FIRST DEFENDER
USER MANUAL

AHURA CORPORATION

46 Jonspin Rd.
Wilmington MA 01887
Telephone: (978) 657-5555
Fax: (978) 657-5921

24/7 Service & Support:
1-800-374-1992

www.ahuracorp.com

Part Number: 110-00001-04 Rev. D

Notices:

This product is covered by a limited warranty. A copy of the warranty is included in this manual.

Information in this document is subject to change without notice and does not represent a commitment on the part of Ahura Corporation. Ahura Corporation has made its best effort to ensure the accuracy of the contents of this document. However, Ahura makes no guarantee that said contents are complete and or correct in all respects; the information contained herein is subject to change without notice.

No responsibility is assumed by Ahura Corporation for the use of this instrumentation or other rights of third parties resulting from its use.

The software described in this document is furnished under a license agreement and may be used or copied only in accordance with the terms of the agreement.

Ahura Corporation products are the subject of US patent applications.

Defender 2000 SC and XS

"The technical information contained within these documents is subject to the Export Administration Regulations. Export of this technical information to foreign persons or foreign companies, within or outside the United States, may require prior written authorization by the U.S. Department of Commerce, Bureau of Industry and Security. Contact Ahura Corporation prior to such a transfer.

Defender 2000 XL and XLS

"The technical data contained within these documents are subject to the export controls imposed by the International Traffic In Arms Regulations. Export of this technical data to foreign persons or foreign companies, within or outside the United States, requires prior written authorization by the U.S. Department of State, Office of Defense Trade Controls."

First Defender is a registered trademark of Ahura Corporation. All other brands and products mentioned are trademarks or registered trademarks of their respective holders.

Warnings and Safety Considerations

The First Defender Handheld Identification System is certified as a CLASS IIIB laser product to the requirements of the U.S. Federal Product Performance Standard for Laser Products contained in the regulations of 21 CFR Sub-Chapter "J" except for deviations pursuant to Department of Health and Human Services issued Laser Notices. Exposure to Class IIIB levels of laser energy can be hazardous. Avoid exposure to the beam. Exposure to specular (mirror like) reflections should also be avoided. The First Defender also complies with IEC 60825-1 Ed. 1.2(2001-2008).

For guidance on safe use of laser products consult the American National Standard ANSI Z136.1 for Safe Use of Lasers or the IEC 60825-14 Users Guide.

This device incorporates a laser diode that emits a 350 mW beam at 785 nm. An 18 mm focal length lens is used to concentrate the energy on a sample. The beam diameter at the focal lens is approximately 9.6 mm.

Calculations performed in accordance with the recommended practices of ANSI Z136.1 and IEC 60825-1 give a Nominal Ocular Hazard Distance (NOHD) of approximately 14" (35 cm) from the focal point of the lens and an estimated optical density (OD) greater than 2.8. Avoid exposure to beam.

Ahura recommends that sample vials be used whenever possible to reduce the possibility of unintended exposure to laser energy.

CAUTION: There are no user adjustable components inside the unit. The battery compartment door may be opened, but the user should not open the protective enclosure or modify electronics contained in the First Defender unit. All service operations must be performed by Ahura Corporation or an authorized service agent of Ahura Corporation. ANY ATTEMPT BY THE USER TO OPEN THE UNIT OR INTERFERE WITH THE INTERLOCKS OR ELECTRONICS WILL RENDER THE ENTIRE PRODUCT WARRANTY NULL AND VOID.

CAUTION: Use of controls, adjustments or performance of procedures other than those specified herein in or those specified by Ahura Corporation personnel may result in hazardous radiation exposure.

There are no user serviceable procedures associated with this device. All service to the First Defender unit and its optics is to be performed only by Ahura Corporation or an authorized service agent of Ahura Corporation.

The First Defender is specifically designed to be used in an every-day environment in the field and is therefore considerably more rugged than a unit for a laboratory. However, the user should recognize that this is a precision scientific instrument and should be treated with care. Abuse and mistreatment may lead to a degradation of performance or premature failure.

CAUTION: Exposure to levels of laser energy above the maximum permissible exposure (MPE) can be harmful to the eye. The emitted energy must travel a minimum distance of 14" (35 cm) before its concentration is below the MPE for normal viewing. This distance is defined as the hazard zone. With proper use exposure to levels above the MPE can be avoided. Avoid exposure to the beam.

In the absence of a work place safety standard or requirements, users are referred to the American National Standard ANSI Z136.1 for the safe use of lasers or the International Standard IEC 60825-14 user's guide for guidance on identifying and controlling hazards associated with laser use. Use of administrative controls, engineering controls, and/or laser safety glasses should be used to avoid exposure to laser radiation within the 14" (35 cm) hazard zone. If laser safety eyewear is used an optical density(OD) >2.8 is suggested. A protective laser shield has been additionally provided to further protect the operator from an exposure above the MPE. It is strongly recommended that this shield be used with the device.

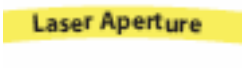
CAUTION: Dark colored materials (liquids and solids) will absorb heat (laser) energy and make them susceptible to being ignited by the unit. Examples of these materials include Explosives (Black Powder, Unstable T-N-T), Flammable Solids (Match Tips) and Light Sensitive Liquids (Organic Peroxides, Pyrophoric Liquids). IF ANY OF THESE MATERIALS ARE SUSPECTED, DO NOT USE THIS DEVICE TO MEASURE THEM! The use of small sample sizes and the lowest possible laser power is always recommended to limit the possible hazards.

The First Defender is NOT designed to be intrinsically safe and the user should take the necessary precautions when using the system.

Safety and Information Labels on the First Defender

A number of labels are attached to the First Defender Handheld Identification System for the convenience of the user and safe use of the system. The labels provide the following information.

a) **Eject Label** - Indicates the location of the Eject button which is located on the top side of the unit under the vial area cover. It is used to remove a vial from the holder.

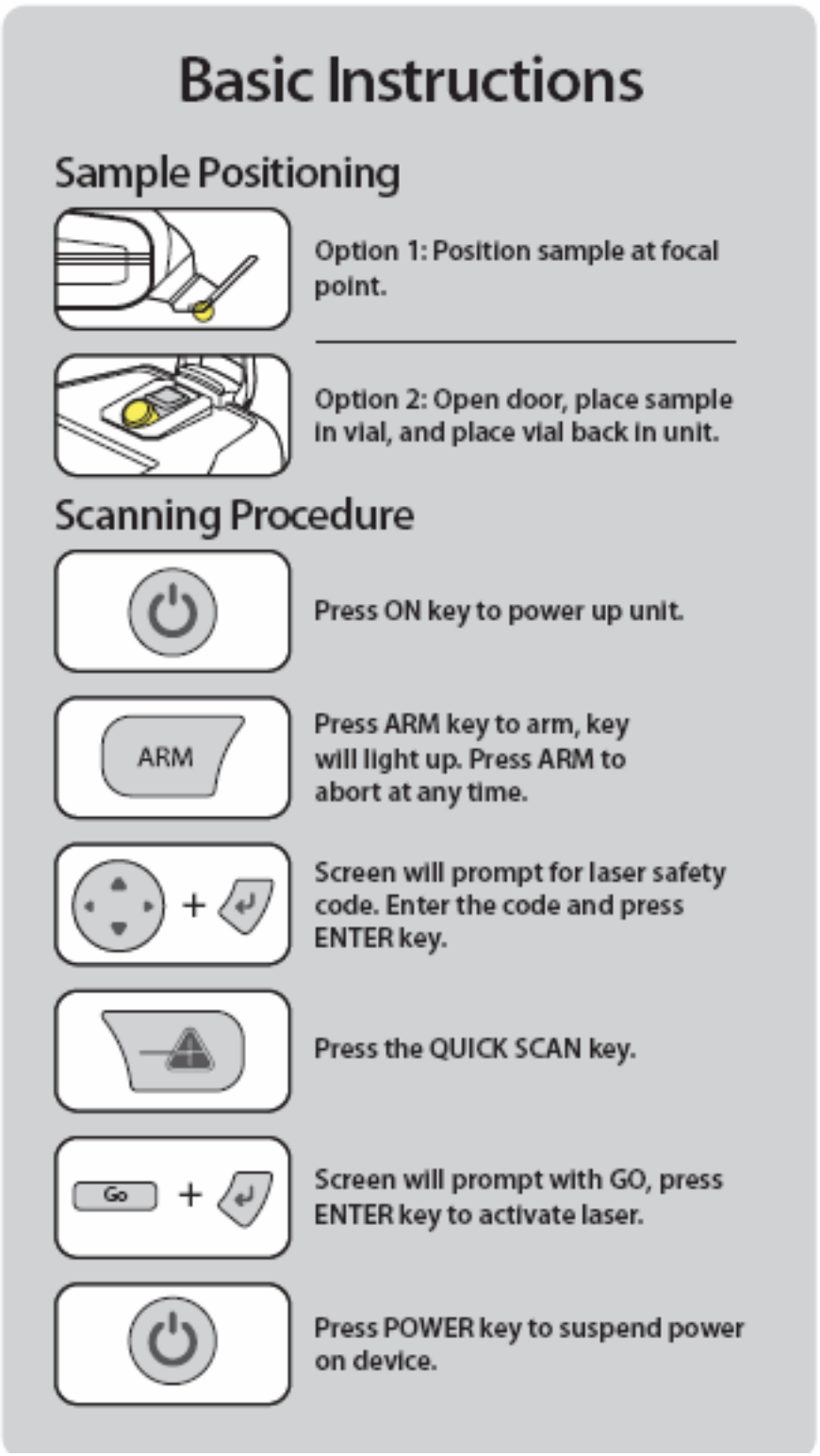


b) **Laser Aperture Label** - Alerts the user that energy from the laser exits the enclosure through an opening on the front nose of the unit. This radiation can be harmful to the eye and the user should take care that the eyes are suitably protected. The label is by the aperture which is located in the front of the unit at the nose.

c) **Laser Aperture Label** - Alerts the user that energy from the laser exits the enclosure through an opening under the hinged vial holder cover to which the label is affixed. This radiation can be harmful to the eye and the user should take care that the eyes are suitably protected. The label is located on the top side of the unit immediately above the screen.

d) **Information label** - Used to identify the unit. If questions arise with respect to the use of the unit, please provide the information on this label to Ahura Corporation. This label is located on the back of the unit near the rear.

e) **Laser Information Label** - This label is provides the user with information on the class, wavelength, and output power of the laser contained within the First Defender product. This label is located on the back of the unit near the rear.



f) **Basic Instructions Label** - This label outlines the procedure employed to scan a sample. It is on the back panel of the First Defender. A detailed discussion of the user interface is presented in Chapter 3.

Limited Warranty

Scope. The First Defender hand-held identification system (the "Product") is sold with the following limited warranty. The limited warranty set forth herein (a) applies only to the initial purchaser of the Product (the "Buyer"), may be acted upon only by the Buyer, and may not be assigned, sold or transferred to any third party, and (b) is provided to the Buyer only by Ahura Corporation d/b/a Ahura Safety Corp. ("Ahura") in the case of a direct sale, or only by Ahura's distributor or reseller, in the case of a purchase by Buyer from a distributor or reseller of Ahura (Ahura, distributor or reseller, as applicable, the "Seller").

Limited Warranty. The Seller warrants only to the Buyer that for the applicable warranty period set forth below the Product shall substantially conform to Ahura's published specifications as of the date of shipment.

Warranty Period. The warranty period shall be (a) one (1) year from shipment by Ahura (whether to Buyer and/or Ahura's distributor or reseller) for all Products designated by Ahura as "First Defender-2000 SC" or "First Defender-2000-XL", and (b) three (3) years from shipment by Ahura (whether to Buyer and/or Ahura's distributor or reseller) for all Products designed by Ahura as "First Defender-2000-XS" or "First Defender-2000-XLS". Notwithstanding the foregoing, in the event that Buyer is purchasing the Product from an Ahura distributor or reseller, the foregoing warranty period shall be extended for an additional period of one (1) month.

Exclusions. Notwithstanding the foregoing, this limited warranty shall not apply to:

- any Product that has been customized, altered or repaired by any person or entity other than personnel of Ahura or personnel specifically authorized by Ahura; or
- any Product that has been subjected to abuse, misuse, damage, neglect, or accident beyond Ahura's published limitations for the Product (including, without limitation, environmental conditions and power requirements); or
- any use or operation of the Product other than in accordance with Ahura's then-current published specifications and instructions for the Product; or
- any non-conformities or defects notified by Buyer to Seller with respect to a Product after the expiration of the applicable warranty period for such Product.

Warranty Disclaimers. THIS LIMITED WARRANTY IS IN LIEU OF ANY OTHER WARRANTY, WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL (INCLUDING, WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT) WITH RESPECT TO THE PRODUCTS, THE MANUFACTURE, SALE, SUPPLYING OR FAILURE OR DELAY IN SUPPLYING OF THE PRODUCTS, SERVICES RELATED THERETO OR THE USE, RESULTS OR DISPOSITION OF THE PRODUCTS. SELLER EXPRESSLY DISCLAIMS ALL WARRANTIES (WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL) WITH RESPECT TO THE RESULTS OBTAINED FROM THE PRODUCT. SELLER DOES NOT WARRANT THAT THE USE OF THE PRODUCT SHALL BE UNINTERRUPTED OR ERROR-FREE.

Remedies. Buyer's sole and exclusive remedy and Seller's sole and exclusive liability for a breach of this limited warranty shall be, at Seller's option, Seller's use of its commercially reasonable efforts to repair or replace the non-conforming Product. A condition of this warranty shall be that Buyer return any non-conforming Product to Ahura or an authorized service representative designated by Ahura within the applicable warranty period; provided, however, that no Product shall be returned to Ahura without Ahura's prior issuance to Buyer of a RMA (Return Material Authorization) number, which number Buyer shall include with any returned Product. Any Product returned to Ahura will have the freight prepaid by Buyer and will contain a detailed statement of the Buyer's claimed or perceived defect. Shipping costs and the risk of loss for a returned Product shall be borne solely by the Buyer, provided that Ahura shall assume the risk of loss while the Product is in the Ahura facility. Products that are repaired or replaced by Ahura (including, without limitation, all software and other updates, patches or other warranty fixes provided to Buyer pursuant to this limited warranty) shall be to be deemed covered only by the limited warranty hereunder for the remaining warranty period for such Product.

No Indirect Damages. IN NO EVENT SHALL SELLER (OR ITS SUPPLIERS OR LICENSORS) BE LIABLE TO BUYER OR ANY THIRD PARTY FOR SPECIAL, INCIDENTAL, CONSEQUENTIAL, EXEMPLARY, PUNITIVE, MULTIPLE OR OTHER INDIRECT DAMAGES, OR FOR LOSS OF PROFITS, LOSS OF DATA OR LOSS OF USE DAMAGES, ARISING OUT OF THE PRODUCTS, MANUFACTURE, SALE, SUPPLYING OR FAILURE OR DELAY IN SUPPLYING OF THE PRODUCTS, SERVICES RELATED THERETO OR THE USE, RESULTS OR DISPOSITION OF THE PRODUCTS, WHETHER BASED UPON WARRANTY, CONTRACT, TORT, STRICT LIABILITY OR OTHERWISE, EVEN IF SELLER HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES OR LOSSES.

Limited Direct Damages. SELLER (AND ITS SUPPLIERS' AND LICENSORS') LIABILITY ARISING OUT OF PRODUCTS, THE MANUFACTURE, SALE, SUPPLYING OR FAILURE OR DELAY IN SUPPLYING OF THE PRODUCTS, SERVICES RELATED THERETO OR THE USE, RESULTS OR DISPOSITION OF THE PRODUCTS, WHETHER BASED UPON WARRANTY, CONTRACT, TORT, STRICT LIABILITY OR OTHERWISE, SHALL NOT EXCEED THE APPLICABLE PURCHASE PRICE PAID BY BUYER FOR THE APPLICABLE PRODUCT.

Governing Law. This limited warranty and any disputes between the Buyer and Ahura relating to the subject matter of this limited warranty shall be governed by and construed in accordance with the laws of the Commonwealth of Massachusetts, excluding: (i) its conflicts of laws principles; (ii) the United Nations Convention on Contracts for the International Sale of Goods; (iii) the 1974 Convention on the Limitation Period in the International Sale of Goods; and (iv) the Protocol amending the 1974 Convention, done at Vienna April 11, 1980.

Exclusive Jurisdiction. The Buyer irrevocably submits to the exclusive jurisdiction of the federal and state courts of the Suffolk County, Commonwealth of Massachusetts. The Buyer hereby irrevocably waives any objection which it may now or hereafter have to the laying of venue of any suit, action or proceeding relating to this Agreement in Boston, Massachusetts and further irrevocably waives any claim that Boston, Massachusetts is not a convenient forum for any such suit, action or proceeding.

Table of Contents

1 Introduction

1.1 Overview

The First Defender is a handheld Raman spectroscopy system for the identification of unknown solids and liquids that is designed to be used by military and civilian first responders. It is light-weight and rugged so that it can be used for in-the-field identification of unknowns by first responders, soldiers, law enforcement and homeland security personnel.

1.2 Features

The critical features of the First Defender include:

- **Accurate Identification of Solids & Liquids** - Weapons of mass destruction (WMD), chemical weapons agents (CW agents), explosives, toxic industrial compounds (TIC) chemicals, white-powders, narcotics, contraband, & forensics are readily identified.
- **Long Battery Life** - The rechargeable battery provides approximately five hours of use when fully charged (at room temperature).
- **A Rugged Design** - The unit withstands shock and vibration. In addition, it is waterproof and is manufactured from chemically resilient materials.
- **Ease of Operation** - The First Defender is lightweight (4 pounds), completely self contained and uses a simple “point and shoot” technology.
- **Rapid Analysis** - Thousands of compounds can be identified in less than a minute.
- **The User can add Compounds to Expand the On-board Library** - The Raman spectra of compounds that are specific to the user can be added.
- **Line of Sight Identification** - Identifies chemicals through glass and plastic bottles, thereby avoiding contamination and maintaining evidence.
- **Integrated Vial Compartment** – Measures samples contained in 4 ml vials.

- **Non-destructive Testing** - Does not consume any sample.
- **Database / File Sharing** - Data can be uploaded and downloaded as desired.

1.3 Theory of Operation

The First Defender includes a laser diode that can provide up to 350 mW at 785 nm. The power of the laser is also user adjustable (50 mW, 150 mW, 300 mW). An 18 mm focal length lens is used to concentrate the energy on the sample to a beam diameter of approximately 150 µm.

There are several scanning methods:

- The sample can be can be placed in a vial and inserted into the on-board vial holder.
- The First Defender can be aimed at a sample (e.g. such as a liquid in a bottle or a solid).

When the energy from the diode interacts with a material, part of the light is transmitted through the material, part it is elastically scattered (scattering of the same wavelength as the diode laser) and part of it is scattered at wavelengths that are different from the diode laser. The intensity of the scattered energy is recorded as a function of scattered wavelength (resulting in a Raman spectrum) by the First Defender. Each molecule has a characteristic Raman spectrum (similar to a fingerprint), a useful attribute for the identification of unknown compounds. First Defender compares the Raman spectrum of an unknown compound to Raman spectra of known compounds in the on-board library using the DecisionEngine™, which makes a probability-based assessment of the identity of the material.

If desired, the user can visually compare the observed spectrum with the spectrum in the library.

Spectra can be stored in the First Defender and downloaded to a personal computer. If desired, the user can add the spectrum of compounds to the on-board library to generate a customized library to meet the specific needs of the user.

A broad range of compounds can be identified via Raman. Typical examples include

- **Organic compounds**

  Petroleum products, Pesticides, Fertilizers, Plastics, Plant Materials
  Drugs (Legal or Illicit)
  Chemical Weapons
  “White Powders”

- **Inorganic Compounds:**

  Mineral acids (sulfuric, nitric, *etc*.)
  Inorganic oxides (rust, titanium dioxide, *etc*.)
  Organometallic species
  Some ionic salts and ions (sulfates, phosphates, carbonates, etc.)

- **Substances in Water**

It should be noted that not all compounds can be identified by Raman measurements. This may be because the Raman spectrum of the material may be too weak in intensity for reliable identification, or because the Raman spectrum of the material is obscured by interfering phenomena. An example of the former is water, which has a very weak Raman signal. This does, however, imply that water is not an interference for Raman analysis – materials in water can be readily identified. Materials or matrices exhibiting significant fluorescence (which include some dyes, compounds of rare earth metals in solution, and some biological entities) are examples of materials that are difficult to identify due to fluorescence interference.

1.4 For Additional Information

For additional information, please contact the manufacturer:

Ahura Corporation
46 Jonspin Rd.
Wilmington MA 01887
Telephone: (978) 657-5555
Fax: (978) 657-5921
www.ahuracorp.com

For 24/7 service or support: 1-800-374-1992

or your local distributor

2 Getting Started

2.1 Unpacking the Unit

The First Defender is shipped in a rugged carrying case which is used to house the unit and the associated components. A list of the components is presented as Table 2-1.

Table 2-1: Items Shipped with the First Defender

Item	Part Number
First Defender Unit	800-00011-01
Battery (a)	400-00291-01
Battery Charger	400-00301-01
User Manual	110-00001-01
AC Adapter	400-00711-01
Flash Card (512 MB)	400-00721-01
Case	490-00041-01

(a) Installed in First Defender unit

In the event that a component of the shipment is damaged or missing, please contact the shipper and Ahura Corporation at once with a detailed description of the discrepancy.

NOTE: To avoid the possibility of injury or damage, do not use the instrument module, AC power supply or battery charger if it is damaged in shipment. Please contact Ahura Corporation for assistance if components appear to be damaged.

2.2 Testing the Unit

It is recommended that the operator use the system to identify a few “known” compounds to become acquainted with the operation of the unit and to verify that it working properly. The First Defender is shipped with a library of more than 1000 compounds and the user should use the system to identify the compounds present in a few pure samples (e.g. acetone, polystyrene).

The operations described in this section are not intended to provide a complete description of the operation of the First Defender. A detailed discussion of the operation and the overall user interaction scheme is presented in Chapter 3.

NOTE: Before you perform this test, make certain that you have reviewed the Safety Information and Warnings on pages iii-iv.

To test the unit:

a) Turn on the unit with the  button. If the battery is charged, the system will immediately wake up and show you the last screen you were on when the unit was last put to sleep. If the unit does not come on, then a fresh battery is needed. Insert the battery (or connect the AC adapter plug) (see Section 5.3), and the system will present an *Initialization* screen (Figure 2-1). The unit then loads the chemical library for about two minutes while the unit boots. This screen text provides general information about the product, product support and related issues.

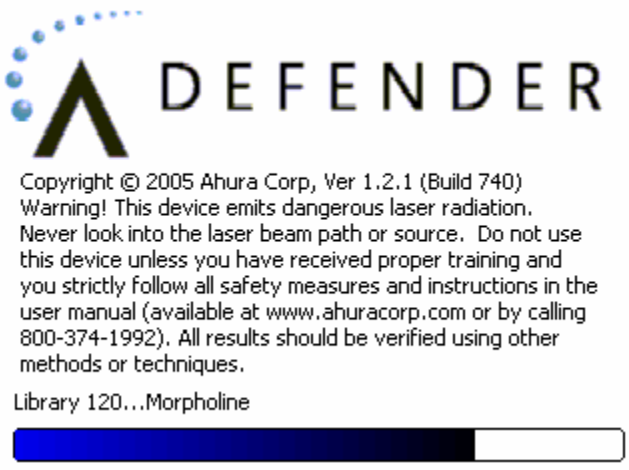


Figure 2-1: Initialization Screen

b) Next, the *Main screen* will be presented (Figure 2-2). The *Plug* icon on the bottom left indicates that the unit is connected to the line voltage; if the unit is operating on battery power, a *Battery* icon is presented. The *ARM* icon is in a gray background, indicating that the unit is not armed at the present time.

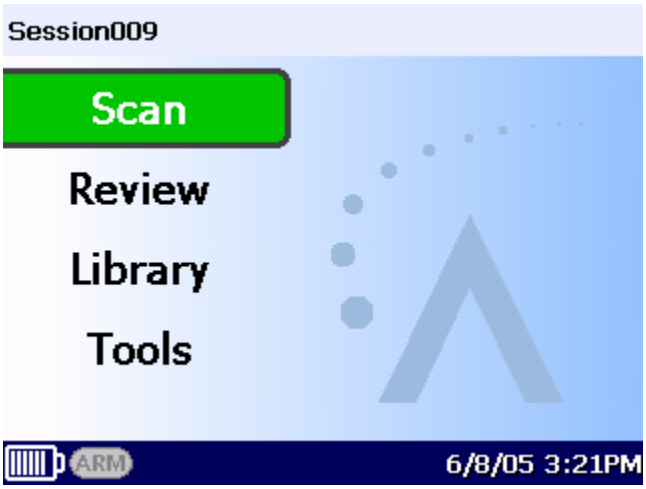


Figure 2-2: Main Screen

c) Press the 

button. The *Laser Password Entry* screen (Figure 2-3) will be presented.

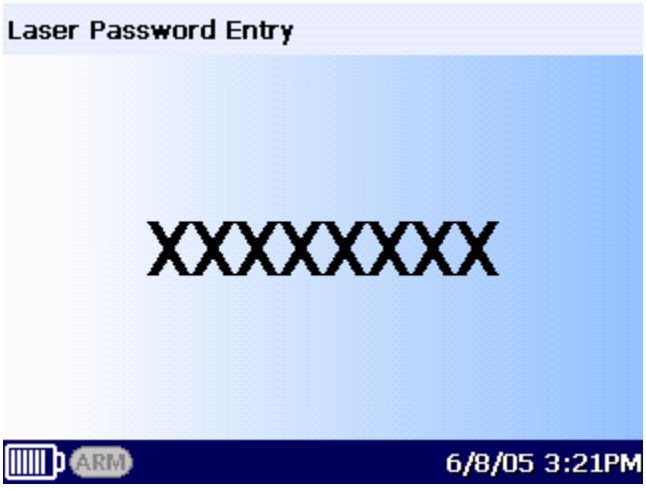


Figure 2-3: Laser Password Entry Screen

d) Enter the password, which is provided separately, followed by the **Enter**  key. The arrows are entered by pressing the  key in the appropriate direction. When the correct password is entered, the legend SUCCESS will be presented under the password and the *ARM* icon on the bottom line will appear in an orange field.

Figure 2-4: Laser Password Entry Screen - Success

e) Press the **Enter**  key to access the Slide-in pane of the *Scan Operations* screen (Figure 2-5).

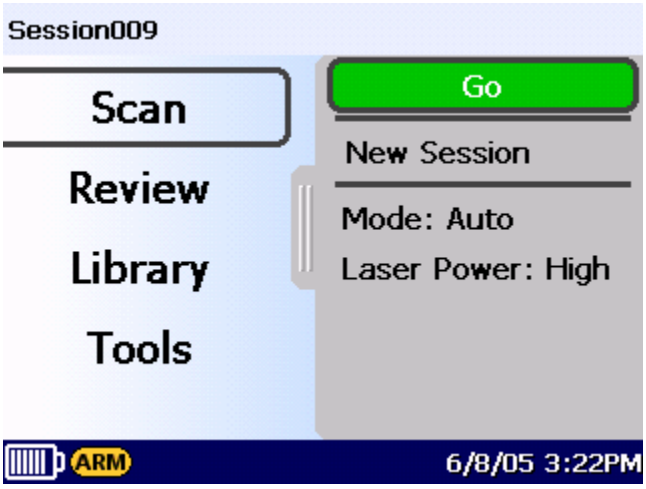


Figure 2-5: Scan Operations Screen

f) The slide-in pane on the right side of the *Scan Operations* screen presents various options that describe the operation of the unit. For this experiment, ensure that the *Auto* Mode and the *High* Laser Power options are indicated and the *Go* region is highlighted.

g) Place a sample (e.g. a vial of methanol) in the sample vial compartment and press the **Enter**  key.

h) The *Laser Warning* screen (Figure 2-6) will be presented and the system will automatically go through the data acquisition process, as indicated by the legend in the red bar at the bottom of the screen.

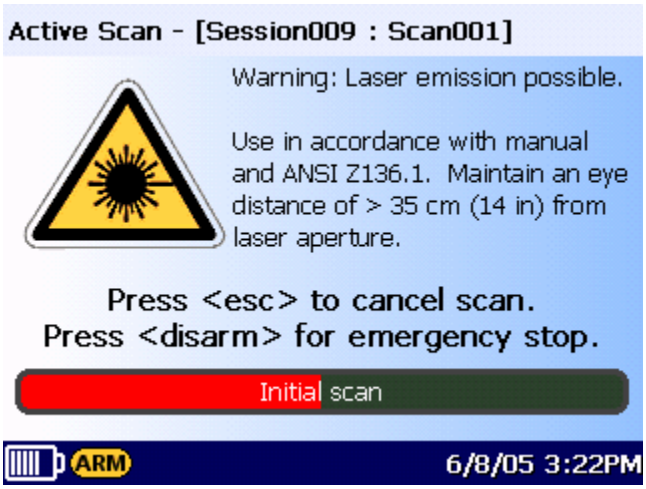


Figure 2-6: Laser Warning Screen

h) After the fingerprint (spectrum) of the material has been collected, it will be compared to each fingerprint (spectrum) in the library as indicated in Figure 2-7.

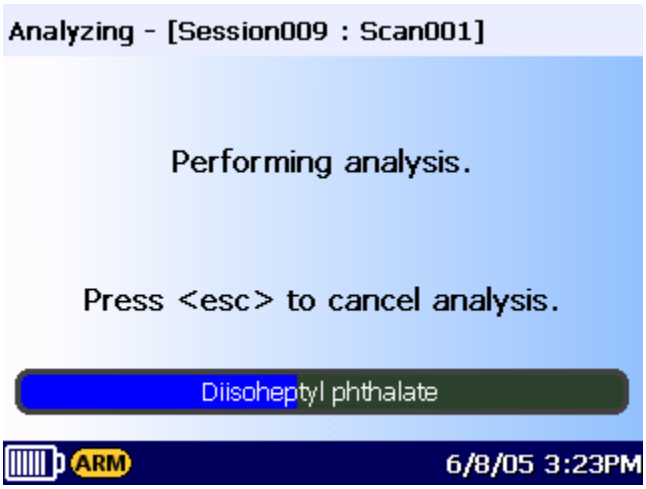


Figure 2-7: Status Screen

i) At the conclusion of the analysis, the *Results* screen (Figure 2-8) will be presented, indicating that a positive match for the library record of pure methanol was obtained.

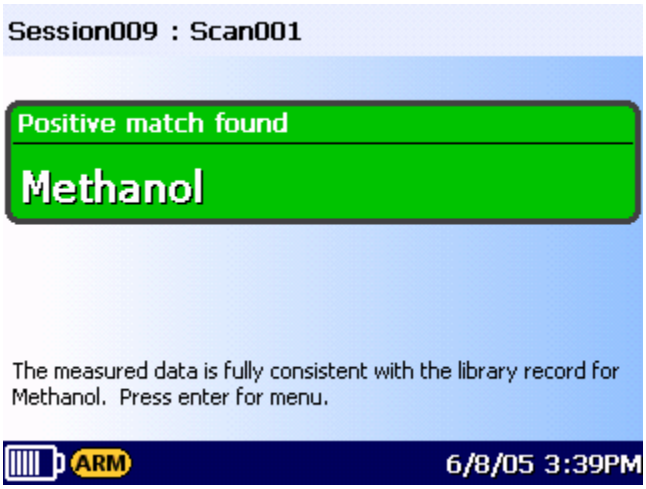


Figure 2-8: Results Screen

j) If you want to obtain more information about the identified compound, press the **Enter**  key to present the Slide-in pane shown in Figure 2-8.

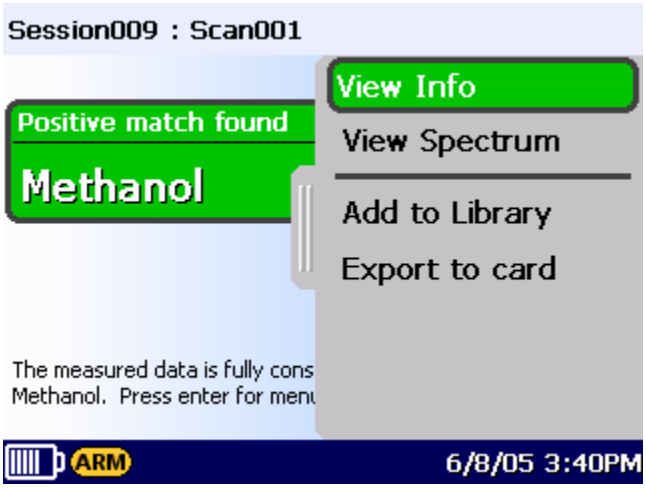


Figure 2-8: Results Screen with Slide-In Tab

k) Select *View Info* to view a series of tabs that present the description of the compound, safety information and other relevant data about the compound (Figure 2-9 and 2-10).

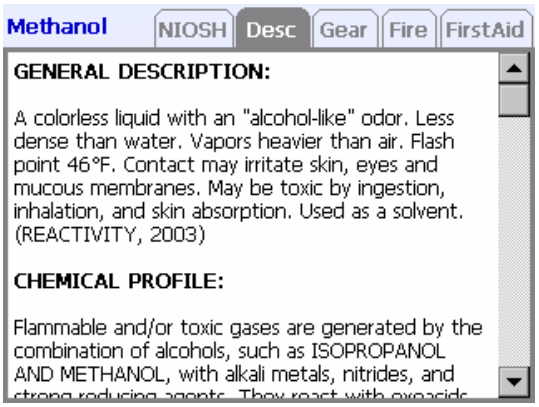


Figure 2-9: Descriptive Information

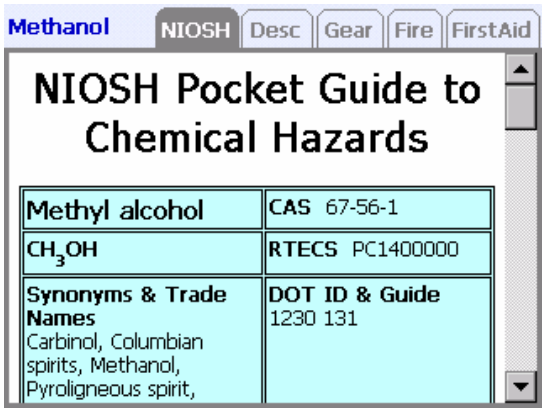


Figure 2-10: NIOSH Information

l) Press the ESC key to return to the *Results* screen with the Slide In tab (Figure 2-8), move the cursor to *View Spectrum* and press **Enter** to view the spectrum (Figure 2-11).

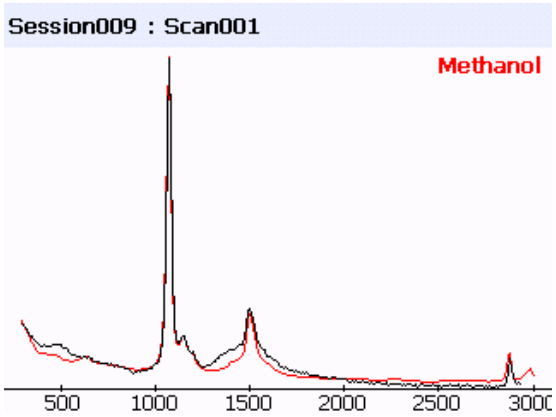


Figure 2-11: Comparison of Spectra

m) To place the unit in standby mode, press the *Power*  key.

3 User Interface

3.1 The User Interaction Scheme

The keys on the front panel (Figure 3-1) are used to control the First Defender.

Figure 3-1: The Keypad

The keys provide the following functions:

Toggles the unit between an on state and a sleep state (power key).

Toggles the unit between a laser armed and laser disarmed state. (Arm key).

Enter key

The arrow keys are used to move the cursor to select the desired option (↑, ↓, ←, →)

Returns the display to the previous display with out accepting any changes (Esc key)

Quick Key, returns to the Main Menu, with the Scan-Go button selected.

A typical display is shown in Figure 3-2.

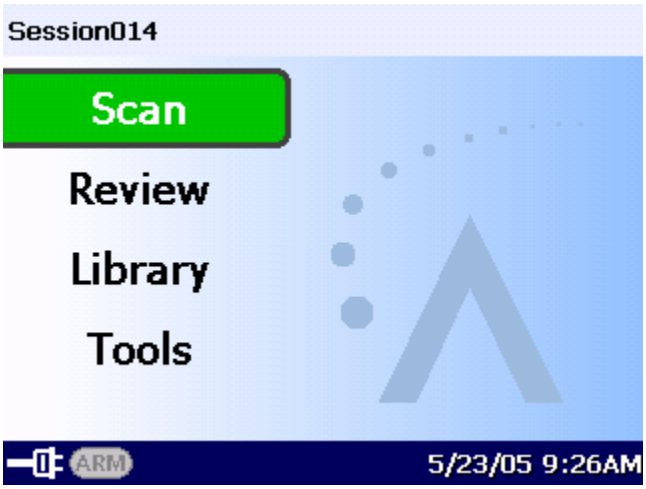


Figure 3-2: A Typical Screen

The top line of the display indicates the present session, which is the storage region where the active data is to be saved/retrieved (see Section 3.4 for details).

The center section is the working area, which is context sensitive and may present information about the status of the system, provide a series of options that are relevant at the present point in the use of the system or display collected spectra and identify compounds.

The bottom line of the display presents the instrument status. The **Plug** icon indicates that the First Defender is operating on line voltage. If it is operating on the battery, a **Battery** icon status will be presented, with bars indicating the current charge. The **Arm** icon has two states—a grayed out state indicating that the unit is not armed, and a active state indicating that the unit is armed. The unit must be armed for data to be collected.

3.2 Starting the First Defender

The First Defender unit operates in a similar manner to modern day PDAs. The power button acts as a toggle button to switch between a sleep state to an on state. There is no true off button.

Upon a battery exchange, however, the unit will be completely "off." When a fresh battery is inserted, the unit will go through a boot-up sequence (cold boot) where it will perform some self diagnostic tests, then it will proceed to load the chemical library files into memory. During this period, a series of screens that contain introductory information is presented. At the successful conclusion of the self testing, the Scan screen (Figure 3-2) is presented.

The main menu provides access to the four major divisions of the program:

- **Scan** (Section 3.3) - used to initiate a scan and determine the composition of a sample.
- **Review** (Section 3.4) - allows for viewing of spectra that were saved.
- **Library** (Section 3.5) - allows for viewing of spectra in the onboard library.
- **Tools** (Section 3.6) - accesses a variety of setup and user functions.

Use the arrow keys to select the desired function and press the **Enter** key.

If you want to perform scans, press the **Arm** key to present the *Password* Screen (Figure 3-3) to enter the correct password and arm the laser. If the laser is not armed, scans which have been stored and related information can be viewed, but you cannot collect new data.

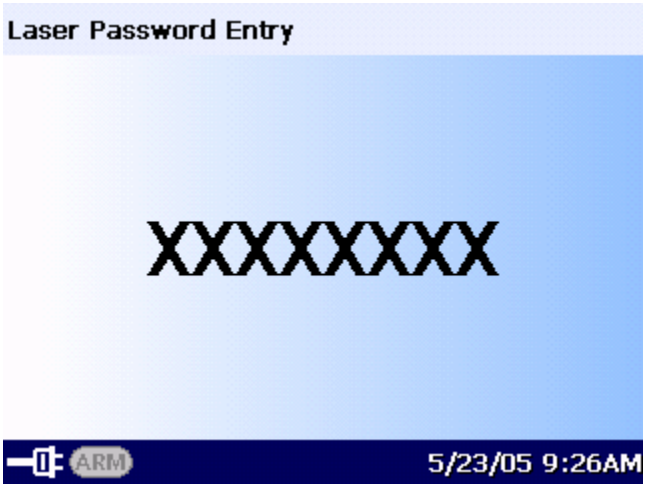


Figure 3-3: The Password Screen

Enter the password, which is provided to the user separately, using the arrow keys.

When the correct password is entered, the legend SUCCESS will be indicated on the display (Figure 3-4) and the ARM icon will be indicated in orange.

Figure 3-4: Successful Password Entry

Press the **Enter** key to return to the *Main* menu.

3.3 Scan

3.3.1 The Scan Screen

When the *Scan* option is selected is made on the *Main* screen, the *Scan* slide-in tab is presented (Figure 3-5).

Figure 3-5: The Scan Screen

Move the cursor to the desired option using the up or down arrow key and press **Enter** to present the choices for that option.

- *Go* - If this option is selected, the First Defender will perform the indicated scan when the **Enter** key is pressed.
- *New Session* - If this option is selected, a new session for data will be generated when the **Enter** key is pressed. A session is a storage area for a series of scans and any number of sessions can be generated (sessions can be deleted as described in Section 3.4). The screen will present the *New Session Name* to name the session (Figure 3-6).

Figure 3-6: The New Session Name Screen

To name the session, move the cursor to the desired first letter (e.g. P) with the arrow keys and press **Enter**. Repeat this process until the session name is complete, then move the cursor to **Done** and press **Enter**.

- *Mode* - If this option is selected, the user can select:

a) *Auto*: The system will use the default conditions for operation of the First Defender.

b) *Library Build*: This mode is used whenever the user wants to acquire data with a higher signal to noise ratio than that used in *Auto.* This mode is used when it is anticipated that the spectrum will be added to the library or when the unit will be used primarily only as a data acquisition instrument. When this mode is selected, the slide-in menu shown in Figure 3-7 will be presented and the Laser Power and the Quality can be chosen.

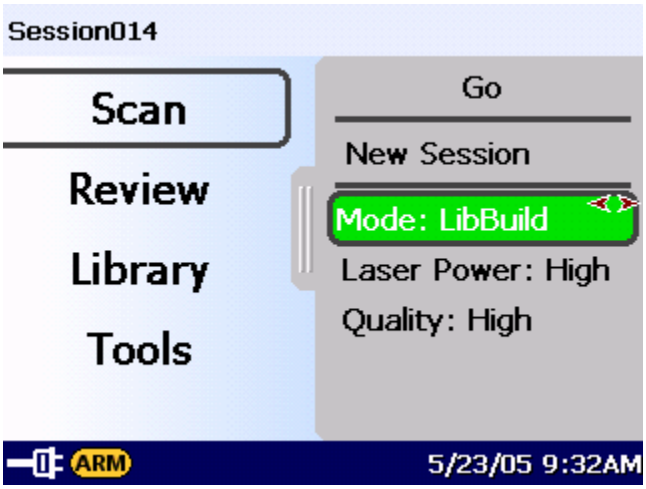


Figure 3-7: The Library Build Slide-In Menu

If you move the cursor to *Laser Power*, and press **Enter**, a new menu with three Laser Power options (low, medium and high) will be selected. Move the cursor to the desired power and press Enter again.

If you move the cursor to *Quality* and press **Enter**, the menu shown in Figure 3-8 will be presented. These options indicate the desired signal to noise ratio of the spectrum to be collected. A high quality spectrum will take longer to collect than a spectrum of lower quality, but will provide greater reliability and analytical resolving power in future identifications of the compounds. Once you have collected the spectrum, it can be stored in the library as described in Section 3.5.

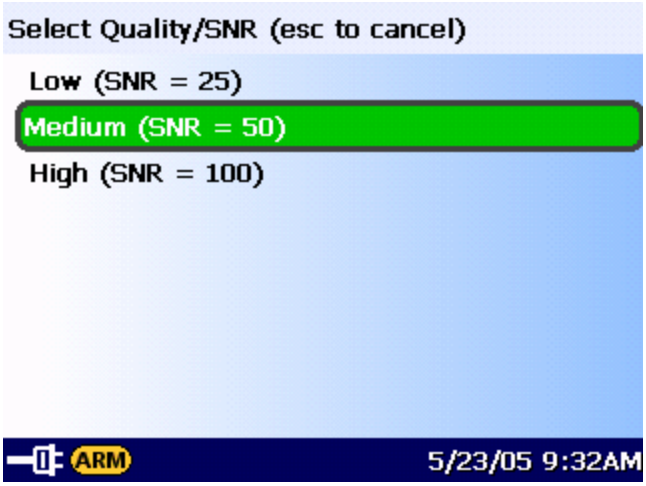


Figure 3-8: Select Spectrum Quality Menu

c) *Manual (advanced only)*: This mode is used when the advanced user wants to manually control the exposure time used to collect the spectrum. Great care must be taken in the correct interpretation of the results in this mode. When this mode is selected, the slide-in menu shown in Figure 3-9 will be presented and the *Laser Power* and the *Exposure time* can be chosen. Moving the highlight to either option will present a screen to select the desired value.

The Laser Power options are *Low*, *Medium* or *High* and the Exposure Time Options are 250 ms, 500 ms, 1 sec, 3 sec, 5 sec and 10 sec.

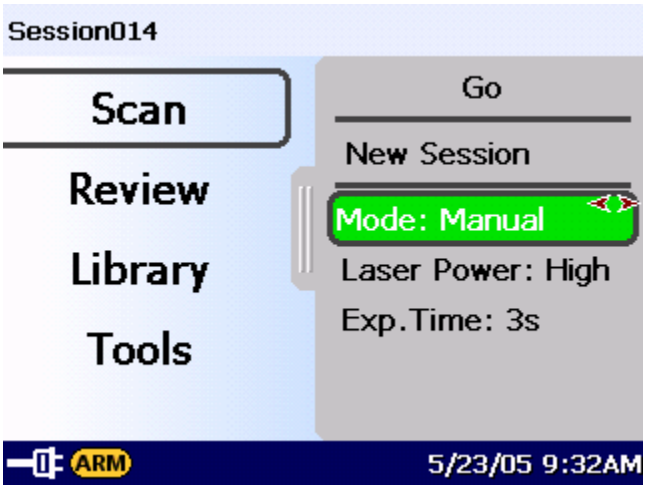


Figure 3-9: The Manual Mode Slide-In Menu

When the desired conditions are indicated, return the highlight to the **Go** command and press **Enter**.

NOTE: The red arrows in the mode box (Figure 3-7 and 3-9) indicate that the desired choice for this parameter can be made via the left or right arrow as an alternative to viewing the Option menu. Similar arrows are presented for the *Laser Power*, *Quality* and *Exp. Time* fields, when these fields are highlighted.

3.3.2 Performing the Scan

When the **Go** key is pressed, the data collection and analysis procedure will be initiated. The display will present the active scan screen (Figure 3-10).

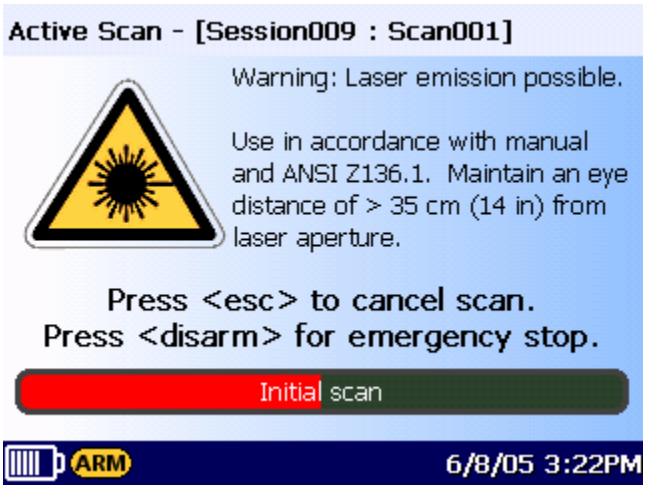


Figure 3-10: The Active Scan Screen

The progress bar on the bottom of the screen indicates the present operation with inset text, and its progress. The operations include:

a) Turn on Laser

b) Laser Read Wavelength

c) Initial Scan

d) Accumulating Data

The period of time required for the scan depends on the Quality parameter selected (Section 3.3.1) and the remaining time for the scan will be indicated on the screen.

After the data has been collected, the decision support software on First Defender will automatically analyze the collected scan. During this period, the display will present a series of screens similar to Figure 3-11

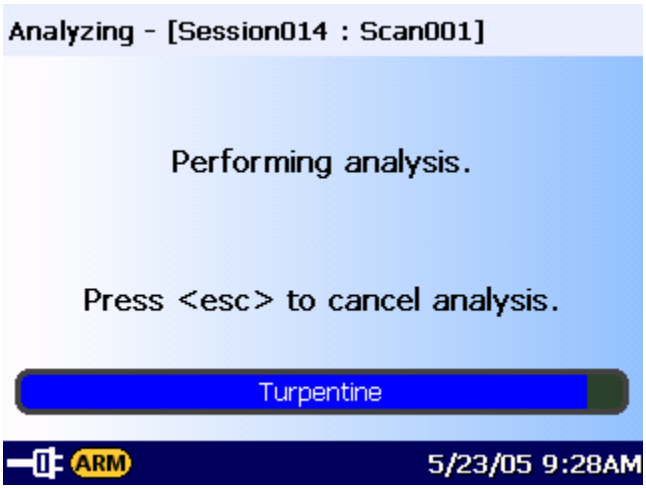


Figure 3-11: Performing Analysis Screen

When the decision support analysis is complete, the display will present a list of library records that are consistent with the Raman spectrum of the measured compound, along with the evidence (reported as a probability) favoring one library record versus another. In the case that only one library record constitutes a match for the measured sample, only that library record will be reported. An example of such a finding is shown in Figure 3-12.

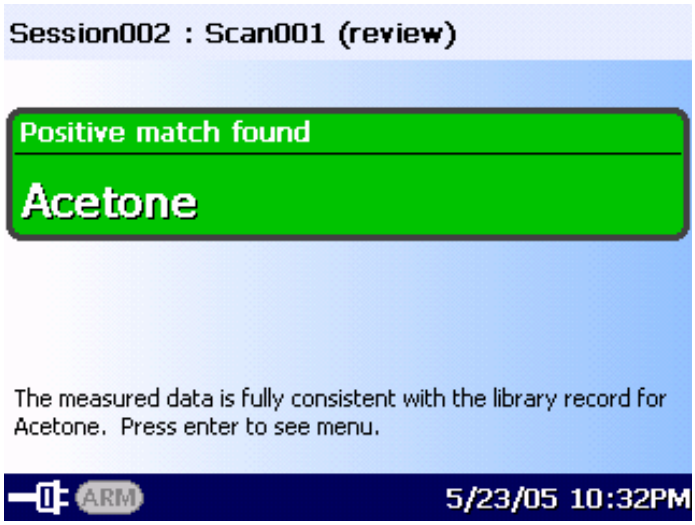


Figure 3-12: Match Report

If two (or more) plausible matches are found, they will all be listed in the *Positive match found* field. This does not imply the measured compound is a mixture of these library record materials, but rather that the measured Raman spectrum of the unknown material is highly similar to all of the individually listed library records, and the measurement material could be any of the listed materials.

In the advanced mode (to access Advanced Mode, see Section 3.6), the field will also indicate the evidence (presented as a probability) favoring each library record. The probabilities do not indicate concentrations.

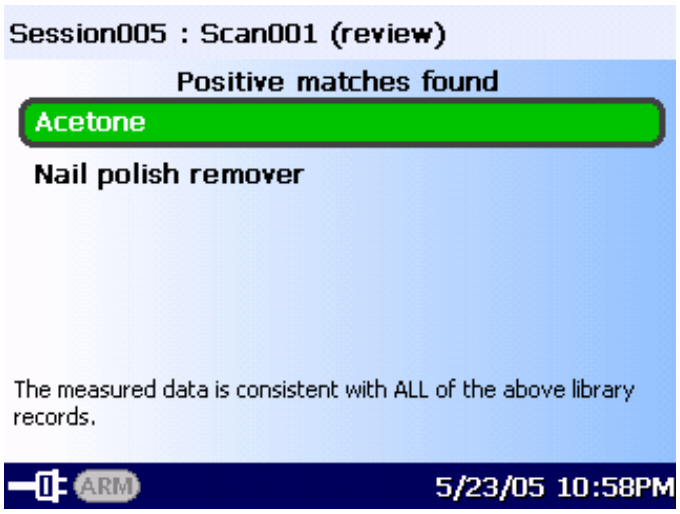


Figure 3-13: Multiple Positive Matches Report

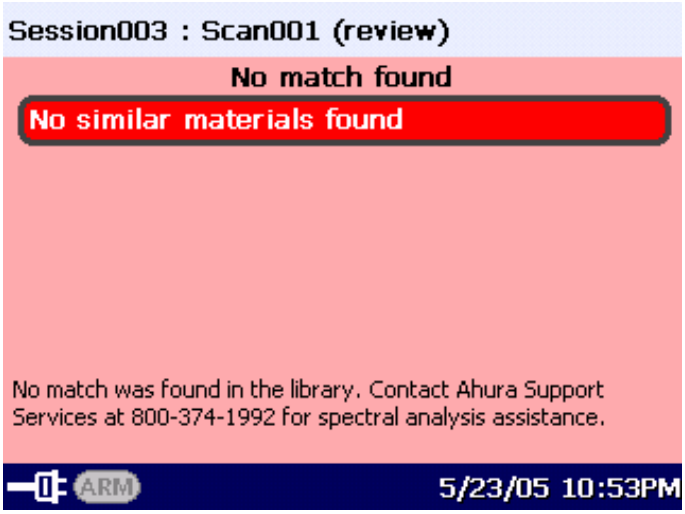


Figure 3-14: No Match Report

If the unit could not find any library records that, on their own, represent an exact match for the sample fingerprint, and if it could not find a mixture of library records that can explain the Raman sample spectrum, Figure 3-14 will be presented. In advanced mode (to access advanced mode, see Section 3.6), the First Defender will report library records that bear some spectral similarity to the Raman sample fingerprint. Oftentimes the sample may be in a similar class of compounds to the materials listed, but this is not universally the case. Ahura Support Services may be able to aid in identifying the sample.

You can find more information about the identified compound(s) by pressing the **Enter** key to access the slide-in screen (Figure 3-15), selecting the desired information type and pressing **Enter** again (if two or more compounds are listed on the report, use the up or down arrow to select the desired compound).

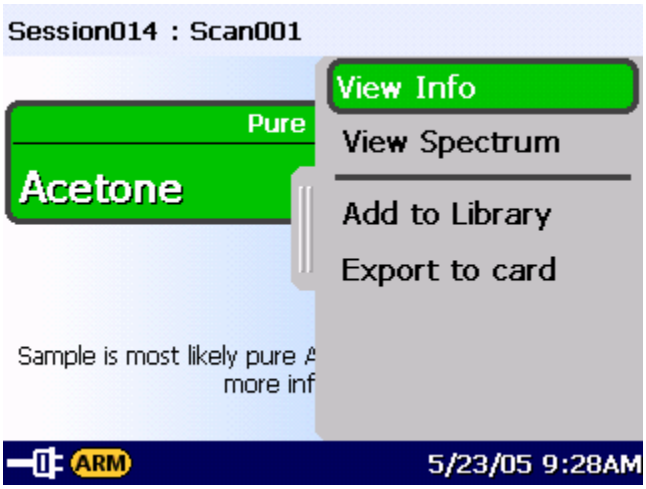


Figure 3-15: Scan Slide in Pane

a) View Info

The **View Info** option presents a screen (Figure 3-16) that provides additional information about the selected compound. Each of the tabs presents information of a different nature about the compound. Use the left and right arrow keys to navigate between tabs.

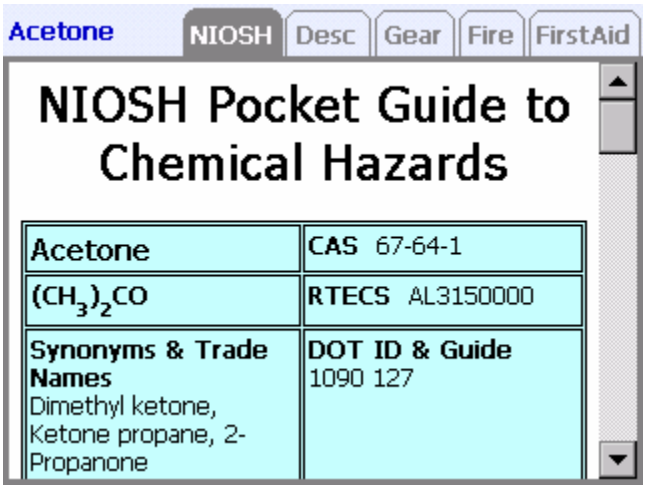


Figure 3-16: Information Screen

b) The **View Spectrum** option shows the spectrum of the compound (Black) and the reference spectrum (Red) (Figure 3-17).

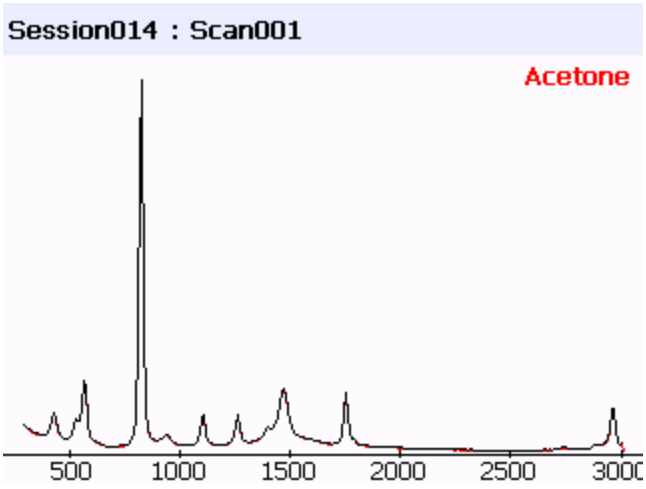


Figure 3-17: Comparison of Spectra

The scan screen has a slide-in menu (Figure 3-18) to allow greater flexibility in viewing the scan.

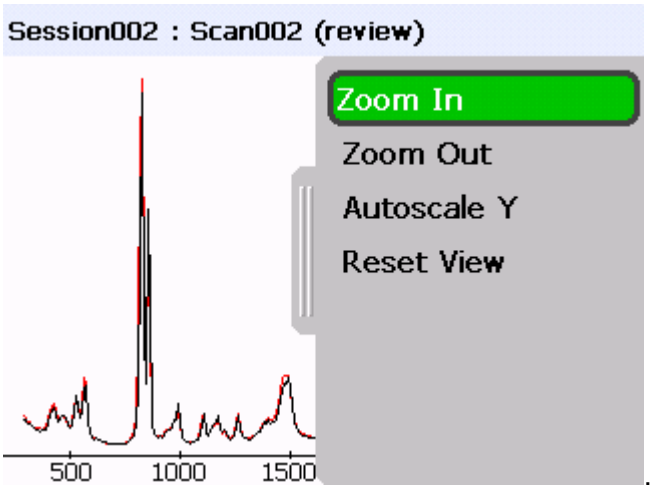


Figure 3-18: Scan Slide in Menu

The Zoom out command expands the spectrum (i.e. a smaller wavelength range is full scale on the display) and the zoom in command (i.e. a larger wavelength range is full scale on the display). Autoscale Y regenerates the plot so that the maximum peak is full scale.

c) Add to Library

The **Add to Library** option presents a screen that lets you select the name of the compound that you want to save. This screen is identical to Figure 3-6 (except that the title refers to the Library, instead of the Session).

d) Export to Card

The spectrum can be saved to the flash card. When the data is exported, the screen indicates the storage area (Figure 3-19).

Figure 3-19: Saving Spectrum

An error message will be presented if the flash card is not present, defective or filled.

3.4 The Review Menu

The *Review* menu is used to view data that has already been collected.

When this option is selected, a list of all sessions is presented (Figure 3-20).

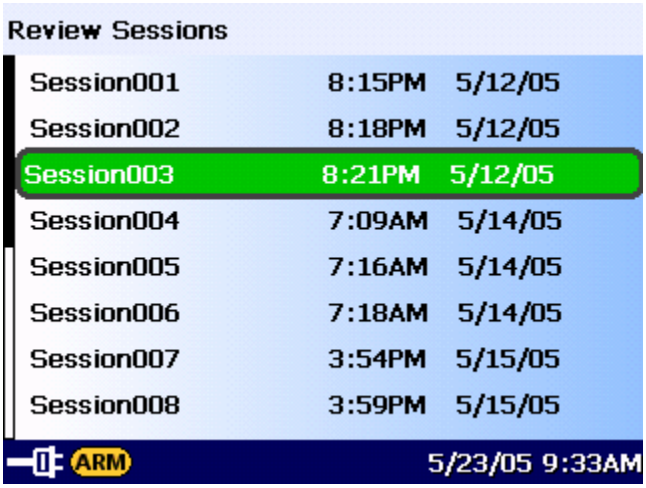


Figure 3-20: The Review Sessions screen

Use the up and down arrow key to select the desired session and press **Enter** to present a screen indicating the options for stored data (Figure 3-21).

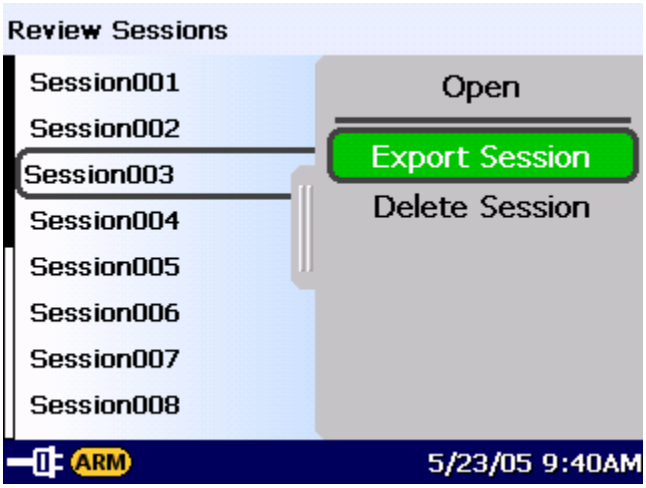


Figure 3-21: Review Options Tab

a) Open

Open presents a list of the scans in the session (Figure 3-22).

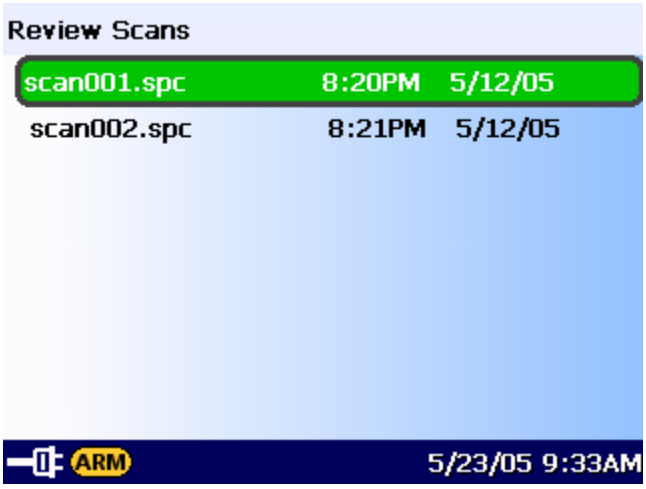


Figure 3-22: List of Scans in a Session

You can highlight a scan and view it (and related information) in the same manner as a newly collected scan. In addition, you can move it to the flash card, delete it, etc. as if it were a newly created scan.

b) Export Session

Exporting a session is identical to exporting a scan described in Section 3.3. A message will be presented indicating the number of scans that were exported.

c) Delete Session

When you indicate that you want to delete a session, the First Defender asks you to confirm the deletion.

3.5 Library

The Library selection presents a list of the compounds in the library (Figure 3-23).

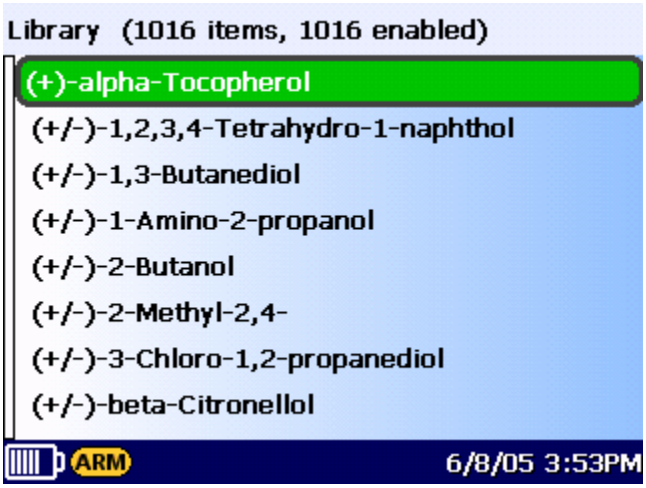


Figure 3-23: Library Screen

Press the **Enter** key to present the Library slide-in screen (Figure 3-24).

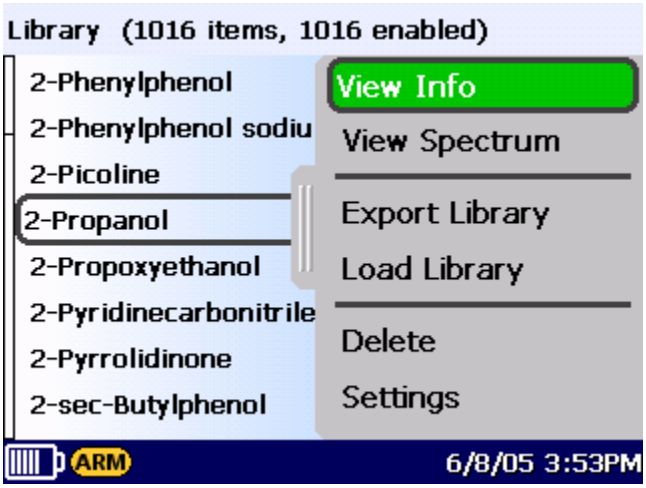


Figure 3-24: Library Slide In Screen

View Info and *View Spectrum* are same as for an identified compound.

Export Library, *Load Library* and *Delete* operate in the same manner as described for a session (Section 3.4).

Settings takes the user to the *Categories* selection screen (Figure 3-25); which allows the user to select which categories should be used to determine the match between the sample and the library. This feature is provided since in many cases, the operator already knows something about the sample, and can save time during analysis by not searching the entire library.

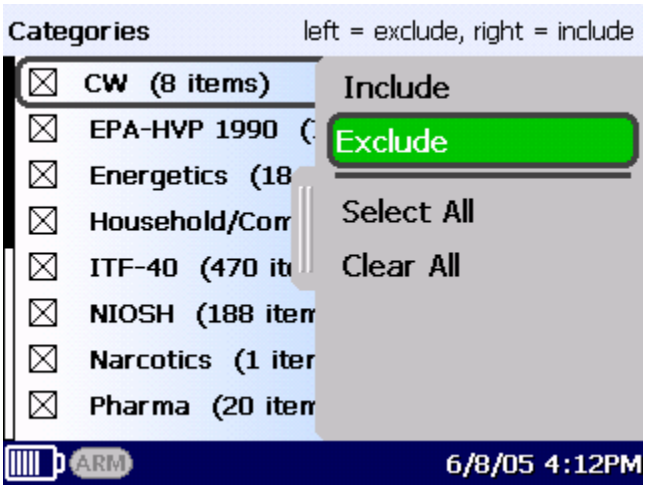


Figure 3-25: Categories Screens

To select (deselect) a category, place an X (remove the X) from the category on the left side of the screen and press Include (Exclude). When you have made your selections, press **Esc** to get back to the Library screen.

3.6 Tools

The Tools menu is used for configuration and for accessing the *Ahura Support* screen. When this menu is opened, three items are presented on the Slide-in menu, *System*, *Settings*, *Utilities*.

If desired, you can set the time and data via the *Settings* menu and you can switch between the normal mode and advanced mode via the *User* menu, which is accessed from the *Settings* menu.

The Ahura Support screen, which is accessed via the Support menu on the System menu, provides the serial number of the unit, as well as additional information which may be useful for troubleshooting assistance from Ahura.

4 Laser Usage

4.1 Overview

The First Defender is a rugged system that is designed to be used in the field for the rapid identification of unknown substances via Raman spectroscopy. A variety of sampling modes are provided, including the use of sample vials and a direct point and shoot mode so that the user can collect information about a broad range of samples.

This chapter discusses how the First Defender should be employed by the operator to optimize system performance and maximize user safety.

NOTE: The First Defender is specifically designed to be used in the field and is therefore considerably more rugged than a unit for a laboratory. However, the user should recognize that this is a precision instrument and should be treated with care. Abuse and mistreatment may lead to a degradation of performance or premature failure.

4.2 Safety Issues

While the First Defender includes a number of safety features to protect the user, a number of issues should be kept in mind to protect the operator.

CAUTION: Exposure to levels of laser energy above the maximum permissible exposure (MPE) can be harmful to the eye. The emitted energy must travel a minimum distance of 14" (35 cm) before its concentration is below the MPE for normal viewing. This distance is defined as the hazard zone. With proper use exposure to levels above the MPE can be avoided. Avoid exposure to the beam.

In the absence of a work place safety standard or requirements, users are referred to the American National Standard ANSI Z136.1 for the safe use of lasers or the International Standard IEC 60825-14 user's guide for guidance on identifying and controlling hazards associated with laser use. Use of

administrative controls, engineering controls, and/or laser safety glasses should be used to avoid exposure to laser radiation within the 14" (35 cm) hazard zone. If laser safety eyewear is used an optical density (OD) >2.8 is suggested. A protective laser shield has been additionally provided to further protect the operator from an exposure above the MPE. It is strongly recommended that this shield be used with the device.

CAUTION: Always aim the First Defender at the sample before you provide power to the laser and take care that the laser beam cannot enter the eye.

If the surface of the sample is reflective, it is possible that the laser beam may reflect off the sample and strike the user.

CAUTION: Dark colored materials (liquids and solids) will absorb heat (laser) energy and make them susceptible to being ignited by the unit. Examples of these materials include Explosives (Black Powder, Unstable T-N-T), Flammable Solids (Match Tips) and Light Sensitive Liquids (Organic Peroxides, Pyrophoric Liquids). IF ANY OF THESE MATERIALS ARE SUSPECTED, DO NOT USE THIS DEVICE TO MEASURE THEM! The use of small sample sizes and the lowest possible laser power is always recommended to limit the possible hazards.

Contacts are provided inside the battery compartment for interfacing an external interlock system with the First Defender using a standard Molex 50079-8000 connector. This panel is opened by turning the two quarter turn fasteners ¼ turn counterclockwise and the contact is shown in the upper left corner of Figure 4-1.

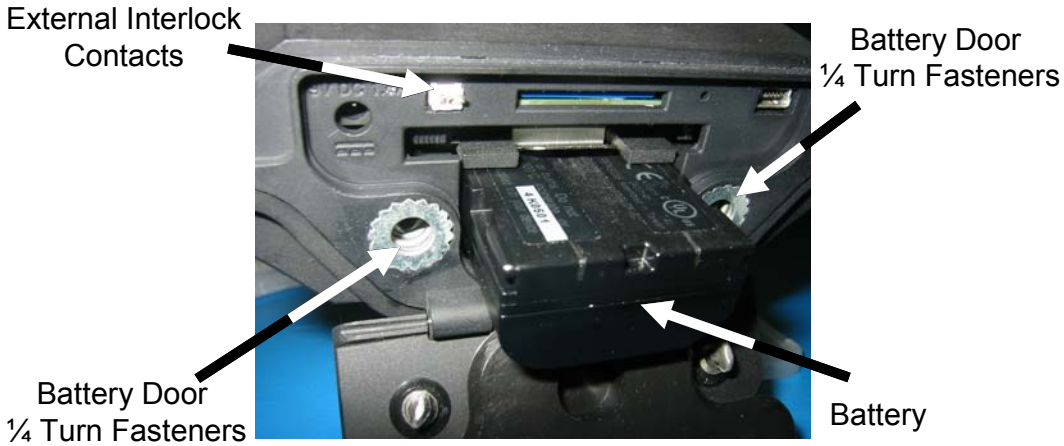


Figure 4-1: Battery Compartment

The battery compartment can be opened by the user. Aside from that, the user should not open the protective enclosure or modify any electronics contained in the First Defender unit as there are no user adjustable components inside the unit. All service operations must be performed by Ahura Corporation or an authorized service agent of Ahura Corporation.

4.3 Scanning Methods

The First Defender system provides two methods for scanning using the two laser apertures shown in Figure 4-2:

- The Laser head can be aimed directly at the sample. In this mode, the focus of the laser is at the tip of the cone and the position of the cone can be selected by the user.

a) For solids and for surface analysis, the nose cone should be at the outer (forward) position. A flat on the topside of the cone is visible in this position.

b) For liquids (e.g. in a bottle) and other cases where the light should go through a sample, the nose cone should be in the inner (rear) position. The flat on the topside of the cone is not visible in this position.

The cone position is determined by a series of detents on the housing of the unit.

The protective shield is provided to additionally protect the user from laser radiation. Take care that your line of sight is behind this shield. It can be removed for cleaning.

NOTE: If the sample is not homogenous, take care that the position of the laser head is kept constant during the collection of data for a given region. It may be necessary to make several scans of the different regions of the sample for a complete analysis.

- The sample can be placed in a 4 mL borosilicate vial and placed in the vial holder which can be accessed by opening the cover on the top face of the unit as shown in Figure 4-2.

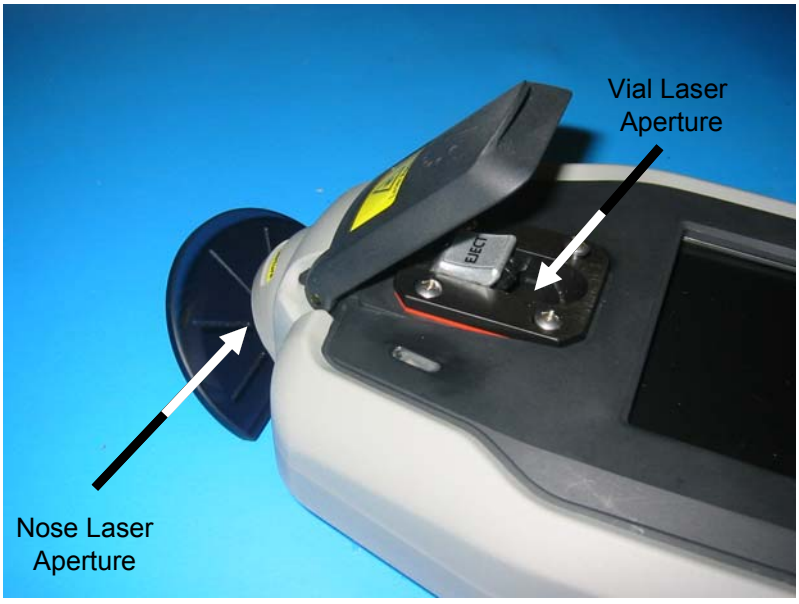


Figure 4-2: The Sample Vial Cover

When you place the sample vial in the First Defender, ensure that the vial is tightly in place and the sample vial cover is closed before measurement. When a vial is in place, the exterior laser emission feature is deactivated.

After you have collected the data, press the **Eject** button to release the sample.

NOTE: The eject mechanism is designed for the weight of a fully filled vial. Vials that are less full will be ejected with more force.

CAUTION: Always use the hand that is depressing the eject button to cover the vial as it is released to ensure against accidental spillage or breakage.

5 Maintenance

5.1 Cleaning Procedure

The First Defender is designed to require a minimum of maintenance activity. The user should keep the unit clean at all times. If the laser head becomes contaminated with sample, clean the lens and mount with a damp soft cloth and alcohol.

If the unit becomes contaminated or covered with external debris, a damp cloth saturated with water, household bleach, or alcohol can be used to wipe the exterior surfaces of the system.

In the event that the system becomes SEVERALLY contaminated with a toxic industrial chemical, a biological agent or chemical agent, follow the suggested procedure after checking with scene commanders:

a) Turn the unit off

b) If the unit is connected using the DC adapter, remove it and close the battery door so that the unit is sealed.

c) Immerse the system in a pan containing household bleach (5% Sodium Hypochlorite) for approximately 10 minutes to clean the unit.

d) Remove the system and place in a pan containing water for approximately 10 minutes to remove traces of bleach. It is important to remove all traces of bleach to avoid corrosion of fasteners and other hardware over time.

NOTE: There are no user serviceable components inside the system.

5.2 Recharging the Battery

The battery in the First Defender is a rechargeable battery and a battery charger is included. The typical battery will provide ~5 hours of use when fully charged.

The battery is charged, if installed, when the unit is operating using the DC wall plug adapter. Alternatively, the battery can be removed (as described in Section 5.3) from the First Defender for charging in the included stand alone battery charger.

It is recommended that the battery be kept fully charged at all times. A replacement battery should be kept on hand so that a fully charged battery is always available.

5.3 Replacing the Battery

To replace the battery:

a) Twist the two quarter-turn fasteners on the back of the First Defender by ¼ turn counterclockwise and remove the back cover to access the Utilities panel.

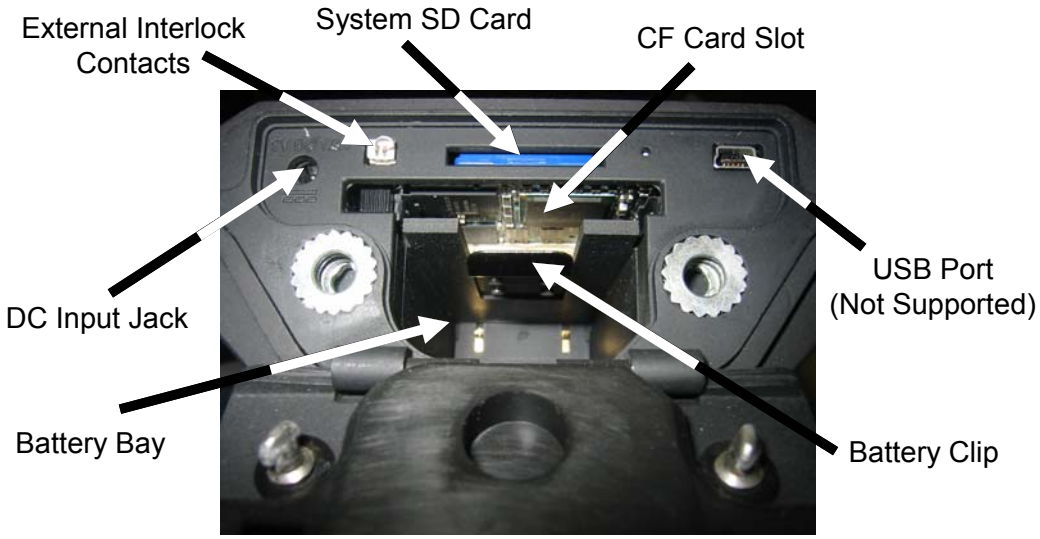


Figure 5-1: Battery Compartment

b) Press the metal clip above the battery up slightly on the battery to release the battery from the battery compartment.

c) Place the battery in the battery charger.

d) When the battery is fully charged, replace it in the First Defender. It should click into place. Replace the cover and twist the quarter-turn fasteners by turning ¼ turn clockwise. Do not overtighten the fasteners.

NOTE: If a significant period of time has elapsed between usages it is possible that the battery indicator on the display panel will indicate LOW or the display panel will not illuminate. If this occurs, replace the battery.

5.4 Installing + Removing the Compact Flash Card (CF)

A compact flash card can be used to transfer data to/from the First Defender unit. A flashcard reader can be used to download the information to a personal computer. To install the CF card, ensure the unit is awake and insert the card into the CF card slot contained in the battery compartment (Figure 5-1). The CF card should slide into position with the pin receptacle (holes) facing the inside of the unit and the raised lip on the opposite side of the card facing up toward the screen and keypad. It is important that the card is only inserted or removed while the unit is awake to ensure that the unit appropriately recognizes the flash card. To remove the CF card, press the square button to the left of the card (Figure 5-1).

CAUTION: The system SD card is not to be removed from the unit. This card is the storage flash for the system. Removal while power is applied to the unit (battery or DC jack) can result in system corruption.

5.5 Battery Operation vs. Line Operation

The battery compartment door (Figure 5-1) provides access to the battery and the jack for the DC wall plug adapter. This door is opened by turning the two quarter turn fasteners ¼ turn counterclockwise.

- Battery Mode - A 7.4 V battery which provides approximately 5 hours of use at room temperature. A battery charger is provided with the unit and it is recommended that a spare battery be fully charged to ensure that the unit is always ready.
- Line Voltage Mode - A transformer is provided which plugs into the DC power jack.

NOTE: The USB port is provided for factory/service use only. Interconnection of the First Defender to other systems is not supported.

5.6 Returning the First Defender to the Manufacturer

If it is necessary to return the First Defender to Ahura or your local Ahura distributor, please follow the following procedure:

a) Contact Ahura or your local Ahura distributor and request a return authorization (RA) number.

b) Decontaminate the system as described in Section 5.1.

NOTE: All units must be decontaminated before shipment to conform to safety and common carrier requirements.

c) Pack the First Defender securely and send to Ahura or your local Ahura distributor. Make certain that your return authorization number is written on the outside of the package.

NOTE: Packages that are not identified via the RA number will not be accepted by Ahura and be returned to the shipper unopened.

Appendix A Specifications

A.1 Optical Specifications

Principle of Operation	Raman Spectroscopy
Monochromator Spectral Range	781 nm - 1014 nm
Raman Spectrum Range	250cm^{-1} to 2875 cm^{-1}
Spectral Resolution	7 to 10.5 cm^{-}1 (FWHM) across range
Laser (excitation wavelength)	785 nm +/- 0.5 nm, 2 cm^{-1} linewidth
Laser Output	Settable, 50 mW, 150 mW, 300 mW
Rayleigh Rejection Filters	OD 7
Identifyor	Silicon CCD 2048 Pixels
Identification Mode	Direct Dispersive
Dispersion Mode	Single Pass Spectrometer (1200 groove/mm Blazed @ 900 nm)
Nose Collection Optics	NA= 0.33
Nose Beam Divergence	15 degrees half angle

A.2 Sampling Specifications

Sampling via Vials	Integrated 4 ml Vial Holder
Remote Mode	Point and Shoot, Sample Distance =18mm

A.3 Electronics and Data Processing Specifications

Computer	Built in single board computer
Calibration	Self Checks on Start up
Algorithm	Proprietary Chemometrics routines
Average Integration Time	Has an Auto feature that optimizes the data or manual mode which allows from 250ms to 10second integration time.
Library	CW's, ITF40 chemicals, Explosives, Toxics chemicals and Narcotics. User can add compounds to the library.
Software	Proprietary but the data can be exported into GRAMS™

A.4 Compliance

Safety Standards	UL-61010-1 and CSA C22.2 No. 61010-1 safety standards.
Laser Safety	Complies with FDA CDRH 1040.1 (Registration Number 0412714) and IEC60825
Emissions	FCC Part 15 Subpart B – Unintentional Radiators and ICES-003 Industry Canada Interference-Causing Equipment Standard-Digital Apparatus specifications. Unit has been tested to comply with 15.107 conducted emissions and 15.109 radiated emissions.

A.5 Environmental Considerations

Temperature	-20°C to +40°C
Pollution Degree	2
Maximum Altitude	Up to 2000 m
Enclosure Type	3R

NOTE: The enclosure is not intended to be exposed to the sun for extended periods.

A.6 Electrical Considerations

Power Supply	Internal 7.4 V Battery Pack DC Wall Adapter, 9 V 1.5 A
Battery Life	> 5 h at 25 °C, rechargable

A.7 Physical Considerations

Weight	<4 lbs (<1.8 kg)
Size	12” x 6” x 3” (30 cm x 15 cm x 7.6 cm)

A.8 MIL-STD-810F Tests Passed

Qualification Test	Detail	Condition
Mechanical Shock	MIL-STD-810F (516.5) Procedure I	Ground Equipment, 40g, 11ms, saw tooth
Vibration	MIL-STD-810F (514.5) Procedure I (Composite Wheeled Vehicle)	1 hour / axis, Category 20 - Composite Wheeled Vibration Exposure
Transit Shock (Drop)	MIL-STD-810F (516.5) Procedure IV	48” Drop onto plywood on concrete, all surfaces, edges and corners, 26 times
Humidity	MIL-STD-810F (507.4)	5X (48 hour) 60C & 95% RH
Sand & Dust	MIL-STD-810F (510.4) Procedure I	Blowing Dust
Thermal Shock	MIL-STD-810F (503.4) Procedure I	<1 min Transition -30 to +60C 1 day
Low Temp. (Operation)	MIL-STD-810F (502.4) Procedure II	-20C 1 day exposure following stabilization (Restrained Glass)
High Temp. (Operation)	MIL-STD-810F (501.4) Procedure II	35C 3-day soak following stabilization
High Temp. (Storage)	MIL-STD-810F (501.4) Procedure I	+60C 7 days exposure
Low Temp. (Storage)	MIL-STD-810F (502.4) Procedure I	-30C 1 day exposure
Immersion	MIL-STD-810F (512.4) Procedure I	30 min at 1 meter depth

Appendix B Spare Parts/ Replacement Parts

Table B-1 presents a list of spare and replacement parts which are available from Ahura Corporation or an authorized distributor.

Table B-1 Spare and Replacement Parts

Item	Part Number
First Defender Unit	800-00011-01
Battery	400-00291-01
Battery Charger	400-00301-01
User Manual	110-00001-01
Transformer	400-00711-01
Flash Card (512 MB)	400-00721-01
Case	490-00041-01

Vials compatible with the integrated holder can be purchased through Ahura Corporation or through VWR International (Part #: 66009-981).

Index