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SINGLE FUEL CONCEPT FOR CROATIAN ARMY GROUND VEHICLES

ABSTRACT

During the process of approaching the European associations and NATO the Republic of Croatia has accepted the single fuel concept for all ground vehicles of the Croatian Army. Croatia has also undertaken to insure that all aircraft, motor vehicles and equipment with turbo-engines or with pressurized fuel injection, for participation in NATO and PfP led operations can operate using the kerosene-based aviation fuel (NATO F-34). The paper gives a brief overview and the results of the carried out activities in the Armed Forces of the Republic of Croatia, the expected behaviour of the motor vehicle and possible delays caused by the use of kerosene fuel (NATO F-34) as fuel for motor vehicles. The paper also gives the advantages and the drawbacks of the single fuel concept. By acquiring new data in the Croatian Armed Forces and experience exchange with other nations about the method of using fuel F-34, the development of the technologies of engine manufacturing and its vital parts or by introducing new standards in the production of fuels and additives new knowledge will certainly be acquired for providing logistics support in the area of operations, and its final implementation will be a big step forward for the Republic of Croatia towards Europe and NATO.

KEY WORDS

military motor vehicles, transport means, implementation, kerosene, gasoline, diesel fuel

1. INTRODUCTION

The idea of using a single military fuel on land originated after the Second World War with the aim of simplifying the logistics supply chain of oil products. NATO ground forces reoriented to kerosene fuel F-34 in the mid-1960s, and the step towards single military fuel was made in the 1970s when NATO air forces agreed to substitute kerosene fuel F-40 with a safer, less flammable kerosene fuel F-34. The use of kerosene fuel F-34 is based on civil aircraft fuel JET A-1, which is identical to kerosene fuel F-35 and which is available worldwide.

During 1988 NATO countries agreed to accept the single fuel concept as a long-term objective. The concept of a single fuel refers to the possibility of using kerosene fuel F-34 for ground vehicles and equipment used by NATO forces and for the ground-based military aircraft. It does not refer to maritime operations nor to the high-density fuels for special purposes.

Technical considerations related to the implementation of the single fuel concept encompassed three different types of fuel in NATO:

- gasoline, NATO F-57,
- different types of kerosene, NATO F-40, F-44, F-35 and F-34,
- diesel fuel, NATO F-54

Gasoline fuels intended for the operation of Otto engines are extremely volatile types of fuel, represent high risk of combustion and are not suitable for use in diesel engines or gas turbines. NATO F-57.

Kerosene fuels –of several types:

F-40 wide cut type – wide fraction (blend of gasoline and oil with kerosene),

F-44 special fuel, with high flash point – used primarily for aircraft on aircraft carriers, and produced only in several refineries worldwide and with a limited purchase,

F-35 kerosene fuel is identical to fuel in use in commercial aviation, A-1,

F-34 fuel for military aircraft turbines based on fuel F-35. The process of conversion of fuel F-35 into F-34 consists of mixing of fuel F-35 with corrosion inhibitor (lubricity improver), fuel system icing inhibitor FSII, and static-dissipator additive SDA. Apart from these three basic additives usually also the stability additive TSA is added.

All the four basic types of kerosene fuels can be used in motor gas turbines with slight modifications of equipment, but only F-44, F-35 and F-34 are suitable to be used in diesel engines. They are characterized by low pour point and good thermal stability. It is estimated that about 80% of kerosene on land is spent for aircraft requirements.

Diesel fuels are used for compression ignition engines (ignition of fuel and air mixture under pressure). Diesel fuels have high caloric value, but relatively poor operability at low temperatures and poor stability factors, and higher potential for microbiological contamination. Their combustion properties are determined by cetane number which gives the assessment of their ignition value. NATO F-54.

2. PRIMARY TASK OF SINGLE FUEL CONCEPT

The primary task of this concept is to simplify the ground fuel logistics for NATO forces involved in land and air operations, so that:

- single fuel, based on kerosene fuel of aircraft turbine, is purchased for land operations;
- fuel is specified, distributed, and used in all NATO countries;
- fuel is received, stored, transported and distributed by NATO system channels.

The top importance remains that the quality of fuel F-34 or F-35 in aviation traffic is not at risk in any way. Furthermore, there should be no changes in the quality control procedures for distribution of F-34 or F-35 to the point of fuel consumption on land.

The introduction of this concept has been planned in three phases:

Phase 1: Substitution of fuel F-40 by fuel F-34 and F-35 in aircraft, land-based in NATO European countries.

Phase 2: Substitution of diesel fuel F-54 by F-34 and F-35 in ground vehicles and equipment with diesel engines or in aircraft with gas turbines, based on land.

Phase 3: Elimination of gasoline for military use.

3. ADVANTAGES AND DRAWBACKS OF THE SINGLE FUEL CONCEPT

The acceptance of kerosene fuel of aircraft turbines as single fuel concept provides technical, logistics, operative and economic advantages in the NATO led operations.

3.1 Technical advantages:

- The basic properties of JET A-1 civil aircraft kerosene fuel are identical to the properties of the fuels F-35 and F-34.
- It is less prone to micro-biological pollution and allows improved stability of storage compared to diesel fuel.
- Purchase/supply of fuel JET A-1, F-35 is possible in the entire world and can be easily converted into fuel F-34 by adding the earlier mentioned additives.
- Fuel F-34 in comparison with fuel F-35 provides better protection against water freezing at low temperatures with addition of stronger microbiologic protection and lubricity. It is also easy to purchase within the military supply system.
- The ignition risk is reduced by elimination of highly unstable gasoline and fuel F-40.

3.2 Logistic advantages:

- Managing only one product.
- Universal product reduces the problems of supply.
- Simpler logistics purchase chain and accompanying infrastructure.

3.3 Operative advantages:

- Improved operability at low temperatures, pour point of fuels F-34 and F-35 is significantly lower (better than -47^0 C) than in diesel fuel.
- Substitution by only one type of fuel (with adequate additives).
- Risk of intercontamination, i. e. fuel contamination is reduced.
- It has significant impact on land sustainability – by improving interoperability of equipment and giving greater flexibility in developing combat formation.
- Possible reduction in maintenance requirements.
- It allows fast re-grouping of forces.

3.4 Economic advantages:

- Reduction of infrastructure costs, using means for a single product only, and for the same storage vol-

umes there is a reduction in the requirements for segregation and cleaning.
- Reduction in transport and distribution costs.

3.5 Environmental protection advantages:

- Fuel F-34 is cleaner fuel which generates reduced emission of exhaust gases, mainly in older diesel engines.
- Elimination of gasoline reduces the inconsistent emissions into the atmosphere eliminating thus the need for expensive fuel vapour return systems.

3.6 Drawbacks of single fuel concept:

- Greater use of single fuel concept – kerosene may increase the demand for fuel F-34.
- There is minor power loss in certain vehicles.
- Minor modifications in vehicles and equipment and/or use of additives will be required in some cases.
- In some countries, kerosene for road use may attract additional taxes thus limiting the single fuel concept during peace-time operations.

4. EXPERIENCES OF CROATIAN ARMED FORCES IN USING FUEL F-34

The first serious testing of fuel F-34 was carried out in 2004. The testing programme planned to test two typical military heavy-duty – off-road motor vehicles in the Croatian Armed Forces, TAM 150 T11 and Torpedo TK 130. The testing was done with fuel F-34 delivered by "INA" d. d. Oil Industry, Zagreb and Oil Refinery Rijeka. The testing was carried out without adding any additional additives or oils.

The testing was carried out in the period from March to June 2004 on heavy-duty – off-road motor vehicles TAM 150 T11 and Torpedo TK 130. The reference vehicles that used diesel fuel were heavy-duty – off-road vehicles of the same make and type. The testing was carried out under the testing site conditions on the runway of the Aeronautical Technical Institute (Zrakoplovno–tehnički zavod), Velika Gorica and on the relation Remontni zavod (Jankomir) – Lučko – Vrbovec – Bjelovar – Virovitica, using Ivanja Reka – Kutina highway. The testing included travelling 10,000 km.

According to the Testing Plan and Programme, the properties of vehicles and engine were monitored by taking respective samples, measuring and recording the exploitation characteristics at the beginning, during (after having travelled 5,000km) and at the end of testing. The recording, measuring and processing of the results and samples was done by an expert team for the operative execution of testing with the assistance of the employees of the Remontni zavod. Oil samples were tested and processed at the Faculty of Mechanical Engineering and Naval Architecture in Zagreb and "INA - Maziva", Rijeka. The analysis of exhaust gases was done at the Vehicle Centre of Croatia (Centar za vozila Hrvatske) in Velika Gorica.

The recording of the status of individual vital engine assemblies and the measured vehicle characteristics during the testing programme of fuel F-34 have given the following results:
- The properties of all high-pressure pumps were checked on the test table. The analysis showed that no either favourable or unfavourable influences of fuel F-34 on the operation of the high-pressure pump were observed, comparing these to the high-pressure pumps operating with diesel fuel, which

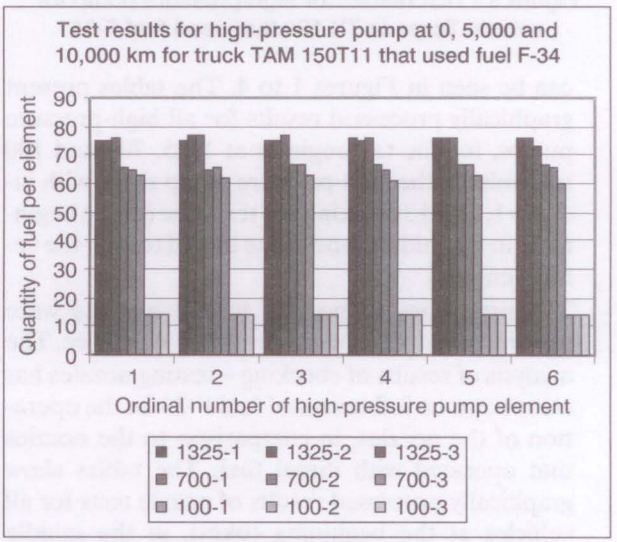

Figure 1 - Test results for high-pressure pump for vehicle TAM 150 T11 that used fuel F-34

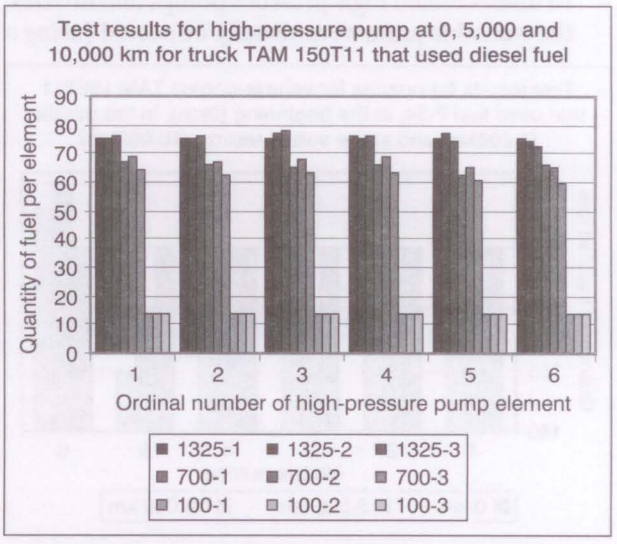

Figure 2 - Test results for high-pressure pump for vehicle TAM 150 T11 that used diesel fuel

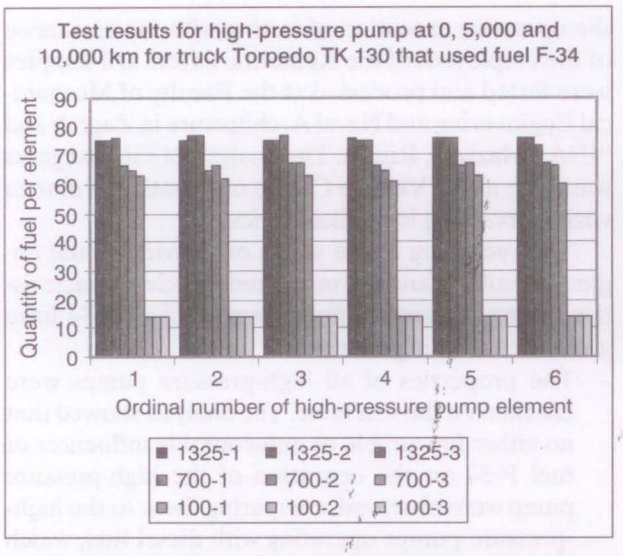

Figure 3 - Test results for high-pressure pump for vehicle Torpedo TK 130 that used fuel F-34

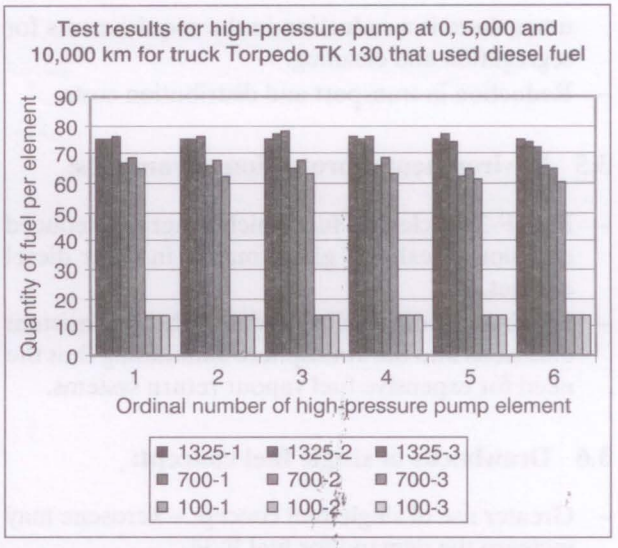

Figure 4 - Test results for high-pressure pump for vehicle Torpedo TK 130 that used diesel fuel

can be seen in Figures 1 to 4. The tables present graphically processed results for all high-pressure pumps, for the test regimes at 1325, 700 and 100 rev. /min. of the high-pressure pump shaft, with indexes 1, 2 and 3 marking the test time (at the beginning, in the middle, and at the end of testing the vehicle engine).

- The properties of nozzles for all engines were checked – tested, using a nozzle testing device. The analysis of results of checking – testing nozzles has also shown no influences of fuel F-34 on the operation of the nozzles, in comparison to the nozzles that operated with diesel fuel. The tables show graphically processed results of nozzle tests for all vehicles at the beginning (0km), in the middle (5,000km) and at the end of testing (10,000km) (Figures 5 to 8).
- In disassembled high-pressure pumps and nozzles, the wearable parts were visually inspected (using a magnifying glass), which are interconnected, causing friction and are lubricated by fuel. It was found that there is no excessive wear of the sliding surfaces on the worn parts of the high-pressure pumps and nozzles on engines that used fuel F-34, in relation to engines that used diesel fuel.
- The compression spaces of the engine were visually inspected and measured. The inspection was carried out on three cylinders of each engine. The comparison of the results did not determine any unfavourable influence of fuel F-34 on the condition of the compression areas of the engines that used fuel F-34, compared to vehicle engines that used diesel fuel.
- The compression and sealing (leaking) in the engine cylinders were checked. Even during this test no unfavourable influence of fuel F-34 on the checked engine characteristics was determined. Their improvement in all engines was determined,

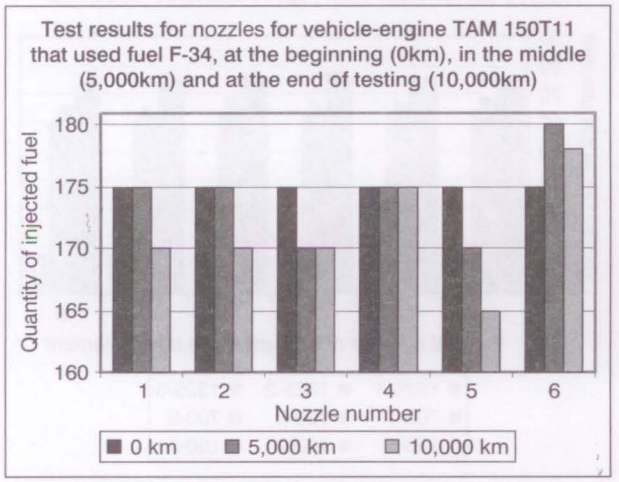

Figure 5 - Graph presenting test results for vehicle TAM 150 T11 that used fuel F-34

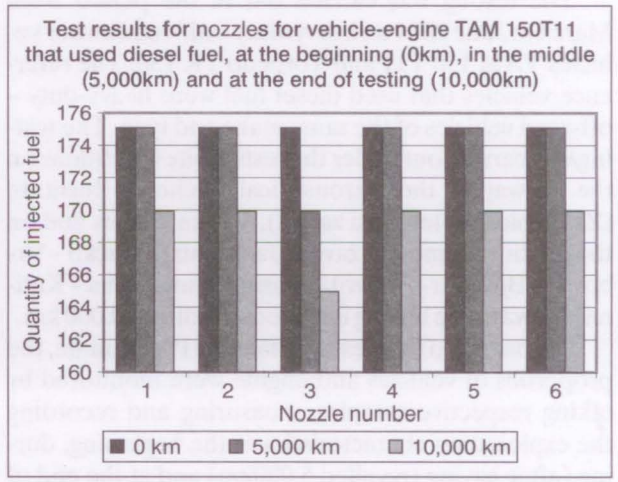

Figure 6 - Graph presenting test results for vehicle TAM 150 T11 that used diesel fuel

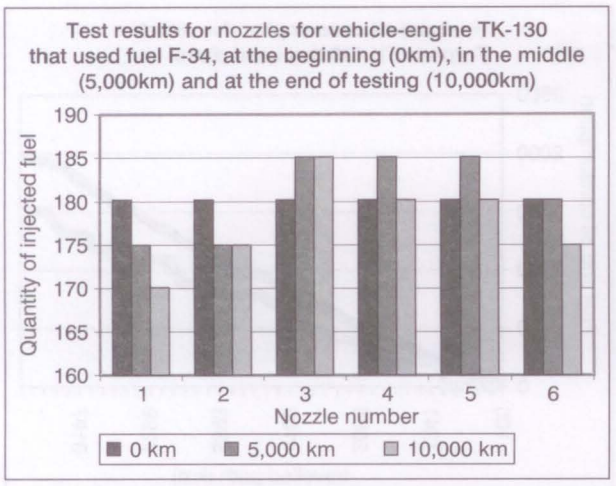

Figure 7 - Graph presenting test results for vehicle Torpedo TK-130 that used fuel F-34

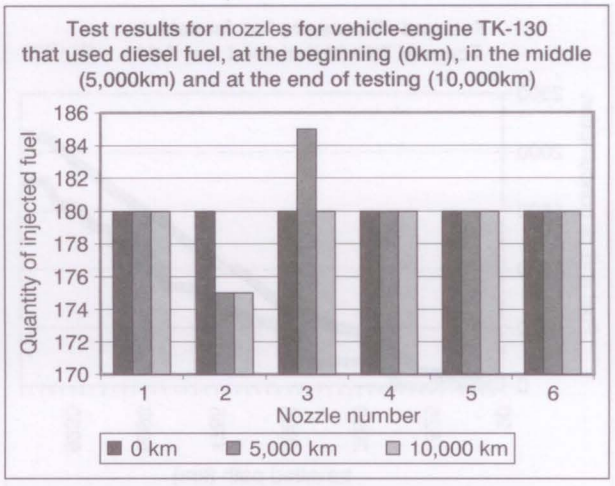

Figure 8 - Graph presenting test results for vehicle Torpedo TK-130 that used diesel fuel

which is most likely caused by better dosjedanje of elements regarding engine running-in.

- The condition of compression areas and engine cylinders that have not been disassembled was controlled endoscopically. No unfavourable influence of fuel F-34 on the condition of engine compression areas was determined in relation to the engines that used diesel fuel.
- During test-site and on-travel testing an increase in fuel consumption and increase in impurities in rough filters (pre-filter for fuel in the cup) was observed in vehicles that used fuel F-34.
- During testing the oil quality control in all engines was carried out, and no unfavourable influence of fuel F-34 on the determined – measured parameters was observed. Figures 9 – 12 show the consumption of fuel and oil during testing for vehicles that used fuel F-34 and the vehicles that used diesel fuel.
- The analysis of exhaust gases has shown that engines of the same type that used fuel F-34 have less blackening in relation to the engines with diesel fuel, i. e. they have cleaner combustion. At the same time, suction engines on vehicles TAM 150 T11 had a cleaner combustion than turbo-fed engines on vehicles Torpedo TK-130.
- By checking the speed characteristics it is obvious that vehicles that use fuel F-34 need more time and longer path to reach the given speed, and also need more time to develop the power necessary to overcome the drag of motion. Figures 13 and 14 show graphically the testing of speed characteristics of vehicles that used fuel F-34 and vehicles that used diesel fuel.

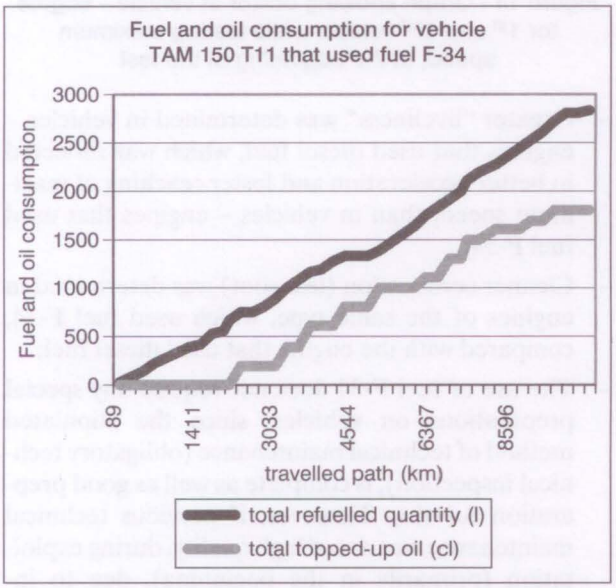

Figure 9 - Fuel and oil consumption for vehicle TAM 150 T11 that used fuel F-34

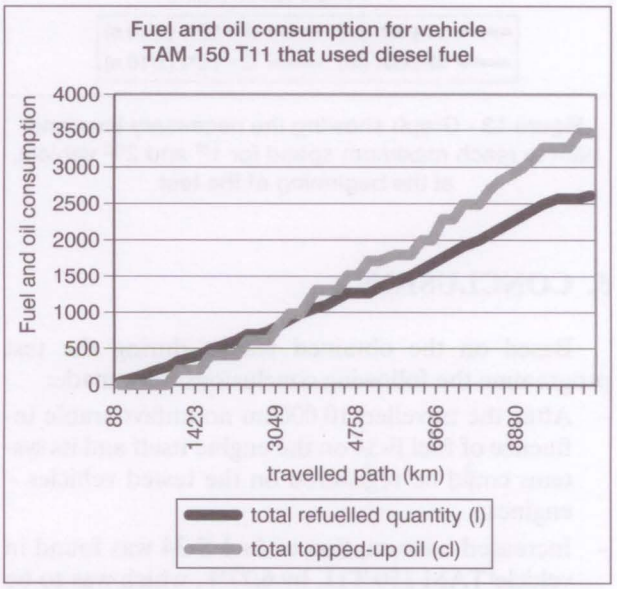

Figure 10 - Fuel and oil consumption for vehicle TAM 150 T11 that used diesel fuel

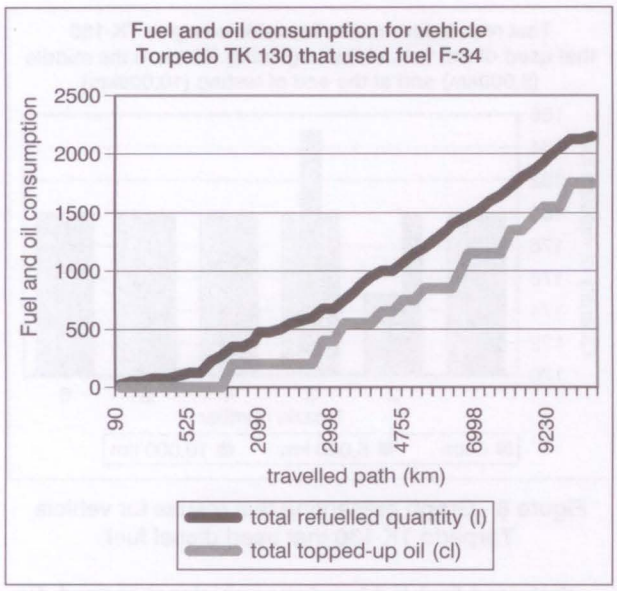

Figure 11 - Fuel and oil consumption for vehicle Torpedo TK 130 that used fuel F-34

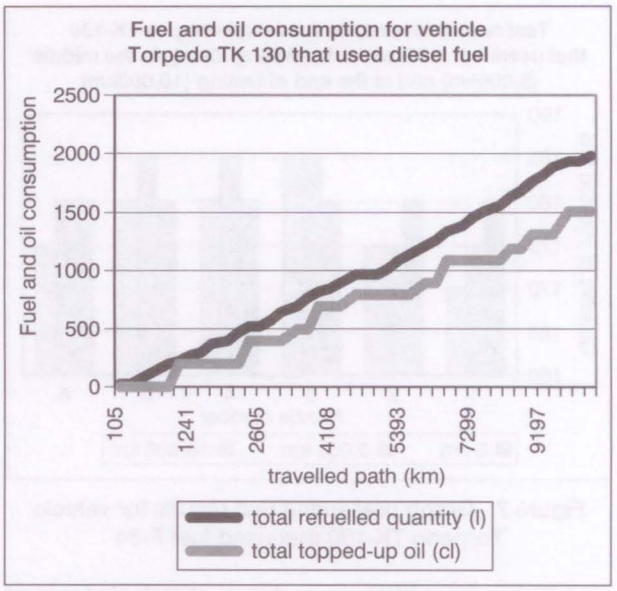

Figure 12 - Fuel and oil consumption for vehicle Torpedo TK 130 that used diesel fuel

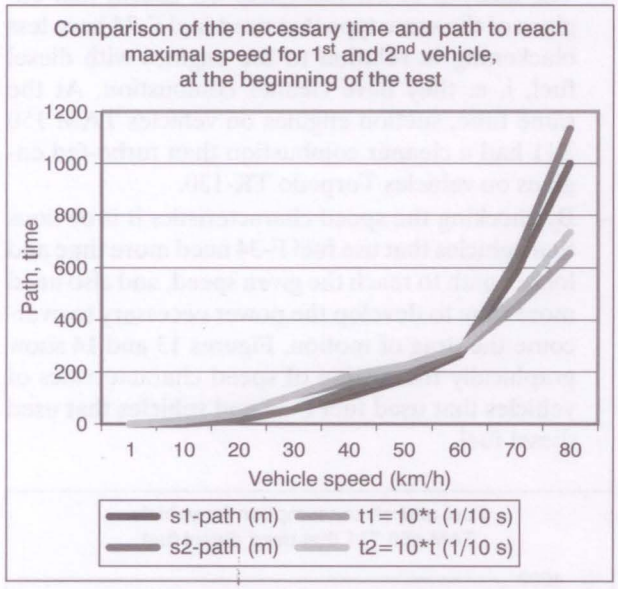

Figure 13 - Graph showing the necessary time and path to reach maximum speed for 1st and 2nd vehicle, at the beginning of the test

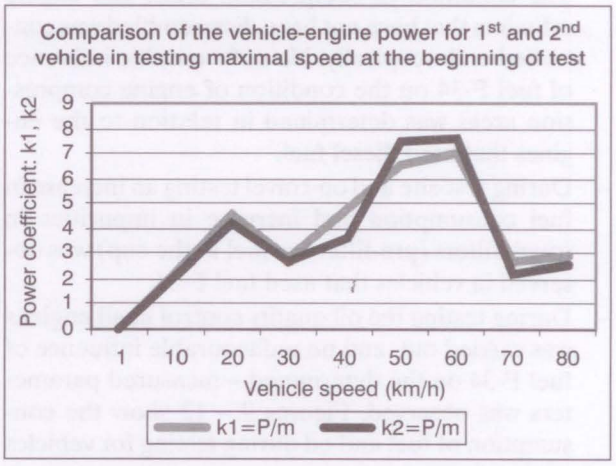

Figure 14 - Graph showing power of vehicle – engine for 1st and 2nd vehicle while testing maximum speed, at the beginning of the test

5. CONCLUSION

Based on the obtained results during the test programme the following conclusions were made:

- After the travelled 10,000km no unfavourable influence of fuel F-34 on the engine itself and its systems could be registered on the tested vehicles – engines;
- Increased consumption of fuel F-34 was found in vehicle TAM 150 T11, by 6.77%, which was to be expected, since fuel F-34 has lower energy value in relation to diesel fuel;
- Greater "liveliness" was determined in vehicles – engines that used diesel fuel, which was reflected in better acceleration and faster reaching of maximum speed, than in vehicles – engines that used fuel F-34;
- Cleaner combustion (less soot) was determined in engines of the same type, which used fuel F-34, compared with the engine that used diesel fuel;
- The use of fuel F-34 does not require any special preparations on vehicles, since the stipulated method of technical maintenance (obligatory technical inspection), is complete as well as good preparation for this. However, if previous technical maintenance was not of high quality, during exploitation (primarily in the beginning), due to increased capability of fuel F-34 to "solve the impurities", the cleaning of the fuel supply system may oc-

cur and the impurities may get carried from the tank towards the engine. The problem is solved by filters which can be easily cleaned and if necessary, replaced. Therefore, it is good to wash out the tanks – reservoirs on vehicles before conversion to using fuel F-34;

- In conditions of conversion from diesel fuel to fuel F-34, the military motor vehicles with diesel engines and classical devices for fuel injection can reliably use fuel F-34 without any consequences regarding their proper operation.

By acquiring new knowledge at the Croatian Armed Forces and through experience exchange with other nations about the method of using fuel F-34, through development of the production technology of engines and their vital parts or by introducing new standards in the manufacture of fuels and additives there will certainly come to new knowledge regarding provision of logistics support in the area of operations, and their final implementation will also be a great step of the Republic of Croatia towards Europe and NATO.

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SAŽETAK

KONCEPT UPORABE JEDNOG GORIVA ZA KOPNENA VOZILA HV

Republika Hrvatska je tijekom procesa približavanja europskim asocijacijama i NATO savezu prihvatila koncept korištenja jednog goriva za sva kopnena vozila hrvatske vojske. Također se obvezala osigurati da svi zrakoplovi, motorna vozila i oprema s turbo punjenim motorima ili s ubrizgavanjem goriva pod tlakom, predviđena za sudjelovanje u NATO i PfP vođenim operacijama mogu djelovati uporabom goriva temeljenog na kerozinskom zrakoplovnom gorivu (NATO oznaka F-34). U radu je prikazan kratak pregled i rezultati provedenih aktivnosti u Oružanim snagama Republike Hrvatske, očekivano ponašanje motornog vozila i mogućim zastojima uzrokovanim uporabom kerozinskog goriva (NATO oznaka F-34) kao pogonskog goriva za motorna vozila. Također su navedeni prednosti i nedostatci koncepta uporabe jednog goriva. Stjecanjem novih spoznaja u OS RH i razmjenom iskustava s drugim nacijama o načinu uporabe goriva F-34, razvojem tehnologija izrade motora i njegovih vitalnih dijelova ili uvođenjem novih standarda pri proizvodnji pogonskih goriva i aditiva sigurno će se doći do novih spoznaja za pružanje logističke potpore u području operacija, a i njegova konačna implementacija biti će veliki iskorak Republike Hrvatske prema Europi i NATO-u.

KLJUČNE RIJEČI

vojna motorna vozila, prijevozna sredstva, implementacija, kerozin, benzin, dizelsko gorivo

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