



Handheld Raman Spectrometers

Market Survey Report

March 2021



Homeland
Security

Science and Technology





The *Handheld Raman Spectrometers Market Survey Report* was prepared by the Pacific Northwest National Laboratory (PNNL) for the U.S. Department of Homeland Security, Science and Technology Directorate, National Urban Security Technology Laboratory.

The *Handheld Raman Spectrometers Market Survey Report* is funded under Interagency Agreement No. 70RSAT18KPM000187 from the U.S. Department of Homeland Security, Science and Technology Directorate.

The views and opinions of authors expressed herein do not necessarily reflect those of the U.S. Government.

Reference herein to any specific commercial products, processes, or services by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government.

The information and statements contained herein shall not be used for the purposes of advertising, nor to imply the endorsement or recommendation of the U.S. Government.

With respect to documentation contained herein, neither the U.S. Government nor any of its employees make any warranty, express or implied, including but not limited to the warranties of merchantability and fitness for a particular purpose. Further, neither the U.S. Government nor any of its employees assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed; nor do they represent that its use would not infringe privately owned rights.

The cover photo was provided by PNNL. Product images included herein were used with permission from the respective manufacturers and vendors, unless otherwise noted.

FOREWORD

The National Urban Security Technology Laboratory (NUSTL) is a federal laboratory organized within the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T). Located in New York City, NUSTL is the only national laboratory focused exclusively on supporting the capabilities of state and local first responders to address the homeland security mission. The laboratory provides first responders with the necessary services, products, and tools to prevent, protect against, mitigate, respond to, and recover from homeland security threats and events.

NUSTL manages the System Assessment and Validation for Emergency Responders (SAVER) Program, which conducts objective assessments and validations on commercially available equipment and systems and develops knowledge products that provide relevant equipment information to the emergency responder community. The SAVER Program mission includes:

- Conducting impartial, practitioner-relevant, operationally oriented assessments and validations of emergency response equipment.
- Providing information, in the form of knowledge products, that enables decision-makers and responders to better select, procure, use and maintain emergency response equipment.

SAVER Program knowledge products provide information on equipment that falls under the categories listed in the DHS Authorized Equipment List (AEL), focusing primarily on two main questions for the responder community: “What equipment is available?” and “How does it perform?” These knowledge products are shared nationally with the responder community, providing a life- and cost-saving asset to DHS, as well as to federal, state, and local responders.

NUSTL is responsible for all SAVER activities, including selecting and prioritizing program topics, developing SAVER knowledge products, coordinating with other organizations, and ensuring flexibility and responsiveness to first responder requirements.

NUSTL provides expertise and analysis on a wide range of key subject areas, including chemical, biological, radiological, nuclear and explosive weapons detection; emergency response and recovery; and related equipment, instrumentation, and technologies. In support of this tasking, the *Handheld Raman Spectrometers Market Survey Report* was prepared by the Pacific Northwest National Laboratory (PNNL) under contract with DHS S&T, National Urban Security Technology Laboratory. This equipment falls under AEL reference numbers titled “07CD-01-DPRS - Detector, Raman Spectroscopy, Point,” and “07ED-01-LASR - Detector, Explosive, Laser-Based”

Visit the SAVER website at www.dhs.gov/science-and-technology/SAVER for more information on the SAVER Program, or to view additional reports on spectroscopy and other technologies. Visit the NUSTL website at www.dhs.gov/science-and-technology/national-urban-security-technology-laboratory, or contact NUSTL@hq.dhs.gov for more information.





POINTS OF CONTACT

National Urban Security Technology Laboratory (NUSTL)
U.S. Department of Homeland Security
Science and Technology Directorate
201 Varick Street
New York, NY 10014
Email: NUSTL@hq.dhs.gov
Website: www.dhs.gov/science-and-technology/saver

Authors:
John Kada, Chemist
Joseph Jankovic, Test Engineer

TECHNICAL AGENT

Pacific Northwest National Laboratory
790 6th Street
Richland, WA 99352
Email: saver@pnnl.gov

Authors:
Ashley Bradley, Biomedical Scientist
Angie Melville, Chemist II
Jonathan Forman, Technical Advisor
Carlos Fraga, Senior Research Scientist
Shane Addleman, Chemist IV
Rich Ozanich, Technical Advisor



EXECUTIVE SUMMARY

Handheld Raman spectrometers are field-portable instruments that provide emergency responders with the ability to nondestructively analyze unknown powders and liquids without making physical contact with them. During hazardous materials (HAZMAT) operations, handheld Raman spectrometers are used to chemically identify unknown solids or liquids so that responders can safely handle and dispose of materials that pose a threat to responders on the scene or to the general public. These instruments typically have spectral libraries allowing for the identification of explosives, fuels, synthetic and prescription drugs, cutting agents, chemical warfare agents, toxic industrial chemicals, common household chemicals, and narcotics, including fentanyl.

Between January 2020 and September 2020, Pacific Northwest National Laboratories (PNNL) and the National Urban Security Technology Laboratory (NUSTL) conducted a market survey of commercially available handheld Raman spectrometers for the Systems Assessment and Validation for Emergency Responders (SAVER) Program. The survey identified 21 instruments produced by 13 different manufacturers, varying in size, capabilities, and cost. This report provides information obtained through this market survey effort, with a focus on features relevant to use by responders in the field including size, weight, laser wavelength, operating time on battery power, connectivity for data export, ambient operating temperature range, and water and dust resistance. A summary table is provided to allow readers to quickly compare the different instruments with respect to these features, and individual descriptions of each instrument provide further detail by providing information about spectrum libraries, accessories, instrument prices, warranties and availability of technical support.

The purpose of this market survey is to provide emergency responders with information that will guide emergency response agencies in making operational and procurement decisions. When making procurement decisions, emergency response agencies should carefully research the overall capabilities, limitations, and technical specifications of each product in relation to their agency's operational needs. Information included in this report has not been independently verified by NUSTL or PNNL.



TABLE OF CONTENTS

1.0 Introduction.....	1
2.0 Raman Spectroscopy Overview	2
2.1 Components of a Handheld Raman Spectrometer.....	3
2.2 Benefits of Raman Spectroscopy	5
2.3 Limitations of Raman Spectroscopy	5
2.4 Standards Applicable to Handheld Raman Spectrometers.....	6
2.4.1 Ingress Protection Ratings.....	6
2.4.2 MIL-STD-810.....	6
3.0 Product Information	7
3.1 Agilent Resolve	10
3.2 Agiltron Pinpointer (PIN-785).....	10
3.3 Anton Paar Cora 100	11
3.4 B&W Tek (a Metrohm Group Company).....	11
3.4.1 TacticID-1064.....	11
3.4.2 TacticID-GP Plus	12
3.4.3 TacticID-N Plus	12
3.5 Bruker Bravo	13
3.6 Chemring PGR-1064	13
3.7 Environics 100 ID	14
3.8 Field Forensics HandyRam II	14
3.9 Metrohm Mira DS	15
3.10 Pendar X10.....	15
3.11 Rigaku	16
3.11.1 Progeny ResQ.....	16
3.11.2 ResQ CQL.....	16
3.11.3 Progeny ResQ FLX.....	17
3.12 Serstech 100 Indicator.....	18
3.13 Smiths Detection ACE-ID	18
3.14 Thermo Scientific	19
3.14.1 FirstDefender RM/RMX	19
3.14.2 Gemini	19
3.14.3 TruNarc	20
4.0 Manufacturer or Vendor Contact Information	21
5.0 Summary	22
6.0 References.....	23



LIST OF FIGURES

Figure 2-1 Diagram of a Typical Raman System	2
Figure 2-2 Example Raman Spectra	4
Figure 3-1 Agilent Resolve	10
Figure 3-2 Agiltron Pinpointer	10
Figure 3-3 Anton Paar Cora 100	11
Figure 3-4 B&W Tek TactiID-1064	11
Figure 3-5 B&W Tek TactiID-GP Plus	12
Figure 3-6 B&W Tek TactiID-N Plus	12
Figure 3-7 Bruker Bravo	13
Figure 3-8 Chemring PGR-1064	13
Figure 3-9 Environics 100 ID	14
Figure 3-10 Field Forensics HandyRam II	14
Figure 3-11 Metrohm Mira DS	15
Figure 3-12 Pendar X10	15
Figure 3-13 Rigaku Progeny ResQ	16
Figure 3-14 Rigaku ResQ CQL	16
Figure 3-15 Rigaku Progeny ResQ FLX	17
Figure 3-16 Serstech 100 Indicator	18
Figure 3-17 Smiths Detection ACE-ID	18
Figure 3-18 Thermo Scientific FirstDefender RM and RMX	19
Figure 3-19 Thermo Scientific Gemini	19
Figure 3-20 Thermo Scientific TruNarc	20

LIST OF TABLES

Table 2-1 Common Functional Groups and their Frequencies	3
Table 3-1 Handheld Raman Spectrometer Product Comparison	8
Table 4-1 Manufacturer and Vender Information	21



1.0 INTRODUCTION

Raman spectroscopy and Fourier transform infrared (FTIR) spectroscopy are two techniques that analyze the unique interactions between light and a material to aid in identification of various substances for law enforcement and emergency response missions. Each method provides information useful for the identification of unknown substances. Raman provides information about a chemical structure's molecular backbone while FTIR can identify functional groups of atoms within a chemical structure. Both technologies use spectral libraries to compare unique features captured by Raman and/or FTIR spectrometers to determine potential matches between the unknown sample and reference spectra in the library. Typically, spectral matching algorithms provide a list of potential matches ranked by their molecular similarities.

Raman and FTIR spectroscopy are considered complimentary and are both used in law enforcement and emergency response applications. These techniques can be used together to achieve a broader range of identification for unknown substances including liquid and solid samples. The systems have spectral libraries allowing for the identification of explosives, fuels, synthetic and prescription drugs, cutting agents, chemical warfare agents, toxic industrial chemicals, common household chemicals, and narcotics, including fentanyl. Handheld systems are smaller, easier to use, and much less costly than laboratory-based Raman instruments. These products provide rapid identification of potentially hazardous materials without destruction of the sample and with minimal to no sample manipulation or preparation.

2.0 RAMAN SPECTROSCOPY OVERVIEW

As light interacts with a material, it can be transmitted, reflected, absorbed, or scattered. Raman spectroscopy utilizes scattered light to identify chemical compounds. An energy source (such as a laser) with a known excitation wavelength emits photons that interact with chemical bonds in a sample material. Raman scattering results in a change in energy and frequency in comparison to the incident excitation light. This change in frequency is known as the Raman shift or Raman effect.

Each substance has a unique pattern of spectral bands (analogous to a “fingerprint”), making Raman a highly selective technique for identification of pure samples or simple mixtures of unknown chemicals. Raman spectroscopy is complementary to FTIR spectroscopy as it can resolve signals originating from homonuclear compounds; however, its spectrum is not affected by water (which produces a particularly strong interference for FTIR).

Handheld Raman spectrometers are made up of a light source (laser), spectrometer, detector (a charge-coupled device (CCD) and a sampling interface (Figure 2-1). In Raman spectroscopy, a monochromatic light source between 785 and 1064 nanometers (nm) interacts with a sample. The scattered light is separated by wavelength using a dispersive element (such as a diffraction grating). This light then reaches a detector resulting in a Raman spectrum. The spectrum is displayed as a plot of scattered light (signal) intensity vs. reciprocal wavelength of the excitation light (referred to as “wavenumber” and reported in inverse cm or cm^{-1}).

The Raman signal is typically proportional to the laser power, therefore a higher laser power tends to lead to a stronger signal. However, it is important to note that each sample has a threshold for laser power and may react or change structure if this threshold is exceeded. In addition, it may be advantageous to reduce laser power for some systems if a fluorescent substance is present. In some instances, a sample may ignite if introduced to a laser with high power. Higher laser power is also a greater concern for ocular safety of the user. Laser power in handheld Raman spectrometers with class 3B lasers may reach up to 500 mW and may have adjustable settings depending on the specific device. The ability to adjust laser power can be advantageous for analyzing certain sample types (e.g., colored samples may generate less fluorescence at lower laser power).

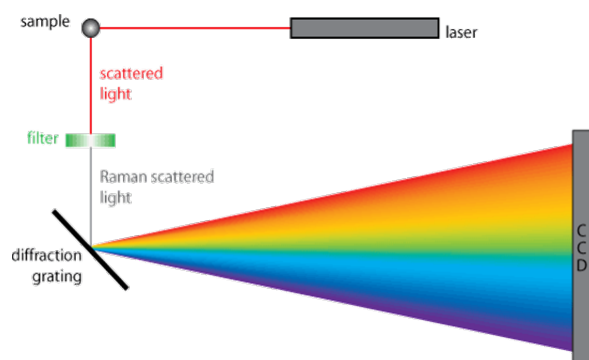


Figure 2-1 Diagram of a Typical Raman System
Photo courtesy of PNNL

2.1 COMPONENTS OF A HANDHELD RAMAN SPECTROMETER

A common Raman excitation wavelength is 785 nm, however, some molecules tend to fluoresce when excited with shorter wavelength light, which can cause interference. To reduce fluorescence interference, longer excitation wavelengths (1064, 1030, 852, 830 nm) have been used.

The spectral range of an instrument is also important for identifying samples. Raman spectra can be recorded from 10 to 4000 cm^{-1} with the unique fingerprint region between 400 and 1800 cm^{-1} . Common functional groups of chemical compounds and their corresponding position (in wavenumber) are listed in Table 2-1.

In most cases, a larger spectral range results in better identification as more features can be defined in the upper and lower limits (though these functional groups are relatively rare). Examples of the Raman spectra of several different chemicals with many of these functional groups are shown in Figure 2-2.

Table 2-1 Common Functional Groups and their Frequencies

Raman Shift (cm^{-1})	Functional Group
3600-3000	O-H
3500-3100	N-H
3100-2800	C-H
2200-2100	$\text{C}\equiv\text{C}$
1750-1700	$\text{C}=\text{O}$
1675-1600	$\text{C}=\text{C}$
1300-700	C-C
1000-900	Aromatic ring
900-800	O-O
850-650	C-Cl

The relative ease of spectral identification also depends on the spectral resolution an instrument can achieve. Spectral resolution is the ability to resolve spectral features into their individual components. A lower cm^{-1} value provides more highly resolved spectra while a higher cm^{-1} value corresponds to lower resolution.

If the resolution is too low, spectral features are more difficult to separate and characterization of an unknown sample may be more difficult, particularly for samples that contain a mixture of different substances. Therefore, higher resolution is preferred for identification purposes. It is important to note that a resolution that is higher than needed can result in long scan times and labor costs with little additional spectral information achieved. However, in general, most handheld Raman spectrometers have similar resolution.

Many handheld Raman spectrometers come with additional sampling attachments to provide flexibility in how a sample is measured. Attachments include vial adapters, 90° -angle (or right-angled) adapters, point-and-shoot add-ons, and fiber-optic probes. Other accessories include tablet holder adapters and large bottle adapters.

To collect the highest quality data and obtain the best results, different types of samples held in different types of containers must be measured using the appropriate adapter or probe at the vendor-recommended instrument settings. Vial holder adapters are used to measure liquid or powdered samples contained in vials. Some handling of the sample may be required if it is not already contained in a vial. Right-angled adapters are useful for making certain samples more accessible and are ideal for measuring larger containers which are only accessible from the top. The point-and-shoot method is ideal for sampling materials in the field without risking exposure from handling the sample directly. Point-and-shoot attachments are often capable of measuring through translucent or transparent containers such as glass and plastic. Use of point-and-shoot attachments can be highly dependent on the proper orientation and placement of the sample relative to the Raman excitation light. Fiber-optic probes allow the user to work with the instrument hands-free during a measurement since the flexible probe can be positioned at the proper orientation relative to a sample.

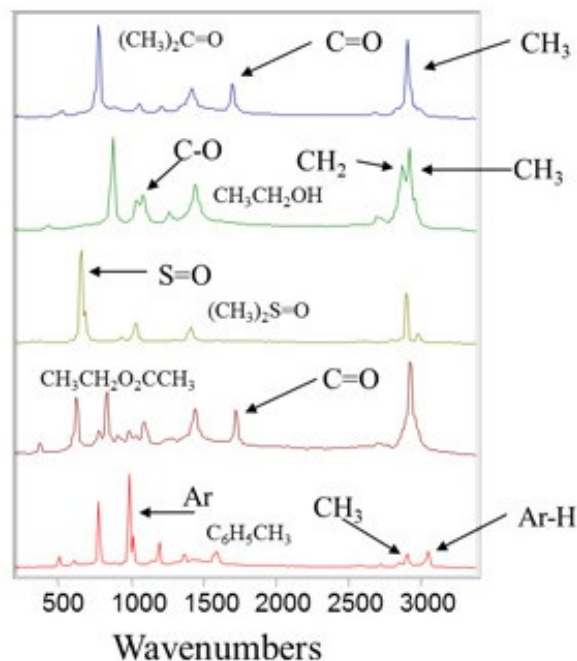


Figure 2-2 Example Raman Spectra
from top to bottom: acetone, ethanol, dimethyl sulfoxide,
acetoin, and toluene

Photo courtesy of B&W Tek



2.2 BENEFITS OF RAMAN SPECTROSCOPY

Raman spectroscopy is widely used by first responders to identify unknown chemical substances. Handheld Raman systems are lightweight (< 5 pounds) and can be made to withstand various types of environmental and field conditions. This technique is also nondestructive of the sample, making it advantageous for certain law enforcement use cases such as evidence preservation. No sample preparation is required for analysis and many instruments can measure through bags and translucent containers.

Raman spectroscopy is also beneficial because it is not affected by strong infrared absorbers, such as water, like FTIR spectroscopy. Some instruments can measure through opaque and/or thick containers. The rapid measurement times of these systems, a few minutes at most, is ideal for field analysis and immediate response. Typically, samples that are weak absorbers in the infrared have strong Raman scattering and, therefore, generate good quality results.

2.3 LIMITATIONS OF RAMAN SPECTROSCOPY

Sample mixtures with more than three components are often challenging for Raman because of the spectral overlap of individual chemical compounds and the difficulty of deconvolving individual component spectra. Compared to FTIR measurements, Raman signals are weak, requiring a visible quantity of sample to be present for analysis (i.e., < 5 milligrams). While traditional handheld Raman spectroscopy is useful for detection of low milligram amounts of sample, it does not enable detection of trace amounts of a substance. A technique known as Surface Enhanced Raman Spectroscopy (SERS) can be used to greatly improve sensitivity, however, Laser excitation of nanoscale roughened metal creates a highly localized (plasmonic) light field.

Molecules absorbed by this light field may exhibit large enhancements in the Raman signal. This signal improvement provides for potential detection of analyte concentrations at parts per million (ppm) levels, though handheld Raman systems are typically limited to parts per hundred levels (5-10%). In addition, SERS can provide results for fluorescent samples that would otherwise be difficult to analyze by traditional Raman spectroscopy, as well as provide sample classification results (e.g., protein, plant material). Recently some vendors have started to offer inexpensive test strips that can be loaded with an unknown sample and scanned using a SERS attachment on a vendor-specific Raman spectrometer. A drawback of SERS is that more sample manipulation is necessary to conduct the assay, which can be particularly challenging if wearing some types of personal protection equipment.



2.4 STANDARDS APPLICABLE TO HANDHELD RAMAN SPECTROMETERS

2.4.1 INGRESS PROTECTION RATINGS

Ingress protection (IP) ratings, defined in International Electrotechnical Commission (IEC) test [standard 60529](#), are two-digit numbers that indicate the level of protection provided by an electronic instrument's casing against intrusion by solid objects and liquids [1]. In practical terms, IP ratings indicate dust and water resistance. IP ratings for the instruments in this report cover the following range:

IP53: Protected from dust and spraying water

IP54: Protected from dust and splashing water

IP65: Dust tight and protected from water jets

IP66: Dust tight and protected from powerful water jets

IP67: Dust tight and submersible up to 1 meter

IP68: Dust tight and submersible beyond 1 meter

2.4.2 MIL-STD-810

MIL-STD-810 is a United States Department of Defense standard containing test methods for assessing whether equipment can withstand a wide range of environmental and operational stresses that might be experienced during actual use [2]. While MIL-STD-810 is specifically intended for testing of military equipment, some Raman instrument manufacturers report that their products conform to MIL-STD-810 testing requirements for resistance to mechanical shock and vibration. A copy of the current version of this standard, MIL-STD-810H, which is over 1,000 pages long, can be downloaded at www.iest.org/Standards-RPs/MIL-STD-810H.



3.0 PRODUCT INFORMATION

This market survey report provides information on 20 handheld Raman systems available from 13 vendors. Product data was obtained directly from the manufacturer or vendor, or their respective websites. The information obtained has not been independently validated by the SAVER Program. These products are listed in Table 3-1 in alphabetical order by manufacturer or vendor. (Some systems are manufactured by one company and licensed for sale to another: if applicable, this is noted in the product descriptions.)

Product features in Table 3-1 are defined as follows:

Manufacturer: The manufacturer or vendor of the spectrometer.

Product: The product name.

Dimensions: Dimensions of the product in inches.

Weight: Weight of the product in pounds.

Battery Type: Type(s) of battery sources used to power the device.

Battery Life: Reported life of battery in hours. This typically assumes the instrument is in continuous use. Please note these are vendor's best estimates. Actual battery life will vary depending on ambient temperature, display screen brightness, battery age, duty cycle of laser, etc.

Connectivity: Type of system used to transfer data from product to another source (e.g. Laptop).

Laser Wavelength: Excitation wavelength of the instrument laser in nanometers (nm).

Laser Power: Optical power output of the laser in milliwatts (mW).

Spectral Resolution: The instrument's ability to resolve nearby features or peaks in a spectrum in cm^{-1} .

Spectral Range: The device's spectral range of measurement in cm^{-1} .

Temperature Range (°F): The operating temperature range of measurements in °F.

IP Rating: The ingress protection (IP) rating represents the product's degree of protection against dust and water, where the first number refers to dust impermeability and the second to liquids.

IP ratings for the handheld Raman systems summarized here include:

- IP53: Protected from dust and spraying water
- IP54: Protected from dust and splashing water
- IP65: Dust tight and protected from water jets
- IP66: Dust tight and protected from powerful water jets
- IP67: Dust tight and submersible up to 1 meter
- IP68: Dust tight and submersible beyond 1 meter

Price: The list price of the product rounded to the nearest U.S. dollar as provided by the vendor or listed on the vendor website.

Table 3-1 Handheld Raman Spectrometer Product Comparison

Manufacturer or Vendor	Product	Dimensions (LxWxH, in)	Weight (lb)	Battery Type	Battery Life (hr)	Connectivity	Laser Wavelength (nm)	Laser Power (mW)	Spectral Resolution (cm ⁻¹)	Spectral Range (cm ⁻¹)	Temperature Range (°F)	IP Rating	Price
Agilent	Resolve	6.1 × 11.4 × 2.9	4.9	Rechargeable Li-ion	4	USB	830	475	~10	350-2000	-4 to 122	67	\$65-72k
Agiltron	PinPointer	8.5 × 4.3 × 2.5	3.0	Rechargeable Li-ion	4	USB	785	5-300	~9	200-3000	-13 to 113	n/a	\$11-12k
Anton Paar	Cora 100	6.2 × 4.0 × 1.1	1.4	Rechargeable Li-ion	8	USB	785	300	10	400-2300	-4 to 122	67	\$27k+
B&W Tek (Metrohm)	TacticID-1064	9.8 × 4.3 × 2.4	3.4	Rechargeable Li-ion or CR123	4	USB, WiFi, Bluetooth	1064	420	11	176-2500	14 to 122	68	\$44.5k
	TacticID-GP Plus	7.5 × 3.9 × 2.0	2.2	Rechargeable Li-ion or CR123	10	USB, WiFi, Bluetooth	785	300	9	176-2900	-4 to 122	65	\$27k
	TacticID-N Plus	7.5 × 3.9 × 2.0	2.2	Rechargeable Li-ion or CR123	10	USB, WiFi, Bluetooth	785	300	9	176-2900	-4 to 122	65	\$20.5k
Bruker	Bravo	10.6 × 6 × 2.4	3.3	Rechargeable Li-ion	4	WiFi, ethernet	785 & 852	150	10-12	300-3200	41 to 95	54	\$60k
Chemring	PGR-1064	2.5 × 7.5 × 6.6	2.25	Rechargeable Li-ion or CR123A	10	USB	1064	50-500	10	350-1800	-4 to 104	66	\$32.5k
EnviroNics	100 ID	6.2 × 4.0 × 1.1	1.4	Rechargeable Li-ion	8	USB	785	300	10	400-2300	-4 to 122	67	\$39k
Field Forensics	HandyRam II	6.2 × 4.0 × 1.1	1.4	Rechargeable Li-ion	8	USB, WiFi, ethernet	785	250	10	400-2300	-4 to 122	67	\$20k
Metrohm	Mira DS	3.5 × 5.0 × 1.8	1.6	Li-ion AA or Rechargeable Li-ion	4	USB, Bluetooth	785	100	8-10	400-2300	-4 to 122	67	\$30.7k+

Manufacturer or Vendor	Product	Dimensions (LxWxH, in)	Weight (lb)	Battery Type	Battery Life (hr)	Connectivity	Laser Wavelength (nm)	Laser Power (mW)	Spectral Resolution (cm ⁻¹)	Spectral Range (cm ⁻¹)	Temperature Range (°F)	IP Rating	Price
Pendar	Pendar X10	11.5 × 10.5 × 5.5	6.0	Rechargeable CR123A	2	USB	830	90	n/a	n/a	-4 to 104	n/a	\$65-70k
Rigaku	CQL	7.28 × 5.9 × 1.1	3.25	Rechargeable Li-ion or CR123A	5-7	USB, WiFi	1064	10-490	8-11	200-2500	-4 to 104	68	\$46k
	Progeny ResQ	11.8 × 3.2 × 2.9	3.7	Rechargeable Li-ion	6-8	USB, WiFi	1064	10-490	8-11	200-2500	-4 to 104	68	\$46k
	Progeny ResQ FLX	11.8 × 3.2 × 2.9	3.7	Rechargeable Li-ion	6-8	USB, WiFi	1064	10-490	8-11	200-2500	-4 to 104	68	\$29.9k
Serstech	100 Indicator	6.2 × 4.0 × 1.1	1.4	Rechargeable Li-ion	8	USB, WiFi, ethernet	785	300	10	400-2300	-4 to 122	67	\$25-30k
Smiths Detection	ACE-ID	5.0 × 3.5 × 2.2	1.0	Rechargeable Li-ion or CR123A	6	Micro-USB	785	55	n/a	350-2350	-4 to 122	53	\$27k
Thermo Scientific	FirstDefender RM	7.6 × 4.2 × 1.75	1.8	Rechargeable Li-ion or 123A	4	Mini SD card	785	250	7-10.5	250-2875	-4 to 122	67	\$57-73k
	FirstDefender RMX	7.7 × 4.5 × 2.4	2.0	Rechargeable Li-ion or 123A	4	Mini SD card	785	250	7-10.5	250-2875	-4 to 122	67	\$64-80k
	Gemini RAMAN/FTIR combo	10.1 × 5.7 × 2.4	4.2	Internal battery pack (Li-polymer)	5	USB	785	250	FTIR: 4 Raman: 7-10.5	FTIR: 4000-650 Raman: 250-2875	-4 to 122	67	\$105-134k
	TruNarc	2.0 × 6.4 × 4.1	1.25	Rechargeable 3.7 V battery pack	10	USB	785	250	7-10.5	250-2875	14 to 122	67	\$23-29k

3.1 AGILENT RESOLVE

The Resolve is 6.1 x 11.4 x 2.9 inches and weighs 4.9 pounds (including the battery). It has an IP rating of 67 and is also shock, drop- and vibration-tested MIL-STD-810. The Resolve can operate in temperatures between -4 and 122 °F. The unit has a class 3B 830 nm laser with adjustable laser power up to 475 mW. The unit has a spectral resolution of approximately 10 cm⁻¹ and a range of 350-2000 cm⁻¹. By utilizing spatially offset Raman spectroscopy, samples can be measured through a wide range of opaque nonmetallic containers, barriers, and packaging. Operation modes include a through-barrier scan mode, surface scan mode, and vial holder mode. The Resolve can be purchased with a variety of spectral library types and sizes. The HAZMAT library package contains 5,500 spectra including drugs, explosives, chemical warfare agents (CWAs), toxic industrial chemicals and toxic industrial materials (TICs/TIMs), and household chemicals. The comprehensive package contains roughly 13,000 spectra. With all library configurations, users can customize or create libraries to fit their specific needs.

Provided accessories include a calibration piece, laser safety glasses, a shoulder strap, carry case, two vendor-specific lithium ion battery packs, one single-bay charger, and a vial holder adapter. The Resolve has a rechargeable lithium ion battery with a four-hour run time. Its large display and buttons are designed for use while wearing personal protective equipment (PPE). A one-year warranty is included at the time of purchase with the option to purchase an extended warranty. Reachback service is available and part of the warranty package.



Figure 3-1 Agilent Resolve
Photo courtesy of Agilent

3.2 AGILTRON PINPOINTER (PIN-785)

The Pinpointer is 8.5 x 4.3 x 2.5 inches and weighs 3 pounds. The unit has a class 3B 785 nm laser with an adjustable laser power up to 300 mW. The unit's spectral resolution is roughly 9 cm⁻¹ with a range of 200-3000 cm⁻¹. It is not IP rated. The Pinpointer can be operated in temperatures between -13 and 113 °F. A limited library is provided, with an option to purchase a specialized library of 10,000 substances. Users can customize or create libraries to fit their specific needs. ID-Find and RSIQ-QUAL add-on software for chemical identification is included in the list price.

The Pinpointer is capable of point-and-shoot measurements and comes with a vial adapter. A storage case, liquid sample holder (for vials), and laser safety glasses are included. The Pinpointer has a rechargeable, hot-swappable, lithium ion battery with a four-hour run time. The single press trigger is compatible with one-handed use and use while wearing PPE. A one-year warranty is included at the time of purchase with the option to purchase an extended warranty. Reachback support is not offered.



Figure 3-2 Agiltron Pinpointer
Photo courtesy of Agiltron/Photonwares Inc.

3.3 ANTON PAAR CORA 100

The Cora 100 is 6.2 x 4.0 x 1.1 inches and weighs 1.4 pounds. The unit has a class 3B 785 nm laser with an adjustable laser power up to 300 mW. The unit has an IP rating of 67 and meets MIL-STD-810G vibration and shock requirements. The Cora 100 can be operated at temperatures between -4 and 122°F. The spectral resolution of the unit is 10 cm⁻¹ with a spectral range of 400-2300 cm⁻¹. A demo library of 340 compounds is provided. The Cora 100 is an instrument that has the same hardware, software, and libraries as the Serstech instrument (Section 3.12). Additional libraries are available for purchase and include chemicals such as explosives, narcotics, CWAs, and hazardous materials. More than 14,000 spectra are available total. Users can add spectra to libraries from the ChemDash spec store or from other sources. Data can be transferred via WiFi, ethernet or by a USB connection.

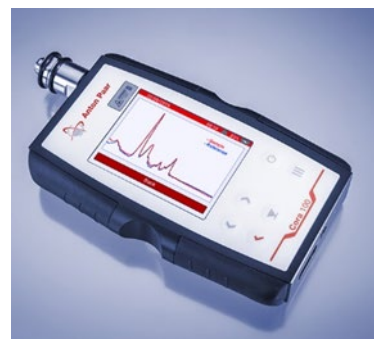


Figure 3-3 Anton Paar Cora 100
Photo courtesy of Anton Paar

A watertight case, shoulder strap, USB cable, point-and-shoot adapter, vial holder, sample vials, and a right-angled sampling adapter are supplied. A built-in calibration target is included in the laser aperture cap. The Cora 100 has a manufacturer-replaceable rechargeable lithium ion battery with an eight-hour runtime. Approximately 60 scans can be taken before the instrument has to be recharged. The Cora 100 has a 3.5-inch backlit color display screen and a set of menu navigation buttons designed for ease of use while wearing PPE. A three-year warranty is included at the time of purchase.

3.4 B&W TEK (A METROHM GROUP COMPANY)

3.4.1 TACTICID-1064

The TacticID-1064 is 9.8 x 4.3 x 2.4 inches and weighs 3.4 pounds. The unit has a class 3B 1064 nm laser with a laser power of 420 mW (adjustable in 1% increments). The TacticID-1064 is IP68 rated and MIL-810-G drop test compliant. It can be operated at temperatures between 14 and 122°F. The unit has a spectral resolution of 11 cm⁻¹ and a range of 176- 2500 cm⁻¹. A library of over 10,000 spectra including explosives, chemicals, and narcotics is provided. Optional libraries include reference spectra of explosives and CWAs. Users can create libraries to fit their specific needs or import existing libraries via the USB function. With Bluetooth, WiFi, and USB connectivity, detailed reports (including photos from the onboard camera) can be downloaded and synched to TID EX PC-based database and reporting software from any system. Reports can also be directly written to a USB drive.



Figure 3-4 B&W Tek TacticID-1064
Photo courtesy of B&W Tek

A point-and-shoot adapter, vial holder, right-angled sampling adapter, and bottle adapters are included. A polystyrene validation cap is also provided for calibration purposes. Optional accessories include a contact immersion probe and large bottle adapter.

The TacticID-1064 has a rechargeable lithium ion battery with a four-hour runtime or can be powered with disposable CR123 batteries and adapter. Large buttons allow for use while wearing protective gear; hard button navigation can be used in place of touch screen. A two-year warranty is included at the time of purchase with the option to purchase the Total Care program for up to three years.

3.4.2 TACTICID-GP PLUS

The TacticID-GP Plus is 7.5 x 3.9 x 2.0 inches and weighs 2.2 pounds. The unit has a class 3B 785 nm laser with a laser power of 300 mW (adjustable in 1% increments). It has an IP rating of 65 and can be operated at temperatures between -4 and 122 °F. The unit has a spectral resolution of 9 cm⁻¹ and a range of 176-2900 cm⁻¹. An extensive library of over 10,000 spectra including explosives, chemicals, and narcotics is provided. Users can create libraries to fit their specific needs or import existing libraries via the USB function. With Bluetooth, WiFi, and USB connectivity, detailed reports (which can include photos from the onboard camera) can be downloaded and synched to TID Plus PC-based database and reporting software on any system. Reports can also be directly written to USB.

A point-and-shoot adapter, vial holder, and a right-angled sampling adapter come with purchase. A polystyrene validation cap is also provided for calibration purposes. A TacPAC adapter using SERS technology is available for an additional cost. Large buttons allow for use while wearing protective gear. The TacticID-GP Plus has a rechargeable lithium ion battery with a 10-hour runtime or can be powered with disposable CR123 batteries. A two-year warranty is included at the time of purchase with the option to purchase the Total Care program for up to three years.

3.4.3 TACTICID-N PLUS

The TacticID-N Plus is 7.5 x 3.9 x 2.0 inches and weighs 2.2 pounds. The unit has a class 3B 785 nm laser with a laser power of 300 mW (adjustable in 1% increments). It has an IP rating of 65 and can be operated at temperatures between -4 and 122 °F. The unit has a spectral resolution of 9 cm⁻¹ and a range of 176-2900 cm⁻¹. A library of over 1,000 compounds including narcotics, pharmaceutical drugs, cutting agents, and precursors is included. Because this system is intended for use in law enforcement applications with potential legal ramifications, this is a closed system, limited to vendor-delivered library updates. With Bluetooth, WiFi, and USB connectivity, detailed reports (with option to include images from the onboard camera) can be downloaded and synched to a PC-based database and reporting software on any system.

A point-and-shoot adapter, vial holder, and right-angled sampling adapter are supplied. A TacPAC adapter and corresponding library that uses SERS technology are also included along with a polystyrene validation cap for calibration purposes.



**Figure 3-5 B&W Tek
TacticID-GP Plus**
*Photo courtesy of
B&W Tek*



**Figure 3-6 B&W Tek
TacticID-N Plus**
*Photo courtesy of
B&W Tek*

Large buttons allow for use while wearing protective gear. The TacticID-N Plus has a rechargeable lithium ion battery with a 10-hour runtime or can be powered with disposable CR123 batteries. A two-year warranty is included with the option to purchase the Total Care program for up to three years.

3.5 BRUKER BRAVO

The Bravo is 10.6 x 6.0 x 2.4 inches and weighs 3.3 pounds. The unit features a class 3B laser with proprietary Duo LASER excitation, with two wavelengths (785 and 852 nm) and a laser power up to 150 mW. The unit has an IP rating of 54 and can be operated at temperatures between 41 and 95 °F. The spectral resolution of the unit is 10-12 cm^{-1} with a spectral range of 300-3200 cm^{-1} . An onboard database of 30,000 compounds can be loaded to the unit, while an additional 50,000 compounds for offline use are available for purchase. Users can customize or create libraries to fit their specific needs. OPUS open-source software package is included for spectral manipulation, managing libraries, and generating of reports. Data can be transferred by an ethernet cable, USB, or WiFi connection.



Figure 3-7 Bruker Bravo
Photo courtesy of Bruker

The Bravo user interface consists of a large touchscreen and buttons and provides a guided workflow for operations on the touchscreen. The Bravo operates on a rechargeable battery with a four-hour runtime. A spare battery is provided with purchase and additional batteries and a docking station are available at additional cost. A one-year warranty with full technical support is included.

3.6 CHEMRING PGR-1064

The PGR-1064 is 2.5 x 7.5 x 6.6 inches and weighs 2.25 pounds. The unit has a class 3B 1064 nm laser with an adjustable laser up to a power up of 500 mW. The unit has an IP rating of 66 and MIL-STD 810G compliant for shock and vibration. The PGR-1064 can be operated at temperatures between -4 and 104 °F. The spectral resolution of the unit is 10 cm^{-1} with a spectral range of 350-1800 cm^{-1} . A customizable library of more than 5,000 compounds is available, which includes explosives, fuels, synthetic and prescription drugs, cutting agents, chemical warfare agents, toxic industrial chemicals, common household chemicals, and narcotics, including fentanyl.



Figure 3-8 Chemring PGR-1064
Photo courtesy of Chemring

The PGR-1064 has a guided workflow provided on the display screen. A joystick and trigger operation allow for one-handed use. The PGR-1064 has a rechargeable lithium ion three-cell pack battery with a 10+ hour runtime. A CR123A battery pack option is also available. A one-year warranty is included with extended warranty options available.

3.7 ENVIRONICS 100 ID

The 100 ID is 6.2 x 4.0 x 1.1 inches and weighs 1.4 pounds. The unit has a class 3B 785 nm laser with an adjustable laser power up to 300 mW. (Three power levels are available.) The unit has an IP rating of 67 and is MIL-STD-810G shock and vibration compliant. The 100 ID can be operated at temperatures between -4 and 122 °F. The spectral resolution of the unit is 10 cm⁻¹ with a spectral range of 400-2300 cm⁻¹. Approximately 14,000 compounds are available with the option for a customizable library. Library options include explosives, narcotics, hazardous chemicals, CWAs, and pharmaceuticals. Users can customize and create libraries to meet their specific needs. The 100 ID has the same hardware, software, and libraries as the Serstech instrument and is licensed from Serstech (Section 3.12). Data can be transferred via WiFi, ethernet, or by a USB connection.

A watertight case, shoulder strap, USB cable, point-and-shoot adapter, vial holder, sample vials, and a right-angle sampling adapter are supplied. A built-in calibration target is included in the laser aperture cap. The 100 ID has a 3.5-inch backlit color display screen and a set of menu navigation buttons designed for ease of use while wearing PPE. The 100 ID has a manufacturer-replaceable rechargeable lithium ion battery with an eight-hour runtime. Approximately 60 scans can be taken before the instrument has to be recharged. A one-year warranty is included with extended warranty options available.



Figure 3-9 Envirionics 100 ID
Photo courtesy of Envirionics

3.8 FIELD FORENSICS HANDYRAM II

The HandyRam II is 6.2 x 4.0 x 1.1 inches and weighs 1.4 pounds. It uses the same hardware as the Serstech instrument but uses Field Forensics' libraries/algorithms (Section 3.12). The unit has a class 3B 785 nm laser with an adjustable laser power up to 300 mW. It has an IP rating of 67 and meets MIL-STD-810G vibration and shock requirements. The HandyRam II can be operated at temperatures between -4 and 122 °F. The spectral resolution is 10 cm⁻¹ with a spectral range of 400-2300 cm⁻¹. A standard library is provided, with a specialized narcotics library of roughly 600 compounds available at an additional cost. Additional libraries can also be purchased with nearly 15,000 compounds from which to select. Data can be transferred via WiFi, ethernet, or by a USB connection.

A watertight case, shoulder strap, USB cable, point-and-shoot adapter, vial holder, sample vials, and a right-angled sampling adapter are supplied. A built-in calibration target is included in the laser aperture cap. The HandyRam II has a 3.5-inch backlit color display screen and a set of menu navigation buttons designed for ease of use while wearing PPE. The HandyRam II has a manufacturer-replaceable rechargeable lithium ion battery with an eight-hour runtime. Approximately 60 scans can be taken before the instrument has to be recharged.



Figure 3-10 Field Forensics HandyRam II
Photo courtesy of Field Forensics

3.9 METROHM MIRA DS

The Mira DS is 3.5 x 5.0 x 1.8 inches and weighs 1.6 pounds. The unit has a class 3B 785 nm laser with a laser power of 20-100mW (five adjustable laser power settings). The unit has an IP rating of 67 and meets MIL-STD-810G specifications for temperature, vibration, and shock. The Mira DS can be operated at temperatures between -4 and 122 °F. The spectral resolution of the unit is 8-10 cm⁻¹. Its spectral range is 400-2300 cm⁻¹. The laser uses raster scanning to measure a larger surface area of a sample, thus potentially better accounting for heterogeneous sample. A library of 1,200 compounds is provided, with more specialized libraries based on application available for purchase. Data can be transferred via Bluetooth or USB connection. MiraCal Mobile allows remote operation of the instrument as well as addition of photographs and other metadata when generating or exporting a scan or report.



Figure 3-11 Metrohm Mira DS
Photo courtesy of Metrohm

The Mira DS comes with three package options: the Mira DS Basic, the Mira DS Advanced, and the Mira DS Flex. All packages include MiraCal DS operating and management software, the illicit materials library, and access to the MiraCal Mobile app for Android. The Basic includes the library of illicit materials, calibration standard, USB cable, and a long, working distance objective lens suitable for scanning through glass containers and thick-walled containers. The Basic package delivers what is needed for essential operation. The Mira DS Advanced includes all elements of the basic package, plus a library of illicit materials, point-and-shoot adapter, right-angle sampling adapter, carrying case, USB power adapter (in addition to the included cable), laser safety glasses, NIR microfiber cleaning cloth, and a sampling blackout cloth. Available enhancements also include a standoff attachment suitable for measuring samples up to 1.5m away, adapters for various containers, and SERS capability.

The Mira DS systems use two AA lithium ion batteries with a four-hour runtime. Single use lithium ion batteries are recommended. An optional rechargeable lithium ion power supply provides a 16-hour runtime. A factory warranty of 18 months is included. Extended warranty and service maintenance programs that include instrument loan and 24/7 reachback support are available.

3.10 PENDAR X10

The Pendar X10 is 11.5 x 10.5 x 5.5 inches and weighs 6 pounds. The unit has a ~830 nm laser with a maximum power of 90 mW. The Pendar X10 can be operated at temperatures between -4 and 104 °F. The Pendar X10 is a short-range standoff point-and-shoot system with measurement distances up to three feet. The Pendar X10 can also be mounted on a tripod for longer measurements. The Pendar X10 is a two-wavelength difference Raman system with ability to measure highly fluorescent materials. The Pendar X10 can measure dark and sensitive materials (e.g. gunpowder) without ignition. The provided library includes explosives, TICs, and narcotics and can be expanded by the user.



Figure 3-12 Pendar X10
Photo courtesy of Pendar

The unit uses a single, one-handed press of a trigger to begin measurements and allows for use while wearing PPE. The unit operates on CR123A batteries that provide a runtime greater than two hours. A one-year warranty is included in the list price with extended warranty options available at an additional cost.

3.11 RIGAKU

3.11.1 PROGENY RESQ

The Progeny ResQ is 11.8 x 3.2 x 2.9 inches and weighs 3.7 pounds. The unit features a class 3B 1064 nm laser with an adjustable laser power up to 490 mW. The device has been third-party tested and certified to meet an IP rating of 68 and MIL-STD 810G shock and vibration requirements. The Progeny ResQ can be operated continuously at temperatures between -4 and 104 °F and up to 122 °F if operated intermittently. The spectral resolution of the unit is 8-11 cm⁻¹ with a spectral range of 200-2500 cm⁻¹. A library of ~12,500 compounds including CWAs, explosives, TICs/TIMs, narcotics, precursors, and cutting agents is included in the list price. An integrated 5-megapixel digital camera allows operators to add image evidence into the analytical reports. Data can be transferred via WiFi or USB connection.



Figure 3-13 Rigaku Progeny ResQ
Photo courtesy of Rigaku Analytical Devices

A base adapter and universal adaptor are included. A specialized vial holder, periscope adapter and bottle adapter to further accommodate sampling needs are available for purchase. The Progeny ResQ can be operated by a touchscreen display or large button navigation for ease of use when wearing PPE. The Progeny ResQ has a rechargeable lithium ion battery with a 5-7 hour runtime. A two-year warranty is included with extended warranty options available. Free software upgrades, library updates, and access to 24/7/365 reachback support for the life of the unit are included with purchase.

3.11.2 RESQ CQL

The ResQ CQL is 7.28 x 5.9 x 3.11 inches and weighs 3.25 pounds. The unit has a class 3B 1064 nm laser with operator adjustable laser power up to 490 mW. The unit has been 3rd party tested and certified to meet an IP68 rating and MIL-STD-810G requirements. The ResQ CQL can be operated at temperatures between -4 and 104 °F continuously (up to 122 °F intermittently). The spectral resolution of the unit is 8-11 cm⁻¹ with a spectral range of 200-2500 cm⁻¹. A library of up to 13,000 compounds including CWA, explosives, precursors, TICs/TIMs, narcotics, precursors, and cutting agents is included in the list price. Data can be transferred via WiFi or USB connection. An integrated five-megapixel digital camera allows operators to add picture evidence into the analytical reports.



Figure 3-14 Rigaku ResQ CQL
Photo courtesy of Rigaku Analytical Devices

QuickDetect software is available from another company (DetectaChem), which can be used with DetectaChem colorimetric test strips for detecting trace amounts of explosives and narcotics. A base adapter and tablet/universal adapter are included as accessories for scanning a wide variety of material and containers. A specialized vial holder, periscope adapter, and bottle adapter are available to purchase to further accommodate sampling needs. The ResQ CQL can be operated by a touchscreen display or large button navigation for ease of use when wearing PPE. The ResQ CQL features a hot-swappable rechargeable lithium polymer battery with a 5-7 hour runtime. The unit is also compatible with CR123A disposable batteries. A two-year warranty is included with extended warranty options available. Free software upgrades, library updates, and access to 24/7/365 reachback support for the life of the unit, are all included with the purchase of the ResQ CQL.

3.11.3 PROGENY RESQ FLX

The Progeny ResQ FLX is 11.8 x 3.2 x 2.9 inches and weighs 3.7 pounds. The unit has a class 3B 1064 nm laser with an adjustable laser power up to 490 mW. The unit has been 3rd party tested and certified to meet a rating of IP68 and MIL-STD-810G requirements. The Progeny ResQ FLX can be operated at temperatures between -4 and 104 °F continuously (up to 122 °F intermittently). The spectral resolution of the unit is 8-11 cm⁻¹ with a spectral range of 200-2500 cm⁻¹. The FLX comes with a library of ~1,000 narcotics, narcotic precursors, cutting agents, and household chemicals. As the unit is built on an expandable platform, optional libraries can be purchased at any time. These can expand the capability from narcotics only to a wide range of chemicals including explosives, CWAs, and TICs/TIMs. Data can be transferred via WiFi or by a USB connection. An integrated five-megapixel digital camera allows operators to add picture evidence into the analytical reports.



Figure 3-15 Rigaku Progeny ResQ FLX
Photo courtesy of Rigaku Analytical Devices

A base adapter and tablet/universal adapter are included as accessories for scanning a wide variety of material and containers. A specialized vial holder, periscope adapter, and bottle adapter are available to purchase to further accommodate sampling needs. The Progeny ResQ FLX can be operated by a touchscreen display or large button navigation for ease of use when wearing PPE. The Progeny ResQ FLX has a rechargeable lithium ion battery with a 5-7-hour runtime. A one-year warranty is included with extended warranty options available. Free library updates are provided for the life of the instrument. Software upgrades and extended 24/7/365 reachback support are available for purchase.

3.12 SERSTECH 100 INDICATOR

Serstech has licenses with three different companies that sell their system (Anton Paar, Field Forensics, and Environics). While some companies use the same hardware and libraries, others use their own libraries/algorithms. The Serstech 100 Indicator is 6.2 x 4.0 x 1.1 inches and weighs 1.4 pounds. The unit has a class 3B 785 nm laser with an adjustable laser power up to 300 mW. The unit has an IP rating of 67 and meets MIL-STD-810G vibration and shock requirements. The Serstech 100 Indicator can be operated at temperatures between -4 and 122 °F. The spectral resolution of the unit is 10 cm⁻¹ with a spectral range of 400-2300 cm⁻¹. A demo library of 340 compounds is provided. Additional libraries are available for purchase and include chemicals such as explosives, narcotics, CWAs, and hazardous materials. More than 14,000 spectra are available total. Users can add spectra to libraries from the ChemDash spec store or from other sources. Data can be transferred via WiFi, ethernet, or USB connection.



Figure 3-16 Serstech

*Photo courtesy of
Serstech*

A watertight case, shoulder strap, USB cable, point-and-shoot adapter, vial holder, sample vials, and right-angled sampling adapter are supplied. A built-in calibration target is included in the laser aperture cap. The Serstech 100 Indicator has a 3.5-inch backlit color display screen and a set of menu navigation buttons designed for ease of use while wearing PPE. The Serstech 100 Indicator has a manufacturer-replaceable rechargeable lithium ion battery with an eight-hour runtime. Approximately 60 scans can be taken before the instrument has to be recharged. A one-year warranty is included with extended warranty options available.

3.13 SMITHS DETECTION ACE-ID

The ACE-ID is 5.0 x 3.0 x 2.2 inches and weighs 1 pound. The unit has a class 3B 785 nm laser with an adjustable laser power up to 55 mW. The unit has an IP rating of 53 and meets MIL-STD-810G requirements. The unit can be operated at temperatures between -4 and 122 °F. The ACE-ID uses orbital raster scanning (ORS) technology to diffuse the laser energy while collecting spectra from a larger area. This allows for a point-and-shoot method of sampling. The spectral range of the unit is 350-2350 cm⁻¹. A spectral library of approximately 500 compounds including explosives, narcotics, and toxic chemicals is provided. Spectra can be added to instrument's library via laptop software. An integration software kit is available for remote operation and generation of reports.



Figure 3-17 Smiths Detection
ACE-ID

*Photo courtesy of
Smiths Detection*

The unit has a touchscreen display that is compatible with gloves and other PPE and large buttons for one-handed use. The ACE-ID is powered by one off-the-shelf lithium ion battery (SureFire or CR123A) or a USB power source. A one-year warranty is included with extended warranty options available. ReachBackID provides 24/7/365 reachback service for the unit.

3.14 THERMO SCIENTIFIC

3.14.1 FIRSTDEFENDER RM/RMX

The FirstDefender is available in two options: The FirstDefender RM or RMX. The FirstDefender RM is 7.6 x 4.2 x 1.75 inches and weighs 1.8 pounds. The RMX is 7.7 x 4.5 x 2.4 inches and weighs 2.0 pounds. The units have a class 3B 785 nm laser with an adjustable laser power that can be adjusted to 75, 125, or 250 mW. The units meet MIL-STD-810G shock/vibration specifications and have an IP rating of 67. The FirstDefender RM and RMX can be operated in temperatures between -4 and 122 °F. The spectral resolution of both units is 7-10.5 cm^{-1} with a spectral range of 250-2875 cm^{-1} . A spectral library of more than 12,000 compounds including explosives, toxic industrial chemicals, CWAs, narcotics, precursors, and white powders is provided for each. Users can create custom libraries based on their needs. A menu driven interface allows for minimal training.



Figure 3-18 Thermo Scientific FirstDefender RM and RMX
Photo courtesy of Thermo Fisher Scientific

The FirstDefender units can be used for point-and-shoot sampling or for measuring samples in a vial with the integrated vial holder. Unlike the RM version, the RMX has a fiber optic probe for sampling. The probe makes proper placement of the laser relative to the sample easier. Also, a sample and the laser probe can be covered to block interfering ambient light without blocking the instrument control/display, making operation easier. The FirstDefender RMX unit also differs from the FirstDefender RM since it can be used as a handheld unit with a fixed probe, through an integrated vial mode or by mounting onto a tactical robot. An integration kit is required from the robot manufacture for mounting and universal control.

Both units have a large display and buttons that are compatible for use when wearing PPE. The systems can be powered using a wall adapter or lithium ion batteries (rechargeable or disposable 123A). A runtime of more than four-hours is typical for both the RM and the RMX. Both 24/7 technical and reachback support are provided for these units.

3.14.2 GEMINI

The Gemini is an integrated handheld Raman and FTIR instrument. The unit is 10.1 x 5.7 x 2.4 inches and weighs 4.2 pounds. The unit has an IP rating of 67 and meets MIL-STD-810G requirements. The Gemini can be operated in temperatures between -4 and 122 °F. The Raman analysis uses a class 3B 785 nm laser with adjustable laser power up to 250 mW. A fiber optic probe and separate vial compartment are built in for Raman analysis. The spectral resolution is 7-10.5 cm^{-1} with a spectral range of 250-2875 cm^{-1} for the Raman analysis. A motorized pressure arm and attenuated total reflectance diamond window are built in for FTIR analysis. The spectral resolution for FTIR is 4 cm^{-1} with a spectral range of 650-4000 cm^{-1} .



Figure 3-19 Thermo Scientific Gemini
Photo courtesy of Thermo Fisher Scientific

A spectral library of more than 16,000 compounds including explosives, toxic industrial chemicals, CWAs, narcotics, precursors, and white powders is provided. Users can create custom libraries based on their needs. A menu driven interface allows for minimal training and ease of use.

The large display and buttons are compatible with use of the unit when wearing PPE. The Gemini can be powered using a wall adapter or lithium ion batteries (rechargeable or disposable 123A). A runtime of more than six-hours is typical for the unit. A standard one-year warranty is included, with additional years available. Both 24/7 technical and reachback support are provided.

3.14.3 TRUNARC

The TruNarc is 6.4 x 4.1 x 2.0 inches and weighs 1.25 pounds. The unit has a class 3B 785 nm laser. The unit has an IP rating of 67 and can be operated in temperatures between 14 and 122 °F. The spectral resolution of the system is 7-10.5 cm^{-1} with a spectral range of 250-2875 cm^{-1} . A library of nearly 500 compounds including narcotics, stimulants, depressants, hallucinogens, and analgesics is provided. The TruNarc analyzer includes a closed loop library to prevent tampering with updates, which are made on a regular basis. A menu driven interface allows for minimal training and ease of use.

The large display and buttons are compatible with use of the unit when wearing PPE. The TruNarc is powered by a rechargeable 3.7 V battery and has a run time of 10-hours. Both 24/7 technical and reachback support are provided.



Figure 3-20 Thermo Scientific TruNarc
Photo courtesy of Thermo Fisher Scientific

4.0 MANUFACTURER OR VENDOR CONTACT INFORMATION

Additional information on the products in this report can be obtained from these companies.

Table 4-1 Manufacturer and Vender Information

Company	Address/Phone	Website
Agilent	5301 Stevens Creek Boulevard Santa Clara, CA 9505 1-800-227-9770	https://agilent.com
Agiltron	15 Presidential Way Woburn, MA 01801 781-935-1200	https://agiltron.com/
Anton Paar	2824 Columbia Street Torrance, CA 90503 310-775-2196	https://www.anton-paar.com/
B&W TEK (A Metrohm Group Company)	19 Shea Way Newark, DE 19713 302-368-7824	https://bwtek.com/
Bruker	40 Manning Road Billerica, MA 01821 978-439-9899	https://www.bruker.com/
Chemring	4205 Westinghouse Commons Drive Charlotte, NC 28273 980-235-2200	http://www.chemringds.com/
Envionics	1107 Wonder Street, Suite 103 Round Rock, TX 78681 737-236-2155 / 737-236-5122	https://www.envionics.com/
Field Forensics	1601 3rd Street South Saint Petersburg, FL 33701 877-809-4253 / 727-490-3609	https://www.fieldforensics.com/
Metrohm	9250 Camden Field Parkway Riverview, FL 33578 813-316-4700	https://www.metrohm.com/
Pendar	30 Spinelli Place Cambridge, MA 02138 617-588-2128	https://www.pendar.com/
Rigaku	30 Upton Drive, Suite 2 Wilmington, MA 01887 281-362-2300	https://handhelds.rigaku.com
Serstech	Ideon Science Park, Sölvegatan 43 SE-223 70 Lund, Sweden +46 46 255 112	https://serstech.com/
Smiths Detection	2202 Lakeside Boulevard Edgewood, MD 21040 410-612-4000	https://www.smithsdetection.com/
Thermo Fisher	168 Third Avenue Waltham, MA 02451 781-622-1000	https://www.thermofisher.com/



5.0 SUMMARY

Handheld Raman spectrometers are small, portable devices that range in weight from one to five pounds and are used to perform rapid chemical analysis in the field. The devices provide fast point and shoot measurement capabilities that support responders performing their duties to find and identify illicit and dangerous materials. The systems have spectral libraries allowing for the identification of explosives, fuels, synthetic and prescription drugs, cutting agents, chemical warfare agents, toxic industrial chemicals, common household chemicals, and narcotics including fentanyl.

The direct detection and rapid measurement times make these systems ideal for fast field analysis. Raman systems identify chemicals of interest in powder or liquid form without destroying the sample. They do this by measuring small but distinctive spectral shifts in the incident light emitted from the instrument and scattered off the sample material. Raman spectroscopy can measure through translucent or transparent materials such as glass, plastic bags, and envelopes. Some instruments can measure through moderately opaque as well as thicker containers.

Handheld Raman systems need small but visible quantities of sample material, typically five milligrams or more, to generate accurate measurements. Raman systems typically can detect specific chemicals of interest in mixtures so long as those chemicals are present at greater than 10% of the sample (depending on sample complexity). Significantly improved sensitivity is possible with a method called Surface Enhanced Raman Spectroscopy (SERS), which typically allows for a lower limit of detection in the parts-per-million range. Additional sample manipulation is necessary for SERS analysis, however, which could prove difficult when wearing certain types of personal protective equipment. Several companies are developing, and some already offer SERS analysis as an option for use with their handheld Raman spectrometers.

Response agencies considering the purchase of handheld Raman spectrometers should carefully consider the overall capabilities and limitations (including cost) in relation to their agency's operational needs. Different applications will have different requirements for spectral resolution, sample matrix, spectral library, operator support, sensitivity, size and weight, ruggedness, battery life, display readability, alarm types, and other specifications and features.



6.0 REFERENCES

- [1] International Electrotechnical Commission, "IP Ratings," [Online]. Available: <https://www.iec.ch/ip-ratings>. [Accessed 25 02 2021].
- [2] Working Group 043 of the IEST Design, Test, and Evaluation Division (WG-DTE043), "MIL-STD-810H," February 2019. [Online]. Available: www.iest.org/Standards-RPs/MIL-STD-810H. [Accessed 25 02 2021].