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Is a Single Fuel on the Battlefield Still a Viable Option?

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ABSTRACT

Garrett, Russell K. (Industrial College of the Armed Forces) **Is a single fuel on the battlefield still a viable option?** The plan for petroleum support in CENTCOM was based on the single fuel on the battlefield concept. Under this concept, land based aircraft and ground vehicles and equipment would operate using a single fuel, Jet A-1. However, when the Persian Gulf War occurred, this plan was set aside. This paper investigates the reasons why the plan to use a single was not followed. Essentially, there were two reasons. One, Jet A-1, diesel fuel, and automotive gasoline were all readily available in Saudi Arabia. Two, some US units were not confident using Jet A-1 in lieu of diesel fuel. Units which used Jet A-1 did not experience any significant fuel-related problems. In fact, the Persian Gulf War further demonstrated that aviation and ground equipment can be operated using the same fuel. In addition, using the same fuel added flexibility and simplicity to petroleum support operations. Therefore, the single fuel on the battlefield concept remains a viable option and one which DOD should continue to strive to attain.

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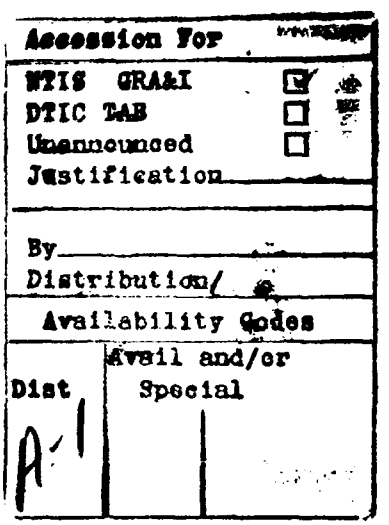

IS A SINGLE FUEL ON THE BATTLEFIELD STILL A VIABLE OPTION?

The Plan

The plan for petroleum support of US Forces deployed within the Central Command (CENTCOM) area of responsibility (AOR) was based on the concept of using a single fuel on the battlefield. This concept envisioned using the same fuel for aircraft and ground equipment operating within a theater.[1] This did not apply to naval operations or include carrier-based aircraft because of the specific operational fuel requirements necessary for shipboard operations. Jet A-1[2] was designated as the single fuel for the CENTCOM AOR. However, during the Persian Gulf War, the single fuel concept was set aside and multiple fuels were provided throughout the war.

The purpose of this paper is to investigate what happened during the Persian Gulf War in terms of providing petroleum to the US Forces. This paper will specifically address:

1. Why is the Army interested in this single fuel concept?
2. Why was the decision made to use multiple fuels during the Gulf war?
3. How was petroleum support provided during the war?
4. Should the US continue to strive to obtain a single fuel on the battlefield in light of the Persian Gulf War experience?

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[1]Department of Defense, Directive 4140.43: Fuel Standardization, (Washington, DC: Office of the Secretary of Defense, 1988), 3.

[2]See Glossary.

The Concept

The single fuel concept is not a new idea. In W.E. Butterworth's book, Black Gold: The Story of Oil, he alludes to this concept in his description of the exploits of James Doolittle. In 1934, Mr. Doolittle, a former Army Air Corps pilot, was advocating the development of a 100-octane, rather than the standard 75-octane, aviation fuel for use in military aircraft. According to Mr. Butterworth, Mr. Doolittle's support on behalf of the military was greeted suspiciously because, although he was a former pilot, he was currently employed by Shell Oil Company.

> "If he was so interested in the army air corps [sic], why had he resigned from service? Wasn't he, after all, an employee of Shell, whose business was selling gasoline? And, if he were a soldier, couldn't he see the wisdom of the policy the military was trying to put into effect of having one fuel for everything with an engine, from a motorcycle to a four-engine bomber?"[3]

Mr. Butterworth further related that Mr. Doolittle reentered the Army as a bomber pilot after the Japanese attack on Pearl Harbor. Major (then) Doolittle later earned the Medal of Honor for his actions in a bombing raid over Tokyo and rose to the rank of Brigadier General. It is significant to note that his bombing of Tokyo was made possible by the fact that the Army had accepted the 100-octane aviation gasoline for use in Army aircraft as he had advocated in 1934.

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[3]William E. Butterworth, Black Gold: The Story of Oil (New York: Four Winds Press, 1975), 153.

The latest impetus for having a single fuel on the battlefield started in 1986,[4] as a consequence of trying to find solutions to two separate problems. The Air Force was working on one problem and the Army was working on the other. The Air Force was trying to find a safer fuel to use in its aircraft based on its experiences in Vietnam. During the Vietnam War, the Air Force lost a significant number of aircraft due to fuel fires after being hit by enemy ground fire. In addition, the Air Force suffered losses of aircraft as a result of fuel fires in peacetime as well. After Vietnam, the Air Force conducted an investigation into these losses and determined that these losses resulted from using JP-4,[5] a highly volatile aviation fuel.[6]

To explain further, one measure of volatility of a fuel, which petroleum personnel use, is the flashpoint. The flashpoint of a fuel is the temperature at which sufficient vapors are generated by the fuel that, in the presence of a spark, the vapors will ignite.[7] For JP-4, the flashpoint is a negative 10 degrees Fahrenheit (-10°F). Another measure of volatility is the range

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[4]Russell K. Garrett, "JP-8 Conversion: The Move Towards a Single Fuel Battlefield," Quartermaster Professional Bulletin, September 1988, 36-38.

[5]See Glossary.

[6]Garrett, "JP-8 Conversion," 36.

[7]Department of Defense, Military Handbook for Petroleum Operations (Washington, DC: Office of the Assistant Secretary of Defense, 1987), 91.

of flammability. When temperatures are too cold, an insufficient amount of vapors will be generated to ignite, in the presence of oxygen and a spark. When temperatures are too hot, too much vapor is produced and the vapors will not ignite, even in the presence of oxygen and a spark. The flammability range is the range of temperatures for which sufficient vapors will be generated such that, in the presence of oxygen and a spark, the fuel will ignite.[8] The flammability range for JP-4 is -10°F to 100°F. The significance of the flammability range is that Air Force personnel in Vietnam and on most air bases worldwide, in peacetime, conducted combat, support, or training missions and refueling operations when the temperatures were within this flammability range. In the studies mentioned above, the Air Force concluded that when aircraft, operating in Vietnam, were hit by enemy ground fire, this provided the spark which ignited the JP-4 fuel vapors and started the fuel fires.[9]

For this reason, the Air Force was looking for a safer fuel to use in its aircraft. One fuel the Air Force tested was an aviation fuel, JP-8. One characteristic of JP-8 which the Air Force liked was that the flashpoint was 100°F. Also, the

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[8]Department of the Army Field Manual 10-69, Petroleum Supply Point Equipment and Operations (Washington, D.C.: Headquarters, Department of the Army, 1986), 9-1.

[9]Garrett, "JP-8 Conversion," 36.

flammability range of JP-8 was 95°F to 165°F[10]. Therefore, JP-8 was a safer fuel than JP-4.

The Army problem involved the new M-1 tank.[11] During the late 1970s and early 1980s, the Army developed and fielded the M-1 Abrams tank. Various armor units in Germany received this tank and, during the winter, these units had problems starting their tanks. The cause of these problems was attributed to the fuel. The M-1 tank is powered by a turbine engine and designed to operate on diesel fuel. The diesel fuel available in Europe was DF-2.[12] DF-2 is a diesel fuel in which wax crystals will form in temperatures below 9°F. Once the fuel starts to crystallize, the wax particles will clog fuel lines and filters. As a result, the tank engines will not start or, if started, will cut off. The armor community surfaced the problem to Headquarters, Department of the Army (HQDA) for resolution. Although a different grade of diesel fuel such as diesel fuel, grade DF-1 or DF-A,[13] would have solved the problem, only diesel fuel, DF-2, was available in Germany.

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[10]Department of the Army Field Manual 10-68, Aircraft Refueling (Washington, DC: Headquarters, Department of the Army, 1987), 7-3.

[11]Garrett, "JP-8 Conversion," 36.

[12]See Glossary.

[13]See Glossary.

When the Air Force approached the Army to discuss the possibility of converting from JP-4 to JP-8, the Army concurred. The Army further proposed using JP-8 also as a substitute for DF-2. The Army's rationale for concurrence was that JP-8 can be used as an aviation fuel to power turbine engine rotary wing aircraft (helicopters) of the Army as well as fixed wing aircraft (jets) of the Air Force. In addition, since JP-8 is a turbine fuel, it should work well in the M-1 tank's turbine engine. Since JP-8 can be used in temperatures down to -40°F, JP-8 could be used in lieu of DF-2 to solve the cold weather start problem in Germany. Finally, since JP-8 is kerosene-based, it could be used as an alternate fuel for diesel engine driven equipment. Hence, JP-8 can be used as a single fuel for both aviation and ground assets on the battlefield.

Of course, it is not that simple because there are items of equipment which are gasoline powered which can not run off of JP-8. Notwithstanding, though, using JP-8 reduces the number of fuels needed from three to two and gives us the potential for achieving the ideal of having a single fuel on the battlefield. It was with this impetus that the Army and Air Force proceeded toward the goal of attaining a single fuel on the battlefield.

Teaming together, personnel from HQDA and Headquarters, Department of the Air Force (HQDAF) developed a briefing

proposing the single fuel concept and conversion to JP-8.[14] This briefing was presented to the service's logistics chiefs and, ultimately, the Joint Chiefs of Staff, J4 (JCS J4) and the combatant command J4s. As a consequence, the proposal was taken to each of the Commanders-in-Chief (CINC) for consideration and the concept was subsequently adopted by each. For reasons unique to each theater, EUCOM adopted JP-8 as the single fuel, CENTCOM adopted Jet A-1, SOUTHCOM adopted JP-5[15], and PACOM adopted JP-8 for portions of its theater. Since EUCOM was one of the first CINCs to approve the proposed conversion and the cold weather problem originated in Germany, EUCOM was the first theater scheduled for conversion.

Unfortunately, most of this occurred without significant participation by the armor community. This later caused some consternation because there were some in the armor community who felt that JP-8 was not the ideal solution for the cold weather start problem. Since there was no hard evidence to substantiate their misgivings, their concerns were overlooked. That is, their concerns were overlooked until it was determined that the M-1 tank could not generate smoke in its on-board Vehicle Engine Exhaust Smoke System (VEESS) when using JP-8. At first, even this was thought to be a minor problem by personnel in the petroleum community. However, to the armor community, this was a

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[14]Garrett, "JP-8 Conversion," 38.

[15]See Glossary.

problem of major proportion. The generation of smoke on the battlefield is a combat multiplier for armor units. It is a capability which armor units must have when engaging the enemy on the battlefield.[16] Because generation of smoke was taken so lightly by the petroleum community, the armor community was skeptical of using JP-8 in the M-1 tank for any reason. So, a major effort was initiated to prove to the armor community that JP-8 was a viable fuel and demonstrate the potential for using JP-8 as a single fuel on the battlefield, if the VEESS smoke generation problem could be solved.

In 1988, the Army Energy Office requested the Belvoir Research, Development, and Engineering Center (BRDEC) conduct a demonstration to confirm the useability of JP-8 for continuous operation in all diesel fuel consuming vehicles and equipment.[17] BRDEC initiated a JP-8 Demonstration Program at Fort Bliss, Texas in October 1988. During the demonstration, JP-8 was substituted for diesel fuel in the various vehicles and equipment operating on Fort Bliss. Over 2850 diesel fuel-consuming vehicles were converted and operated satisfactorily on JP-8. As a result of the two-year demonstration program, Fort Bliss was permanently

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[16]Francis M. Durel, Colonel, "Smoke/Obscurants Technology," Army Research, Development, and Acquisition Bulletin, January-February 1988, 1-3.

[17]W.E. Butler, Jr. and others, Field Demonstration of Aviation Turbine Fuel MIL-T-83133C, Grade JP-8 (NATO Code F-34) at Fort Bliss, Texas (Fort Belvoir: US Army Belvoir Research, Development, and Engineering Center, 1990), DTIC, AD A233441.

converted to JP-8.[18]

Although the demonstration program should have convinced skeptics that JP-8 could be used as a single fuel on the battlefield, there were still some nonbelievers. When various units were deployed to Saudi Arabia, there were some who still had misgivings about having to use JP-8 in ground equipment, especially in M-1 tanks. Plus, JP-8 was not available in Saudi Arabia. Jet A-1 was the proposed single fuel for the CENTCOM AOR and would be issued in lieu of JP-8. Petroleum personnel understood that Jet A-1 was the same fuel as JP-8, with the exception that JP-8 had three military additives included in it. However, non petroleum personnel were now even more resistant to change because they were preparing to go into battle using a fuel in which they were not confident. So, when units, which were introduced to Jet A-1 for the first time in Saudi Arabia, experienced problems such as filter clogging, these units insisted on having DF-2 for their tanks.

There were many concerns expressed to substantiate the need for using DF-2 in the M-1 tank and other ground weapons systems. Of course, there was the concern that Jet A-1 could not produce smoke, which was and remains a valid concern. Then, the fuel filters clogged rapidly. Some units were unaware that, since Jet A-1 is a cleaner burning fuel, it will loosen residue left from

[18]Ibid.

using DF-2. This residue will, of course, clog the fuel filters until the filters have been changed a couple of times. Also, there was a concern that Jet A-1 was not as safe as DF-2, because the flashpoint of Jet A-1 (100°F) is not as high as DF-2 (140°F). It is true that Jet A-1 has a lower flashpoint than DF-2, but is still a safe fuel. Further, there were incidents of vehicle fires whose causes were at first attributed to the use of Jet A-1.[19]

In response to the expressed concerns, the CENTCOM Army component (ARCENT) requested a team of experts to conduct an evaluation of the issues surrounding the use of Jet A-1 fuel.[20] The team was asked specifically to comment on whether or not ARCENT should insist on adhering to the single fuel concept. A team of personnel, including a representative from BRDEC, traveled to Saudi Arabia and visited various units in the theater. There was insufficient evidence to conclude that the fires resulted from the use of Jet A-1. However, the team recommended that, since DF-2 was available, a fuel of choice policy should be adopted.[21] This resulted in units which had previously used JP-8 using Jet

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[19]COMUSARCENT message, G4, dated 201900Z Nov 90, subject: Use of Jet A-1 During Operation Desert Shield.

[20]Ibid.

[21]BRDEC memorandum, STRBE-VF, dated 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 11534.

A-1 and those which desired DF-2 using DF-2. This essentially ended the Army's attempt to achieve a single fuel on this battlefield.

The Support (Doctrine)

In planning for petroleum support of a fighting force in an overseas theater, a petroleum logistics planner may view the theater as developed or undeveloped. In the developed theater, an existing petroleum distribution system is normally operating in support of the peacetime civilian economy and military forces.[22] Europe is an example of a developed theater. Bulk petroleum for US forces stationed in Germany is received at tanker (vessel) off-loading facilities in France. The fuel is introduced into the Donges-Metz Pipeline System and pumped across France to Germany where it is introduced into the Central Europe Pipeline System. The fuel is pumped to various petroleum storage facilities throughout Germany. From these storage facilities, the petroleum is either moved by rail or tank truck to US Army facilities, where it is distributed to Army units.

In an undeveloped theater, there is usually no existing petroleum distribution system. When a division deploys to a theater, it relies on its organic units for petroleum support. These units

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[22]Department of the Army Field Manual 10-67 w/C1, Petroleum Supply in Theaters of Operations (Washington, DC: Headquarters, Department of the Army, 1985), 2-5.

will normally have a fuel system supply point, consisting of a selected number of 10,000 gallon collapsible fabric tanks for storage, and petroleum tank vehicles for distributing the petroleum to using equipment. As more divisions arrive in the theater, a corps is formed. Petroleum support in a corps includes additional fuel system supply points augmented by 50,000 gallon collapsible fabric tanks for storage. Distribution from a corps to a division is accomplished through the use of 5,000 gallon tank trucks. As the theater matures and additional forces arrive in the theater, a theater army is formed. Additional petroleum assets such as a tactical petroleum terminal is installed which provides enough storage capacity to off-load oceangoing petroleum tankers (vessels). Distribution from the terminal overland is accomplished through the use of a hoseline or coupled pipeline as far forward as possible and tank trucks. Bulk petroleum is delivered to the theater by the Navy and pumped ashore through its off-shore petroleum discharge system to the Army's tactical petroleum terminal, if petroleum can not be obtained locally.[23]

This support presupposes that petroleum units are deployed in consonance with the requirement for support needed. That is, normally the logistical support is planned such that the units performing the support are deployed in sequence with the

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[23]Department of the Army Field Manual 10-1, Quartermaster Principles (Washington, DC: Headquarters, Department of the Army, 1991), 6-3.

personnel requiring the support. This is done mainly for the reason that combat units only carry a limited quantity of supplies for sustainment.

The Support (During the war)

In analyzing the data concerning Operation Desert Shield/Desert Storm, logistical units were not deployed in sequence with the combat units requiring the support. Because the Iraqi army had invaded Kuwait and set poised to continue their invasion into Saudi Arabia, the Commander in Chief, Central Command (CINCCENT) designated that combat units would be given priority in the deployment.[24] This was done primarily "to ensure the greatest amount of ground combat power was available as soon as possible."[25] As a consequence, the support structure for Operation Desert Shield/Desert Storm had to be developed as units were arriving in the theater. The support structure was developed under the direction of Major General (then) Pagonis, ARCENT G-4. As he relates in Moving Mountains, he arrived to find the initial elements of the 82nd Airborne Division had already arrived and were milling around in blazing (130°F) hot

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[24]Department of Defense, Conduct of the Persian Gulf War: Final report to Congress, April 1992, 3-2.

[25]Ibid.

sun.[26] Without hesitation, he started arranging for the movement of these troops to nearby military barracks. This initiated the first phase of his logistical support plan which was based on three phases--reception, onward movement, and sustainment.

> Reception--"reception of troops in-theater, during which they receive supplies and weapons that have been shipped from the home base;"
>
> Onward movement--"onward movement to a designated location to take up their defensive position;"
>
> Sustainment-- "sustainment of those troops for the duration of the mission."[27]

The second phase of his plan was accomplished through the use of buses to move the troops to their defensive positions and Bedouin-tents to provide shelter. Equipment was moved through the use of heavy equipment transport trucks.

The third phase of his plan was based on the concept of establishing a series of large logistics bases or logbases. When supplies were delivered to Saudi Arabia, they were originally stored in warehouses at the seaports. With the movement of troops to defensive positions, supplies were needed in forward locations. As a consequence, Logbase Bastogne was originally established. Logbase Bastogne was designed to provide supplies

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[26]William G. Pagonis, Lieutenant General with Jeffrey L. Cruikshank, Moving Mountains: Lessons in Leadership and Logistics from the Gulf War (Boston, Massachusetts: Harvard Business School Press, 1992), 85.

[27]Pagonis, Moving Mountains, 69.

such as food, water, and other material; ammunition; and fuel. Later, Logbase Alpha was established. As the theater matured with the arrival of additional personnel, additional logbases, Bravo and Delta, were established. When the VII Corps and XVIII Airborne Corps shifted to the west prior to the ground offensive, more logbases were established.

> "These designated logistics bases--Alpha, Bravo, Charlie, Delta, and Echo--were stocked with all classes of supply to support two corps: class I (food and water), class II (clothing), class III (fuel), class IV (barrier materials such as barbed wire and sandbags), class V (ammunition), class VII (major end items, such as M1A1 Abrams tanks and M2/3 Bradley fighting vehicles, to replace losses), class VIII (medical items), and class IX (repair parts)."[28]

During the ground offensive, logbases Golf, Oscar, and November were not fully established because of the rapid pace of the war and its short duration. In fact, Logbases Hotel and Romeo which were planned for Iraq were not established. Although the war was fast paced and of short duration, this logbase concept proved effective in providing needed supplies.

Looking specifically at petroleum, the 82nd Airborne Division was the first Army ground combat unit deployed to the theater. Organic to the division was a supply and service company which was responsible for providing its petroleum. Prior to the

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[28]William G. Pagonis, Lieutenant General, and Colonel Michael D. Krause, "Theater Logistics in the Gulf War," Army Logistician, July-August 1992, 2-8.

arrival of the division, the commander of the Defense Fuel Region, Mideast arranged with Saudi Arabian contractors to provide petroleum products to US forces. When the 82nd Airborne Division moved to its defensive position, fuel was delivered to its forward location by contractors. This practice continued until the logbases were established. However, units operating to the rear of the logbases continued to be supplied by the civilian contractors. Once the logbases were established with their Tactical Petroleum Terminals using 50,000 gallon collapsible fabric tanks, fuel was moved forward by Army tank trucks. In addition, a portion of the Southwest Asia Petroleum Distribution Operations Project pipeline set was used to provide additional overland distribution of petroleum from Logbase Bastogne to Logbase Alpha. Since the movement of supplies and equipment was done over long distances, various rest areas were established along the main supply route to provide food, water, fuel, and a rest for the drivers.

This support structure relied heavily on the use of 5,000 gallon tank trucks, provided by host nation support. As mentioned above, when combat units moved into their defensive positions, fuel was delivered by tank trucks. As logbases were established, fuel was brought in and off-loaded from tank trucks. In resupplying units from the logbases, fuel was primarily delivered by tank trucks. Because the pace of the ground offensive was so fast, fuel was supplied by tank trucks directly into using

vehicles. This was done, for example, in the case of the 82nd Airborne Division, because there was no time to install a fuel system supply point, receive fuel, issue fuel, and recover the equipment and still keep pace with the offensive.[29] Fuel was also supplied to convoys of vehicles using refuel on the move (ROM) equipment. Usually, positioned adjacent to a supply route, the ROM equipment was set up to provide a refueling point. The ROM equipment, used with a 5,000 gallon tank truck or another source, provides the capability to refuel 6 to 8 vehicles simultaneously.

Besides the above, the Army supplied petroleum to the other Services. The Army constructed and operated pipelines from Ras Tanura refinery to King Fahd airport in support of the Air Force and to Al Jubayl in support of the Marine Corps. The US received Jet A-1, diesel fuel and automotive gasoline from this refinery. JP-5 was not available in Saudi Arabia, but the Navy required JP-5 for its carrier operations. Afloat Prepositioning Ships delivered the initial supply of JP-5. DFSC arranged for follow-on supply of JP-5 to be brought into the theater by oceangoing tankers. In total, the US used twenty-seven tankers to deliver over six million tons of petroleum products to the theater.[30]

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[29]Interview with personnel in the Army Energy Office, Headquarters, Department of the Army conducted 22 October 1992 in the Pentagon.

[30]Briefing conducted by the Military Sealift Command personnel on 30 March 1993 at the Military Ocean Terminal, Bayonne.

In essence, this was the petroleum support structure developed to support the war. Although it was not structured exactly as depicted in Army doctrine, it was effective in providing the needed support. The Army supplied 19 million gallons of petroleum products a day during the war.[31] This feat was made possible by the support obtained from Saudi Arabia. If Saudi Arabia had not supplied the petroleum products and tank trucks, the Army could not have provided the quantities of fuel used.

The Single Fuel

In thinking about the number of tank trucks used to deliver 19 million gallons of petroleum products per day, it must be remembered that this quantity does not represent just one fuel. During Operation Desert Shield/Desert Storm, there were five different fuels supplied to the coalition forces--Jet A-1, JP-4, JP-5, DF-2, and automotive gasoline. Because each is unique and has specific characteristics, these products must be segregated. This means that the trucks used to deliver these products must continuously carry the designated product or the trucks have to be cleaned between the conversion from one product to another. Of course, storage systems must also be segregated. So, fabric tanks used to store diesel fuel, for example, must remain designated for diesel fuel storage. As a consequence, this increases the burden placed on the Army petroleum personnel in

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[31]Department of Defense, Conduct of the Persian Gulf War, F-2.

maintaining these fuels in separate systems.

Moreover, the requirement to provide these separate fuels meant that units had to maintain an account of how much of each product was on hand and how much storage capacity was available to receive additional fuel. This was essential for ensuring units had sufficient quantities of the right fuel to conduct operations.

Further, the requirement to provide different fuels restricts flexibility. As a matter of procedure, tank trucks are filled as soon as possible after emptying or at the end of the day. As mentioned above, tank trucks are continuously used to deliver the same product. So, as unit fuel status reports are received at the division or corps support command, the petroleum officer can arrange delivery of fuel to the particular unit that needs it. If a unit has a requirement for diesel fuel, the petroleum officer will arrange for the closest petroleum unit to provide the fuel. However, if the only tank trucks available are loaded with JP-4, then these tank trucks can not be used. The petroleum officer will then have to coordinate delivery from another source. On the other hand, if a single fuel is used to satisfy both aviation and ground fuel requirements, the petroleum officer would have no problem filling the requirement of the combat unit.

This is indeed one of the major advantages to the Army for

conversion to a single fuel on the battlefield. By using a single fuel on the battlefield concept, most tank trucks would receive and issue the single fuel. The full capacity of the fuel system supply point could be used to store a single fuel rather than be divided to store two fuels. The need to clean tank trucks between conversion from one product to another would be virtually eliminated.

Another aspect of using a single fuel on the battlefield is that the same fuel can be supplied to helicopters or tanks. During Operation Desert Shield/Desert Storm, aviation units were briefed daily on the areas over which they were to fly and were told where refueling points would be set up. Because of the pace of the war, these refueling points were sometimes not where they were supposed to be. One day, while flying a mission, a pilot ran low on fuel. He flew to the designated refueling point, but the unit was not there. In trying to return to the rear, he spotted a convoy refueling beside a road, so he landed next to them. Because the refueling point had Jet A-1 on hand, he was able to refuel and continue flying.[32] Having a single fuel on the battlefield makes this scenario possible.

When HQDA was considering the conversion from JP-4 to JP-8 as proposed by HQDAF, there were a number of advantages found. In

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[32]Informal discussion held with an ICAF student who participated in Operation Desert Shield/Desert Storm on 5 February 1993.

addition to the advantages already mentioned such as safer fuel, elimination of cold weather start problems in the M1 tank, and flexibility, these advantages included:[33]

Conversion from JP-4 to JP-8

- o improved crash survivability.
- o achievement of standardization with NATO member nations.
- o promotion of NATO interoperability.
- o 3-5% increase in aircraft range.

Conversion from DF-2 to JP-8

- o simplify battlefield logistics.
- o enhance interoperability.
- o improve engine maintenance since JP-8 is a cleaner burning fuel.

There were disadvantages to conversion, not the least of which was the smoke generation issue. Also enumerated as disadvantages were:

- o higher acquisition cost for JP-8 versus JP-4.
- o product availability.
- o potential power loss.[34]

Briefly, product availability was a concern because JP-8 is made from a smaller portion of feed stocks during the crude petroleum refining process. Commercial jet fuel and JP-5 are also made from these same feed stocks. So, there is an increased and competing demand for these feed stocks if industry makes JP-8 to supply the military. There was no competing demand when the military used JP-4 because the JP-4 production was based on a different portion of crude petroleum feed stocks.

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[33]Garrett, "JP-8 Conversion," 37.

[34]Ibid.

The problem concerning potential power loss was determined during laboratory engine tests conducted by BRDEC. The finding was that there was a potential for a 10% power loss in the engines powering the Army's high mobility multipurpose wheel vehicle (HMMWV) and common unit cargo vehicle (CUCV).

The advantages, though, of conversion to JP-8 appeared to far outweigh the disadvantages. Therefore, HQDA concurred with the proposal to convert from JP-4 to JP-8 and further supported the use of JP-8 in lieu of DF-2 in overseas theaters. The Army also participated in the formulation of a DOD policy to adopt a single fuel on the battlefield by year 2010.[35]

The outcome of Operation Desert Shield/Desert Storm has vindicated the Army's and DOD's decisions in 1988 to pursue a single fuel on the battlefield. First, a fuel, Jet A-1, which could have been used as a single fuel for aviation and ground compression engine equipment, was available. Those units which had used JP-8 in both aviation and ground equipment prior to Operation Desert Shield/Desert Storm experienced little or no difficulty in using Jet A-1 during the war. Using Jet A-1 for both aviation and ground vehicles allowed aviation and ground combat units to refuel from the same refueling point. Units which used Jet A-1 for both aviation and ground equipment simplified their logistical support system because they combined

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[35]Ibid.

their jet fuel and diesel fuel requirements into a common fuel requirement.

Surprisingly, one of the major reasons for resistance to converting to Jet A-1, besides the smoke issue, appears to have been the education of the users. For years, the Army has taught its personnel that they must be especially careful when refueling equipment and vehicles to ensure that the correct fuel is put into the vehicles. Gasoline can not be put in a vehicle which uses diesel fuel. Neither gasoline nor diesel fuel can be put into helicopters. Failure to adhere to these strictures could result in dire consequences such as explosion, fire, and death. Now, personnel are told Jet A-1 can be used in both helicopters and tanks. Also, stories were passed that, in order to use Jet A-1 in ground equipment, some type of oil had to be added to it. It did not help that, when units originally switched to Jet A-1, fuel filters clogged rapidly, causing an increase in replacements. All of these factors contributed to a reluctance to convert.[36] It is also understandable that combat units must be confident in their equipment. If switching to an unknown fuel reduces their confidence, then by all means, they should be given the fuel of their choice, if it is available. Since both Jet A-1 and diesel fuel were available in Operation Desert Shield/Desert Storm, the correct decision was made to give units the option of

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[36]BRDEC memorandum, subject: Trip Report. . .

choosing which fuel they would use.

A Viable Option

The question, though, is a single fuel on the battlefield still a viable option? Yes, it is. It was proven in Operation Desert Shield/Desert Storm as well as in the JP-8 demonstration at Fort Bliss that ground equipment can be operated using JP-8/Jet A-1 without significant problems. Using Jet A-1 in Operation Desert Shield/Desert Storm added flexibility for petroleum support in that helicopters could be refueled at the same sites as tanks and trucks. Units using Jet A-1 appeared to have less maintenance problems.

There were two problems which existed prior to Operation Desert Shield/Desert Storm and still exist today. One is the fact that persistent smoke can not be produced in the M-1 tank VEESS when using JP-8/Jet A-1. This did not prove significant in Operation Desert Shield/Desert Storm because of the temperatures in the region. Because of the high temperatures, smoke generation would not have been effective. However, since smoke generation is a significant issue with the armor community, a solution must be found.

The second problem involves gasoline engine driven equipment. Although JP-8 and Jet A-1 can be used in compression engine or diesel engine driven equipment, it can not be used in gasoline

engine powered equipment. As long as this type of equipment is needed on the battlefield, automotive gasoline will be needed. There is an ongoing vehicle/equipment modernization program in which gasoline engine powered equipment is being replaced by diesel engine driven equipment. For example, 3 kilowatt and 5 kilowatt generators which have been gasoline consuming equipment are being replaced by generators powered by diesel engines. As this modernization program continues, the requirement for automotive gasoline on the battlefield will be greatly reduced.

Since the conclusion of Operation Desert Shield/Desert Storm, additional Army posts have requested conversion to JP-8. Fort Hood has already converted and Fort Stewart has requested conversion. With increased use of JP-8 during peacetime, there will be an increase in confidence in using JP-8.

Therefore, a single fuel on the battlefield is indeed a viable option and one which DOD should continue to seek.

GLOSSARY

Jet Fuel--Jet fuels are used in aircraft turbine engines, ramjet engines, and rocket engines and other turbine powered equipment. These fuels are derived from petroleum as are gasolines. Jet fuels cannot be used in reciprocating type (piston-type) aircraft engines. (MIL-HDBK-201B)

Jet A-1 - is the standard fuel used by all commercial airline companies worldwide, except within the US where Jet A is principally used. Jet A-1 differs from Jet A only in its lower freeze point requirement.

JP-4 - is an aviation turbine fuel made from a 40:60, 50:50, or 60:40 mixture of kerosene with gasoline-type blending stock. It is called a "wide-cut fuel." It is not usually considered as an acceptable substitute for diesel-fueled equipment.

JP-5 - is a kerosene-type aviation turbine fuel. It has a high flashpoint specification of 140°F (minimum). This fuel is used for all sea-based aircraft because of a safety requirement for on-board aircraft carrier operation.

JP-8 - is a kerosene-type aviation turbine fuel. JP-8 is essentially Jet A-1 with the addition of three military additives. It has a 100°F (minimum) flashpoint specification.

Diesel Fuel--Diesel fuels are used in compression ignition engines in which air enters the engine at atmospheric pressure or is forced in under higher pressures by a pump or blower. In a diesel engine, fuel is injected into a combustion space through an injection nozzle which breaks up the fuel into a fine spray and fuel vapor which is ignited by the heat of the air in the cylinder. The air obtains its heat as a result of being compressed by the piston. Diesel fuels are used to operate compression engines in submarines, destroyer escorts, landing craft, auxiliary equipment aboard larger craft as well as buses, heavy trucks, tractors, railroad diesel locomotives, stationary plants, and in other auxiliary units. (MIL-HDBK-201B)

DF-A--is intended for use in high speed automotive type diesel engines and in pot type burner space heaters, in areas in which the ambient temperatures lower than minus 25°F occur.

DF-1--is intended for use in high speed automotive service in areas in which ambient temperatures as low as minus 25°F.

DF-2--is intended for use in all automotive high speed engines in areas in which ambient temperatures are above 0°F.

DF-A and some DF-1 fuels are essentially kerosene, which are very similar to JP-8. (BRDEC, JP-8)

Automotive gasoline (MOGAS)--Gasolines are used to fuel spark ignition internal combustion engines which power motor vehicles, combat vehicles, portable auxiliary power plants, and stationary units. (MIL-HDBK-201B)

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