Fraunhofer ICT - Laboratory Test Report of RAMAN handheld spectrometer

Certificate of Compliance and Performance

RS DYNAMICS - microRAMAN   RS-uRM10

Test Facility:
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Date of Testing:
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This certification report presents the results of a functional and performance evaluation of the **microRAMAN handheld spectrometer**. The primary objective of the testing was to verify the instrument's proper operation and assess its key analytical parameters, including identification capabilities, detection limits, and analysis speed. The identification performance was thoroughly tested using a wide range of representative samples, including compounds from the **explosives group**, **pharmaceuticals and/or psychoactive substances**, **food & additives**, as well as **organic and inorganic chemicals**, and various **liquid samples.** All tests were conducted under controlled laboratory conditions using standardized procedures to ensure data reliability, reproducibility, and alignment with expected specifications for field or laboratory use.

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1. Summary

Test start date	05.05.2025
Test end date	07.07.2025
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Tested device:

Manufacturer	RS DYNAMICS
Model	microRAMAN RS-uRM10
Serial number	23021992
System hardware	785nm
System version	1.8.4
Spectral library	ST Japan, 24,000+ spectra
Auxiliary hardware	Direct sampling adapter 0.2 mm - DS, Vial sample holder - VH

Used laboratory equipment:

Analytical balance	Mettler Toledo (0.1 mg/210g) XPR204S/M, ser. No: 21807869
Special sample preparation	NP2.12 - Nanoplotter from Gesim, ser. No: 2189

2. Description of testing methodology

The testing methodology was structured into four distinct tests, each targeting a specific aspect of the system's analytical capabilities:

Test 1 – Single compound identification:

This phase focused on the identification and classification of individual, pure chemical compounds under controlled conditions. The goal was to assess the system's baseline detection performance in the absence of complex matrices or interfering substances.

Test 2 – Low-concentration sensitivity:

In this phase, selected target compounds were diluted in water to simulate trace-level concentrations. The objective was to evaluate the instrument's detection limits and its ability to reliably identify substances present at very low levels, reflecting real-world scenarios such as environmental or forensic sampling.

Test 3 – Trace detection capabilities:

The purpose of this test is to verify whether the tested device is capable of correctly identifying even minimal amounts of substances of interest from the explosives category.

Test 4 – Identification time:

This test measured the speed and efficiency of the system in providing a positive identification once a sample was introduced. Time-to-result is a critical performance metric, especially in field operations or time-sensitive environments and applications.

2.1. Test 1: Single compounds identification test

This test is focused on the identification of individual chemical compounds listed in Annex A. The testing is conducted by the Fraunhofer Institute with careful consideration of both safety protocols and the physical properties of the substances. All materials—particularly explosives—must be handled in small, controlled quantities to minimize risk. Special attention is given to dark or highly absorptive substances, as these may be prone to thermal damage or combustion when exposed to high laser power during Raman measurement.

The user-defined similarity threshold for spectral matching is set at 20%. Each compound is initially analyzed in auto-exposure mode ("Fast mode") to allow rapid assessment. If identification is unsuccessful in this mode, the test proceeds in manual-exposure mode ("Precision mode"), where appropriate settings for laser power, exposure time, and the number of integrations are adjusted to optimize detection.

If the substance cannot be identified using the reference spectra provided in the manufacturer's factory library, the Fraunhofer Institute will evaluate whether this is due to the absence of the compound in the supplied library. In such cases, a note is recorded in the test report under the column "Factory Lib." The corresponding spectral data is then added to the user-defined portion of the library, and the identification process is repeated. If successful, the result is documented under the column "User Lib."

Upon completion of the measurements, all acquired data will be exported in CSV format, and a full test report will be generated as a PDF document directly by the tested instrument.

Subsequently, the results will be statistically evaluated and aggregated into functional groups, and a summary table will be compiled. This table will include counts of individual identification outcomes, categorizing them according to whether the identification was successful, required library expansion, or failed entirely. The statistical summary will serve to assess overall system performance across different chemical categories.

Each group represents a category based on the typical physicochemical or functional properties of the compounds, and reflects their practical relevance for field detection and security applications. It should be noted that, due to the multifaceted nature of certain substances, a single physical sample may belong to more than one substance group. For example, a compound may simultaneously qualify as both a liquid and foods & additives. As such, the classification presented in this annex is not mutually exclusive, and some entries may appear in overlapping groups where justified by their chemical characteristics or practical relevance.

The table in Annex A.2 lists all tested compounds from Annex A.1 and assigns each one to its corresponding groups. These groups are: Inorganics, explosives, foods & additives, liquids, pharma & psychoactive, other organics and cosmetics.

2.2. Test 2: Low concentration detection limits of specified compounds diluted in water

This test is focused on finding detection limits for selected compounds diluted in water. For determination of detection limits it is mostly required to use manual detection mode (Precision) and find suitable parameters of exposure time and averaging with laser power usually set to 400mW.

Detection limit is typically below 1% volume concentration. For the test we suggest to walk through the sequence of volume concentrations e.g. 10% - 5% - 2% - 1% - 0.5% (V/V). In case of successful detections even below 1%. Tested compounds are listed in Annex B.

Special test vials made of low fluorescence glass were supplied with the instrument. The use of proper vials is essential for this test.

During the test, the lowest detection limit, the lowest achievable volume concentration of the substance of interest at which the instrument under test is still able to correctly identify the substance of interest, is found for each substance from the list.

2.3. Test 3: Trace detection capabilities

This test verifies how high, almost trace, amounts of specific substances of interest from the explosives category the tested device is capable of correctly identifying.

For these special tests, it is necessary to use very accurate and repeatable dosing. For this purpose, a unique method of sample preparation was used with a nanoplotter. The NP2.12 nanoplotter from

Gesim uses special piezoelectric pipettes to produce a defined surface coverage of explosives on substrates.

The NP2.12 nanoplotter is capable of dosing diluted substances in droplets of 50–350 pL with precise positioning in 10 µm increments. The nanoplotter allows 5000-10000 droplets to be placed per 1 cm^2 of prepared sample.

An alternative method for testing is the direct, precise weighing of minimum masses of substances in a solid state in the form of powder.

2.4. Test 4: Identification time

The purpose of this test is to demonstrate the maximum achievable identification speed of the instrument. Six substances (Sulfur, Benzonitrile, Cyclo-hexane, Toluene, Acetone, 2-Propanol) will be tested in automatic and manual mode.

The identification time will be measured in two modes, automatic and manual (Precision), where the operator will aim for the shortest possible exposure that will still lead to a successful identification.

In the manual mode, two measurements will be performed for each substance, one with the full range of library spectra set, the other will aim to actually maximize the measurement speed, where the shortest possible exposure times will be manually set with single exposure settings and limiting the range of the spectra library to the demo set (max. 300 substances). For most test substances, manual exposure setting of 80mW and 80ms should be sufficient.

3. Results

3.1. Identification test

Group	Description of tested substances	Used sampling adapters
GRP 1	Inorganics	14 x DS
GRP 2	Explosives	40 x DS
GRP 3	Foods & additives	11 x DS
GRP 4	Liquids	23 x VH,
GRP 5	Pharma & psychoactive	20 x DS
GRP 6	Other organics	3 x DS, 1 x VH,
GRP 7	Cosmetics	1 x DS

Test Results	GRP 1	GRP 2	GRP 3	GRP 4	GRP 5	GRP 6	GRP 7
Total items	14	40	11	23	20	4	1
not measurable		3(decomposition)					
wrong identification							
no match		1					
spectrally similar substance							
correct identification of component from user library		6					
correct identification of component from factory library		18					
correct identification from user library		5					
correct identification from factory library	14	7	11	23	20	4	1

The test was performed using the internal ST Japan spectrum library in a configuration of more than 24,000 spectra

3.2. Low concentration sensitivity - Detection limit test

Item no.	Tested substances	Concentration (volume) [V/V %]	Mode [Auto / Manual]	Identification successful [Y / N]
1	2-Propanol	10.0	Auto	Y
2		5.0	Auto	Y
3		2.0	Auto	Y
4		1.0	Precision	Y
5		0.5	Precision	Y
6		0.2	Precision	Y
7		0.1	Precision	N
8	Methanol	10.0	Auto	Y
9		5.0	Auto	Y
10		2.0	Auto	Y
11		1.0	Auto	Y
12		0.5	Precision	Y
13		0.2	Precision	N
14	Ethanol	10.0	Auto	Y
15		5.0	Auto	Y
16		2.0	Auto	Y
17		1.0	Precision	N
18		0.5	Precision	N
19	Acetone	10.0	Auto	Y
20		5.0	Auto	Y
21		2.0	Auto	Y
22		1.0	Auto	Y
23		0.5	Precision	N
24	Acetonitrile	10.0	Auto	Y
25		5.0	Auto	Y
26		2.0	Auto	Y
27		1.0	Auto	Y
28		0.5	Precision	Y
29		0.2	Precision	N
30	Acetic Acid	10.0	Auto	Y
31		5.0	Auto	Y
32		2.0	Precision	Y
33		1.0	Precision	N
34		0.5	Precision	N

The achievable **detection limit** is about **0.5% V/V** for selected substances

3.3. Trace detection capabilities

The sample produced by the nanoplotter, each with a coverage of 500 µg ammonium nitrate and 500 µg RDX (hexogen), were identified using the handheld spectrometer. The test sample was prepared on an area of 1 cm^2 using a nanoplotter in two passes with a step size of 200 µm. In the second pass, the grid was shifted by 100 µm in both directions, producing a diagonal grid with a total of 51 x 51 + 50 x 50 = 5101 points. Hexogen was prepared as a DMSO solution (20.34 mg/ml) and ammonium nitrate as an aqueous solution (100 mg/ml). It can be considered, that detection limit is significantly below the introduced amount placed on one square centimeter **(below µg order)** since active area of the active laser spot is deeply below one square millimeter. The TNT/RDX fingerprint was applied manually using TNT/RDX powder on an aluminum substrate; the balanced amount of TNT was 4.6 mg from RDX 6.8 mg. All test measurements were carried out with the 0.2 mm direct sampling adapter.

3.4. Identification time – speed test

Item name		Sulfur	Benzo nitrile	Cyclohexane	Toluene	Acetone	2-Propanol
Item CAS		7704-34-9	100-47-0	110-82-7	108-88-3	67-64-1	67-63-0
Note		powder	liquid	liquid	liquid	liquid	liquid
Automatic mode	Power [mW]	15	325	325	325	325	450
	Exposure time [ms]	200	200	200	200	350	353
	Integral number [x]	1	1	1	1	1	1
	Identification time full library set [sec.]	10	10	10	9.5	11	11
Manual mode	Power [mW]	15	450	450	450	450	450
	Exposure time [ms]	50	50	50	50	50	50
	Integral number [x]	1	1	1	1	1	1
	Identification time full library set [sec]	8	8	8	7.5	8	8
	Identification time with limited library demo set [sec]	1.5	2	1.5	2.5	1.5	2.5

The achievable **identification time** is about **1.5 seconds** for selected substances in limited library set.

4. List of referenced documents:

Annex A – Test results of the “Single compound identification” test in functional groups

Annex B – Test results of the “Low concentration detection limit” test

Annex C – Test results of the “Trace detection capabilities” test

5. Signature

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