Aerospace & Advanced Composites GmbH
Viktor-Kaplan-Straße 2
2700 Wiener Neustadt, Österreich
office@aac-research.at
+43 2622 90550-50
+43 2622 90550-99

# Outgassing tests offered by AAC

To qualify materials for their suitability for space applications, assessment of outgassing properties is required. "Outgassing" is defined as the mass loss of a sample due to vacuum exposure at elevated temperature. Two different approaches may be used:

## Outgassing test acc. to ECSS-Q-ST-70-02

During this test the outgassing behaviour is assessed by measuring the weight of the samples before and after thermal treatment. Furthermore, the mass gain of cooled collectors due to condensed matter is measured. By measuring the condensed mass, it is possible to evaluate the possible contamination of sensible components (such as mirrors) by outgassed material. As for many applications the water-loss is not relevant, samples are also weighted after a post-conditioning (24 hours at 22°C and 55%rH) allowing recovery of lost moisture.

An outgassing measurement is performed in the following steps:

- Pre-conditioning of samples: 24 hours at 22°C and 55%rH
- Weighing of samples, empty sample cups and collectors
- Thermal vacuum test: 24 hours at 125°C in vacuum ($P < 10^{-5}$ mbar)
- Weighing of samples and collectors
- Post-conditioning of samples: 24 hours at 22°C and 55%rH
- Weighing of samples

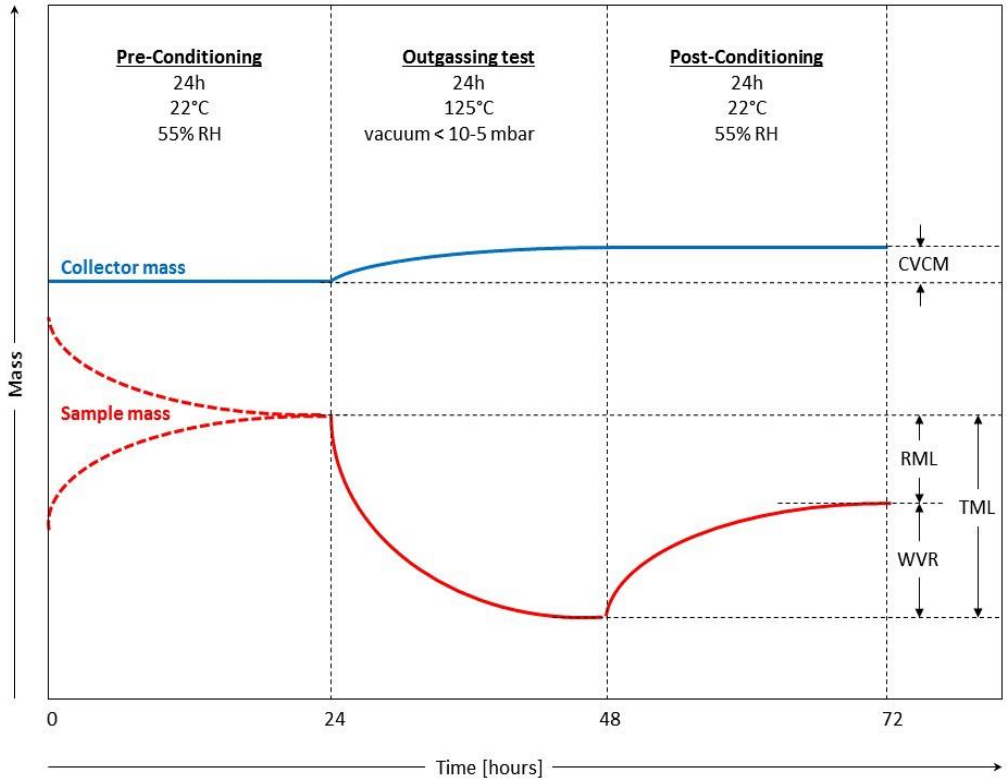


*Figure 1: Schematic representation of characteristic parameters TML, RML, WVR and CVCM*

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The following parameters are determined as result of the standard outgassing test:

- **TML** (Total Mass Loss)
  Total mass loss relative to the initial sample mass
- **RML** (Recovered Mass Loss)
  Mass loss after water absorption during post-test conditioning (relative to initial sample mass)
- **WVR** (Water Vapour Regained)
  Mass gain during post-test conditioning (relative to initial sample mass).
- **CVCM** (Collected Volatile Condensable Material)
  Mass gain of collectors relative to initial sample mass.

| Outgassing test according to ECSS-Q-ST-70-02 | |
|---|---|
| **Sample dimensions** | 3 samples per material required by ECSS for statistical evaluation<br>Each sample weight 100 – 300 mg<br>Max. size per sample 8x8x10 mm |
| **Materials per test run** | For each test run 4 materials plus 1 empty sample cup (reference) is measured (i.e. 15 samples) |
| **Vacuum** | P < $10^{-5}$ mbar |
| **Temperatures** | 22°C 24 hours (pre-conditioning at 55%rH)<br>125 °C 24 hours (thermal vacuum test)<br>(up to 300°C on request (non-ECSS))<br>22°C 24 hours (post-conditioning at 55%rH) |
| **Results & ECSS requirements** | TML: mean value < 1.0% standard deviation < 0.1 * mean value standard<br>RML: mean value < 1.0% deviation < 0.1 * mean value standard deviation<br>CVCM: mean value < 0.1% < 0.2 * mean value |

Your contact at AAC: Mr. Christian JOGL
senior scientist
T +43 (0) 2622 90550-470
M +43 (0) 664 8464023
F +43 (0) 2622 90550-99
christian.jogl@aac-research.at
http://www.aac-research.at

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## Advanced outgassing test

This test is used in extension to ECSS Q-ST-70-02C and in accordance to ECSS-Q-TM-70-52A (kinetic outgassing of materials for space). The test setup has been developed according to an in-house-standard agreed with ESTEC.

The advanced outgassing test offers high sensitivity and may be used for a detailed investigation of the mass transport of materials under thermal vacuum (e.g. mass-loss due to sublimation, evaporation, outgassing, etc.). Since a vacuum microbalance records mass changes "in-situ" during the thermal vacuum measurement, mass loss is measured online. Furthermore, the species of the outgassing or evaporated particles can be analysed by online Quadrupole mass spectroscopy. Due to the Quadrupole and the installation of the micro balance it is not possible to obtain CVCM (Collected Volatile Condensable Material) - values as for the standard outgassing test. Optionally, an in-situ infrared analysis can be used. The so-called "ConMon" includes a TQCM where molecular organic contaminants (MOCs) condense allow to measure their mass. Using an infrared laser (IRRAS) these MOCs can be analysed in-situ for their chemical nature.

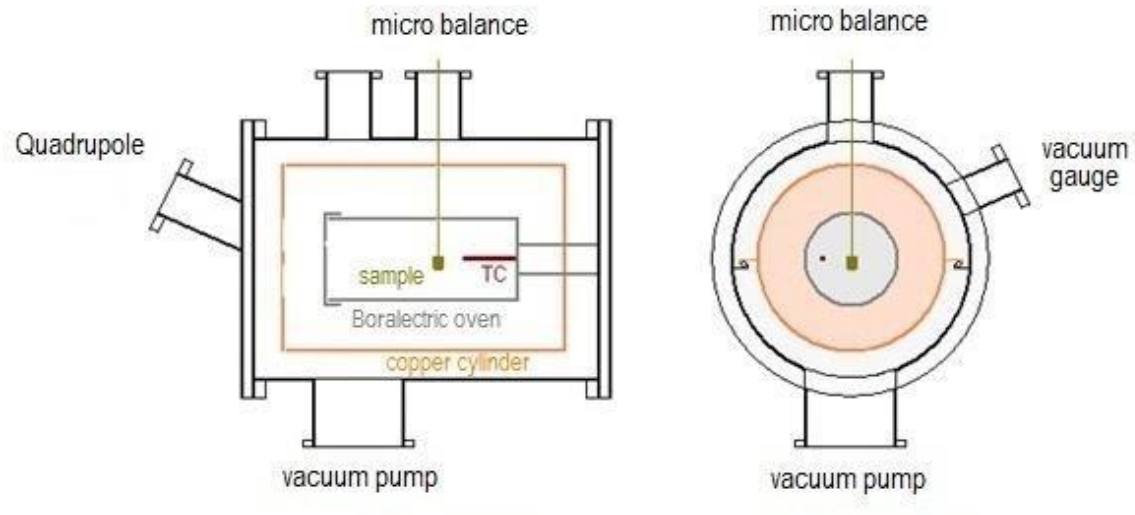


*Figure 2: Schematic representation of advanced outgassing test rig. (left: side view, right: front view)*

For the advanced outgassing test different procedures are available:

- Dynamic test: The temperature is increased with constant rate until severe mass loss is observed. This test mode may be used to identify the critical temperature range for the material under investigation. Furthermore, using the online mass spectroscopy it is possible to assess at which temperature which chemical species is emitted from the sample.

- Static test: The temperature is increased as fast as possible to a certain level and then held constant, until a constant sublimation rate is gained. This mode of operation is the direct extension to ECSS Q-ST-70-02C (standard outgassing).

- Kinetic outgassing test (ECSS-Q-TM-70-52A): The temperature is increased in steps of e.g. 25°C and held constant for e.g. 24hours. This procedure allows long-term prediction of the outgassing behaviour in accordance to ECSS-Q-TM-70-52A.

- Vapour pressure test: The vapour pressure of an outgassing material is calculated using Langmuir's equations. For low temperatures only poor accuracy is obtained but temperatures up to 400°C are available.

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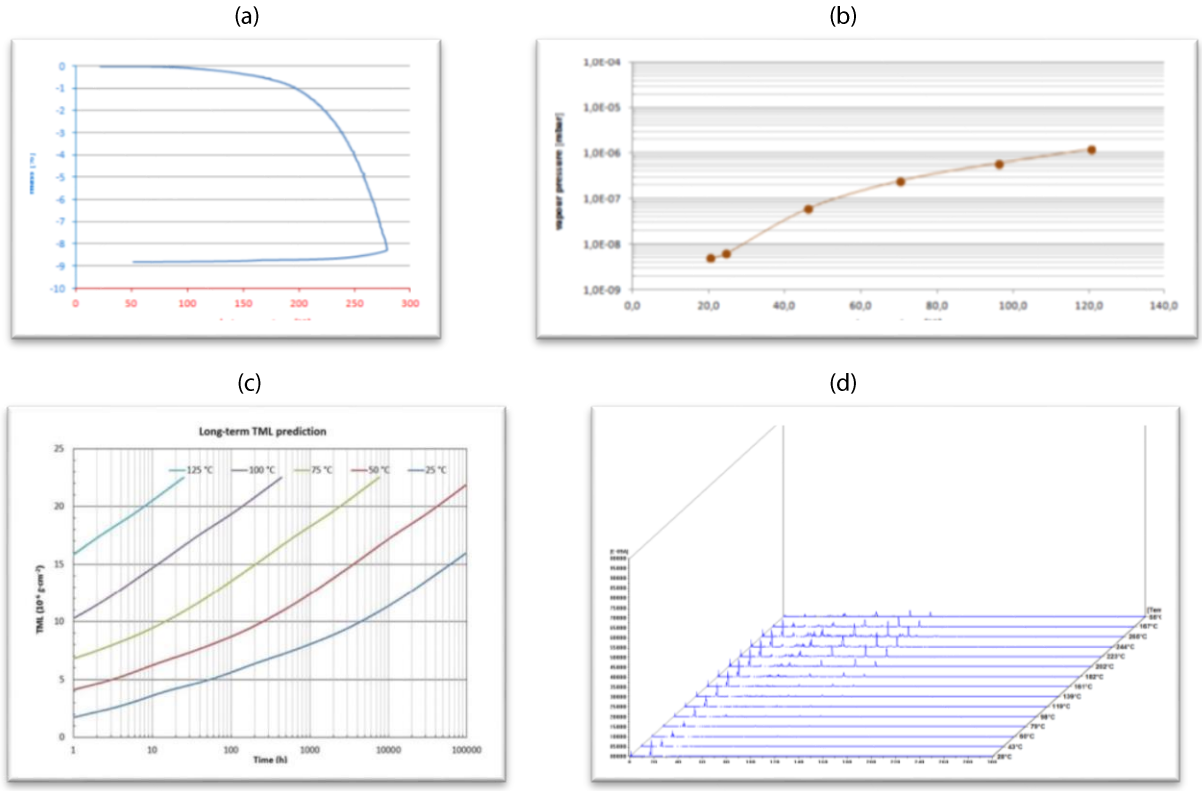


Figure 3: Advanced outgassing examples: (a) dynamic test, (b) vapour pressure calculation, (c) long-term outgassing prediction (kinetic test), (d) residual gas analysis vs. temperature

| Advanced Outgassing Test | |
|---|---|
| **Sample dimensions** | 1 sample per test run<br>max. 25 g<br>different geometries, max size: spherical shape diameter 60 mm |
| **Vacuum** | P < $10^{-6}$ mbar |
| **Temperatures** | from RT up to + 450 °C |
| **Accuracy** | vacuum-balance: ±1µg<br>time drift of vacuum-balance: < 5x$10^{-7}$ g/h<br>sample temperature: ±1°C |
| **Results** | online measurement of<br>• mass loss as function of time / temperature<br>• residual gas analysis (mass spectrometer of outgassing particles)<br>• in-situ IRRAS analysis of redeposited material on TQCM |

Your contact at AAC: Mr. Roland HOLZBAUER
junior scientist
T +43 (0) 2622 90550-360
M +43 (0) 664 88606182
F +43 (0) 2622 90550-99
roland.holzbauer@aac-research.at
http://www.aac-research.at