LVC Facility Description

The aim of the LVC test facility is the simulation of thermal vacuum conditions, e.g. space environment in open space and sun exposure. The vacuum chamber offers an inner diameter of 1,500 mm and a height of 1,500 mm (volume: approx. 1.5 m^3).

The temperature of the hardware under investigation is adjusted by means of a temperature controlled copper plate mounted inside the vacuum chamber. The plate is heated electrically, the cooling is performed by liquid nitrogen (LN2: T = -196 °C). General specifications of this plate are:

- Available dimensions: 1000x700 mm^2, 500x500 mm^2, extension plates 1,000x1,000 mm^2
- 60x50 mm grid of M6 threads for sample fixation
- Heating rate up to 5-6 K/min
- Maximum operating temperature +250 °C (short time), +200 °C (continuous)
- Cooling rate up to 5-6 K/min
- Minimum operating temperature -185 °C in vacuum
- Various copper shields for improved thermal homogeneity available
- For specific applications 2 heating/cooling plates may be used in parallel, either in sandwich configuration or mounted in two stages for larger amount of test items

The LVC test rig is positioned in a “visible clean” laboratory clean environment next to an ISO7 clean room that may be used for sample preparation. Figure 1 shows an overview image of the LVC test rig, the following sections describe the sub-systems in detail.

<u>Figure 1:</u> Overview of LVC Thermal Vacuum Chamber

Chamber Setup

To allow the connection of measurement devices for the characterisation of the test object (e.g. thermocouples, Si-diode sensors, motors, etc.) and to connect the cooling and heating devices the chamber is equipped with the following flanges on the circumference of the chamber:

- 6xCF40
- 4xCF63
- 2xCF160
- 1xCF200

Vacuum Generation and Control

A vacuum pressure of 10^{-6} mbar can be achieved. Alternatively, it is possible to perform tests in defined gas atmosphere (e.g. 100 mbar N_2). Various non-corrosive gases at pressures below ambient can be used for the testing. The following equipment is used to maintain and control the pressure:

- Rotary vane pump — Pfeiffer DUO 65 M
- Turbo pump — Pfeiffer TPU 1201 (1,250 Nl/s)
- Rough vacuum gauge — Pfeiffer TPR 018 (Pirani gauge head)
- High vacuum gauge — Pfeiffer IKR 060 (inverted magnetron gauge)
- Pressure control — Pfeiffer RVC300/EVR 116 valve/CMR361 gauge

All pressure measurement cells are calibrated by manufacturer. Additional calibration on customer request may be done on customer´s expense at Pfeiffer Vacuum; expect lead time of ~ 2 weeks.

Temperature Control and Measurement

To achieve the required temperature on the hardware, two Eurotherm temperature controllers are available. They allow the definition of complex temperature profiles which can be completed automatically. The temperature is measured by thermo-sensors at several positions inside the LVC. For each setup all thermo-sensors are calibrated using an Ametek CTC-650 calibration furnace (calibrated by manufacturer).

The following equipment is used:

- 2x Eurotherm 2416 with Thyristor
- up to 24 thermocouples type K (Ø 0.5 mm)
- On request: 20 PT100, Ø 2.0 mm, measurement performed by Keithley 2700 Multimeter

If required, additional Eurotherm 2416 units will be installed for operating a cold plate or additional heating systems for the respective test.

Electrical Measurements

Various feedthroughs for connecting electrical/electronic devices, sensors, actuators, are available. Most feedthroughs are DSUB25 or DSUB9 type, with male pins both on vacuum and air side.
Please indicate the required type and number of feedthroughs.
Airside gender changers and crossing cables are available.

For higher power demand, several feedthroughs with up to 60A/pin are available.

Measurement can be made by customer´s own electronic boxes, or AAC may provide power supplies, and – on specific request – customer specific electronics for operating a device.

Additional Support Equipment

- For specific applications the measurement of electrical properties (e.g. electrical resistivity, voltage, current) is required. For this purpose, a Keithley 2700 Multimeter equipped with Keithley 7700 multiplexer is available. Up to 20 channels may be read out simultaneously. This device is also used to read the PT100 temperature sensors (if installed).
- To assess the amount of material evaporated from the sample during the thermal vacuum test a TQCM (**T**emperature-controlled **Q**uartz **C**rystal **M**icrobalance) may be installed.
- For RGA analysis (**R**esidual **G**as **A**nalysis) a quadrupole mass spectrometer, model ThermoScientific Smart IQ+ with 0-200 amu range, can be attached to the chamber.
- All devices listed above are controlled by a commercially available PC. The software to control all devices and to record all parameters has been developed at AAC.
- To test the performance of moving parts (e.g. potentiometers, slip rings …) under space environment, a drive train can be mounted on the LVC chamber. It is equipped with servo or stepper motors and different torque gauges.
- All devices listed above are controlled by PC. The TherESA software to control all devices and to record all parameters has been developed at AAC.

Cleaning Procedure

The step-by-step procedures, how tests are performed in the LVC rig can be found in the according test specifications and in the test procedures available at AAC. However, one common step to prepare the test rig for the tests is the cleaning procedure. For all operations performed in the clean room, cleanroom smocks and cleanroom snoods should be worn during cleaning operations and for handling the hardware.

The chamber and all installed support equipment are being wiped with IPA using non-linting cleanroom tissues. In specific cases, other permitted solvents may be used, too. The cleanliness is tested and documented by performing wiping tests: The tissue is soaked with IPA and the inner side of the CF flange where the water-cooled turbo-molecular pump is mounted, is wiped. The tissue is put into a sample bag and the sample bag is stored in plastic sheets together with the project's process slip. Also a contamination protocol is stored.

Chamber Bakeout

The amount of molecular organic contaminants (MOC) is most efficiently reduced by chamber bake-out under vacuum. This is typically done in two stages:

- Facility Cleaning Bake-Out:
  Standard temperature 165 °C on process plate(s)
  Duration at least 24 hours
  Target value $<<1x10^{-5}$ mbar
- Blank Bake-Out
  Temperature and duration depending on customer specification
  Duration typically 72h
  Target vacuum $<1x10^{-5}$ mbar (typically $<3x10^{-6}$ mbar)
  Optional: TQCM monitoring
  Installation of MOC / PFO samples (to be provided by customer)

Table of Equipment

To summarise the information given above, Table 1 lists the equipment used at the LVC test facility. Optional equipment is listed *in italics* at the end of the Table.

Table 1: List of equipment used for LVC test rig

Equipment	Type	Device Number	Serial Nr	Remark
Rotary vane pump	Pfeiffer DUO 65 M	PK D46 035 E	22093766	
Oil Mist Eliminator	Pfeiffer OME 40S	PK Z40 150	104887	
Turbo pump	Pfeiffer TPU 1201	PM P03 696	14561399	
Rough vacuum gauge	Pfeiffer TPR 018	PTR15014	44478318 TES69	Pirani gauge head
High vacuum gauge	Pfeiffer IKR 060	PTR18751	44243821 TES18	Inverted magnetron gauge head
Vacuum Monitor	Balzers TPG 300	PT546900-T	44482210	Controller for TPR and IKR gauges
Vacuum Controller	Pfeiffer RVC300	PFI00792A	45569203	Controller for EVR116/CMR361
Vacuum control valve	Pfeiffer EVR 116	PFl39931	45643637	Electro-mechanical dosing valve
Vacuum gauge for gas pressure control	Pfeiffer CMR361	PTR24601	44578326 TES105	Piezo transducer, 1-1,300 mbar
Temperature Controllers	2x Eurotherm 2416		FC1317000986 FC1317000987	Upper and lower plate controllers
Thermocouples and Signal Converters	16x Type K ∅ 0.5 mm Inconel shielded TCs Datexel	DAT3018 A/D	n/a – AAC equipment ID# TES68a/b	ICCP, Austria (sensors), Datexel LLC (A/D Converters)
Main Control Computer	Lenovo VS20-15IKL	10NK002MGE	PCOUN5A2	Standard Mini Desktop PC
Data Acquisition and Control Software	TherESA Version 8.4.0			AAC internal development
On request: Additional Thermocouples and Signal Converters	*8x Type K ∅0.5 mm Inconel shielded TCs Datexel*	*DAT3018 A/D*	*n/a – AAC equipment ID# TES121*	*ICCP, Austria (sensors), Datexel LLC (A/D Converters)*
Multimeter	*Keithley 2700*		*4045974*	*with Keithley 7700 multiplexer, 20 channels*
PT100 thermo-elements	*OMEGA Thinfilm RTD Element F3105*		*n/a*	*Optional. Only on request.*
TQCM Sensor Unit	*BeamTec / McVac Inc. Twin Sensor Head*	*Model MV-700-009S*	*n/a*	*6 MHz crystal*
TQCM Controller	*Colnatec EON-LT*		*20160812AAC*	
RGA	*ThermoScientific Smart IQ+*		*1703-01-182-3*	*0-200 amu*
Calibration furnace	*Ametek*	*CTC-650 B RS232*	*620568-00905*	*For temperature sensors*

List of Consumables

The standard consumables are listed in Table 2 below:

Table 2: Permitted consumables in the LVC test rig

Consumable	Quality	Vendor / Article ID#
Cleaning fluids – General Use: • Acetone • Ethanol • 2-Propanol	 technical grade technical grade technical grade	 W. Neuber's Enkel Roth Lactane Roth Lactane
Cleaning fluids – Sensitive Test Items: • 2-Propanol (mostly used) • Acetone • Ethanol • n-Pentane	 AnalaR NORMAPUR ACS/REAG.PE/REAG.USP IR grade TechniSolv reinst AnalaR NORMAPUR zur Analyse	 VWR Chemicals Roth Lactane VWR Chemicals VWR Chemicals
Cleaning Tissue: • Standard: White paper tissues • Optional: Cleanroom Wipers	 OTS non-linting	 Various suppliers VWR 115-0036
Mounting samples and thermo-sensors: • Kapton tape	ECSS-Q-ST-70-02C passed	RS-Components Art.-No. 436-2778
Purging / Venting: • Nitrogen (standard) • Argon (on request) • Carbon dioxide (on request)	 Grade 5.0, 99.999% Grade 5.0, 99.999% Grade 3.0, 99.9%	Messer Austria
Thermal Shielding / Homogenisation: • Aluminium foil • Multi-layer isolation (up to 150 °C)	 OTS MLI Coolcat 2	 Various suppliers RUAG Space Austria

Please note: Other consumables may be used if agreed on between AAC and Customer.

Contact

For any questions, please contact

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