.0	0.5	1.0	1.0	1.0
Flash Point, °C	48.4	49.4	49.4	47.0	48.4	46.6	49.4	48.3
Water Reaction:								
VOL Change	-2.0	-2.0	0.0	0.0	-1.0	-1.0	-2 0	-
FSII	0.0	0.0	0.0	0.0	0 0	0.0	0.0	-
Viscosity @ 40°C	1.2	1.3	1 2	1.5	1 2	1.3	1 5	1.2
Particulates: mg/L	1 8	0.5	**71.3**	1.0	0.3	0 5	0.3	0.7

** Sample Sources from Vehicle Fuel Tanks—*

A - CWC 533rd Trans
B - CWC 533rd Trans
C - 533rd Trans, WO 341
D - 7th GRP 24th, WO AW 305
E - 426th Trans 101st
F - A Co 101st
G - CWC 503rd MT Co
H - S&T 3rd ACR

Table 8 lists the average values of properties of the Jet A-1 samples analyzed. Similar data are also presented for the one DF-2 sample analyzed.

Table 8. Average Fuel Analysis Results for Selected Properties

Property	Jet A-1	MIL-T-83133C Limits	DF-2	VV-F-800D Limits
Number of Samples	10	—	1	—
Sulfur, mass%	0.05	0.30, max	0.75	0.30, max
Distillation, °C				
50% Evaporation	196	Report	285	Report
90% Evaporation	231	Report	348	357, max
End Point	260	300, max	371	370, max
Density, kg/L	0.7912	0.775 to 0.840	0.8408	0.815 to 0.860
Cloud Point,°C	-51	NR*	-1	Local
Flash Point,°C	46	38, min	73	52, min
Kinematic Viscosity,				
cSt, at 40°C	1.16	NR	2.99	NR
Net Heat of Combustion,				
MJ/kg	42.915	42.8, min	42.477	NR
Cetane Number	47.6	NR	51.4	45, min

** NR = Not Required*

In summary, the Jet A-1 fuel used by the U.S. ground forces in ODS, as represented by the samples analyzed herein, generally met all MIL-T-83133C (JP-8) specifications with the exception of the three additives required in JP-8. Some of the Jet A-1 samples showed varying levels of contamination by DF-M. It is not known if the DF-M was residue in the fuel cells from CONUS operations or from DF-M obtained and used during ODS. The one sample of diesel fuel analyzed was of VV-F-800D specification quality with the exception of sulfur and accelerated stability results. One sample of Jet A-1 fuel taken from a vehicle was found to be grossly contaminated with sand/dirt.

Performance

Power Loss

Maintenance and user personnel were evenly split as to whether there was a power loss, resulting in less vehicle performance when using Jet A-1 in lieu of DF-M. Criteria used to determine power loss was decreased speed in some vehicles and longer project completion times for military construction equipment such as Caterpillar tractors, backhoes, and road graders. Power was reportedly restored in some vehicles when filters and fuel systems were cleaned and in other vehicles when engines and transmissions were changed. Some reported power losses continued throughout the campaign. No objective data were submitted to support the claimed power losses.

Fuel Consumption

Comments about fuel consumption in ground diesel-burning equipment were reported as follows:

- No differences in fuel consumption were noted by most using units since fuel was plentiful and vehicles were "topped off" as needed.

- A small percentage increase in Jet A-1 fuel consumption was reported for some vehicles.

- In at least one instance, a 50-percent fuel consumption increase was determined by comparing fuel consumption in gallons, computed by a G-3 planning section, and the actual number of gallons reportedly required to make the move. However, the 50-percent increase was an isolated one and uncorroborated by any other source. (Note: Increases of this magnitude appear to be suspect, based upon all data compiled to date on use of JP-8, JP-5, and Jet A-1 fuels.)

- Some fuel consumption increases were attributed to heavy combat ammunition and equipment loads, off-road terrain conditions (i.e., heavy sand, over-traveled roads and steep hills). Use of Nuclear, Biological, and Chemical (NBC) equipment in M1A1 tanks also contributed to high fuel consumption.

Fuel-Wetted Components

By far the major problem encountered when using Jet A-1 fuel in Southwest Asia centered around the rotary fuel injection pump used on the GMC 6.2L engines of the Commercial Utility Cargo Vehicle (CUCV) and High Mobility Multipurpose Wheeled Vehicle (HMMWV). A lack of lubricity in the Jet A-1 fuel was blamed for this phenomena. This belief resulted in at least three practices by most using personnel:

- Mixing engine oil or transmission fluid with the Jet A-1 fuel in varying quantities.

- Breaking the glass bead in the fuel return line of the Stanadyne injection pump.

- Replacing the military fuel filter in CUCVs with a commercial "screw-in" type filter, which bypassed the fuel/water sensor system.

However, some fleets of HMMWVs were operated thousands of miles without experiencing any fuel pump problems. No actions were required other than draining

water from the fuel filter system two to three times daily. It was documented and known that the Stanadyne fuel injection pumps manufactured through 1985 were subject to a nonfuel-related malfunction (i.e., flex-ring failure) while those produced after 1985 were less likely to experience problems. More likely reasons for the fuel injection pump failures were the flex-ring retainers (i.e., those pumps containing the pre-1985 part), close production toler ces that exacerbated the dirt/sand contamination that occurred in Southwest Asia, inter nal breakage of the glass bead in the return line, and addition of the nonauthorized oils/fluids thought to improve Jet A-1 lubricity.

Other fuel-wetted components reportedly affected when using Jet A-1 were fuel transfer pumps on the M915 engines (Cummins), which failed due to the fuel and high ambient temperatures. (Note: These failures were a function of inadequate lubricity.) This problem can be solved by redesigning the transfer pump.

All personnel were unanimous that the use of Jet A-1 in personnel heaters was very satisfactory.

Fuel injector nozzle fouling responses varied from "none" to a very large number. One unit stated that cleaning fuel injector nozzles was "a daily chore" when using Saudi Arabian DF-M. Only about 4 percent of personnel interviewed stated that they had an increase in fuel injector nozzle fouling using DF-M, while about 29 percent reported an increase when using Jet A-1. One fuel injector nozzle was given to the survey team at Fort Bliss, TX, with a clogged tip. The material scraped off the end of the nozzle appeared to be soot, which could be expected when the Jet A-1 fuel has been mixed with engine oil or transmission fluid.

Fuel-Wetted Component Analysis

As previously stated, increased failure rates associated with diesel fuel injection systems were reported during Operation Desert Shield/Storm. As a result, a number of BFLRF reports have been issued detailing the results of post-failure examinations of both Stanadyne and Bosch Model M50 pumps.[7, 8, 9] The pumps evaluated at BFLRF were removed from a range of equipment, including HMMWVs, CUCVs, and generator sets.

Many of the pumps were seized and could not be operated, while others were out of specification when tested on a pump calibration stand. The primary causes of failures were moisture and particulate contamination. Clearances on the order of 100 millionths of an inch are present in several areas of the pump. These close tolerances are required to prevent internal pump leakage in high-pressure sections and also to maintain hydrodynamic bearing films. Clearly, oxide rust particles or hard debris will promote severe wear in these critical areas.

A number of other common causes of pump failure have also been identified. Quality problems during production/rebuild promoted some of failures, for example, disintegrated elastomeric flex rings on Stanadyne pumps and out-of-specification/ incorrect components. Rapid changes in ambient temperature will promote instantaneous pump seizure, i.e., during cleaning or artificial cooling to assist in hot engine restarts. Seizure will occur no matter what type of fuel is used.

None of the field failures examined at BFLRF was directly attributed to the use of low-viscosity/lubricity fuels such as Jet A-1. However, each of the pumps examined had a unique operating history and may have operated on a number of fuel types. As a result, no quantitative wear measurements could be performed to define the affects of Jet A-1 on the fuel injection system. However, qualitative comparison of the failed pumps with similar nonmilitary units that operated on diesel fuel and have a known history indicates that more severe wear may generally be present with Jet A-1. Similarly, pumps that contain an improve metallurgy designed for use with low-viscosity fuels in arctic conditions normally displayed less wear than their standard counterparts.

Safety

Reportedly, a few military personnel were apprehensive at first that the lower flash point of Jet A-1 fuel would present a hazard. The apprehension was quickly dispelled in spite of several reported vehicle fires. The fires were later determined to have been caused by other means and were not attributable to fuel. A limited series of tests were conducted at BFLRF and the results reported in Letter Report No. BFLRF-90-003 (Revised), entitled "Comparative Flammability Testing of Jet A-1, JP-5 and DF-2," dated April 1991. To more fully determine the effects of live ammunition impacts when Jet A-1 fuel was heated to 170° to 180°F (72° to 82°C), BFLRF recommended that live fire/full-scale tests be conducted to verify vehicle fire suppression system effectiveness.

Fuel Lubricity Requirements

Many fuels provide a limited range of contact conditions in which successful lubrication is possible. Fuel systems are designed to reflect these needs; however, seemingly minor changes in fuel composition or equipment design may significantly alter component durability. During the mid 1960s, improvements in the refining and treatment processes removed many of the compounds required for effective lubrication in aviation kerosene. Since that time, considerable effort has been expended in the study of wear mechanisms present with low lubricity fuels in aviation, using the Ball-on-Cylinder Lubricity Evaluator (BOCLE).[10] A standard procedure to measure fuel-related wear using the BOCLE has been produced;[11] nonetheless, there currently exists no minimum lubricity requirement for aviation fuels.

At present, the lubricity requirements of the diesel injection system on compression-ignition equipment are largely undefined. JP-8 has successfully undergone extensive testing in both the laboratory and in field trials.[12-18] Direct comparison is not possible between pump failures during ODS with Jet A-1 and the previous studies performed using JP-8. Jet A-1 contains no lubricity additives and consists solely of kerosene fractions, while use of a corrosion inhibitor as a lubricity enhancer is now mandatory in JP-8. This inhibitor is commonly a dimeric organic acid, usually dilinoleaic acid (DLA), which curtails the high material removal rates associated with oxidative wear. A systematic evaluation of pump performance and fuel lubricity was required under carefully controlled laboratory conditions.

With this in mind, endurance tests were performed using a motorized pump stand to define the effect of fuel lubricity on pump durability. The test series included both standard and arctic pumps that contain an improved metallurgy to allow effective comparison. Initial tests and calculations indicated that pump seizure was not primarily due to the decreased viscosity of the aviation fuels. As a result, the test series was designed to highlight the effects of pump degradation due to corrosive/oxidative wear and failure of the boundary film in low-lubricity fuels. To eliminate the effects of hydrodynamic/elastohydrodynamic lift, the tests were performed with fuels of varying lubricity but similar viscosity. Clay-treated Jet A-1 was used as the base fuel, and selected additives were included to provide the level of lubricity required. Baseline tests were also performed with diesel fuel for comparison. Overall, degradation in performance was defined by operating each pump on an engine test and a pump calibration stand both before and after each test. In addition, each pump was completely disassembled, and qualitative and quantitative wear measurements were performed. Finally, the results obtained from these measurements were correlated with both standard and nonstandard bench wear tests.

Use of poor lubricity fuel under these controlled conditions was found to greatly reduce both pump durability and engine performance.[19, 20] However, both improved metallurgy and fuel lubricity additives significantly reduced wear. Good correlation was obtained between the standard BOCLE bench wear test and lightly loaded pump components. However, high contact loads on isolated components produced a more severe wear mechanism that is not well reflected by the BOCLE. The use of a more sophisticated wear-mapping technique indicates that this variation may be due to the onset of adhesive wear and scuffing. In general, however, the BOCLE wear test was at least qualitatively correct. The results of the BOCLE are not absolute, but provide a directional indication of fuel lubricity, which is likely to be the optimum available from a single bench wear test. The results of this study indicate that a BOCLE scar diameter of approximately 0.6 to 0.65 mm appears to provide acceptable wear protection. This value may never be absolutely precise, but is similar to that currently used in aviation.

General

Military units from Fort Bliss experienced fewer difficulties with Jet A-1 fuel than did all other units that used Jet A-1 for the first time in Southwest Asia. Those units in the 1st Cavalry Division from Fort Hood that had time to switch to JP-5 before deploying to Southwest Asia had fewer problems also. All units that were on DF-2 when arriving in Southwest Asia and then switched to Jet A-1 experienced filter clogging due to solid contaminants and residue that had formed either during CONUS operations or in transit to Southwest Asia. The stability of the diesel fuel being flushed from fuel cells was questionable.

Troop awareness of the type and grade of fuels they used in Southwest Asia was in direct proportion to their expertise and access to information about the fuels. Personnel at the bulk storage and handling level were completely aware of the type, grade, and quality of the fuel they received. Personnel at intermediate levels were not as cognizant of the identity and quality of fuels used, and user/operator personnel almost never knew the type and grade of fuel used unless someone told them. The discrepancies as to the identity of some fuels, such as JP-8, JP-5, JP-4, or DF-M were due to mislabeling of fuel tankers, tank and pump units (TPUs), and tank trailers that were deployed from CONUS or Europe. There were undoubtedly many times when Jet A-1 fuel and DF-M were mixed intentionally, i.e., some users reported "topping off" with DF-M when there was insufficient Jet A-1 at the refuel point to completely fill their tanker truck or trailer.

Information about such items as Jet A-1 being a suitable substitute for DF-M and procedures for the changeover to Jet A-1, including admixing of fuels, proper fuel cell labeling, and safety, typically did not reach all the way down to V/E operators.

In all cases, there were reported increases in fuel filter replacements. There was filter plugging when the change to Jet A-1 took effect; about 70 percent of the personnel interviewed said the instances of filter plugging were excessive. However, those units with new vehicles saw little change in usage of fuel filters.

Except for the 24th Infantry Division (Mech), which reverted to DF-M fuel by choice after its initial 2 to 4 weeks use of Jet A-1, no other unit reported adding biocides/biostats to their fuel to alleviate or prevent microbiological growth.

No known blending of any fuel with additives CI, FSII, or SDA occurred in Southwest Asia for ground V/E. The host nation did not have the downstream injection systems nor did the Army or Marine Corps organizations and units have the injection systems or additives to use. No information concerning formulas for individual user/operators in individual fuel cells was ever reported by any of the personnel interviewed. Further, at

least two POL experts, one U.S. Marine and one U.S. Army, strongly recommend that no CI, FSII, or SDA be injected into the fuel below refinery level. These recommendations were made because of the belief that the organizational maintenance/user personnel performing the injections in wartime fluid situations could result in the fuel being under or over treated.

Dirt and sand were always a problem, but the situation was normal to the military personnel in Southwest Asia who had been members of organizations that participated in exercises at the National Training Center (NTC) at Fort Irwin, CA, and at the U.S. Marines Air-Ground Combat Center (AGCC) at Twenty-Nine Palms, CA. Neither dirt/sand contamination nor high ambient temperatures were a problem for them in relation to the use of fuel. These personnel refueled during lulls of blowing sand/dirt, wiped away sand/dirt from fuel cell filter necks, reduced the number of times fuel cell caps were removed, and covered the filler necks to the fuel cells.

No problems were experienced by user/operator or maintenance personnel when the different fuels were admixed in V/E fuel cells.

Replies to the question of whether V/E maintenance increased with DF-M or Jet A-1 fuel varied. About 3 percent of the personnel interviewed stated that V/E maintenance increased when DF-M was used, and about 29 percent stated that V/E maintenance increased when Jet A-1 was used.

There were instances during ODS when aircraft and ground V/E were refueled from the same fuel tankers (Heavy Expanded Mobility Tactical Trucks (HEMTTs)) in forward areas. When this refueling was done, permission to refuel the aircraft was received by the pilot; usually, only sufficient fuel to return the aircraft safely to its home base was loaded. There was one reported instance when a ground vehicle was refueled from a dedicated aircraft fuel tanker.

Personnel in one unit reported that they visually inspected the fuel delivered to them. If the fuel was clear (like water), it was considered to have no lubricity and oil or transmission fluid was added to the fuel.

LUBRICANTS

Availability

Despite some shortages of a specific type and grade of engine oil, sufficient quantities of engine oil were available to military units to allow them to perform their missions. Those units authorized to do so took their unit basic load (UBL) of engine/transmission oils and related products with them from their previous base. Bulk package product supply points were able to obtain commercial oils through a host nation agreement. Because individual units were discouraged from obtaining locally purchased items due to quality concerns, most oils obtained by the individual units were issued through the proper supply channels. OE/HDO-15/40 grade oil (MIL-L-2104) appeared to have been in short supply longer than any of the engine oils used in Southwest Asia. Generally, there was a shortage of all lubricants, greases, and related products at the beginning of ODS. Units arriving in Southwest Asia relied on their UBL during the first few weeks. In many cases, these initial supplies did not last long. As a result, immediate shortages occurred since bulk package Class III supply points were not yet fully stocked. In addition, many reserve and National Guard units were deployed with no basic loads at all since they were not authorized to stock them. In some cases, these units were told they could receive their basic loads in-country. When back ordered requisitions were finally filled, adequate supplies were on hand even if the distribution system itself occasionally caused temporary shortages.

Quality

No problems were reported with any oils, military or commercial, that would indicate the oils were inadequate for their intended purpose. A few of the ground units interviewed stated that they did draw used oil samples and turned them in to their next higher echelon for forwarding to an Army Oil Analysis Program (AOAP) lab. However, none of the units interviewed, that had forwarded samples, received any results. Most of the units interviewed would have welcomed an AOAP capability in Southwest Asia. According to information in an AOAP briefing, two mobile AOAP laboratories were deployed to Southwest Asia, one in October 1990 and the second in February 1991. These AOAP laboratories were severely hindered by lack of qualified military personnel and had to utilize DA civilians and contractor personnel to maintain operations, highlighting the fact that requirements for staffing the AOAP laboratories with military personnel need to be reviewed.

Performance

Practically speaking, ODS was too brief to establish lubricant performance criteria. No engine, transmission, or final-drive oil problems were reported by using units. Even though it was reported that some MIL-L-46152 qualified oils (administrative engine oil) were used in combat/tactical engines and transmissions, no harmful results were noted.

Analysis

Samples of new oils and used oil samples from randomly selected vehicles brought back from Southwest Asia were obtained during visits to Forts Bliss and Hood. The oils were analyzed by Belvoir Fuels and Lubricants Research Facility (BFLRF).

Two new oil samples were obtained. One engine oil sample was obtained from the Third Armored Cavalry Regiment (ACR) at Fort Bliss, TX (AL-19732-L). The other sample was a commercial 1-liter metal can of Dexron-II® (Shell), which was obtained commercially in Saudi Arabia by the 13th Signal Battalion at Fort Hood, TX (AL-19729-L). The physical/chemical properties of these two oils are presented in Table 9, and their respective Fourier Transform Infrared (FTIR) traces are shown in Figures 1 and 2. The engine oil met the requirements for SAE 40 viscosity grade and, judging by the VI of this oil, it might meet the requirements of SAE 15W-40. The low-temperature viscosity tests needed to define the oil were not run because of equipment problems. Oil AL-19732-L had a Total Base Number (TBN) (D 664) of only 5.5 and a sulfated ash of 0.74 percent and contained a calcium/magnesium-based detergent-dispersant package. Based on its properties, this oil should be satisfactory for short-term use in combat/tactical equipment. The Dexron-II® sample contained calcium, phosphorus, and boron additive elements, with a sulfated ash of 0.22 percent.

Table 9. New Oil Properties

Oil Description	**Engine Oil**	**Dexron-II®**
Oil ID	**(AL-19732-L)**	**(AL-19729-L)**
Analyses		
K. Vis. cSt, at		
40°C	104.15	35.62
100°C	13.9	7.04
VI	134	164
TAN	3.5	1.3
TBN, D664	5.5	2.6
Sulfated Ash, wt %	0.74	0.22
S, XRF, wt%	0.52	0.84
N, CLM, wt%	0.035	0.053
Elements, ICP, ppm		
Ca	1,315	831
Mg	87	3
P	1,037	157
Zn	1,105	3
Ag	3	<1
Al	1	<1
B	5	168
Ba	<1	<1
Cr	1	<1
Cu	<1	3
Fe	5	2
Na	7	8
Ni	1	1
Pb	<1	1
Si	3	3
Sn	<1	<1

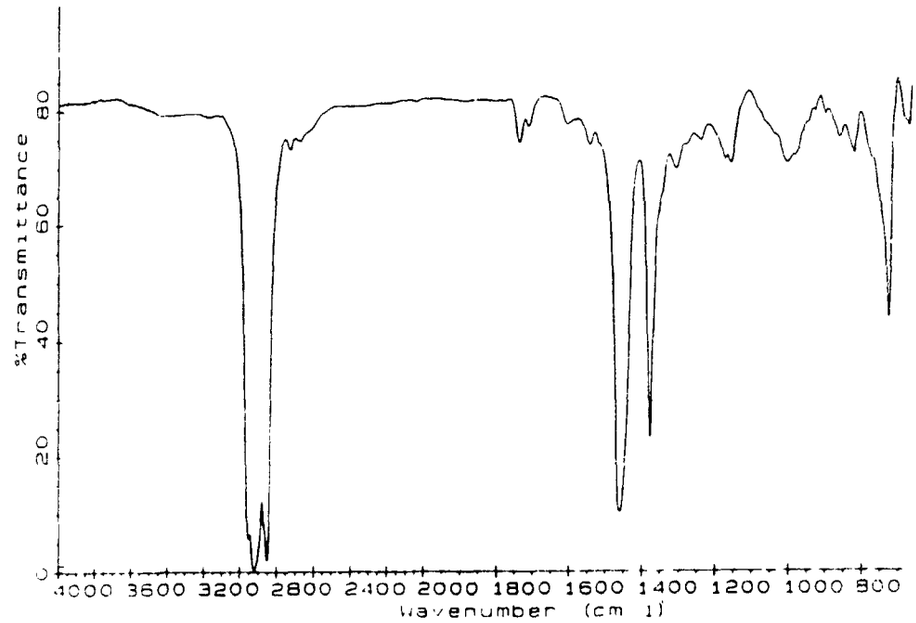

Figure 1. FTIR Trace for Engine Oil (AL-19732-L)

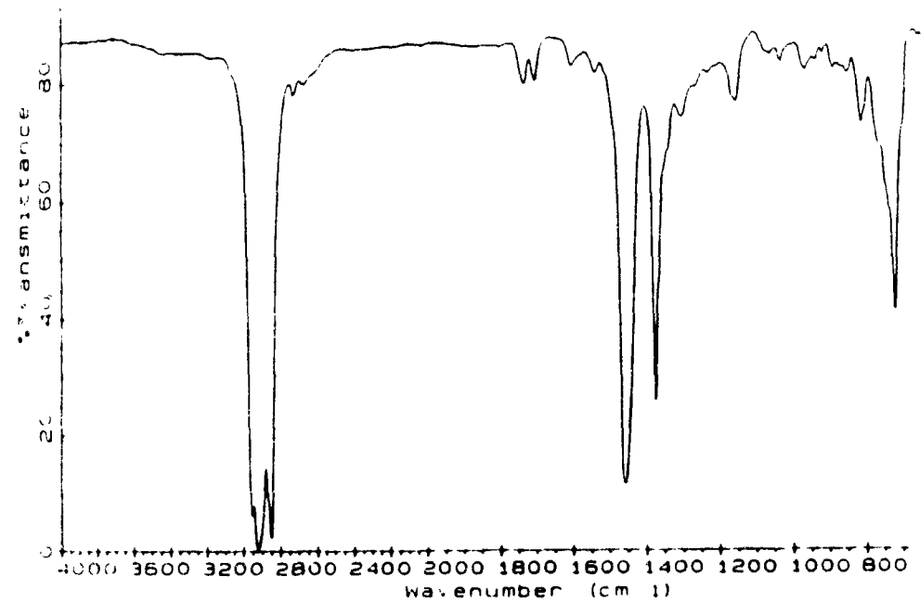

Figure 2. FTIR Trace for Dexron II® (AL-19729-L)

The used oils were obtained from randomly selected equipment of the Third Armored Cavalry Regiment at Fort Bliss, TX. Samples were taken from both the engine sump and transmission after the vehicles had been fully warmed up. Table 10 lists the used oil samples and their sources. One used oil sample was from a 5kW generator set at Fort Hood, TX, which was sampled without engine warmup. Analyses of the used sump oils are presented in Table 11, and the FTIR traces for these oils are in Appendix E. No water or coolant contamination was observed by FTIR. The used sump oil analyses were compared with AOAP wear metal/contamination limits published in Army TM 38-301-4 JOAP Manual, Vol. IV, Laboratory Analytical Methodology and Equipment Criteria (Nonaeronautical), June 15, 1989. All elements were in the normal range except for those listed below:

AL-No.	Equipment	Element	Comment
19753	M3A2	Cu, 34 ppm	High
19754	M3A2	Sn, 4 ppm	Marginal
19759	M109A2	Cu, 61 ppm	Marginal
19759	M109A2	Pb, 42 ppm	High
19764	M54A2	Fe, 256 ppm	Marginal

Table 10. Used Oil Samples from 3rd ACR, Fort Bliss, TX

Equipment	Component	Designation	No. Sampled
M1A2	Engine	AGT-1500	4
M3A2	Engine	VTA-903T	2
M977	Engine	8V-92TA	4
M109A2 (Howitzer)	Engine	8V-71T	1
M998	Engine	6.2L	1
M54A2	Engine	LDS-465	1
M1A2	Transmission	X1100-3B	4
M3A2	Transmission	HMPT-500	2
M977	Transmission	HT740D	1
M109A2 (Howitzer)	Transmission	G-411-2A	1
5-kW Generator*	Engine	Not Specified	1

** Sample from Fort Hood, TX.*

Table 11. Used Oils–Engines

Equipment Type	M1A2				M3A2		M977				M109A2	M998	M54A2	5 kW
Engine Oil ID	AGT-1500				VTA-903T		DDC 8V-92TA				8V-71T	6 2L	LDS-465	Generator
ID Analyses	AL-19755	AL-19756	AL-19757	AL-19750	AL-19753	AL-19754	AL-19760	AL-19761	AL-19763	AL-19765	AL-19759	AL-19762	AL-19764	AL-19728
k Vis, cSt, at														
40°C	25 29	25 3	25 06	25 7	82 41	82 94	77 63	110 01	43 25	95 25	86 53	106 79	84 69	127 77
100°C	4 95	5 00	5 01	5 01	11 62	11 68	11 48	12 45	7 21	11 25	10 59	12 27	11 21	15 23
VI	122	126	136	123	133	132	140	104	129	104	105	106	120	123
TAN	0 2	0 2	0 2	0.5	4 4	3 5	4 3	4 3	2 9	2 7	2	4 3	5 3	2 8
TBN, D664	0	0	0	0	2 3	3 6	2 8	4 4	2 1	2 7	5	2 8	1 8	3 8
Soot, TGA, wt%	0 27	0 07	0 17	ND*	0 25	0 19	0 07	0 92	0 36	0 66	0 25	0 55	0 13	0 23
Sulfur, XRF, wt%	0 02	0 02	0 01	ND	0 53	0 84	0 81	1 11	0 9	0 7	0 99	0 77	0 94	1 39
Elements, ICP, ppm														
Ca	2	<1	4	7	334	1,239	1,336	3,300	809	1,753	1,791	845	1,471	1,753
Mg	<1	<1	1	1	1,260	590	990	395	1,222	578	801	1,452	715	578
P	2,044	2,073	2,089	1,965	1,114	1,162	1,054	802	837	1,005	1,063	1,086	900	1,005
Zn	<1	<1	<1	<1	1,238	1,239	1,134	921	953	1,199	1,168	1,267	1,022	1,199
Ag	<1	<1	<1	<1	1	2	<1	<1	<1	<1	<1	<1	<1	<1
Al	<1	<1	<1	1	2	2	4	3	4	12	4	7	27	12
B	<1	10	6	12	60	20	33	20	35	24	63	46	35	24
Ba	<1	<1	<1	<1	23	7	2	1	2	2	3	8	1	2
Cr	<1	<1	<1	<1	8	5	4	4	4	6	3	5	20	6
Cu	<1	<1	<1	<1	34	13	55	7	6	22	61	5	17	22
Fe	1	3	4	4	42	45	95	92	51	85	76	81	236	85
Na	2	14	12	25	11	5	29	13	11	27	26	11	16	27
Ni	<1	<1	<1	<1	1	1	2	2	2	2	1	4	4	2
Pb	<1	1	<1	<1	10	6	11	6	10	10	42	25	17	10
Si	<1	2	1	2	9	11	27	13	13	56	29	13	31	56
Sn	1	2	<1	3	2	4	17	12	6	31	16	13	13	31

** ND = Not Determined.*

The M998 and 5 kW generator set did not have AOAP limits for comparison; however, both used oils appeared to have "normal" wear/contamination elements, except for the Si content (56 ppm) of the generator set, which is a little high. The used turbine engine oils from the M1A2 vehicles were in excellent condition and had no increase in Total Acid Number (TAN). Sample AL-19763 from an M 77 (8V-92TA engine) was unusual in that it was only an SAE 20 viscosity grade. This sample had a relatively high VI of 129, which indicates this could be a sheared down commercial multigrade lubricant such as a 20W-50. The remainder of the used sump oils were in good condition with some limited reserve alkalinity remaining and low soot contents. Used oil AL-19764 from the LDS-465 engine appeared to be nearing a change point because of its TAN. Based on the used oil elements, no indication of excessive sand contamination was found.
Analyses of the used transmission oils are presented in Table 12, and the FTIR traces for these oils are in Appendix F. No water contamination was observed by FTIR. The used transmission oil analyses were compared with the above-cited AOAP criteria. All elements were in the normal range except for those listed below:

AL-No.	Equipment	Element	Comment
19747	M1A2	Ag, 11 ppm	High
19745	M3A2	Pb, 61 ppm	Marginal
19751	M109A2	Cu, 226 ppm	Marginal

Except for the above-listed oils, the remainder of the used transmission oils were in acceptable condition.

Containers

With one unverified exception, all commercial lubricant containers were marked in English and Arabic lettering. This English marking allowed military users to determine the type and grade of the products in the containers and to determine the proper use for the products. Some lubricants were received in 55-gallon drums, which were impractical for small unit use. The awkwardness of drawing a small quantity from the large container and the difficulty in handling the drums during loading and unloading procedures were distinct disadvantages for the using units. After a container was opened, it became susceptible to dirt/sand and other contamination, resulting in a large amount of waste. Some units were reported to abandon their Class III supplies in place when they moved, expecting to be resupplied at their new location.

Table 12. Used Oils—Transmissions

Equipment Type	M1A2				M3A2		M977	M109A2
Transmission Type	X1100-3B				HMPT-500		HT740D	G-411-2A
Oil ID Analyses	AL-19747	AL-19748	AL-19749	AL-19758	AL-19745	AL-19746	AL-19752	AL-19751
K Vis, cSt, at								
40°C	101 03	84 82	85 96	101 03	57 5	70 27	35 62	42 64
100°C	11 38	11 37	11 62	11 54	9 63	9 93	6 21	6 68
VI	99	123	125	101	152	123	123	110
TAN	3 1	3 4	3 2	2 6	3.2	3.5	3 1	3 2
TBN D 664	4 8	4 7	4 4	4 8	2 2	4 9	2 1	3 8
Elements, ICP ppm								
Ca	1,442	1,595	1,549	1,485	434	1,328	1,380	1 507
Mg	444	538	449	484	1,161	569	492	567
P	1,142	1,288	1,133	1,248	1,137	1,176	1,198	1,094
Zn	1,597	1,816	1,592	1,710	1,226	1,276	1,336	1 341
Ag	11	5	3	3	2	1	1	13
Al	10	11	9	9	10	7	8	5
B	6	4	4	7	46	<1	57	37
Ba	4	4	3	3	23	7	1	8
Cr	1	<1	1	1	1	<1	<1	1
Cu	225	257	184	210	267	84	22	226
Fe	74	60	62	65	56	36	21	129
Na	19	22	16	20	15	9	22	13
Ni	1	2	<1	2	1	1	1	1
Pb	224	142	79	106	61	14	6	74
Si	7	6	7	7	11	14	5	39
Sn	4	5	6	5	1	<1	1	4

Oil Changes

Almost all units reported decreasing the lubrication order intervals for oil changes by about one-half (approximately doubling the number of oil changes). Since AOAP capabilities were nonexistent as far as ground vehicle and equipment operators were concerned, commanders had to establish arbitrary intervals based on maintenance/user personnel oil condition assessments, environmental impact (sand/dirt contamination), time available, and availability of oil and filters. A few units reported that they used regular intervals and, in one instance, extended the interval between oil changes because of a filter shortage. Oil filters were changed when oil was changed. Saving drained oil when repairing an engine was virtually impossible because of contamination. Sand/dirt contamination and high ambient temperatures were not reported to be as much of a problem to operational vehicles.

Unauthorized products were seen and photographed by the earlier Department of the Army three-man investigative team in addition to those reportedly used by Fort Hood units. The Fort Hood units reported that the unauthorized products separated in the can.

HYDRAULIC AND BRAKE FLUIDS

Two units stated that hydraulic fluids were in short supply. One of these units stated that a shortage of "specification" hydraulic fluids was their biggest maintenance problem. Three units from Fort Hood, TX, reported using Dexron II® (a transmission fluid) in the hydraulic systems of their M113 personnel carrier ramps (tail gates). SAE-10 grade oil (MIL-L-2104) was also reportedly used as a hydraulic fluid. These field expedients appeared to have enabled the units to perform their mission. However, most units reported taking enough hydraulic fluid with them to Southwest Asia, while others were able to obtain commercial hydraulic fluids that worked quite well. It should be noted that these commercia fluids did not have the fire resistant properties of MIL-H-46170 Fire Resistant Hydraulic Fluid (FRH). About 60 percent of the units interviewed changed hydraulic fluids in accordance with the normal lube order service schedules. At least one unit said it never had to change hydraulic fluids. When seals remained in good condition, dirt and sand contamination did not present a problem. Sand/dirt contamination was reported as a problem in gun control systems, brake systems, power steering pumps, hydraulic quick connect/disconnect lines, and M113 hydraulic pumps. None of these problems made any systems inoperable, but they did exist. Worn "protective" boots appeared to be the cause of most sand/dirt contamination.

Brake fluids and brake systems did not appear to be significant problems on military V/E. One report stated that sand contamination reduced the effectiveness of HEMTT brake systems. One unit stated that fewer Hydrovac replacements were made in Southwest Asia than in the United States. High ambient temperatures were not a problem with hydraulic or brake systems.

GREASES AND SOLVENTS

More than 65 percent of units interviewed stated that greases were not in short supply except, in some cases, at the beginning of ODS. When asked if they used MIL-G-10924F or MIL-G-0010924E versions of GAA, maintenance/user personnel stated they did not know, they only knew that they had GAA grease. MIL-G-10924F and MIL-G-0010924E are polyalphaolefin (PAO) base lithium complex grease with a minimum dropping point of 220°C. The obsolete MIL-G-10924D is a petroleum base calcium grease with a minimum dropping point of 138°C. The "F" and "E" version greases also provide better corrosion protection than the obsolete "D" version grease. Greases were usually in 5-gallons cans, which several maintenance personnel said were too large. They said that they recommended that the grease be issued in plastic containers, which could be used to refill grease guns. Some commercial greases were purchased locally or otherwise provided through the host nation agreement for Class III products. While the users and maintenance personnel said that almost all greases used were good, little could be learned about the identities or composition of the commercial greases.

Intervals between lubrication services ranged from none to regularly scheduled lube order intervals to "whenever we could." Sand/dirt was always a problem, although it was routinely dealt with by maintenance/user personnel. As usually stated, most sand/dirt contamination occurred when protective "boots" became torn or frayed enough to allow sand/dirt entry. High ambient temperatures did have an effect on some vehicle components such as wheel and road bearings, ball joints, and tie-rod endings by causing the grease to separate and run. Some stored greases in unopened cans separated due to high ambient temperatures. One unit said the separation of grease was especially prevalent in products that were unauthorized for use. WTR (MIL-G-83122, grease aircraft, general purpose wide temperature range) grease, in most cases, was used interchangeably with GAA grease. The U.S. Marines, in particular, preferred WTR grease and stated they planned to convert to full time use of WTR. However, WTR grease was reported to be in short supply or unavailable.

Solvents were used to clean components and adjacent areas of grease, sand/dirt, and other contaminants. Some of the solvents used included Jet A-1, DF-2, dry cleaning solvent, MOGAS, and "whatever they had available."

COOLANTS/ANTIFREEZES

Introduction

Several commercial coolant/antifreeze products were used as substitutes because of shortages of the military antifreeze (MIL-A-46153). No antifreeze extender additive (i.e., MIL-A-53009) was used. Potable water, bottled water, and local water were used as make-up for the coolant/antifreeze mix. Some distilled water was used, but not very much. No significant coolant/antifreeze problems were reported by maintenance/user personnel. Except for one unit that reported successfully saving drained antifreeze, reuse was prohibited because of sand/dirt contamination.

There was a significant problem reported with a "preservative" mixture reportedly added to protect the coolant systems while vehicles and equipment were on PMS ships. A contaminant described as "black and slimy" subsequently formed. The coolant had to be drained, and the coolant system flushed to restore coolant system efficiency. (Note: No antifreeze preservative as such is available within the military supply system.) The presence of a black slime accompanied with a foul smell as reported would indicate that U.S. Marine Corps units may have inadvertently used some improperly packaged MIL-A-46153 antifreeze that had been introduced to the field several years ago but subsequently recalled. The MIL-A-46153 antifreeze, manufactured by Octagon Process Co., was improperly packaged in metal 5-gallon cans and 55 gallon drums without plastic inserts. When the concentrated antifreeze comes in contact with metal, one of the

corrosion inhibitors breaks down, and a foul smell and black slime-like deposit are generated. Subsequent use of this antifreeze generates considerable maintenance problems.

High ambient temperature did not appear to affect vehicle operations or to cause the engines to run hotter. Some units reported using the Standard Test Strips (A-A-51461) to determine if coolant/antifreeze mixtures were satisfactory to use. Most units reported using a hydrometer to determine coolant/antifreeze conditions. All changes were stated to have been brought about because of engine changes or engine repairs. No change was attributed to dirt/sand or other contamination.

Analysis

Five coolant samples taken from vehicles returning from ODS and one unused sample of a Saudi Arabian engine coolant labeled Petromin 500 were analyzed by BRDEC.

Analysis of five coolant samples taken from vehicles used in ODS

Five coolant samples were taken from four randomly selected vehicles which had no previous record of field problems associated with the engine cooling system or other systems. The vehicles were chosen from the fleet of the 1st and 2d Squadrons, 3d Armored Cavalry Regiment, located at Fort Bliss, TX. These vehicles were returning from ODS and still contained the coolant used during ODS.

The coolant samples were subjected to standard ASTM tests along with atomic absorption (AA) and atomic emission (AE) metal analysis and visual inspection. The ASTM tests included: Use of the Refractometer for Determining the Freezing Point of Aqueous Engine Coolants (D-3321); pH of Engine Antifreeze, Antirusts, and Coolants (D-1287); Reserve Alkalinity (RA) of Engine Antifreeze, Antirusts, and Coolants (D-1121); and Water and Sediment in Distillate Fuels by Centrifuge (D-2709). The results are listed in the following tables.

Table 13. Appearance of Coolant Samples Taken from Vehicles (Returning from ODS)

AL-19740-X	Sample taken from an M3A2 Bradley Fighting Vehicle. Vehicle accumulated 2,000 kilometers during use in Saudi Arabia. Blue-green color; sample contained a small amount of dirt/sand compared to the other samples. Sample appeared clear before and after shaking. No phase separations were observed.
AL-19741-X	Sample taken from an M109A2 Self-Propelled Howitzer. No mileage data available. Yellowish color; sample contained a large amount of dirt/sand compared to the other samples. Sample appeared clear when allowed to stand for several hours. Upon shaking, sample color changed from yellowish to a yellowish-brown. Color change believed to be due to the excessive amount of dirt/sand present. No phase separations were observed.
AL-19742-X	Sample taken from an HEMTT 10-Ton Truck. No mileage data available. Olive-green color; sample contained a moderate amount of dirt/sand compared to the other samples. Sample was murky in appearance before and after shaking. No phase separations were observed.
AL-19743-X	Sample taken from same truck as sample AL-19742-X. Green color; sample contained a large to moderate amount of dirt/sand compared to other samples. Sample appeared slightly cloudy when allowed to stand and cloudier immediately after shaking. No phase separations were observed.
AL-19744-X	Sample taken from an M54A2 Cargo Truck. No mileage data available. Blue-green color; sample contained a small amount of dirt/sand compared to the other samples. Sample appeared clear before and after shaking. No phase separations were observed.

Table 14. Analysis of Coolant Samples Taken from Vehicles Returning from Operation Desert Storm

AA AND ICP METAL ANALYSIS, PPM

Sample	Aluminum	Copper	Iron	Lead	Tin	Silicon
AL-19740-X	5	< 1	4	7	95	5
AL-19741-X	8	2	26	10	44	4
AL-19742-X	1	28	29	206	165	28
AL-19743-X	< 1	1	2	153	148	12
AL-19744-X	< 1	< 1	< 1	1	96	10

Physical Properties

Sample	pH	RA	Freeze Point (FP)	Percent Water based on FP	Sediment*
AL-19740-X	7.7	10.5 mL	-22°F	55% by vol	<0.1%
AL-19741-X	8.6	0.8 mL	+22°F	87% by vol	0.188%
AL-19742-X	7.1	15.3 mL	-50°F	44% by vol	0.125%
AL-19743-X	7.3	15.3 mL	-50°F	44% by vol	0.125%
AL-19744-X	7.7	11.7 mL	-27°F	52% by vol	0.05%
New MIL-A-46153	7.7	14.5 mL	-34°F	50% by vol	<0.05

* *Volume percent by D2709*

Samples AL-19740-X and AL-19744-X may be aqueous solutions of military specification antifreeze, MIL-A-46153. This assumption is based primarily on the color of each sample compared to the blue-green color of new MIL-A-46153. However, identification is uncertain since other types of antifreeze may also use blue-green dye. The remaining samples appear of blue-green color. A more exact identification of the samples would require prior knowledge of the original full.

The pH, RA, and water concentrations for all samples are at suitable levels for service except AL-19741-X. This sample is too dilute and corrosion problems are expected with its continued use. However, the metal analysis of AL-19741-X indicated no serious corrosion problems. The lead and tin concentrations of AL-19742-X and AL-19743-X suggest the coolant may not have provided sufficient protection against solder corrosion. For AL-19744-X and AL-19740-X, the tin is comparatively high, but the lead

concentration is relatively low. These results are opposite of what is expected for normal solder corrosion. Other corrosion mechanisms may account for the additional tin corrosion.

Conclusions

As in each appearance observation, all samples contained varying amounts of dirt/sand contamination. Although some samples contained more than others, all had unacceptable amounts to the point where cooling system problems are expected to occur if the selected vehicles are allowed to remain in service. The large amounts of dirt/sand observed in these samples suggest that contamination occurred during maintenance operations of the vehicles and not through system leaks. For example, during maintenance operations such as checking the coolant level, contaminants could have been introduced into the system by wind-blown sand or a radiator cap inadvertently placed on the ground. This type of contamination suggests that greater care must be taken to prevent contamination of coolant during dusty or sandy conditions.

Recommendations

Recommend that the cooling system of these vehicles be drained and replaced with a fresh 50:50 mixture of clean, potable water and MIL-A-46153 antifreeze without delay. Unfortunately, the coolant samples we received were not identified by vehicle bumper number, but we do know that they were from the 1st and 2nd Squadrons of the 3rd Armored Cavalry Regiment. Perhaps these units have a record of which vehicles were sampled.

If these samples were typical of vehicles returning from Southwest Asia, all vehicle cooling systems should be inspected for contamination as soon as possible to preclude damage that could occur if contaminated coolant remains in the vehicles. Any vehicles that were serviced with commercial antifreeze or products of unknown origin in Southwest Asia should have the coolant immediately replaced with MIL-A-46153 antifreeze.

Analysis of one unused sample of Saudi Arabian engine coolant labeled Petromin 500

Background

During the war with Iraq logistical problems caused delays of all packaged petroleum products from CONUS. As a temporary solution, BRDEC was requested to examine substitute commercial products locally available in Saudi Arabia. Various product samples were taken from Saudi Arabia based Petromin Lubricating Oil Company which

has some products already qualified. The initial suspense date for this request was short and BRDEC was allowed only a cursory review of a small number of samples.

As a follow-up study, BRDEC obtained additional samples and a more extensive investigation was performed. This letter report covers one engine coolant that was submitted as an alternative.

Experimental

The sample was labeled Petromin 500, a premixed coolant diluted approximately 50 percent by volume ethylene glycol (EG). The coolant sample was subjected to standard ASTM coolant tests including: Use of the Refractometer for Determining the Freezing Point of Aqueous Engine Coolants (D-3321); pH of Engine Antifreezes, Antirusts, and Coolants (D-1287); Corrosion of Cast Aluminum Alloys in Engine Coolant Under Heat-Rejection Conditions (D-4340); Reserve Alkalinity (RA) of Engine Antifreeze, Antirusts, and Coolants (D-1121); Trace Chloride Ion in Engine Coolants (D-3634); Corrosion Test for Engine Coolants in Glassware (D-1384); Boiling Point of Engine Coolants (D-1120); Ash Content of Engine Coolants and Antirust (D-1119); and Foaming Tendencies of Engine Coolants in Glassware (D-1881). The test results were as follows:

Table 15. Physical Properties

Sample	Petromin 500	50/50-Soln' MIL-A-46153
Freeze Protection (FP), D-3321	-40°F	-34°F
Water by vol based on FP	48%	50%
pH, D-1287	8.6	7.7
Reserve Alkalinity, D-1121	8.2mL	14.5mL
Ash Content, D-1119	0.6%	1.0% max
Foam, break time, D-1881	187mL, 7 sec	42mL, 1 sec
Boiling Point, D-1120	112.0°C	12.0°C
Chloride Content, D-3634	57ppm	4.5ppm
Aluminum Corrosion, D-4340	5.6mg/cm^2/wk	na
Color	yellow-green	blue-green

Table 16. Glassware Corrosion Test, D-1384

c rrected weight losses, mg

Sample	Brass	Copper	Solder	Aluminum	Iron	Steel
Petromin 500	0	-2	-38	+6	0	+1
MIL-A-46153	-3	-1	-7	+1	-1	-2
ASTM D-4656 maximum	-10	-10	-30	-30	-10	-10

Results

For comparison purposes, test results of new MIL-A-46153 military antifreeze and 50-50 solutions of MIL-A-46153 are included. For the test methods that required dilution of the antifreeze concentrate prior to conducting the test, the Petromin sample was diluted to the prescribed volume with either ASTM corrosive water or distilled water depending on the test method. For example, for test method D-1384, the Petromin coolant was diluted with ASTM corrosive water to obtain test solutions with 0°F freeze points.

The Petromin test results for freeze protection, pH, ash content, and boiling point are all satisfactory compared to MIL-A-46153. The smaller RA could possibly cause Petromin 500 to have a shorter service life compared to MIL-A-46153, if acid contamination became excessive. The results of remaining test indicate more clearly that Petromin 500 may be inappropriate as an alternate coolant for MIL-A-46153.

The Petromin 500 foam test results did not meet the specification requirements of MIL-A-46153 of the ASTM recommended maximum for new coolants (i.e., 150mL max, w/sec break time), for both diesel and automotive applications, and could possibly cause problems in the field. The same is true of the chloride test results.

For new MIL-A-46153, the current specification calls for a negative test for chloride or zero chloride. A sample tested contained 9 ppm but, for comparison purposes, the value was divided by 2 to simulate the Petromin 500, 50 percent by volume dilution. And for the purposes of this investigation, it is assumed that reagent grade water, similar to ASTM D-1193, Type IV, having a chloride content of 0.05 ppm, can be readily used in the production of the prediluted coolant.

Though the military antifreeze sample fails to meet the specification requirements, it is well within the ASTM recommended maximum of 25 ppm for heavy-duty antifreeze concentrate (D-4985). The Petromin sample was tested neat (without dilution) during the chloride test and a value of 57 ppm was obtained as shown in Table 16. The recently adopted ASTM standard D-4656 for prediluted automotive type coolants also

recommends a maximum of 25 ppm for a neat sample. The Petromin result is more than twice the recommended maximum and suggest that corrosion problems may occur. Results of the two corrosion performance tests, D-4340 and D-1384, also indicate that Petromin 500 may have a propensity toward corrosion.

As an automotive coolant, the Petromin sample failed to meet the ASTM recommended aluminum corrosion rate, 1.0mg.cm^2/week, for new prediluted coolants. The sample also failed the glassware corrosion test, as evidenced by the solder specimen weight loss in Table 16.

Conclusions and Recommendations

Based on the unfavorable results of the foam, chloride aluminum, and glassware test it is recommended Petromin 500 not be used as an substitute for MIL-A-46153 antifreeze. Laboratory test results indicate Petromin 500 may be deleterious to both diesel and automotive engine cooling systems and therefore should not be used.

It is further recommended that any vehicles serviced with Petromin antifreeze have their cooling systems drained and flushed immediately, then serviced with MIL-A-46153 antifreeze to preclude possible corrosion or excessive foaming.

WEAPONS LUBRICANTS/SOLID LUBRICANTS

No satisfactory solid lubricants/weapons lubricants were available to maintenance and user personnel. CLP (MIL-L-63460), LSA (MIL-L-46000), and Break Free (one qualified supplier of CLP) were the most prevalent lubricants used. However, rust and sand/dirt contamination were problems as is normal. A new commercial proprietary product "Bore Cote" was used by one Marine unit in Southwest Asia. However, the unit did not use this product in combat. Although it reportedly protected the individual weapons better than CLP or LSA, without sand/dirt accumulation, it had not been used in combat. The product was, therefore, suspect until further testing had been conducted. CLP and LSA were the expressed preferences for large caliber weapons; whereas CLP and the commercial proprietary "DRYSLIDE" were the preferred lubricants for small caliber weapons. Another preference for large caliber weapons, 30 caliber and higher, was GMD (MIL-G-21164D). "DRYSLIDE" was used by some units, although one unit in the 24th Infantry Division prohibited its use because of a reported tendency to thicken when subjected to high ambient temperatures or heat generated by firing the weapon. No other units reported this phenomenon. One weapons lubricant was identified to the survey team as "duck grease." However, no one could identify the product as to its brand name, if commercial, or specification number, if military authorized. WD-40 was widely used on small arms both as a cleaner and a lubricant. Common sense solutions overcame dirt/sand contamination problems with constant cleaning being the method most widely used. There was no reported mixing of solid lubricants with grease or fluids.

Section V

Conclusions

The following conclusions are drawn from the experiences in ODS:

- Jet A-1 proved to be a satisfactory fuel for military ground V/E for those units that used the fuel throughout ODS and had confidence to continue to use this fuel in spite of the perceived problems.

- There was insufficient information and data about Jet A-1 fuel and its suitability for use in diesel-burning ground combat/tactical vehicles and equipment at all levels of command in Southwest Asia.

  — JP-8 fuel demonstration at Fort Bliss, TX, was still ongoing at the onset of ODS. Information and data generated at that time were still mostly in the hands of the research and development community.

  — No technical manual changes were available for reference by fuel storage and handling personnel.

  — No information or data had been distributed down to user/organizational level.

  — This lack of information resulted in misunderstandings and frustration on the part of user personnel all the way up to combat commanders (especially at Division level).

  — No information or data about the use of JP-5 at Panama nor its relationship to Jet A-1, JP-8 had been disseminated.

- The Jet A-1 fuel and DF-M fuel provided by Saudi Arabia to bulk storage and handling tank farms were good quality fuels except that the diesel fuel exceeded the maximum sulfur limits.

  — Fuel delivery systems below bulk storage and handling facilities, especially fuel delivered using host nation/foreign nation vehicles and drivers, appeared to have contributed some fluid and solid contaminants to fuel, especially in the beginning of ODS.

- In some areas, a mixture of Jet A-1 fuel and DF-M was delivered to using units at one time or another.

- DF-M fuel was known to have a high sulfur content, which could have been harmful to engines if used for a long period of time. To preclude excessive corrosion deposits and wear-related problems, modified oil change intervals (half normal change intervals) were established. Some units complied, others did not.

- DF-M had a marginal cloud point and could impact the startability of M1A1 heavy-duty battle tanks.

- Both Jet A-1 fuel and DF-M fuel were available in adequate quantities.

- Commercial host nation tank trucks used initially to refuel vehicles did not use filtration. Later, these tank trucks transferred fuel to military refuelers. A problem with incompatible hose connections was readily overcome by a field expedient fix.

- All units were pleased with the performance of the HEMTT refueler.

- Generally, separate refuelers were used for ground V/E and for aircraft. There were some reports of sporadic use of common refueling from the same refueler.

- There were a few problems with some units in converting to Jet A-1 fuel.

  - Units that had been using Jet A-1 or JP-5 fuel prior to deployment had little or no problems.

  - Units that were using DF-2 and switched to Jet-1 when arriving in Southwest Asia experienced filter clogging. Fuel filter changes significantly increased.

- A few military personnel were apprehensive at first that the lower flash point of Jet-A1 fuel would be a fire hazard. This apprehension was quickly dispelled with continued use of the fuel.

- Conflicting statements by user/maintenance personnel and prior knowledge about fuel system component deficiencies as well as other failure mechanisms prevented conclusions that the Jet A-1 fuel caused fuel system failures.

— CUCV fuel injection pump with 1985 or earlier flex ring.

— Use of unauthorized oils/fluids added to Jet A-1 in an attempt to increase lubricity.

— Thermal-induced pump failures.

— High prevailing temperatures.

— Moisture/corrosion problems.

— Dirt/sand contamination, which became almost like talcum powder.

— Usage rates (hours and miles of operation) far in excess of normal mission/training activities in CONUS.

(Eighty-eight failed pumps were subjected to tear down inspections. Results are shown in Appendix H.)

— No known blending of Jet A-1 fuel with additives CI,FSII, or SDA occurred during ODS for ground V/E.

— The host nation did not have downstream injection systems nor did the Army or Marine Corps organizations and units have any injection systems or additives to use.

— There is an urgent need for a means/capability to rapidly dispense measured amounts of additives into fuels such as Jet A-1, which is available worldwide.

- One unit reported adding biocides/biostats to DFM to alleviate or prevent microbiological growth.

  — There is a need for faster, easier way to add biocides/biostats to diesel fuels.

- In the case of ODS, the host nation was able to provide adequate lubricants and related POL products to support U.S. Forces until bulk packaged product depots could be established to receive, store, and issue regular supplies.

  — The logistics of the supply of host nation POL products was confusing to the point that it was difficult to fully determine what products were used. Further, reporting back through maintenance was equally confusing providing the possibility that there may have been greater problems than reported.

— Use of host nation POL products was a field expedient fix. There was not a good handle on what was really acceptable because there was no way to rapidly assess the quality levels and compatibility of these products. Engineering judgments on their acceptability were made by reviewing limited data which was inadequate but used because of the expediency of the need. A quick-response and reliable evaluation of these products was needed. In view of future contingencies there is a need to develop fast and simple tests to measure the quality and compatibility of host nation commercial POL products with U.S. military POL products.

— In some areas, OE/HDO-15/40 grade oil (MIL-L-2104), OE/HDO-10 grade oil (MIL-L-2104), and wide temperature range (WTR) aviation grease (MIL-G-81322) were in short supply throughout ODS.

— OE/HDO-10 grade oil (MIL-L-2104) and Dexron II® were also used in some hydraulic systems when regular FRH or OHT fluids were not available.

— OE/HDO-30 (meeting the requirements of MIL-L-2104) and SAE-30 grade oils (both commercial or meeting the requirements of MIL-L-46152) were used in lieu of OE/HDO-15/40 grade oil until it became available. Continued use of the SAE-30 grade oils (commercial or MIL-L-46152) over a longer period of time could have caused damage to the heavy equipment.

— ODS did not last long enough to fully establish engine and gear train lubricant performance criteria.

- Unauthorized products were used by some units that claimed the oils did not adequately lubricate vehicle and generator engines and greases separated in the can during storage and in vehicle component use.

- Some units could only acquire lubricants in 55-gallon drums. This caused handling problems and waste due to contamination once the drums were opened.

- Coolants/antifreezes functioned satisfactorily during ODS with some exceptions. A bad experience with antifreeze occurred when some antifreeze was used that had been stored in bare metal drums instead of plastic-lined containers.

— A locally procured coolant, "Petromin 500", was issued to some units as an alternative to MIL-A-46153 military antifreeze during ODS. Subsequent laboratory tests of this product showed that it was an inadequate substitute for MIL-A-46153 because of excessive foaming and inadequate corrosion protection. Used coolant analyses from five vehicles returned from ODS showed that all had unacceptable levels of sand/dirt contamination. One sample was too diluted and had little corrosion or freeze protection. If ODS

had lasted longer, major long-term cooling system maintenance problems could have been expected.

— Although some units had antifreeze extender additive (MIL-A-53009) on hand, none reported using the additive in their V/E.

- No real satisfactory weapons lubricants/dry lubricants were available for use during ODS. Only constant cleaning and care of small and large caliber weapons kept them operationally ready.

- Mobile and fixed petroleum testing laboratories were in Southwest Asia to provide AOAP support and quality surveillance of fuel and lubricants. These mobile petroleum laboratories (trailer mounted) were too big, too slow, too labor intensive, and were too far away to meet the demands of the faster paced more fluid battlefield environment. There is an urgent need for a quick-response fuel/lubricant analysis system that is smaller, lighter, more mobile and that contains some instruments that are man-portable to aid in fast and simple "go" and "no go" decisions.

- Two mobile (trailer mounted) FORSCOM AOAP laboratories were deployed but were severely hampered by lack of qualified military personnel. Ultimately, these laboratories were staffed by a combination of military DA civilian, and contractor personnel. The first laboratory was dispatched to the theater of operations by surface ship. The ship incurred an underway breakdown, thus significantly delaying AOAP support in theater. A few ground units interviewed indicated that they had taken AOAP samples but not received any feedback. Most units interviewed wanted AOAP support.

- Five mobile (trailer mounted) Petroleum Testing Laboratories from the 475th Petroleum Group were deployed to provide quality surveillance of fuel and lubricants. The 240th QM Battalion (22nd Petroleum Lab) operated from September 1990 through May 1991, the 260th QM Battalion's laboratory operated from November 1990 through February 1991. The three remaining laboratories (540th, 383th and 387th Battalions') did not arrive in theater until February 1991 and were never put into operation.

- An air mobile laboratory from the 426th S&T Battalion, 101st Airborne Division Assault, was deployed but never put into service.

- U.S. Air Force and commercial petroleum testing laboratories also provided support.

Section VI

Recommendations

Based on the data and information presented in this report, the following recommendations are made:

- Lubricity requirements for fuels used in diesel-burning ground vehicles and equipment should be defined and accepted by all agencies and activities involved with ground mobility fuels.

- Changes should be made in technical manuals, handbooks, and other publications dealing with fuel storage and handling procedures to include JP-8, JP-5, and Jet A-1 aviation fuels.

  — The present one fuel forward scenario envisions one fuel instead of three (JP-4, diesel, and MOGAS fuels), which will simplify and reduce logistical burdens and result in lower energy costs and greater combat readiness.

  — Because it will be used for aviation as well as ground assets, the fuel should be handled so as to meet aircraft use specification at all times.

  — Where aircraft may be fueled or have been refueled with JP-4 grade fuel, fuel handlers must be made aware of the aircraft's having been fueled with JP-4 so no safety precautions will be ignored because the fuel handler believes he is dealing strictly with JP-8 or JP-5 fuel.

- As soon as possible, an information booklet containing all useful facts about JP-8 and JP-5 fuels be published and distributed down to driver/operator level.

- The requirements for staffing both fixed and mobile AOAP laboratories should be immediately addressed.

  — Military personnel with appropriate training and Military Occupational Specialty should be designated in appropriate Tables of Equipment and Tables of Allowances authorization documents.

  — The echelon level that will be responsible for providing and staffing a mobile fuel/lubricant analysis laboratory should be determined.

— Wartime procedures should be established for appropriate personnel at all levels to assure the most accurate and fastest results obtainable when processing fuel and oil samples.

- A requirements document for the development of a Petroleum Quality Analysis System (PQAS) needs to be staffed immediately.

  — The objective of the PQAS program is to move petroleum quality surveillance testing as far forward as possible. Capitalizing on emerging technology to provide multi-functional testing capabilities, this system will be smaller and more mobile with some instruments being man-portable. It will provide the automatic quick-response fuel/lubricant analysis required to quantify and project the limitations in using lower quality fuels and lubricants that may be provided by host nations.

  — In the near term, there is a real need to upgrade the petroleum testing equipment in the existing mobile petroleum laboratories with current state-of-the-art in petroleum testing equipment and methodologies. The existing laboratories utilize old cumbersome testing equipment (1950s era) which is slow and labor intensive.

- U.S. military posts, camps, and stations worldwide should be authorized for the use of JP-8 fuel as soon as feasible. Training with an untried fuel during peace time is much better than being required to accept it under an imminent attack situation.

- Research and development efforts should continue in order to:

  — Define the "lubricity requirements" for fuel-lubricated compression-ignition engine components.

  — Evaluate those additives (including selected packaged petroleum products) that can be added to reduce those "lubricity" deficiencies that have been defined.

  — Determine an easier way to inject additives into fuels such as Jet A-1.

  — Explore the use of improved biocide/stabilizer additives and find a faster, easier way of injecting those additives into diesel fuel.

  — Develop a satisfactory weapons lubricant for a sand environment such as experienced during ODS.

- Research and development efforts are needed to provide a means to rapidly determine the presence of unique fuel acid contamination intentionally introduced into fuels in field environments. Presence of these unique contaminates in fuels reportedly defeats mobility operations by causing engine malfunctioning.

  — A concept feasibility model of a relatively simple test kit for acid fuel contamination has been developed.

  — Proof of principal was demonstrated but additional efforts are needed to validate the device and to confirm limits of detection versus impact on both compression-ignition and turbine engines.

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List of Acronyms and Abbreviations

AMC	Army Material Command
AOAP	Army Oil Analysis Program
ARCENT	U.S. Army Central Command
ASTM	American Society For Testing Materials
BFLRF	Belvoir Fuels and Lubricants Research Facility (SwRI)
BOCLE	Ball-on-Cylinder Lubricity Evaluation
BRDEC	Belvoir Research Development and Engineering Center
CENTCOM	U.S. Forces Central Command
CI	Corrosion Inhibitor
CMMC	Corps Maintenance Management Center
COSCOM	Corps Support Command
CUCV	Commercial Utility Cargo Vehicle
DF-M	Diesel Fuel Provided By Host Nation
DFM	Diesel Fuel Marine
DFSC	Defense Fuel Supply Center
DISCOM	Division Support Command
DMMC	Division Maintenance Management Center
DOD	Department of Defense
FORSCOM	U.S. Forces Command
FSII	Fuel System Icing Inhibitor
FSSC	Force Support Service Centers
FSSG	Force Support Service Groups
GMC	General Motors Corporation
HEMTT	Heavy Expanded Mobility Tactical Truck
HMMWV	High Mobility Multipurpose Wheeled Vehicle
JPO	Joint Petroleum Office
LAO	Logistics Assistance Officers
MARCENT	U.S. Marine Central Command
MEF	Marine Expeditionary Force
MOS	Military Occupational Specialty
MPS	Marine Maritime Prepositioning Ships
NATO	North Atlantic Treaty Organization
NBC	Nuclear, Biological and Chemical
NTC	National Training Center (Army)
ODS	Operation Desert Shield/Storm
OE/HDO	Engine Oil, Heavy-Duty

POL	Petroleum, Oil and Lubricants
QPL	Qualified Product List
RAM-D	Reliability, Availability, Maintainability, and Durability
RMMC	Regimental Maintenance Management Center
SAE	Society of Automotive Engineers
SDA	Static Dissipator Additive
SwRI	Southwest Research Institute
TA	Tables of Allowances
TOE	Tables of Equipment
TPUs	Tank and Pump Units
TRADOC	Training and Doctrine Command
UBL	Unit Basic Load
V/E	Vehicles and Equipment
WTR	Wide Temperature Range

Appendix A
QUESTIONS AND ANSWERS, RECOMMENDATIONS ON FUELS AND LUBRICANTS AND RELATED MATERIALS (SOUTHWEST ASIA)

10 October 1990

QUESTIONS & ANSWERS, COMMENTS AND RECOMMENDATIONS ON FUELS AND LUBRICANTS AND RELATED MATERIAL FOR USE IN OPERATION DESERT SHIELD

There have been many questions concerning the use, type, etc. of fuel, lubricant or related material in Saudi Arabia. We are putting this brochure together to pass on this information to all units, and hope that you find it usefull. Please do not hesitate to contact the BELVOIR RD&E CENTER if you have any more questions or need clarification.

A. FUELS and FUEL ADDITIVES: [JP-5 and JET A-1]

1. Can JP-5 or JET A-1 be used in vehicles/equipment designed for diesel fuel? ANSWER: YES. JP-5 was approved as an alternate for diesel fuel in 1978 and has been since then, satisfactorily in ground vehicles and equipment. JET A-1 also was approved as an Alternate for diesel fuel in 1986. Use of either JP-5 or JET A-1 will provide acceptable performance in diesel fueled vehicles or equipment.

2 What is JET A-1? ANSWER: JET A-1 is the industry standard fuel for all commercial airline carriers worldwide. JP-8 is JET A-1 with addition of the three (3) mandatory additives; Fuel System Icing Inhibitor, Corrosion Inhibitor, and Static Dissipator Additive.

3. Have there been any major problems with using JP-5 or JET A-1 in ground vehicle and equipment? ANSWER: NO. The Army and Navy have both tested these fuels.

There are two exceptions however-

o Vehicles using either fuel will not make smoke from on-board vehicle engine exhaust smoke systems (VEESS) that has any persistence or ability to obscure vehicles, especially in high temperature environments (90 degrees F or higher).

o Certain vehicles such as the M88 Recovery Vehicle, which are already somewhat power limited with diesel fuel, will have additional loss of pulling power when using JP-5 or JET A-1.

4 Are there any additives you can add to JET A-1 or JP-5 to enhance smoke production when the fuel in introduced into the VEESS? ANSWER: NO. There are no additives available that will increase smoke.

5. Can JP-5 or JET-1 be used in gasoline-fueled ground vehicles and equipment?	ANSWER:	NO, NO. Kerosene fuels <u>cannot</u> be used in any spark-ignition engine.
6. Will using either JET A-1 or JP-5 cause a significant increase in fuel consumption?	ANSWER:	NO. On some vehicles there may be a marginal increase of 1 to 5 %.
7. Will using either JET-1 or JP-5 plug fuel filters?	ANSWER:	NO. Both JP-5 and JET A-1 are cleaner than diesel fuel.
8. What causes filter plugging?	ANSWER:	Plugging is caused by high particulate contamination (e.g., dirt, insoluble

particles, etc.); fuel deterioration products (e.g., oxidized reaction products, insoluble gums, etc.); presence of microbiological organisms; emulsions produced by residual water bottoms in fuel tanks; or a combination of any of the above.

9. Can either JET A-1 or JP-5 be directly added to vehicles and equipment containing diesel fuel in their tanks?	ANSWER:	YES. No problem adding either to a fuel tank with diesel fuel.
10. Will using JET A-1 Cause wear in fuel pumps and injectors of diesel Engines?	ANSWER:	NO.
11. Will microbiological organisms grow in both JET A-1 and diesel fuels?	ANSWER:	YES. Faster in diesel fuel than JET A-1. Diesel Fuel tends to entrain

more water, has poorer water separation qualities, and contains higher amounts of normal paraffin-type hydrocarbons than JET A-1, which are good nutrients for the various micro-organisms.

12. What causes growth of microbiological organisms (i.e , bugs) in fuel?	ANSWER:	The presence of separated water. The 'bugs' start to form at the fuel-

water interface and subsequently develop strands, fibers and/or 'mats' into the fuel and may produce a slime on the interior surfaces of the tank. Warmer temperatures accelerate the growth and proliferation of these micro-organisms.

13. What additives should be used for controlling micro-biological growth in fuel?

ANSWER: There are 3 additives in the supply system used to prevent growth in water bottoms of fuel tanks or cells. Two are currently specified in JP-4, JP-5, and JP-8 aviation turbine fuels. They are called 'Fuel System Icing Inhibitor' and are described in MIL-I-27686 and MIL-I-85470. The chemical ingredients are Ethylene Glycol Monomethyl Ether (EGME) and Diethylene Glycol Monomethyl Ether (DIEGME), respectively. The recommended treatment level for either is 0.15% vol. JP-5 already contains Fuel System Icing Inhibitor (FSII).

The third additive, specified for diesel fuel, is called Diesel Fuel Stabilizer Additive and is described in MIL-S-53021. Two variations have been qualified - a two-package and one-package system. The two-package type has the biocide in one package, and the stabilizer/corrosion inhibitor in the second package. Both of them must be ordered and used together for maximum effectiveness. They are each used at the rate of one gallon per 5000 gallons of fuel. The one-package system has both ingredients blended together in one container, and is used at the rate of one gallon of additive per 3500 gallons of fuel.

National Stock Numbers for the three additives are:

Specification	Type	Container	NSN
MIL-I-27686	FSII (EGME)	5-Gal	6850-00-753-5061
MIL-1-27686	FSII (EGME)	55-Gal	6850-00-060-5312
MIL-I-85470	FSII (DIEGME)	5-Gal	6850-01-057-6427
MIL-I-85470	FSII (DIEGME)	55-Gal	6850-01-089-5514
MIL-S-53021	Single Pkg	5-Gal	6850-01-246-6544
MIL-S-53021	Single Pkg	55-Gal	6850-01-246-6545
MIL-S-53021	Biocide/Two Pkg	5-Gal	6840-01-173-6940
MIL-S-53021	Biocide/Two Pkg	55-Gal	6840-01-041-0098
MIL-S-53021	Stabil/Two Pkg	5-Gal	6850-01-167-4789
MIL-S-53021	Stabil/Two Pkg	55-Gal	6850-01-167-4788

B. FUELS and FUEL ADDITIVES: [DIESEL FUEL]

1. What commercial diesel fuels are available in Saudi Arabia?

ANSWER: There are nominally two types - 'A-888, Diesel Gas Oil' (similar to our Diesel Fuel, Marine (MIL-F-16884); and 'A-892, Bunker Diesel Fuel Oil' (a heavier fuel somewhat like our commercial 4-D Diesel or No 4 Fuel Oil).

2. Are either of these commercial diesel fuels OK to use?

ANSWER. The A-888 Diesel Gas Oil is an acceptable alternate for our diesel fuel (VV-F-800). The A-892 Bunker Diesel Fuel Oil is only an emergency fuel and should not be used.

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Diesel fuel originating in the Middle East has generally had fuel sulphur values ranging in the 0.7 to 1.0% wt. range. Some sample data has shown fuel sulphur values at times will exceed 1.0% wt.

Diesel fuels in the Middle East area generally do not have adequate thermal stability or storage stability when compared to JET A-1 or JP-5 turbine fuels. Their use in vehicles operating in Saudi Arabia may cause an increase in fuel-related maintenance; particularly, in two-cycle diesel engines and turbine engines. The increased maintenance will be seen in injector or nozzle fouling or sticking, increased filter plugging, and/or formation of deposits (slime/bugs/emulsions) in fuel tanks.

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RECOMMENDATIONS REGARDING FUEL FOR OPERATION DESERT SHIELD

o Do not use heavier fuels such as 'Bunker Diesel Fuel Oil' fuels as these are emergency fuels

o Heavier distillate fuels such as 4-D (or the DF-4 reportedly used in Saudi Arabia) are not acceptable substitutes for the primary diesel fuel DF-2 - they are to be used only as emergency fuels. There are acceptable alternatives to DF-2 diesel fuel available in the Saudi Arabia area:

Fuel	Specification/Standard
JET A-1	ASTM D1655
JP-5	MIL-T-5624
F-76/Marine Diesel/DFM	MIL-F-16884
DF-2 (OCONUS)	VV-F-800 (if available)

o Water contamination due to condensation in fuel tanks/cells must be checked daily to prevent microbiological growth problems.

o Do not add engine oils (OE/HDO) or DEXRON automatic transmission fluid to JET A-1/JP-5 fuels to improve their 'lubrication qualities'. Adding these oils provides questionable benefit, and can cause increased nozzle/injector deposit and ring sticking problems.

C. ENGINE OILS:

1. Can the OE/HDO-15W/40 tactical engine oil (MIL-L-2104) be used in the high temperature environment of Desert Shield?	ANSWER:	YES. Tests have shown satisfactory performance to 120°F (+49°C)
2. Does the high ambient temperature require that a Grade 50 engine oil be used?	ANSWER:	NO. OE/HDO-15W/40 is satisfactory and available. OE/HDO-40 can be

used in place of OE/HDO-15W/40 if so desired.

3. Is a OE/HDO-50 product available in the supply system?	ANSWER:	NO. Dropped from MIL-L-2104 when the OE/HDO-15W/40 was introduced.
4. Are OE/HDO (MIL-L-2104) and PE (MIL-L-21260) engine oils compatible with each other?	ANSWER:	YES. They have the same performance level. (MIL-L-21260 has an additional prservative component
5. Can MIL-L-46152 (Administrative Engine Oils) be used in lieu of MIL-L-2104 oils?	ANSWER:	NO, NO. ADM Engine Oils will not provide needed performance. Serious engine wear and deposits will arise.

****

Vehicles/equipment arriving from Depot/CONUS/OCONUS locations should be checked to assure that the proper oil/lube and designated grades are being used. If unable to identify, drain and replace with recommended product (see 'Fuel and Lubricant Recommendations' Chart).

Use of a diesel fuel having fuel sulphur values in this range (i.e., in excess of 0.7% wt.) will cause an increase in the wear of oil-wetted engine components; particularly in two-cycle stroke engines which power combat vehicles such as the M55/A1, M106A1/A2, M125A1/A2, M548/A1, M992, M577A1/A2, M730, M113A1/A2, M981, M110A1/A2, M109A1/A2, M578, M983, etc.

Vehicles/equipment operating in higher ambient temperatures and using diesel fuels with the higher sulfur content require more frequent oil drain intervals. Recommend that the normal criteria of mileage/operating hours for normal oil change be reduced by factor of two.

Vehicles/equipment operating in desert regions will encounter increased levels of dirt or particulate contamination.

Air that appears clean is actually laden with fine dust, even on a clear day. To avoid excessive wear from ingested dust, recommend that periods of operation (i.e., miles or hours) for normal oil change be reduced by by a factor of two. To further reduce contamination, recommend increased air/oil filter servicing, and use of smaller sized containers of lubricant, if possible, which will be consumed more quickly.

Do not use any engine oils manufactured by either Battenfeld Oil and Grease Corporation or Battenfeld-America Inc. The products (MIL-L-2104, MIL-L-21260, and MIL-L-46152) manufactured by either of these companies were improperly formulated and will not provide satisfactory lubrication in new operating environments.

Do not use any MIL-L-46152 type administrative engine oils in place of MIL-L-2104 (OE/HDO) tactical engine oils. Administrative service engine oils will not, repeat, will not perform adequately in combat/tactical equipment designed for MIL-L-2104 engine oils.

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D. GREASES & GEAR OILS:

1. What grease should be used in ground vehicles or equipment?

ANSWER: MIL-G-0010924E(ME) or MIL-G-10924F Grease Automotive and Artillery (GAA) should be used as they possess a significantly higher operating temperature capability than the previous MIL-G-10924D Amd 2 version. If at all possible, the MIL-G-10924D Amd 2 GAA should not be used unless there is no other option available since its somewhat lower Dropping Point may cause oil leakage problems in high operating temperatures. If the recommended MIL-G-0010924E (ME) or MIL-G-10924F grease is not available, use of MIL-G-83122 Grease Aircraft, General Purpose, Wide Temperature Range (WTR) is strongly recommended.

****

Vehicles/equipment arriving from Depot/CONUS/OCONUS locations may show some degree of 'Grease Bleeding/Softening' at lubrication points such as wheel hubs, road wheels, etc., due to the prevailing high ambient temperatures initially encountered. Where this 'grease bleeding/softening' is evident, remove and relubricate with GAA (either MIL-G-0010924E or MIL-G-10924F) or WTR (MIL-G-83122). Care should be taken to wipe clean any excess grease as this will attract sand particles and cause contamination of grease.

****

GEAR OILS - Vehicles/equipment arriving from Depot/CONUS/OCONUS locations should be checked to assure that the proper oil/lube and designated grades are being used. If unable to identify, drain and replace with recommended product (see 'Fuel and Lubricant Recommendations' Chart).

Do not use any gear oils manufactured by either Battenfeld Oil and Grease Corporation or Battenfeld-America Inc. The MIL-L-2105 products which either of these companies manufactured were improperly formulated and will not provide satisfactory lubrication.

E. ANTIFREEZE/COOLANTS:

1. Will increasing the ratio of antifreeze (MIL-A-46153) to water improve the heat transfer qualities of the antifreeze-water mixture?

ANSWER: NO. Increasing the ratio will lower the heat transfer properties. For best results, use the 50:50 mixture of MIL-A-46153 and water.

2. Can local water be used in cooling systems of engines?

ANSWER: NO, NO. Use either distilled water, if available, or treated, potable water. Local water in Saudi Arabia is very saline and will calcify in cooling systems and reduce the cooling capacity.

3. Can commercial antifreeze be used in lieu of MIL-A-46153?

ANSWER: NO. Mixing commercial antifreeze with MIL-A-46153 will produce incompatibility problems leading to increased cooling system maintenance problems or possibly failures.

****

Do not use any MIL-A-46153 antifreeze taken from unlined 5-gal or 55-gal drums. MIL-A-46153 must be packaged/stored in plastic or metal containers fitted with plastic inserts.

Use of the antifreeze extender additive (MIL-A-53009) is recommended as a means to insure against potential high temperature aluminum corrosion of engine cooling systems that may occur. Treatment levels are one half quart of MIL-A-53009 to seventeen quarts of antifreeze solution (a treatment level of 3%) However, more than one treatment with MIL-A-53009 is not recommended.

****

F. BRAKE FLUIDS

Vehicles from arriving Depot/CONUS/OCONUS locations should be checked to assure that the brake systems are filled with MIL-B-46176/BFS. If during maintenance checks, the wheel cylinders are bled and other than a purplish or clear fluid exit the bleeder hose (e g., brown-colored, two phase mixture, etc), this indicates the presence of conventional-type polyglycol brake fluid (DOT 3). If this occurs, the vehicle brake system needs to be drained, flushed at least two times with MIL-B-46176, and refilled with MIL-B-46176.

Do not use any conventional-type polyglycol base brake fluids (i.e., DOT-3, cancelled VV-B-680, commercial brake fluids, etc.) as mixing these fluids with the silicone brake fluid (MIL-B-46176/BFS) will cause possible brake fade problems and other system malfunctions when subjected to these operating environments.

G. HYDRAULIC FLUIDS

Self propelled artillery and other tactical materiel currently using OHT hydraulic fluid (MIL-H-6083) should, wherever possible, change to FRH hydraulic fluid (MIL-H-46170). FRH is more capable of sustained performance in a high ambient temperature environment because it uses a synthetic base fluid and it also offers some fire resistance protection. Both FRH and OHT are compatible with each other.

H. FUEL CONVERSIONS AND VEHICLE PROCEDURES:

1 Do you have to change fuel filters on vehicles or equipment that had previously used diesel fuel when using JET A-1 or JP-5?

ANSWER: No. No requirement exists for changing fuel filters on those vehicles or equipment that have been routinely exercised and properly maintained. If they have had extended periods of inactivity or there is some suspicion that maintenance may not have been as complete as desired, changing of fuel filter elements should be considered as an insurance measure.

2 Are there any special requirements for servicing tank truck refuelers that have previously hauled diesel fuel prior to their use with JET A-1 or JP-5?

ANSWER: No. If the tank truck refuelers will be servicing only ground vehicles or equipment, no special requirements or changes are needed. For example, the dispensing filter/separator element does not need changing.

YES. If these tank truck refuelers are to service any aircraft or helicopters, the tank interior and lines should be flushed at least once with JP-5 or JET A-1, and the dispensing filter/separator element replaced.

3. Will there be additional maintenance problems if JET A-1 or JP-5 are use in vehicles or equipment that previously used diesel fuel?

ANSWER: No. There will be no problems if the vehicles or equipment have been routinely operated and properly maintained. There could be a slight increase in replacement of fuel filters if the vehicles or equipment have been inactive or not had proper maintenance such as routine removal of water and debris from fuel cell or tank sumps, etc.

4. What procedures should be followed to remove residual fuels from combat/tactical vehicles that are experiencing excessive fuel filter plugging problems?

ANSWER: Vehicle fuel filters will eventually remove this contamination but may require a large number of filter changes. The best solution is to clean the fuel tank by flushing with new fuel as follows:

a. Pump out and drain all old fuel from each fuel tank.

b. Fill with the new fuel and run the vehicle for at least fifteen minutes preferably over rough terrain to provide agitation.

c. Remove the flush fuel and discard or label for special use (i.e., intended for non fuel-sensitive ground vehicles or equipment).

d. New filters should then be installed on the vehicle and new fuel put into the vehicle.

e. The new fuel, either JET A-1 or Diesel should be treated with the FSII or the diesel fuel stabilizer to prevent further microbiological growth.

Flushing may not be practical, particularly when there is no use for the flush fuel or it cannot be discarded easily. In these cases, a refueling vehicle, such as a HEMTT tanker, Tank and Pump Unit, etc., may be used. It should never be designated for aircraft refueling. For this case, the alternative procedure is:

a. Fill vehicle with the new fuel. Run the vehicle for at least fifteen minutes to agitate the fuel.

b. Connect defueling hoses from the refueler vehicle to the inlet connection(s) on the vehicle fuel tank.

c. Defuel the vehicle's fuel tank(s) through the refueling vehicle's filter separator.

d. Add either FSII or the diesel fuel stabilizer to provide insurance against further microbiological growth.

e. Refuel the vehicle with the filtered fuel.

f. Discard the filter element on the refueler vehicle.

g. If refueler is to be used later for aircraft refueling, it must be thoroughly cleaned as per instructions in FM 10-71.

h. New fuel filters should be installed on the vehicle and new fuel added.

i. Treat the new fuel with FSII or the diesel fuel stabilizer to prevent further microbiological growth.

FUEL AND LUBRICANT RECOMMENDATIONS[1] FOR GROUND MATERIEL IN OPERATION DESERT SHIELD

PRODUCT	SPECIFICATION/MILITARY SYMBOL	RECOMMENDED USE
Fuels	MIL-T-5624/JP-5 ASTM D1655/JET A-1[2] W-F-800/Grade DF-2 (OCONUS)	Use only JP-5, JET A-1, or DF-2 (OCONUS). MIL-F-16884/DFM is an acceptable alternate fuel.
Engine Oils		
— Internal Combustion	MIL-L-2104/OE-HDO MIL-L-21260/PE	Use only OE/HDO-15/40 or OE/HDO-40. Use only PE-15/40 or PE-40.
— Turbine	MIL-L-23699	Use only MIL-L-23699.
Gear Oils	MIL-L-2105/GO	Use only GO-85/140 or GO-80/90.
Hydraulic Fluids	MIL-H-46170/FRH	Use only FRH as it possess superior high temperature operability over OHT (MIL-H-6083) and offers greater fire resistance.
Transmission Fluids[3]	MIL-L-2104/OE-HDO MIL-L-21260/PE DEXRON Fluid	Use only OE/HDO-15/40 or OE/HDO-10. Use only PE-15/40 or PE-10. If DEXRON Fluid is not available, use of OE/HDO-10 is acceptable.
Brake Fluids	MIL-B-46176/BFS	Use only BFS as other conventional brake fluids (e.g., DOT 3) are unacceptable.
Greases	MIL-G-0010924E/GAA MIL-G-10924F/GAA	Use current GAA (i.e., E & F versions only). GAA can be substituted in ground vehicle/equipment applications currently specifying WIR (MIL-G-83122).
	MIL-G-83122/WIR	Use for all WIR applications. WIR may be used as substitute for GAA if GAA is not available.

1/ Recommendations given are not intended to supersede existing LUBE Order documents.
2/ JET A-1 is JP-8 without its three mandatory additives.
3/ Products being recommended apply to all vehicles except M1/M1A1 series Abrams tank. For M1/M1A1, use only OE/HDO-30 or PE-30 in transmissions.

(ENCLOSURE 1)

PRODUCT	SPECIFICATION/MILITARY SYMBOL	RECOMMENDED USE
Coolant/Antifreeze	MIL-A-46153	Use 50:50 mixture of MIL-A-46153 and water. Do not use commercial antifreeze formulations. Use only potable water.
— Test Strip Kit	A-A-51461	Use to monitor condition/quality of antifreeze in service. Test strip should give blue color rating. If green, add Extender Additive (MIL-A-53009). If yellow, replace antifreeze.
— Extender Additive	MIL-A-53009	Add to antifreeze if Test Strip Kit gives green color rating.
Weapons Lubricants	MIL-L-46000/LSA MIL-L-46150/LSA-T DOD-L-85336 MIL-L-63460/CLP	Use lubricant as is specified on LLBE Orders
Fuel Additives	MIL-I-27686/FSII MIL-I-85470/FSII MIL-S-53021	Use either FSII or Diesel Fuel Stabilizer (MIL-S-53021) to control microbiological growth problems (i.e., bugs in fuel).

Appendix B

TRIP REPORT, 02-13 DECEMBER 1990 "INVESTIGATION OF THE USE OF JET A-1 FUEL DURING OPERATION DESERT SHIELD," DATED 17 DECEMBER 1990

DEPARTMENT OF THE ARMY

US ARMY BELVOIR RESEARCH DEVELOPMENT AND ENGINEERING CENTER
FORT BELVOIR, VIRGINIA 22060-5606

STRBE-VF (620)

17 December 1990

TRAVEL MEMORANDUM

SUBJECT: Trip Report, 2 December through 13 December 1990, Investigation of the Use of JET A-1 Fuel During Operation Desert Shield, Riyadh and Dhahran, Saudi Arabia, Travel Order Number 11634

THRU: Director, Materials Fuels and Lubricants Laboratory
Associate Technical Director (R&D)
Commander, US Army Belvoir RD&E Center

TO: Commanding General, US Army Troop Support Command

1. PURPOSE OF TRAVEL: Mr. LePera visited Saudi Arabia as a member of the three man team which had been requested by ARCENT G-4 (Enclosure 1). The purpose of this visit was to determine the impact on Command readiness posture when using JET A-1 aviation turbine fuel in diesel fueled ground materiel. The evaluation was to encompass maintenance, safety, fuel quality, product availability, smoke generation, and any other problems issues.

2. SYNOPSIS OF ESSENTIAL INFORMATION:

a. Background: JET A-1 fuel had been initially identified as the single fuel to be used for both aviation and diesel fueled ground materiel assets involved in Operation Desert Shield. During the initial two months following deployment, a series of fuel-related vehicle and equipment problems surfaced which apparently created a concern among some of the using units as to the acceptability of JET A-1 (JAL) in diesel fueled engines and other diesel fuel consuming materiel. This concern intensified with two reported armor vehicle fuel fires (i.e., M109 and M548) in which the JAL was unfortunately identified as contributing to the hazard. With the scheduled deployment of the 7th Corps from Germany and the need to project future ground fuel requirements, BG Monroe (ARCENT G4/Deputy Host Nation Support) directed that facts be developed upon which a decision could be made. Initially, a JAL Fact Finding Trip was conducted by CW4 Robinson (Maintenance Technician, ARCENT G4) during 23-25 November 1990. As these findings apparently generated additional questions,

STRBE-VT 6300, 17 December 1990
SUBJECT: Trip Report, 2 December through 10 December 1990, Investigation of the Use of JET A-1 Fuel During Operation Desert Shield, Riyadh and Dhahran, Saudi Arabia, Travel Order Number 11834

BG Monroe then requested that a team visit Saudi Arabia and thoroughly evaluate all issues relative to using JAI in Operation Desert Shield (Enclosure 1).

The team subsequently assembled included COL R. M. Weimer (Project Manager for Petroleum and Water Logistics), Mr. M. E. LePera (Belvoir RD&E Center, TROSCOM), and Dr. R. E. McClelland (Automotive RD&E Center, TACOM). COL Weimer was the team chief. CW4 S. R. Robinson (ARCENT G4) was also a member of this team. At the onset of the visit, ARCENT G4 had generated a series of issues/questions that were to be covered during the investigation. These issues were provided in the AFRD-GD Memorandum dated 5 December 1990, subject: Fuel Option for Operation Desert Shield (Enclosure 2).

Following the initial briefing on 6 December 1990 at ARCENT G4 in Riyadh, the team traveled to Dhahran and subsequently conducted a series of visits to field units to collect facts, opinions, perceptions, and other pertinent data. A total of some sixteen plus activities/units were visited during the period 7-10 December 1990 in an attempt to collect the necessary data as a means to address all issues/questions listed in Enclosure 2. These activities/units included both US Army and US Marine Corps as well as commercial contractors in-country. Following these visits and assessing of all collected data, a briefing was prepared and given to BG Monroe and his staff as well as representatives from CENTCOM's J3 on 11 December 1990.

c. Key Accomplishments: The investigation revealed the primary problems are occurring in certain wheeled vehicles and generator sets with three fuel pump systems involved, namely, (1) the Fuel Transfer Pump in the Cummins NTC 400 engine which powers the M915, (2) the Stanadyne DB2 Rotary-type Fuel Injector Pump in the General Motors Corporation 6.2L engine which powers the CUCV and HMMWV series of vehicles, and (3) the Stanadyne DB/DC Rotary-type Fuel Injector Pumps used in the 4/6-Cylinder engines which power the 15KW, 30KW, and 60KW generator sets. In gathering this information, many inconsistencies surfaced wherein conflicting statements were given within the same units; that is, one operator was very supportive in using JAI whereas another operator would be very critical of JAI. Specific facts were relatively hard to obtain as vast numbers of fuel pumps had been turned in but few had been actually disassembled to assess the cause of their failure. In addition to the significant affects of heavy contamination of fuel by the talc-like sand, there were

STRBE-VT 8996, 17 December 1990
SUBJECT: Trip Report, 2 December through 13 December 1990, Investigation of the Use of JET A-1 Fuel During Operation Desert Shield, Riyadh and Dhahran, Saudi Arabia, Travel Order Number 11604

a number of "quickie fixes" that obviously have contributed to the reported problems; e.g., breaking the glass bead in the fuel return check valve in the Standyne DB2 pump, unauthorized additions of engine oil, transmission fluid, hydraulic fluid, brake fluid, removal of fuel filters, etc. Specific findings are briefly summarized as follows:

(1) M915 Fuel Transfer Pump. This part also exists on M2, M3, M809, M939, and M9. However, failures have only occurred on M915s as severe line haul duty exacerbates the problem. Failure is definitely fuel and ambient temperature related. Cummins has already developed an alternate part (i.e., the Bronze Bushed version) which has since been incorporated into the 600hp M2/M3 version. As failures can be expected to continue with JA1 at higher ambient temperatures, recommend that this part be replaced on M915 and Bradley fleets only.

(2) CUCV/HMMWV Stanadyne DB2 Rotary-type Fuel Injector Pump. Failure rate was higher for the CUCVs than HMMWVs. Early version Flex Ring component (prior to 1985) failure is predictable and evident. Dirt accounts for a significant percentage of failures; however, the mixture of failure modes makes the fuel contribution to failures very difficult to determine. Recommended that the "Arctic modification" pump be procured for replacement and that TACOM conduct a detailed survey of failed pumps. Improved filtration on vehicles will reduce the failure rate.

(3) Stanadyne DB/DC Rotary-type Fuel Injector Pumps on 15, 21, and 60 KW Generator Sets. The Stanadyne DB/DC pumps are not the same as the DB2 version used in the CUCV/HMMWV; however, they are fuel lubricated and fuel sensitive. The mode of operation for these generator sets has been relatively severe and far in excess of what CONUS service has been. The impact of JA1 is not conclusive as such. Five (5) failed pumps returned to CONUS have revealed the failure was not related to use of JA1, but instead excessive contamination, removal of inlet filters, and improper assembling of components.

(4) Engine Oil Usage and Change Intervals. Contrary to previous information, units are unfortunately using engine and gear oil products (i.e., MIL-L-2104 and MIL-L-2105) manufactured by the Battenfeld companies. These products were improperly formulated and are not specification quality products. Messages

have been distributed to units advising them not to use any Battenfeld product but either because of supply/distribution problems or other unknown reasons the products are apparently being used. Of equal concern was the finding that MIL-L-46152 (the administrative serve engine oil) oils are also being utilized in tactical/combat vehicles. MIL-L-46152 oils are not designed to perform satisfactorily in heavy-duty diesel equipment. Additionally, some motor pools were using commercially-procured oils with little or no identification as to their performance level. The use of non-specification quality oils in an environment as harsh as Saudi Arabia when coupled to the severe service being encountered, the use of a high sulfur diesel fuel, and the questionable oil drain frequencies being utilized can only serve to intensify the potential for failure of oil-wetted engine components and/or significant increases in engine maintenance problems.

As was noted previously, the findings of this team investigation were briefed to BG Monroe on 11 December 1990. The summary conclusions were as follows:

- Insufficient evident to support conclusion that JAI is a major factor in fuel system failures.
- Non-fuel related variables are major contributing factors (i.e., heat, dirt, usage, known defective parts).
- Failure rates fuel pumps is considered reasonable under scenario (i.e., up to 30% on certain vehicles/equipment).
- Failure rates predictable for some pumps.
- Quality of Saudi Arabian diesel fuel is acceptable (sulfur content exceeds standards, but usable with the understanding that military specification oils are being utilized).
- If smoke is necessary, diesel fuel is required.
- Theater distribution plan can support continued use of JAI.

JTPSE-IT &&Co. 17 December 1990
SUBJECT: Trip Report, 2 December through 13 December 1990, Investigation of the Use of JET A-1 Fuel During Operation Desert Shield, Riyadh and Dhahran, Saudi Arabia, Travel Order Number 11504

c. Reduced availability of JA1 supports putting VII Corps on diesel (RAS TANNOUR refinery fire may impact availability of JA1).

Recommendations were provided to BG Monroe at the end of the briefing. These were (1) the policy of ARCENT in coordination with CENTCOM'S JPO should be that commanders have a "fuel of choice in the theater", and (2) a command message be sent to disseminate the results of this investigation to the field. With this "fuel of choice" policy, JA1 would continue to be used by the 3rd ACR, 1st CAV DIV, 101st AASLT, and USMC whereas diesel fuel would continue to be used by the 18th ABC, 82nd ABN, and the 24th MID. BG Monroe concurred with these recommendations and had requested that the team brief LTG Yeosock. However, the team was subsequently advised that LTG Yeosock also concurred with these recommendations. Prior to departing, a draft command message was prepared for COL Hill's staff by the team which is attached as Enclosure 3.

Apart from the JA1 issue, the writer was requested by CENTCOM's JPO to attend a meeting with representatives from Petromin Lubricating Oil Company regarding an agreement wherein Petromin has been identified as the company who will be supplying all packaged Class III products to the US at no cost. Abdullah Shalabi Qwaida from Petromin was explaining that Petromin will be furnishing "locally blended products" that include MIL-L-2104D, MIL-L-2104E, MIL-L-46152D, Dexron and MIL-F-12070. Additionally, they plan to provide additional "imported products" that include all other fluids, lubricants, and greases used by DOD. It was not clear as to how they are to be obtained or whether Petromin would become a reblender or rebrander of these other assorted products. Of immediate concern however was Abdullah Shalabi Qwaida's desire to furnish the MIL-L-2104D MC-3076 QPL product which was an obsolete approval containing an Paramins additive system. In checking with Belvoir RD&E personnel, the MC-3076 was one of the approved formulations that EXXON had recently "decommercialized" because of the current on-going investigation by the Defense Criminal Investigative Service (DCIS). Since there is a question as to whether this formulation really possesses OD-II performance quality, the writer requested that DOD not accept this product due to the risks involved and also because of legal implications. In terms of packaging, MIL-L-2104 products will not be provided in 1 Qt (1 liter) cans but only in

resealable 1 Gal (3.8 liter) cans and drums. This will be the major supporting area to receive all the Petromin products.

c. Required Actions: An Action List has been prepared as a follow-up to this visit and is attached as Enclosure 4.

d. Recommendations: Those items listed under the Action List (Enclosure 4) will be executed as quickly as possible. Because much of what was learned during this visit reflected a basic misunderstanding of JET A-1 capability in fully satisfying diesel engines which also became clouded by other factors such as excessive sand/dirt contamination, questionable maintenance, etc, additional mechanisms for quick dissemination of information to the field will be initiated to hopefully clarify some of the incorrect perceptions that currently exist. In this context, a summary listing of observations gathered by the writer during visits to the some sixteen units was generated. This summary listing entitled "Observations and Facts Gathered During Investigating Use of JET A-1, 7-10 December 1990" is attached as Enclosure 5.

3. REQUIRED FOLLOW-UP MILESTONES: See Enclosure 4

4. ESTIMATED COST: Approximately $1131.

Maurice E. Lepera

Enclosures

MAURICE E. LEPERA
Chief, Fuels and Lubricants Division
Materials Fuels and Lubricants Laboratory

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HQ AMC
TELECOMMUNICATION CENTER

PAGE 2 0200.3 2./0735Z
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RHCOSRB/USARCENT REAR FT MCPHERSON GA//AFRD-CS//
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RUKGNBA/CDRBRDEC FT BELVOIR VA//
RUQCHAA/DFR MIDEAST BAHRAIN//
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BT
UNCLAS
SUBJ: USE OF JET A-1 DURING OPERATION DESERT SHIELD
1. SEVERAL ISSUES SURROUNDING THE USE OF JET A-1 FOR GROUND VEHICLES HAS ARISEN. IN ORDER TO PROPERLY EVALUATE THE USE OF JET A-1 DURING OPERATION DESERT SHIELD REQUEST YOUR OFFICE COORDINATE A 2-3 MAN TEAM OF EXPERTS TO SEND TO SAUDI ARABIA IN ORDER TO EVALUATE THE ISSUES. THE ISSUES INCLUDE: CHARACTERISTICS OF JET A-1 COMPARED TO DF-2, SAFETY OF JET A-1, MECHANICAL PROBLEMS THAT MAY BE CAUSED BY JET A-1, LUBRICITY OF ADDITIVES AND JET A-1 AND JET A-1'S LONG-TERM EFFECT ON ENGINE PARTS GIVEN THE OPERATING CONDITIONS IN THE MIDDLE EAST.
2. REQUEST NAME, GRADE, SSN, ORGANIZATION OF TEAM MEMBERS WITH PROJECTED VISIT SCHEDULE BE FORWARDED TO THIS HQ AS SOON AS POSSIBLE. THE TEAM WOULD INBRIEF AT ARCENT G-4 UPON ARRIVAL.
3. THE POC FOR THIS ACTION IS COL HILL, COMM 473-1963 OR MAJ BOCHERT COMM 966-1-477-[illegible] EXT 4157.
BT
#0599
NNNN

(ENCLOSURE 1)

HEADQUARTERS
UNITED STATES ARMY CENTRAL COMMAND MAIN
RIYADH, SAUDI ARABIA
APO NEW YORK 09852

AFRD-GD 5 December 1990

MEMORANDUM FOR Colonel Robert M. Weimer, PM, Petroleum & Water, TROSCOM
Mr. Maurice E. Lepera, Chief Fuel & Lubricants Division, Ft Belvoir Research & Development
Mr. Richard E. McClelland, Chief, Propulsion Systems Division

SUBJECT: Fuel Options for OPERATION DESERT SHIELD

1. Request the following issues be addressed at the conclusion of your investigation:

a. Does Jet A-1 cause mechanical problems? Diesel oil?

b. If mechanical parts are effected due to the use of Jet A-1 what is the expected risk of failure? Also for Diesel oil?

c. Does the Saudi Arabian Jet A-1 meet acceptable standards and if not what are the differences?

d. Are there any additives that can be added to Jet A-1 that will alleviate the lubricity problem should there be one?

e. What is the risk of using Saudi Arabian Diesel oil in Army ground equipment (sulfur content and cloud point)?

f. Are there any additives or blending procedures to bring Saudi Arabian Diesel oil into spec, if it is out?

g. Will Commanders support the use of Jet A-1 fuel as their primary fuel if the issue of possible mechanical failures is resolved?

h. Can the Commanders use Jet A-1 with additives to make smoke?

i. Are there any other Diesel oil characteristics that will effect the performance of Army equipment? Any other Jet A-1 characteristics?

j. What do you recommend as the primary fuel for Operation Desert Shield be? Provide rationale.

(Enclosure 2)

AFRD-GD
SUBJECT: Fuel Options for OPERATION DESERT SHIELD

k. What is the best method available in order to build the confidence of the commander for your recommended fuel?

l. Analyze the reasons for different failure rates in units using Jet A1 and Diesel oil.

m. Why is Jet A-1 being used instead of diesel? Why should diesel be used instead of Jet A-1?

n. Are there any safety impacts of Jet A-1 relative to flash point? Is Jet A-1 safe?

o. Are engines on ground equipment designed to operate on more than one type of fuel? Is Jet A-1 included?

2. Due to the sensitive nature of this subject and the critical time schedule to build fuel stocks in country, it is requested that the investigation be conducted in the shortest and most efficient manner possible.

3. POC this action is MAJ Bochert, ARCENT G4, COMM 403-9756.

JAMES W. MONROE
Brigadier General, U.S. Army
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-DRAFT-

FM CDR USARCENT (MAIN)
TO AIG

SUBJECT: FUEL IN THE SWA THEATER OF OPERATIONS

1. SEVERAL STUDIES HAVE BEEN CONCLUDED TO EVALUATE THE USE OF DIESEL AND JET A1 FUELS IN THEATER. THE AIM OF THESE STUDIES WAS TO ANSWER: SHOULD WE INSIST ON A SINGLE FUEL ON THE BATTLEFIELD. THE ANSWER IS NO.

2. SPECIFICALLY, THESE STUDIES HAVE ADDRESSED:
   a. FUEL RELATED MAINTENANCE PROBLEMS
   b. QUALITY OF FUELS BEING PROCURED
   c. RELATIVE SAFETY OF THE TWO FUELS
   d. VEHICLE ENGINE EXHAUST SMOKE SYSTEM (VEESS)
   e. AVAILABILITY AND DISTRIBUTION

3. THE CONCLUSIONS ARE AS FOLLOWS:

   a. WHILE MOST OF THE EQUIPMENT IN THEATER HAS PERFORMED SATISFACTORILY IN SWA, TWO SYSTEMS HAVE EXPERIENCED UNACCEPTABLE FAILURE RATES. THE M915 SERIES VEHICLES ARE SHOWING A HIGH FAILURE RATE OF THE FUEL TRANSFER PUMP. AS THIS IS A KNOWN FAILURE MODE ON LOW VISCOSITY FUELS, USE OF DIESEL FUEL IS ENCOURAGED. ALL SYSTEMS USING THE STANADYNE ROTARY FUEL PUMP (CUCV, HMMWV, AND 15, 30, 60 KW GENERATOR) ARE ALSO SHOWING HIGH FAILURE RATES. THE PRIMARY FAILURE MODE APPEARS TO BE DIRT. FAILURES OF THE GOVERNOR RETAINER IS NOT FUEL RELATED AND WILL BE ADDRESSED BY MWO ASAP. THE COMMON PRACTICE OF REMOVING THE PRESSURE REGULATING "GLASS BALL" AS A FIELD EXPEDIENT FIX CEASED AND REPLACEMENT BALLS ORDERED.

   b. THE USERS OF JET A1 NEED TO BE REASSURED THAT JET A1 IS AN ACCEPTABLE SUBSTITUTE FOR DIESEL AND IS BEING SUCCESSFULLY USED BY A LARGE PERCENTAGE OF USERS WITHIN THE THEATER . ADDITION OF OILS, FLUIDS, ETC. INTENDED TO IMPROVE LUBRICITY MUST CEASE AS THE UNCONTROLLED USEE AND QUESTIONABLE LONG TERM EFFECTS OF THE ADDED MATERIALS ARE A CONCERN. THE ADDITIVE COMMONLY USED BY THE AIR FORCE TO ENHANCE LUBRICITY 9I.E., MIL-I-25017) WILL BE ADDED TO GROUND FUEL STOCKS AT THE WHOLESALE LEVEL.

   c. THE COMMERCIAL DIESEL BEING PROVIDED IN COUNTRY IS NOT TYPICAL OF CONUS AND GERMANY. ALTHOUGH IT POSSESSES HIGHER FUEL SULFUR CONTENT, ITS USE SHOULD CREATE NO PROBLEMS IF OIL CHANGE FREQUENCIES ARE HALVED AND USEE OF APPROVED MIL-SPEC OILS IS ADHERED TO.

(Enclosure 3)

d. JET A1 FUEL IS AFE FOR USE IN ALL GROUND VEHICLES AND EQUIPMENT. "FUEL RELATED" FIRES IN VEHICLES HAVE NOT BEEN PROVEN TO BE CAUSED BY CHOICE OF FUEL. FUEL FIRES IN THE ENGINE COMPARTMENT CAN OCCUR WITH EITHER DF2 OR JET A1 WITH EQUAL LIKELIHOOD.

e. THE VEHICLE ENGINE EXHAUST SMOKE SYSTEM (VEESS) ON ARMORED VEHICLES IS INEFFECTIVE WHEN FUELED WITH JET A1. IF SMOKE IS CRITICAL TO COMMANDERS OPERATIONAL PLANS, DIESEL FUEL SHOULD BE USED.

f. AVAILABILITY OF ADEQUATE SUPPLIES OF BOTH DIESEL AND JET A1 APPEARS TO BE ASSURED.

4. THE POLICY OF ARCENT, COORDINATED WITH CENTCOM JPO, IS THAT WE HAVE A FUEL OF CHOICE IN THE THEATER. ITS AVAILABILITY WILL DEPEND UPON ACCURATE FORECASTS.

ACTION LIST EVOLVING FROM TRIP TO
SAUDI ARABIA, 2-13 DECEMBER 1990

1. Check on availability of Ball-On-Cylinder Lubricator Evaluation (BOCLE) test apparatus for shipment to 240th QM BN as a means to enhance their capability for monitoring adequate levels of MIL-I-25017 corrosion inhibitor in JET A-1. This needs to be expedited as quickly as possible.

2. Develop a field procedure for addition of MIL-I-25017 to tank truck quantities (Note: procedure should be similar to that which was developed for blending kerosene/JP-8 into diesel fuel. This needs to be developed as soon as possible.)

3. Advise Defense General Supply Center that units are not able to requisition adequate amounts of packaged products and some are unable to obtain OE/HDO-15/40.

4. Develop information on cool-down rates of diesel fuel in M1A1 fuel tanks and clarify wnether start-up at an ambient equal to a fuel's cloud point will create starting/operational problems.

5. Develop a relatively simple procedure for 240th QM BN to enable their being able to rapidly determine the presence of micro-organisms in fuel samples. Also, consider developing an easier means to add biocides to either diesel fuel or JET A-1.

6. Develop a list of recommended oil change intervals for vehicles/equipment operating in Saudi Arabia on either JET A-1 or commercial diesel fuel and coordinate with TACOM. This is needed as no AOAP is being performed on ground materiel.

7. Follow-up on the Petromin Lubricating Oil Company's new agreement with DOD and process any waivers required for the MIL-L-46152 and the obsolete OE/HDO-50 products which are being requested by the USMC. Advise the Defense Criminal Investigative Service (DCIS) as to the planned use of MC-3076 formulation.

(Enclosure 4)

OBSERVATIONS AND FACTS GATHERED DURING INVESTIGATING
USE OF JET A-1, 7-10 DECEMBER 1990

The following is a series of observations and facts that were gleaned from the visits/interviews which occurred in Saudi Arabia during the period of 7-10 December 1990.

- Potential for talc-like sand contamination in vehicle/equipment systems is overwhelming and appears primarily responsible for large numbers of fuel-related maintenance problems.

- More rigorous maintenance of vehicles/equipment needed due to harshness of environment (i.e., oil drain frequencies being halved, increased replacement of fuel filters, etc) appears to be falling considerably short of its mark.

- Operating frequencies/usage rate of vehicles/equipment would appear for some items to be far in excess of original design criteria and for others considerably in excess of either past CONUS or NATO practices.

- Quality of lubricants products is highly questionable and unacceptable in some instances as (1) Battenfeld products are being routinely utilized, (2) administrative service (i.e., commercial vehicles) engine oils (MIL-L-46152) are being used in combat/tactical heavy duty engines, and (3) commercial locally-procured oils are being used and no one has any idea as to the performance levels of these products. When questioned as to the rationale for these unacceptable practices, field personnel indicated that either nothing else was available or that product was being provided in response to their requisitions.

- Many "failures" on the Stanadyne Fuel Injector Pump have been reported but no quantitative determination has been performed to assess whether the pumps had actually failed and what had caused the failure. In many cases, only one or two pumps out of a total of forty plus pumps had been disassembled and inspected.

- Many of these "failed" Stanadyne Fuel Injector Pumps in all probability had their glass bead check valve broken as this "field fix" became unofficially a cure to the JET A-1 problem.

(Enclosure 5)

- The problems occurring on the Cummins Fuel Transfer Pump in M915 appears primarily related to use of JET A-1. However, the usage of the M915s in Saudi Arabia far exceeds any operating practices ever encountered previously.

- The problems in the Electric Fuel Pump of the PATRIOT's powerplant system that reportedly occurred with JET A-1 remain a mystery. The PATRIOT batteries in/or near Riyand are using JET A-1 successfully with no problems. Those PATRIOT batteries near Dhahran and elsewhere have converted back to diesel fuels because of repeated pump "burn-outs" that reportedly occurred when using JET A-1.

- Operator's perception seems to be one of the primary factors in the acceptance or rejection of JET A-1 fuel. In some locations visited, one group would be "pro JET A-1" whereas another group within that same location would be "anti JET A-1". Any facts solicited were generally qualitative at best.

- Idea of JET A-1 solvency and detergency (i.e., it cleans out fuel tanks that had previous service with diesel fuel) is widespread and is being used as the basis for many reported problems. Unfortunately, the facts do not appear to support this as no FSII was found in those samples of JET A-1 taken. Moreover, no one appears to be adding FSII to the JET A-1 fuel.

- Idea of JET A-1 having "insufficient lubricity" has become an institutionalized "fact of life" with field personnel. Because of the strong belief which exists, many units are routinely adding quarts of oil, transmission fluid, hydraulic fluid, etc. to the JET A-1 in varying amounts and maintain this makes their equipment run better. Based upon limited testing to date, addition of these oils/fluids does not offer any real enhancement off lubricity but instead can increase fuel system and engine maintenance problems. The problem has been made worse by (1) correspondence from Cummins Engine Co in the United Kingdom which in fact suggests adding up to 20% engine oil, (2) informal recommendations given by some of the in-country LARs, and (3) recommendations given by the General Dynamics Land Systems support group in-country.

- Evidence available indicate no FSII being added to JET A-1 or diesel fuel nor any MIL-S-53021 diesel fuel stabilizer being added to diesel fuel as a means to control growth of micro-organisms in fuel tank environments. In the environment which exists in Saudi

Arabia, continued use of JET A-1 or diesel fuel unreared can only increase probability for microbiological growth problems. Moreover, many of these "problems" which have occurred could have been the result of micro-organisms being present.

- The fuel safety issue (i.e., JET A-1 will cause explosions) was improperly reported. The M109 had a leaking fuel pump, its wires were exposed, the engine was running at the time while it concurrently was being fueled, yet JET A-1 was identified as contributing to the fire. If diesel fuel had been used, a similar fire would also have occurred under those conditions.

- Many units that had experienced problems with use of JET A-1 early on now say the problems have diminished. Their belief is based upon the "flushing theory". This reduced intensity in problems may be the result however of operator familiarity, a better understanding of JET A-1's acceptable performance, initiating increased maintenance, etc.

- Many commercial fuel tanker operators hauling fuel from Dhahran to field locations routinely operate with the tank compartment covers open which only serves to increase fuel contamination problems.

INVESTIGATION OF USING JET A-1 IN OPERATION DESERT SHIELD -
Chronology of Meeting/Visit Summaries, 7-10 Dec 1990

Initial Meeting with COL Hill of ARCENT MAIN G4 and CENTCOM JPO (6 December 1990):

Preliminary guidance was given as to what was expected to be accomplished. JPO personnel explained that two corps are established with one additional corps being provisional. A total of 4M gallons/of fuel/day is the current projected requirement for the Army with essentially 2M gallons/day per corps. The ratio of Jet A-1 (JA1) to diesel fuel is 30:70. A brief comment was made relative to the reported M109 fuel fire which had been the basis for subsequent statements that JA1 was an unsafe fuel. The wires to the fuel pump ignited the leaking fuel and the heater was being operated. However, there was no connection of the heater being operated and the JA1 leaking from the fuel pump.

SUPPORT COMMAND (6 December 1990):

LTC Carr of SUPCOM provided a brief overview of the POL supply/distribution picture. Fuel is being moved primarily by line haulers (M915s and commercial tank trucks) out of Dhahran. There will be three corps established. When established, the fuel requirements may peak at 15M gallons/day. The USMC have no intent to change back to diesel. We were asked to nail down the maintenance issue. More discussion evolved relative to the one M109 fuel fire. As was explained, the fuel pump on the engine was loose, the wires to it were loose, the engine was running, fuel spillage occurred, the vehicle was being fueled, and the heater was being operated. As is obvious, the fuel fire was totally not related to the heater operation or to JA1. JA1 merely became a convenient scapegoat.

475th QM GROUP (7 December 1990):

It was reported that the 3rd ACR does not want to convert back to diesel fuel as their preference is JA1. A draft petroleum distribution plan was discussed.

240th QM BATTALION (7 December 1990):

An urgent need exists for having the two mobile petroleum laboratories perform the Ball-on-Cylinder Lubrication Evaluator (BOCLE) test on JA1 after USAF has injected the MIL-I-25017 corrosion inhibitor. This test is not available in country and samples must be flown to Europe for determining if the proper amount of inhibitor is present. Because of the urgency, Belvoir agreed to see whether we could directly purchase one or possibly two BOCLE units and have them air shipped to the 240th QM BN. Mention was made of a FOX vehicle fuel contamination problem where rather large amounts of water contamination had occurred. The 240th QM BN has run some 700 fuel sample analyses to date. There has been a policy established on checking fuel from commercial tankers and on tanker inspections themselves. All tankers are being top-loaded.

46th COMBAT SUPPORT GROUP (7 December 1990):

MAJ Griffin reported 23 out of 47 M915s were down because of JA1. "It burns hotter, gives less power, and degrades O-rings." The M915s came from Ft Benning and are about 10 years old. Several operators were reportedly mixing DEXRON, OHT/FRH, or Two-Cycle Engine Oil (TC) at the dosage of 1 QT/50 GAL to correct the problem. They also have 7-8 HMMWVs down because of JA1 and have changed over to diesel fuel for generator sets. Cold cranking also is a problem with using JA1. MAJ Grifffin said you can use JA1 if you properly flush the vehicle's fuel system, but he felt the M915s are really being strained. He also asked the question of why are we extending ourselves in trying to use JA1.

GENERAL DYNAMICS LAND SYSTEMS (7 December 1990):

An overview was given by CPT D'Alio who is the COR for the in-country GDLS contract. He provided the opinions given by Cummins and Detroit Diesel and also distributed the Cummins Daventry letter which shows that 20% of oil must be added to a kerosene fuel to have it give an equivalent diesel fuel viscosity. CPT D'Alio briefly commented on the M915 fuel transfer pump problem. Numbers were given such as 1105 M915s had been processed in the past 85 days. Of those, 23 had either turbocharger, fuel pump, engine problems, etc. maintenance. Some 4-5 of these had fuel transfer pumps with broken shafts. He again reiterated that Cummins Daventry (UK) does not recommend using JA1 as the pump was designed solely for diesel fuel. CPT D'Alio also reported that they had a number of HMMWVs that had a low end knock problem which resulted in some 15 engines being replaced. Regarding the Stanadyne fuel rotary injector pump, they worked on some 210 pump failures which occurred in only the first month. However, they disassembled only 2 pumps as the remainder were returned to SASCO for rebuild. CPT D'Alio commented that the 18th ABN Corps is

negotiating a contract with SASCO (Saudi Arabian Engineering Company) to have them (i.e., SASCO) rebuild pumps. Comments were made by other General Dynamics personnel that vehicles are being refueled in dirty environments and that the fuel separators on HEMTTs are being disabled allowing dirty fuel to be introduced into vehicle fuel tanks. They also commented that engine oils being drained from CUCVS AND HMMWVs looks like a very low viscosity fluid (i.e., water-like) and feel this is causing other problems. Mention was also made of a MK4K forklift which has a Stanadyne fuel rotary injector pump and that this had a frozen ball check valve due to dirt/gunk in the fuel. Lastly, CPT D'Allo noted that the 11th ADA Patriot generator sets at the port were having problems with their electric fuel pumps. Three had burned out (i.e., failed) in a row. The unit had subsequently changed the fuel and resolved the problem. They are now using diesel fuel.

533rd TRANSPORTATION MOTOR COMPANY (7 December 1990):

This unit has 50 M915s and 10 have had fuel transfer pumps replaced. These M915s are seeing rather severe line haul service as the M915s have an average of 7600 miles/truck to date. They average 45 line hauls/day and their problems started about two weeks after being in country. Regarding use of JA1, they commented "it burns hot, has a high flash point, and causes oil leaks due to head gasket failures". Their service now is approximately 5 times that which they were doing in the states. They have seen no CUCV fuel pump failures and are still using JA1. Regarding the M915s, they cannot check fuel filters but noted on some transfer fuel pump failures, the fuel filters were examined and found to be clean. They are using OE/HDO 15/40 and change every 6000 miles.

503rd MAINTENANCE BATTALION (7 December 1990):

CPT Starling and SGT Stark commented on the problems with their CUCVs that originates from the residual diesel in tanks and the "flushing action" of the JA1. After about 4 fuel filter changes, the problems become non-existent. They have replaced 550 fuel injector pumps from CUCVs and 15 fuel injector pumps from HMMWVs in the first 30 days of deployment. However, only a few pumps were disassembled and examined. SGT Stark noted the DS in the 82nd ABN DIV reported plugged fuel return check valves on CUCVs and somehow the field units decided to break the glass bead in this fuel return check valve as a quick field fix. Once broken, fuel flow occurs but this then creates secondary problems such as hard starting to occurs which cause the pumps to be returned to the maintenance activity. Another reported fix was to add 1-2 quarts of DEXRON transmission fluid per every two tank-fulls of JA1. They would prefer going back to diesel fuel however.

Again, comments were made that head gaskets are breaking down because of JA1. No nozzle/injector problems were reported. Regarding engine oil, CPT Starling stated they are short on CE/HDO-30. However, their lube stocks revealed sizeable quantities of the Battenfeld's CE/HDO-30 (MC-3298/Batch J-600-89), GO 80/90 (MG-1143/F-644-89) and GO 80/90 (MG-1170/4-616-89) products which were being used. Additionally, quantities of MIL-L-46152 Grade 15W/40 were being used for combat vehicles as well as red 5-gallon pails marked only with "Engine Oil SAE 30". When questioned as to why these products are in use, personnel commented "that is all we were given".

101st ABN DIVISION (7 December 1990):

LTC Nowlin commented that their 801st Maintenance Battalion had questioned using JA1. The generator sets are their major concern. They are having a high number of broken pump shafts and questioned that fuel debris/dirt may not be the root cause of failure, but instead JA1 itself.

801st MAINTENANCE-BATTALION (7 December 1990):

LTC Perry commented that they support some 28 battalions. They have seen a large percentage of fuel injector pump failures on CUCVS/HMMWVs; the problems being either a breakdown of the drive shaft or the key on the drive tang. They suspect fuel lubricity as the problem. Because of the reported flushing action of JA1, they started a process about three weeks ago involving the complete purging of fuel tanks and systems. About 40 plus CUCVs/HMMWVs have been processed to date. Once flushed, there appears to be no more problems. Of all their pump failures, they only examined six fuel injector pumps. Only one had the older flex ring retainer component. Hard starting has been reported on many of their CUCVs. Apparently, the "field fix" of breaking the glass bead in the fuel check valve was evident as 75% of returned vehicles had this glass bead broken. MAJ Curtis stated they seem to have stopped this practice as well as the adding of oil. He commented further that they found some fuel injector pumps on vehicles that had no check valves. When questioned, MAJ Curtis stated that they have seen no nozzle/injector problems.

7th ENGINEER BATTALION, USMC (7 December 1990):

They commented that some of their CUCVs have experienced fuel injector pump failures. However, they strongly support using JA1 or JP-5 in lieu of diesel fuel. In contrasting their experience with that of the US Army, the USMC maintained that a large percentage of their vehicles/equipment was new or from Roll-On/Roll-Off ships whereas a vast majority of Army came from the field and was not in an equivalent "as new" condition.

1st FSSG, 1st MAINTENANCE BATTALION, USMC (8 December 199):

Out of a CUCV density of 600-700 vehicles, they have seen some 180 fuel injector pump failures. It was not abundantly clear as to whether the failed pumps had been taken apart to determine the cause of their failure. They however maintained that dirt was a major contributing factor. It was noted that their oil stocks contained in addition to OE/HDO-15/40 products, commercial CALTEX and CITGO SAE 10W products. No performance level or specification was identified on the containers.

3rd ACR (8 December 1990)

An operator for a 30KW Generator Set was interviewed. He commented that JA1 is being used and there have been no problems. When questioned as to why he was using an OE/HDO-30 product, he commented that the preferred OE/HDO-15/40 was not available.

24th ID, DISCOM (8 December 1990):

The 24th ID when initially deployed in country used JA1 for approximately one month then switched back to diesel fuel. They reportedly ran back-to-back tests in vehicles (i.e., JA1 vs diesel fuel) which confirmed their power loss issue. During that first month, they replaced about 15 fuel injector pumps on CUCVs out of a population of 50-75 vehicles. They have since replaced about 4-5 pumps after changeover to diesel fuel. Some leaking with these fuel injector pumps was noted during use of JA1. In interviewing some personnel within C Company, they reported that using JA1 in their CUCVs had produced no problems. It was equally interesting that some soldiers were convinced that they were using both diesel and JP-4 as the tank trucks deployed from Ft Stewart still had the "JP-4" markings on their sides. In observing their lube oil stocks, Battenfeld OE/HDO-15/40 products were again most visible.

Meeting with TACOM LARs, Dhahran (9 December 1990):

A meeting of all the TACOM LARs was convened to solicit additional information. They reported the following facts -

- Users cannot obtain adequate stocks of OE/HDO-40 oil.
- They (i.e., the LARs) have instructed soldiers not to use any Battenfeld products.
- A fuel pump being replaced does not mean that the pump is defective.

- The Army's maintenance program is essentially non-existent.

- The CUCV water separator sensor was found to be bad in 1984 and GM actually was offering new kits. This problem should not be even remotely associated with DAI.

- Within the 101st ABN DIV, someone had spread the word that you need to break the glass bead in the fuel return check valve (the Stanadyne fuel injector pump) to take care of all problems.

- They did not see a lot of failures with the Cummins fuel transfer pump in the M915s.

- This "perceived fuel problem" is really a preventative maintenance problem.

- Operators of fuel tank trucks are having their lids left open which obviously allows for greater dirt/sand contamination.

- Units in some instances have not replaced secondary filters and also are installing filters improperly.

- Units are not changing oil as frequently as they should.

- The 533rd S&S Battalion was sent a drum of Battenfeld engine oil from the New Cumberland Army Depot. Even they were surprised that this shipment had occurred.

US ARMY SUPPORT CENTER/DESCOM (10 December 1990):

This activity was visited in an attempt to collect data on failed Stanadyne fuel injector pumps. Serial numbers was taken on a number of fuel pumps that had been turned in. The numbers were collected in an attempt to ascertain whether the pumps were 1985 vintage or later. Although none of these had been disassembled, this activity was starting to become a depot activity to essentially rebuild the Stanadyne fuel injector pumpsand other component items.

429th REPAIR PARTS COMPANY (10 December 1990):

This unit was queried on whether they had received/processed any failed Stanadyne fuel injector pumps. None were available as a number had recently been shipped to Maintz Depot in Germany for rebuild.

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Appendix C

BELVOIR RD&E CENTER DATA COLLECTION PLAN/ QUESTIONNAIRE

DEPARTMENT OF THE ARMY LEPERA/jr/AV345-3416
US ARMY BELVOIR RESEARCH DEVELOPMENT AND ENGINEERING CENTER
FORT BELVOIR VIRGINIA 22060-5606

REPLY TO ATTENTION OF

FUELS AND LUBRICANTS DATA COLLECTION PLAN

Objective: To define Petroleum, Oils, and Lubricants (POL) problems encountered during Operation Desert Shield/Storm (ODS) and determine changes needed in POL equipment, utilization practices, and necessary product research and development.

Scope:

- Products- Fuels, engine and drivetrain oils, greases, brake and hydraulic fluids, coolant/antifreeze, and weapons lubricants.
- Equipment- Combat and tactical vehicles and combat service support equipment.

Approach:

- Questionnaire- A list of generic questions has been developed and is attached. Team members will collect qualitative and where possible quantitative data on POL issues. Units contacted are not asked to complete any questionnaire or forms, but any supporting documentation developed prior to the visit would be appreciated.
- Interviews- Candidate units and representative target hardware are shown on attached list. Respondents desired include: Staff level POL officers (S-4), unit level maintenance and motor pool officers/NCO's, and vehicle commanders.
- POL Sampling- Samples of unused fuels, oils and other associated products brought back from South West Asia as part of the unit's basic load will be surveyed. Team members will obtain samples of "used" products from randomly selected vehicles.

SAMPLES OBTAINED FROM

REPRESENTATIVE HARDWARE to be sampled	FUEL CELLS	ENGINE SUMP	HYDRAULIC RESERVOIR	OTHER
M1A1	X	X	X	TRANSMISSION
M2/M3	X	X	X	TRANSMISSION
M88A1	X	X	X	TRANSMISSION
M915 (HET)	X	X	-	-
M109A1/A3	X	X	X	-
M578	X	X	X	-
M985 (HEMTT)	X	X	-	-
M1037 (HMMWV)	X	X	-	-
MEP 30 KW GEN SET	X	X	-	-
150KW/400HZ GEN SET	X	X	-	-

Results:

- o A report on the findings evolving from this survey will be completed by mid July and copies will be provided to those units interviewed.

BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ODS QUESTIONNAIRE

PACKAGED PRODUCTS

	Yes	No
1. Were packaged POL products taken by the units as part of their unit basic load (UBL)?		
2. Were packaged POL products acquired from local companies through local purchasing procedures?		
3. Were POL products packaged in unit quantities that were convenient for use and reduced waste?		
4. Were packaged POL products labeled as to manufacturer, grade, or other information to allow judgment in use?		
5. Did commercial packaged POL products include:		
a. oils		
b. dry lubricants		
c. greases		
d. antifreeze		
e. hydraulic fluids		
f. brake fluids		
6. Were shortages noted in Class III packaged products?		
7. Were any Battenfeld Company manufactured products (i.e., primary engine and gear oils) used?		
8. If Battenfeld products were used, was it because:		
a. Units had not been notified they should not?		
b. Shortages forced the use of the products?		

BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ODS QUESTIONNAIRE

FUELS

	Yes	No
1. Was the fuel delivered to the POL tank farms (bladders, etc.) filtered?		
2. Were any inspections, visual or otherwise, made at the tank farm?		
3. Were any inspections, visual or otherwise, made at unit level?		
4. Were fuel analysis laboratories, either mobile or fixed, available to either or both wholesale and retail levels?		
5. Were any abnormalities noted in the fuels delivered (color, smell, appearance)?		
6. Were the users (operators) satisfied that they received good quality fuel in adequate quantities?		
7. Were logistics, maintenance and user personnel aware of what type and grade of fuel they used?		
8. Were bulk fuels delivered in host nation or other foreign nation vehicles?		
9. Was adequate information supplied down to user level on proper fuels and lubricants utilization practices?		
10. Were the following fuels available for use by military aircraft?		
— JP-4		
— JP-8		
— JP-5		
— Jet A-1		
11. When used in aircraft were problems experienced with one or more of the aviation fuels?		
12. Were the following fuels available for use by diesel-burning ground vehicles and equipment?		
— JP-5		
— Jet A-1		
— DF-2		

BELVOIR RESEARCH, DEVELOP'1ENT AND ENGINEERING CENTER
ODS QUESTIONNAIRE

FUELS (Continued)

	Yes	No
13. Which of the fuels were used in the diesel-burning ground vehicles and equipment? — JP-5 — Jet A-1 — DF-2		
14. Was there any noticeable decrease in power output when aviation fuel was used in diesel-burning ground vehicles and equipment?		
15. Was any blending of engine oils or hydraulic fluids into aviation fuel practiced?		
16. Were any procedures established for changing from one fuel to another, such as DF-2 to aviation fuel or one aviation fuel to another aviation fuel?		
17. Did user personnel know that Jet A-1 fuel was a satisfactory replacement fuel for DF-2?		
18. Were increased replacements of fuel filters needed following changeover?		
19. Did fuel filter plugging occur?		
20. If fuel filter plugging occurred, was it considered excessive?		
21. Was a "black residue" observed on any fuel filters that were changed?		
22. Were biocides/biostats used to control microbiological growth in fuel cells?		
23. Were any additives blended with the Jet A-1 fuel, such as CI, FSII or static dissipater?		

BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ODS QUESTIONNAIRE

FUELS (Continued)

	Yes	No
24. Were fuel handlers and operator personnel fearful that Jet A-1 would be hazardous because of the lower flashpoint?		
25. Were there any "waxing problems" with the use of the host nation supplied diesel fuel?		
26. Were vehicles routinely refueled by:		
— TPU's		
— Military Tankers		
— Commercial Tankers		
27. Was dirt/sand a problem during fuel transfers?		
28. Was there a perceptible increase in maintenance when:		
— DF-2 was used?		
— Jet A-1 was used?		
29. To alleviate dirt/sand problems during fuel transfers, were:		
— Calm atmospheric conditions waited for?		
— Fuel opening recesses blown or brushed free of dirt/sand?		
— Opening of fuel fill ports reduced to a minimum during PM services?		
30. Was there a perceptible increase in fuel injector nozzle fouling when using:		
— DF-2 fuel?		
— Jet A-1 fuel?		
31. Did use of DF-2 in armored vehicles VEESS produce adequate smoke in the high ambient temperature environments?		
32. If vehicles/equipment were using Jet A-1, did they "run hotter?"		

BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ODS QUESTIONNAIRE

FUELS (Continued)

	Yes	No
33. Were there any perceptible problems associated with admixing fuels during fuel changeovers?		
34. In units that utilized Jet A-1, were ground vehicles and aircraft refueled from the same fuel tankers?		
35. Were there any problems in using vehicle personnel heaters with either Jet A-1 or DF-2?		

NOTES

BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ODS QUESTIONNAIRE

LUBRICANTS

	Yes	No
1. Were the following engine oils available for use?		
— OE/HDO-10		
— OE/HDO-30		
— OE/HDO-40		
— OE/HDO-15/40		
2. Was any MIL-L-46152 (administrative service) engine oil used?		
3. Were oil analysis laboratories available?		
4. Were normal lube order oil change intervals used for engine oil?		
5. If changes were made in normal lube order intervals, were the intervals:		
— Increased?		
— Decreased?		
6. Were normal lube order service intervals used for:		
— Transmissions?		
— Power Transfer Units?		
— Differentials?		
— Hydraulic Systems?		
— Brake Systems?		
7. Was there any evidence of "oil breakdown" (i.e., oil too thin, excessive oil consumption, etc.)?		
8. Were there problems in performing lubricant-related maintenance?		
9. If oil analysis laboratories were available, were oil samples taken and sent to them?		
10. If oil samples were sent to a laboratory for analysis, were any results ever received.		

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ODS QUESTIONNAIRE

LUBRICANTS (Continued)

	Yes	No
11. Did dirt/sand contaminant cause any problems with:		
— Wheel Bearings?		
— Gear Drives?		
— Gun Positioning Systems?		
12. Did hot ambient temperatures cause any oil-related problems?		
13. If the OE/HDO-15/40 tactical engine oil (MIL-L-2104) was not used, was it because:		
— The oil got too thin?		
— The engine ran hotter?		
— The oil was not available?		
14. Were any or all of the following gear oils (MIL-L-2105) used?		
— 85W-140		
— 90		
— 80W-90		
15. Were oil filters changed each time the engine oil was changed?		

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ODS QUESTIONNAIRE

HYDRAULIC AND BRAKE FLUIDS

	Yes	No

1. Were any or all of the following hydraulic and gun control system fluids used?

   — OHT ("cherry juice")
   — FRH (Fire Resistant Hydraulic Fluid)
   — Dexron-II

2. Did the hot ambient temperatures affect those self-propelled gun systems using "cherry juice" (MIL-H-6083)?

3. Was sand contamination a problem with operation of any hydraulic or brake fluid system?

4. If vehicle brake systems using silicone brake fluid (MIL-B-46176) were topped off with conventional/commercial-type automotive brake fluids, were any differences in braking performance noticeable?

5. Did the hot ambient temperatures cause brake fade problems?

6. Were filters in those hydraulic systems employing filters routinely changed?

7. Did the hot ambient temperatures cause more frequent topping off of both hydraulic and brake systems?

8. Were there any occurrences in which "cherry juice" (MIL-H-6083/OHT) was added to hydraulic systems using the MIL-H-46170/FRH hydraulic fluid or vice-versa?

9. Were any AOAP samples taken from hydraulic systems?

10. Did the higher ambient temperatures create an overall increase in the maintenance of hydraulic and gun control systems?

11. Did the higher ambient temperatures create an overall increase in the maintenance of vehicle brake systems?

HYDRAULIC AND BRAKE FLUIDS (Continued)

	Yes	No
12. Were fluid changes accomplished at intervals scheduled in authorized lube orders?		

NOTES

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ODS QUESTIONNAIRE

GREASES

	Yes	No
1. Was MIL-G-10924F or MIL-G-0010924E versions of GAA grease available for use?		
2. Was WTR (MIL-G-83122) grease automatically substituted where GAA was required?		
3. Did the hot ambient temperatures cause excessive grease breakdown and leakage?		
4. Did the hot ambient temperatures affect the shelf-life of the unused GAA and other greases?		
5. Where WTR grease was used interchangeably with GAA at lubrication points previously lubricated with GAA, were any performance differences noted?		
6. Were relubrication intervals changed from those specified in authorized lube orders?		
7. Were solvents used to clean parts before relubricating components such as wheel bearings, CV joints, etc?		
8. Were sand particles evident in bearing components during disassembly?		
9. Did the higher ambient temperatures create an overall increase in the maintenance of any grease-lubricated components on vehicle/equipment systems?		

NOTES

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ODS QUESTIONNAIRE

COOLANTS/ANTIFREEZES

	Yes	No
1. Was any commercial-type antifreeze used in lieu of MIL-A-46153 antifreeze?		
2. Was the antifreeze extender additive (MIL-A-53009) used?		
3. Was it possible to save drained antifreeze for reuse when cooling systems were drained and filled?		
4. Were any of the following make-up waters used?		
— potable water		
— distilled water		
— bottled water		
— local water		
5. Did the hot ambient temperatures cause engines to run hotter?		
6. Were there any leaking or corrosion problems attributed to the antifreeze or hard water (i.e., local water) that may have been used?		
7. Were the standard Test Strip Kits used to measure if the antifreeze was okay?		
8. When antifreeze was changed for a reason other than one required by the standard test strip, was it because:		
— Of an engine change?		
— Repair of an engine?		
— Dirt/sand contamination?		
— Other contamination?		
9. Was any MIL-A-46153 antifreeze provided to you in metal containers?		
10. Were the metal containers plastic lined?		
11. Did the higher ambient temperatures create an overall increase in the maintenance of engine cooling system components?		
12. Was flushing of cooling systems a problem due to the limitations on available water?		

Appendix D

BELVOIR RD&E CENTER ODS FACT-FINDING TEAM SURVEY RESULTS

BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ODS QUESTIONNAIRE CONSOLIDATION
FT. BLISS, TX

PACKAGED PRODUCTS

Question		HHT SPT SQDN 3rd ACR	HHT 1st SQDN, 3rd ACR	HHT 2nd SQDN, 3rd ACR	2/1st ADA BN, 11th ADA BDE	3/43rd ADA BN, 11th ADA BDE	HQ, 5/62nd ADA BN, 11th ADA BDE
1 Were packaged POL products taken by the units as part of their unit basic load (UBL)?		Not Asked	Not Asked[1]	Not Asked[1]	Not Asked[1]	Not Asked[1]	Not Asked[1]
2 Were packaged POL products acquired from local companies through local purchase procedures?		No	Yes[2]	Yes[3]	Yes[4]	Yes[5]	No
3 Were POL products packaged in unit quantities that were convenient for use and reduced waste?		N/A	No Answer	No Answer	No Answer	No Answer	N/A
4 Were packaged POL products labeled as to manufacturer grade or other information to allow judgment in use?		N/A	Yes	Yes	Yes	No Answer	N/A
5 Did commercial packaged POL products include	a Oils	No Answer	Yes	Yes	Yes	Yes	No
	b Dry Lubricants	No Answer	Yes	No	No	No	No
	c Greases	No Answer	Yes	No	Yes	No	No
	d Antifreeze	No Answer	No	No	No	No	No
	e Hydraulic fluids	No Answer	No	Yes	No	No	No
	f Brake fluids	No Answer	No	No	No	No	No
6 Were shortages noted in Class III packaged products?		Yes[6]	Yes[7]	Yes[8]	Yes[9]	None Listed	Yes[10]
7 Were Battenfeld Company manufactured products (e primary engine and gear oils) used?		No	No	No	No	No	No
8 If Battenfeld products were used was it because	a Units hadn t been notified they should not?	N/A	N/A	N/A	N/A	N/A	N/A
	b Shortages forced the use of the products	N/A	N/A	N/A	N/A	N/A	N/A

[1] Not asked until subsequent interviews conducted with revised questionnaires
[2] 30-wt GAA (blue and white cans) purchased locally
[3] Turbine engine oil (can had a picture of a Concorde aircraft)
[4] Wheel bearing grease and 15W-40 oil from Sears
[5] MIL Spec 30-wt oil used in 15- and 30-kW generators, commercial 40-wt oil Exxon turbine oil for 150-kW generator
[6] Shortage of FRH
[7] Shortage of FRH and 15W-40 oil
[8] Lube oils and FRH
[9] 15W-40 oil was hard to get after about 2 months
[10] Antifreeze and "Cherry Juice" (OHT)

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FUELS

Question		HHT SPT SQDN, 3rd ACR	HHT, 1st SQDN 3rd ACR	HHT 2nd SQDN 3rd ACR	2/1st ADA BN 11th ADA BDE	3/43rd ADA BN 11th ADA BDE	HQ 5 62nd ADA BN 11th ADA BDE
1 Was the fuel delivered to the POL tank farms (bladders, etc) filtered?		Not Asked[1]	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked
2. Were any inspections, visual or otherwise, made at the tank farm?		Yes[2]	N/A	N/A	N/A	No	No Answer
3 Were any inspections, visual or otherwise, made at unit level?		N/A	Yes[3]	Yes[4]	Yes[5]	No Answer	No Answer
4 Were fuel analysis laboratories, either mobile or fixed, available to either or both wholesale and retail levels?		Yes	No	Yes	Yes	No	No Answer
5 Were any abnormalities noted in the fuels delivered (color, smell, appearance)?		No	No	Yes[6]	Yes	No	No Answer
6 Were the users (operators) satisfied that they received good quality fuel in adequate quantities?		No Answer	Yes	Yes	Yes	Yes[7]	Yes
7 Were logistics, maintenance, and user personnel aware of the type and grade of fuel they used?		No Answer	Not Always Sure	Yes	Not Sure	Yes	No Answer
8. Were bulk fuels delivered in host nation or other for eign nation vehicles?		No Answer	No	No	No	Yes[8]	No
9. Was adequate information provided down to user level on proper fuels and lubricants utilization practices?		No Answer	No	No	No	No	No Answer
10 Were the following fuels available for use by military aircraft?	a. JP-4	No Answer	No Answer	No	N/A	N/A	N/A
	b. JP-8	No Answer	No Answer	N/A	N/A	N/A	N/A
	c. JP-5	No Answer	No Answer	N/A	N/A	N/A	N/A
	d. Jet A-1	Yes	No Answer	N/A	N/A	N/A	N/A
11 When used in aircraft, were problems experienced with one or more of the aviation fuels?		No	N/A	N/A	N/A	N/A	N/A
12 Were the following fuels available for use by diesel-burning ground vehicles & equipment?	a. JP-5	No Answer	No	No	No	No	No
	b. Jet A-1	No Answer	Yes	Yes	Yes	Yes	Yes
	c DF-2	No Answer	No	No	Yes	Yes	No
13 Which of the fuels were used in the diesel-burning ground vehicles and equipment?	a. JP-5	No Answer	No	No	No	No	No
	b. Jet A-1	No Answer	Yes	Yes	Yes	Yes	Yes
	c DF-2	No Answer	No	No	Yes[9]	Yes	No
14 Was there any noticeable decrease in power output when aviation fuel was used in diesel-burning ground vehicles and equipment?		No Answer	None Noted	None Noted	Yes[10]	None Noted	Yes

[1] Not asked until subsequent interviews conducted with revised questionnaire.
[2] Monthly samples on HEMTTs sent to 240th or 260th QM detchments.
[3] Every 30 days on HEMTTs Also ran milipore test
[4] Once per month on HEMTTs.
[5] After fuel problems started, samples were taken from every TPU in the battalion and sent to the fuel lab; a visual inspection was made. "If fuel was clear it had no lubricant added so unit added oil."
[6] Some fuel looked pink; black residue on fuel filters.
[7] Unit had problems with DDA and Stanadyne fuel injector pumps, went back to using diesel.
[8] Unit initially supplied by host nation tankers; no filtering watsoever.
[9] Switched to DF-2 after 2 to 3 months operation on Jet A-1.
[10] A lot of injector pump problems with CUCV and generators.

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ODS QUESTIONNAIRE CONSOLIDATION
FT. BLISS, TX

FUELS

Question		HHT SPT SQDN, 3rd ACR	HHT 1st SQDN 3rd ACR	HHT 2nd SQDN 3rd ACR	2/1st ADA BN 11th ADA BDE	3/43rd ADA BN 11th ADA BDE	HQ 5/62nd ADA BN 11th ADA BDE
15 Was any blending of engine oils or hydraulic fluids into aviation fuel practiced?		No Answer	Yes[1]	None	Yes[1]	No	No
16 Were any procedures established for changing from one fuel to another, such as DF-2 to aviation fuel or one aviation fuel to another aviation fuel?		No Answer	No Answer	N/A	None	None	No Answer
17 Did user personnel know that Jet A-1 fuel was a satisfactory replacement fuel for DF-2?		No Answer	Yes	Yes[2]	Not Convinced	Not Convinced	No Answer
18 Were increased replacements of fuel filters needed following changeover?		No Answer	Yes	Yes	Yes	Yes	No
19 Did fuel filter plugging occur?		No Answer	Yes	Yes	None	No Answer	No Answer
20 If fuel filter plugging occurred, was it considered excessive?		No Answer	Yes[3]	Yes[4]	No	No	No
21 Was a "black residue" observed on any fuel filters that were changed?		No Answer	Yes[5]	Yes	No	No	Yes
22 Were biocides/biostats used to control microbiological growth in fuel cells?		None	N/A	N/A	No Answer	None Mentioned	No Answer
23 Were any additives blended with the Jet A-1 fuel, such as CI, FSII, or static dissipater?		No Answer	No	None	No	No	No
24 Were fuel handlers and operator personnel fearful that Jet A-1 would be hazardous because of the lower flashpoint?		No Answer	No	No	No	None Mentioned	No Answer
25 Were there any "waxing" problems with the use of the host nation supplied diesel fuel?		No Answer	No	No	No	No	No Answer
26 Were vehicles routinely refueled by	a TPUs?	No	No	No	Yes	No	No
	b Military tankers?	Yes[6]	Yes	Yes	Yes	Yes	Yes
	c. Commercial tankers?	Yes[7]	No	No	No	Yes[7]	No
27 Was dirt/sand a problem during fuel transfers?		No Answer	Yes[8]	No	No	No	No Answer
28 Was there a perceptible increase in maintenance when,	a. DF-2 was used?	No Answer	N/A	N/A	No Answer	Yes	N/A
	b Jet A-1 was used?	No Answer	No	No	Yes[9]	Yes[20]	Yes[21]

[1] One pint to 1 quart of 10-wt oil per tankful (about 16-18 gallons)
[2] Strongly supports use of Jet A-1
[3] Occurred when using DF-2
[4] Possibly "bad fuel" was used Occurred only in hot weather
[5] Occurred only in hot weather
[6] After initial deliveries made by commercial tankers
[7] When unit had just arrived in Saudi Arabia
[8] When sand was blowing too hard they shut down refueling operations
[9] CUCV filters and Stanadyne fuel injector pumps were major culprits Unit used a commercial "screw-in" filter which would "bypass" the sensor systems associated with the CUCV fuel filter
[20] Roosamaster fuel injector pumps and DDA mechanical fuel pumps failed on 15-kW 30-kW and 150-kW generators within hours after Jet A-1 used
[21] Had problems with Stanadyne fuel injector pumps in CUCVs Broke glass beads to increase fuel flow Fuel filters in M113s reported completely black

General Note The 5/62nd ADA Bn 11th BDE reported they operated 93 HMMWVs 5 000 to 15 000 miles (some 20,000 miles) with only two fuel injector pumps being replaced Ran up to 3600 miles each on M113 Vulcans Replaced nine Vulcans, four APCs and one M577 (all M113 chassis) Replaced three engines and 10-15 transmissions

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FUELS

Question		HHT SPT SQDN, 3rd ACR	HHT 1st SQDN 3rd ACR	HHT 2nd SQDN 3rd ACR	2/1st ADA BN, 11th ADA BDE	3/43rd ADA BN 11th ADA BDE	HQ 5 62nd ADA BN 11th ADA BDE
29 To alleviate dirt/sand problems during fuel transfers, were:	a. Calm atmospheric conditions waited for?	No Answer	Yes	Yes	Yes	No[22]	No Answer
	b. Fuel opening recesses blown or brushed free of dirt/sand?	No Answer	No Answer	No Answer	No Answer	Not Mentioned	Not Mentioned
	c Opening of fuel fill ports reduced to a minimum during PM services?	No Answer	No Answer	No Answer	No Answer	Not Mentioned	No Answer
30 Was there a perceptible increase in fuel injector nozzle fouling when using	a DF-2 fuel?	No Answer	N/A	N/A	No Answer	Yes[23]	N/A
	b Jet A-1 fuel?	No Answer	Yes[24]	Yes[24]	No Answer	No Answer	No Answer
31. Did use of DF-2 in armored vehicles VEESS produce adequate smoke in the high ambient temperature environments?		No Answer	N/A	N/A	No Answer	No Answer	No Answer
32 If vehicles/equipment were using Jet A-1, did they "run hotter"?		No Answer	No	None Reported	No Answer	No Answer	No Answer
33. Were there any perceptible problems associated with admixing fuels during fuel changeovers?		No Answer	No	No	Yes[25]	Yes[26]	No
34 In units that utilized Jet A-1, were ground vehicles and aircraft refueled from the same fuel tankers?		No	N/A	N/A	N/A	No	No Input
35 Were there any problems in using vehicle personnel heaters with either Jet A-1 or DF-2?		No Answer	No	None	No Answer	No Answer	No

[22]Relied on HEMTT filter system and generator and vehicle filters
[23]Cleaning and changing fuel nozzles a daily chore
[24]Injector problems were reported as fuel lubricity problems, however, dirt was suspected
[25]Yes Jet A-1 used fo 2 or 3 months, then was replaced by DF-2 No stated problems after switch to DF-2
[26]There was an admixture when DF-2 was added to Jet A-1, which caused an increase in cleaning and changing in injector nozzles
Preventive maintenance intervals were
Jet A-1—after 750 hours of operation
DF-2—after 100 hours of operation

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LUBRICANTS

Question		HHT SPT SQDN 3rd ACR	HHT 1st SQDN, 3rd ACR	HHT 2nd SQDN 3rd ACR	2/1st ADA BN 11th ADA BDE	3.43rd ADA BN 11th ADA BDE	HQ 5/62nd ADA BN 11th ADA BDE
1 Were the following engine oils available for use?	a OE/HDO-10	No Input	No Input	No Input	Yes	No	No Input
	b OE/HDO-30/SAE 30	No Input	No/Yes[1]	No/Yes[1]	No	Yes/No	No Input
	c OE/HDO-40	No Input	No Input	No Input	No	No	No Input
	d OE/HDO-15/40	No Input	No[2]	No[3]	No	No[3]	No Input
2 Was MIL-L-46152 (administrative service) engine oil used?		No	No	No	No Input	No Input	No Input
3 Were oil analysis laboratories available?		No Input	No[4]	Yes[5]	Yes[6]	No	No Input
4 Were normal lube order oil change intervals used for engine oil?		No Input	No[7]	No	No	No	No
5 If changes were made in normal intervals, were the intervals	a Increased?	No Input	Yes	Yes[8]	No	No	No
	b Decreased?	No Input	No	Yes	Yes	Yes	Yes
6 Were normal lube order service intervals used for	a Transmissions?	No Input	Yes	No[9]	Yes	Yes	Yes
	b Power transfer units?	No Input	Yes	No[9]	Yes	Yes	Yes
	c Differentials?	No Input	Yes	No[9]	Yes	Yes	Yes
	d Hydraulic systems?	No Input	Yes	Yes	Yes	Yes	Yes
	e Brake systems?	No Input	Yes	Yes	Yes	Yes	Yes
7 Was there any evidence of "oil breakdown" (i e , oil too thin, excessive oil consumption, etc)?		No Input	No	None Noted	No	No Input	No Input
8 Were there problems in performing lubricant-related maintenance?		No Input	No Input	No Input	Yes[10]	No Input	No Input
9 If oil analysis laboratories were available were oil samples taken and sent to them?		No Input	No	Yes	Yes	No	No Input
10 If oil samples were sent to a laboratory for analysis were any results ever received?		N/A	N/A	No	No	No	N/A
11 Did dirt/sand contamination cause any problems with	a Wheel bearings	No Input	No	No	No	No Input	No Input
	b Gear drives?	No Input	No	No	No	No Input	No Input
	c Gun positioning systems?	No Input	No	Yes[11]	No	No Input	No Input
12 Did hot ambient temperatures cause any oil-related problems?		No Input	No	None Noted	No	No Input	No Input

[1] Blue and white quart cans labeled SAE30
[2] 15W-40 oil was not available
[3] Commercial turbine oils were used for M1A1s
[4] Would have used AOAP procedures if labs available
[5] Several samples were sent to Camp Manley, no analysis reports received
[6] Samples taken from some valves and dipstick tubes, sent to Mannheim, Ger No results
[7] Did not change oil due to low mileages
[8] Intervals for engine oil changes extended due to OE/HDO oil shortages
[9] Not changed because oils were too hard to get
[10] No place to dump used oils
[11] Yes Found in sealed gun sights

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LUBRICANTS

Question		HHT SPT SQDN 3rd ACR	HHT 1st SQDN 3rd ACR	HHT 2nd SQDN 3rd ACR	2 1st ADA BN 1th ADA BDE	3 43rd ADA BN 1th ADA BDE	HQ 5 62nd ADA BN 1th ADA BDE
13 If the OE/HDO-15/40 tactical engine oil (MIL-L-2104) was not used was it because	a The oil got too thin?	No Input	No	No	No	No Input	No Input
	b The engine ran hotter?	No Input	No	No	No	No Input	No Input
	c The oil was not available?	No Input	Yes	Yes	Yes	No Input	No Input
14 Were any or all of the following gear oils (MIL-L-2105) used?	a 85W-140	No Input	No Input	No Input	No Input	No Input	No Input
	b 90	No Input	No Input	No Input	Yes	No Input	No Input
	c 80W-90	No Input	No Input	No Input	Yes	No Input	No Input
15 Were oil filters changed each time the engine oil was changed?		NO ENTRY	UNKNOWN	UNKNOWN	YES	YES	NO ENTRY

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HYDRAULIC AND BRAKE FLUIDS

Question		HHT SPT SQDN 3rd ACR	HHT 1st SQDN 3rd ACR	HHT 2nd SQDN 3rd ACR	2/1st ADA BN 11th ADA BDE	3.43rd ADA BN. 11th ADA BDE	HQ 5/62nd ADA BN 11th ADA BDE
1 Were any or all of the following hydraulic and gun control systems fluids used?	a OHT ("Cherry Juice")	No Input	MIL Standard	MIL Standard	MIL Spec 10 Wt	Unknown	Yes[1]
	b FRH (fire resistant hydraulic fluid)	No Input	MIL Standard	MIL Standard	No Input	Unknown	No Input
	c Dexron-II	No Input	No Input	No Input	No Input	Unknown	No Input
2 Did the hot ambient temperatures affect those self-propelled gun systems using "Cherry Juice" (MIL-H-6083)?		No Input	No	No	No	No	No Input
3 Was sand contamination a problem with operation of any hydraulic or brake fluid system?		No Input	Yes[2]	No Input	No	No	No Input
4 If vehicle brake systems using silicone brake fluid (MIL-B-46176) were topped off with conventional commercial-type automotive brake fluids were any differences in braking performance noticeable?		No Input	No	No	No	No	No Input
5 Did the hot ambient temperatures cause brake fade problems?		No Input	No	No[3]	No	No	No Input
6 Were filters in those hydraulic systems employing filters routinely changed?		No Input	No Input	No Input	No	No	No Input
7 Did the hot ambient temperatures cause more frequent topping off of both hydraulic and brake systems?		No Input	No	No	No	No	No Input
8 Were there any occurrences in which "cherry juice" (MIL-H-6083/OHT) was added to hydraulic systems using the MIL-H-46170/FRH hydraulic fluid or vice versa?		No Input	No	No	No	No	No Input
9 Were any AOAP samples taken from hydraulic systems?		No Input	No	No	No	No	No
10 Did the higher ambient temperatures create an overall increase in the maintenance of hydraulic and gun control systems?		No Input	No Input	No Input	No	No	No
11 Did the higher ambient temperatures create an overall increase in the maintenance of vehicle brake systems?		No Input	No	No	No	No	No Input
12 Were fluid changes accomplished at intervals scheduled in authorized lube orders?		N/A	N/A	N/A	N/A	N/A	N/A

[1]Used when available
[2]Reduced brake effectiveness on HEMTTs
[3]No problems with brakes. Fewer Hydrovac replacements in SWA operations than in CONUS

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GREASES

Question	HHT SPT SQDN 3rd ACR	HHT 1st SQDN 3rd ACR	HHT 2nd SQDN 3rd ACR	2/1st ADA BN 11th ADA BDE	3/43rd ADA BN 11th ADA BDE	HQ 5/62nd ADA BN 11th ADA BDE
1 Was MIL-G-10924F or MIL-G-0010924E versions of GAA grease available for use?	No Input	GAA Was Available	Yes	No Input	No Input	No Input
2 Was WTR (MIL-G-83122) grease automatically substituted where GAA was required?	No Input	No Input	Yes	Yes	No Input	No
3 Did the hot ambient temperatures cause excessive grease breakdown and leakage?	No Input	Yes[2]	No	No	No Input	No
4 Did the hot ambient temperatures affect the shelf life of the unused GAA and other greases?	No Input	No	Yes[3]	Yes[4]	No Input	No Input
5 Where WTR grease was used interchangeably with GAA at lubrication points previously lubricated with GAA, were any performance differences noted?	No Input	No Input	Yes	Yes	No Input	No Input
6 Were relubrication intervals changed from those specified in authorized lube orders?	No Input	No Input	No Input	Yes[5]	No Input	Yes[6]
7 Were solvents used to clean parts before relubricating components such as wheel bearings, CV joints, etc?	No Input	No Input	No Input	Yes[7]	No Input	Yes[7]
8 Were sand particles evident in bearing components during disassembly?	No Input	No Input	No Input	Yes[8]	No Input	No Input
9 Did the higher ambient temperatures create an overall increase in the maintenance of any grease-lubricated components on vehicle/equipment systems?	No Input	No Input	No Input	Yes[9]	No Input	No Input

[1]No WTR grease was available to use
[2]Grease separated and bled in M88 road wheel suspension systems. Use of WTR grease eliminated problems
[3]Grease turned brown in can
[4]GAA grease
[5]Every 1 to 2 weeks
[6]Weekly
[7]Cleaning solvent: MOGAS, diesel
[8]Yes, if dust boots were worn
[9]Yes. CUCV and M900 series vehicles appeared to have problems with right front wheel bearings. Bearings repeatedly siezed no matter whether GAA or WTR grease used

BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ODS QUESTIONNAIRE CONSOLIDATION
FT. BLISS, TX

COOLANTS/ANTIFREEZE

Question		HHT SPT SQDN 3rd ACR	HHT 1st SQDN 3rd ACR	HHT 2nd SQDN, 3rd ACR	2/1st ADA BN 11th ADA BDE	3.43rd ADA BN 11th ADA BDE	HQ 5/62nd ADA BN 11th ADA BDE
1 Was any commercial type antifreeze used in lieu of MIL-A-46153 antifreeze?		No Input	No	No	No	No Input	Yes
2 Was the antifreeze extender additive (MIL-A-53009) used?		No Input	No	No	No	No Input	No Input
3 Was it possible to save drained antifreeze for reuse when cooling systems were drained and filled?		No Input	No Input	No Input	No	No Input	No Input
4 Were any of the following make-up waters used?	a Potable water	No Input	No	No	Yes	No Input	Yes
	b Distilled water	No Input	No	Yes	Yes	No Input	Yes
	c Bottled water	No Input	Yes	No	No	No Input	No
	d Local water	No Input	No	No	Yes	No Input	No
5 Did the hot ambient temperatures cause engines to run hotter?		No Input	No	No	Yes	No Input	No Input
6 Were there any leaking or corrosion problems attributed to the antifreeze or hard water (i e local water) that may have been used?		No Input	No	No	Yes	No Input	No Input
7 Were the standard Test Strip Kits used to measure if the antifreeze was okay?		No Input	Yes	No	No	No Input	No Input
8 When antifreeze was changed for a reason other than one required by the standard test strip was it because	a Of an engine change?	No Input	N/A	N/A	No	No Input	No Input
	b Repair of an engine?	No Input	N/A	N/A	No	No Input	No Input
	c Dirt/sand contamination?	No Input	N/A	N/A	No	No Input	No Input
	d Other contamination?	No Input	N/A	N/A	Yes	No Input	No Input
9 Was any MIL-A-46153 antifreeze provided to you in metal containers?		No Input	No Input	Yes	No	No Input	No Input
10 Were the metal containers plastic lined?		N/A	N/A	Yes	N/A	N/A	N/A
11 Did the higher ambient temperatures create an overall increase in the maintenance of engine cooling system components?		No Input	No	No	No	No Input	No Input
12 Was flushing of cooling systems a problem due to the limitations on available water?		No Input	No	N/A	No	No Input	No Input
13 Were there any instances that undiluted antifreeze was added directly in refilling cooling systems?		No Input	No	No	No Input	No Input	No Input
14 When topping off radiator systems was	a Water only used?	No Input	Yes	Yes	No Input	No Input	No Input
	b Antifreeze only used?	No Input	No	No	No Input	No Input	No Input
	c Water-antifreeze mixture used?	No Input	No	No	No Input	No Input	No Input
Radiator leaks							

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WEAPONS LUBRICANTS/SOLID LUBRICANTS

Questions		HHT SPT SQDN 3rd ACR	HHT 1st SQDN 3rd ACR	HHT 2nd SQDN 3rd ACR	2/1st ADA BN 11th ADA BDE	3/43rd ADA BN 11th ADA BDE	HQ 5 62nd ADA BN 11th ADA BDE
1 Were military specification products used?		No Input	No	Yes	Yes	No Input	Yes
2 In addition to those required specification products were other proprietary commercial products also used? For example	a TW-25	No Input	No	No	No	No Input	No
	b Dryslide	No Input	No	No	No	No Input	No
	c WD-40	No Input	No	No	Yes	No Input	No
	d Other	No Input	Yes[1]	No	No	No Input	Yes[2]
3 If these proprietary products were also used was there a noticeable change in the performance or a reason that necessitated their use?		No Input	No Input	No Input	No	No Input	No Input
4 Were the hot ambient temperatures creating lubrication problems for weapons/gun systems?		No Input	No Input	No Input	No Input	No Input	No Input
5 Was dirt/sand adhesion a significant problem?		No Input	No Input	No Input	Yes[3]	No Input	No Input
6 If dirt/sand adhesion was a significant problem, was it resolved satisfactorily?		No Input	No Input	No Input	No	No Input	No Input
7 Were any solid film lubricants used?		No Input	No Input	No Input	No	No Input	No Input
8 Were there any mixing or compatibility problems (i e . solid lubes with greases or fluids)?		No Input	No Input	No Input	No	No Input	No Input
9 Were solid lubricants applied by	a User personnel?	No Input	No Input	No Input	N/A	No Input	No Input
	b Ordnance personnel?	No Input	No Input	No Input	N/A	No Input	No Input
	c Other?	No Input	No Input	No Input	N/A	No Input	No Input
10 Did the higher ambient temperatures create an overall increase in the maintenance of oil/fluid/grease lubricated weapons systems components?		No Input	No Input	No Input	No Input	No Input	No Input
11 Was there a "preferred" weapons lubricant for	a Large caliber weapons?	No Input	No Input	No Input	No Input	No Input	No Input
	b Small caliber weapons?	No Input	No Input	No Input	OE/HDO 10	No Input	No Input

[1] "Duck" grease used to lubricate machine gun parts
[2] Dry lubricant received from AMC LARs Worked great, easy to use, sand did not stick to dry lubricant
[3] Very big problem with buildup of sand

BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
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PACKAGED PRODUCTS

Question		6th Cavalry Brigade (Air Combat)	602nd Mntc Co 169th Mntc Bn 13th COSCOM	13th COSCOM	1st BDE 1st Armd Cav Div	1/82nd Arty Bn, 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn, 2nd BDE 1st Armd Cav Div	2/8th Armd Cav Bn 1st BDE 1st Armd Cav Div	DMMC Class III Officer 1st Armd Cav Div	4th MMC 13th COSCOM 18th Airborne Corps Area (Bulk Fuels)	4th MMC 13th COSCOM (P) Products 18th Airborne Corps Area
1 Were packaged POL products taken by the units as part of their unit basic load (UBL)?		Not Asked[1]	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked
2 Were packaged POL products acquired from local companies through local purchase procedures?		Yes	Yes	Yes	Yes	Yes	No Answer	Yes	No	Yes	Yes
3 Were POL products packaged in unit quantities that were convenient for use and reduced waste?		Yes	No Input	Yes	No[2]	No[2]	No Input	No[2]	Yes	Yes	Yes
4 Were packaged POL products labeled as to manufacturer grade or other information to allow judgment in use?		Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	N/A	Not Asked	N/A	Not Asked	Not Asked
5 Did commercial packaged POL products include	a Oils	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes[3]
	b Dry Lubricants	No	No	No	No	No	No	No	No	No	No
	c Greases	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	d Antifreeze	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	e Hydraulic fluids	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	f Brake fluids	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

[1]This question asked on subsequent interviews after questionnaire revision

[2]Antifreeze issued in 55 gallon drums once opened drums were immediately suspect for solid contaminants

[3]10 wt 30 wt 40 wt and 15W 40 MIL L 2104D grade engine oils, 85W 140 90W and 80W 90 MIL L 2105D gear oils, Jet Oil II (MIL L 23699) Mobil turboshaft oil (MIL L 23699) Exxon Dexron II transmission oils Saudi Arabia National Mobil and Exxon FRH (MIL L 46170) Exxon coolant/antifreeze (did not met MIL spec) Mobil grease 28 (MIL G 83122) Exxon aviation grease 22 (Mil G 8312) other different greases were all purchased by the 4th MMC 13th COSCOM for use by all the units

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PACKAGED PRODUCTS

Question		6th Cavalry Brigade (Air Combat)	602nd Maint Co 169th Maint Bn 13th COSCOM	13th COSCOM	1st BDE 1st Armd Cav Div	1/82nd Arty Bn 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn 2nd BDE 1st Armd Cav Div	2/8th Armd Cav Bn 1st BDE 1st Armd Cav Div	DMMC Class III Officer 1st Armd Cav Div	4th MMC 13th COSCOM 18th Airborne Corps Area (Bulk Fuels)	4th MMC 13th COSCOM (P) Products 18th Airborne Corps Area
6 Were shortages noted in Class III packaged products?		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes[4]
7 Were Battenfeld Company manufactured products (i e primary engine and gear oils) used?		No	No Answer	Yes[5]	No	Didn t Notice	No Answer	No	No	No[6]	No Answer
8 If Battenfeld products were used was it because	a Units hadn t been notified they should not?	N A	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A
	b Shortages forced the use of the products	N/A	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A

[4]Initially all Class III (P) products were in short supply Engine turbine oils and gear oils were the initial concern It was never completely solved, however units were given approximately 5 to 7 days basic load Some units hoarded supplies at their bases and would abandon their stocks expecting to receive more at their next location Weapon oil was always in short supply Hydraulic oil was always a battle Local purchased supplies would be distributed in hours Shortages eased up in January as some of our shipments started getting to the units

[5]Several units used Battenfeld grease but encountered separation problems in the can

[6]"All Battenfeld products that came into my yard were put on hold and not used "

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FUELS

Question	6th Cavalry Brigade (Air Combat)	602nd Mntc Co 169th Mntc Bn 13th COSCOM	13th COSCOM	1st BDE 1st Armd Cav Div	1/82nd Arty Bn 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn, 2nd BDE, 1st Armd Cav Div	2/8th Armd Cav Bn, 1st BDE 1st Armd Cav Div	DMMC Class III Officer, 1st Armd Cav Div	4th MMC 13th COSCOM 18th Airborne Corps Area (Bulk Fuels)	4th MMC, 13th COSCOM (P) Products 18th Airborne Corps Area
1 Was the fuel delivered to the POL tank farms (bladders, etc) filtered?	Not Asked	Not Asked	Unknown	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Unknown[1]	N/A
2 Were any inspections, visual or other wise, made at the tank farm?	Not Asked	Not Asked	Unknown	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Yes[1]	N/A
3 Were any inspections, visual or other wise, made at unit level?	Yes[2]	No Answer	Unknown	No Answer	No Answer	No Answer	No Answer	No Answer	Unknown	N/A
4 Were fuel analysis laboratories, either mobile or fixed, available to either or both wholesale and retail levels?	Yes[3]	No Answer	Yes[4]	No	No	No Answe	No	Yes[5]	Yes	N/A
5 Were any abnormalities noted in the fuels delivered (color, smell, appearance)?	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked
6 Were the users (operators) satisfied that they received good quality fuel in adequate quantities?	Yes	No Answer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7 Were logistics, maintenance, and user personnel aware of the type and grade of fuel they used?	Yes	No Answer	Yes	Yes	No Answer	Yes	Yes	No Answer	Yes	Yes
8 Were bulk fuels delivered in host nation or other foreign nation vehicles?	No	No Answer	No	No	No Answer	No Answer	Yes[6]	Yes	-	No
9 Was adequate information provided down to user level on proper fuels and lubricants utilization practices?	Yes	No Answer	Yes	Yes	No Answer	No Answer	Yes	Yes	-	Yes

[1] 13th COSCOM had to obtain couplings that would allow HEMTT 4" fittings to be attached to host nation vehicle 3" fittings Quality assurance at origin was controlled by the 321st TMMC Units operating the tactical petroleum terminals (TPT) were responsible for the testing of their stocks as directed by the 18th Airborne Corps G-4 and the CMMC At unit levels, HEMTT and TPU liters were relied upon

[2] For aircraft only

[3] Normal fuel sampling done for aircraft Samples sent to Air Force lab at Dhaharan No sampling done for ground vehicles or equipment

[4] The 240th and 260th QM Lab Detachments

[5] After the F/S daily in the Aviation Bde

[6] Host nation or foreign national but still military tankers

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FUELS

Question		6th Cavalry Brigade (Air Combat)	602nd Mntc Co 169th Mntc Bn 13th COSCOM	13th COSCOM	1st BDE 1st Armd Cav Div	1/82nd Arty Bn, 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn 2nd BDE, 1st Armd Cav Div	2/8th Armd Cav Bn, 1st BDE 1st Armd Cav Div	DMMC Class III Officer 1st Armd Cav Div	4th MMC 13th COSCOM 18th Airborne Corps Area (Bulk Fuels)	4th MMC, 13th COSCOM (P) Products, 18th Airborne Corps Area
10 Were the following fuels available for use by military aircraft?	a JP 4	No	No Answer	No Answer	No	Didn t Know	No Answer	Didn t Know	No	No	Didn t Know
	b JP 8	No	No	No	N/A	N/A	N/A	N/A	N/A	No	No
	c JP 5	Yes[7]	No Answer	Yes	N/A	N/A	N/A	N/A	N/A	Yes	N/A
	d Jet A 1	Yes	No Answer	Yes	N/A	N/A	N/A	N/A[8]	N/A	Yes	N/A
11 When used in aircraft were problems experienced with one or more of the aviation fuels?		None	No Answer	None	N/A	N/A	N/A	No	N/A	N/A	N/A
12 Were the following fuels available for use by diesel burning ground vehicles & equipment?	a JP 5	Yes	No Answer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	b Jet A 1	Yes	No Answer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	c DF 2	Yes	No Answer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13 Which of the fuels were used in the diesel burning ground vehicles and equipment?	a JP 5	Yes	No Answer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	b Jet A 1	Yes	No Answer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	c DF 2	Yes	No Answer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14 Was there any noticeable decrease in power output when aviation fuel was used in diesel burning ground vehicles and equipment?		No[9]	No Answer	No	No	No	No Answer	No	No	No Answer	No
15 Was any blending of engine oils or hydraulic fluids into aviation fuel practiced?		No[10]	No Answer	Yes	No	No	No Answer	Yes	No	Not Authorized	No

[7]Until JP 5 taken to SWA by the 13th COSCOM ran out
[8]Unit did refuel some helicopters with enough fuel to get them back to a fueling point
[9]No loss of power for aircraft Because Jet A 1 is heavier than JP 4 less payload could be lifted HMMWVs were said to exhibit some power loss
[10]Started using about 1/2 pint per tank full (ground vehicles only) but then were told not to

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FUELS

Question	6th Cavalry Brigade (Air Combat)	602nd Mntc Co 169th Mntc Bn, 13th COSCOM	13th COSCOM	1st BDE 1st Armd Cav Div	1/82nd Arty Bn 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn, 2nd BDE 1st Armd Cav Div	2/8th Armd Cav Bn, 1st BDE, 1st Armd Cav Div	DMMC Class III Officer 1st Armd Cav Div	4th MMC 13th COSCOM 18th Airborne Corps Area (Bulk Fuels)	4th MMC, 13th COSCOM (P) Products 18th Airborne Corps Area
16 Were any procedures established for changing from one fuel to another such as DF 2 to aviation fuel or one aviation fuel to another aviation fuel?	Yes	No Answer	Yes[11]	Yes	Yes	No Answer	Yes	Yes	Yes	Yes
17 Did user personnel know that Jet A 1 fuel was a satisfactory replacement fuel for DF 2?	Yes	No Answer	Yes	Yes	No Answer	No Answer	Yes	Yes	Yes	Yes
18 Were increased replacements of fuel filters needed following changeover?	No	No Answer	Yes[12]	No	No[13]	Yes	No Answer	Yes	No Answer	Yes
19 Did fuel filter plugging occur?	Yes[14]	No Answer	Yes[15]	Yes	Yes	Yes	Yes	Yes	No Answer	Yes
20 If fuel filter plugging occurred, was it considered excessive?	No	No Answer	Yes	No Answer	No Answer	No Answer	No Answer	No Answer	No Answer	Yes[16]
21 Was a "black residue" observed on any fuel filters that were changed?	No	No	No	No	No	No	No	No	No	No
22 Were biocides/biostats used to control microbiological growth in fuel cells?	No	No Answer	No	No	No	No Answer	No	No	No	Not Known
23 Were any additives blended with the Jet A 1 fuel, such as CI, FSII, or static dissipater?	No	No Answer	No	No	No	No Answer	No	No	No	Not Known
24 Were fuel handlers and operator personnel fearful that Jet A 1 would be hazardous because of the lower flashpoint?	No	No Answer	Yes[17]	No	No Answer	No Answer	No	No	No Answer	Yes[17]

[11] Units were advised to begin changeover gradually i e 3/4 tank DF 2 1/4 tank JP 5, 1/2 tank DF 2 1/2 tank JP 5, 1/4 tank DF 2-3/4 tank JP 5, Full tank JP 5 Units were also advised as to flushing fuel tanks for both ground and aviation assets (bulk fuelers) Some vehicles were to be kept full with clean Jet A 1 fuel in case aircraft had to refuel from ground bulk tankers

[12] Units with new vehicles saw little change in usage of filters

[13] Were told only aircraft and M1s needed to change filters

[14] CUCVs no more problems with ground vehicles when CUCVs replaced by HMMWVs

[15] Occurred in older vehicles filters displayed a heavy gooey deposit

[16] Some units Others changed over gradually without experiencing excessive filter changes

[17] An explosion in one vehicle and a fire in another created some anxiety at first Resulted in one ADA unit switching back to DF 2

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FUELS

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25 Were there any "waxing" problems with the use of the host nation supplied diesel fuel?		No	No Answer	No	No	No	No Answer	No	No	No Answer	No
26 Were vehicles routinely refueled by	a TPUs?	No	No Answer	No	No	No Answer	No Answer	No	Yes	No Answer	Yes
	b Military tankers?	Yes	No Answer	Yes	Yes	No Answer	No Answer	Yes	Yes	No Answer	Yes
	c Commercial tankers?	No	No Answer	No	No	No Answer	No Answer	Yes[18]	Yes	No Answer	Yes
27 Was dirt/sand a problem during fuel transfers?			No Answer	Yes	No Answer	No Answer	No Answer	Yes	No	No Answer	No
28 Was there a perceptible increase in maintenance when	a DF 2 was used?	No	No Answer	No	No Answer	No Answer	No Answer	No	No Answer	No Answer	No Answer
	b Jet A 1 was used?	No	No Answer	Yes[19]	No Answer	No Answer	No Answer	No	No Answer	No Answer	No Answer
29 To alleviate dirt/sand problems during fuel transfers, were	a Calm atmospheric conditions waited for?	Yes	No Answer	No	Yes	No Answer	No Answer	No	N/A	No Answer	No Answer
	b Fuel opening recesses blown or bushed free of dirt/sand?	Yes	No Answer	Yes	Yes	No Answer	No Answer	Yes	N/A	No Answer	No Answer
	c Opening of fuel fill ports reduced to a minimum during PM services?	Yes	No Answer	No	No	No Answer	No Answer	No	N A	No Answer	No Answer

[18] Foreign nationals vehicles [illegible] still military
[19] CUCV and HMMWV fuel n[illegible] pump replacements

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FUELS

Question		6th Cavalry Brigade (Air Combat)	602nd Mntc Co 169th Mntc Bn 13th COSCOM	13th COSCOM	1st BDE 1st Armd Cav Div	1/82nd Arty Bn, 1st Armd Cav Div Arty	HHC, 1/5th Armd Cav Bn 2nd BDE, 1st Armd Cav Div	2/8th Armd Cav Bn, 1st BDE 1st Armd Cav Div	DMMC Class III Officer 1st Armd Cav Div	4th MMC, 13th COSCOM 18th Airborne Corps Area (Bulk Fuels)	4th MMC, 13th COSCOM (P) Products 18th Airborne Corps Area
30 Was there a perceptible increase in fuel injector nozzle fouling when using	a DF 2 fuel?	No	No Answer	No	No	No Answer	No Answer	No	No Answer	No Answer	No Answer
	b Jet A 1 fuel?	Yes[20]	No Answer	No	No	No Answer	No Answer	No	No Answer	No Answer	No Answer
31 Did use of DF 2 in armored vehicles VEESS produce adequate smoke in the high ambient temperature environments?		N/A	No Answer	No Answer	No[21]	No Answer	No Answer	No[22]	No Answer	No Answer	No Answer
32 If vehicles/equipment were using Jet A 1 did they "run hotter"?		No	No[23]	Yes	No Answer	No Answer	No Answer	Yes	No Answer	No Answer	No Answer
33 Were there any perceptible problems associated with admixing fuels during fuel changeovers?		No	No Answer	No	No	No	No	No	No Answer	No Answer	No Answer
34 In units that utilized Jet A 1 were ground vehicles and aircraft refueled from the same fuel tankers?		Yes[24]	No Answer	Yes	Yes	No Answer	No Answer	Yes[24]	No Answer	No Answer	No Answer
35 Were there any problems in using vehicle personnel heaters with either Jet A 1 or DF 2?		No	No Answer	No	No	No Answer	No Answer	No	No Answer	No Answer	No Answer

[20] No problems with injector nozzle fouling after CUCVs replaced by HMMWVs
[21] Tested but did not use Less than desired smoke was observed Unit stopped because of concern that the fuel might be too volatile and perhaps explode
[22] Didn't have to use smoke
[23] When drivers did not follow "Glo Plug" start procedures, Glo Plugs would overheat and burn out
[24] There were some instances when helicopters were refueled from forward ground fuel tankers

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LUBRICANTS

Question		6th Cavalry Brigade (Air Combat)	602nd Mntc Co 169th Mntc Bn 13th COSCOM	13th COSCOM	1st BDE 1st Armd Cav Div	1/82nd Arty Bn 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn 2nd BDE, 1st Armd Cav Div	2/8th Armd Cav Bn 1st BDE, 1st Armd Cav Div	DMMC Class III Officer 1st Armd Cav Div	4th MMC 13th COSCOM 18th Airborne Corps Area (Bulk Fuels)	4th MMC 13th COSCOM (P) Products 18th Airborne Corps Area
1 Were the following engine oils available for use?	a OE/HDO 10	No Input	No Input	Yes	No	No Input	No	No	Yes	No Input	No Input
	b OE/HDO 30	No Input	No Input	Yes	No	No Input	No	No	Yes	No Input	No Input
	c OE/HDO 40	No Input	No Input	Yes	No	No Input	No	No	No	No Input	No Input
	d OE/HDO 15/40	No Input	No Input	Yes	Yes	No Input	Yes	Yes	Yes	No Input	No Input
2 Was MIL L 46152 (administrative service) engine oil used?		No	No	No	No	No	No	No	No	No	No
3 Were oil analysis laboratories available?		No	No	No	No	No	No	No	No	No	No
4 Were normal lube order oil change intervals used for engine oil?		Yes	No Input	Yes	Yes	No Input	No Input	Yes	No Input	No Input	No Input
5 If changes were made in normal intervals were the intervals	a Increased?	N/A	N A	No	No	N/A	N/A	No	N/A	N/A	N/A
	b Decreased?	N/A	N/A	Yes	Yes	N/A	N/A	Yes	N/A	N/A	N/A
6 Were normal lube order service intervals used for	a Transmissions?	Yes	No Input	Yes	No[1]	No Input	No Input	No[1]	No Input	No Input	No Input
	b Power transfer units?	Yes	No Input	Yes	No	No Input	No Input	No	No Input	No Input	No Input
	c Differentials?	Yes	No Input	Yes	No	No Input	No Input	No	No Input	No Input	No Input
	d Hydraulic systems?	Yes	No Input	Yes	No	No Input	No Input	No	No Input	No Input	No Input
	e Brake systems?	Yes	No Input	Yes	No	No Input	No Input	No	No Input	No Input	No Input
7 Was there any evidence of "oil breakdown" (i e oil too thin excessive oil consumption etc)?		No	No Input	No	No	No Input	No Input	No Input	Yes[2]	No Input	No Input
8 Were there problems in performing lubricant related maintenance?		No	No Input	No	No	No Input	No Input	No Input	No	No Input	No Input

[1] 1/2 normal service intervals times were used
[2] In GAA only

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LUBRICANTS

Question		6th Cavalry Brigade (Air Combat)	602nd Mntc Co 169th Mntc Bn, 13th COSCOM	13th COSCOM	1st BDE 1st Armd Cav Div	1/82nd Arty Bn, 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn, 2nd BDE, 1st Armd Cav Div	2/8th Armd Cav Bn 1st BDE 1st Armd Cav Div	DMMC Class III Officer, 1st Armd Cav Div	4th MMC 13th COSCOM 18th Airborne Corps Area (Bulk Fuels)	4th MMC 13th COSCOM (P) Products 18th Airborne Corps Area
9 If oil analysis laboratories were available were oil samples taken and sent to them?		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10 If oil samples were sent to a laboratory for analysis were any results ever received?		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11 Did dirt/sand contamination cause any problems with	a Wheel bearings	No	No Input	No	No	No Input	No Input	No Input	No	No Input	No Input
	b Gear drives?	No	No Input	No	No	No Input	No Input	No Input	No	No Input	No Input
	c Gun positioning systems?	No	No Input	No	No	No Input	No Input	No Input	No	No Input	No Input
12 Did hot ambient temperatures cause any oil related problems?		No	No Input	No	No	No Input	No Input	No	No	No Input	No Input
13 If the OE/HDO 15/40 tactical engine oil (MIL L 2104) was not used was it because	a The oil got too thin?	No Input	No Input	No	No	No Input	No Input	N/A	No Input	No Input	No Input
	b The engine ran hotter?	No Input	No Input	No	No	No Input	No Input	N/A	No Input	No Input	No Input
	c The oil was not available?	No Input	No Input	Yes	Yes	No Input	No Input	N/A	No Input	No Input	No Input
14 Were any or all of the following gear oils (MIL L 2105) used?	a 85W 140	No Input	No Input	Yes	No	No Input	No Input	No	No	No Input	No Input
	b 90	No Input	No Input	Yes	No	No Input	No Input	No	No	No Input	No Input
	c 80W 90	No Input	No Input	Yes	No	No Input	No Input	No	Yes	No Input	No Input
15 Were oil filters changed each time the engine oil was changed?		Yes	No Input	Yes[3]	Yes	No Input	No Input	Yes	No Input	No Input	No Input

[3]When filters were available

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GREASES

Question	6th Cavalry Brigade (Air Combat)	602nd Mntc Co, 169th Mntc Bn 13th COSCOM	13th COSCOM	1st BDE 1st Armd Cav Div	1/82nd Arty Bn 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn 2nd BDE 1st Armd Cav Div	2/8th Armd Cav Bn, 1st BDE 1st Armd Cav Div	DMMC Class III Officer 1st Armd Cav Div	4th MMC, 13th COSCOM, 18th Airborne Corps Area (Bulk Fuels)	4th MMC 13th COSCOM (P) Products 18th Airborne Corps Area
1 Was MIL G 10924F or MIL G 0010924E versions of GAA grease available for use?	Yes	No Input	Yes	Yes	Yes[1]	Yes[2]	Yes	Yes	No Input	No Input
2 Was WTR (MIL G 83122) grease automatically substituted where GAA was required?	No[3]	No Input	Yes[4]	Yes	No[3]	No Input	Yes	No	No Input	No Input
3 Did the hot ambient temperatures cause excessive grease breakdown and leakage?	No	No Input	Yes[5]	No	Yes	No Input	No	Yes[6]	No Input	No Input
4 Did the hot ambient temperatures affect the shelf life of the unused GAA and other greases?	No	No Input	Yes[5]	No	No	No Input	No	No	No Input	No Input
5 Where WTR grease was used interchangeably with GAA at lubrication points previously lubricated with GAA were any performance differences noted?	No	No Input	No	No	No[3]	No Input	No	No	No Input	No Input
6 Were relubrication intervals changed from those specified in authorized lube orders?	No	No Input	Yes[7]	No	No Input	No Input	Yes[8]	No Input	No Input	No Input

[1] Also used TIA same as GAA used on road wheels
[2] Used GAA on guns
[3] Not available
[4] When available
[5] GAA Especially products produced by Battenfeld
[6] Started using 9150 01 197 7692 exclusively (GAA)
[7] Combat vehicles were lubed whenever vehicles hauled during long runs

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GREASES

Question	6th Cavalry Brigade (Air Combat)	602nd Mntc Co 169th Mntc Bn, 13th COSCOM	13th COSCOM	1st BDE, 1st Armd Cav Div	1/82nd Arty Bn, 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn 2nd BDE 1st Armd Cav Div	2/8th Armd Cav Bn 1st BDE 1st Armd Cav Div	DMMC, Class III Officer, 1st Armd Cav Div	4th MMC 13th COSCOM 18th Airborne Corps Area (Bulk Fuels)	4th MMC 13th COSCOM (P) Products 18th Airborne Corps Area
7 Were solvents used to clean parts before relubricating components such as wheel bearings, CV joints etc?	Yes[9]	No Input	Yes[10]	Yes[10]	Yes[9]	No Input	Yes[10]	No Input	No Input	No Input
8 Were sand particles evident in bearing components during disassembly?	No	No Input	Yes[11]	Yes	No Input	No Input	Yes	No	No Input	No Input
9 Did the higher ambient temperatures create an overall increase in the maintenance of any grease lubricated components on vehicle/equipment systems?	No	No Input	No	No	No	No Input	No	No Input	No Input	No Input

[8] Lubed whenever time allowed probably resulted in more than normal lubrication
[9] Jet A 1 or whatever they could get
[10] MOGAS DF 2 Jet A 1 and dry solvents
[11] Many seals and rubber C V joint boots failed

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HYDRAULIC AND BRAKE FLUIDS

Question		6th Cavalry Brigade (Air Combat)	602nd Mntc Co 169th Mntc Bn, 13th COSCOM	13th COSCOM	1st BDE 1st Armd Cav Div	1/82nd Arty Bn, 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn 2nd BDE, 1st Armd Cav Div	2/8th Armd Cav Bn, 1st BDE 1st Armd Cav Div	DMMC Class III Officer 1st Armd Cav Div	4th MMC 13th COSCOM 18th Airborne Corps Area (Bulk Fuels)	4th MMC, 13th COSCOM (P) Products, 18th Airborne Corps Area
1 Were any or all of the following hydraulic and gun control systems fluids used?	a OHT ("Cherry Juice")	Yes	No[1]	No	No	Yes[1]	Yes	No	No	No Input	No Input
	b FRH (fire resistant hydraulic fluid)	Yes	No	No	No	No	Yes	No	No	No Input	No Input
	c Dexron II	No	No	Yes	Yes	No	No	Yes	No	No Input	No Input
2 Did the hot ambient temperatures affect those self propelled gun systems using "Cherry Juice" (MIL H 6083)?		No	No	No	No[2]	No Input	No Input	No Input	No	No Input	No Input
3 Was sand contamination a problem with operation of any hydraulic or brake fluid system?		No	Yes	No	No	No Input	No Input	No Input	No	No Input	No Input
4 If vehicle brake systems using silicone brake fluid (MIL B 46176) were topped off with conventional/commercial type automotive brake fluids were any differences in braking performance noticeable?		No	No Input	N/A[3]	No Input	No Input	No Input	No Input	N/A[3]	No Input	No Input
5 Did the hot ambient temperatures cause brake fade problems?		Yes	No Input	No	No	No Input	No Input	No Input	No	No Input	No Input
6 Were filters in those hydraulic systems employing filters routinely changed?		No	No Input	Yes	Yes	No Input	No Input	No Input	Yes[4]	No Input	No Input

[1]Used 10 wt oil purchased locally
[2]Could not get "Cherry Juice"
[3]Used silicone brake fluid only
[4]Sand particles found in system

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HYDRAULIC AND BRAKE FLUIDS

Question	6th Cavalry Brigade (Air Combat)	602nd Mntc Co 169th Mntc Bn 13th COSCOM	13th COSCOM	1st BDE 1st Armd Cav Div	1/82nd Arty Bn, 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn, 2nd BDE, 1st Armd Cav Div	2/8th Armd Cav Bn, 1st BDE, 1st Armd Cav Div	DMMC Class III Offcur 1st Armd Cav Div	4th MMC 13th COSCOM 18th Airborne Corps Area (Bulk Fuels)	4th MMC, 13th COSCOM (P) Products 18th Airborne Corps Area
7 Did the hot ambient temperatures cause more frequent topping off of both hydraulic and brake systems?	No	No Input	No	No	No Input	No Input	No Input	No	No Input	No Input
8 Were there any occurrences in which "cherry juice" (MIL H-6083/OHT) was added to hydraulic systems using the MIL-H 46170/FRH hydraulic fluid or vice versa?	No	No Input	Unknown	N/A	No Input	No Input	No Input	No Input	No Input	No Input
9 Were any AOAP samples taken from hydraulic systems?	No	No Input	No Input	No	No	No Input	No Input	No	No Input	No Input
10 Did the higher ambient temperatures create an overall increase in the maintenance of hydraulic and gun control systems?	No	No Input	No	No	No Input	No Input	No Input	No Input	No Input	No Input
11 Did the higher ambient temperatures create an overall increase in the maintenance of vehicle brake systems?	No	No Input	No	No	No Input	No Input	No Input	No Input	No Input	No Input
12 Were fluid changes accomplished at intervals scheduled in authorized lube orders?	Not Asked[5]	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked

[5]Question asked on revised questionnaire

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COOLANTS/ANTIFREEZE

Question		6th Cavalry Brigade (Air Combat)	602nd Mntc Co 169th Mntc Bn 13th COSCOM	13th COSCOM	1st BDE, 1st Armd Cav Div	1/82nd Arty Bn, 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn, 2nd BDE, 1st Armd Cav Div	2/8th Armd Cav Bn, 1st BDE, 1st Armd Cav Div	DMMC Class III Officer 1st Armd Cav Div	4th MMC, 13th COSCOM 18th Airborne Corps Area (Bulk Fuels)	4th MMC, 13th COSCOM (P) Products 18th Airborne Corps Area
1 Was any commercial type antifreeze used in lieu of MIL A-46153 antifreeze?		No	No Input	No	Yes	Yes	No Input	Yes	No	No Input	No Input
2 Was the antifreeze extender additive (MIL A-53009) used?		No	No Input	No	No	No	No Input	No	No	No Input	No Input
3 Was it possible to save drained antifreeze for reuse when cooling systems were drained and filled?		Not Asked[1]	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked	Not Asked
4 Were any of the following make-up waters used?	a Potable water	N/A[2]	No Input	Yes	Yes	Yes	No Input	No	No	No Input	No Input
	b Distilled water	N/A	No Input	Yes	Yes	No	No Input	Yes	No	No Input	No Input
	c Bottled water	N/A	No Input	Yes	Yes	Yes	No Input	Yes	Yes	No Input	No Input
	d Local water	N/A	No Input	Yes	No	Yes	No Input	No	Yes	No Input	No Input
5 Did the hot ambient temperatures cause engines to run hotter?		No	No Input	No	No	No	No Input	No	No	No Input	No Input
6 Were there any leaking or corrosion problems attributed to the antifreeze or hard water (i e , local water) that may have been used?		No	No Input	No	No	No Input	No Input	No	No Input	No Input	No Input
7 Were the standard Test Strip Kits used to measure if the antifreeze was okay?		No	No Input	No	No	No	No Input	No	No Input	No Input	No Input

[1]Question included in a subsequent questionnaire
[2]Took enough antifreeze to SWA so unit had no need to mix antifreeze with water

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COOLANTS/ANTIFREEZE

Question		6th Cavalry Brigade (Air Combat)	602nd Maint Co 169th Maint Bn 13th COSCOM	13th COSCOM	1st BDE 1st Armd Cav Div	1/82nd Arty Bn 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn, 2nd BDE 1st Armd Cav Div	2/8th Armd Cav Bn 1st BDE 1st Armd Cav Div	DMMC Class III Officer 1st Armd Cav Div	4th MMC 13th COSCOM 18th Airborne Corps Area (Bulk Fuels)	4th MMC, 13th COSCOM (P) Products 18th Airborne Corps Area
8 When antifreeze was changed for a reason other than one required by the standard test strip was it because	a Of an engine change?	N/A	No Input	No Input	No[3]	No Input	No Input	No[3]	No Input	No Input	No Input
	b Repair of an engine?	N/A	No Input	No Input	No	No Input	No Input	No	No Input	No Input	No Input
	c Dirt/sand contamination?	N/A	No Input	No Input	No	No Input	No Input	No	No Input	No Input	No Input
	d Other contamination?	N/A	No Input	No Input	No	No Input	No Input	No	No Input	No Input	No Input
9 Was any MIL A 46153 antifreeze provided to you in metal containers?		No	No Input	Yes	No Input	No	No Input	No Input	No	No Input	No Input
10 Were the metal containers plastic lined?		N/A	N/A	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11 Did the higher ambient temperatures create an overall increase in the maintenance of engine cooling system components?		No	No Input	No	No Input	No	No Input	No Input	No Input	No Input	No Input
12 Was flushing of cooling systems a problem due to the limitations on available water?		No	No Input	No	No	No	No Input	No	No Input	No Input	No Input
13 Were there any instances that undiluted antifreeze was added directly in refilling cooling systems?		No	No Input	Yes[4]	No	No	No Input	No	No Input	No Input	No Input
14 When topping off radiator systems was	a Water only used?	N/A	No Input	No	No	No	No Input	No Input	No Input	No Input	No Input
	b Antifreeze only used?	N/A	No Input	No	No	No	No Input	No Input	No Input	No Input	No Input
	c Water antifreeze mixture used?	N/A	No Input	Yes	No	No	No Input	No Input	No Input	No Input	No Input

[3]Used a hydrometer
[4]Only in isolated cases results unknown

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WEAPONS LUBRICANTS/SOLID LUBRICANTS

Questions	6th Cavalry Brigade (Air Combat)	602nd Mntc Co 169th Mntc Bn 13th COSCOM	13th COSCOM	1st BDE 1st Armd Cav Div	1/82nd Arty Bn 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn 2nd BDE, 1st Armd Cav Div	2/8th Armd Cav Bn, 1st BDE, 1st Armd Cav Div	DMMC Class III Officer, 1st Armd Cav Div	4th MMC 13th COSCOM, 18th Airborne Corps Area (Bulk Fuels)	4th MMC, 13th COSCOM (P) Products 18th Airborne Corps Area
1 Were military specification products used?	Yes	No Input	Yes	Yes	Yes	No Input	Yes	Yes	No Input	No Input
2 In addition to those required specification products were other proprietary commercial products also used? For example a TW 25	No	No Input	No	No	No	No Input	No	No	No Input	No Input
b Drysilde	No	No Input	No	No	No	No Input	No	No	No Input	No Input
c WD 40	Yes	No Input	Yes	Yes	Yes	No Input	Yes	No	No Input	No Input
3 If these proprietary products were also used was there a noticeable change in the performance or a reason that necessitated their use?	No	No Input	No	No	No Input	No Input	No Input	No Input	No Input	No Input
4 Was the hot ambient temperatures creating lubrication problems for weapons/gun systems?	No	No Input	No	No	No Input	No Input	No	No	No Input	No Input
5 Was dirt/sand adhesion a significant problem?	No	No Input	No	Yes[1]	Yes	No Input	No Input	No	No Input	No Input
6 If dirt/sand adhesion was a significant problem was it resolved satisfactorily?	N/A	N/A	N/A	Yes[2]	Yes	No Input	N/A	N/A	N/A	N/A
7 Were any solid film lubricants used?	N/A	No Input	N/A	No Input	No Input	N/A	No Input	No Input	No Input	No Input
8 Was there any mixing or compatibility problems (i e solid lubes with greases or fluids)?	No	No Input	No	No	No Input	No Input	No Input	No	No Input	No Input

[1]A problem but units dealt with it
[2]Had to clean weapons every 3 to 4 days

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WEAPONS LUBRICANTS/SOLID LUBRICANTS

Questions		6th Cavalry Brigade (Air Combat)	602nd Mntc Co 169th Mntc Bn, 13th COSCOM	13th COSCOM	1st BDE 1st Armd Cav Div	1/82nd Arty Bn, 1st Armd Cav Div Arty	HHC 1/5th Armd Cav Bn, 2nd BDE, 1st Armd Cav Div	2/8th Armd Cav Bn, 1st BDE, 1st Armd Cav Div	DMMC Class III Officer, 1st Armd Cav Div	4th MMC, 13th COSCOM 18th Airborne Corps Area (Bulk Fuels)	4th MMC, 13th COSCOM (P) Products 18th Airborne Corps Area
9 Were solid lubricants applied by	a User personnel?	N/A	No Input	N/A	No Input	No Input	No Input	No Input	No Input	No Input	No Input
	b Ordnance personnel?	N/A	No Input	N/A	No Input	No Input	No Input	No Input	No Input	No Input	No Input
	c Other?	N/A	No Input	N/A	No Input	No Input	No Input	No Input	No Input	No Input	No Input
10 Did the higher ambient temperatures create an overall increase in the maintenance of oil/fluid/grease lubricated weapons systems components?		No	No Input	No	No	No Input	No Input	No Input	No Input	No Input	No Input
11 Was there a "preferred" weapons lubricant for	a Large caliber weapons?	N/A	No Input	Unknown	No Input	No Input	No Input	No Input	No Input	No Input	No Input
	b Small caliber weapons?	Yes[3]	No Input	Yes[3]	No Input	No Input	No Input	No Input	No Input	No Input	No Input

[3]WD 40

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PACKAGED PRODUCTS

Question		1st Tk Bn, 1st Marine Div	H&S Co, 1st Tk Bn, 1st Marine Div	1st Arty Bn, 11th Marines, 1st Marine Div	1st LAI Bn, 1st Marine Div	3rd AAV Bn, 1st Marine Div	MTM Co, 1st Mntc Bn, 1st FSSG	Bulk Fuel Co 7th Eng Supt Bn, 1st FSSG
1 Were packaged POL products taken by the units as part of their unit basic load (UBL)?		Yes	No	Yes	Yes	No	Yes	
2 Were packaged POL products acquired from local companies through local purchase procedures?		Yes[1]	Yes	Yes	Yes	Yes	Yes	
3 Were POL products packaged in unit quantities that were convenient for use and reduced waste?		No[2]	No	No	Unknown	No[2]	Yes	
4 Were packaged POL products labeled as to manufac-turer, grade, or other information to allow judgment in use?		Yes	Yes	No	Unknown	No	Yes	
5 Did commercial packaged POL products include	a Oils	Yes	Yes	Yes	Yes	Yes	Yes	
	b Dry lubricants	No	No	No	No	Unknown	Yes	
	c Greases	Yes	No	No	Yes	Unknown	Yes	
	d Antifreeze	No	No	No	Yes	No	Yes	
	e Hydraulic fluids	No	No	No	No	No	Yes	
	f Brake fluids	No	No	No	No	Unknown	Yes	
6 Were shortages noted in Class III packaged products?		Yes[3]	Yes	Yes	Yes	Yes	Yes	
7 Were Battenfeld Company manufactured products (i e , primary engine and gear oils) used?		No	No	No	No	No	No	No
8 If Battenfeld products were used was it because	a Units hadn t been notified they should not?	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	b Shortages forced the use of the products	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[1]Some OE HDO-10W and SAE-50 oils obtained from Saudi sources by contract through division supply
[2]Hydraulic fluids in 5-gal cans, could not get quart size Antifreeze in 55-gal drums Toward the end, FRH came in gal cans Oil obtained in 55 gal drums troops wanted 5-gal cans
[3]GAA OE HDO-10 LSA fuel filters, OE/HDO-15/40 not available until end of war

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FUELS

Question		1st Tk Bn, 1st Marine Div	H&S Co, 1st Tk Bn, 1st Marine Div	1st Arty Bn, 11th Marines, 1st Marine Div	1st LAI Bn, 1st Marine Div	3rd AAV Bn, 1st Marine Div	MTM Co, 1st Mntc Bn, 1st FSSG	Bulk Fuel Co, 7th Eng Supt Bn, 1st FSSG
1 Was the fuel delivered to the POL tank farms (bladders, etc) filtered?		N/A	N/A	N/A	N/A	N/A	Yes	Yes
2 Were any inspections, visual or other wise made at the tank farm?		N/A	N/A	No	No	N/A	No	Yes
3 Were any inspections, visual or other wise made at unit level?		No	No	No	Unknown	Yes	No	N/A
4 Were fuel analysis laboratories, either mobile or fixed, available to either or both wholesale and retail levels?		No	No	No	No	No	Yes	Yes
5 Were any abnormalities noted in the fuels delivered (color smell, appearance)?		No	No	Yes[1]	No	Yes	Yes	No
6 Were the users (operators) satisfied that they received good quality fuel in adequate quantities?		Yes	Yes	Yes	Yes	No	Yes	Yes
7 Were logistics, maintenance, and user personnel aware of the type and grade of fuel they used?		No	No	Yes	No	No	Yes	Yes
8 Were bulk fuels delivered in host nation or other foreign nation vehicles?		No	No	No	No	No	Yes	Yes
9 Was adequate information provided down to user level on proper fuels and lubricants utilization practices?		No	No	Yes	No	No	Yes	No
10 Were the following fuels available for use by military aircraft?	a JP-4	N/A	N/A	N/A	Yes	N/A	N/A	No
	b JP-8	N/A	N/A	N/A	Yes	N/A	N/A	No
	c JP-5	N/A	N/A	N/A	Yes	N/A	N/A	No
	d Jet A-1	N/A	N/A	N/A	Yes	N/A	N/A	Yes
11 When used in aircraft were problems expenenced with one or more of the aviation fuels?		N/A	N/A	N/A	No	N/A	N/A	No
12 Were the following fuels available for use by diesel-burning ground vehicles & equipment?	a JP-5	Didn't know	Didn't know	Yes	Yes	Yes	Yes	No
	b Jet A-1	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	c DF-2	Yes	Yes	No	No	Yes	Yes	No
13 Which of the fuels were used in the diesel-burning ground vehicles and equipment?	a JP-5	Didn t know	Didn t know	No	Yes	No	No	N/A
	b Jet A-1	Mostly	Mostly	Yes	Yes	Yes	Yes	N/A
	c DF 2	At port	At port	No	No	Yes at port	No	N/A

[1] Noted different colors

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FUELS

Question		1st Tk Bn, 1st Marine Div	H&S Co, 1st Tk Bn, 1st Marine Div	1st Arty Bn, 11th Marines, 1st Marine Div	1st LAI Bn, 1st Marine Div	3rd AAV Bn, 1st Marine Div	MTM Co 1st Mntc Bn, 1st FSSG	Bulk Fuel Co, 7th Eng Supt Bn 1st FSSG
14 Was there any noticeable decrease in power output when aviation fuel was used in diesel-burning ground vehicles and equipment?		Yes[2]	Yes3	Yes	Yes[4]	Yes[5]	Yes	N/A
15 Was any blending of engine oils or hydraulic fluids into aviation fuel practiced?		Yes[6]	Yes[6]	Yes[6]	Yes[6]	Yes	Yes	No
16 Were any procedures established for changing from one fuel to another, such as DF-2 to aviation fuel or one aviation fuel to another aviation fuel?		No	No	No	No	No	Yes	No
17 Did user personnel know that Jet A-1 fuel was a satisfactory replacement fuel for DF-2?		No	No	No	No	Yes	Yes	Yes
18 Were increased replacements of fuel filters needed following changeover?		Yes	Yes[7]	Yes[8]	Yes	Yes	Yes	N/A
19 Did fuel filter plugging occur?		Yes	Yes	Yes	Yes	Yes	Yes	No
20 If fuel filter plugging occurred, was it considered excessive?		Yes	Yes	Yes	Yes	Yes	Yes	N/A
21 Was a "black residue" observed on any fuel filters that were changed?		Yes	Yes	Yes	Yes	Yes	Yes	No
22 Were biocides/biostats used to control microbiological growth in fuel cells?		N/A	N/A	No	No[9]	No	No	No
23 Were any additives blended with the Jet A 1 fuel such as CI, FSII, or static dissipater?		No	No	No	No	No	No	No
24 Were fuel handlers and operator personnel fearful that Jet A-1 would be hazardous because of the lower flashpoint?		No	Yes, initially	No	No	Yes, little bit	No	No
25 Were there any "waxing" problems with the use of the host nation supplied diesel fuel?		N/A	N/A	N/A	N/A	N/A	No	N/A
26 Were vehicles routinely refueled by	a TPUs?	Yes	-	No	Yes	Yes	Yes	No
	b Military tankers?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	c Commercial tankers?	No	No	No	No	No	Yes	Yes

[2]Power returned after transition period, which included filter changes and filter pump changes No problems with M-88s
[3]Power loss occurred and increased as operations continued
[4]7 percent power loss
[5]Power did not resume at any time
[6]1 pt DEXRON-II per 18 gal (HMMWV) 10-wt oil mixed 50 1 and then changed to 20 1 for M60A1 tanks or 1 qt 10 wt per every 10 gallons
[7]Fuel filters were in short supply
[8]Some vehicles sometimes twice
[9]Did have microbiological growth problems

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FUELS

Question		1st Tk Bn, 1st Marine Div	H&S Co, 1st Tk Bn, 1st Marine Div	1st Arty Bn, 11th Marines, 1st Marine Div	1st LAI Bn, 1st Marine Div	3rd AAV Bn, 1st Marine Div	MTM Co, 1st Mntc Bn, 1st FSSG	Bulk Fuel Co, 7th Eng Supt Bn, 1st FSSG
27 Was dirt/sand a problem during fuel transfers?		No	No	Yes[10]	Yes	No	Yes	Yes
28 Was there a perceptible increase in maintenance when	a DF-2 was used?	No	No	No	No	No	No	N/A
	b Jet A-1 was used?	Yes[11]	Yes[12]	Yes	Yes	Yes	Yes	N/A
29 To alleviate dirt/sand problems during fuel transfers, were	a Calm atmospheric conditions waited for?	No	No	No	No	No	Used common sense	Nothing special
	b Fuel opening recesses blown or bushed free of dirt/sand?	Yes	Yes	Yes	Yes	Yes	Used common sense	Nothing special
	c Opening of fuel fill ports reduced to a minimum during PM services?	No	No	No	No	N/A	Used common sense	Nothing special
30 Was there a perceptible increase in fuel injector nozzle fouling when using	a DF-2 fuel?	No	No	No	N/A	No	No	No
	b Jet A-1 fuel?	No	Yes[13]	Yes[14]	Yes	Yes	Yes	Yes[15]
31 Did use of DF-2 in armored vehicles VEESS produce adequate smoke in the high ambient temperature environments?		N/A	N/A	N/A	N/A	Yes	N/A	N/A
32 If vehicles/equipment were using Jet A 1 did they "run hotter"?		Yes	Yes	Yes	No	No	Yes	No
33 Were there any perceptible problems associated with admixing fuels during fuel changeovers?		No	No	Unknown	Unknown	No	No	N/A
34 In units that utilized Jet A-1 were ground vehicles and aircraft refueled from the same fuel tankers?		N/A	N/A	N/A	N/A	No	No	N/A
35 Were there any problems in using vehicle personnel heaters with either Jet A 1 or DF 2?		No	No	No	No	No	No	No

[10] Sometimes careless handling of fuel transfer equipment
[11] Burning holes in engines (pistons cylinder walls and blocks) Locking up injector pumps
[12] Repairs of fuel injection pumps increased for individual units because of maintenance overload at 3rd echelon level
[13] Nozzle tips were burned
[14] On older vehicles
[15] Happened to 600-GPM pumps but could not be positively attributed to fuel

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LUBRICANTS

Question		1st Tk Bn, 1st Marine Div	H&S Co, 1st Tk Bn, 1st Marine Div	1st Arty Bn, 11th Marines, 1st Marine Div	1st LAI Bn, 1st Marine Div	3rd AAV Bn, 1st Marine Div	MTM Co, 1st Mntc Bn, 1st FSSG	Bulk Fuel Co, 7th Eng Supt Bn, 1st FSSG
1 Were the following engine oils available for use?	a OE/HDO-10	Yes	Yes	Yes	Yes	No	Yes	
	b OE/HDO-30	Yes	Yes	Yes	Yes	Yes	Yes	
	c OE/HDO-40/SAE 50	Yes	No/Yes	Yes	No/Yes	No	No/Yes	
	d OE/HDO-15/40/SAE10/40	At end of war	At end of war	No	No/Yes	Yes	No	
2 Was MIL-L-46152 (administrative service) engine oil used?		No	No	No	Unknown	No	No	
3 Were oil analysis laboratories available?		No	No	No	No	No	No	
4 Were normal lube order oil change intervals used for engine oil?		No	No	No	No	No	Yes	
5 If changes were made in normal intervals, were the invervals	a Increased?	No	No	No	Yes	Yes	N/A	
	b Decreased?	Yes	Yes	Yes	No	No	N/A	
6 Were normal lube order service intervals used for	a Transmissions?	Yes	Yes	No[1]	Yes	Yes	Yes	
	b Power transfer units?	Yes	Yes	No[1]	Yes	Yes	Yes	
	c Differentials?	Yes	Yes	No[1]	Yes	Yes	Yes	
	d Hydraulic systems?	Yes	Yes	No[1]	Yes	Yes	Yes	
	e Brake systems?	Yes	Yes	No[1]	Yes	Yes	Yes	
7 Was there any evidence of "oil breakdown" (i e oil too thin, excessive oil consumption etc)?		Yes[2]	No	No	Unknown	No	No	
8 Were there problems in performing lubricant related maintenance?		No	No	Yes	Yes	Yes[3]	No	
9 If oil analysis laboratories were available, were oil samples taken and sent to them?		No	No	No	Yes	No	N/A	
10 If oil samples were sent to a laboratory for analysis were any results ever received?		No	No	N/A	No	N/A	N/A	
11 Did dirt/sand contamination cause any problems with	a Wheel bearings	No	No	Yes[4]	Unknown	No	Unknown	
	b Gear drives?	No	No	Yes[4]	Unknown	No	Unknown	
	c Gun positioning systems?	No	No	Yes[4]	Unknown	No	Unknown	
12 Did hot ambient temperatures cause any oil-related problems?		No	No	No	No	No	No	
13 If the OE HDO-15/40 tactical engine oil (MIL-L-2104) was not used, was it because	a The oil got too thin?	No	No	No	No	N/A	No	
	b The engine ran hotter?	No	No	No	No	N/A	No	
	c The oil was not available?	Yes	Yes	Yes	Yes	N/A	Yes	

[1] When required
[2] SAE 50 wt in M60A1 final drives became too thin and some water was found
[3] Sand got in open 5-gal containers
[4] Same problems at Twenty-nine Palms, CA

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LUBRICANTS

Question		1st Tk Bn, 1st Marine Div	H&S Co, 1st Tk Bn, 1st Marine Div	1st Arty Bn, 11th Marines, 1st Marine Div	1st LAI Bn, 1st Marine Div	3rd AAV Bn, 1st Marine Div	MTM Co, 1st Mntc Bn, 1st FSSG	Bulk Fuel Co, 7th Eng Supt Bn, 1st FSSG
14 Were any or all of the following gear oils (MIL-L-2105) used?	a 85W-140	No	–	Yes	No	No	No	
	b 90	No	Yes	Yes	Yes	No	No	
	c 80W-90	Yes	–	Yes	No	Yes	Yes	
15 Were oil filters changed each time the engine oil was changed?		Yes[5]	Yes[5]	Yes	No	Yes[5]	Yes	

[5] If available

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HYDRAULIC AND BRAKE FLUIDS

Question		1st Tk Bn, 1st Marine Div	H&S Co, 1st Tk Bn, 1st Marine Div	1st Arty Bn, 11th Marines, 1st Marine Div	1st LAI Bn, 1st Marine Div	3rd AAV Bn, 1st Marine Div	MTM Co, 1st Mntc Bn 1st FSSG	Bulk Fuel Co, 7th Eng Supt Bn, 1st FSSG
1 Were any or all of the following hydraulic and gun control systems fluids used?	a OHT/OHA ("Cherry Juice")	No	Yes	Yes	No	Yes[1]	Yes/Yes	
	b FRH (fire resistant hydraulic fluid)	Yes	Didn't use	No	Yes	No	Yes	
	c Dexron-II	Yes	Yes	Yes	No	Yes	Yes	
2 Did the hot ambient temperatures affect those self-propelled gun systems using "Cherry Juice" (MIL-H-6083)?		N/A	No	No	N/A	Unknown	N/A	
3 Was sand contamination a problem with operation of any hydraulic or brake fluid system?		No	Yes[2]	Yes[3]	Yes	No	Yes[4]	
4 If vehicle brake systems using silicone brake fluid (MIL B-46176) were topped off with conventional/commercial-type automotive brake fluids were any differences in braking performance noticeable?		N/A	N/A	N/A	N/A	N/A	N/A	
5 Did the hot ambient temperatures cause brake fade problems?		No	No	No	No	No	No	
6 Were filters in those hydraulic systems employing filters routinely changed?		No	No	Yes[5]	No	Yes	N/A	
7 Did the hot ambient temperatures cause more frequent topping off of both hydraulic and brake systems?		No	No	No	No	No	No	
8 Were there any occurrences in which "cherry juice" (MIL-H-6083/OHT) was added to hydraulic systems using the MIL H 46170 FRH hydraulic fluid or vice versa?		N/A	N/A	N/A	N/A	N/A	Didn't know	
9 Were any AOAP samples taken from hydraulic systems?		No	No	No	No	No	No	
10 Did the higher ambient temperatures create an overall increase in the maintenance of hydraulic and gun control systems?		No	No	No	No	No	No	
11 Did the higher ambient temperatures create an overall increase in the maintenance of vehicle brake systems?		No	No	No	No	No	No	
12 Were fluid changes accomplished at intervals scheduled in authorized lube orders?		Yes	No[6]	No	Unknown	No	Yes	

[1] OHT used when OHA ran out
[2] Wheel master cylinders
[3] Sand problem with spade hydraulic cylinders
[4] Hydraulic system of HMMWVs had a sand build up in hydraulic booster
[5] When available
[6] More frequently

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GREASES

Question	1st Tk Bn, 1st Marine Div	H&S Co, 1st Tk Bn, 1st Marine Div	1st Arty Bn, 11th Marines, 1st Marine Div	1st LAI Bn, 1st Marine Div	3rd AAV Bn 1st Marine Div	MTM Co, 1st Mntc Bn 1st FSSG	Bulk Fuel Co, 7th Eng Supt Bn, 1st FSSG
1 Was MIL-G-10924F or MIL-G-0010924E versions of GAA grease available for use?	Didn't know Just knew they had GAA	Didn't know Just knew they had GAA	Yes	Unknown	Yes	Yes	
2 Was WTR (MIL-G-83122) grease automatically substituted where GAA was required?	No	Yes	Yes	Yes	No	Yes	
3 Did the hot ambient temperatures cause excessive grease breakdown and leakage?	No	Yes[1]	Yes	Yes	Yes	No	
4 Did the hot ambient temperatures affect the shelf life of the unused GAA and other greases?	No	Yes[2]	Yes	Yes	Yes	No	
5 Where WTR grease was used interchangeably with GAA at lubrication points previously lubricated with GAA, were any performance differences noted?	N/A	No	No	No	No	No	
6 Were relubrication intervals changed from those specified in authorized lube orders?	No	Yes[3]	Yes	No	Yes	No	
7 Were solvents used to clean parts before relubricating components such as wheel bearings CV joints, etc?	Yes[4]	Yes[4]	Yes[4]	Yes[4]	Yes[4]	Yes[4]	
8 Were sand particles evident in bearing components during disassembly?	No	Some[5]	Yes	No	No	Yes	
9 Did the higher ambient temperatures create an overall increase in the maintenance of any grease-lubricated components on vehicle/equipment systems?	No	No	Yes	Yes	No	No	

[1] Had a breakdown with GAA and used WTR with no problems
[2] I can GAA
[3] Anything with zert fittings were relubricated more often
[4] Jet A-1
[5] Did not have to disassemble very many times

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COOLANTS/ANTIFREEZE

Question		1st Tk Bn, 1st Marine Div	H&S Co, 1st Tk Bn, 1st Marine Div	1st Arty Bn, 11th Marines, 1st Marine Div	1st LAI Bn, 1st Marine Div	3rd AAV Bn, 1st Marine Div	MTM Co 1st Mntc Bn, 1st FSSG	Bulk Fuel Co, 7th Eng Supt Bn, 1st FSSG
1 Was any commercial type antifreeze used in lieu of MIL-A-46153 antifreeze?		N/A	Yes	No	Yes	No	Yes	Yes
2 Was the antifreeze extender additive (MIL-A-53009) used?		N/A	No	No	No	No	No	
3 Was it possible to save drained antifreeze for reuse when cooling systems were drained and filled?		N/A	No	No	No	No	No	
4 Were any of the following make-up waters used?	a Potable water	N/A	Yes	Yes	Yes	Yes	Yes	
	b Distilled water	N/A	No	No	No	No	No	
	c Bottled water	N/A	Yes	Yes	No	No	No	
	d Local water	N/A	Yes	Yes	No	No	Yes	
5 Did the hot ambient temperatures cause engines to run hotter?		N/A	Yes[1]	No	Yes[1]	No	Yes	
6 Were there any leaking or corrosion problems attributed to the antifreeze or hard water (i e , local water) that may have been used?		N/A	No	No	Yes	No	No	
7 Were the standard Test Strip Kits used to measure if the antifreeze was okay?		N/A	No	No	No	No	No	
8 When antifreeze was changed for a reason other than one required by the standard test strip, was it because	a Of an engine change?	Yes	Yes	Yes	Yes	Yes	Yes	
	b Repair of an engine?	Yes	Yes	Yes	Yes	Yes	Yes	
	c Dirt/sand contamination?	N/A	N/A	N/A	N/A	N/A	No	
	d Other contamination?	N/A	Yes	Yes	Yes	Yes	No	
9 Was any MIL A-46153 antifreeze provided to you in metal containers?		N/A	Yes	Yes	No	Yes	Yes	
10 Were the metal containers plastic lined?		N/A	Yes	Yes	N/A	Yes	Yes	
11 Did the higher ambient temperatures create an overall increase in the maintenance of engine cooling system components?		N/A	Yes[2]	No	No	No	No	
12 Was flushing of cooling systems a problem due to the limitations on available water?		N/A	No	No	Yes	Yes	No	
13 Were there any instances that undiluted antifreeze was added directly in refilling cooling systems?		N/A	No	No	No	No	No	

[1] Running hotter but not overheating
[2] Initially Believed to be caused by a preservative fluid (black, degraded hoses, stuck thermostats) put in while stored on PMS ships

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COOLANTS/ANTIFREEZE

Question		1st Tk Bn 1st Marine Div	H&S Co, 1st Tk Bn, 1st Marine Div	1st Arty Bn, 11th Marines, 1st Marine Div	1st LAI Bn, 1st Marine Div	3rd AAV Bn 1st Marine Div	MTM Co 1st Mntc Bn 1st FSSG	Bulk Fuel Co 7th Eng Supt Bn 1st FSSG
14 When topping off radiator systems was	a Water only used?	N/A	Yes[3]	Yes	Yes	Yes	Yes	
	b Antifreeze only used?	N/A	No	No	No	No	No	
	c Water-antifreeze mixture used?	N/A	Yes[3]	No	No	No	No	

[3]When temperature went down to -20°F, they added antifreeze.

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WEAPONS LUBRICANTS/SOLID LUBRICANTS

Questions		1st Tk Bn 1st Marine Div	H&S Co, 1st Tk Bn, 1st Marine Div	1st Arty Bn 11th Marines, 1st Marine Div	1st LAI Bn, 1st Marine Div	3rd AAV Bn, 1st Marine Div	MTM Co, 1st Mntc Bn 1st FSSG	Bulk Fuel Co 7th Eng Supt Bn, 1st FSSG
1 Were military specification products used?		Yes	Yes	Yes	Yes	Yes		
2 In addition to those required specification products were other proprietary commercial products also used? For example	a TW-25	No	No	No	No	No		
	b Dryslide	Yes[1]	No	No	Yes	N/A		
	c WD-40	No	No	No	No	No		
	d Bore-Cote	Yes[2]	No	No	No	No		
3 If these proprietary products were also used, was there a noticeable change in the performance or a reason that necessitated their use?		N/A	N/A	N/A	Unknown	N/A		
4 Were the hot ambient temperatures creating lubrication problems for weapons/gun systems?		No	No	No	Yes	No		
5 Was dirt/sand adhesion a significant problem?		No	No	Yes	Yes	Yes		
6 If dirt/sand adhesion was a significant problem was it resolved satisfactorily?		N/A	N/A	Yes	Yes	Yes		
7 Were any solid film lubricants used?		Yes[3]	No	No	Unknown	No		
8 Were there any mixing or compatibility problems (i e solid lubes with greases or fluids)?		No	No	N/A	Unknown	N/A		
9 Were solid lubricants applied by	a User personnel?	No	N/A	N/A	Unknown	N/A		
	b Ordnance personnel?	Yes	N/A	N/A	Unknown	N/A		
	c Other?	No	N/A	N/A	Unknown	N/A		
10 Did the higher ambient temperatures create an overall increase in the maintenance of oil/fluid/grease lubricated weapons systems components?		No	No	No	Yes	No		

[1]Procured but never used
[2]Used on rifles but were not going to fire weapons until cleaned and lubed with MIL-SPEC lubricants
[3]Was not trusted for combat Weapons recleaned before firing

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WEAPONS LUBRICANTS/SOLID LUBRICANTS

Questions		1st Tk Bn, 1st Marine Div	H&S Co, 1st Tk Bn, 1st Marine Div	1st Arty Bn, 11th Marines, 1st Marine Div	1st LAI Bn, 1st Marine Div	3rd AAV Bn 1st Marine Div	MTM Co, 1st Mntc Bn, 1st FSSG	Bulk Fuel Co 7th Eng Supt Bn, 1st FSSG
11 Was there a "preferred" weapons lubricant for	a Large caliber weapons?	Yes[4]	Yes4	Yes	Yes[5]	Yes[5]		
	b Small caliber weapons?	Yes[6]	Yes[6]	Yes[5]	Yes[7]	Yes[5]		

[4] LSA for 30 caliber and up
[5] CLP
[6] CLP, rust was a problem
[7] Dryslide
General 1 Used metal auto brake tubing from wrecked vehicles to repair fuel hoses
2 Not enough lubricity in Jet A-1 for HMMWVs

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PACKAGED PRODUCTS

Question		Survey Group 1	Survey Group 2	Survey Group 3
1 Were packaged POL products taken by the units as part of their unit basic load (UBL)?		No	N/A	Yes
2 Were packaged POL products acquired from local companies through local purchase procedures?		Yes	Yes	Yes
3 Were POL products packaged in unit quantities that were convenient for use and reduced waste?		Yes[1]	Yes	Yes[1]
4 Were packaged POL products labeled as to manufacturer, grade, or other information to allow judgment in use?		Yes	Yes	Yes
5 Did commercial packaged POL products include	a Oils	Yes	Yes	Yes
	b Dry lubricants	No	No	No
	c Greases	N/A	Yes	No
	d Antifreeze	N/A	No	Yes
	e Hydraulic fluids	No	No	Yes
	f Brake fluids	No	No	No
6 Were shortages noted in Class III packaged products?		Yes[2]	Yes	Yes[3]
7 Were Battenfeld Company manufactured products (i.e., primary engine and gear oils) used?		No	No	No
8 If Battenfeld products were used, was it because	a Units hadn't been notified they should not?	No	N/A	N/A
	b Shortages forced the use of the products	N/A	N/A	N/A

[1]Answer suitable for bulk handlers
[2]Shortages alternated between overages due to procurement fluctuations
[3]Turbo-shaft oil, OHT, FRH, GA, GMB, WTR, damping fluid.
General Note: 2nd Tank Bn, 2nd Marine Division were issued MIAs on a "temporary loan" basis in SWA. Had trouble convincing their supply chain that they needed different transmission (turbo-shaft oils) and FRH hydraulic fluids.

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FUELS

Question		Survey Group 1	Survey Group 2	Survey Group 3
1 Was the fuel delivered to the POL tank farms (bladders, etc) filtered?		No[1]	Yes	N/A
2 Were any inspections, visual or otherwise, made at the tank farm?		Yes	Yes	N/A
3 Were any inspections, visual or otherwise, made at unit level?		Yes	No	Yes
4 Were fuel analysis laboratories, either mobile or fixed, available to either or both wholesale and retail levels?		Yes[2]	Yes[3]	Yes[2]
5 Were any abnormalities noted in the fuels delivered (color, smell, appearance)?		No[4]	No	No
6 Were the users (operators) satisfied that they received good quality fuel in adequate quantities?		Yes	Yes	Yes
7 Were logistics, maintenance, and user personnel aware of the type and grade of fuel they used?		Yes	Yes	Yes
8 Were bulk fuels delivered in host nation or other foreign nation vehicles?		Yes	Yes	Yes
9 Was adequate information provided down to user level on proper fuels and lubricants utilization practices?		Yes	No	Yes
10 Were the following fuels available for use by military aircraft?	a JP-4	No	No	N/A
	b JP-8	No	No	N/A
	c JP-5	No	No	N/A
	d Jet A-1	Yes	Yes	N/A
11 When used in aircraft, were problems experienced with one or more of the aviation fuels?		No	No	N/A
12 Were the following fuels available for use by diesel-burning ground vehicles & equipment?	a JP-5	Yes	No	No
	b Jet A-1	Yes	Yes	Yes
	c DF-2	Yes	No	No
13 Which of the fuels were used in the diesel-burning ground vehicles and equipment?	a JP-5	Yes (Little)	No	No
	b Jet A-1	Yes (>95%)	Yes	Yes
	c DF-2	Yes (Little)	No	No
14 Was there any noticeable decrease in power output when aviation fuel was used in diesel-burning ground vehicles and equipment?		No	Yes[5]	Yes[6]
15 Was any blending of engine oils or hydraulic fluids into aviation fuel practiced?		Yes	Yes	Yes

[1]Were unaware of prior fuel filtering
[2]Labs available but not used
[3]For aviation resources
[4]A red color was associated with fuel standing in delivery line for one or more days
[5]M60 tanks
[6]Pertains to engineer construction equipment (D7s graders) claimed vehicles used more fuel

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FUELS

Question		Survey Group 1	Survey Group 2	Survey Group 3
16 Were any procedures established for changing from one fuel to another, such as DF-2 to aviation fuel or one aviation fuel to another aviation fuel?		Yes	No	Yes
17 Did user personnel know that Jet A-1 fuel was a satisfactory replacement fuel for DF-2?		Yes[7]	Yes7	Yes
18 Were increased replacements of fuel filters needed following changeover?		Yes[8]	No	Yes
19 Did fuel filter plugging occur?		Yes[8]	No	Yes
20 If fuel filter plugging occurred, was it considered excessive?		Yes[8]	N/A	No
21 Was a "black residue" observed on any fuel filters that were changed?		N/A	No	Yes
22 Were biocides/biostats used to control microbiological growth in fuel cells?		No	No	No
23 Were any additives blended with the Jet A-1 fuel, such as CI, FSII, or static dissipater?		No[9]	No	No
24 Were fuel handlers and operator personnel fearful that Jet A-1 would be hazardous because of the lower flashpoint?		No	No	No
25. Were there any "waxing" problems with the use of the host nation supplied diesel fuel?		N/A	N/A	N/A
26. Were vehicles routinely refueled by	a TPUs?	No	Yes	No
	b Military tankers?	Yes	Yes	Yes
	c Commercial tankers?	No	No	Yes
27 Was dirt/sand a problem during fuel transfers?		No	No	Yes
28 Was there a perceptible increase in maintenance when	a DF-2 was used?	N/A	N/A	N/A
	b Jet A-1 was used?	Yes[10]	Yes[10]	Yes[11]
29 To alleviate dirt/sand problems during fuel transfers, were	a Calm atmospheric conditions waited for?	No	No	No
	b Fuel opening recesses blown or brushed free of dirt/sand?	Yes	No	Yes
	c Opening of fuel fill ports reduced to a minimum during PM services?	No	No	No

[7]Users were told but all personnel did not accept assurance
[8]Only for units which did not flush fuel systems and change filters
[9]In their opinion CI, FSII and static dissipator should not be injected below wholesale level
[10]Especially CUCV and HMMWV fuel injection pumps
[11]Increase due to failed PT pumps on AA vehicles

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FUELS

Question		Survey Group 1	Survey Group 2	Survey Group 3
30 Was there a perceptible increase in fuel injector nozzle fouling when using	a DF-2 fuel?	N/A	N/A	N/A
	b Jet A-1 fuel?	No	No[12]	No
31 Did use of DF-2 in armored vehicles VEESS produce adequate smoke in the high ambient temperature environments?		N/A	N/A	N/A
32 If vehicles/equipment were using Jet A-1, did they "run hotter"?		No	Yes	Yes
33 Were there any perceptible problems associated with admixing fuels during fuel changeovers?		No	No	No
34 In units that utilized Jet A-1, were ground vehicles and aircraft refueled from the same fuel tankers?		No	Yes[13]	N/A
35 Were there any problems in using vehicle personnel heaters with either Jet A-1 or DF-2?		No	Yes	No

[12]One unit reported fuel injector nozzles burning and fouling out in the NHC 250 and NTC 400 Cummins engines
[13]Ground vehicles were refueled from aviation fuel qualified military tankers.
General Note. One unit reported that they did not mix oil or hydraulic fluid with their fuel They reported using 200 HMMWVs for over 500,000 miles with no problems except one Stanadyne pump Followed preventive maintenance services with fuel filters drained of water two to three times a day

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LUBRICANTS

Question		Survey Group 1	Survey Group 2	Survey Group 3
1 Were the following engine oils available for use?	a OE/HDO-10		Yes	Yes
	b OE/HDO-30		No	Yes
	c OE/HDO-40/10W-30		No	No/Yes
	d OE/HDO-15/40/SAE 50		Yes	Yes
2 Was MIL-L-46152 (administrative service) engine oil used?			No	No
3 Were oil analysis laboratories available?			No	No
4 Were normal lube order oil change intervals used for engine oil?			Yes	No[1]
5 If changes were made in normal intervals, were the invervals	a. Increased?		N/A	No
	b Decreased?		N/A	Yes[1]
6 Were normal lube order service intervals used for	a Transmissions?		Yes	Yes[1]
	b Power transfer units?		Yes	Yes[1]
	c Differentials?		Yes	Yes[1]
	d Hydraulic systems?		Yes	Yes[1]
	e Brake systems?		Yes	Yes[1]
7 Was there any evidence of "oil breakdown" (i e , oil too thin, excessive oil consumption, etc.)?			No	No
8 Were there problems in performing lubricant-related maintenance?			No	Yes
9 If oil analysis laboratories were available, were oil samples taken and sent to them?			N/A	N/A
10 If oil samples were sent to a laboratory for analysis, were any results ever received?			N/A	N/A
11 Did dirt/sand contamination cause any problems with	a. Wheel bearings		No	Yes
	b Gear drives?		No	Yes
	c Gun positioning systems?		No	Yes
12 Did hot ambient temperatures cause any oil-related problems?			No	No
13 If the OE/HDO-15/40 tactical engine oil (MIL-L-2104) was not used, was it because	a. The oil got too thin?		N/A	N/A
	b. The engine ran hotter?		N/A	N/A
	c The oil was not available?		N/A	N/A
14 Were any or all of the following gear oils (MIL-L-2105) used?	a 85W-140		No	Yes
	b 90		No	Yes
	c 80W-90		Yes	Yes
15 Were oil filters changed each time the engine oil was changed?			Yes	Yes

[1] Lube interval was reduced by one-half

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HYDRAULIC AND BRAKE FLUIDS

Question		Survey Gorup 1	Survey Gorup 2	Survey Gorup 3
1 Were any or all of the following hydraulic and gun control systems fluids used?	a OHT ("Cherry Juice")		No	Yes
	b FRH (fire resistant hydraulic fluid)		No	Yes
	c Dexron-II		Yes	Yes
2 Did the hot ambient temperatures affect those self-propelled gun systems using "Cherry Juice" (MIL-H-6083)?			N/A	No
3 Was sand contamination a problem with operation of any hydraulic or brake fluid system?			Yes[1]	Yes[1]
4 If vehicle brake systems using silicone brake fluid (MIL-B-46176) were topped off with conventional/commercial-type automotive brake fluids, were any differences in braking performance noticeable?			N/A	N/A
5 Did the hot ambient temperatures cause brake fade problems?			No	No
6 Were filters in those hydraulic systems employing filters routinely changed?			Yes	Yes
7 Did the hot ambient temperatures cause more frequent topping off of both hydraulic and brake systems?			No	No
8 Were there any occurrences in which "cherry juice" (MIL-H-6083/OHT) was added to hydraulic systems using the MIL-H-46170/FRH hydraulic fluid or vice versa?			N/A	No[2]
9 Were any AOAP samples taken from hydraulic systems?			No	N/A
10 Did the higher ambient temperatures create an overall increase in the maintenance of hydraulic and gun control systems?			No	No
11 Did the higher ambient temperatures create an overall increase in the maintenance of vehicle brake systems?			No	No
12 Were fluid changes accomplished at intervals scheduled in authorized lube orders?			Yes	No

[1] Had problems with hydraulic seals on 6000-lb forklifts.
[2] A question was raised about Type I and Type II FRH fluids. Type I cannot be mixed with Type II and the unit was issued Type I when they needed Type II. The situation was resolved when the FRH was removed from the unit's AVLBs and used in the MIAIs.

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GREASES

Question	Survey Gorup 1	Survey Gorup 2	Survey Gorup 3
1 Was MIL-G-10924F or MIL-G-0010924E versions of GAA grease available for use?		Yes	Yes[1]
2 Was WTR (MIL-G-83122) grease automatically substituted where GAA was required?		Yes[2]	Yes
3 Did the hot ambient temperatures cause excessive grease break down and leakage?		No	No
4 Did the hot ambient temperatures affect the shelf life of the unused GAA and other greases?		No	Yes
5 Where WTR grease was used interchangeably with GAA at lubrication points previously lubricated with GAA, were any performance differences noted?		No	No
6 Were relubrication intervals changed from those specified in authorized lube orders?		No	Yes[3]
7 Were solvents used to clean parts before relubricating components such as wheel bearings, CV joints, etc?		Yes	Yes
8 Were sand particles evident in bearing components during disassembly?		No	Yes
9 Did the higher ambient temperatures create an overall increase in the maintenance of any grease-lubricated components on vehicle/equipment systems?		No	No

[1]Unit wanted GA but received GAA instead
[2]Substituted WTR in track tension cylinders on M60 tanks, stated that the Marine Corps is transitioning to WTR from GAA grease
[3]Intervals were decreased by 1/2

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COOLANTS/ANTIFREEZE

Question		Survey Group 1	Survey Group 2	Survey Group 3
1 Was any commercial type antifreeze used in lieu of MIL-A-46153 antifreeze?			No	Yes
2. Was the antifreeze extender additive (MIL-A-53009) used?			No	No
3 Was it possible to save drained antifreeze for reuse when cooling systems were drained and filled?			No	No
4 Were any of the following make-up waters used?	a Potable water		Yes	Yes
	b Distilled water		No	Yes
	c Bottled water		No	Yes
	d Local water		No	Yes
5 Did the hot ambient temperatures cause engines to run hotter?			No	No
6 Were there any leaking or corrosion problems attributed to the antifreeze or hard water (i e , local water) that may have been used?			No	No
7 Were the standard Test Strip Kits used to measure if the antifreeze was okay?			No	No
8. When antifreeze was changed for a reason other than one required by the standard test strip, was it because.	a Of an engine change?		Yes	Yes
	b Repair of an engine?		Yes	Yes
	c Dirt/sand contamination?		No	Yes
	d Other contamination?		No	Yes
9 Was any MIL-A-46153 antifreeze provided to you in metal containers?			No	Yes[1]
10 Were the metal containers plastic lined?			N/A	No[1]
11 Did the higher ambient temperatures create an overall increase in the maintenance of engine cooling system components?			No	No
12 Was flushing of cooling systems a problem due to the limitations on available water?			No	No
13 Were there any instances that undiluted antifreeze was added directly in refilling cooling systems?			No	No
14 When topping off radiator systems, was	a Water only used?		No	Yes
	b Antifreeze only used?		No	Yes
	c. Water-antifreeze mixture used?		Yes	Yes

[1]Two 55-gal drums other containers were plastic

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WEAPONS LUBRICANTS/SOLID LUBRICANTS

Questions		Survey Group 1	Survey Group 2	Survey Group 3
1 Were military specification products used?			Yes	Yes
2 In addition to those required specification products, were other proprietary commercial products also used? For example,	a TW-25		No	No
	b Dryslide		No	Yes
	c WD-40		No	Yes
3 If these proprietary products were also used, was there a noticeable change in the performance or a reason that necessitated their use?			N/A	No
4 Was the hot ambient temperatures creating lubrication problems for weapons/gun systems?			No	No
5 Was dirt/sand adhesion a significant problem?			Yes	Yes
6 If dirt/sand adhesion was a significant problem, was it resolved satisfactorily?			Yes	Yes
7 Were any solid film lubricants used?			No	Yes
8 Were there any mixing or compatibility problems (i e , solid lubes with greases or fluids)?			N/A	No
9 Were solid lubricants applied by	a User personnel?		N/A	Yes
	b Ordnance personnel?		N/A	No
	c Other?		N/A	No
10 Did the higher ambient temperatures create an overall increase in the maintenance of oil/fluid/grease lubricated weapons systems components?			No	No
11 Was there a "preferred" weapons lubricant for	a. Large caliber weapons?		Yes (CLP)	Yes (CLP)
	b Small caliber weapons?		Yes (CLP)	Yes (CLP)

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PACKAGED PRODUCTS

Question		724th Spt Bn,, (Main) 24th Inf Div	A Co , 224th Spt Bn, 24th Inf Div	hg 2nd Bde (S-4) 24th Inf Div	HHC, 3/15th Inf (Mech) 24th Inf Div	A Co 3/15th Inf (Mech) 24th Inf Div
1. Were packaged POL products taken by the units as part of their unit basic load (UBL)?		Yes	Yes	Yes	Yes	Yes
2. Were packaged POL products acquired from local companies through local purchase procedures?		Yes	Yes	Yes	Yes	Yes
3 Were POL products packaged in unit quantities that were convenient for use and reduced waste?		Yes	Yes	No[1]	Yes[2]	Yes
4 Were packaged POL products labeled as to manufacturer, grade, or other information to allow judgment in use?		Yes	Yes	Yes	No[3]	Yes
5 Did commercial packaged POL products include:	a. Oils	Yes	Yes	Yes	Yes	Yes
	b. Dry lubricants	No	No	Yes	No	No
	c. Greases	No	Yes	No	Yes	No
	d. Antifreeze	Yes	No	No	No	No
	e. Hydraulic fluids	Yes	Yes	No	No	No
	f. Brake fluids	Yes	No	No	No	No
6 Were shortages noted in Class III packaged products?		Yes[4]	No	Yes[5]	No[6]	No
7 Were Battenfeld Company manufactured products (i e , primary engine and gear oils) used?		No	No	No	No	No
8 If Battenfeld products were used, was it because,	a Units hadn't been notified they should not?	N/A	N/A	N/A	N/A	N/A
	b Shortages forced the use of the products	N/A	N/A	N/A	N/A	N/A

[1]a Preferred DEXRON II in quarts versus 5-gallon cans
b Preferred Turbo-Shaft oil in 55-gallon drums
[2]Except for 30-wt oil which was available only in 55-gallon drums
[3]Claimed only Arabic language used on containers
[4]Initially during first week no problems after that
[5]10-wt throughout 30 wt was sporadic. GMD
General 1 A box was built on top of HEMTT Tanks for transport and storage of packaged products
2 Prefer plastic containers with "screw-on" caps for lubricants container
[6]Not after the first month

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FUELS

Question		724th Spt Bn , (Main) 24th Inf Div	A Co , 224th Spt Bn, 24th Inf Div	Hg 2nd Bde (S-4) 24th Inf Div	HHC, 3/15th Inf (Mech) 24th Inf Div	A Co 3/15th Inf (Mech) 24th Inf Div
1 Was the fuel delivered to the POL tank farms (bladders, etc.) filtered?		Yes	N/A	N/A	Yes	N/A
2. Were any inspections, visual or otherwise, made at the tank farm?		Yes	N/A	N/A	No	N/A
3 Were any inspections, visual or otherwise, made at unit level?		N/A	Yes	Yes	No	No
4 Were fuel analysis laboratories, either mobile or fixed, available to either or both wholesale and retail levels?		No	Yes[1]	Yes	No[2]	No
5. Were any abnormalities noted in the fuels delivered (color, smell, appearance)?		Yes[3]	No	Yes[4]	No	Yes[5]
6 Were the users (operators) satisfied that they received good quality fuel in adequate quantities?		Yes	Yes	Yes	Yes	Yes
7 Were logistics, maintenance, and user personnel aware of the type and grade of fuel they used?		Yes	Yes	Yes	Yes	No
8. Were bulk fuels delivered in host nation or other foreign nation vehicles?		Yes[6]	Yes	Yes	No	No
9 Was adequate information provided down to user level on proper fuels and lubricants utilization practices?		No	No	No	No	No
10. Were the following fuels available for use by military aircraft?	a. JP-4	N/A	No	N/A	N/A	N/A
	b JP-8	N/A	No	N/A	N/A	N/A
	c. JP-5	N/A	No	N/A	N/A	N/A
	d. Jet A-1	N/A	Yes	N/A	N/A	N/A
11 When used in aircraft, were problems experienced with one or more of the aviation fuels?		N/A	No	N/A	N/A	N/A
12. Were the following fuels available for use by diesel-burning ground vehicles & equipment?	a. JP-5	No	No	No	No	No
	b. Jet A-1	Yes	Yes	Yes	Yes	Yes
	c. DF-2	Yes	Yes	Yes	Yes	Yes
13. Which of the fuels were used in the diesel-burning ground vehicles and equipment?	a. JP-5	No	No	No	No	No
	b Jet A-1	Yes	Yes	Yes	Yes	Yes
	c. DF-2	Yes	Yes	Yes	Yes	Yes
14 Was there any noticeable decrease in power output when aviation fuel was used in diesel-burning ground vehicles and equipment?		Yes[7]	Yes	Yes[8]	No	No
15. Was any blending of engine oils or hydraulic fluids into aviation fuel practiced?		No	No	No	No	No

[1]Flew samples to Air Force Lab at KFMC Heard that results were good.
[2]Captive fuel test kits available but not used
[3]Bad odor, fungus
[4]Red in color (looked like KoolAid)–DF-2
[5]Different color than used in U S (looked like pea green soup)
[6]To the Tank Farm
[7]a. New fuel injector pumps apparently restored power as determined by STE-ICE equipment (wheeled vehicles)
b M88 power restored after engine and transmission change
[8]a Did not know whether to contribute loss of power in M1 tanks to air induction problems or fuel problems
b HMMWVs

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FUELS

Question		724th Spt Bn (Main) 24th Inf Div	A Co., 224th Spt Bn, 24th Inf Div	Hg 2nd Bde (S-4) 24th Inf Div	HHC, 3/15th Inf (Mech) 24th Inf Div	A Co 3/15th Inf (Mech) 24th Inf Div
16 Were any procedures established for changing from one fuel to another, such as DF-2 to aviation fuel or one aviation fuel to another aviation fuel?		No	No	No	No	No
17 Did user personnel know that Jet A-1 fuel was a satisfactory replacement fuel for DF-2?		Yes	Yes	No	No	N/A
18 Were increased replacements of fuel filters needed following changeover?		Yes[9]	No	Yes	No	Yes[10]
19 Did fuel filter plugging occur?		Yes	No	Yes[11]	No	Yes[12]
20 If fuel filter plugging occurred, was it considered excessive?		No	N/A	Yes	N/A	Yes
21 Was a "black residue" observed on any fuel filters that were changed?		Yes[13]	Yes	Yes[14]	No	No
22. Were biocides/biostats used to control microbiological growth in fuel cells?		No	No	No	No	No
23. Were any additives blended with the Jet A-1 fuel, such as CI, FSII, or static dissipater?		No	No	No	No	No
24 Were fuel handlers and operator personnel fearful that Jet A-1 would be hazardous because of the lower flashpoint?		No	No	No	No	No
25. Were there any "waxing" problems with the use of the host nation supplied diesel fuel?		Yes[15]	No	No	No	No
26. Were vehicles routinely refueled by:	a. TPUs?	No	Yes	Yes	No	No
	b. Military tankers?	Yes	Yes	Yes	Yes	Yes
	c. Commercial tankers?	No	No	No	No	No
27. Was dirt/sand a problem during fuel transfers?		Yes	No	Yes[16]	Yes	No
28 Was there a perceptible increase in maintenance when:	a. DF-2 was used?	No	No	No	No	No
	b. Jet A-1 was used?	Yes[17]	No	Yes[18]	No	No
29 To alleviate dirt/sand problems during fuel transfers, were:	a. Calm atmospheric conditions waited for?	No	Yes	No	No	No
	b. Fuel opening recesses blown or brushed free of dirt/sand?	Common Sense	Yes	Yes	Yes	Yes
	c. Opening of fuel fill ports reduced to a minimum during PM services?	Common Sense	No	No	Yes	No

[9]On M1 tanks only, rate was normal for all other vehicles
[10]Excess water in fuel
[11]Had big problems with engine ful/water separator filters plugging up--milk to gray colors observed on filters
[12]Plugged with rust
[13]Both fuels
[14]M113s, M1s and M88s
[15]Some
[16]August to mid-October
[17]For HMMWV and CUCV fuel injector pumps.
[18]HMMWV and M1 engines, maybe not a fuel problem but an air induction problem

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FUELS

Question		724th Spt Bn. (Main) 24th Inf Div	A Co. 224th Spt Bn 24th Inf Div	Hq 2nd Bde (S-4) 24th Inf Div	HHC 3/15th Inf (Mech) 24th Inf Div	A Co 3/15th Inf (Mech) 24th Inf Div
30. Was there a perceptible increase in fuel injector nozzle fouling when using:	a. DF-2 fuel?	No	No	No	No	No
	b. Jet A-1 fuel?	No	No	No	No	No
31. Did use of DF-2 in armored vehicles VEESS produce adequate smoke in the high ambient temperature environments?		Yes	N/A	Yes[19]	Yes	Yes
32. If vehicles/equipment were using Jet A-1, did they "run hotter"?		No	No	Yes[20]	Yes	Yes
33. Were there any perceptible problems associated with admixing fuels during fuel changeovers?		No	No	No	No	No
34. In units that utilized Jet A-1, were ground vehicles and aircraft refueled from the same fuel tankers?		N/A	No	No	No	N/A
35. Were there any problems in using vehicle personnel heaters with either Jet A-1 or DF-2?		N/A	No[21]	Unknown	No	No

[19]90°F-100°F range

[20]M88s ran hotter, possible burnt valves and burned holes in pistons when "pink" fuel was used.

[21]Claimed no personnel heaters in their vehicles

General

1. 724th Spt. Bn (Main)–Some crews broke glass beads in HMMWV and CUCV Stanadyne pump return fuel lines
2. A Co 224th Spt Bn –Claimed a lot more fuel was used when Jet A-1 was used
3. Hq, 2nd Bde (S-4)
   a. Recommends navigational aid for military vehicles
   b. Recommends larger screen mesh for fuel cell (cited ROM refueling practices)

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HYDRAULIC AND BRAKE FLUIDS

Question		724th Spt Bn, (Main) 24th Inf Div	A Co, 224th Spt Bn, 24th Inf Div	Hg 2nd Bde (S-4) 24th Inf Div	HHC, 3/15th Inf (Mech) 24th Inf Div	A Co 3/15th Inf (Mech) 24th Inf Div
1 Were any or all of the following hydraulic and gun control systems fluids used?	a OHT ("Cherry Juice")	Yes	N/A	Yes	Yes	Yes
	b FRH (fire resistant hydraulic fluid)	Yes[1]	N/A	Yes	Yes	Yes
	c Dexron-II	Yes	N/A	Yes	Yes	Yes
2 Did the hot ambient temperatures affect those self-propelled gun systems using "Cherry Juice" (MIL-H-6083)?		No	N/A	No	N/A	N/A
3 Was sand contamination a problem with operation of any hydraulic or brake fluid system?		Yes[2]	N/A	Yes[3]	No	Yes[4]
4 If vehicle brake systems using silicone brake fluid (MIL-B-46176) were topped off with conventional/ commercial-type automotive brake fluids, were any differences in braking performance noticeable?		N/A	No	No	No	No
5 Did the hot ambient temperatures cause brake fade problems?		No	No	No	No	No
6 Were filters in those hydraulic systems employing filters routinely changed?		Yes	No	No	No	No
7 Did the hot ambient temperatures cause more frequent topping off of both hydraulic and brake systems?		No	N/A	No	Yes	No
8 Were there any occurrences in which "cherry juice" (MIL-H-6083/OHT) was added to hydraulic systems using the MIL-H-46170/FRH hydraulic fluid or vice versa?		No	N/A	No	No	No
9 Were any AOAP samples taken from hydraulic systems?		No	No	No	No	No
10 Did the higher ambient temperatures create an overall increase in the maintenance of hydraulic and gun control systems?		Yes[5]	N/A	No	Yes[6]	No
11 Did the higher ambient temperatures create an overall increase in the maintenance of vehicle brake systems?		No	No	No	Yes	No
12 Were fluid changes accomplished at intervals scheduled in authorized lube orders?		Yes	Yes	Yes[6]	No	Yes

[1] "Apple juice" type
[2] Not considered excessive
[3] a HMMWV brake systems and power steering pumps
b Sand wear on M1 hydraulic quick connects/disconnects
[4] M113 ramps, filters got more than normal dirt in ramp pumps
[5] Some degradation to gun control systems but did not make systems inoperable
[6] Consumed a little bit more hydraulic fluids

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LUBRICANTS

Question		724th Spt. Bn., (Main) 24th Inf Div	A Co., 224th Spt Bn, 24th Inf Div	Hg 2nd Bde (S-4) 24th Inf Div	HHC 3/15th Inf (Mech) 24th Inf Div	A Co 3/15th Inf (Mech) 24th Inf Div
1 Were the following engine oils available for use?	a. OE/HDO-10	Yes	Yes	Yes	Yes	Yes
	b OE/HDO-30	Yes	Yes	Yes	Yes	Yes
	c OE/HDO-40/10W-30	Yes/Yes	Yes	No	No	No
	d OE/HDO-15/40	Yes	Yes	Yes	Yes	Yes
2 Was MIL-L-46152 (administrative service) engine oil used?		Yes[1]	Yes	No	No	No
3 Were oil analysis laboratories available?		No	Yes	No	Yes	No
4 Were normal lubo order oil change intervals usad for engine oil?		No	Yes	Yes	Yes	Yes
5 If changes were made in normal intervals, were the invervals	a Increased?	No	N/A	No	N/A	N/A
	b Decreased?	Yes	N/A	Yes[2]	N/A	N/A
6 Were normal lube order service intervals used for	a Transmissions?	Yes	Yes	Yes	Yes	Yes
	b Power transfer units?	Yes	Yes	Yes	Yes	Yes
	c Differentials?	Yes	Yes	Yes	Yes	Yes
	d Hydraulic systems?	Yes	Yes	Yes	Yes	Yes
	e Brake systems?	Yes	Yes	Yes	Yes	Yes
7 Was there any evidence of "oil breakdown (i e , oil too thin, excessive oil consumption, etc)?		Yes	No	No	No	No
8 Were there problems in performing lubricant-related maintenance?		Yes	Yes	Yes	Yes	No
9 If oil analysis laboratories were available, were oil samples taken and sent to them?		No	Yes	N/A	Yes	N/A
10 If oil samples were sent to a laboratory for analysis, were any results ever received?		N/A	No[3]	N/A	No	N/A
11 Did dirt/sand contamination cause any problems with	a Wheel bearings	No	No	No	Yes[4]	No
	b Gear drives?	No	No	Yes[5]	Yes	No
	c Gun positioning systems?	No	No	No	Yes	No
12 Did hot ambient temperatures cause any oil-related problems?		No	No	No	No	No
13 If the OE/HDO-15/40 tactical engine oil (MIL-L-2104) was not used, was it because	a. The oil got too thin?	No	N/A	N/A	No	N/A
	b The engine ran hotter?	No	N/A	N/A	No	N/A
	c The oil was not available?	Yes	N/A	N/A	Yes	N/A
14 Were any or all of the following gear oils (MIL-L-2105) used?	a 85W-140	Yes	No[6]	Yes	No	No
	b 90	Yes	No[6]	Yes	No	No
	c 80W-90	Yes	Yes	Yes	Yes	Yes
15 Were oil filters changed each time the engine oil was changed?		Yes[7]	Yes	Yes[7]	Yes	Yes

[1]10W-30 used in mostly wheeled vehicle engines may have used 10 wt in differentials etc
[2]For grease lubrication
[3]Took oil samples turned in to BMO results unknown
[4]A little more than usual
[5]Trouble with turntables on HEMTT cranes because of sand buildup
[6]On hand but did not use
[7]Oil filters were available

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GREASES

Question	724th Spt Bn, (Main) 24th Inf Div	A Co, 224th Spt Bn, 24th Inf Div	Hg 2nd Bde (S-4) 24th Inf Div	HHC, 3/15th Inf (Mech) 24th Inf Div	A Co 3/15th Inf (Mech) 24th Inf Div
1 Was MIL-G-10924F or MIL-G-0010924E versions of GAA grease available for use?	Yes[1]	Yes	Yes	Yes	Yes
2 Was WTR (MIL-G-83122) grease automatically substituted where GAA was required?	No	No	No	Yes	No
3 Did the hot ambient temperatures cause excessive grease breakdown and leakage?	Yes[2]	No	Yes[3]	No	No
4 Did the hot ambient temperatures affect the shelf life of the unused GAA and other greases?	No	No	No	No	Yes[4]
5 Where WTR grease was used interchangeably with GAA at lubrication points previously lubricated with GAA, were any performance differences noted?	N/A	N/A	N/A	No	N/A
6 Were relubrication intervals changed from those specified in authorized lube orders?	No	Yes	Yes[5]	No	Yes
7 Were solvents used to clean parts before relubricating components such as wheel bearings, CV joints, etc?	Yes[6]	Yes[7]	Yes[7]	Yes[7]	Yes[7]
8 Were sand particles evident in bearing components during disassembly?	Yes	Yes	Yes	Yes	Yes
9 Did the higher ambient temperatures create an overall increase in the maintenance of any grease-lubricated components on vehicle/equipment systems?	Yes	No	Yes	No	No

[1]Used wheel bearing grease went with units in basic load
[2]GAA more than br (bearing grease)
[3]Didn't know had what was considered an excessive number of ball joint and tie-rod ends failing
[4]One 5-gallon can
[5]Increased number of maintenance intervals severely
[6]Denatured alcohol used for brake cleaning solvent
[7]Dry cleaning solvent

General
1 Would prefer GAA grease in tubes
2 GAA grease used in road wheel hubs instead of lube order oils in Bradley vehicles.
3 In some cases burned oil contaminated brake shoes in sand which absorbed the oil

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COOLANTS/ANTIFREEZE

Question		724th Spt Bn , (Main) 24th Inf Div	A Co , 224th Spt Bn, 24th Inf Div	Hg 2nd Bde (S-4) 24th Inf Div	HHC, 3/15th Inf (Mech) 24th Inf Div	A Co 3/15th Inf (Mech) 24th Inf Div
1 Was any commercial type antifreeze used in lieu of MIL-A-46153 antifreeze?		Yes	Unknown	No	No	No
2 Was the antifreeze extender additive (MIL-A-53009) used?		No	Unknown	No	No	No
3 Was it possible to save drained antifreeze for reuse when cooling systems were drained and filled?		Yes	No	No	No	No
4 Were any of the following make-up waters used?	a Potable water	Yes	Yes	Yes	Yes	Yes
	b Distilled water	Yes	Yes	Yes	No	No
	c Bottled water	Yes	Yes	Yes	Yes	No
	d Local water	No	No	Not sure	No	No
5 Did the hot ambient temperatures cause engines to run hotter?		No	No	Yes[1]	Yes	No
6 Were there any leaking or corrosion problems attributed to the antifreeze or hard water (i e., local water) that may have been used?		No	No	No	No	No
7 Were the standard Test Strip Kits used to measure if the antifreeze was okay?		No	No[2]	No	No	No[2]
8 When antifreeze was changed for a reason other than one required by the standard test strip, was it because	a Of an engine change?	Yes	No	Yes	Yes	Yes
	b Repair of an engine?	Yes	No	Yes	Yes	Yes
	c Dirt/sand contamination?	No	No	No	No	No
	d Other contamination?	No	No	No	No	No
9 Was any MIL-A-46153 antifreeze provided to you in metal containers?		Yes	Yes	No	Yes	Yes
10 Were the metal containers plastic lined?		Yes	Yes	N/A	Yes	Yes
11 Did the higher ambient temperatures create an overall increase in the maintenance of engine cooling system components?		No	No	No	No	No
12 Was flushing of cooling systems a problem due to the limitations on available water?		No	No	Yes[3], No[4]	No	No
13 Were there any instances that undiluted antifreeze was added directly in refilling cooling systems?		No	No	Yes	No	No
14 When topping off radiator systems, was	a Water only used?	Yes	No	Yes	No	Yes
	b Antifreeze only used?	No	No	Yes	No	Yes
	c Water-antifreeze mixture used?	No	Yes	Yes	Yes	Yes

[1]M113s
[2]Used hydrometer
[3]Desert Shield
[4]Desert Storm

BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ODS QUESTIONNAIRE CONSOLIDATION
FT. STEWART, GA

WEAPONS LUBRICANTS/SOLID LUBRICANTS

Questions		724th Spt Bn, (Main) 24th Inf Div	A Co., 224th Spt Bn, 24th Inf Div	Hg 2nd Bde (S-4) 24th Inf Div	HHC, 3/15th Inf (Mech) 24th Inf Div	A Co 3/15th Inf (Mech) 24th Inf Div
1 Were military specification products used?		Yes	Yes	Yes	Yes[1]	Yes
2 In addition to those required specification products, were other propnetary commercial products also used? For example,	a TW-25	Yes	No	Unknown	No	No
	b Dryslide	Yes	No	Yes	Yes[2]	No
	c WD-40	Yes	Yes	Yes	Yes	Yes
	d Break-Free	No Answer	Yes	Yes	Yes	Yes
3 If these propnetary products were also used, was there a noticeable change in the performance or a reason that necessitated their use?		Yes	Yes	Yes	Yes	No
4 Was the hot ambient temperatures creating lubrication problems for weapons/gun systems?		Yes	No	Yes	Yes	No
5. Was dirt/sand adhesion a significant problem?		Yes	Yes	Yes	Yes	Yes
6 If dirt/sand adhesion was a significant problem, was it resolved satisfactorily?		Yes	Yes	Yes	Yes	Yes
7 Were any solid film lubricants used?		No	No	Yes	Yes	Yes
8 Were there any mixing or compatibility problems (i e , solid lubes with greases or fluids)?		No	No	No	No	No
9 Were solid lubricants applied by	a. User personnel?	N/A	N/A	Yes	Yes	Yes
	b Ordnance personnel?	N/A	N/A	No	No	No
	c Other?	N/A	N/A	No	No	No
10 Did the higher ambient temperatures create an overall increase in the maintenance of oil/fluid/grease lubricated weapons systems components?		No	No	No	Yes	No
11 Was there a "preferred" weapons lubricant for	a. Large caliber weapons?	N/A	Whatever they had	TW-25	Break-free	GMD
	b Small caliber weapons?	Yes	Whatever they had	TW-25	Break-free	Break-free

[1]LSA
[2]Could not fire weapons with Dry Slide because Dry Slide will gum-up when heated. Dry Slide disapproved for use.

Appendix E
INDIVIDUAL INPUT AND NOTABLE FIELD EXPEDIENTS

BELVOIR FUELS AND LUBRICANTS RESEARCH FACILITY (SwRI)
6220 CULEBRA ROAD--P O DRAWER 28510 PH: 512-684-5111 SAN ANTONIO, TEXAS 78228-0510

BFLRF

File. 02-1955-153
03 May 1991

Commander
U.S. Army Belvoir Research, Development and Engineering Center
Attn. STRBE-VF, Mr. M E. LePera
Fort Belvoir, Virginia 22060-5606

Subject. **Feedback on 3rd ACR Use of Jet A-1 Fuel in Operation Desert Shield/Storm (ODS)**

Dear Sir

The enclosed memorandum from BFLRF s Mr Ruben Alvarez concerning subject use of Jet A-1 fuel is forwarded for your information This memo is the result of recent discussions at Ft. Bliss, Texas, between Mr. Alvarez and Major Schifferle, the 3rd ACR S-4 Officer, shortly after Major Schifferle returned from ODS

The memorandum was coordinated with Major Schifferle, who stated it may be given further distribution in support of the JP-8 Demonstration Program. Please call Mr. Alvarez at (512) 522-3264 or the undersigned if there are any questions.

In addition to the JP 8 Demonstration Program at Ft Bliss, BFLRF monitors will explore the possibility of holding additional feedback discussions on all POL products used in ODS by the 3rd ACR and the other line units that have returned to Ft Bliss (i e., the 11th ADA Bde and 70th ORD Bn) BFLRF will keep your office informed on the status of any subsequent arrangements/discussions.

Very truly yours,

S.J. Lestz
Director

SJL/ec
RAA H)

Enclosure

cc U S Army Belvoir Research, Development and Engineering Center, Attn: STRBE-VF, Mr T C. Bowen
Commander, 3rd Armored Cavalry Regiment, Attn AFDF-D, Major Schifferle, Ft Bliss, Texas 79916-5000
Belvoir Fuels and Lubricants Research Facility (SwRI), Messrs Ruben Alvarez, Walt Butler, Doug Yost, and Steven R Westbrook

MEMORANDUM

File 02-1955-153
03 May 1991

TO: Sid J Lestz, Director, BFLRF (SwRI)

FROM: Ruben A. Alvarez

SUBJECT: **Conversation With Major Schifferle, S4, 3rd ACR, Concerning Use of Jet A-1 During Operation Desert Shield/Storm**

On 17 April 1991, the BFLRF JP-8 monitor met with Major Peter Schifferle, S4, 3rd ACR, to obtain his personal observations of the Regiment's use of Jet A-1 fuel during Operation Desert Shield/Storm in Saudi Arabia and Iraq. According to Major Schifferle, the Regiment did not experience any operational problems with Jet A-1 fuel. Due to the Regiment's involvement with the JP-8 program at Ft. Bliss, it did not go through the "growing pains" that other units experienced coming from a diesel environment (plugged filters). Jet A-1 was used exclusively in all diesel-burning equipment and aircraft attached to the Regiment with the exception of six M93 FOX NBC Recon vehicles that initially used diesel fuel, but were then also switched to exclusive use of Jet A-1 fuel.

The aircraft were refueled with the same fuel as wheeled and tracked vehicles; however, the HEMTT fuel tankers refueling aircraft were dedicated tankers assigned to the 4th squadron Major Schifferle said that, to his knowledge, HEMTT tankers used to retuel ground equipment did not refuel aircraft.

The 3rd ACR was issued 28 HEMTT fuel tankers over the Table of Organization and Equipment (TO&E) authorization. The additional tankers were used extensively prior to and during Operation Desert Storm They were absolutely essential when the 5,000-gallon semitrailer tankers became stuck in the mud shortly after the ground phase began. Fuel was shuttled from

In closing comments, Major Schifferle reiterated the advantage that the Regiment had derived by having been on the JP-8 demonstration program at Ft. Bliss. He personally was very gratetul that the transition to Jet A-1 was accomplished without any problems.

/ec

MEMORANDUM

File: 02-1955-150
31 July 1991

THROUGH: S.J. Lestz, Director, BFLRF

TO: Messrs. M.E. LePera and Al Rasberry, STRBE-VF, Belvoir RDE Center

FROM: W E. Butler, Jr., BFLRF

SUBJECT: **Miscellaneous Information From Logistics, Maintenance, and User Personnel of Units, Which Participated in Operations Desert Shield/Desert Storm (ODS)**

1. The following notes were taken from various individuals interviewed at random during the recent U.S. Army Belvoir Research, Development and Engineering Center (Belvoir RDE Center) Survey Team's visits to Ft. Bliss and Ft. Hood. The answers do not readily fit the formal matrix already prepared but should be considered because of the additional insight into "how things really were" during the brief conflict.

Ft Bliss, Texas —

a. AMC LAR, Ms. Gladys Balogh —

Fuel filters from M1s, M3s, and 5-ton trucks used in the North exhibited a "black residue." Vehicles in the Riyadh area had no "black residue." Ms. Balogh suggested contacting 1st Armored Cavalry Division (1st Armd Cav Div) at Ft. Hood to see if they experienced "black residue" problems.

e 2/1st ADA Bn, CW1 Frank —

(1) Bn went through about 100 to 150 fuel injector pumps. Rotors would turn blue, presumably from heat generated because of the lack of lubricity

(2) Fuel filter systems on Commercial Utility Cargo Vehicles (CUCVs) were modified by using a "screw in" commercial filter and bypassing the military fuel filter system.

(3) The backing plate for the CUCV fuel filter was replaced because of poor performance. The fuel-water sensor was particularly bothersome.

f 5/62nd ADA Bn, CW2 Gallegos —

(1) Obtained a dry lubricant (grease) from some unit in the 1st Armd Cav Div. The grease (molybdenum disulfide) left no oily film. Were told grease was an experimental test item and when 5/62nd ran out they were unable to obtain anymore.

(2) Hydraulic systems were reported as presenting their biggest maintenance problems.

g 11th ADA Brigade (11th ADA Bde), Mr. Walt Cowling —

(1) Units used JP-8, Jet A-1, DF-2, and DF-4

(2) After about 2 months in country, he ordered all 11th Bde ADA battalions to use DF-2 fuel and use one half normal service intervals as published in lube orders for maintenance services.

(3) Attributed most pump and injector nozzle failures to usage rather than fuels.

c. D Co (Maintenance), 1/3rd Aviation Regiment, CPT Benedict Fuata, and CW2 Starkey, Instructor Pilot —

(1) Will move to Ft. Campbell and become part of the 101st Airborne Div.

(2) Attached to the 6th Cav Bde (Air Combat)

(3) Filled up with JP-5 before they left Ft. Hood, stayed at the port in Saudi 5 days, and then headed inland. Ended up about 60 miles from Iraq.

(4) When asked about power loss, CW2 Starkey said there was none. That, because Jet A-1, JP-8, and JP-5 are heavier than JP-4, the total weight of the aircraft, with fuel, increases and, therefore, the aircraft can only lift a lesser load adjusted to compensate for that heavier weight. He did say that he got a longer range in flight with Jet A-1, etc. than he did with JP-4.

d 553rd S&S Battalion, CW2 Everhart —

(1) Could not get antifreeze for 6 months.

(2) Had to use water only, which caused overheating and increased maintenance.

(3) Obtained 15W-40 and 30 weight oils commercially from ~~a company called~~ "CA~~LEB-BRET located at Ras Tanura~~.

(4) Fuel tests consisted of visual inspections.

(5) Could not get grease. Estimated 2 percent obtained through regular channels, 30 percent obtained commercially, and 68 percent scrounged.

(6) STP grease worked fine.

(7) Obtained very small percentage of grease from "ROCOT", a British company. It is believed the "dry lubricant" used by the 5/62nd ADA Bn from Ft. Bliss came from this source.

(8) Saudi Arabia came out with their own grease and would not allow any other company's grease to be purchased by the military units.

(9) Could not get any brake fluid.

f 1st Bde, 1st Armd Cav Div —

The M113 vehicles used a high viscosity lubricating oil to prevent leakage from the cooling fan drive. Ninety weight oil and GAA were substituted for 30 weight oil and no other problems were encountered.

g 2/8th Cav Motor Pool, LT Broderick, BMO —

M88s had no problems whatsoever with JP-5 fuel in Saudi Arabia. Pulled M1 tanks in the sand.

h 27th Mntc Support Bn —

(1) Received Belvoir fact package.
(2) No major problems with aircraft.
(3) Oils were MIL-spec. Believed some 30 weight oil bought commercially.

4 Al, this completes the recollections from my notes. I am sure you have others (I forgot to put in about the MRE dust boot for CV joints on the HMMWVs). If you need anything else, please let me know

lap

1989 Ft Stewart - Problems with M1s - used biocides
Hot and Humid — Blew lots of EMFS units

In SWA ran on Jet A-1 - 2 weeks — Everything clogged up Every tank went through 4 to 5 filters in about a 10 day period

Other than tanks? — All other equipment included in problems

Replaced Stanadyne pumps — November-December timeframe
No filter problems

Turned in M1A1 tanks and drew M1A1 HA tanks in SWA

Medium truck convoys went to get fuel (about 250 miles)

Division consumed Al given consumption chart

Switched tanks and Bradley's again back at Ft Stewart -
Wheel & track vehicles being changed out

Lube orders need updating

Division wrote 91 maintenance letters for lower units

Division found out that the Division would run out of fuel every 100 hours (DF-2)

Turbine shaft oil received through normal channels

A/C did not use commercial oils - 15W-40 oil in short supply

Temperature about 135° - No humidity - Cooling systems on vehicles did not overheat very much

Blowing talcum powder (gypsum like stuff) which worked like lapping compound. High iron content

BFLRF will X-ray SWA sand samples for iron particles

Greases - Tried to get "roller bearing" grease

TW-25B "Semi-Fluid Lubricant for Extreme Climates" *Sand does not stick to it*

Did not work good on 30mm MG on Apache

Did not work for "coax" guns on Bradley

Crew applied with brush or finger

MIL-Comm (MIL-Comm Products Company, Inc., P O. Box 43278, Upper Montclair NJ 07043, (201) 744-5191

260th O'M only did AQUA-Glo tests

Fuel filtered from big fuel bags into 5000 gallon tankers

Only filters they had problem getting was M1 Air filters

1 M1 fire - burnt to ground - undetermined cause — Running on DF-2

No problem brought to LAO's attention with anti-freeze — Plenty of coolant in 5 gallon drums

Ran low on "cherry juice" at one time — Mainly used w/AVLBs - could be FRH

No AOAP in theater

Water, in batteries, was distilled (1), bottled (2), or potable water (3) — In coolant systems - high chlorine content water

24th Inf Div claims DF-2 produced smoke at 135°F

Kerosene fuel great for space heaters (pot bellies)

Recommends biocides be added at wholesale levels — Should be put in contract

Division maintenance services went from every 30 days to every 15 days (Used 1/2 intervals)

Mineral Contents of Southwest Asia Soil

Maintenance support personnel of the 24th Infantry Division (Mech) reported what appeared to be electrical shorts in some engine alternators or starters due to the sand/dirt contamination in the area of operations. When it was pointed out that silica is not a conductor, the maintenance personnel stated that they believed metal particles in the talcum-like dust were causing the problem.

Since BFLRF had actual soil samples from Southwest Asia, a check was made on three samples for metal contents The results are shown in the following table.

MINERAL CONTENTS OF SOUTHWEST ASIA SOIL SAMPLES

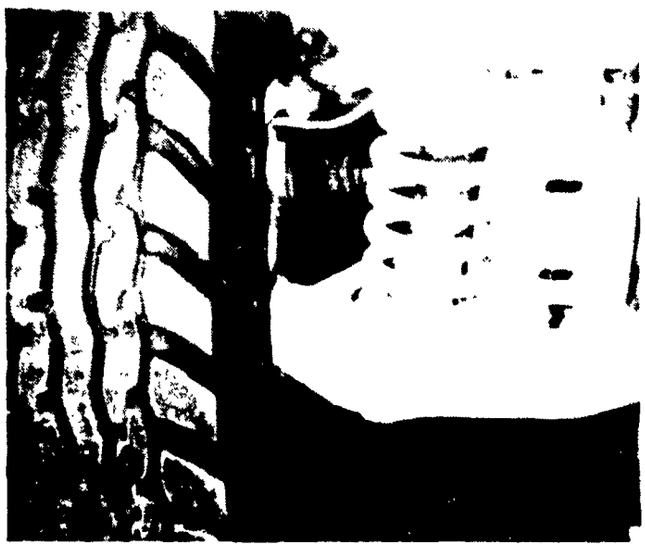
Relative Amounts*

BFLRF No.	Mg	Al	Si	K	Ca	Ti	Fe	S	Cl	Cr
AL-19623-X	VS	S	L	M	VL	VS	VL			
AL-19624-X	VS	S	L	M	VL	VS	VL	S	VS	S
AL-19625-X	VS	VS	M	VS	VL	VS	VL	VS	S	

* VS = Very Small
S = Small
M = Medium
L = Large
VL = Very Large

1. When CV boots for the CV joints on MMMWV's would become cracked or torn some units used Meals Ready to Eat (MRE) package covers to serve as interim boots until authorized boots could be obtained to replace them. Figures 1 through 5 show the transition from a regular CV boot to an "MRE" plastic boot. Ties used to secure the plastic cover to the CV joints were:

    a. ZIPLOC electrical ZIP ties (Class 9)
    b. 100-mph tape (Green)
    c. Electrical tape
    d. Lacing wire



Regular CV Boot

MRE Packet, Separated and Tape

Completed Temporary Boot

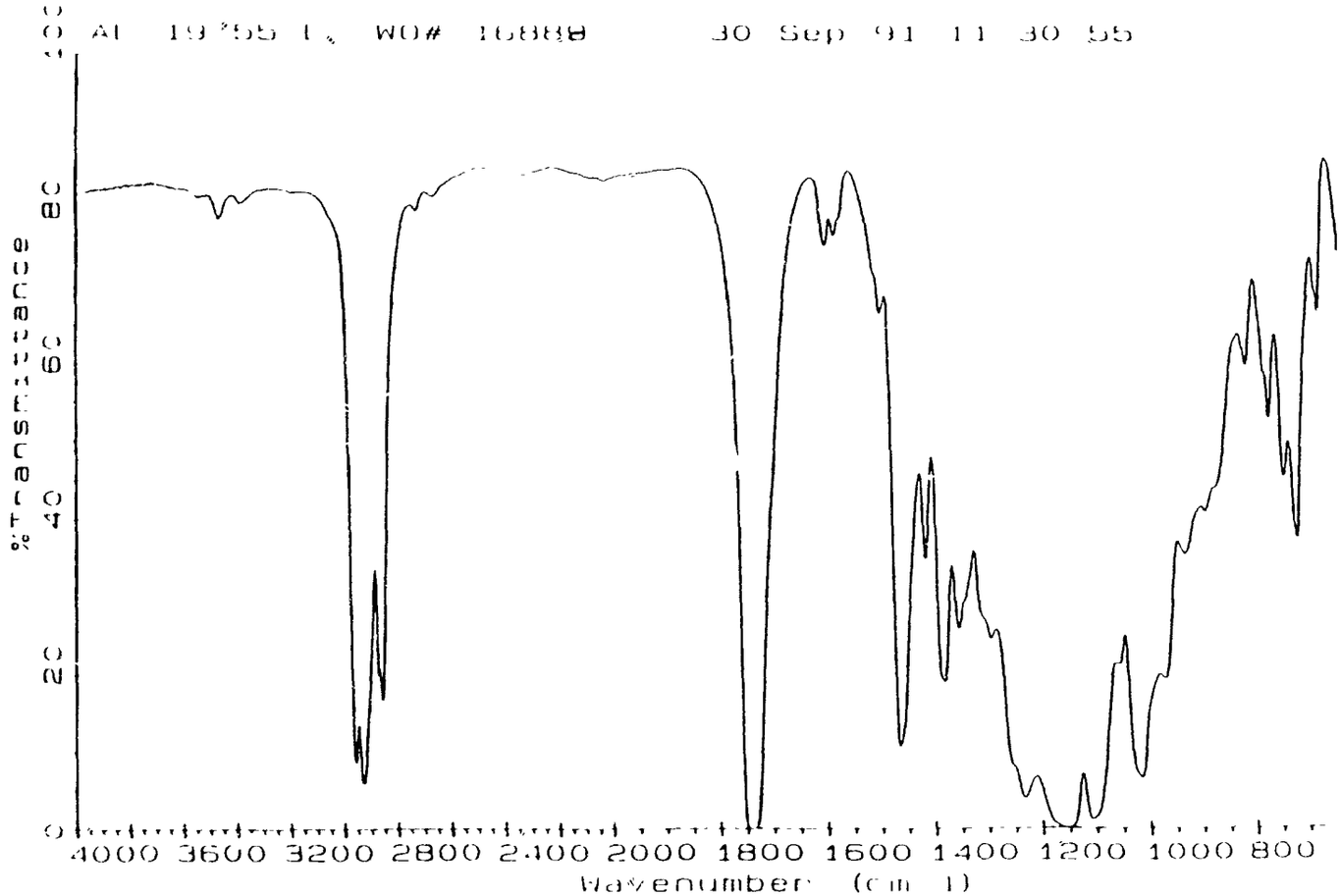
2. Diesel "glo-plugs" would swell and break in place when operators did not use proper starting procedures. To remove the glo-plugs, the normal procedure is to remove the engine head. However, personnel removed the injector nozzles and slipped a 2.5-ton truck windshield wiper blade into the opening. They then tapped the broken glo-plug onto the wiper blade and removed it from the head. This practice saved a lot of time and trouble. Apparently only a windshield wiper blade from a 2.5-ton truck will work.

3. Some operators reported using metal brake lines from destroyed vehicles along the route of march to repair or replace fuel lines in their own vehicles.

4. Wooden boxes (called "coffins" by operator personnel) were built atop the 5000-gallon semitrailers to hold fuel handling equipment, which otherwise had no assigned storage space.

Appendix F
FTIR OF USED SUMP OILS

F-2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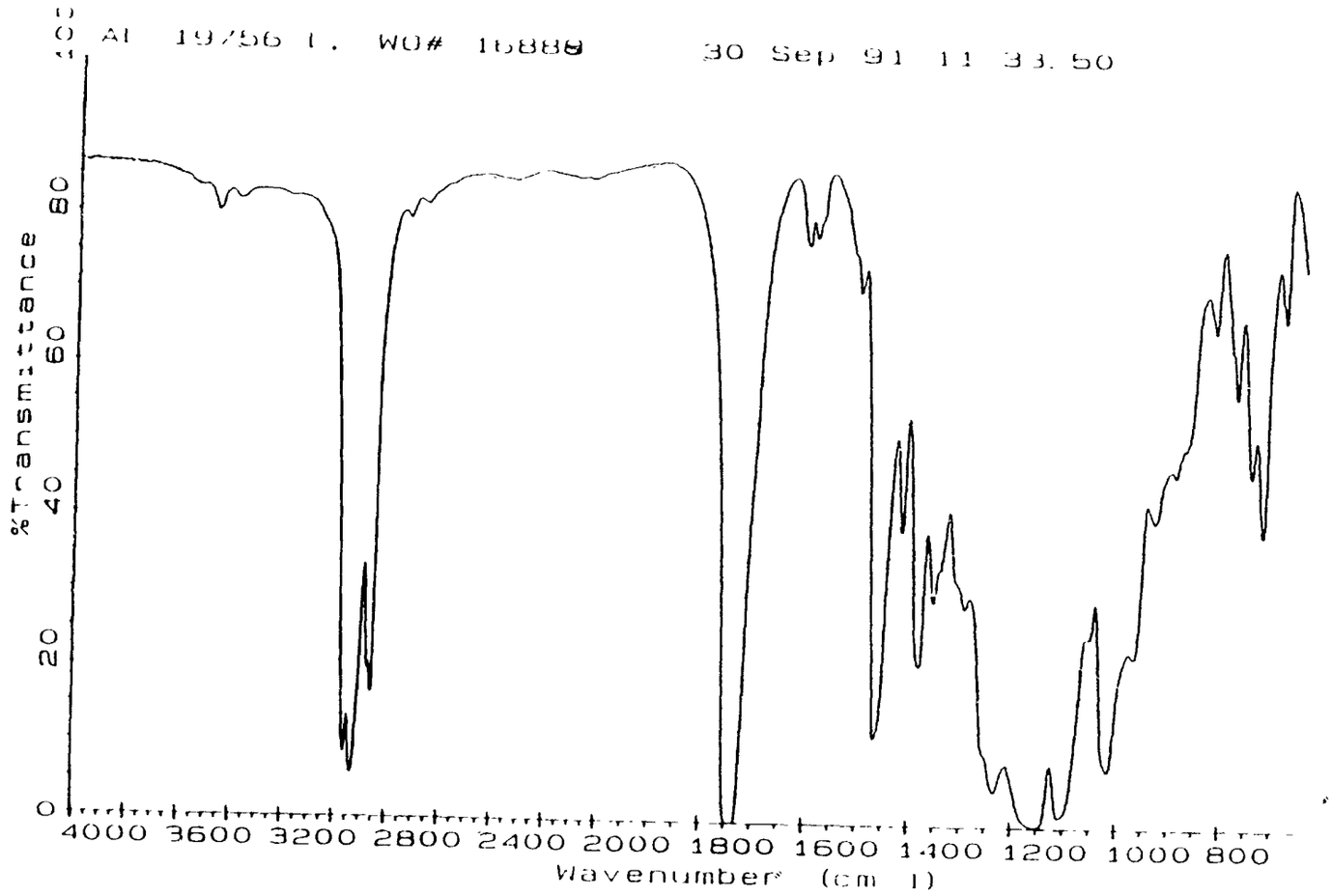
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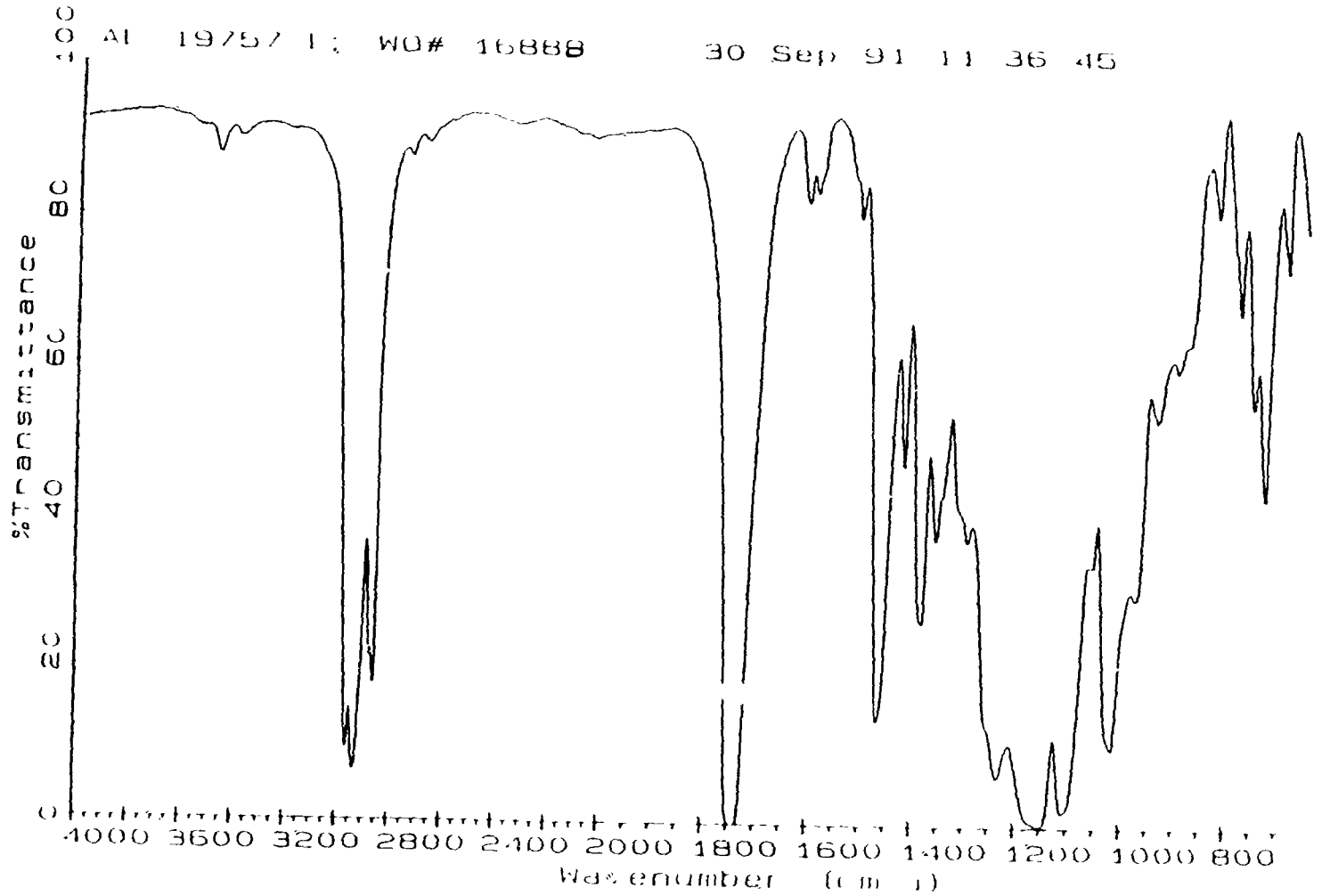
F-4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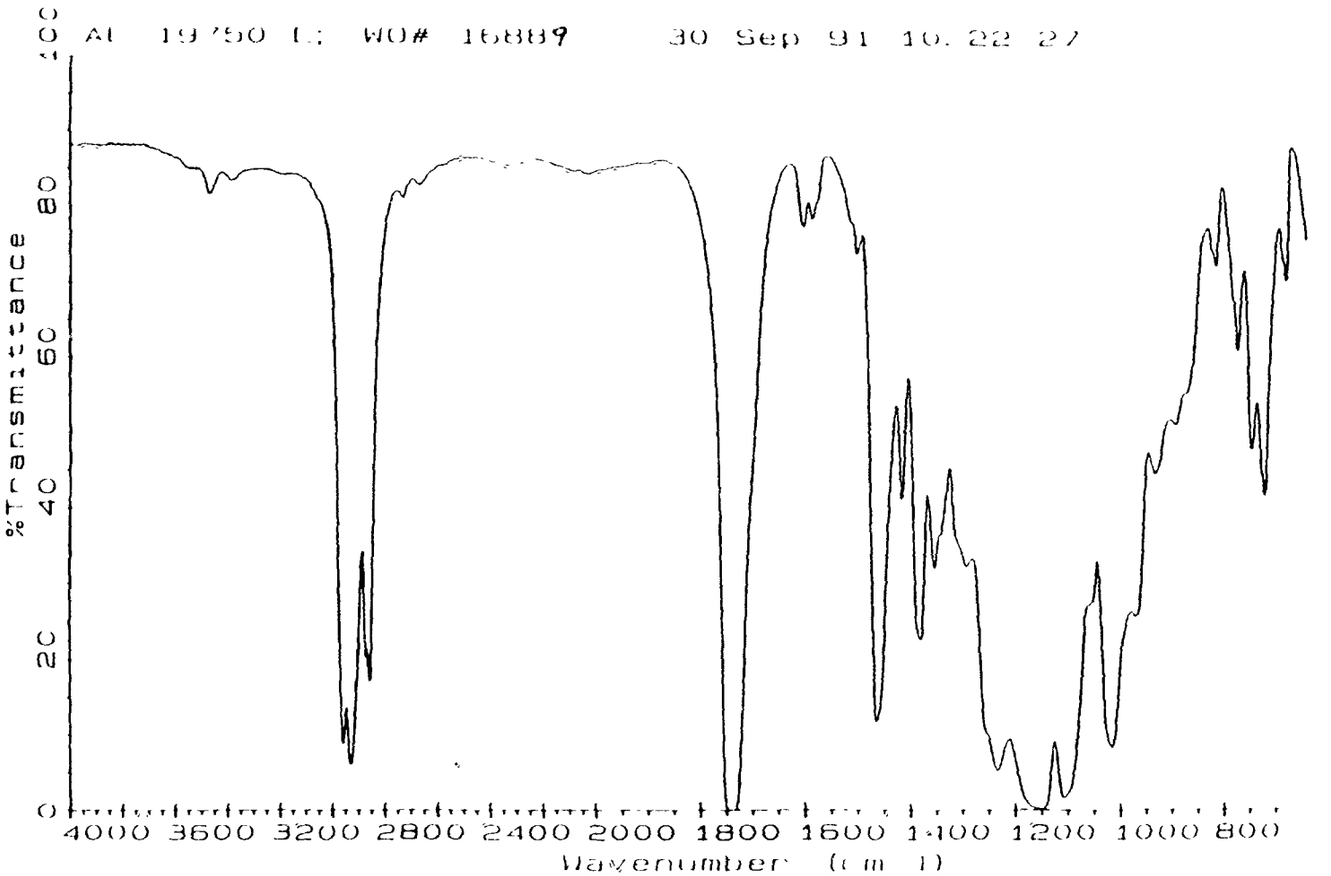
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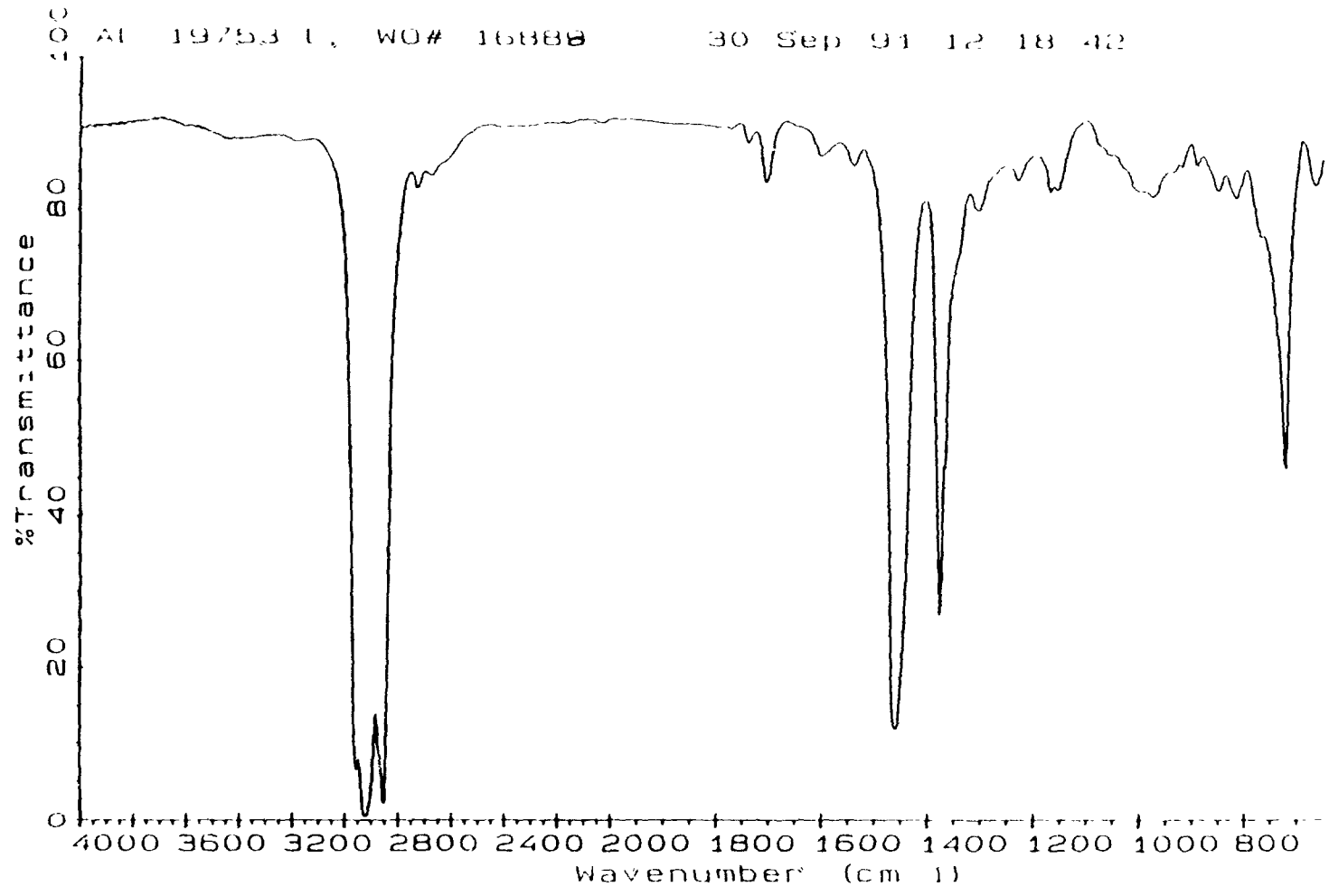
F-5

F6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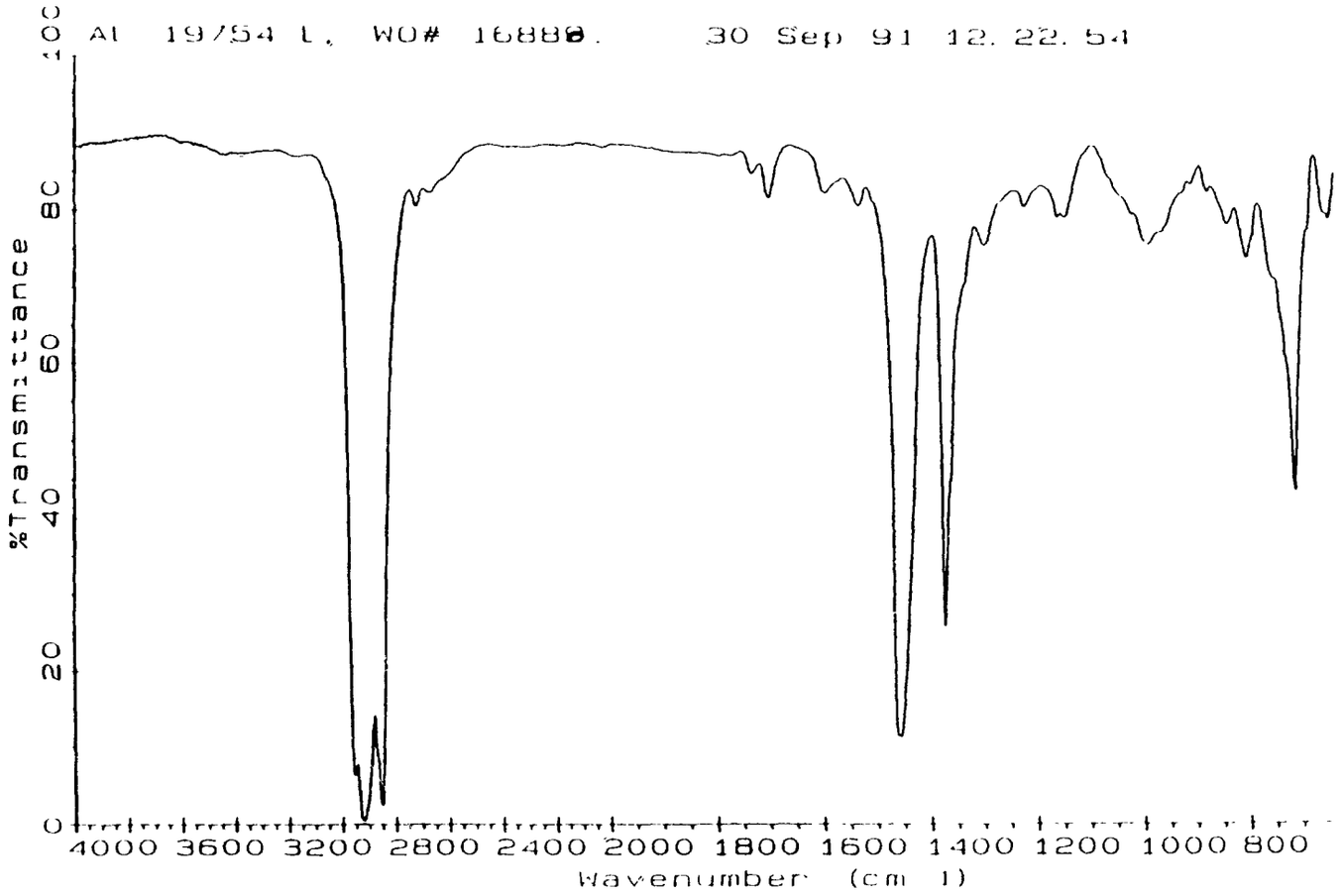
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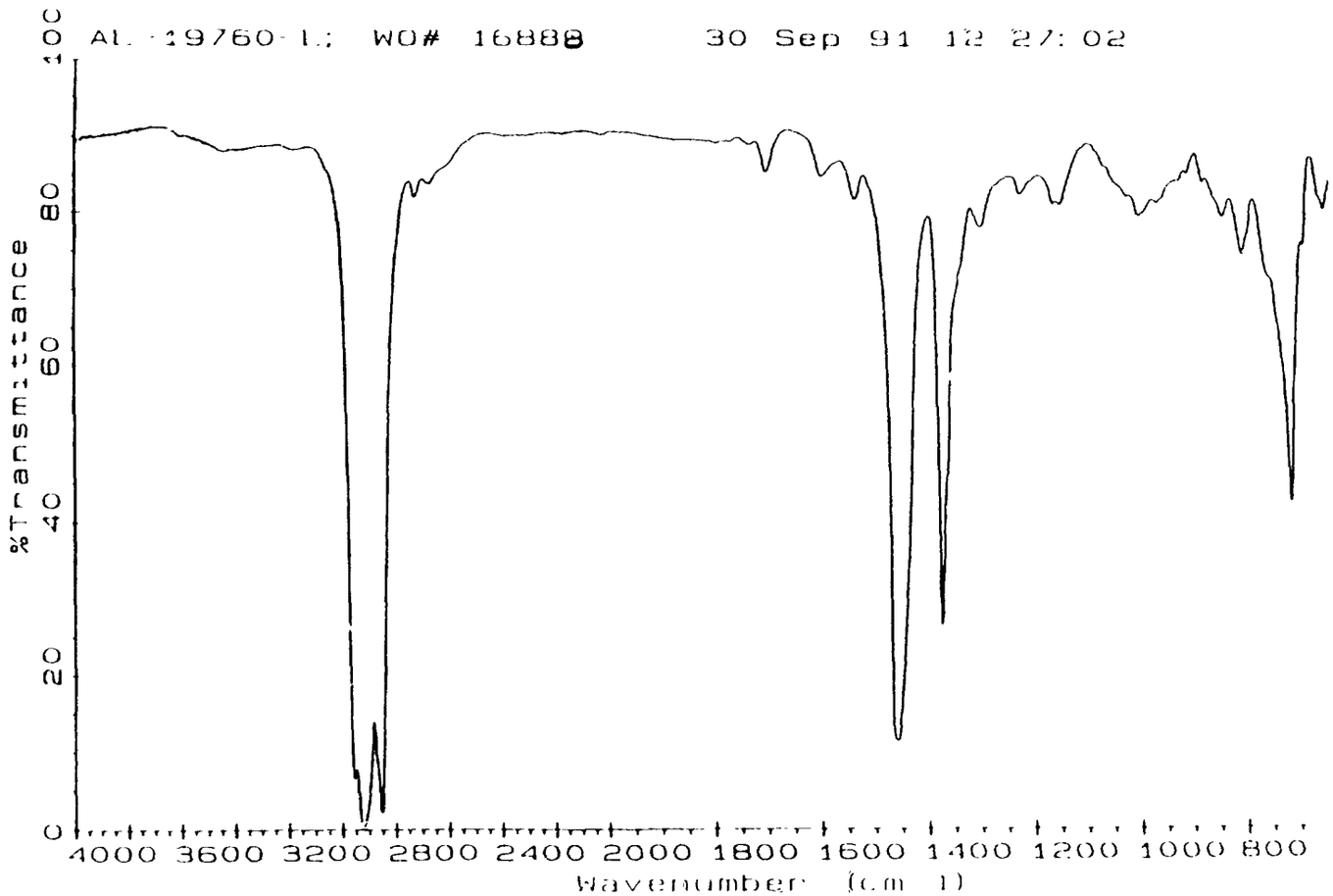
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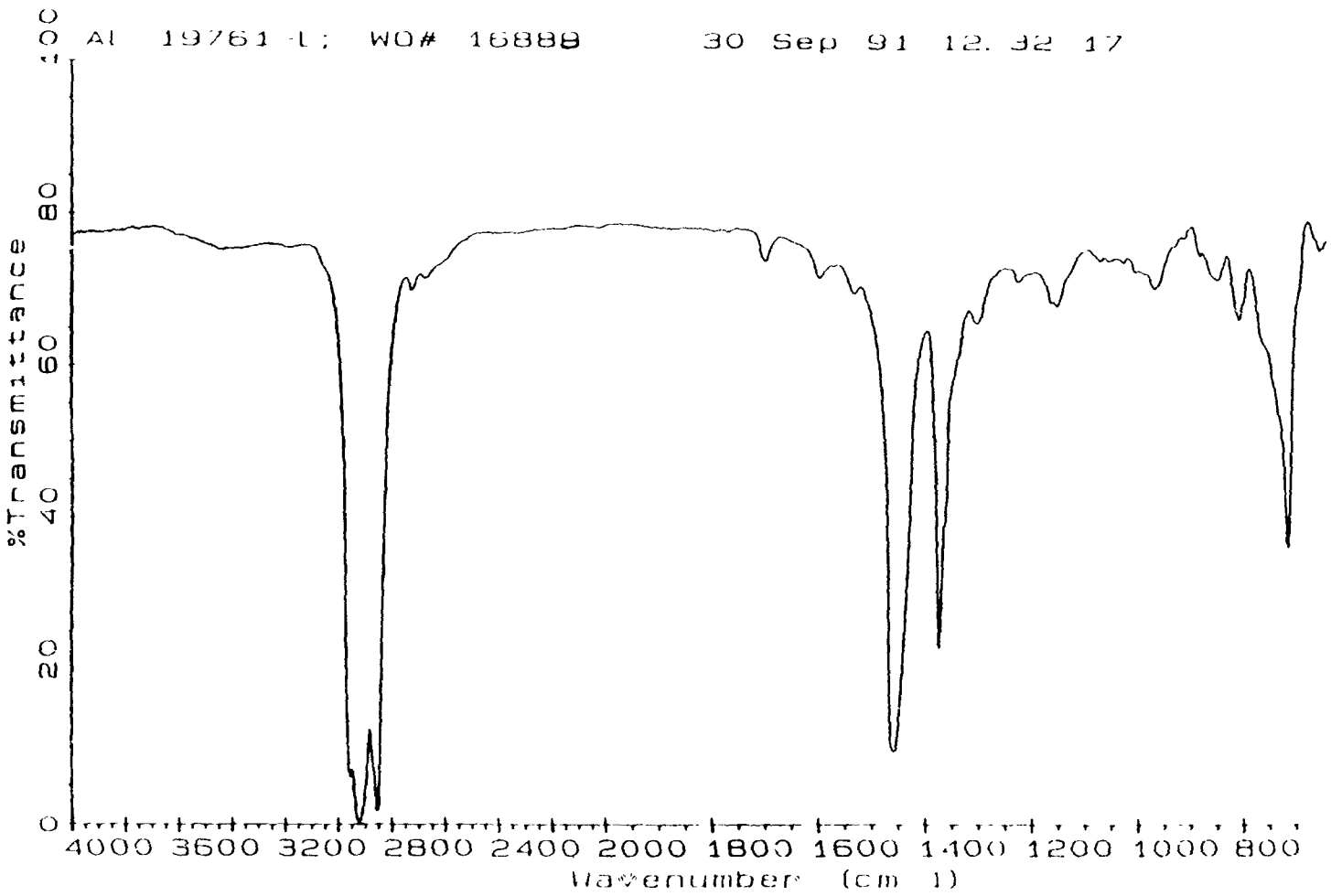
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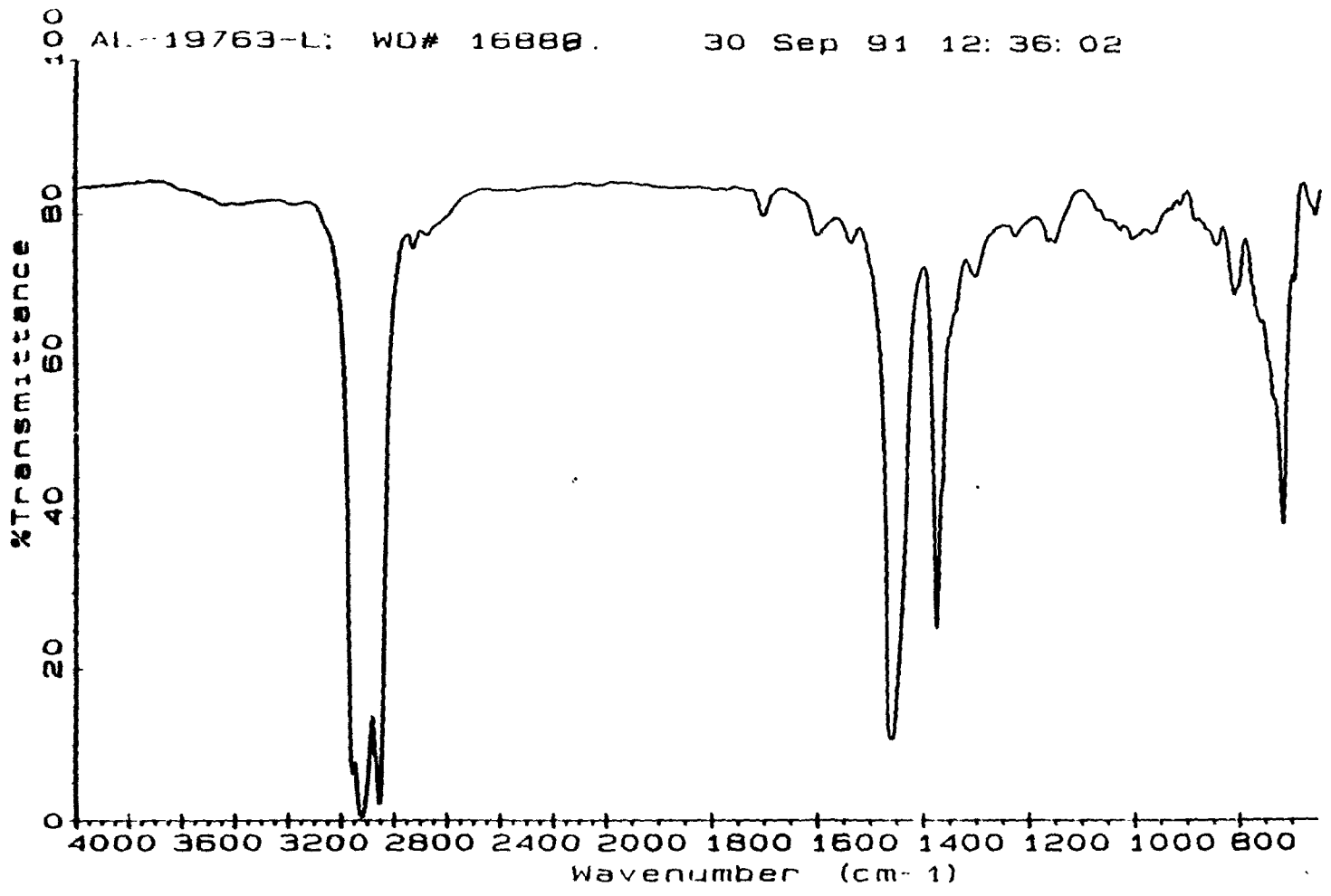
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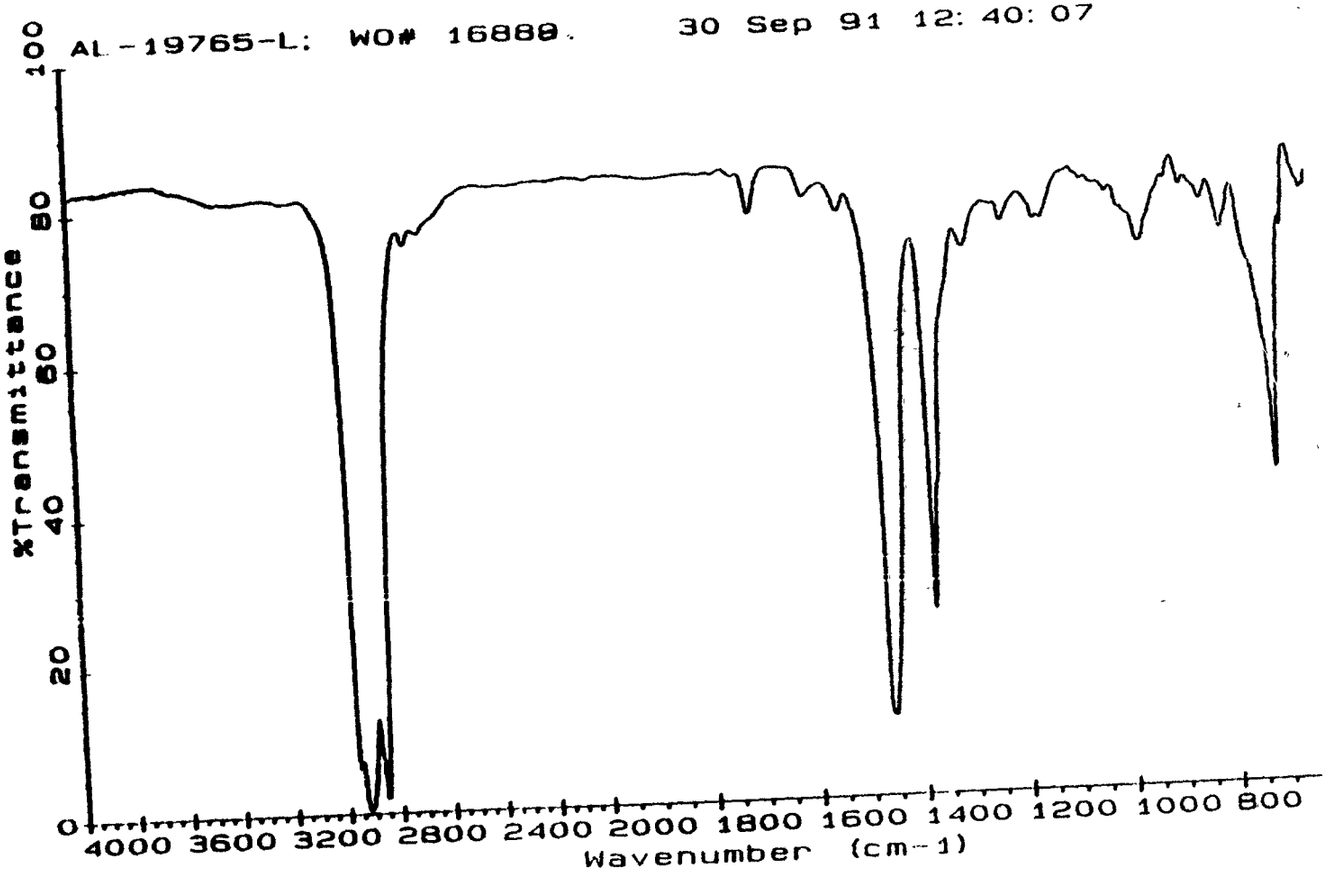
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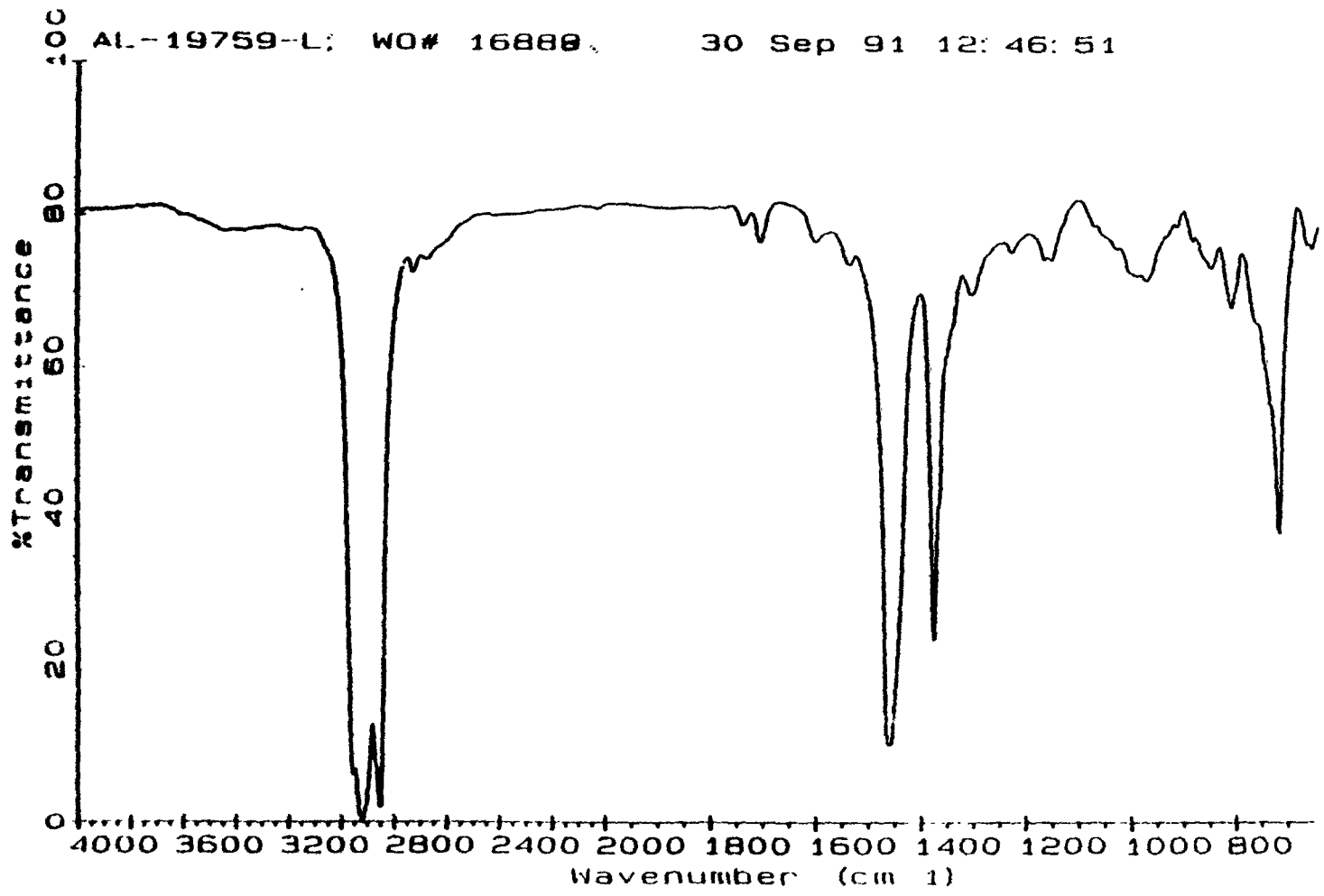
F-12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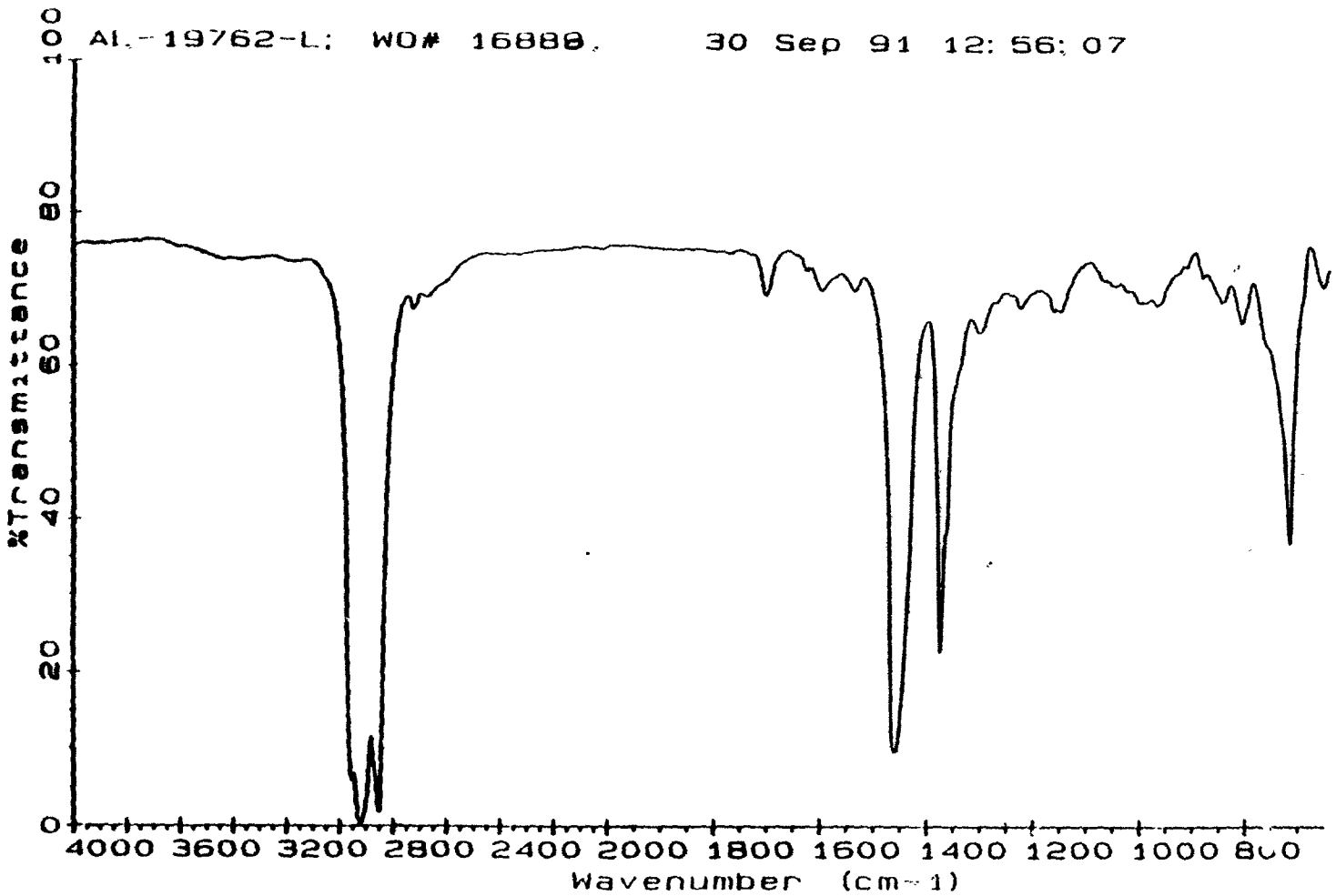
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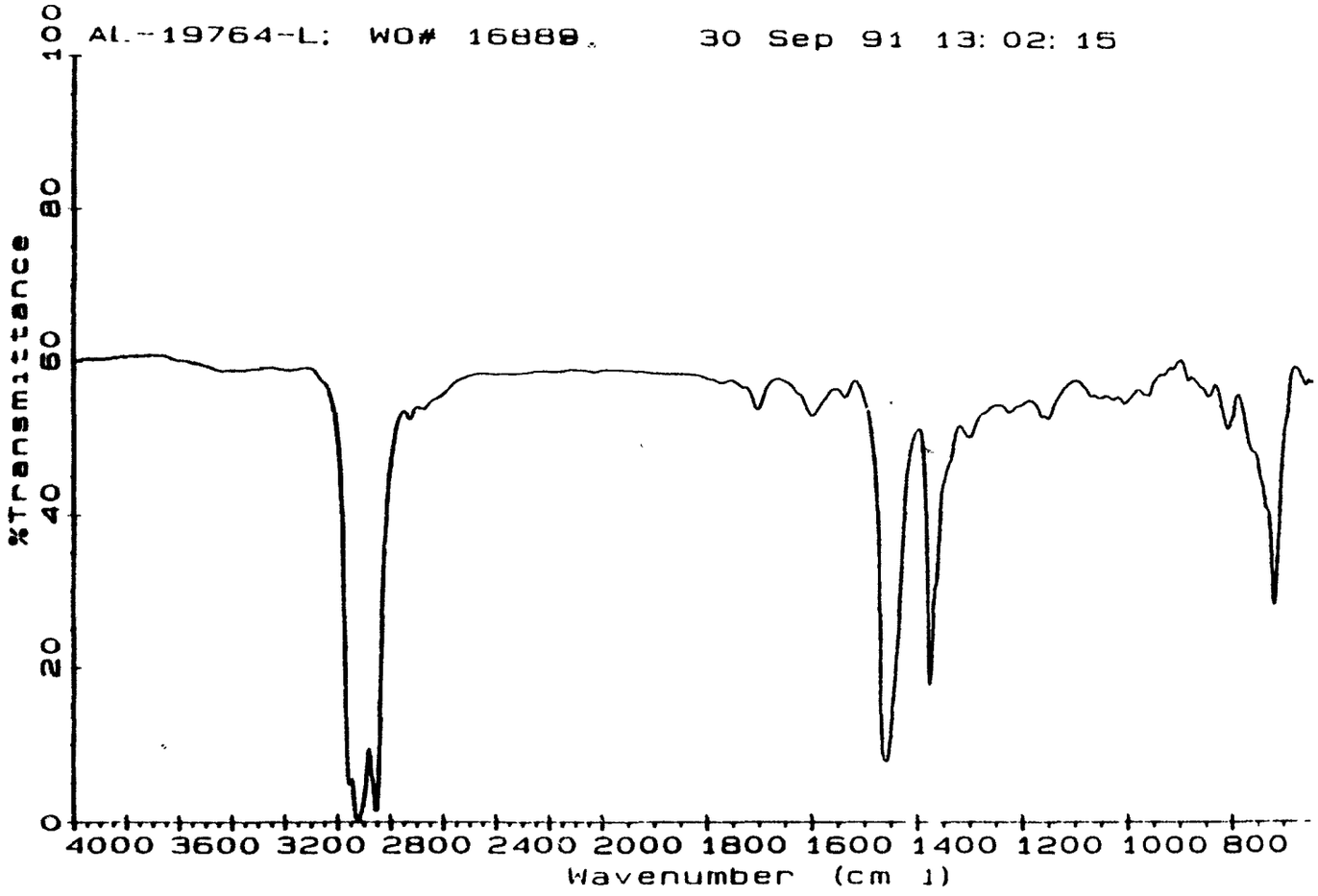
F-14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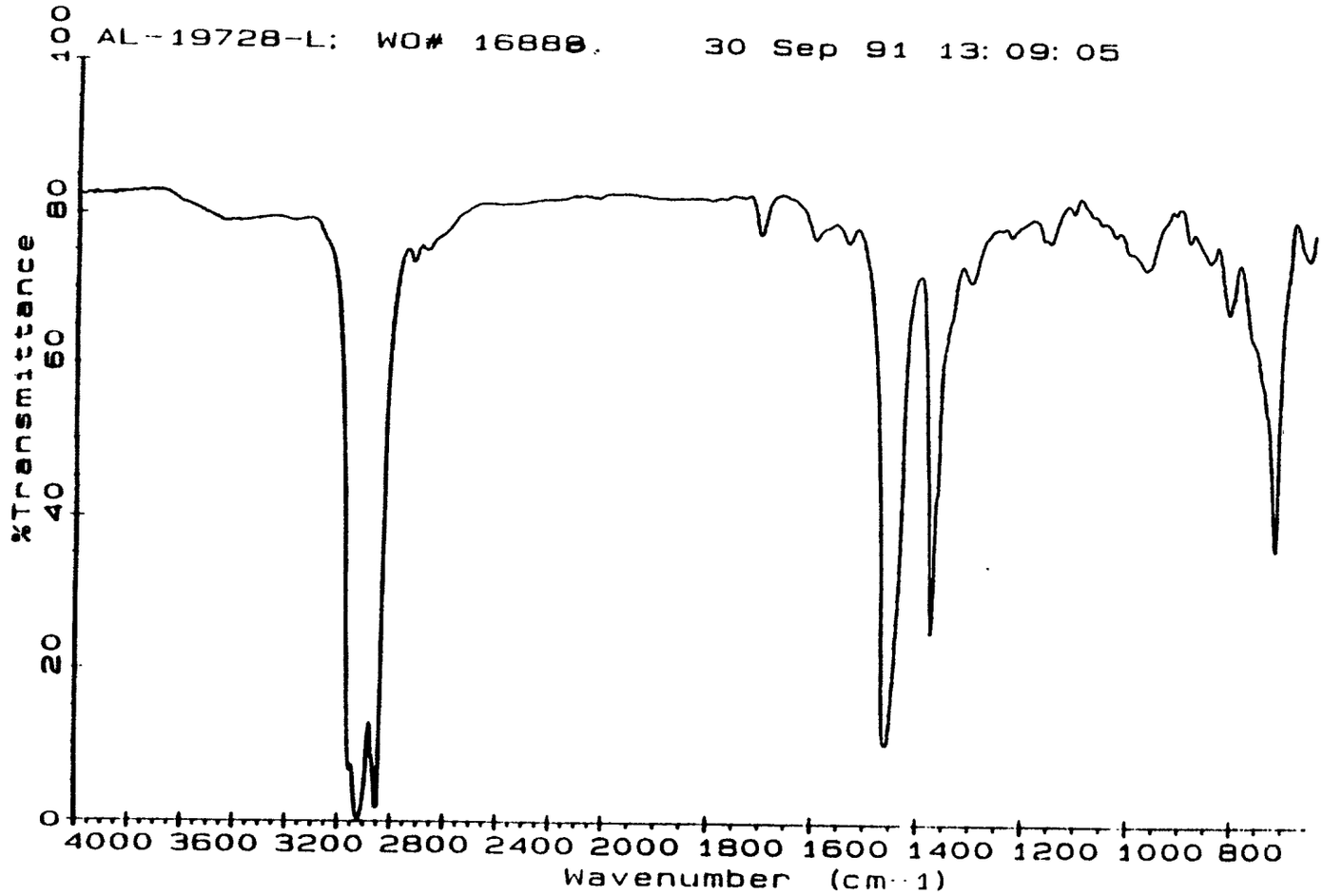
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F-15

Appendix G
FTIR OF USED TRANSMISSION OILS

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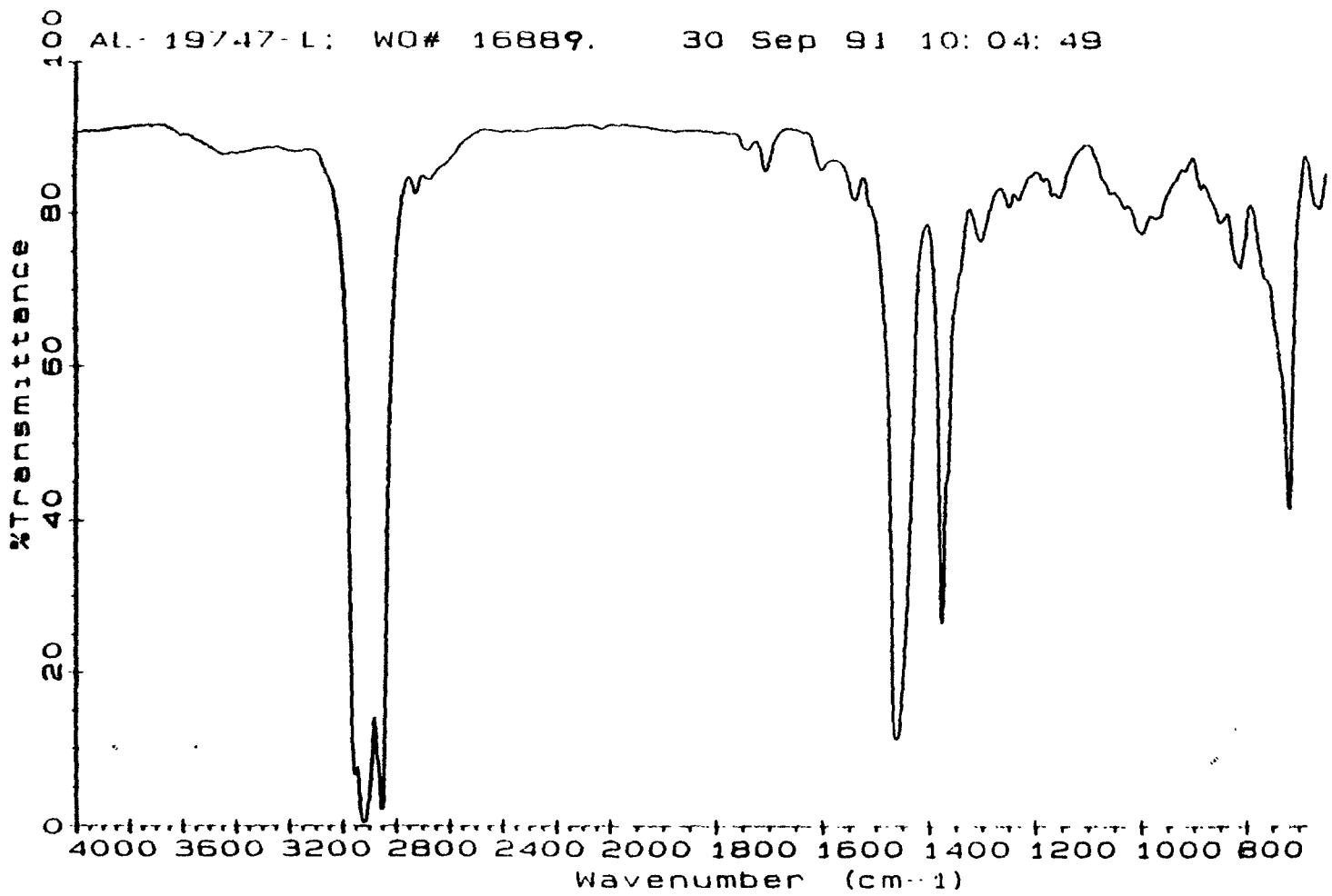
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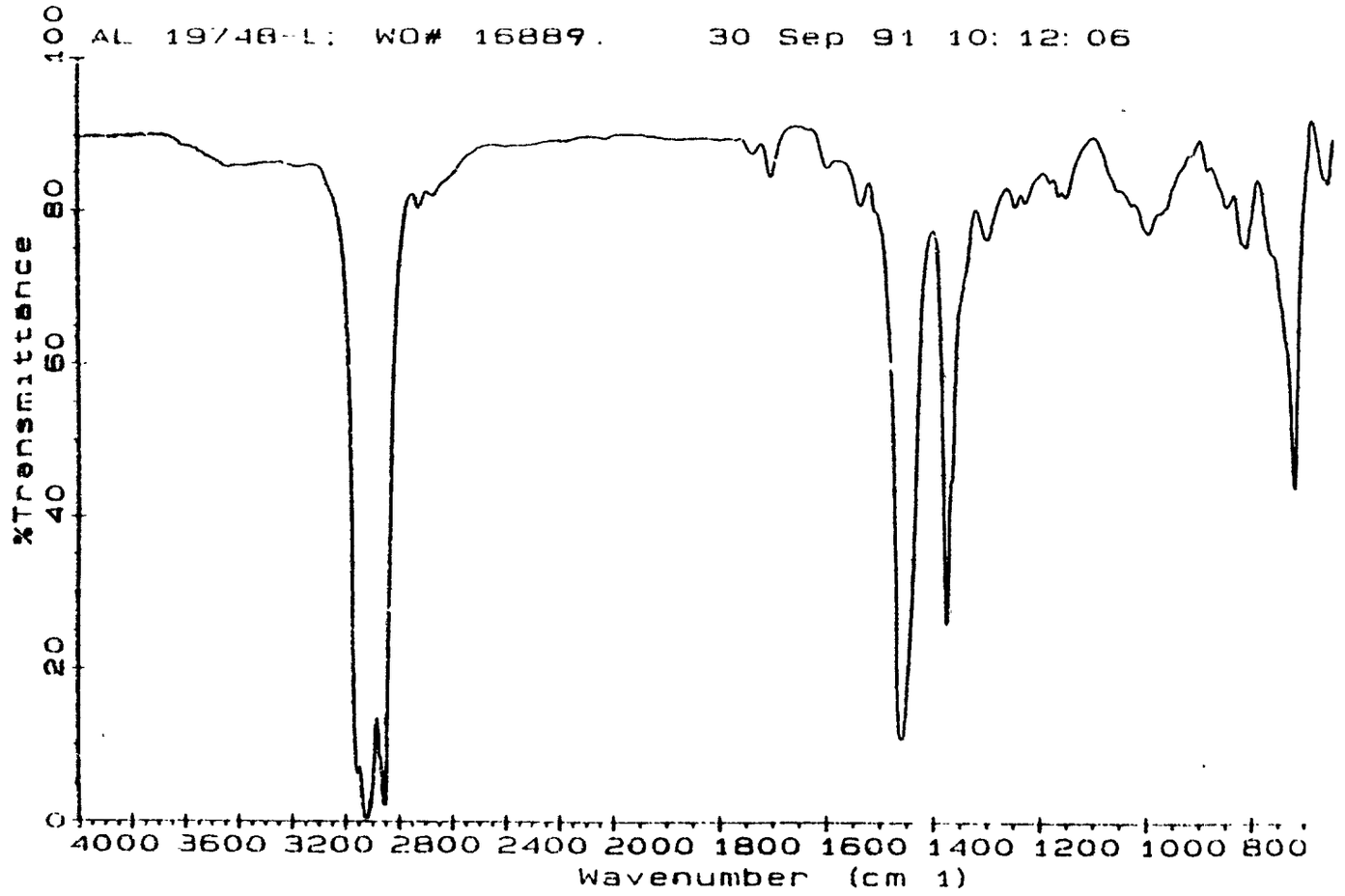
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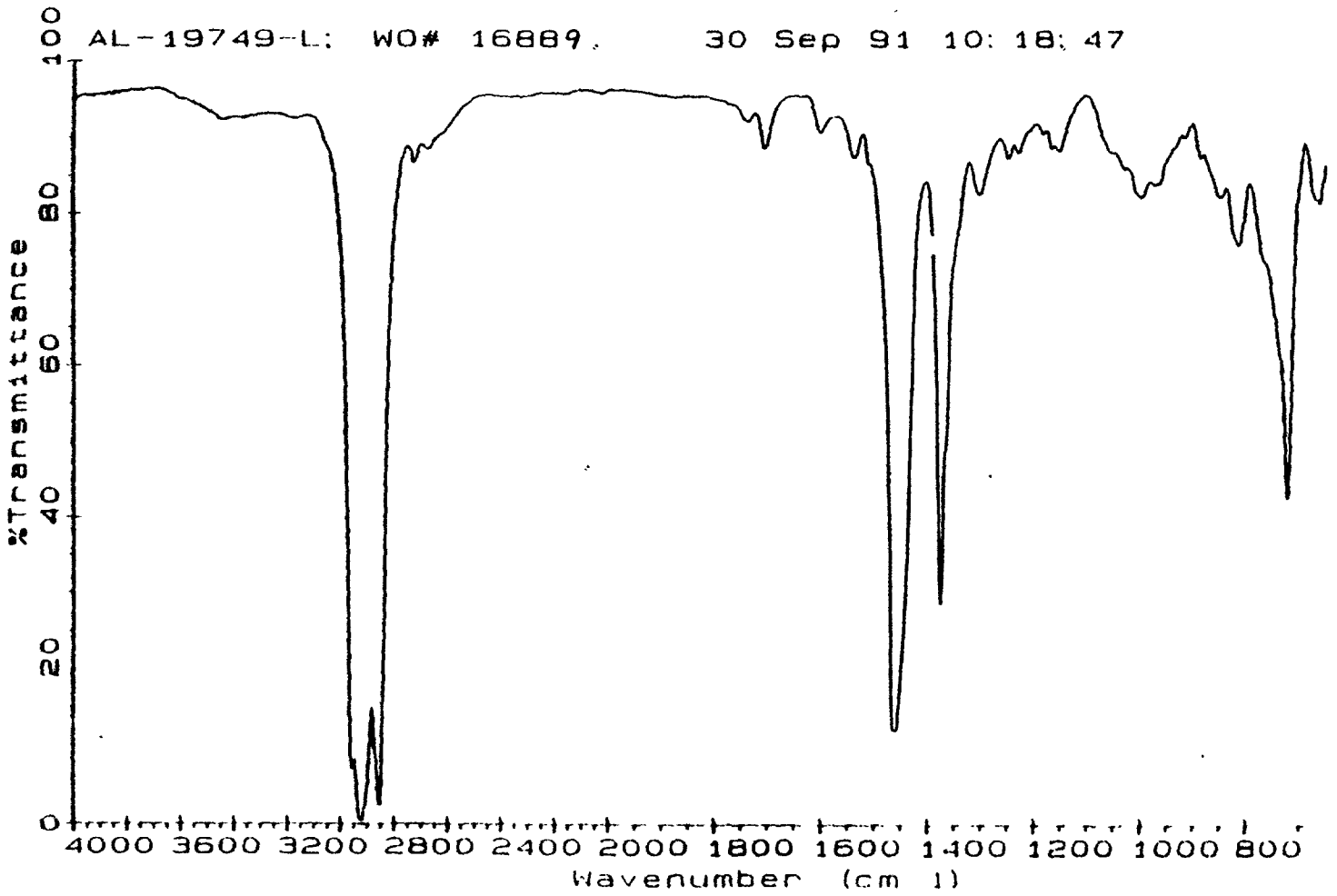
Wavenumber (cm 1)

G-4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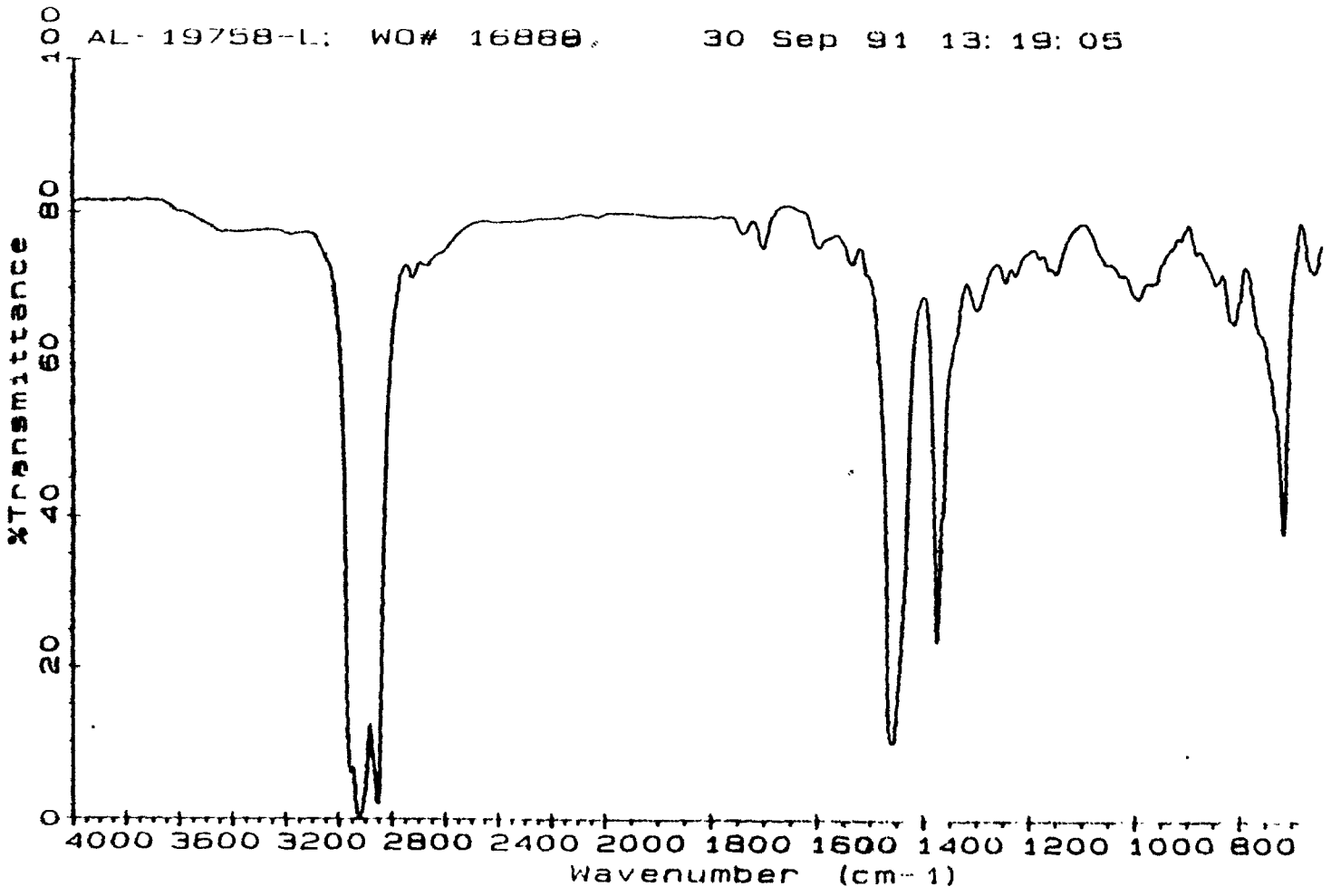
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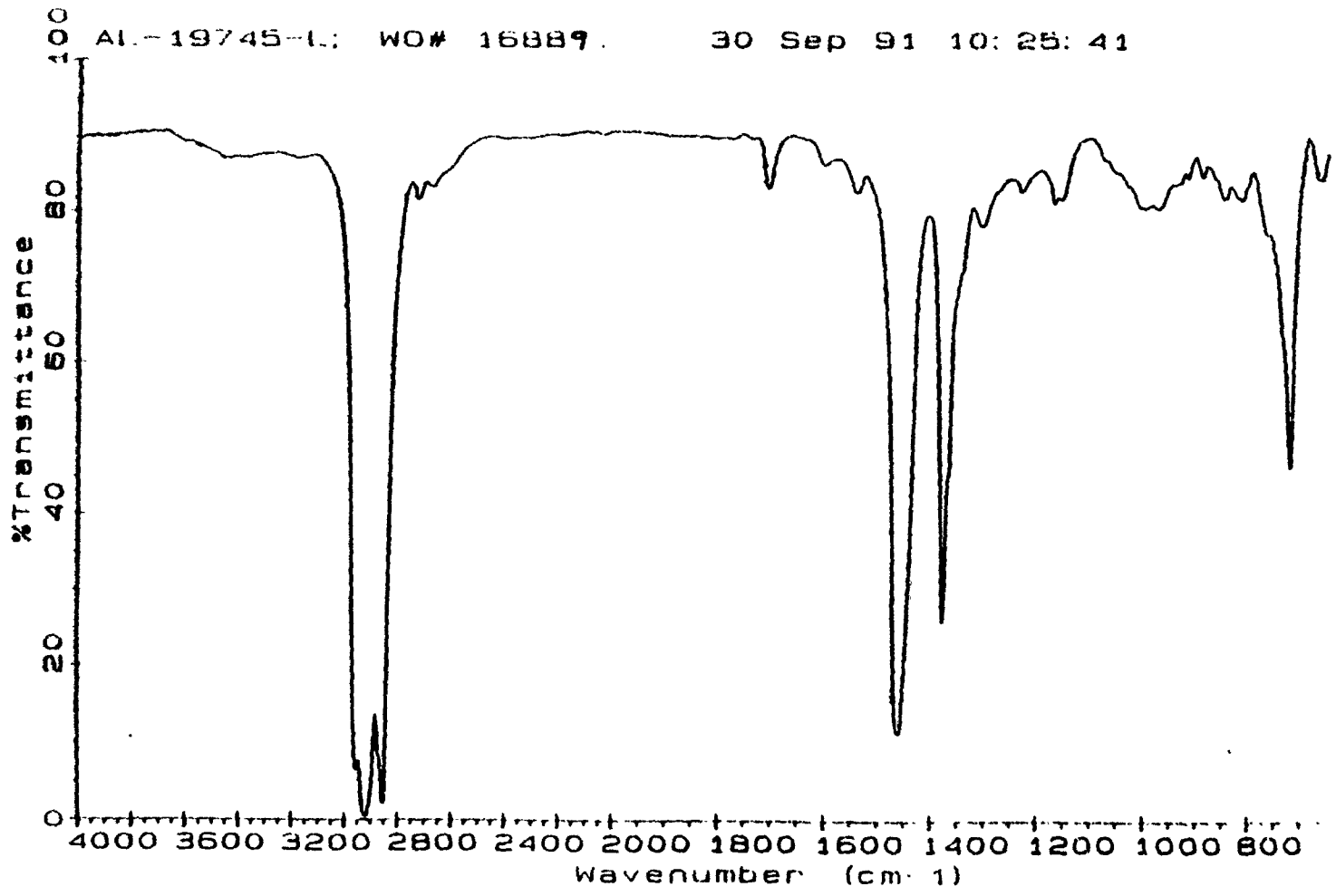
G5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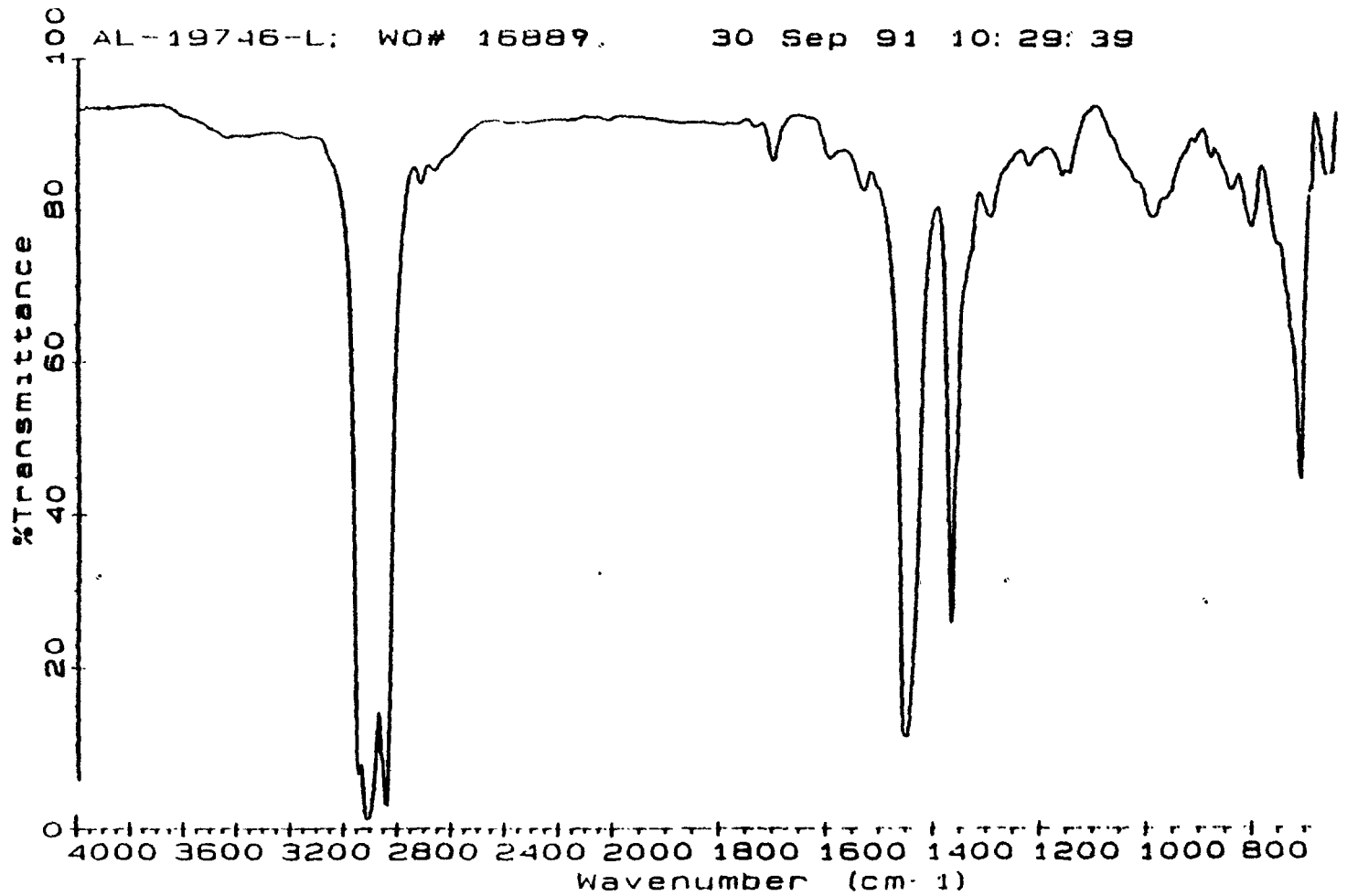
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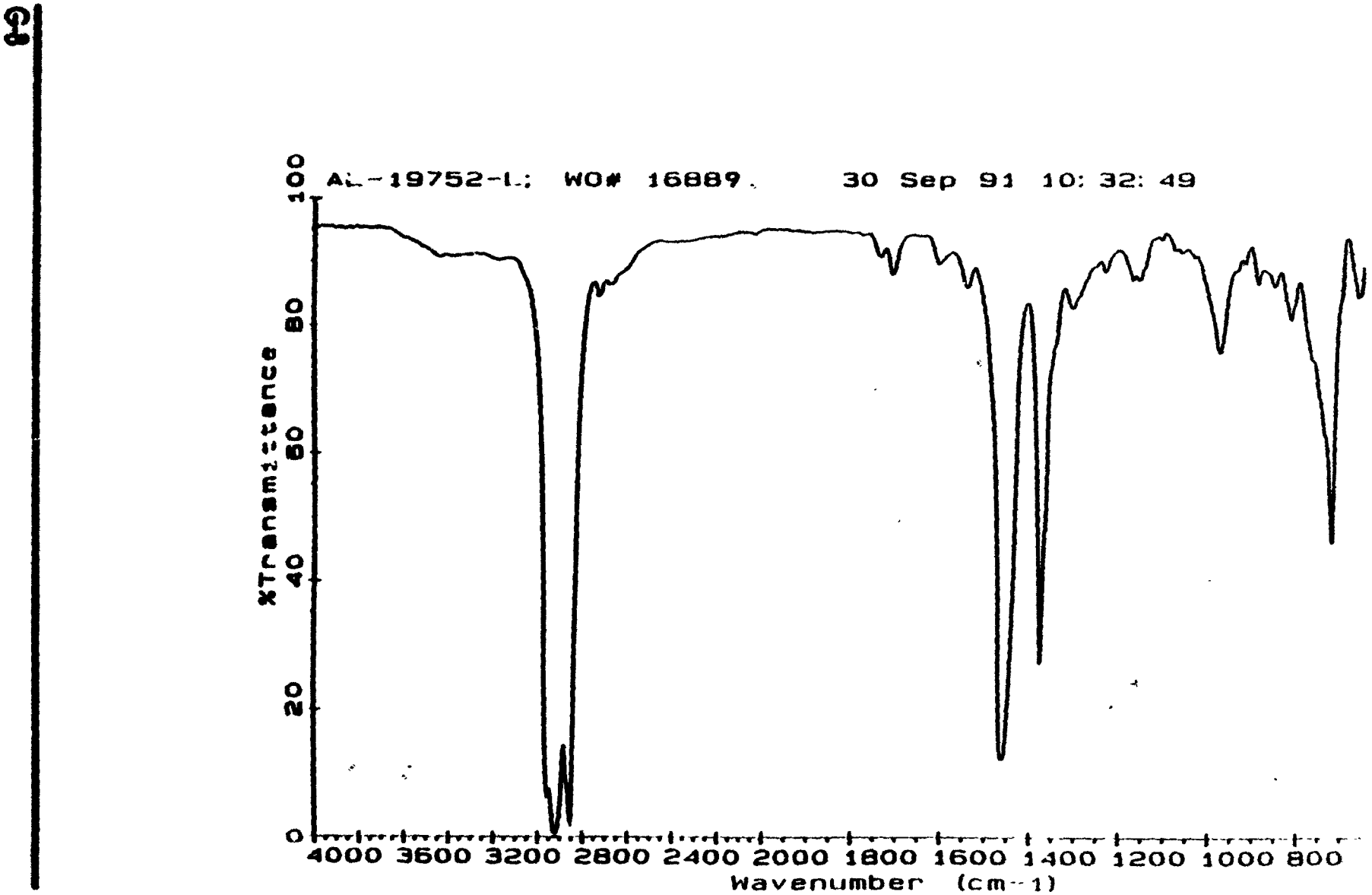
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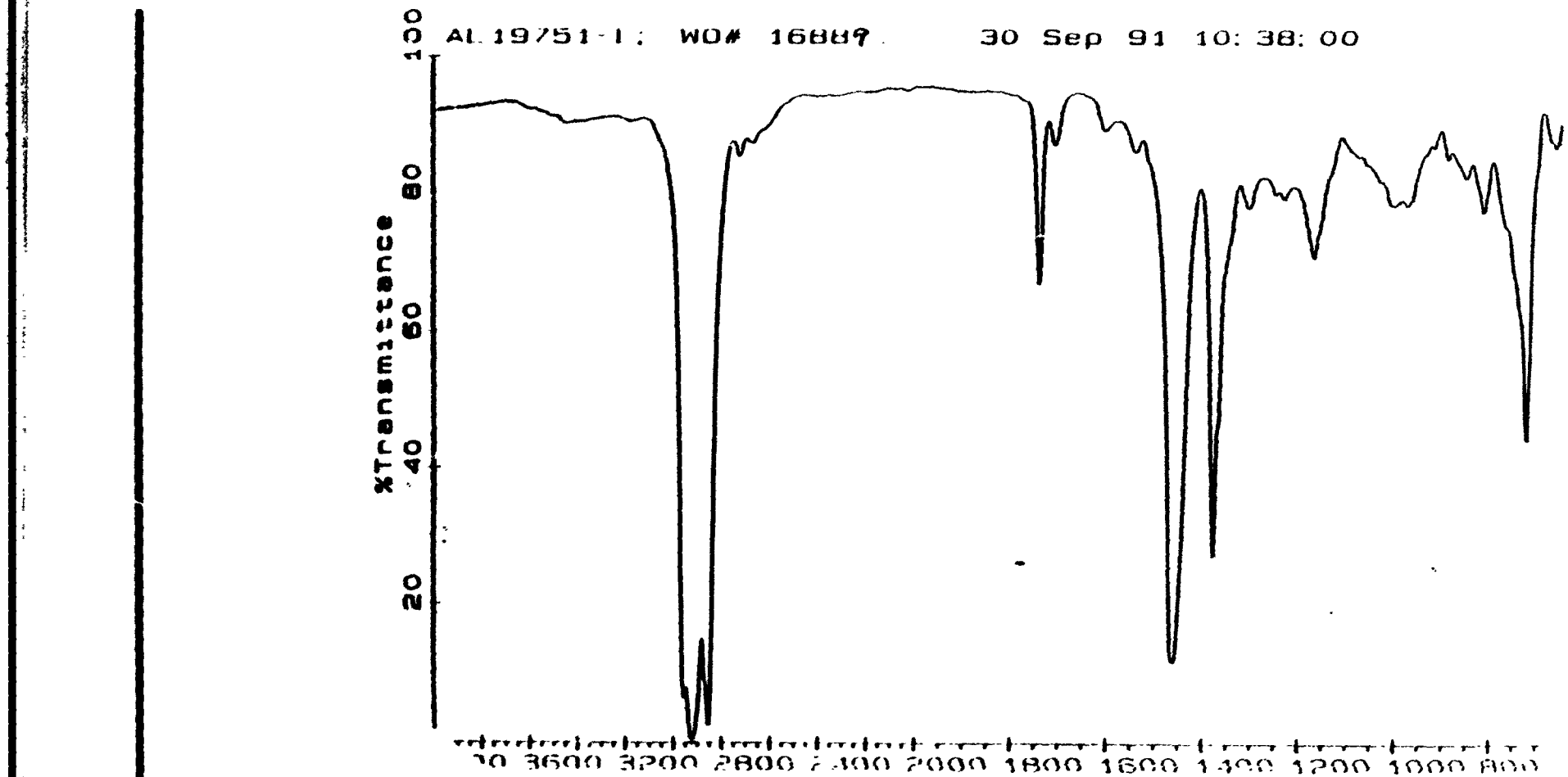
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cm

Appendix H

RESULTS OF TEARDOWN INSPECTIONS OF FAILED INJECTOR PUMPS FROM CUCVs AND HUMMWVs

MAINZ ARMY DEPOT JET A-1 INSPECTIONS

88 PUMPS TOTAL

	HMMWV	CUCV
• SEIZED	60%	14%
• FLEX-RING	0	54%
• DUST	77%	36%
• WATER	31%	19%
• AGE/WEAR	31%	25%
• REPAIRABLE	38%	69%

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