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Report Date: 2/6/2008

Project Information

Title: FirstDefender™ Chemical Identification System Evaluation

Evaluation Type: Instrumentation

Stakeholder: Ahura Scientific, Inc., NFSTC FIDO Program/Mobile Laboratory Project

Start Date: 10/11/2007

End Date: 02/01/2008

Manufacturer Information

Manufacturer: Ahura Scientific, Inc.

Address: 132 11th Street, Tierra Verde FL 33715

Contact Person: Bill Murphy

Phone Number: (727) 249-9110

Evaluation Overview

The National Forensic Science Technology Center (NFSTC) conducted an assessment of the FirstDefender™ chemical identification system manufactured by the Ahura Corporation. This portable handheld Raman instrument is currently utilized by civilian first responders, military, and homeland security personnel for the rapid identification of unknown solid and liquid chemical substances. The purpose of this performance evaluation was to establish the suitability of this innovative technology for use in the analysis and identification of forensically relevant substances. The samples used during this assessment were selected as a small representative subset from each of the following groups: controlled substances, non-controlled substances (including common cutting-agents), and ignitable liquids.

The following observations were noted during the evaluation process:

- The instrument is engineered with a rugged exterior housing coupled with a removable protective boot that shields the handheld unit from excessive shock, vibration, chemical exposure, and water submersion. The system is environmentally robust and has passed a subset of MIL STD 810F tests.
- The FirstDefender™ has a well integrated software platform that utilizes a patented DecisionEngine™ technology that is intended for sample mixture interpretation.
- The instrument uses non-destructive sample testing techniques.
- Most sample results can be obtained quickly. However, samples containing more than one chemical component can be very problematic for this type of technology.
- The handheld device can be used to analyze powder and liquid samples.
- The data collected during this evaluation supports the conclusion that the Ahura Raman instrument detects and identifies drug and ignitable liquid samples provided that the:
 - Compound of interest is not a minor component in the interrogated mixture



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- Sample is not heavily pigmented.
- Compound of interest is not combined with an interfering fluorescent component(s).

Evaluation Team

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NFSTC Laboratory Manager

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Physical Analytical Scientist

Product Specifications

Photos of Product:



Product Name: FirstDefender™ Chemical Identification System

Model Number: Unknown model number

Serial/Lot Number: FD1700

Brief Description: The FirstDefender™ is a portable, hand-held, point-and-shoot, Raman instrument that has been engineered to operate in harsh field environments. The FirstDefender™ incorporates an innovative internal component system with an external rugged design that provides the unit with protection from: shock, vibration, direct chemical exposure, and water submersion.

This chemical identification system utilizes a class IIIB laser to provide a monochromatic excitation incident light source that is focused onto the test sample. The incident light excites the molecules of the compound(s) present within the sample. In turn, the excited molecules scatter the incident light. Most of the light scattered will have the same wavelength (λ) as the incident light (Rayleigh Scatter); however, some of the light will scatter at different wavelengths causing inelastic or Raman scatter.



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The Raman Shift (E_v) is equal to the difference of the incident light (E_i) and the Raman scattered light (E_s) and is defined as the energy involved in changing the molecule's vibrational state. The equation is $E_v = E_i - E_s$.

During the analysis, the unit provides a spectra or material "fingerprint" consisting of a plot of the Raman intensity versus the Raman Shift. This plot will consist of several different Raman shifted signals as a result of either vibrational or rotational motions of the molecules within the sample. After the analysis is complete, this unique compound spectra or "fingerprint" identifier is compared to the spectra library of known compounds. The unit identifies the compound(s) present if a probability match is found within the library.

Product Uses: This hand-held instrument is intended for in the field analysis and identification of unknown solid and liquid substances. According to the manufacturer, the FirstDefender™ is capable of detecting and identifying the following substances: hazardous chemical waste, explosives, drugs, WMD (nerve and blister agents), CWA, common chemicals, and household materials.

Detection System Dimensions: 6.0 in x 12.0 in x 2.25 in (w/ protective boot)

Weight: 1725.4 g (3.80 lbs)

Storage Conditions: Not applicable

Operational Conditions: -20 to 40°C (Provided by manufacturer)

Power Requirements: Model MCR-1821J/1-H Lithium Ion Rechargeable Battery

Cost: MSRP \$25,000 to \$49,000

Evaluation

Objectives:

- To assess the FirstDefender™ for applications in the analysis and identification of:
 - Controlled and non-controlled drugs including common cutting agents/diluents
 - Actual forensic street drug cases containing controlled/non-controlled drugs with cutting agents and/or fillers
 - Ignitable liquids
- To add new substances to user library
- To provide user feedback to the manufacturer

Instrument Setup Performed By:

- Manufacturer
- Manufacturer and NFSTC Laboratory Staff
- NFSTC Laboratory Staff Only

Instrument Setup Comments: The instrument was transported from the Ahura Corporation to the NFSTC laboratory facility by a representative from the Ahura Corporation. The following components were provided with the hand held Raman instrument:

- Black foam lined Pelican™ type case



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- Compact Flash Card
- Thunderbolt CF Card Reader
- Wall Plug Adapter and Battery Charger
- Two Model MCR-1821J/1-H Lithium Ion Rechargeable Batteries
- *Quick Reference Guide*

The instrument was placed on a laboratory bench; a lithium ion battery was placed into the unit and the unit was powered on. The second lithium ion battery was placed into the table top battery charger. After inserting the battery, it took approximately 40 seconds for the instrument to boot and reach operational readiness.

Level of Operator Knowledge As Set by Manufacturer:

- Non-Scientist ✓
- Technician
- Scientist

Standards, Controls, and Samples Used in Evaluation

Table 1: Cutting Agents/Standards	
NuStevia	Quinine
Nicinamide	Benzocaine
Tetracaine	Procaine
Scopolamine	Atropine
Noscapine	Lidocaine
D-Mannitol	



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Table 2: Case Samples			
Sample #	Case #	Description	Laboratory I.D.
15	04-3287	White powder	Cocaine Base
13	04-8647	White powder	Cocaine Base
31	03-51135	Lt. tan powder	Heroin
42	04-8157	Off white powder	Cocaine
36	03-54075 Item2A	Off white powder	Heroin
701	Not provided	Lt. blue tablet	1 mg Alprazolam
702	Not provided	Peach tablet	40 mg Methadone
7	04-10390	White powder	Cocaine
9	04-12507	White powder	Acetaminophen
33	03-27124	White powder	Heroin and Caffeine
39	04-7732	Lt. Brown powder	Heroin
703	Not provided	Broken pink tablet	Propoxyphene 100mg/650 APAP
704	Not provided	Broken in half Lt. Green tablet	10 mg hydrocodone/650 APAP
705	06-63845	Lt. tan powder material	Heroin
706	Not provided	Crushed cream colored chunk of material	Cocaine, benzocaine and tetracocaine
47	04-22103 Item1D	White powder	Cocaine
707	07-1637 Item2-2	White crystalline powder	Methamphetamine
49	04-10188 Item 1	White chunky material	Cocaine Base
35	03-54078 Item 2C	Off white powder	Heroin
50	04-22103 Item 1B	White powder	Cocaine

Table 3: Ignitable Liquids	
Ethyl alcohol	Ozark Trail Camping Fuel
BP 87 Octane Gasoline	Lamplight Lamp Oil
BP Diesel	Goo Gone
Soot-Free Stove Fuel	Klean Strip VM&P Naphtha Thinner
HEET Gas Antifreeze and water remover	Ronsonol Lighter Fluid
Kingford Charcoal Lighter Fluid	Klean Strip Turpentine
Klean Strip Low Odor Mineral Spirits	Klean Strip EasyLiquid Sander



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Equipment and Consumables

- Ahura 4mL sample vials with Teflon caps
- Spatula(s)
- Fischer Scientific Certified ACS Methanol (used to clean spatula)

Synopsis of Experiments

Experiments were designed to assess the ability of the FirstDefender™ to correctly identify forensically relevant compounds. The samples used during this assessment were selected as a small representative subset from each of the following groups: controlled and non-controlled substances, cutting-agents, and ignitable liquids. This area of the assessment was divided into three separate parts based on the type of substance under analysis:

Part I: Controlled and Non-Controlled Substances

- Testing was conducted at the Forensic Chemistry Laboratory of the Manatee County Sheriff's Office Investigative Bureau using twenty adjudicated forensic drug cases.
- Each sample was either placed into an appropriately labeled sample vial or was analyzed by the point-and-shoot method.
- Samples were randomly selected and consisted of powders, chunky material, or tablets.
- Table 2 lists: the sample number, agency case number, sample description, and laboratory findings.
- The following information was recorded for each sample: sample number, scan number, sample description, packaging, actual lab identification, and FirstDefender™ identification.

Part II: Cutting-Agents and Other Chemical Substances

- All samples were analyzed using appropriately labeled vials with caps.
- A list of the cutting-agents used in this evaluation can be found in Table 1.
- The following information was recorded for each sample: sample number, scan number, manufacturer, lot number, catalog number, and FirstDefender™ identification.

Part III: Ignitable Liquids

- All ignitable liquid samples were analyzed using appropriately labeled vials with caps provided by the instrument manufacturer
- Each vial was filled with approximately 2mL of the respective liquid.
- The list of samples used in this part of the evaluation can be found in Table 3.
- The following information was recorded for each sample: sample number, scan number, manufacturer, and FirstDefender™ identification.



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The spectra illustrated in Figures 1-4 below are a representative sampling of the data obtained during the FirstDefender™ assessment.

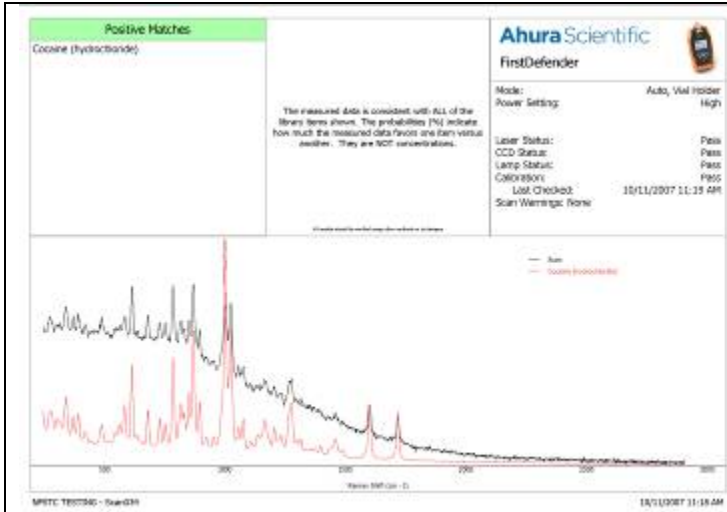


Figure 1: White powder (#7), Cocaine HCl (Scan#034)

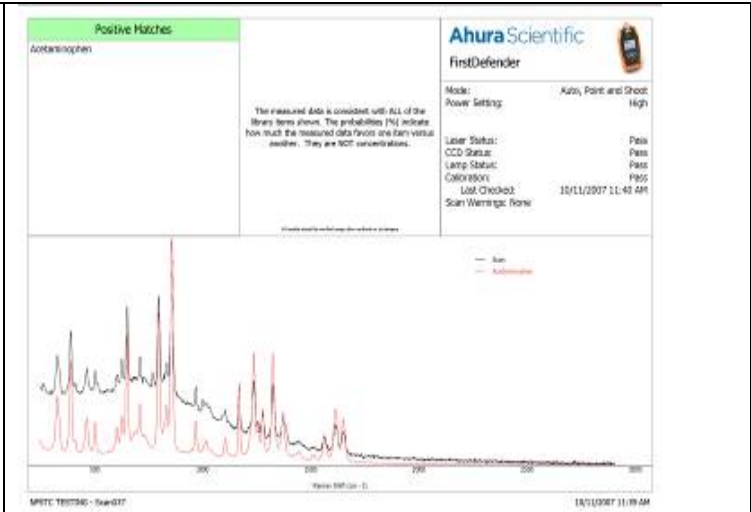


Figure 2: Broken pink tablet (#703), Propoxyphene 100mg/APAP 650 mg (Scan#037)

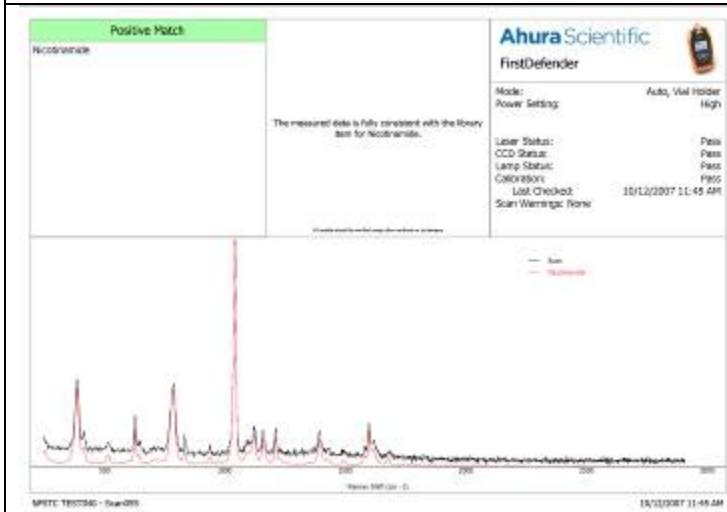


Figure 3: White powder, Nicotinamide (Scan #055)

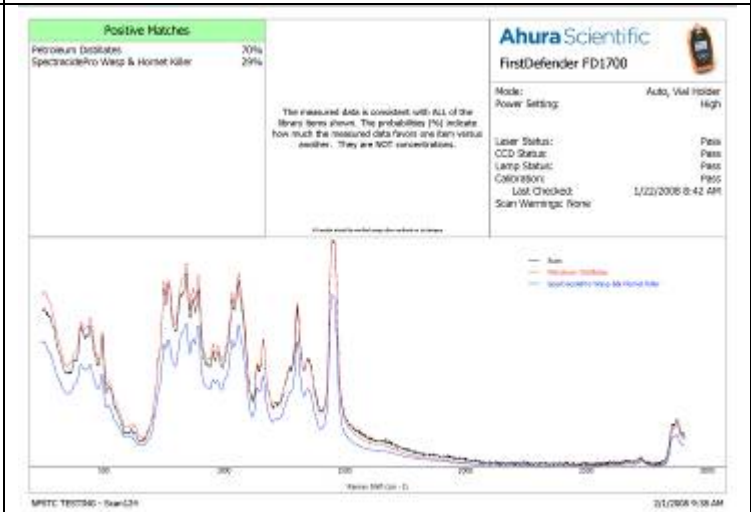


Figure 4: Colorless Liquid, Kingsford Charcoal Lighter Fluid (Scan #124)



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Findings

Strengths

- The device weighs less than four pounds and possesses a very small foot print that allows for easy transport and usage in many different field environments.
- The instrument is engineered with a rugged exterior housing coupled with a removable protective boot that shields the handheld unit from excessive shock, vibration, chemical exposure, and water submersion.
- The FirstDefender™ has a well integrated software platform that utilizes a patented DecisionEngine™ technology allowing for sample mixture interpretation through a user friendly interface.
- The instrument uses non-destructive sample testing techniques.
- Most sample results can be obtained quickly.
- The handheld device can be used to analyze powder or liquid samples.
- The point-and-shoot method allows some sample identification to occur through the original container (transparent glass or plastic bottles, transparent plastic bags, etc.)
- Easy-to-use *Quick Reference Guide*. This guide is written for the novice user.

Opportunities for Improvement

- An LED indicator on the door of the "Vial Compartment Cover" would be better suited to alert the operator when a vial is present within the unit rather than the small "V" icon currently displayed in the status bar. On several occasions, the previous sample vial was mistakenly left in the vial chamber prior to performing the next point-and-shoot analysis.
- Optional PC software for FirstDefender™ data manipulation would allow easier spectra upload, sample information edits, custom report generation, and data archiving capabilities.
- No data or file name customization is available until after the analysis of the sample is complete. Prior to performing a scan, the operator should have the option of entering a custom sample name and/or a brief sample description. This information should accompany the scan number. The sample customization option should be a global setting that can be turned on or off depending on the user's preferences. This sample information can become important when multiple sample analyses are conducted at one scene or incident.
- A faster library build feature would provide enhanced efficiency. Currently, a single sample library build can take several minutes to over an hour to complete. This time is compound specific and depends on molecular and fluorescence signal.
- Locking mechanism for the "Compartment Door" should be clearly marked to indicate lock position as either "locked" or "unlocked". This would prevent accidental environmental exposure to the internal components of the unit.
- Battery removal mechanism does not allow for easy battery replacement. After battery release button is depressed, the battery should leave the unit with ease. However, this does not occur, the unit has to be carefully shaken to loosen the battery from the slotted position.



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Limitations

- Raman spectroscopy does have limitations with respect to trace analysis. To overcome the problems associated with these types of samples, a nanometer scale roughed silver or gold surface technique also known as Surface Enhanced Raman Scattering (SERS) can be used to enhance detection up to 106 (ppm).
- Raman spectroscopy can be troubled by fluorescence, which is a strong light emission from the sample that interferes with and often completely swamps the weak Raman signal. However, the fluorescence exhibited by the unknown sample is strongly dependent on the wavelength of the laser used for excitation. Although the FirstDefender™ utilizes a 785nm near-IR laser to reduce fluorescence, some samples were noted as exhibiting severe fluorescent interference. Some Raman instrument manufacturers have incorporated a photo-bleaching technique to help alleviate or reduce this type of interference.
- Mixtures can be problematic with this type of technology. After analyzing several mixture samples, only the major component (filler, APAP, etc.) was identified while the minor component (the scheduled drug) was missed entirely.
- Heat is generated from molecular vibrational energy created from the laser, which can be potentially dangerous with thermally sensitive materials.
- The instrument was not successfully used on dark colored solid powders or through black colored plastics.

Training Requirements

- The *FirstDefender™ User Manual* was not provided with the instrument. However, the NFSTC was given a *Quick Reference Guide* along with a day of hands-on training by the manufacturer. Minimal training is required to operate this instrument. It is recommended by the evaluation team that most of the training focus on sample and instrument limitations.
- The *Quick Reference Guide* is a spiral bound guide that has colorful illustrations and easy-to-understand instructions. The pages of this guide are well indexed and durable, which makes it a great training tool and reference for inexperienced instrument operators during sample analysis.
- The user interface of the FirstDefender™ was designed to suit both non-technical and technical personnel.

Health and Safety Issues

- This instrument utilizes a Class III B laser that can be hazardous to the eyes of the operator and/or bystanders if the necessary safety precautions are not taken.
- The *Quick Reference Guide* explicitly warns the user of potential exposure hazards associated with the use of the instrument.
- This instrument has the potential of igniting materials due to the fact that some materials absorb laser energy and heat up. The manufacturer cautions the user to not use the unit for the measurement of thermally sensitive materials.
- This unit can be considered safe if personnel are properly trained.