Report Documentation Page			*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
13 OCT 2010	**N/A**	**-**

4. TITLE AND SUBTITLE **Evalustion of Alternative Technologies to Measure Fuel Density**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) **Joel Schmitigal; James Mainero**	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000, USA**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) **US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000, USA**	10. SPONSOR/MONITOR’S ACRONYM(S) **TACOM/TARDEC/RDECOM**
	11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

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13. SUPPLEMENTARY NOTES

The original document contains color images.

14. ABSTRACT

The object of this effort was to evaluate portable technologies for measuring fuel density that can be utilized as an alternative to instrumentation reqired by ASTM D 1298.

15. SUBJECT TERMS

Density, API gravity, Fuel, JP-8, Diesel

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
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-Technical Report-

Evaluation of Alternative Technologies to Measure Fuel Density

Joel Schmitigal
James Mainero

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October 2010

U.S. Army Tank Automotive Research, Development, and Engineering Center
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James Mainero
Force Projection Technology

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Contents

List of Figures

List of Tables

1. **Introduction**

Density generally increases with increasing molecular weight of the hydrocarbon molecules of fuel and therefore increases with the increasing number of carbons found in the compounds composing the fuel. The density of fuel, being a bulk property of a complex mixture, is the volume average of the densities of all the components that make up the fuel. Kerosene-type jet fuels are composed of a complex mixture of molecules with carbon number distributions between about 8 to 16 carbons while diesel fuels are composed of molecules with carbon distributions of between 10 and 22 carbon atoms each. Because density, commonly expressed as API gravity, changes with temperature, it is standard practice to convert the measurements to a standard temperature of 15°C or 60°F to be able to perform comparisons of the data.

FM 10-67-1 (1), Concepts and Equipment of Petroleum Operations, Appendix I describes a procedure for classifying fuel type by measuring the density of the fuel. Figure I-1 from FM 10-67-1 provides a graph of typical API gravity ranges for determining fuel type. The fuel densities summarized in Table 1 has been developed from Figure I-1 from FM 10-67-1 and specifications for fuels utilized by the Army. However, the overlap in the acceptable values for the densities of Diesel and Jet fuels prevents density from being the sole determining factor for fuel type identification.

	Density kg/L at 15 °C	API Gravity at 60 °F
Diesel 2[1]	.8156 - .8762	30-42
JP-8[2]	0.775 - 0.840	37-51
JP-5[3]	0.788 - 0.845	36-48
Jet A and A1[4]	0.775 – 0-840	37-51

Table 1. Density and API gravity fuel classification limits.

Note: [1] Diesel 2 limit derived from FM 10-67-1, [2] JP-8 limit from MIL-DTL-83133E, [3] JP-5 limit from MIL-DTL-5624U, [4] Jet A and A1 limit from ASTM D 1655 – 06

In an effort to identify portable instrumentation with the ability to enhance performance or reduce lifecycle cost of Army petroleum quality surveillance and fuel handling equipment, the US Army's Tank Automotive Research, Development, and Engineering Center (TARDEC) identified several portable density meters and performed an evaluation of Anton Paar's DMA35N EX Petrol portable density meter. The Anton Paar DMA35N EX Petrol device was selected for evaluation due to its current use in theater (Iraq and Afghanistan) and the Aviation Fuel Contamination Test Kit (AFCTK) System Acquisition Manager (SAM) proposal to add it to new configurations of the AFCTK. The density meter's performance was also compared to the density property predictions of a Near Infrared Spectrometer (NIR), Bruker Optics's FuelEx spectrometer, that is being developed for used in the Petroleum Test Kit (PTK). For this reason a comparison of density data obtained from both instruments is provided.

2. **Approach**

The Anton Paar DMA35N EX Petrol portable density meter works on the Mass-Spring Model in which an oscillating U-tube is used to calculate the density of a fuel of interest. This technique derives the density of the fuel from an electronic measurement of the frequency of oscillation of a U tube filled with fuel (2). To evaluate the accuracy of the of the Anton Paar's DMA35N EX Petrol portable density meter 113 diesel and JP-8 fuels where tested sampled and the results compared to measurement data obtained ASTM D 1298 (3).

The Bruker Optics FuelEx Near Infrared spectrometer calculates the density of a sample by utilizing chemometic models developed with a library of fuels with known densities (4). To evaluate the accuracy of the NIR spectrometer measurements were taken on 113 Diesel and JP-8 fuels and compared against values obtained by testing the fuels against ASTM D 1298.

3. **Analysis**

3.1. Density Meter Analysis

The average difference in API gravity between the density meter reading and the ASTM D 1298 method for the fuels tested was 0.10 with a standard deviation of 0.18. The API gravity as calculated by the density meter plotted against the API gravity as measured by ASTM D 1298 is shown in Figure 1.

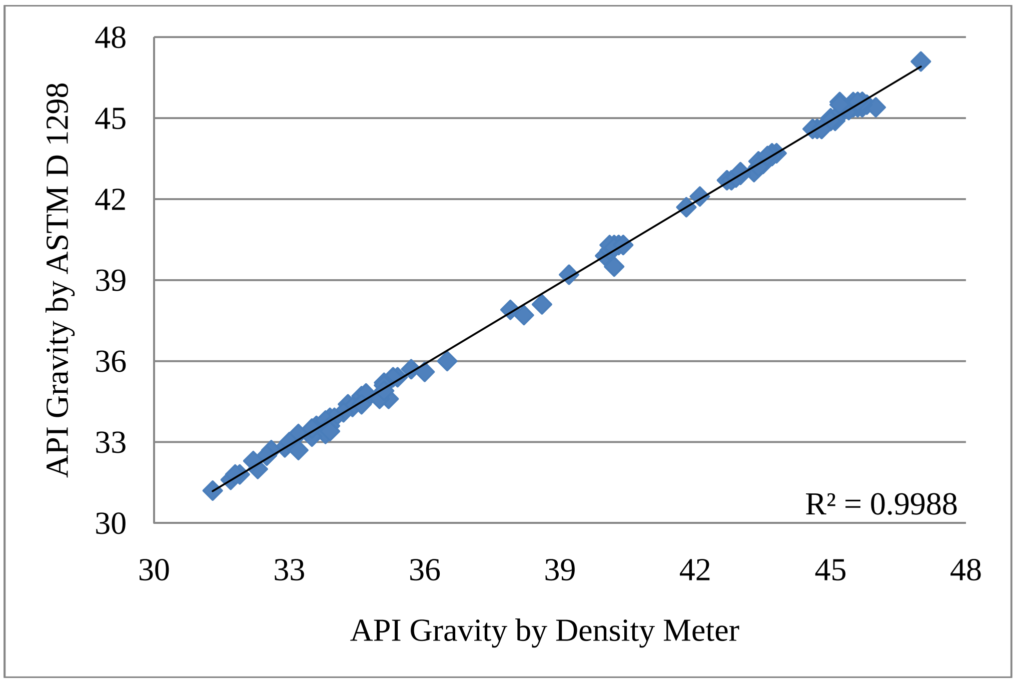

Figure 1. API Gravity as calculated by density meter vs. API gravity by ASTM D 1298.

3.2. Near-Infrared Property Prediction Evaluation

The predicted API gravity as calculated by the NIR spectrometer had an average difference in API gravity versus the ASTM D 1298 method of -0.11 and a standard deviation of 0.31. The predicted API gravity as calculated by the NIR spectrometer, of the 113 fuels, plotted against the API gravity as measured by ASTM D 1298 is shown in Figure 1.

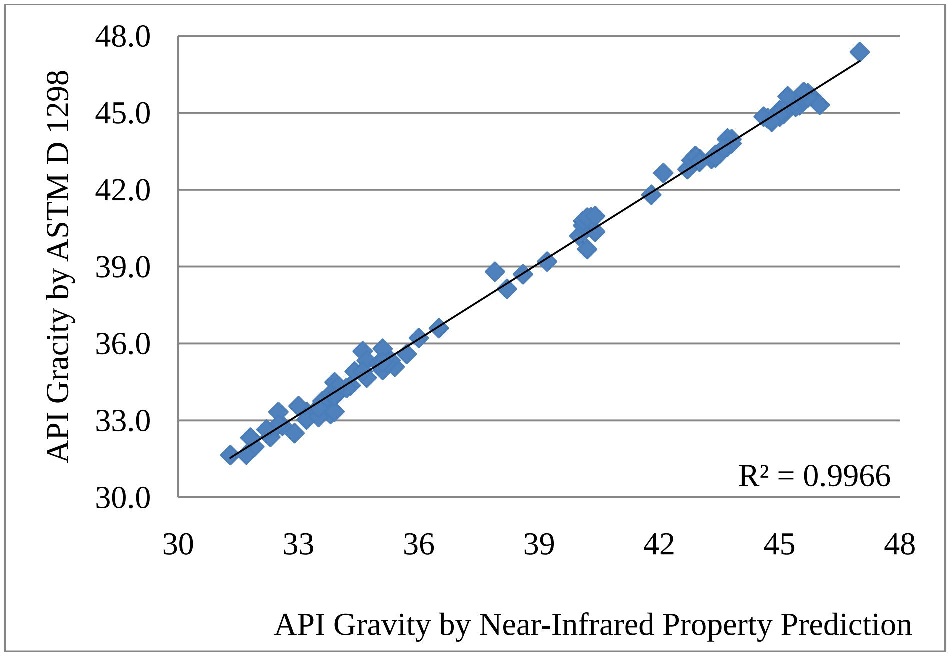

Figure 2. API gravity by Near-Infrared property prediction vs. API gravity by ASTM D 1298.

4. **Conclusion**

The Anton Paar DMA35N EX Petrol portable density meter and the Bruker Optics's FuelEx NIR spectrometer provided acceptable response to fuel densities in comparison to the density values obtained when utilizing ASTM D 1298. Both instruments are capable of providing a fuel density measurement that is accurate enough for the user to determine fuel type and track for fuel commingling, although it is recommended that density not be the sole factor in determining fuel type and quality.

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