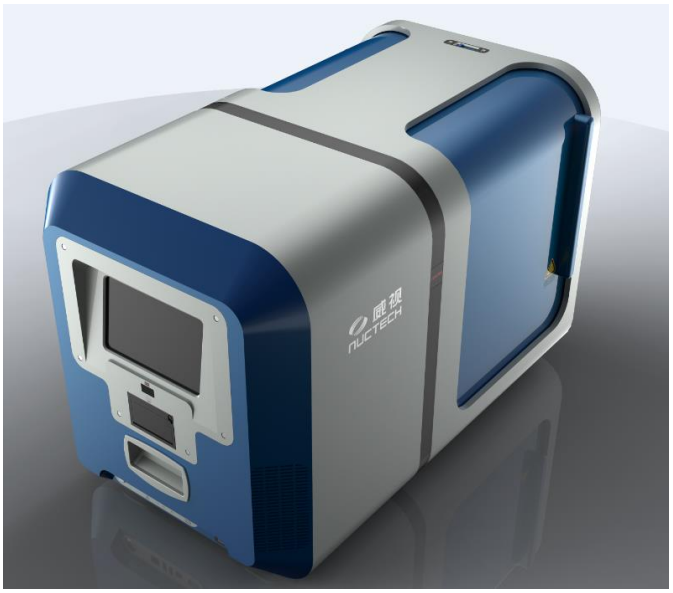
同方威视技术股份有限公司
NUCTECH COMPANY LIMITED

RT1003E Liquid Security Inspector

Concept of Operations

for ECAC LEDS Test



CONOPS RT1003E V3.1
Dated 2014-11-19

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1 Product profile

NUCTECH® RT1003E Raman Liquid Explosive Detection System (LEDS) has been designed and manufactured by Nuctech Company Limited for security inspection applications. This version has been specifically designed with the requirements of airport security lanes in mind since a single RT1003E can be located between, and accessed from, two adjacent lanes. In this application it meets the requirements of the ECAC Type B Liquid Explosive Detection Systems (LEDs)

The RT1003E uses Raman spectrum technology and identifies the material at the molecular level. RT1003E can analyse most dangerous materials in most types of container and identifies the threat material. The inspection process is simple, rapid (a few seconds) and the False Alarm Rate is very low. These characteristics make the RT100E very efficient in airports for security inspection of Liquids, Aerosols and Gels (LAGs).

RT1003E employs a two sided door to enclose the laser beam whilst providing easy access from either side. This means it can be used for between two security inspection channels and improving efficiency by minimising the distance the Security Staff have to move.

The outer appearance of the RT1003E is shown in Figure 1. Further details are shown in Figure 2 to Figure 5.

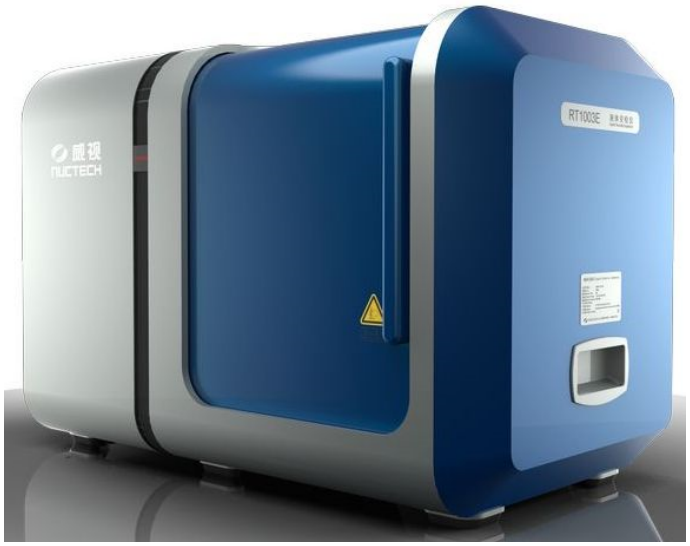


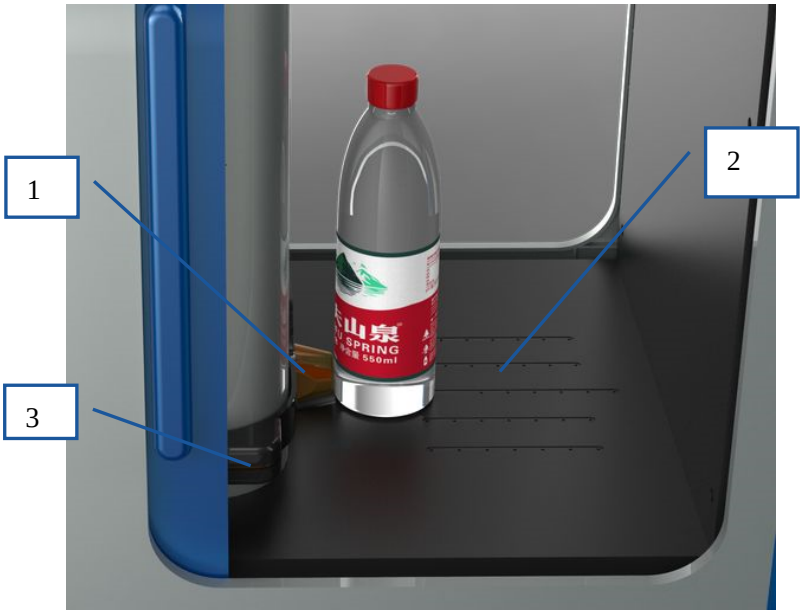
Figure 1 RT1003E's outer appearance

1 LCD touch screen, **2** Barcode scanner, **3** Printer

Figure 2 Operation Panel

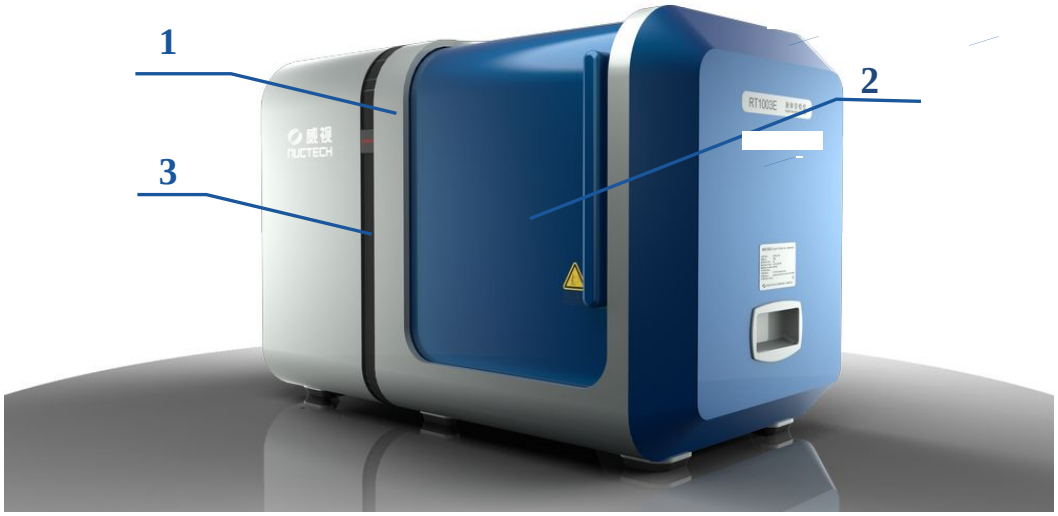
1 RJ45 network interface used for network transmission, **2** Type B USB interface used for equipment support, **3**Power cord, **4 2-off** Type A USB interfaces used to connect external USB devices such as a USB keyboard, mouse, or USB disk, **5** RS-232 interface used for peripherals such as a printer; **6** Power switch.

Figure 3 Communication Interfaces and power supply connections



1 Probe, **2** Platform where the substance to be inspected is placed, **3** Handle to adjust height

Figure 4 Inside of the sample chamber



1 Outer cover, **2** Inspection Chamber door; **3** Indicator light band

Figure 5 Outside of the sample chamber

The sample chamber comprises the optical probe, the height of which can be quickly and easily adjusted to suit various containers, and a protection cover / door, which are designed to ensure the safety of the Operator when the laser is active.

2 Technical characteristics

❒ RT1003E uses **Raman spectroscopy to analyse the material being examined**.

- The Raman spectrum of a material has 'unique fingerprint' type properties, and RT1003E assesses these to identify the material
- RT1003E provides **nondestructive inspection of the material** and does not destroy any of the material.
- With a **fast inspection throughput capability** the RT1003E can complete the analysis in a few seconds. The next inspection can be carried out without any recovery interval being required.
- Thanks to its' **capability and automatic spectrogram database updating function** RT1003E can inspect and analyze most common dangerous liquids, aerosols and gels and analyze their composition. It can automatically update the spectrogram database according to specific requirements of users to expand the inspection scope and enhance the range of materials it can identify.
- RT1003E provides a **user-friendly Operator interface** that comprises a 7-inch LCD touch display and software interfaces designed with ergonomic considerations as a key driver. It can store analysed data and has a wide range of data interface- options to export data and integrate with other devices.
- RT1003E does not use a **radioactive** or ionising source and is safe for Operators to use.

3 Technical principle

3.1 Technical theory of Raman spectroscopy

When a substance is irradiated, some of the scattered photons change their energy. This phenomenon is called inelastic scattering. It was first discovered by Indian physicist C.V. Raman in 1928 and was named Raman scattering. The energy change of the inelastic scattering depends on the molecular energy level of the irradiated substance. Different molecules have different rotational and vibrational energy levels, therefore, Raman spectrums have fingerprint properties, and molecules can be identified by analyzing the spectrum of Raman scattering light.

RT1003E has a large spectra library composed of Raman spectrum of dangerous liquids. When a substance is inspected, it is irradiated by laser light and the Raman spectrum is collected. Substances are identified by comparing their Raman spectra with those in the library.

The RT1003E's optical part comprises the following primary parts: (A) laser transmitter (B) external light path and (C) spectrometer.

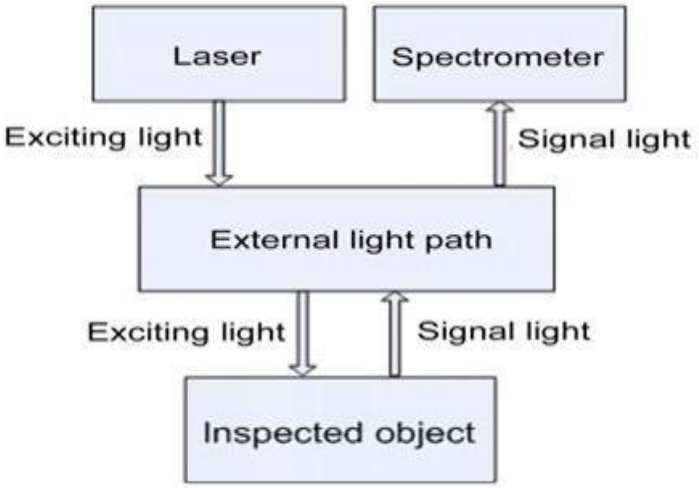


Figure 6 Optical part

The entire inspection process of RT1003E generally includes excitation, collection, optical filtering, spectrum splitting, examining and analyzing functions.

- **Excitation**:
  The laser transmitter emits laser light, which passes through the filter to remove the background radiation and is then focused on the substance to be examined.
- **Collection:**
  After the substance is irradiated, the incident photons are scattered by the molecules of the substance. The scattered light includes Rayleigh scattering whose wavelength is the same with that of the incident light and Raman scattering whose wavelength is different from that of the incident light. Part of the scattered light is collected by lens and collimated.
- **Optical Filtering:**
  The collected and collimated scattered light will pass through a specially coated lens which filters out the Rayleigh scattering. The Raman scattering will pass through the lens.
- **Spectrum splitting**:
  On entering the spectrometer, the filtered Raman scattering light is diffracted by the grating of the spectrometer into with different wavelengths which are received by different pixels of the Charge-coupled Device (CCD).
- **Examining and analyzing**:
  The CCD can turn optical signals into electronic signals. By analyzing electronic signal intensity on different pixels, the CCD can obtain the light signal intensity and then obtain the Raman spectrum of the substance. By comparing the peak position and intensity of the Raman spectrum collected with those of spectrums in the database, the device can analyze whether the substance is dangerous and which category it is.

3.2 Raman spectrums of common dangerous substances

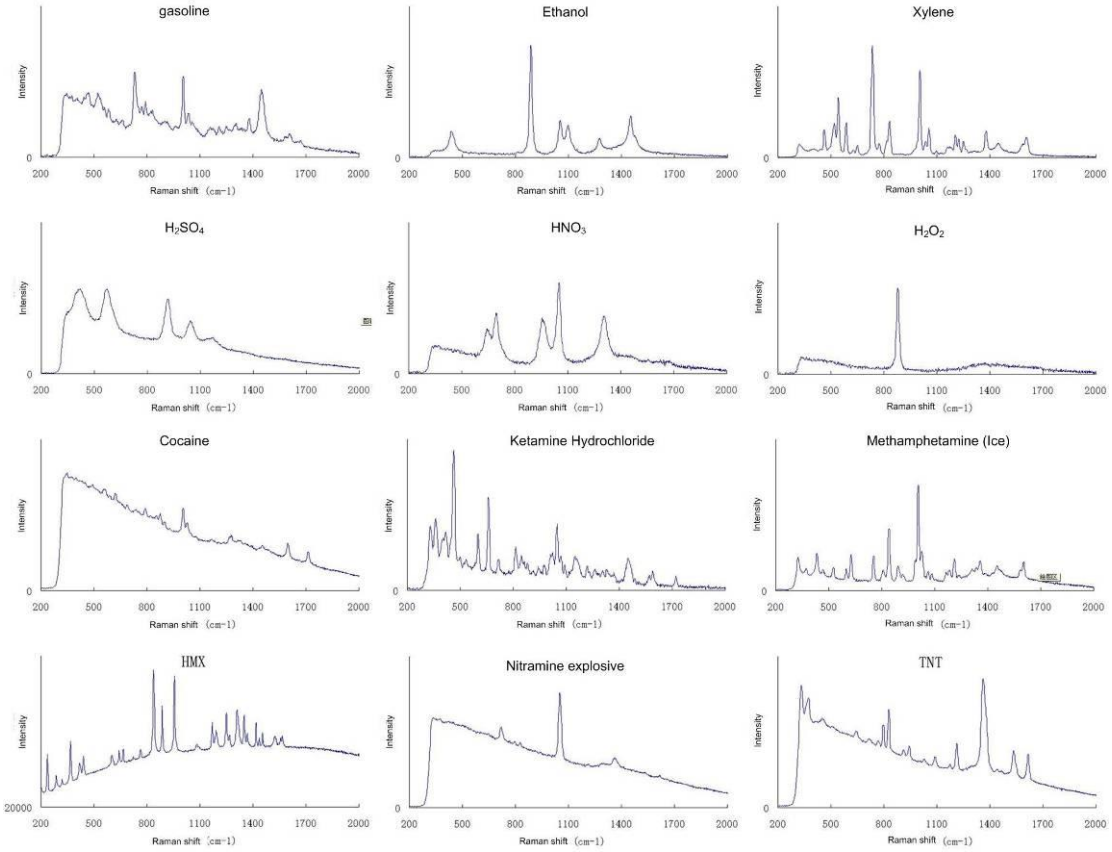


Figure 7 Raman spectrums of common dangerous substances (relative data, for explaining the theory only)

4 System structure and function

Overall the RT1003E can be considered as composing the optical module, the machine control subsystem and the Operator interface subsystem.

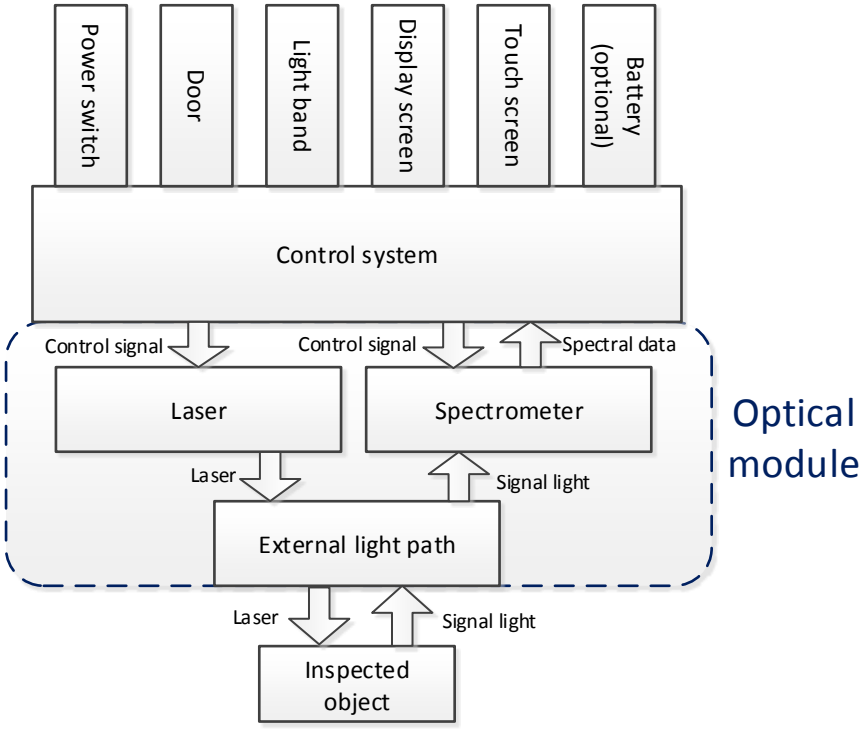


Figure 8 System structure and functions of inspection section

4.1 Optical module

The optical module is the critical part of RT1003E and is described above.

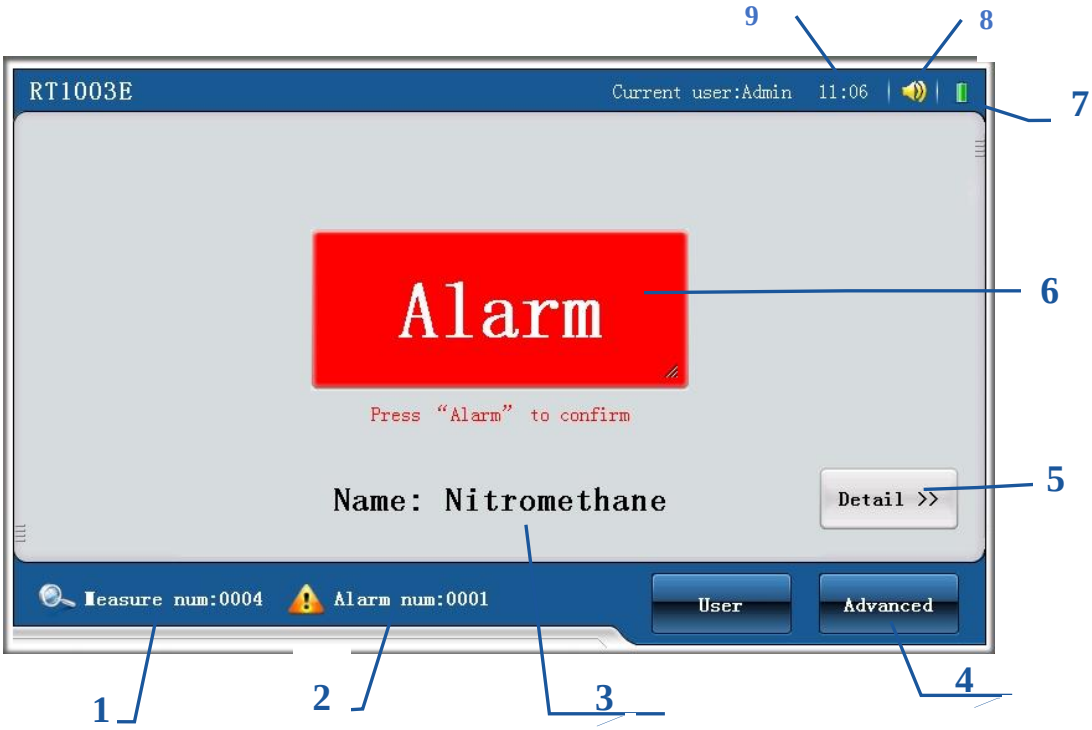
4.2 Control subsystem

The control subsystem has the following functions: supplying power for the laser transmitter and spectrometer; running the operating system and software; controlling the laser transmitter and spectrometer; collecting and analyzing spectrum signals from the spectrometer; controlling the touch display, indicator lights, buzzer and fans.

4.3 Operator interface subsystem

The subsystem is designed to provide the Operator-machine interaction, give warnings and send the user's operations on the touch display or alarm confirm button to the control subsystem.

The light band is used to indicate the result of the analysis. The LCD is also an important Operator-machine interface as it also gives the inspection results and show all prompts/additional information, as shown in Figure 9 (typical data).



1 Counter; **2** Alarm counter; **3** Inspect result name; **4** Advanced Function; **5** Detail Button; **6** Inspection result; **7** Battery status (option); **8** Buzzer; **9** Time

Figure 9 Software Interface

5 Operation Manual

5.1 Power on

As shown in Figure 10, insert the power line into the power socket. Turn on the RT1003E by pressing the power switch. The RT1003E will then perform a self-test.

Figure 10 Power supply and power switch

When the start-up process is finished, the equipment enters into the ready state, as shown in

Figure 11, and then an inspection can be performed.

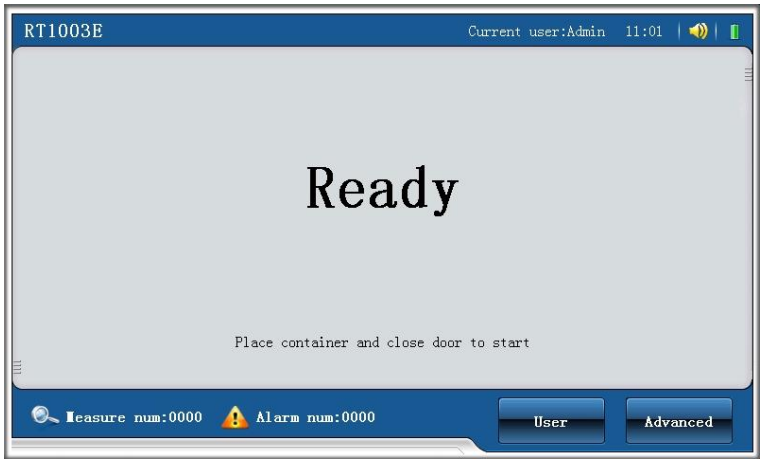


Figure 11 Ready state

5.2 Sample Inspection

In the ready state, an inspection process can be started by closing the door. The following step by step description will show you how the inspection is carried out.

a) Remove the package of the sample. Open the door and place the sample into the chamber.

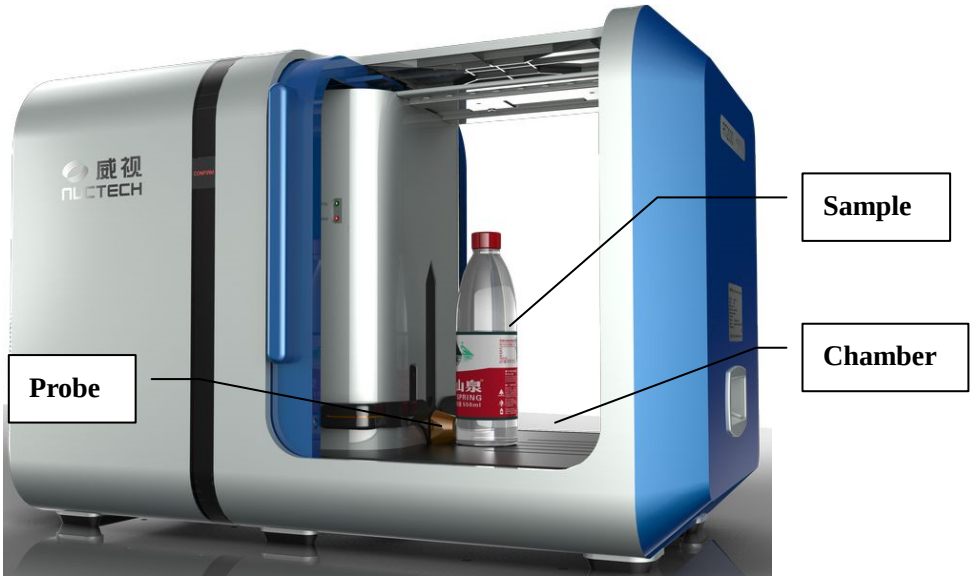


Figure 12 Place the sample into the chamber

b) Adjust the height of the probe to make sure the liquid in the bottle is being analysed. Adjust the sample to make sure the transparent part of the bottle pointing at and adhering to the probe (as shown in Figure 13), and the probe should under the liquid level. The probe should prevent pointing to the label, corner, embossed text or uneven surface of the inspected container.

Figure 13 Probe contacts the container at the liquid level

c) Close the door of the chamber to start the inspection process. After a few seconds, the inspection result will be given.

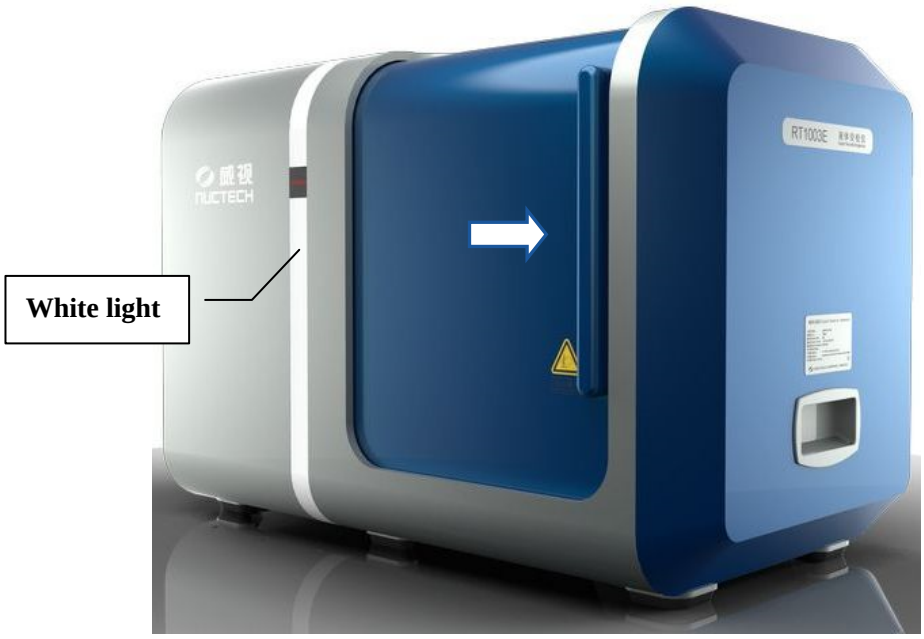


Figure 14 Close the door to start the inspection process

Note: 1) when the door is closed, the light band will turn white for one second to show that an inspection process is underway. During this process the door will be locked closed and should not be forcibly opened.

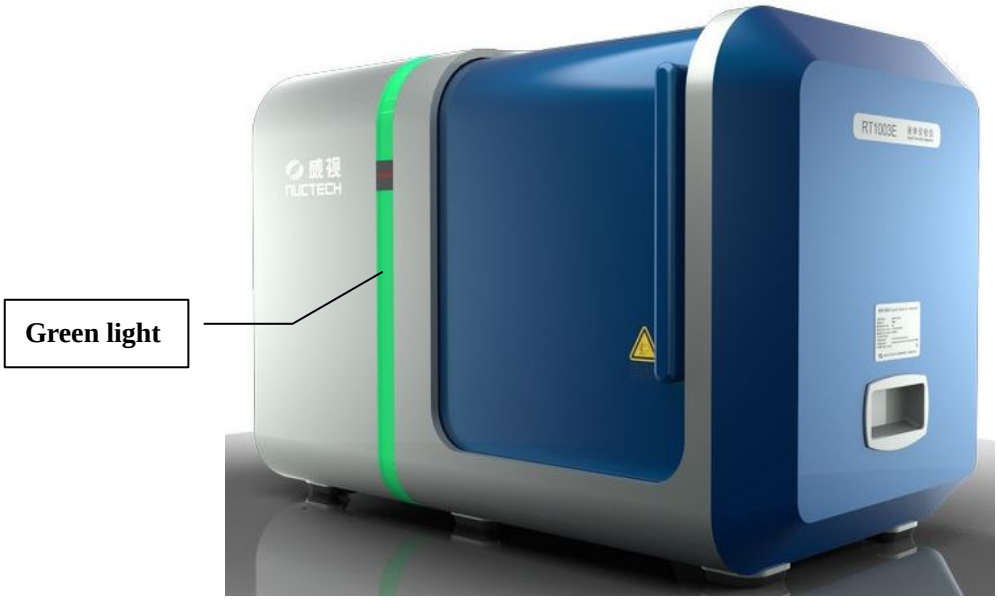
2) The equipment supply delay inspection function. If this function is enable, when close the door, the light band turns white for predefined time (meanwhile the LCD shows countdown) and then the inspection process starts. Configuring this function can be realized by successively clicking the "Advance" → "System management" → "Parameter" → "delay measurement" option. If the round button "Yes" is checked and the desired delay time is selected, clicking the "Save" button, this function will be active. If "No" is checked, the delay inspection function will be disable.

5.3 Inspection results

When the inspection process is finished, the inspection result will be given. There are three categories of results.

5.3.1 Clear

Green light band indicates the substance inspected is safe. Meanwhile, the LCD interface shows “Clear”. When the clear result is given, the door will unlock automatically and the operator can open it to remove the container and start the next inspection cycle.



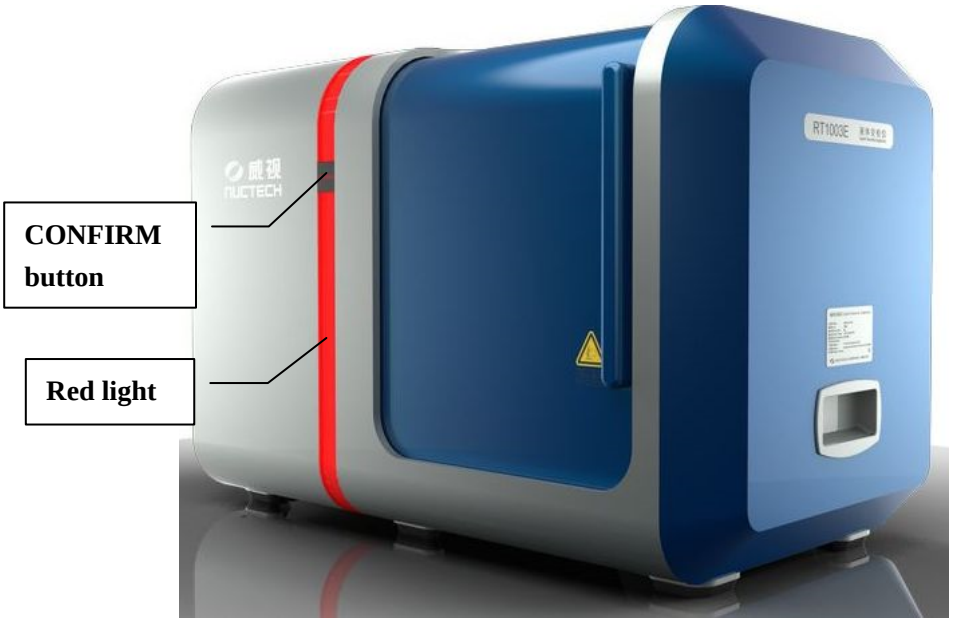
(a) Light band turns GREEN light for a SAFE result

(b) LCD interface shows the safe result

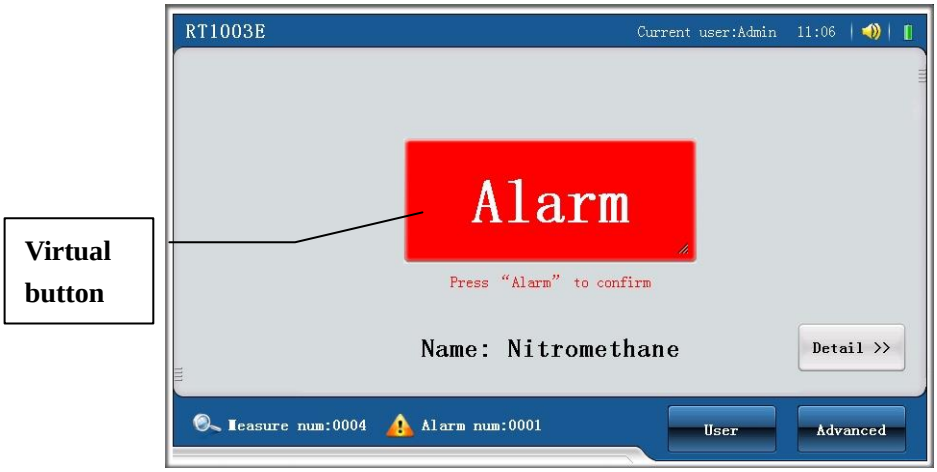
Figure 15 Clear result

5.3.2 Alarm

Red light band indicates the substance inspected has been identified as potentially dangerous. In addition the LCD screen displays **"Alarm"**.



(a) Light band turns RED light for a potentially 'dangerous' result



(b) LCD interface shows the dangerous result

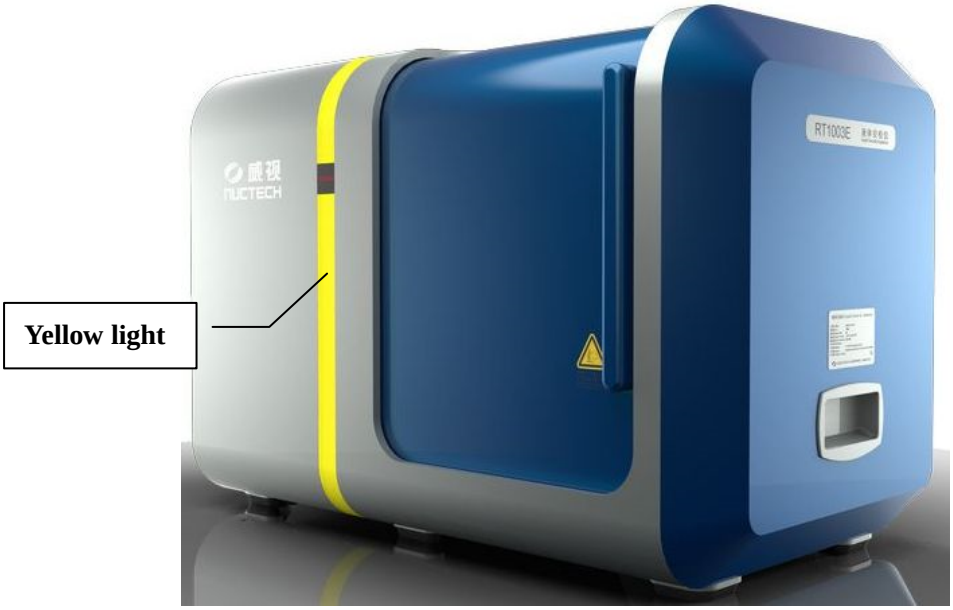
Figure16 Alarm result

Note: When the Alarm result is given, the operator has to press the "CONFIRM" button (shown in Figure 16(a)) or click the "Alarm" virtual button in the screen (shown in Figure 16(b)) to confirm the alarm state has been noted. The door will then open slightly to allow for the container to be remove, and the machine returns to the Ready state to prepare for the next inspection.

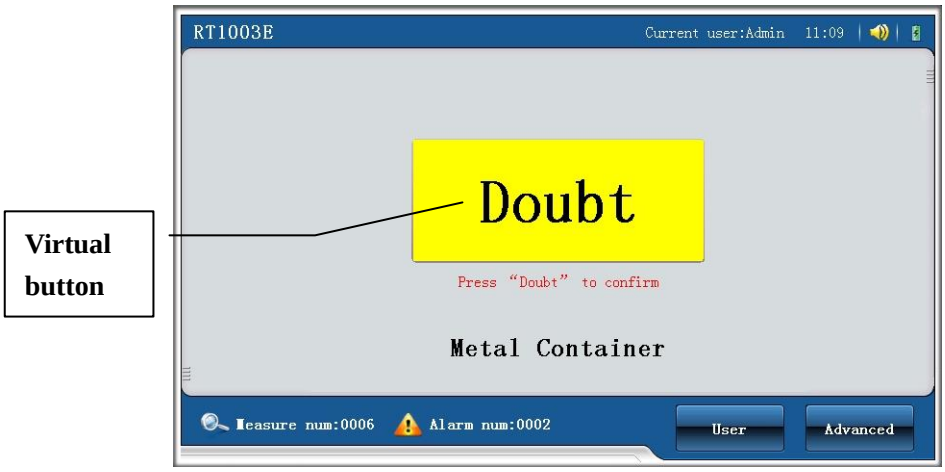
5.3.3 Doubt

If metal container is inspected, the light band turns yellow and the screen will display **"Doubt"**. It indicates that the substance cannot be inspected correctly by the RT1003E and the

airport should follow its' defined procedure for these items. When the Doubt result is given, the operator has to press the “CONFIRM” button (shown in Figure 16(a)) or click the “Doubt” virtual button in the screen (shown in Figure 17(b)) to confirm the 'doubt' state has been noted. In that case, the substance inspected should be considered to be dangerous and the inspected result should be classed into **Alarm**.



(a) Light band turns YELLOW light for a 'doubt' result



(b) LCD interface shows the doubt result

Figure 17 Doubt Interface

5.4 Power Off

Press the power switch to power off the device.

6 Routine Care and Maintenance

Equipment verification

In the startup process to calibrate the RT 1003E place the verification sample into the chamber (Figure 18) and follow the prompts shown in the LCD (Figure 19) to complete the verification process.

During the running process, the equipment also requires to be verified at predefined intervals in order to keep the performance. In this case, the light band will twinkle blue light to urge the user to operate following the prompt shown in the LCD interface.

Figure 18 Place the verification sample into the chamber

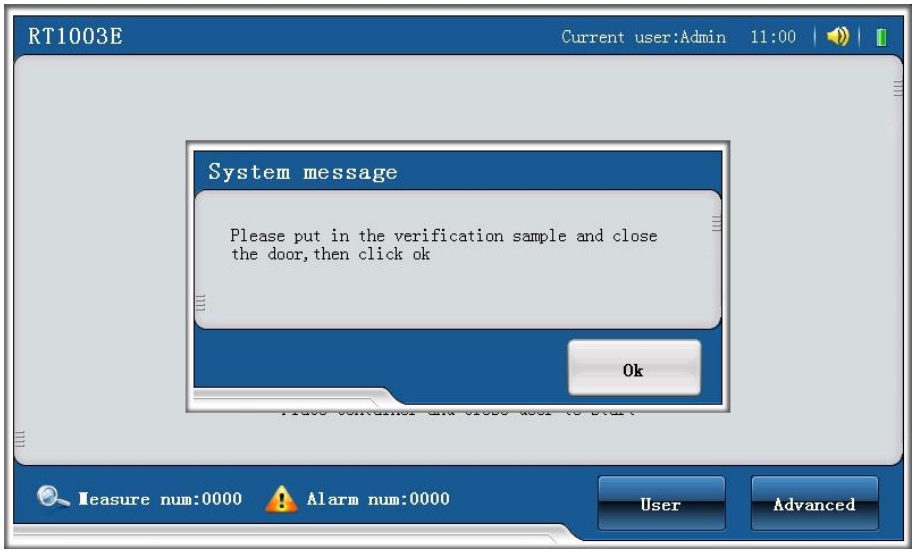


Figure 19 Prompt for the verification process

If the verification is carried out successfully, “Normal device” will be shown if the device is normal (as shown in Figure 20). In that case, press “OK” buttons and the ready interface will appear (as shown in Figure 11). The RT1003E is then ready for use.

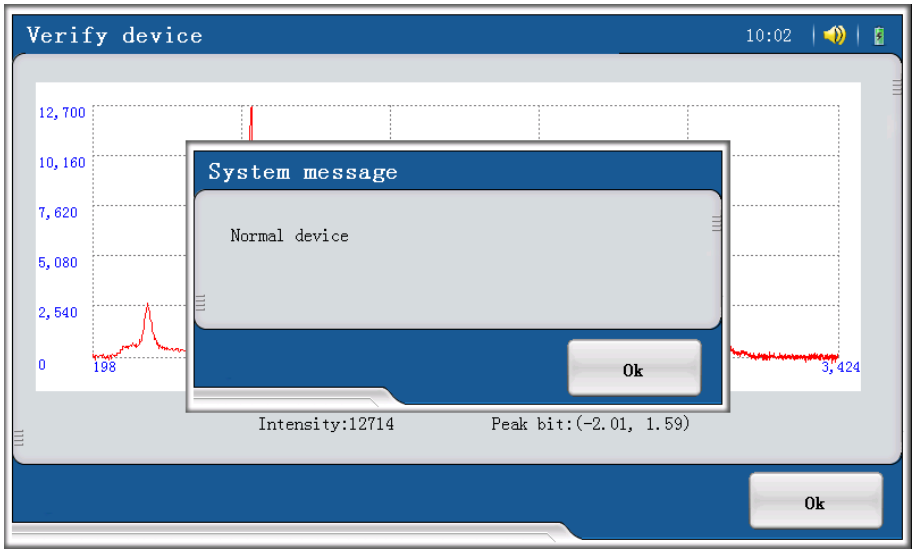


Figure 20 Normal verification interface

If there is a requirement to check the performance of the RT1003E at any time this can be done using the Advance Function Interface as follows:

1, In the "Ready" interface, click the "Advance" button to go to Advanced Function Interface,

2, Click "System management" button,

3, Select "Maintenance" interface, and click "verification" button,

4, Place the verification sample in correct position, and close the door, click "OK" button in the LCD interface.

If the equipment fails to pass the verification and the software prompts the necessity of calibration, please calibrate the equipment properly.

RT1003E Calibration

If it is necessary to calibrate the equipment using the calibration sample follow the following steps:

1, In the "Ready" interface, click the "Advance" button to go to Advanced Function Interface,

2, Click "System management" button,

3, Select "Maintenance" interface, and click "calibration" button,

4, Place the calibration sample in correct position, close the door and click "OK" button.

Clean the window

It is possible that dust or dirt will collect in the light window of the probe during the running of the equipment. The dust or dirt can affect the intensity of optical signals and hence the performance of the RT1003E. Periodically clean the window using lens paper or cotton swabs dipped with ethanol.

Check whether the system time is correct

If the system time is incorrect, reset the time. Then Check the time after restarting the equipment. If the time is still incorrect, please contact the vendor.

7 Points of note

- When the door is closed and the inspection process is in progress (shown by the light band being white), the door should not be opened. If it is opened during the inspection process, the light band will twinkle blue light and the LCD interface simultaneously shows that the scan process is interrupted incorrectly. In this case, please close the door again to restart the inspection process.
- The surface of the verification sample bottle should be kept clean. Otherwise the verification may fail. If the verification fails, please adjust the location of the bottle of the verification sample, clear its surface or the probe lens, and then verify again following the prompt in the display interface.
- When an 'alarm' or 'doubt' result is given, please press the confirm button or the virtual confirm button in the display interface and should not open the door forcedly without confirming. Otherwise the light band will twinkle red or yellow light. In this case, please close the door again to restart the inspection process.
- In the inspection process, it is important to ensure that the probe is set at a height below the top of the liquid in the container and at a transparent part of the bottle with the bottle touching the probe.
- Do not place items on the top of the equipment.
- If any other exceptions are notified on the Operator screen, please following the prompts in the display interface.

8 Precautions

- AVOID TRAPPING A HAND WHEN CLOSING THE DOOR.
- DO NOT ALLOW LIQUID TO ENTER INTO THE EQUIPMENT.
- DO NOT MOVE THE EQUIPMENT WHEN IT IS POWERED ON.

9 Product configuration

9.1 Standard configuration

Item	Quantity	Unit
Inspection section	1	Set
Power supply line	1	Set
Instrument container	1	Set
Verification sample	1	Bottle
Calibration sample	1	Bottle
User manual	1	Copy

9.2 Optional accessories

- ❒ Sample bottle
- ❒ Disposable siphon

10 RT1003E's technical specification

Item	Indicators and parameters
Technology	Raman spectroscopy
Library	Users can add new categories into the database if needed.
Inspection time	〈8s (typically)
Startup time	〈60s
Data storage	25,000 copies of data, supporting backup through USB and Ethernet.
Computer interface	USB/Ethernet
Size	755mm (length)×415mm (width)×491mm(height)
Weight	22kg
Power supply	L/N AC 110V/220V 50Hz/60Hz 50W
Storage temperature	-20°C - +55°C
Operating temperature	0°C - +40°C