

**STRATEGY
RESEARCH
PROJECT**

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**STRATEGIC IMPLICATIONS FOR
A SINGLE-FUEL CONCEPT**

BY

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Abstract

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The primary purpose of this paper is to review the strategic implications of converting the military services to a single fuel. It will attempt to answer the following questions: Is a single fuel concept the right strategy for the U.S. Army? Is a single fuel concept right for all land-based forces? Is a single fuel concept right for all military forces within DoD?

This paper will also briefly discuss the history of fuel usage from World War II to the present. It demonstrates the need for a safe, cost effective fuel that can be utilized by all the services. It will also discuss the decisions that led up to the present doctrine which supports a single-fuel strategy. This paper also discusses some of the problems associated with this concept and finally offers some solutions or compromises to make this a workable concept.

Introduction

The purpose of this paper is to examine the 1988 Department of Defense (DOD) decision to standardize fuel support for air and land forces. This paper will also discuss the current status of this conversion process and make recommendations as to whether this program should continue into the next century.

A single fuel concept has significant strategic implications for the U.S. Military as it moves into the next millennium. This is because of DoD's efforts to downsize the force and to cut the Defense budget. DoD's multibillion dollar investment in fuel support has become a lucrative target. Accordingly, the Defense Fuel Supply Center (DFSC), DoD's fuel procurement agent, has been exploring ways of finding cheaper and more efficient ways of doing business. Converting the majority of DoD fuel-burning equipment to a single fuel has become the main focus of the fuel standardization effort. This paper will discuss the advantages and disadvantages of standardizing fuel support for the services. It will also describe some problems and misconceptions that have plagued the conversion process.

This paper reviews some early discussions that led up to the decision for a single fuel for aircraft and ground equipment. It examines where we are today in that conversion process, draws

some conclusions, and makes recommendations regarding whether this is the right fuel support strategy for DoD.

ASSUMPTIONS

As we move toward the 21st Century, the military services must make hard decisions concerning the makeup and size of the force and what types of new equipment it must purchase. These decisions will have a profound impact on whether DOD continues to pursue a fuel standardization program. However, before we began the discussion, we should consider certain assumptions regarding DoD's uses of fuel:

1. The price of crude oil, worldwide, will continue to increase gradually and the supply will remain constant. Refined products will remain available through foreign and domestic sources.

2. No new energy sources will become available on a large-scale basis for the foreseeable future. The fossil fuel burning engine will be with us until the year 2025 and probably beyond.

3. The DoD budget will continue to shrink, as will the procurement of new equipment for many years. Big ticket items such as tanks and helicopters - will receive what funding is available. Therefore, money to replace old and worn-out combat service support equipment will probably not be available. Such items as petroleum-handling equipment have a limited shelf life; therefore, some funding needs to be available to replace this

equipment.

4. DoD energy requirements will decrease over the next 25 years unless there is an unforeseen event on the horizon such as another Operation Desert Storm. Military Operations Other Than War (MOOTW) will not dramatically increase DoD's fuel consumption.¹

BACKGROUND

Throughout history, military commanders have lost battles and wars because they lacked sufficient or timely logistical support to sustain their fighting forces. Field Marshall Erwin Rommel provides an example of a respected military leader who experienced defeat on the battlefield because he could not sustain his Army. He faced many problems he had never experienced before as he attempted to defeat the Allied forces in North Africa. As he fought his way across Libya, he extended his lines of communications to the absolute breaking point. He simply had to stop in place until his fuel, ammunition, food, water and repair parts could catch up to him. The Germans were not accustomed to operating with such long lines of communications. The distance's Rommel had to cover in North Africa were greater than the distance from Berlin to Moscow. He was eventually defeated due to inadequate support. Rommel

¹Robert L. Jarvis, What fuels our Future, (USAWC Military Studies Program Paper), 3.

realized much too late how important his logistical support was to his victory on the battlefield:

The first essential condition for an Army to be able to stand the strain of battle is an adequate stock of weapons, petrol and ammunition. In fact, the battle is fought and decided by the quartermasters before the shooting begins.²

The lesson that we can all learn from Rommel's experience is that logistics is as vital to the campaign planning process as any other aspect. Some would argue that it is the most important. The best-trained and best-led Armies in the world cannot fight and win if they cannot sustain themselves.

When the U. S. Army entered World War II, it became a heavily mechanized force. Tanks, trucks, half-tracks and motorized artillery consumed enormous quantities of fuel. In addition, the Army had to move its massive logistical support structure by truck, another large consumer of fuel. The majority of the Army's equipment was powered by motor gasoline (Mogas); this equipment consumed huge quantities of fuel. Other services were also heavily dependent upon fuel. The Army Air Corps had become the largest U.S. military consumer of aviation gasoline (Avgas), and the Navy ships were consuming enormous quantities of a diesel-type fuel.³ Fortunately for the U.S. military, fuel was easy to obtain from refineries around the world, which was

² Martin Van Creveld, Supplying War: Logistics From Wallenstein To Patton, (New York: Cambridge University Press), 181-200.

³Jarvis, 6.

producing great quantities of the required type of fuel.⁴

Of all the U.S. supplies shipped into Europe during WWII, petroleum accounted for over half of the total tonnage. Fuel shipments weighed sixteen times more than food shipments to Europe.⁵ Re-supply of fuel was fairly simple during WWII because the Army and the Air Corps used primarily only two types of fuel. Mogas was used by most ground forces, and Avgas was used by the Air Corps. Both products were extremely dangerous due to their volatility, but Avgas was the most dangerous.

The introduction of the jet engine into the military inventory produced a need for another fuel, jet propellant-4 (JP-4). JP-4 is a 50:50 mixture of naphtha and kerosene; it was readily available and economical. However, JP-4 was highly volatile because of its low flash point (see Appendix II).

Once the U.S. entered the Vietnam conflict, the services relied on three primary fuels: jet fuel (JP-4), diesel fuel (DF-2), and motor gasoline (Mogas). DF-2 was becoming the preferred fuel for ground equipment because it is less volatile than mogas and it was readily available. However, since each fuel requires its own dedicated storage and distribution assets, the services encountered problems in acquiring, transporting, storing, and distributing sufficient quantities of each fuel to the right place at the right time. Also, the logistician had to balance

⁴Richard P. Dacey and Gregory J. Rosenthal, "The Single-Fuel Battlefield," Army Logistician (January-February 1989): 2

⁵Dacey, 2

the fuel requirements against available assets to ensure that all requirements were met.

During the Vietnam conflict, the Air Force consumed huge quantities of JP-4. The Navy decided to use JP-5 instead of the more volatile JP-4 (See Appendix II). Aircraft using JP-4 had a much higher combat loss rate due to a higher incidence of fires caused by static electricity than Navy aircraft using JP-5. Crash data indicated that the probability of fire was close to 100% for those aircraft using JP-4, but only 35% for those using the kerosene-type fuel, JP-5. JP-4 can ignite at room temperature, while JP-5 ignites at a temperature of 140 degrees fahrenheit or greater. So the Navy decided to use JP-5 instead of JP-4 for safety reasons. After the Vietnam conflict, the Air Force Tactical Air Command (TAC) concluded that over half of their Vietnam aircraft combat losses had been caused by gunfire induced fuel fires and explosions.⁶ The Air Force studies eventually led to the development of a replacement fuel for the Air Force, JP-8.⁷

The military specification for JP-8 was published in 1976. The characteristics of JP-8 are very similar to JP-5: Both fuels are straight kerosene-type fuels which have high flash points of 100 degrees and 140 degrees fahrenheit respectively (See Appendix II). The safety and availability of JP-8 makes it the preferred

⁶Jarvis, 7.

⁷Del Leese, "JP-8 Fuel Conversion," Flightfax vol. 23 (December 1994): 1

fuel. JP-8 is almost identical to the commonly used commercial jet fuel (Jet A-1), except for the three military additives: (1) corrosion inhibitor/lubricity improver; (2) fuel systems icing inhibitor; and (3) static dissipator additive. Due to improved safety, availability, and interoperability with allies, JP-8 was chosen by the Air Force to replace JP-4 within the North Atlantic Treaty Organization (NATO). The Air Force began the conversion process in 1979 at air bases in the United Kingdom; then the conversion was expanded to include all U. S. forces in NATO by 1988.⁸

In the early 1970's safety concerns prompted the services to begin replacing mogas-burning vehicles with safer diesel-burning vehicles. The rationale was simple: Diesel fuel is a much safer fuel than mogas. Gasoline ignites at temperatures well below the freezing point of water while diesel fuel will not ignite until the temperature is around 133 degrees fahrenheit.

The Army shared the same safety concerns as the Air Force for the continued use of JP-4 in Army helicopters. The U.S. Army also saw a possible use for JP-8 in ground, diesel-burning equipment. In Europe the Army was experiencing severe fuel waxing problems with the use of NATO standard diesel, (F-54). The field expedient solution was to mix either JP-5 or JP-8 with F-54 at the rate of approximately 50-50 to lower the cloud point of the diesel so that the diesel engine could produce enough

⁸E.C. Owens, M.E. LePera and S.J. Lestz, "Use of Aviation Turbine Fuel JP-8 as the Single Fuel on the Battlefield," no. 892071 (September 1989): 1

combustion to startup. This fix was referred to as "M1 fuel mix".⁹ The other NATO countries were also experiencing low temperature operability problems, so they were also exploring the potential of using other commercially available fuels.

In 1985 the U.S. published a report "JP-8 and JP-5 as Compression-Ignition (C.I.) Engine Fuels". This report confirmed what was already assumed by most, that JP-8 and JP-5 could be used as a substitute for F-54 or diesel fuel. It also confirmed that the use of JP-8 in the M1 tank would eliminate the waxing problems caused by the cold weather.¹⁰

As a result, Army Regulation (AR) 703-1 (1987) specified JP-8 as an authorized alternate for diesel-fueled equipment. Following extensive coordination, DoD Directive 4140.43 mandated fuel standardization:

1. Primary fuel support for land-based air and ground forces in overseas theaters shall be accomplished using a single kerosene-type fuel, designated JP-8, when approved by the Unified Commander. In overseas theaters where predominant fuel requirements are in support of the Navy, JP-5 may be substituted for JP-8 when approved by the Unified Commander.

2. Primary fuel support for sea-based aircraft shall be a kerosene-type fuel, designated JP-5. Conventionally-powered ships shall use a distillate-type fuel, designated F-76.

⁹"Conversion to JP-8 Fuel," JP-8 The Single Fuel Forward: Information Compendium, January 1996, 39

¹⁰E.C. Owens, 1

3. No new equipment designed to use gasoline-type fuels shall be acquired, except for equipment not intended for deployment and/or employment outside the United States.

Through this fuel standardization program, DoD sought to reduce the number of fuels used by DoD and to convert the vast majority of military equipment to one fuel, JP-8.

Discussion

The single-fuel concept offers DoD many advantages. In addition to the increased safety advantages of JP-8, significant logistical benefits are also realized. Procurement of fewer fuels and consolidation of previously segregated fuel distribution systems simplifies battlefield logistics. When our deployed services require more than one fuel, pipeline operations become extremely complex. Multi-product (more than one fuel at a time) pipeline operations involve batching and scheduling different fuels through the same pipeline. Experienced pipeline operators and petroleum laboratory technicians must work together to prevent co-mingling of the different fuels, which could result in contamination and loss of product. Therefore, pipeline operations are greatly simplified when the services require only one fuel.

The Army

Needing only one fuel on the battlefield, the ground commander has the flexibility to refuel ground and air assets with the same refueler. There are also maintenance advantages to utilizing JP-8, since it is a cleaner burning fuel. Engines do not require as many oil filter and fuel filter changes as with diesel fuel.¹¹

One of the disadvantages of diesel fuel is that it is not a stable fuel. If diesel is not used or rotated on a regular basis, it deteriorates. When water is introduced into diesel fuel by natural condensation or from other sources, it readily emulsifies to provide a fertile environment for micro-organisms to grow. Filter separators can effectively remove both water and particulate matter from diesel fuel, but they cannot prevent the accumulation of contaminants in a vehicle fuel system.

Although there are many advantages to a single fuel concept, conversion to a single fuel still raises real concerns. Safety is still a consideration, since JP-8 a ("Jet Fuel"), is more dangerous than diesel fuel, because it has a lower flash point. However, both fuels are considered low-volatility fuels. According to the National Fire Protection Associations Flammable and Combustible Liquid Code, NFPA 30, both JP-8 and diesel fuel are combustible liquids not flammable liquids. Flammable liquids have a flash point below 100 degrees fahrenheit: neither JP-8 nor

¹¹"Proposed Recommendations for transitioning JP-8(F-34) fuel into U.S. Army Ground Diesel Fuel-Consuming Vehicle and Equipment material," JP-8 The Single Fuel Forward: Information Compendium, 49.

diesel flashes below 100 degrees.

Another consideration is cleanliness. JP-8 is primarily used as an aviation fuel, but it can be used in lieu of diesel fuel. The Army has always viewed their ground vehicle refuelers as "dirty" because little regard was paid to the cleanliness of the refuelers or of the diesel fuel in them. But aviation refuelers are treated as "clean," since the fuel has to be maintained at aviation standards. The Army must change the way it views refuelers and treat all refuelers as "clean," since they will be transporting aviation fuel that may be used for ground or air assets. The need for higher standards is laid out in "JP-8 - The Single Fuel Forward Information Compendium"; it states that "any mind-set that believes JP-8 is intended for ground equipment could be handled as though it were diesel fuel would be contrary to the single-fuel-forward concept. The JP-8 is to be used in ground equipment and must be handled as if it were to be used in aviation equipment."¹² So the single-fuel concept mandates that the Army must raise its standards for handling fuel.

The Army National Guard and the Army Reserve units throughout the country still have many gasoline-powered vehicles in their inventories. The Army's 1980's modernization program called for replacing all of this equipment with diesel-powered vehicles and equipment in the future. But this modernization has been a slow and costly process. Desert Shield/Storm did

¹²Ibid., 57.

accelerate the process for many Reserve and Guard units, but the modernization process is still not a 100% complete. Nonetheless, there will always be a small requirement for gasoline and other fuels for use in small-engine type equipment. But such limited needs can be served through local contractors. Or limited quantities of gasoline may be transported from the U.S. in drums or other portable containers.

Some further problems have come up concerning the use of JP-8 and its authorized substitute, Jet A-1. During Operation Desert Shield/Storm, Jet A-1 fuel was the primary fuel used by U.S. Forces. However, DF-M (Diesel Fuel-Marine) was available when requested.¹³ The only significant difference between JP-8 and Jet A-1 is the additives in JP-8 (See Appendix III). The Saudi Arabian refineries did not have the capability of injecting the three mandatory additives to the Jet A-1 to convert the fuel to JP-8. The U.S. Air Force operations require JP-8, not Jet A-1. Therefore, the Air Force decided to furnish the Saudis with additive injection equipment to convert the Jet A-1 to JP-8 for their usage.¹⁴

One of the prevalent arguments against using jet fuel in ground equipment is that it tends to clog oil and fuel filters. This is normally true, because the Jet fuel has a cleansing effect on an engine. Not only will the filters clog, but the

¹³Trip Report, 5.

¹⁴Ibid

injector will sometimes clog on engines that have not been maintained properly. This "cleaning action" of JP-8 is a result of (1) the presence of the biostat/icing inhibitor which gradually kills micro-organisms, (2) the combined surface activity of the corrosion inhibitor and the static charge reduction additive, (3) possible increased solvency of the aromatic hydrocarbons found in the JP-8, and (4) the lower viscosity of the JP-8.¹⁵

Despite these concerns, which are being addressed, the Army has supported the single fuel concept, or "Single-Fuel-On-The-Battlefield" as it is referred to. The U.S. Army Belvoir Research, Development and Engineering Center at Fort Belvoir, Virginia, in conjunction with the Belvoir Fuels and Lubricants Research Facility, Southwest Research Institute in San Antonio, Texas, has done extensive testing on JP-8. They have conducted numerous tests over the years to prove that a kerosene grade fuel, used as an alternative to diesel fuel, can be used in a combustion ignition (CI) engine.

In the early 70's, the Army considered the use of JP-5 as an alternative fuel for all CI engines. Following some short term testing by the Army and the Navy, approval was given in September 1978 to use JP-5 as an alternate to VV-F-800 (diesel fuels) when operating Outside the Continental United States (OCONUS), where

¹⁵Chief, Fuels and Lubricants Division, Maurice E. LePera, "Interim Response to JP-8 Problem with USAF Ground Support Vehicles in Korea," memorandum for CDR SA ALC, ATTN: SFT, 1014 Billy Mitchell Blvd, STE 1, Kelly AFB, TX 78241-5603, 6 June 1995.

the predominate fuel requirements are in support of the Navy.¹⁶

Army Regulation (AR) 703-1, dated 5 January 1987, upgraded JP-8 from an emergency fuel to an alternate fuel for diesel-powered vehicles and equipment. Department of Defense (DoD) Directive 4140.43, dated 11 March 1988, specified that primary fuel support for overseas land-based air and ground forces be provided as JP-8 or JP-5. About the same time, the Army Material Command (AMC) conducted the planning required to formally verify acceptance of JP-8 in all diesel burning ground equipment.¹⁷

The Army Material Command (AMC), Training and Doctrine Command (TRADOC), and U.S. Army Forces Command (FORSCOM) decided to conduct the JP-8 Fuel Demonstration Program at Fort Bliss, Texas. The U.S. Army Belvoir Research, Development and Engineering Center, ran the demonstration program. The purpose of the program was "to fully confirm the usability of JP-8 for continuous operations in all diesel fuel consuming vehicles and equipment." Substituting JP-8 for diesel fuel, a total of 2,857 vehicles and equipment were satisfactorily operated on JP-8, with the following findings: ¹⁸

- o No catastrophic failures occurred using JP-8.
- o No unsurmountable JP-8 related concerns surfaced;

¹⁶U.S. Department of Defense. Department of Defense Directive Number 4140.25-M Vol I, Washington, D.C., 11 March 1988.

¹⁷Final Report On Field Demonstration Of Aviation Turbine Fuel MIL-T-83133C, Grade JP-8 (NATO F-34) At Fort Bliss, TX. (Ft Belvoir, VA.), 2.

¹⁸Compendium, 45.

that is, no mission or safety related matters.

- o User perception was favorable, with widespread acceptance of JP-8 at Fort Bliss.
- o No significant differences in vehicles/equipment fuel consumption rates were noticed.
- o Several major training exercises took place and no JP-8 fuel-related problems surfaced.
- o Army Oil Analysis Program (AOAP) analyses of used oil showed that recommended oil change intervals were increased somewhat.
- o Acknowledging satisfactory performance Fort Bliss was convinced to permanently convert to JP-8.

The program was scheduled to run from 1 February 1989 to 30 September 1991. An interim report, BFLRF NO. 264, titled "Field Demonstration of Aviation Turbine Fuel, MIL-T-83133C, Grade JP-8 (NATO F-34) at Fort Bliss, Texas," was published for the period 1 February 1989 through 31 July 1990. In the fall of 1990 over 2,000 of the 2800 plus pieces of equipment were deployed to the Middle East to participate in Operation Desert Shield/Storm.¹⁹ This provided a unique opportunity for the Army to test JP-8 in a combat environment. The initial plan was to utilize JP-8 in theater. But, as we have seen, it was determined that JP-8 (including its three mandatory additives) was not available. Therefore, Jet A-1 was directed to be used in all ground

¹⁹Final Report, Abstract.

equipment. While many of the units that did not have experience with a kerosene-base fuel experienced problems with Jet A-1, the Fort Bliss ground equipment operated with only "minor fuel-related complaints."²⁰

Due to the success of the Demonstration Program at Fort Bliss, the Army and DoD decided to convert both JP-4 burning equipment and diesel-powered equipment to JP-8.

On 1 October 1993, the Environmental Protection Agency (EPA) enacted a new regulation, Fuel Quality Regulations for Highway Diesel fuel (low sulfur diesel fuel standards - LSDFS).²¹ As a result, use of JP-8 as a diesel fuel substitute was viewed as a violation of the law. The new regulation stated that fuel sulfur content could not exceed 0.05 wt.% maximum. The JP-8 specification permits the maximum sulfur to be 0.30 wt%. At that time, five CONUS installations had converted from JP-4 to JP-8. But contracts then had to be modified to require refineries to provide a "low sulfur JP-8" to meet EPA compliance. As expected, these changes drove up the price of JP-8. Further, the Defense Fuel Supply Points (DFSP's) responsible for providing the JP-8 to CONUS installations lost the flexibility of using multiple suppliers, since not all refineries could produce the low-sulfur

²⁰Compendium, 45.

²¹Ibid., 57.

product.²²

Since the Army had recognized that kerosene fuels do not generate the same levels of exhaust emissions as do diesel fuels, they conducted a series of engine dynamometer tests for exhaust emissions of military engines. The results of the study showed "that the gaseous emissions using kerosene-based JP-8 fuel are essentially equal to values obtained with the 0.035 wt% sulfur EPA certification diesel fuel, and that an appropriate sulfur level of 0.21 wt% in kerosene-type JP-8 fuel would be equivalent to the 0.035 wt% sulfur reference fuel."²³

Although the JP-8 sulfur level specification was 0.30 wt%, an Army survey showed that of 93 samples tested, actual sulfur levels were only 0.07 wt%. The average sulfur levels of all JP-8 tested at Fort Bliss during the Demonstration Program was 0.03 wt%. As a result of the Army engine fuel emission study and the determination of actual JP-8 sulfur levels, the Army concluded that "The use of JP-8 on highway application will have no effect on gaseous emissions..."²⁴ Based upon this data, the Office of the UnderSecretary of Defense (Environmental Security) formally requested EPA concur with the unrestricted use of JP-8 by the military for highway use. The EPA responded that "...JP-8 is not subject to the Agency's Regulation of Fuel and Fuel additives for

²²Ibid., 58.

²³Ibid., 146.

²⁴Ibid., 58.

Highway Diesel fuel."²⁵ Therefore, the Army was not in violation of the law when it used JP-8 as a diesel fuel substitute.

However, mechanical problems began to surface during Operation Desert Shield/Storm. This theater served as a testing ground for the use of a kerosene-type fuel as a substitute for diesel in ground equipment. During the initial months following deployment, a series of fuel-related vehicle and equipment problems surfaced in units using Jet A-1 in diesel engines. They reported filter-clogging problems and fuel-pump failures. The problems were investigated by a team of experts from the U.S.; they found that most of the problems were occurring in certain wheeled vehicles and generator sets that had three particular fuel pump systems.²⁶

A subsequent investigation concluded that there was insufficient evidence to support any conclusion that Jet A-1 was a major factor in fuel system failures. It determined that many problems were caused by "non-fuel related variables" such as heat, dirt, and excessive usage. As a result of the investigation, CENTCOM decided upon a fuel usage policy that would give commanders a "fuel of choice in the theater." Commanders could use Jet A-1 or diesel fuel. The majority of the

²⁵Ibid., 57.

²⁶Trip Report, 2.

commanders used Jet A-1.²⁷

Some investigators believed that the fuel pump problems were caused by "insufficient lubricity." As a result, many units routinely added quarts of oil, transmission fluid, hydraulic fluid, and other lubricants to the fuel. However, tests have shown that these additions do not offer any real enhancement of lubricity; in fact they can increase fuel system and engine maintenance problems.²⁸

The Air Force

In Korea and Alaska, the Air Force has experienced mechanical problems with use of JP-8 in their ground support vehicles, primarily commercially designed equipment. The Air Force states that "PACAF bases in Korea and Alaska have been and continue to experience severe mechanical problems with vehicles using JP-8 fuel."²⁹ Symptoms include accelerated wear in the fuel injection pumps resulting in premature pump failure, poor engine performance, hard starting, and inability to immediately restart the engine after shutdown.

The Air Force has developed four courses of action: (1) change the specification of the fuel, raising the low-end

²⁷Ibid., 5.

²⁸Ibid., Enclosure 5.

²⁹HQ PACAF-LGS, , "DF-8 Ground Fuel Concerns/Actions Follow-up," Electronic Message to Defense Fuel Supply Center, (152032Z NOV 95). 25 Nov 1995.

viscosity, (2) replace/retrofit all affected fuel injection pumps with a heavy-duty pump, (3) add a lubricity enhancer to JP-8 destined for vehicle use, and (4) revert back to diesel fuel. They felt that the best solution was to raise the low-end viscosity of JP-8, yet they were concerned with the adverse impact it would have on jet engines. The Air Force decided to convert back to diesel fuel for ground use in Korea and Alaska.³⁰

The Army's interim response to the Air Force test found that the particular test the Air Force was using to assess lubricity of diesel fuel, the "Bocle test", was never intended to evaluate lubricity requirements of fuel injection pumps in diesel engines. The Army thus concluded that the Air Force assumption that JP-8 is the problem may be an incorrect finding. In all of the Army's investigations concerning lubricity problems, it was determined that "JP-8 did not contribute to an increase in the replacement rate of fuel injection pumps."³¹ So the Air Force problem is currently unresolved.

Conversion

The initial proposal to convert from JP-4 to JP-8 for aircraft usage was made in 1976. The process has been an extremely slow and arduous, a process that is still going on

³⁰Ibid., 3.

³¹Interim Response.

today as a result of the costly investigation. We have reviewed numerous concerns in accepting JP-8 as a replacement fuel. JP-8 has been found more acceptable for use in aircraft than for use in ground vehicles. The Air Force was an early advocate for JP-8 due primarily to its increased safety features. Initially, conversion to JP-8 was planned only for outside the continental United States (OCNUS). Part of reason for OCNUS only conversion was that most U.S. refineries felt that they could not produce the quantities of JP-8 required by DoD.³²

NATO completed the conversion of the Central European Pipeline (CEPS) from JP-4 (F-40) to JP-8 (F-34) on 18 August 1988. Land-based aircraft were completely converted to JP-8 by October of 1989. U.S. conversion from diesel fuel to JP-8 for ground vehicles/equipment was completed by 1992.³³

After the successful completion of the Fort Bliss JP-8 Demonstration Program in October 1991, other CONUS bases began to start their conversion process. The Air Force began converting their West coast CONUS bases in 1993.³⁴

The current status of the worldwide conversion to JP-8 is as follows:³⁵

CONUS - All storage in the continental United States

³²Jarvis, 9.

³³Compendium, 41.

³⁴Ibid.

³⁵Robert L. Jarvis (rjarvis@dfsc.dla.mil), "FW: JP-4 Conversion Status," Electronic mail message to Donald G. Weir (weird@carlisle-emh2.army.mil), 3 Mar 1996.

has been converted to JP-8 with the exception of Ellsworth Air Force Base where 16,000 barrels of JP-4 inventory remain. Final conversion was anticipated to be 30 March 1996.

Europe - Complete.

Korea - All storage has been converted with the exception of Yechon (tactical site), where 53,000 barrels of JP-4 remain. Final conversion is anticipated by August 1996.

Alaska - All DFSC operated storage has been converted. However, both the Air Force and the Army continue to use JP-4 for operation of ground vehicles/equipment and helicopters.

Turkey - Conversion to JP-8 in Turkey began in the fall of 1995. Conversion to JP-8 should be completed by the end of calendar year 1996.

So the conversion process is nearly complete. But U.S. Army Reserve and National Guard units will continue to use JP-4 and diesel for the foreseeable future. The reserve component units normally have small volume underground storage tanks, less than a 7,500 gallon tanker (normal civilian bulk fuel hauler). Further, most line haul companies transporting JP-8 from DFSC Supply Points will not make a drop of less than a full tanker load. Therefore, the Guard and Reserve units will continue to use diesel and JP-4 fuel in their equipment.³⁶

Conclusion.

³⁶Del Leese, U.S. Army Petroleum Center, Tape recorded Interview by author, 16 February, 1996.

DoD's decision to convert the military services to a single fuel was the right operational decision. The conversion program was not intended to completely eliminate other fuels, but to convert the majority of military equipment to one fuel. The Navy decided to utilize JP-5 for safety reasons; it will continue to use JP-5 aboard ships. The Air Force and Army have converted to JP-8 for all aircraft refueling with relatively few problems. Army helicopters have experienced some cold weather starting problems in Alaska. They have decided that JP-4 would be the appropriate on-site cold-weather fuel, rather than spending 20 million dollars to fix the problem by installing in-line heaters for each helicopter's fuel system.

Ground equipment conversions have been slower than expected, due to such perceived problems as lubricity. The Air Force has experienced problems with their commercial support vehicles, so it has converted back to diesel fuel for ground equipment at two bases in Korea.

The single fuel strategy did not work for all units during Desert Shield/Storm. JP-8 was not used because suppliers lacked equipment to inject the additives required to produce it. Jet A-1 was utilized by many of the units, but many units elected not to use "Jet Fuel" due to many misconceived perceptions that JP-8 was bad for their equipment.

Despite these programs, conversion to a single fuel concept is the right strategy for DoD. It streamlines logistics and reduces the need for additional fuel handling equipment, thus

saving millions of dollars.

This paper has discussed the many advantages of this concept. It has also considered the disadvantages. DoD made the decision to convert many years ago. It has made remarkable progress in such a complex and expensive endeavor. Buying, using and handling just one fuel seems an unassailable premise. Using a single fuel will generate some real cost savings due to a reduction in sheer numbers of storage systems, of trucks to dispense the fuel, and of managing multiple fuels. Logistics will be greatly simplified, and users will be more efficiently served.

As we continue to downsize our military and reduce the Defense budget, a fuel standardization program makes more sense today than ever. As we simplify and streamline the logistical support systems, we shorten the "Log Tail" and provide the war-fighting CINC with more flexibility and many other advantages. Logistics will surely become a true "combat-multiplier" when standardized, streamlined products and services free up personnel and funds for other warfighting needs.

Recommendations

DoD has put an enormous amount of work into proving the acceptability and practicability of a single fuel concept. No longer do we need to plan for numerous fuels on the battlefield, only one. To complete this conversion to a single fuel, we

should expeditiously take the following actions:

- (1) All future design specifications for military equipment must ensure that JP-8 will be the primary fuel source.
- (2) All new equipment must utilize a fuel pump that is compatible with JP-8.
- (3) Once technology has progressed to the point where it can produce small, light-weight kerosene burning engines, all gasoline-driven equipment in the inventory should be phased out.
- (4) All administrative support equipment purchased by all services should be certified to use JP-8 as its primary fuel source.

The strategic implications of adopting and fully implementing a single fuel concept are tremendous. A streamlined logistics system will provide our military commanders with the flexibility of a system that can help them successfully accomplish their missions. This streamlining will not only reduce fuel- handling equipment requirements but may also reduce manpower requirements. The single fuel concept is a necessary and effective combat multiplier. The concept is well on the way to optimal realization in the field. The recommendations in this study will lead to a full implementation of a far-sighted and far-reaching program that began in 1976.

GLOSSARY OF PETROLEUM TERMS

Additives:

Corrosion Inhibitor. A corrosion inhibitor conforming to MIL-I-25017 shall be blended into the F-34 grade fuel by the contractor. The corrosion inhibitor additive is optional for F-35. The amount added shall be equal to or greater than the minimum effective concentration and shall not exceed the maximum allowable concentration listed in the latest revision of QPL-25017.

Fuel System Icing Inhibitor. The fuel system icing inhibitor is mandatory for F-34 (JP-8) and shall conform to MIL-I-27686 or MIL-I-85470. The fuel system icing inhibitor is not to be added to NATO F-35 unless so directed by the procuring activity.

Static Dissipator Additive. An additive shall be added to the fuels in sufficient concentration to increase the conductivity of the fuel to within the range specified.

Barrel (BBL): The unit of measure of bulk petroleum liquids. It equals 42 U.S. standard gallons.

Class III (POL): Petroleum, Oils and Lubricants (POL).

Cloud Point: The temperature at which wax crystals in an oil separate, causing the oil to appear cloudy and hazy. The process is called waxing.

Distillation: The refining process used to make petroleum products from crude oil. The type of refined product is based on the distillation range (point from the initial boiling to the final product evaporated). Petroleum products with a "wider" boiling or distillation range are more plentiful per refined barrel of oil than those with a "narrow" boiling range.

Flash Point: The lowest temperature at which an ignition source will cause the fuel to flash or ignite. The most common test for measuring volatility and is a measure of the safe handling/use properties of a petroleum product.

Fuel: Also referred to as a product, petroleum fuel or POL product. Any type of refined hydrocarbon fuel from crude oil that is used as an energy source for an internal combustion

engine.

Military Fuels: These fuels are refined to a standard or specification, also known as "specs". Military fuels are similar to commercial fuels although they may contain extra additives that are unique to military needs and applications. Some of the military fuels are listed below;

AVGAS: Aviation gasoline (Avgas) is a highly volatile fuel. This fuel is normally used by reciprocating engine aircraft. As these aircraft leave the inventory the use of this fuel will continue to decline, therefore, this product will move from a bulk item to that of a packaged item.

Diesel Fuel: (NATO F-54) Diesel fuel is far less volatile and somewhat stable, unless water is introduced, than jet fuels. The various grades of military diesel are: DF-2 for ground equipment use (NATO F-76), DFM for marine use (NATO F-76), and DFA for extreme cold weather use.

JP-4: (NATO F-40) A wide-cut turbine jet fuel that includes both the naphtha (gasoline) and kerosene fractions of the distillate. JP-4 is typically made up of 50 to 60 percent gasoline and rest is kerosene. It was the standard jet fuel for the Air Force and the Army until the 1980's when concerns of it's safety came about and the single fuel concept began to gain momentum.

JP-5: (NATO F44) A high flash point kerosene base turbine jet fuel. The high flash point, (140 degrees fahrenheit), makes it a much safer fuel than of JP-4, therefore, the Navy uses it aboard ship.

JP-8: (NATO F-34) A kerosene turbine jet fuel, similar to Jet A-1 only with military additives, with a flash point of 100 degrees fahrenheit. The additives are fuel system icing inhibitor, anti-static additive, and corrosion inhibitors. Initially developed by the U.S. Air Force as a safer alternative jet fuel to JP-4. JP-8 can be used in both turbine and non-turbine engines.

Jet A-1: (NATO F-35) A kerosene turbine jet fuel used by commercial aviation. It is an acceptable substitute for JP-8, however, it does not have the military additives.

SOURCE: FM 10-71-1, "Petroleum Reference Data", and Robert L. Jarvis, What Fuels Our Future, (USAWC Military Studies Program Paper) Class of 1991.

JET FUEL SPECIFICATIONS

	<u>JP-4</u>	<u>JP-5</u>	<u>JP-8</u>	<u>JET-A</u>
Gravity, API	45-57	36-48	37-51	37-51
Flash Point, F (Min)	-	140	100	100
Reid Vapor Pressure, psia	2-3	-	-	-
Freezing Point, F (min)	-72	-51	-58	-40
Smoke Point, MM (min)	2 0	19	19	20
Heat of Combustion	120.0	125.0	124.6	125.0

FUEL DEFINITIONS

<u>FUEL</u>	<u>NATO CODE</u>	<u>COMPOSITION</u>	<u>MILITARY ADDITIVES REQUIRED</u>
JP-4	F-40	50:50 MIX OF NAPHTHA & KEROSENE	YES
JP-5	F-44	KEROSENE	YES
JP-8	F-34	KEROSENE	YES
JET A-1	F-35	KEROSENE	NO
JET 1	NO	SAME AS JET A-1 BUT ALLOWS A -40 C MAX FREEZE POINT	NO
DF-A	NO	KEROSENE	NO

APPENDIX III

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