**Report Documentation Page**

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE  
   03 MAY 2006

2. REPORT TYPE  
   N/A

3. DATES COVERED

4. TITLE AND SUBTITLE  
   Near-Infrared Fuel Analysis

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

6. AUTHOR(S)  
   Schmitigal / Joel

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)  
   USATACOM 651 E 11 Mile Road Warren, MI 48397-5008

8. PERFORMING ORGANIZATION REPORT NUMBER
   15772

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)  
   TACOM TARDEC

10. SPONSOR/MONITOR’S ACRONYM(S)

11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT  
   Approved for public release, distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:  
   a. REPORT  
      unclassified
   b. ABSTRACT  
      unclassified
   c. THIS PAGE  
      unclassified

17. LIMITATION OF ABSTRACT  
   SAR

18. NUMBER OF PAGES  
   22

19a. NAME OF RESPONSIBLE PERSON

---

*Standard Form 298 (Rev. 8-98)*

Prepared by ANSI Z39.18
JOEL SCHMITTIGAL
Near-Infrared Fuel Analysis

SUPERIOR TECHNOLOGY

FOR A

SUPERIOR ARMY

RDECOM
TACOM

TARDEC
• Portable, Ruggedized, Near Infrared Spectrometer

• Chemometrics using Principal Component Analysis and Partial Least Squares or Soft Independent Modeling of Class Analogies Method (SIMCA)

• Manufactured by Micron Optical Systems Inc.
  - Suffolk, VA

• Army Small Business Innovative Research (SBIR)
  - Phase II awarded
  - 1/11/2001
Size
- 4.25" x 5.25" x 11.75"

Detector
- Substrate: InGaAs one dimensional array
- Pixels: 512 pixels
- Electronic Shutter: Integration from 1 ms to minutes
- Readout and Display Update: 50 spectra / second

Spectrograph
- Grating: Volume Holographic transmission grating
- Spectral Range: 1000-1600 nm
- Spectral Dispersion: 1.56 or 0.98 nm/pixel

Source
- Feedback-Stabilized High-Intensity tungsten halide lamp with peak intensity at 1100nm.
ADVANTAGES

- Small Size: 4.25” x 5.25” x 11.75”
- Light Weight
- Adaptable fiber optic probe
- Easy to use
- Fast Analysis: Results in less than 1s
- No hazardous waste generated

LIMITATIONS

- Correlative measurement: the accuracy of your results are dependant on the accuracy of the ASTM data used to build the models
- Correlation to properties dependent on molecular structure
- Range/Quantity of fuel samples
- Sensitivity directly related to composition of fuel
<table>
<thead>
<tr>
<th>Property</th>
<th>ASTM Method</th>
<th>ASTM Reproducibility</th>
<th>SEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling point at 10% dist</td>
<td>D 86</td>
<td>3.74 - 12.02 °C</td>
<td>8.35 °C</td>
</tr>
<tr>
<td>Boiling point at 90% dist</td>
<td>D 86</td>
<td>3.74-10.52 °C</td>
<td>9.40 °C</td>
</tr>
<tr>
<td>Dist End Point</td>
<td>D 86</td>
<td>10.5 °C</td>
<td>12.87 °C</td>
</tr>
<tr>
<td>Density</td>
<td>D 1298</td>
<td>0.0012 g/mL</td>
<td>0.0041 g/mL</td>
</tr>
<tr>
<td>API Gravity</td>
<td>D 1298</td>
<td>0.3</td>
<td>0.9384</td>
</tr>
<tr>
<td>Flashpoint</td>
<td>D 93</td>
<td>6 °C</td>
<td>5.141 °C</td>
</tr>
<tr>
<td>Viscosity at 40 °C</td>
<td>D 445</td>
<td>0.013 - 0.046 cSt</td>
<td>0.156 cSt</td>
</tr>
<tr>
<td>Cetane Index</td>
<td>D 976</td>
<td>2</td>
<td>1.183</td>
</tr>
<tr>
<td>Aromatics %</td>
<td>D 1319</td>
<td>1.5-3.3%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Cloud Point</td>
<td>D 2500</td>
<td>4 °C</td>
<td>5.8 °C</td>
</tr>
<tr>
<td>Freeze Point</td>
<td>D 5972</td>
<td>.80 °C</td>
<td>0.75 °C</td>
</tr>
<tr>
<td>Net Heat of Combustion</td>
<td>D 4809</td>
<td>0.046 MJ/kg</td>
<td>0.098 MJ/kg</td>
</tr>
<tr>
<td>Hydrogen Content</td>
<td>D 3343</td>
<td>0.012-0.015%</td>
<td>0.22%</td>
</tr>
</tbody>
</table>
BOILING POINT AT 90% DISTILLED

\[ R^2 = 0.941 \]
\[ SEV = 9.403 \]
\[ ASTM = 3.737 - 10.518 \degree C \]
$R^2 = 0.8976$

$SEV = 12.8702$

$ASTM = 10.5 \, ^\circ C$
DENSITY

$R^2 = 0.9711$
$SEV = 0.0041$
$ASTM = 0.0012 \text{ g/mL}$
API GRAVITY

$R^2 = 0.9384$
$SEV = 0.8159$
$ASTM = 0.3$
FLASHPOINT °C

$R^2 = 0.762$

SEV = 5.141

ASTM = 6 °C
\[ R^2 = 0.946 \]
\[ SEV = 0.156 \]
\[ ASTM = 0.013 - 0.046 \text{cSt} \]
R^2 = 0.768
SEV = 1.183
ASTM = 2
PERCENT AROMATICS

$R^2 = 0.9627$
$SEV = 1.8977$
$ASTM = 1.5-3.3\%$
CLOUD POINT

R2 = 0.6673
SEV = 5.8 °C
ASTM = 4 °C
\[ R^2 = 0.7959 \]
\[ SEV = 0.098 \text{ MJ/kg} \]
\[ ASTM = 0.046 \text{ MJ/kg} \]
HYDROGEN CONTENT

\[
\begin{align*}
R^2 &= 0.7196 \\
SEV &= 0.2188 \\
ASTM &= 0.012 - 0.015\% \\
\end{align*}
\]
Obtaining fuels needed for modeling effort:

- Jet A
- Diesel 1
- JP-5
- Off Specification fuels (procuring or manufacturing)

Improve laboratory results for modeling

- Pour Point
- FSII detection