

PARTICULATE, MOLECULAR AND BIOLOGICAL CLEANLINESS CONTROL OF THE RAMAN LASER SPECTROMETER FOR THE EXOMARS 2020 MISSION

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Abstract

The Raman Laser Spectrometer (RLS) is one of the three instruments located within the Rover ALD (Analytical Laboratory Drawer) of the ExoMars 2020 mission.

One of the main ExoMars mission scientific objectives, is to find traces of past life on Mars. So, protect Mars environment from terrestrial biological contamination and protect Mars sample properties to avoid false positive is required. Also, it is necessary to prevent and control molecular and particulate contamination that could degrade the RLS performances or could contaminate others instruments.

In order to achieve the specified cleanliness (molecular and particulate) and bioburden levels during the programme life (from design to delivery) different activities must be detailed and planned.

1. Introduction

The main ExoMars 2020 mission scientific objective is "Searching for evidence of past and present life on Mars". The RLS will contribute to this scientific goal through the precise identification of the mineral phases and the capability to detect organics on the powdered samples. In order to not lead to a false positive, contamination has to be controlled.

The main drivers of the Planetary Protection (PP) and Contamination Control are:

- Avoid contamination that can influence on RLS performances (losses of system signal and degradation of the signal to noise ratio)
- Avoid contamination propagation to other instruments or ALD.
- Protect Mars environment from terrestrial biological contamination.

2. Cleanliness and Bioburden Levels

The RLS units, being part of the ALD of the Rover, are required to comply with following levels at delivery:

- Particulate Contamination (PAC) Level 500, which means less than 3814 mm²/m² (Level 1 for CT)
- Molecular Contamination (MOC) Level A (10⁻⁶ g/cm²) (Level A/100 (10⁻⁸ g/cm²) for CT)
- Bioburden Level shall be less than 1000 spores/m² on average (0.03 spores/m² for CT)

Due to the existence of contamination sensitive items in SPU and iOH units, levels are more stringent:

- PAC Level 300 (329 mm²/m²)
- MOC Level A/20 (5*10⁻⁸ g/cm²)

For activities on RLS units, cleanrooms and laminar flow cabinets located at INTA facilities are used.

The verification of the bioburden level is done by trained personnel (PP course Level 3) at the PP laboratory created for the RLS project at INTA. The bioburden assays are performed according to the ExoMars 2018 Bioburden assays procedures tailored for ExoMars, standard swab assay.

PAC verification is done with PFO (Particle Fall-Out) witnesses, which are measured with Particle Fall Out Photometer Mk5-5. Final particulate contamination verification on RLS units are done according to ECSS-Q-ST-70-50C, tape lift method of transferring particulate contamination from a surface with an adhesive tape.

MOC verification is done with witness measured according to ECSS-Q-ST-70-05C, indirect sampling of contaminants by washing and wiping by INTA laboratory.

3. Bioburden control

The bioburden assessments on the RLS units have been performed in significant moments:

- Before applying bioburden reductions procedures (DHMR or H₂O₂)

- Before, during and after integration of RLS units. Special attention to assays at last physical access
- Before and after transport and testing
- After detection of spores in a previous assay
- Before delivery

The number of bio assays needed to verify that the RLS units are free from spores is specified as “3-5 swabs for surface areas of 0.1 m²”.

The following table shows the internal-external surfaces and the volume of each unit:

Unit	Surface (cm ²)	Swab maximum	Swab minimum	PP-31 [IR16] ==> 5 swabs/0.1m ² : • 1 swab/200cm ² [NR00] ==> 3-5 swabs/0.1m ² : • 3 swabs ==> 333.3cm ² • 4 swabs ==> 250cm ² • 5 swabs ==> 200cm ²
SPU	611.88	3	2	
iOH	344.24	2	1	
EH	550	3	2	
OH	89.78	2	1	
ICEU	777.6	3	2	
CT	8	1	1	

Type of biological samples:

- **Monitoring assays:** Samples taken directly on the RLS units or GSE.
- **Control Petri:** To control the environment during activities.

Analysis performed by INTA laboratory.

PP training given by PPO ESA and staff involved in PP tasks was certified.

Sterilization processes applied:

- Dry Heat Microbial Reduction (DHMR) as bulk sterilization method used in SPU, iOH, EH and CT.
- Hydrogen peroxide (H₂O₂) sterilization, which has effect on surfaces accessible for gas exchange. It was used on OH and ICEU.

4. Molecular control

The Infrared Spectrophotometer (Fourier Transform Infrared, FT/IR) Spectrometer) used for the verification of the molecular contamination levels is a JASCO, FT/IR-4200, with serial number C089761018. This equipment is located at INTA facilities (Material Department). The equipment is calibrated annually.

The limit of quantification of the FTIR equipment measured for each contaminant is as follows:

- Hydrocarbons < 2.8 ng/cm²
- Esters < 5.6 ng/cm²
- Methyl silicones < 2.8 ng/cm²

- Phenyl silicones < 3.1 ng/cm²

The total molecular contamination will be the sum of the obtained results of each group.

Two type of witnesses are used:

- Activity witnesses
- Tracking witness

Material used was characterised in order to know the molecular contamination contribution.

Analysis performed by INTA laboratory.

Unit in contact with the sample (Calibration Target):

For detecting less than 10⁻⁸ g/cm² molecular contamination, the TD GC-MS (Thermal Desorption, Gas Chromatography Mass Spectrometry) was used since FTIR cannot be used (detection threshold is around 5·10⁻⁸ ng/cm²). The TD GC-MS was calibrated to detect any of the 20 materials especially critical for MOMA. The molecular witness for CT measurements was a set of cylindrical stainless steel tubes.

Analysis performed by ESA-VSC laboratory in Valencia.

5. Particulate control

The Particle Fall Out Photometer Mk5-5, used for the particulate contamination level verification, is located at INTA facilities (inside a laminar flux cabinet). The equipment is calibrated annually.

In order to determine the dispersion measurements produced in the measurement process (equipment and operator), a characterization of it was performed obtaining the following result:

- ±3 ppm

They are used two type of witness:

- Activity witnesses
- Tracking witness

The Leica MEF4M Optics Microscope used for the verification of the particulate contamination levels by tape lift method (according to INTA internal procedure) is located at INTA facilities. Leica MeF4 is an inverted metallographic microscope with magnification between 1x and 1880x. The petri dish with the tape is placed facing down on the sample holder of the microscope.

Unit in contact with the sample (Calibration Target):

For detecting particles of 1 micron or less, it was used the SEM counting to analyse the AI plate witness.

Both analyses performed by INTA laboratory.