Owner's Manual

ACONITY*MIDI*

Version: 2018-04

Attention!

This manual contains essential instructions that must be complied with during commissioning, operation and maintenance of the LBM Research Equipment!

Content

1 General Information

1.1 Identification Data

Machine type:	LBM Research Equipment
Model Name:	Aconity***MIDI***
Serial Number:	500154-1
Order Number:	2000043796
Year:	2019

1.2 Customer Registrations

Inventory Number:	D001116
Location:	University of South Carolina Department of Mechanical Engineering McNAIR Aerospace Center 1000 Catawba St Columbia, SC 29201 USA

1.3 Manufacturer Address

Company Name	Aconity3D GmbH
Street	Kaiserstr. 98
ZIP Code	52134
City	Herzogenrath
Country	Germany
Phone	+49 2407 55292-00
Fax	+49 2407 55292-99
Website	www.aconity3d.com
Email	info@aconity3d.com

1.4 Spare Parts and Customer Service

In case of need of spare parts or any additional process or product information, please contact our customer service via the contact data stated above.

1.5 Further Documents

Manuals of essential components integrated into the LBM system will be made accessible independently from this manual.

1.6 Operating Manual Information

Document No.	Aconity***MIDI*** EN
Version	2018-01
Date	April 2018
Last Modifications and Alterations:	April 2018

This document has been issued for reasons of familiarizing the operators with operating the LBM Research Equipment Aconity***MIDI***, focusing on safety precautions, modes of function, operation and maintenance.

This operation manual is subject to updating on a regular basis. Please always refer to its current version and contact us for the current one and any additional information!

2 General Safety Information and Regulations

2.1 Basic Safety Information

Knowledge of safety precautions and regulations is the basic prerequisite for safe handling and trouble-free operation of the LBM Research Equipment.

It is mandatory for any individual – staff or other – charged with maintaining, servicing, operating or any other handling of the LBM Research Equipment to be completely familiar with the contents of the operating manual. In particular the safety precautions and regulations are to be studied carefully and need to be understood.

Keep this manual in the direct vicinity of the LBM Research Equipment. It is mandatory for any individual maintaining, operating or handling the LBM Research Equipment to have free access to the operating manual and the safety precautions and regulations at any time and to strictly comply with these.

Aconity3D GmbH is not liable for any damages resulting from ignorance or misunderstanding of or non-compliance with information contained within this user's manual.

2.2 Safety Symbols

DANGER!

The adjacent symbol is made use of as a general warning symbol against any potential dangers or risks to any user. It is mandatory for potential damage prevention to comply with all statements referring to safety instructions marked by this symbol.

DANGER implies high risk potential of harm resulting in possible death or severe injuries when ignored.

WARNING!

WARNING implies medium risk potential of harm, resulting in death or severe injury, when ignored.

CAUTION!

CAUTION implies low risk potential of harm, resulting in minor to moderate injury, when ignored.

Risk of harm due to laser radiation.

Risk of harm due to high electric voltages.

Risk of harm due to hot surfaces.

Risk of harm due to magnetic fields.

Risk of hand injuries due to moving parts.

Risk of harm due to toxic material.

Risk of harm due to explosive material.

Risk of harm due to inflammable material.

Risk of harm due to electromagnetic fields.

Risk of harm due to suffocation.

Risk of harm due to high-frequent radiation.

This sign warns against high frequent radiation. Individuals fitted with cardiac pacemakers, defibrillators or other implanted electronic devices are not allowed access in areas marked by this symbol, as high-frequent radiation may interfere with the proper functioning of the above-mentioned devices.

Read and understand the user's manual before working with the LBM research equipment.

Please wear protective gloves.
The protective gloves must comply with the following criteria:

- Flame retardant
- Dustproof

Please wear protective eye glasses!

The kind of protective eye glasses advised is stated in the respective safety data sheet.

Please wear full respiratory protective mask with particle filter (filter category P3) and powder protective glasses!

Please wear protective apparel, complying with the following criteria:

- Long sleeves
- Tight fitting
- Flame and heat resistant

Please wear safety shoes with integrated steel cap!

Please wear anti-static safety shoes to avoid spark formation

IMPORTANT!

This symbol instructs proper use of LBM research equipment. Ignoring this safety symbol may result in mal-functioning of LBM Research Equipment or its components.

2.3 Qualification of Personnel

The LBM research equipment Aconity***MIDI*** is to be exclusively operated by authorized personnel, trained by Aconity3D staff members.

DANGER!

Danger of personal injury and damage!

Unqualified personnel are subject to danger due to misconduct while working with the LBM research equipment.

- The LBM system may only be operated by authorized personnel, trained by Aconity3D staff members.
- All work on electrical equipment of the LBM system may only be carried out by a qualified electrician according to the electrotechnical regulations.
- Read and understand the manual before working with the LBM system.

Personnel competences for operating the LBM research equipment, refitting, retrofitting and maintenance are defined in Table 1.

Personnel Activities	Trained	With technical qualification	Qualified Electricians	Supervisor with proper competence*
Packaging & Transport	**x**	**x**	**-**	**x**
Commissioning	**x**	**-**	**x**	**x**
Operation	**x**	**x**	**-**	**x**
Trouble shooting	**x**	**-**	**x**	**x**
Trouble shooting: Mechanical parts	**x**	**-**	**-**	**x**

Trouble shooting: Electrical parts	-	-	x	x
Machine set-up & Preparation	x	x	-	x
Maintenance	x	x	x	x
Repair works	x	-	-	x
Decommissioning, Storage	x	x	-	x

Table 1: Survey of authorized staff activities

*Competence: Personnel trained by Aconity3D GmbH.

2.4 Safety Briefing

Operation of LBM Research Equipment is only permitted to personnel, subsequent to acquiring the Completion Certificate (Safety Briefing) as for risks due to laser radiation. This safety briefing is to be provided by the operating company.

2.5 Organizational Measures

Any protective apparel and laser safety glasses for the personnel are to be provided by the operating company.

Any protective devices provided are to be checked for functionality by the operating company on a regular basis.

All safety instructions and warning signs regarding the LBM Research Equipment are to be kept in fully readable state or replaced if required.

2.6 Additional Safety Regulations

Please comply with the complete range of national regulations, safety and injury prevention rules and environmental regulations, as well as the specific domestic rules for safe and professional working practices.

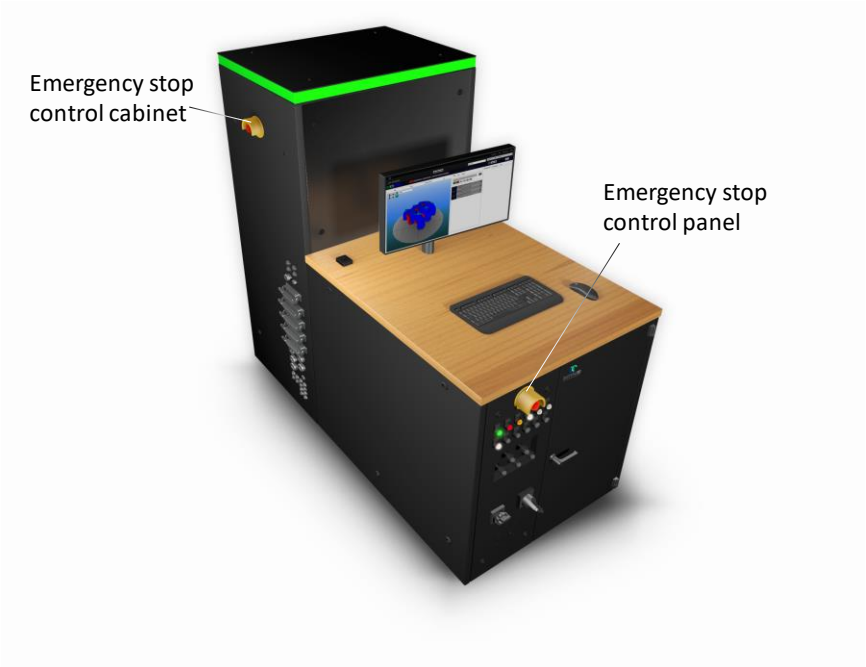
In addition to the safety notices within this manual, please also comply with the safety notices within the manuals of third party component providers.

2.7 Procedure in Case of Emergency

Upon malfunction of the LBM system, please comply with the following steps:

- Immediately stop the machine by means of one of the redundant emergency stop buttons on the control cabinet, or the control panel of the machine (see Figure 1).
- Get promptly authorized personnel, who can determine the cause of the emergency and eliminate it.
- If one of the redundant emergency stop buttons fails, use an alternative on the control cabinet or control panel (see Figure 1).

Figure 1 Schematic illustration of the emergency stop buttons



DANGER!

Acute danger of personal injuries or material damages!

When pressing the emergency stop button, the following components of the LBM Research Equipment are still powered via main switch:

- Mains supply line
- Control cabinet computer and screen

- Peripheral units
- Control current circuit 24 VDC

2.8 Intended use of LBM research equipment

The machine is intended for exclusive use for experiments in the research and development of laser melting processes of powdered materials. Use the research equipment exclusively as described in the operating instructions. If you have any questions regarding the intended use of the machine, please contact the Aconity3D GmbH support.

2.9 Non-intended use of LBM research equipment

To avoid misuse, please ensure the following:

- Commissioning of LBM research equipment and peripheral devices is to be exclusively executed by Aconity3D GmbH service staff.
- LBM Research Equipment and peripheral devices are not to be modified or altered in any form by unauthorized individuals.
- Any bypassing of travel limit switches, valves and safety and control elements is strictly prohibited.
- None of the limits stipulated in the operating manual (pressures, flow rates, temperatures, dimensions, etc.) are to be exceeded.
- Any technical failures or damages, displayed by the system or other non-displayed, are to be reported immediately for elimination
- Any malfunctions or damage indicated by the system or otherwise identified shall be reported and rectified promptly.

2.10 Protection Devices

For operation of LBM research equipment all protective devices are to be duly attached and in full functional state.

Protective systems may only be removed, if:

- Machine is on halt
- Machine is secured against re-starting (e.g. locked main switch)

The operating personnel are liable for ensuring full functionality of all protective devices before each start of operation.

2.11 Operation of LBM Research Equipment

Strictly operate LBM research equipment with all protective devices fully functional.

Please check LBM research equipment for any external damages and full functionality of all protective devices prior to start of operation.

Please ensure proper operational environmental requirements of research equipment to be fully complied with (see 5.2.2).

Please ensure safeguarding any by-standing individuals prior to start of operation.

2.12 Materials Used

Within the LBM system, metallic powder is used as raw material, which can be subject to safety regulations. Always observe the manufacturer's safety data sheets when handling metallic powders, as well as the safety requirements in section 3.7.

When processing metallic powder materials by means of laser radiation, a metal condensate can be formed. Depending on the process parameters selected and the powder material used, the amount of metal condensate formed may vary. The metal condensate is suctioned off during the process and collected in a filter unit (see 11.2).

Metal condensates are considered highly flammable and can form an explosive atmosphere in conjunction with air. Always observe the safety instructions in section 3.7 when handling metallic condensates.

2.13 Laser Safety

This system is classified as a laser system according to ISO 11145. Essentially, the laser system consists of a process chamber, an electrical cabinet, a control cabinet, an optical mount and a laser source.

The wave length of the processing laser is 1070 nm with a maximum power of 200 - 1000 W in operational mode.

Optionally, additional laser beam sources of various wave lengths may be mounted. In this context, please refer to section 6.1.8 for detailed information as for further options.

The installation corresponds to the use of an optional laser protection enclosure according to DIN EN 60825 of the laser protection class 1. Without the use of a laser protection enclosure, the system corresponds to the laser protection class 4 and may only be operated using further protective devices. Please observe the warning notices for laser safety in section 3.2 when using the system.

3 General Safety Instructions

3.1 Fire Precautions

DANGER!

Fire and Explosion Hazard!

While operating the LBM research equipment, igniting sources such as laser radiation, heat sources or electrostatic discharge can lead to life-threatening fire and explosion risks.

- In the direct vicinity of the area affected by laser radiation or in areas affected by reflected laser radiation, no flammable materials, e.g. paper, fabrics or thin wood sheets may be used.
- In the work area of the research equipment, no containers with flammable liquids, e.g. solvents or cleaning agents may be stored
- Strictly avoid electro-static discharges.
- Do not smoke in the operation area and in the immediate vicinity. Avoid exposure to open light, fire and sources of ignition.
- Please comply with domestic national regulations when firefighting.
- For firefighting strictly disconnect research equipment from main power switch and, if possible, from general power supply for efficient fighting of fires caused by electricity.
- Provide appropriate fire extinguishing agents (fire blanket, fire extinguishers, etc.).

DANGER!

Danger caused by using unsuitable extinguishing media!

Fire extinguishing agents advised by *A*conity3D GmbH:

In case of fires caused by electricity:

- A-B-C-extinguishing agents

In case of fires of processing materials:

- Sand or D-extinguishing agents

In case of fires of operating supplies:

- Sand

DANGER!

Danger caused by restricted or improper firefighting!

If the fire extinguishers are not ready for use or are unsuitable for the specific fire class, fire injuries may result in death or serious damage to property.

- Please make sure that fire extinguishers are suitable for the specific fire class only.
- Regularly check fire extinguishers for operational readiness.
- Refill fire extinguishers after each use.
- Only use fire extinguishers, propellants and spare parts which are in accordance with the recognized model specified on the fire extinguisher.
- Observe the safety and operating instructions on the fire extinguisher before using.
- Observe the operating temperature range of the fire extinguisher before using.

3.2 Laser Safety

CAUTION!

Danger caused by laser safety class 1 laser radiation!

When equipped with an optional laser proof protection enclosure according to DIN EN 60825, the LBM research system corresponds to a laser system of the laser safety class 1.

- Operation of the LBM research equipment for laser protection class 1 systems is not permitted without corresponding use of the laser proof protection, bridging of safety switches, or failure to integrate into a facility safety concept (restricted access area with interruption contact and warning signal at the door).
- The laser system shall be installed or fixed, including devices located in the beam path, in such a way as to avoid any unintentional change in its position and beam direction.

DANGER!

Danger caused by laser safety class 4 laser radiation!

Without the optional laser proof protection enclosure, according to DIN EN 60825, the LBM research system corresponds to a laser system of the laser safety class 4.

Irradiation of the eye or skin by direct or scattered laser radiation leads to serious injuries.

- The system may only be used when integrated into a facility safety concept.
- Operation of the laser safety class 4 system is only allowed for in a restricted room with equipped with a laser emission indicator lamp.
- The interlock safety circuit of the research equipment must be connected to the entrance door of the room via the interface provided on the control cabinet.
- Directional and diffuse laser beam reflections must be avoided as they are highly energetic and invisible.

- The operator must ensure that all safety measures used are adapted to the corresponding laser protection class, the wavelength, the laser system and the emitted laser beam power.
- Indicate the used laser beam (wavelength, laser regime, average output power) at the entrance door of the research facility in which the research equipment is placed.
- Never operate the research equipment without suitable laser protection goggles according to DIN EN 207 (DIN 58215) for the applied wavelength range.
- Wear suitable personal protective equipment such as gloves and protective apparel made of flame and heat resistant material.

3.3 Spare Parts

DANGER!

Danger caused by use of improper spare parts!

The use of improper or defective spare parts may lead to personal injuries, material damages, malfunction or machine breakdown**.**

- Exclusively use Aconity3D GmbH spare parts or those authorized by them.
- In case of doubt, please contact Aconity 3D GmbH.

3.4 Danger caused by Electricity

DANGER!

Danger due to electric voltages!

Acute danger to life caused by electric shock when touching live parts!

- In case of damages to insulation of live parts, immediately switch off power supply and put repair works into action!
- Work on electrical components is strictly to be performed by qualified electricians.

- Prior to any electric works, maintenance, cleaning and repair works the research equipment is to be switched off, checked for zero potential and secured against re-starting.
- Strictly no by-passing and/or disabling of fuses. In case of fuse replacements exclusively use fuses with correct power level indications.
- Strictly avoid moisture in the vicinity of the research equipment, as it causes short circuits.

DANGER!

Acute danger to life caused by stored charges!

Electric charges can be stored in electronic components, which are retained even after switching off and disconnecting from the power supply. Contact with these components can result in serious or even fatal injuries.

- Strictly cut off electric components completely from power supply and allow the capacitors 10 min for complete discharge prior to any works with electric components

DANGER!

Danger caused by residual electro-static potentials!

Reactive metal powders may initiate violent reactions (fire, explosions) due to sparking and electro-static charges in combination with ambient atmosphere.

- Please ensure anti-static design of all components, tools and devices used for sucking up, vacuuming!
- Please ensure anti-static quality of protective apparel!

3.5 Danger Caused by Handling Moving Parts

WARNING!

Danger of personal injuries caused by moving parts!

Rotating and/ or linearly moving parts may cause severe injuries.

- Strictly avoid getting within reach of moving parts or touching them during operation.
- Strictly do not open covers during operation.
- Please check for follow-up time and ensure complete stop of moving parts prior to removal of covers.
- Please wear only tight-fitting protective apparel with low resistance to tearing within hazardous areas.

WARNING!

Danger of personal injuries due to negligent handling of tools!

Incorrect handling of the tools can cause bruises or cuts.

- Please handle tools properly and with necessary care.
- Please consider the weight of tools during transport.
- Please wear protective gloves and safety shoes when handling tools.

WARNING!

Risk of cutting!

Broken glass may have sharp edges.

- Please handle broken glass with great care.
- Please wear protective gloves when disposing of it.

WARNING!

Squeeze and shearing danger!

When installing the process chamber, hands, arms and feet can be squeezed between the process chamber and the structure of the optical mounting unit.

When moving the axes, also limbs may be squeezed.

- Strictly keep hands, arms and feet off the hazardous areas.
- Please wear safety shoes.

3.6 Danger Caused by Exposures to Gases

WARNING!

Suffocation risk due to exposure to argon!

When in high concentration, leaking out argon displaces oxygen in the ambient air, thus causing loss of consciousness or even suffocation when inhaled.

- Strictly consult safety data sheet provided by manufacturer.
- Provide readily available self-contained breathing apparatus in case of emergency.
- Always lead the exhaust gases into the open air directly or via an exhaust system of the facility.

- When using an exhaust air system, make sure exhaust gases are completely and permanently sucked off.
- Ensure there are no pits, shafts, or other bumps in the ground where argon might accumulate.
- Ensure that the installation site is equipped with an oxygen monitor.
- When Argon is flowing into the surrounding, always ensure fresh air supply.
- In case of accidental inhalation, take affected person immediately to fresh air in a stable side position. If breathing is stopped, seek medical attention immediately and initiate first aid measures

3.7 Danger Caused by Handling Powder Materials and Metallic Condensate

WARNUNG!

Risk of injury by contact with or by inhalation of hazardous dusts!

Skin and eye contact with, as well as inhaling and swallowing of powder materials may cause severe health impairment.

- Please refer to safety data sheets of the powders used.
- Only trained personnel are allowed to handle powder materials.
- Use powder materials only in well-ventilated rooms.
- Always wear personal protective equipment, such as powder-tight gloves, protective clothing, safety goggles and respiratory protection.
- Change and wash the safety clothing at regular intervals to prevent excessive dust contamination.
- Please ensure that all personal protective gear is removed after completion of the work in order to not

carry dust that is within the textile fabric beyond the working area.

DANGER!

Danger to life caused by fire and explosions of powder materials!

Powder materials are prone to ignition or formation of explosive gas when in contact with ambient air.

- Avoid electro-static discharges! Always wear anti-static wristband, connected to LBM Research Equipment via ground cable. Furthermore, always wear anti-static safety shoes when handling powder materials.
- Strictly refrain from smoking within hazardous area and vicinity of LBM research equipment! Refrain from handling open light, fire or ignition sources of all kinds.
- Please provide proper extinguishing agents (extinguish blanket, fire extinguisher) and keep them readily available.
- In case of heavy dust formation, immediately stop all works, allow for the dust to settle and remove dust layer subsequently.
- In case of fire, immediately stop all works, evacuate hazardous area until all-clear signal and contact fire department.
- Keep hazardous area dust-free at all times.
- Strictly use vacuum cleaners certified for removing inflammable and explosive powder materials and dusts.
- When handling powder materials, always wear appropriate personal protective equipment such as

safety gloves, respiratory protection, safety clothing and safety goggles with a leather hood.

DANGER!

Danger to life caused by fire and explosions of metallic condensate!

Metallic condensate is highly flammable and can be ignited or form an explosive mixture in the ambient air.

- Avoid electro-static discharges! Always wear anti-static wristband, connected to LBM Research Equipment via ground cable. Furthermore, always wear anti-static safety shoes when handling powder materials.
- Strictly refrain from smoking within hazardous area and vicinity of LBM research equipment! Refrain from handling open light, fire or ignition sources of all kinds.
- Please provide proper extinguishing agents (extinguish blanket, fire extinguisher) and keep them readily available.
- In case of heavy dust formation, immediately stop all works, allow for the dust to settle and remove dust layer subsequently.
- In case of fire, immediately stop all works, evacuate hazardous area until all-clear signal and contact fire department.
- Keep hazardous area dust-free at all times.
- Never use vacuum cleaners for picking up metallic condensate.
- When handling powder materials, always wear appropriate personal protective equipment such as safety gloves, respiratory protection, safety clothing and safety goggles with a leather hood.

3.8 Danger Caused by Exposure to High Temperatures

Risk of burns!

Process chamber and component surfaces heat heavily up during operation.

- Risk of skin burns when in contact with hot components and build platform.
- Risk of skin burns when in contact with heating elements.
- Prior to any works please ensure cooling down of all surfaces to ambient temperatures.
- Wear appropriate heat-resistant gloves and protective clothing for all work with hot surfaces.

3.9 Danger Caused by LBM Research Equipment Operation Noises

The outgoing continuous sound pressure level of the Research Equipment is ≤ 73 dB (A).

Due to local ambient conditions, higher noise levels may occur, causing hearing impairment. With higher noise levels, please use proper noise protection.

4 Scope of Supply, Dimensions and Weights

4.1 Scope of Supply

4.1.1 Standard Scope of Supply

The standard scope of supply comprises the following components:

- Machine
- Software
    - Windows 10
    - Aconity***Studio***
- Protective equipment
    - 1 x package disposable silicon gloves
    - 1 x disposable respiratory protection
- Tools
    - 1 x brush, 1 x scraper, 1 x scoop
    - key to control cabinet
- Key to Laser beam source
- Maximum 2 days on-site training at customer’s location while installing LBM Research Equipment
- Operating Manual

4.1.2 Accessories and Options

The following accessories and options supplementary to the standard scope of supply are available:

- System components

- Chiller
- Heating
- Wet separators

- Software modules
  - Magics 20, ILT-Build processor, SG + module
  - AutoDesk Netfabb Standard / Premium / Ultimate

4.2 Dimensions and Weights

4.2.1 Packaging

Shipping of standard scope of supply in 3 boxes with the following Specifications listed in Table 116.1 below.

Shipping: Dimensions and Weights Standard Scope of Supply		
Control cabinet (W x D x H)	Box 2000 x 1300 x 2300 mm³	650 kg
Process chamber incl. optical mount (W x D x H)	Box 1500 x 1500 x 2300 mm³	800 kg
Periphery (W x D x H)	Box 1250 x 1200 x 1050 mm³	200 kg

Table 1: Shipping: Dimensions und Weights Standard Scope of Supply

Dimensions and weights listed are standard indications and may vary according to the specifications ordered in agreement with the customer.

The shipping dimensions of accessories and options are listed in Table 2.

Shipping: Dimensions and Weights Accessories and Options		
Chiller (W x D x H)	Box 1500 x 1050 x 1900 mm³	400 kg
Induction heating* (W x D x H) *only with extra shipping	Box 1200 x 1000 x 1070 mm³	120 kg
Wet separator (W x D x H)	Pallet / Box 600 x 850 x 1200 mm³	150 kg
Setup station control cabinet & process chamber (W x D x H)	Box 1600 x 1400 x 2400 mm³	620 kg

Table 2: Shipping: Dimensions and Weights Accessories and Options

Accessories and options may be shipped in separate packaging units, such as stated above or in a single larger combined packaging unit.

4.2.2 Operational Status

Dimensions and weights of the machine in operational status are listed in Table 3 below.

Operational Status: Dimensions and Weights Standard Scope of Supply		
SLM process module (W x D x H)	710 x 860 x 1350 mm³	350 kg
Control cabinet (W x D x H)	1040 x 1550 x 1985 mm³	500 kg
Optical mount (W x D x H)	1050 x 980 x 2150 mm³	460 kg

Table 3: Operational Status: Dimensions and Weights Standard Scope of Supply

Dimensions and weights listed are standard and may vary according to the specifications ordered in agreement with the customer. Dimensions and weights of accessories and options in operational status are listed Table 4 below.

Operational Status: Dimensions and Weights Accessories and Options		
Chiller (W x D x H)	620 x 880 x 1230 mm³	159,5 kg
Induction heating* (W x D x H) *fitted into control cabinet	Generator 483 x 662 x 133 mm³	29 kg
	Outer circle 114 x 355 x 181 mm³	12 kg
Wet separator (W x D x H)	570 x 800 x 850 mm³	95 kg
Process monitoring device* (W x D x H) *fitted into control cabinet resp. optical mount of Research Equipment	Optical mount 1200 x 700 x 200 mm³	8 kg
	Laser beam source Lighting 19 “ 2 HU	5 kg
Pyrometry* (W x D x H) *fitted to optical mount	Optical mount 1200 x 700 x 200 mm³	6 kg
Control cabinet setup station (W x D x H)	680 x 1000 x 2100 mm³	280 kg
Additional process module (W x D x H)	710 x 860 x 1340 mm³	140 kg

Table 4: Operational Status: Dimensions and Status of Accessories and Options

Dimensions and weights listed are standard and may vary according to specifications in agreement with the customer.

5 Installation Site and Ambient Requirements

5.1 General Information

5.1.1 Transportation, Installation and Commissioning of LBM Research Equipment

Transportation, installation and commissioning of the LBM research equipment may involve dangers and risks.

DANGER!

Danger of personal injuries and material damages!

Improper transportation, defective installation and improper commissioning cause danger of personal injuries and material damages.

- Machine and accessories are to be removed from pallet by Aconity3D personnel exclusively.
- Machine and accessories commissioning by Aconity3D personnel exclusively.

For trouble-free transportation, installation and commissioning the customer is bound to comply with the following instructions:

- Transport routes to installation site are to be kept clear.
- Transport routes to installation site are to be barrier-free.
- Transport routes to installation site are to be clear of bumps and sleepers.
- Transport routes to installation site are to be sufficiently dimensioned for shipment units (boxes/pallets see section 4.2). Entrances and passages are to exceed dimension requirements for shipment units inclusive of respective means of transportation used by 5 cm minimum.

- Maximal floor load capacity (see Directory 5.3.4) is to exceed weight of shipment units (boxes / pallets) inclusive of respective means of transportation (forklift / pallet truck).

- Forklift and pallet truck of proper load capacity and fork length for transportation purposes are to be provided by customer (see section 4.2).

In-house movement is only to be executed after prior consultation as for requirements and dated with Aconity3D GmbH staff members. The to-be installation site is to be arranged by the customer in strict compliance with the specified requirements stated in this document.

5.1.2 Delivery and Storage

Machine and accessories are delivered by a forwarding agent at place and date stipulated, either in separated packaging units or in a single larger combined packaging unit (see section 4.2).

On delivery, the dispatch is checked by the customer for intactness and completeness. Open damages are to be immediately recorded on delivery documents, duly photographed and reported to Aconity3D GmbH in written form. Hidden defects are to be equally photographed and to be reported in written form to Aconity3D GmbH within 7 days after delivery at the latest.

The customer is liable for unloading of the dispatch and storage in weather-proof conditions (see section 5.5) until the stipulated acceptance date.

5.1.3 Installation

On the date of commissioning stipulated, a staff member of Aconity3D GmbH, present at the location of commissioning, assists, if required, with the unpacking of the dispatch, checking the scope of supply for completeness and intactness.

An Aconity3D GmbH staff member subsequently installs the machine at the installation site indicated

5.1.4 Commissioning

Commissioning of the machine and accessories is to be executed by an Aconity3D staff member exclusively.

For commissioning purposes, an amount of 20 kg of the powder material and 3 substrate plates from specified material - as stipulated in the order -

are to be provided. Both, powder material and substrate plates are part of the scope of supply under form of “acceptance kit”.

Roughly 2 kg of powder material is used up during commissioning. The rest may be re-used by the customer after a sieving procedure.

For commissioning purposes, please ensure a sufficient supply of argon and cooling water (see section 0) for an operation time of 8 h.

5.1.5 Floor Load Capacity

For machine set-up strictly comply with the maximum floor load capacity

DANGER!

Danger of collapse!

The floor in set-up space risks collapsing if the machine weight exceeds the maximum floor load capacity in this area.

Please ensure maximum floor load capacity to be strictly complied with by minding the following aspects prior to machine set-up:

- Machine weight in operational mode inclusive of powder fillings
- Weight of accessories
- Weight of individuals
- Weight of supplementary components in close vicinity to machine

Table 5 defines machine floor load.

Floor Load Machine	
Machine supports	4 x heavy load rolls
Optical mount supports	4 x heavy load rolls
Control cabinet supports	6 x heavy load rolls
Control cabinet setup station supports	4 x rolls

Maximum floor load	≤ 1000 kg/m²

Table 5: Floor load machine

5.1.6 Machine Power Connection

The machine power connection is defined according to section 5.2.4 and possible further options in sections 5.3, 5.3.2, 5.3.3, 5.3.4, 5.3.5, 5.3.6. The customer is responsible for providing the power connections in the building. The connections for media such as inert gas, compressed air and power are located on the right side of the LBM Research Equipment.

CAUTION!

Caution, trip hazard!

Improper installation of connecting lines may cause trip hazard with subsequent risk of personal injuries.

- Please care for proper installation with proper installation agents!
- Please comply with domestic regulation for installation of connecting lines!

DANGER!

Danger due to electric voltages!

Acute danger to life caused by electric shock when touching live parts!

- In case of damages to insulation of live parts, immediately switch off power supply and put repair works into action!
- Work on electrical components is strictly to be performed by qualified electricians.
- Prior to any electric works, maintenance, cleaning and repair works the research equipment is to be switched off, checked for zero potential and secured against re-starting.

- Strictly no by-passing and/or disabling of fuses. In case of fuse replacements exclusively use fuses with correct power level indications.
- Strictly avoid moisture in the vicinity of the research equipment, as it causes short circuits.

5.1.7 Floor Property Requirements

The machine set-up space is to comply with the following properties:

- Solid, level, inclination-free, deviation from level < 5 mm/m
- Vibration-free
- Easy-clean (metal powder is not to cling to it)
- Suitable for moist cleaning against swirling up of powder
- Skid-resistant
- Solvent-resistant
- Electrically conductive or antistatic
- Antistatic mat to be placed in front of the machine and earthed via machine

Please comply with the following safety instructions:

DANGER!

Danger of personal injuries and material damages caused by ignition and explosion of powder material!

Powder materials are prone to ignition or formation of explosive mixtures when in contact with ambient air.

- Strictly avoid electrostatic discharges!
- Use antistatic mat for machine operation to avoid ignition caused by static discharges

5.1.8 Tools

Aconity3D advises provisioning of the following tools for unimpeded maintenance works:

Tools Advised for Provisioning	
Multimeter	
Slide gauge	
Spirit level	30 cm / 10 cm
Tape measure	3 m
Hammer	
Water pump pliers	
Side cutter	
Combination pliers	
LED flash light	
Imbus-set with spherical heads	1,5 / 2 / 2,5 / 3 / 4 / 5 / 6 / 8 / 10 mm
Set of ring spanners/ Set of open-ended wrenches	8 – 24 mm
Ratch 1/2''	8 – 24 mm
Screw driver PH	2 x 23 mm / 1 x 74 mm / 2 x 100 mm
Screw driver SL	6,5 x 38 mm / 5 x 65 mm / 6,5 x 100 mm
Torx key	9 / 10 / 15 / 20 / 25 / 27 / 30 / 40 / 50

Table 6: Tools advised for provisioning

WARNING!

Danger of personal injuries due to negligent handling of tools!

Incorrect handling of the tools can cause bruises or cuts.

- Please handle tools properly and with necessary care.
- Please consider weight of tools during transport.
- Please wear protective gloves and safety shoes when handling tools.

5.1.9 Exhaust Air

During operation the LBM Research Equipment emits heavier than air argon, which may replace the ambient air.

WARNING!

Suffocation risk due to exposure to argon!

When in high concentration, leaking out argon displaces oxygen in the ambient air, thus causing loss of consciousness or even suffocation when inhaled.

- Strictly consult safety data sheet provided by manufacturer.
- Provide readily available self-contained breathing apparatus in case of emergency.
- Always lead the exhaust gases into the open air directly or via an exhaust system of the facility.
- When using an exhaust air system, make sure exhaust gases are completely and permanently sucked off.
- Ensure there are no pits, shafts, or other bumps in the ground where argon might accumulate.

- Ensure that the installation site is equipped with an oxygen monitor.
- When Argon is flowing into the surrounding, always ensure fresh air supply.
- In case of accidental inhalation, take affected person immediately to fresh air in a stable side position. If breathing is stopped, seek medical attention immediately and initiate first aid measures

The machine operator is responsible for providing connection to the in-house exhaust air ventilation system or direct ventilation of the exhaust air into open air.

The specifications for ventilation of exhaust air are listed as follows:

Direct Exhaust Air Ventilation	
Connection	JohnGuest® 8 mm
Lengths max.	10 m
Exhaust air flow of in-house exhaust air ventilation system	5 m^3/h
Pressure difference compared to ambient pressure	Max: - 5 mbar

Table 7: Specifications for ventilation of exhaust air

5.2 Machine Requirements

5.2.1 Technical Specifications

The overall technical specifications of the system are given below.

Technical Data Machine	
Build envelope (D x H)	Ø 170 mm x 200 mm
Laser power	400 W air cooled 1000 W water-cooled (optional)
Laser safety class	Class 1 / 4 with / without laser proof enclosure
Laser wavelength	λ = 1070 nm
Variable layer thickness	Min. 10 µm
Min. focus size (F-Theta lens)	80 µm
Focus size (3D Scan head)	80 – 500 µm
Max. scan speed	10 m/s
Average inert gas consumption in process	5 l/min
Average inert gas consumption purging	< 30 l/min
Residual oxygen content	< 100 ppm during process
Dimensions (L x W x H)	2170 mm x 1590 mm x 2140 mm
Weight	1480 kg

5.2.2 Site Ambient Requirements

The site ambience has a major impact on the functionality of the LBM Research Equipment and the quality of the builds manufactured.

GEFAHR!

Danger of personal injuries and material damages!

In case of non-compliance with the following site ambient requirements, malfunction risk of machine, accessories and safety systems with negative impact on all builds to be expected!

- Study carefully and understand the following ambient site requirements!
- Regularly inspect closely compliance with site ambient requirements!

To achieve high quality build results, the machine must be placed in a surrounding as specified below.

Ambient Requirements Machine	
Range of temperatures in relative ambient humidity and switched off machine without powder	10 – 40 °C / 20 – 80 %
Range of temperatures in relative ambient humidity operational mode	15 – 20 °C / 80 % max. 20 – 25 °C / 60 % max. 25 – 30 °C / 40 % max.
Local temperature gradient	± 5 °C
Deviation of inert gas temperature from ambient temperature	± 5 °C
Formation of condensate in cooling circuits	Not allowed
Installation location	Vented room
Max. Altitude	3.000 m

EMC	Do not place devices, emitting high-frequent radiation in vicinity of machine
	Do not place any electrical installation interfering with the machine into vicinity

Important!

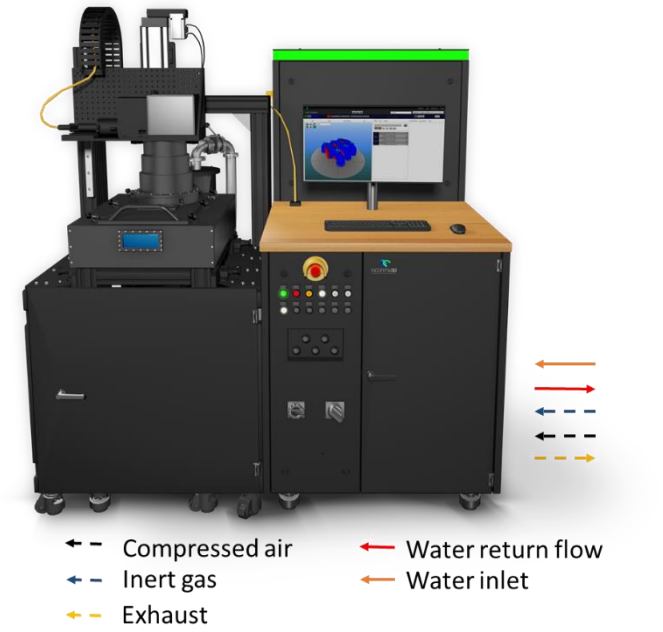
To ensure the operability of the machine, please regularly check if the media supply and ambient conditions meet the specifications given above.

- Check ambient conditions regularly
- Check electricity supply
- Check supply of pressurized air
- Check supply of inert gas
- Check water supply

5.2.3 Interfaces and Fittings

In Figure 2 a basic overview of the connections for the Aconity***MIDI*** system is given.

Figure 2
Overview of the connections for the Aconity***MIDI*** system



Accordingly, the system must be supplied with energy, compressed air, inert gas and cooling from the right-hand side, according to the following sections.

5.2.4 Energy

The Aconity***MIDI*** needs to be supplied with energy according to the following specifications.

Energy Machine	
Voltage supply	400 V, 50 Hz
Connection	Open ended w/o plug 3P + N + PE
Fuse	32 A
Connection value	Max. 15 kW
Power consumption	3 x 20 A

5.2.5 Gas

In Figure 3 the couplings for the connection of compressed air and inert gas are illustrated

Figure 3 JohnGuest® couplings for connections of compressed air

JohnGuest® Couplings 8 mm

Accordingly, 8 mm couplings are applied for connection of the gas input.

Compressed air is applied for cooling of the scanning mirrors. For this purpose, clean air shall be provided by the customer according to the following specifications.

Compressed Air Machine	
Type	ISO 8573-1:2010 [1:4:1]
Pressure	Min. 4 bar Max. 6 bar
Min. flow rate	50 l/min
Connection	John Guest 8 mm

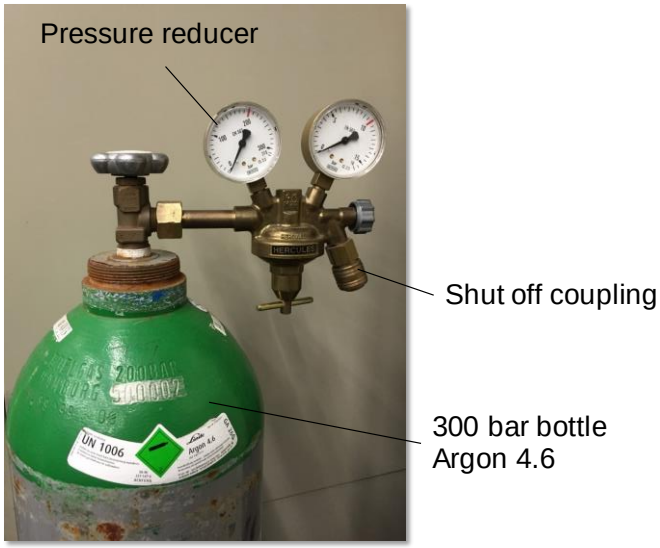
During a build job, the process chamber is purged with argon to prevent oxidization of the metal. The process chamber is kept under a pressure of ~ 50 mbar above ambient atmosphere during the lengths of a build job. In the following table, the specifications of the inert gas as well as connections are listed.

Inert Gas Machine	
Type	Argon 4.6 / Nitrogen
Pressure	Min. 4 bar Max. 6 bar

Min. flow rate	15 l/min
Connection	JohnGuest® 12 mm

For supply of inert gas usage of 300 bar gas bottles with adequate pressure reducer, as illustrated in Figure 4 are recommended.

Figure 4 Exemplified illustration of a 300 bar bottle and adequate pressure reducer for supply of Argon inert gas



5.2.6 Cooling

For cooling of the optional preheating and laser sources above 400 W output power, as well as optical components a cooling aggregate is necessary.

In Figure 5 an exemplified image of the cooling aggregate is illustrated. To prevent losses through decrease of the cross section in quick couplings, direct hose connections with 19 mm inner diameter are applied.

Figure 5 Exemplified illustration of the cooling aggregate

Source: Riedel

In the following table, the specifications of the cooling water are defined.

Cooling Machine	
Type	Demineralized Water with Corrosion Inhibitor and Biocide
Pressure Forward Flow	Min. 5 bar Max. 6 bar
Pressure Return Flow	Max. 1 bar
Min. Volume Flow	> 8 l/min
Temperature	Min. 21 °C Max 24 °C
Connection Forward Flow	Hose fitting with internal diameter of 19 mm:
Connection Return Flow	Hose fitting with internal diameter of 19 mm
Recommended cooling capacity	7 kW

Supplying the system with adequate water amount and assuring the proper quality lies in the sole responsibility of the customer.

5.2.7 Emission of the Machine

The machine emits EMC radiation, waste heat noise and inert gas, which is flushed through the system. In order to ensure a save working environment, the inert gas must be let outside by means of the supplied exhaust coupling.

Emission Machine	
EMC	ISM device class A, Group 1 according to EN55011

Waste heat	Approx. 1,5 kW (w/o heating device)
Noise level	65 dB (A) max. 73 dB(A)
Inert gas	Argon < 30 l/min
Exhaust coupling	JohnGuest® 12 mm

5.3 Requirement of the Optional Equipment

5.3.1 Cooling Unit (Optional)

Table 8 defines ambient requirements and technical specification for cooling unit.

Technical Data Cooling Unit (Air – Water)	
Cooling agents	R134a
Coolant	Water without inhibitors
Cooling capacity	7,6 kW
Tank capacity	80 l
Dimensions (W x D x H)	620 mm x 880 mm x 1230 mm
Weight	159,5 kg
Safety class	IP 54

Ambient Requirements Cooling Unit (Air – Water)	
Range of temperatures in relative humidity in switch-off mode	15 – 45 °C at 20 – 80 %

Power Cooling Unit (Air – Water)	
Voltage Supply	400 V, 50 Hz
Power Connection	CEE 3-Phase Plug 3P + N + PE
Fuse	16 A
Connection value	Max. 4,6 kW
Power consumption	Max. 9 A

Emissions Cooling Unit	
Sound pressure	≤ 73 dB(A)
Waste heat	≤ 9 kW

Table 8: Ambient requirements and technical specifications for cooling unit (air-water)

Important!

Ambience impact and improper installation may cause malfunction of cooling unit:

- Please ensure maximum unimpeded flow of cooling air
- Do not install cooling unit in vicinity of heating
- Please install cooling unit at machine level
- Please ensure unimpeded escape of waste heat or place cooling unit in a separate ventilated room

Please comply with operating instructions provided by cooling unit manufacturer for installation requirements and proper use for cooling unit.

5.3.2 Inductive Heating (Optional)

The inductive heating requires further optional interfaces and fittings as specified below.

Technical Data Inductive Preheating	
Dimensions (W x D x H)* * This option is inside the 19 ‘’ cabinet (Generator) or beneath the process chamber (outer circuit)	Generator 483 x 662 x 133 mm³
	Outer circuit 114 x 355 x 181 mm³
Weight	Generator 29 kg
	Outer circuit 12 kg
Maximum temperature	1200 °C
Effective build envelope (D x H)	Ø 70 mm x 150 mm
Output power	5 kW
Output frequency	50 kHz – 800 kHz
Output voltage	Max 600 V
Output current	Max 20 A
Protection rating	IP 54

Ambient Requirements Inductive Heating	
Range of temperatures in relative ambient humidity and switched off machine without powder	10 – 40 °C at 20 – 80 %
Range of temperatures in relative ambient humidity operational mode	15 – 20 °C / 80 % max. 20 – 25 °C / 60 % max. 25 – 30 °C / 45 % max.

Energy Inductive Heating	
Voltage supply	400 V, 50 Hz
Connection	Open ended w/o plug 3P + N + PE
Fuse	16 A
Connection value	Max. 7.5 kW
Power consumption	3 x 11 A

Cooling Inductive Heating	
Type	Demineralized Water with Corrosion Inhibitor and Biocide
Pressure	Min. 4 bar Max. 6 bar
Min. Volume Flow	> 4.5 l/min
Temperature	Min. 21 °C Max 24 °C
Connection	Connected inside the machine

Emission Inductive Heating	
EMC	ISM device class A, Group 2 according to EN55011
Noise level	≤ 60 dB (A)
Waste heat	≤ 7,5 kW

Table 9: Ambient requirements and technical specifications for induction heating

IMPORTANT!

Damaging ambient parameters and improper installation may result in mal-functioning of induction heating.

During set-up and use of induction generator please comply with manufacturer's operating instructions. Please also comply with the safety instructions regarding thermal hazards, provided in section 3.8.

DANGER!

Danger due to electro-magnetic fields!

In vicinity of inductor coils, formation of strong electro-magnetic fields occur. These may have damaging impacts on active and passive health aids, such as pacemakers, implants, etc.

The inductor forms an electro-magnetic field, inducing eddy currents in a metal part, thus heating it up. Field expansion reaches beyond inductor and part (stray fields). Strength and expansion of stray fields are strongly dependent on inductor size and amount of alternating current flow within inductor.

Stray fields may have damaging impacts on the ambiance:

- Any metal objects in close vicinity to inductor, such as implants, metal jewelry may heat up.
- Interference with electrical devices in close vicinity of inductor, such as pacemakers or other electronic body implants.

Exclusively use induction heating with closed chamber lid only, as electromagnetic fields may be reduced due to formation of a Faraday cage.

DANGER!

Acute danger to life due to high voltages!

The high voltages occurring in both, generator and inductor represent an acute danger to life!

To generate the electro-magnetic fields required for induction, the generator generates voltages, constituting a high risk to human life or health impairment. These

voltages occur equally within the generator, the outer circle, in the inductor and the terminal jaws. Operators or any other individuals in close vicinity to the generator under operation risk personal injuries when coming in contact with inductor voltages.

- Strictly never open generator when connected to power supply!
- Strictly never remove plastic enclosure of inductor and outer circle when connected to power supply!
- Strictly never touch inductor coil under operation!
- Exclusively operate induction heating with closed chamber lid!
- Strictly install all plastic covers of powered lines (see section 6.7.3) after maintenance in order to avoid accidental touching of these during operation.

5.3.3 Wet Scrubber (Optional)

Table 10 defines ambient requirements and technical specifications for wet separator.

Technical Data Wet Scrubber	
Dimensions (W x D x H)	570 x 800 x 850 mm³
Weight	95 kg

Ambient Requirements Wet Scrubber	
Range of temperatures in relative humidity in switch-off mode	0 – 30 °C at 30 – 95 %

Power Wet Scrubber	
Voltage supply	230 V, 50 Hz

Connection	European Wall Plug
Fuse	16 A
Power consumption	7,6 A

Emissions Wet Scrubber	
Sound pressure	≤ 60 dB(A)

Table 10: Ambient requirements and technical specifications for wet scrubber

IMPORTANT!

Damaging ambient impact and improper installation may cause malfunction of wet scrubber:

- Please ensure wet scrubber to be emptied at regular intervals!
- Please ensure proper disposal of sucked up material and comply with instructions on safety sheet data provided by powder manufacturer!
- When installing and operating wet scrubber please comply with manufacturer's operating instructions

DANGER!

Acute danger of explosion and fire!

To avoid electro-static ignition of explosive mixtures, the wet separator must be connected with the LBM Research Equipment via equipotential bonding conductor.

5.3.4 Process Monitoring (Optional)

Table 11 defines ambient requirements and technical data for process-monitoring.

Technical Data Process Monitoring	
Process-monitoring* (W x D x H) *This option is fitted into electric cabinet resp. optical mount	Optical mount 1200 x 700 x 200 mm³
	Laser beam source 19“ 2HE
Weight	Optical mount 8 kg
	Laser beam source 5 kg
Laser output	40 W
Laser safety class	Class 1 / 4 with / without Laser proof enclosure
Laser wavelength	λ = 808 nm

Ambient Requirements Process-Monitoring	
Range of temperatures in relative ambient humidity and switched off machine without powder	10 – 40 °C at 20 – 80 %
Range of temperatures in relative ambient humidity operational mode	15 – 20 °C / 80 % max. 20 – 25 °C / 60 % max. 25 – 30 °C / 45 % max.

Power Process-Monitoring* *Laser resp. camera is power supplied via LBM Research Equipment	
Voltage supply	230V AC / 24V DC
Connection	European wall plug / Terminal block

Fuse	16 Amp / 4 Amp
Connection value	700 W
Power consumption	3 Amp

Cooling Process Monitoring	
Type	Air cooled

Emissions Process Monitoring	
Sound pressure	≤ 70 dB(A)
Waste heat	≤ 0,7 kW

Table 11: Ambient requirements and technical specifications for process-monitoring

CAUTION!

Danger caused by laser safety class 1 laser radiation!

When equipped with an optional laser proof protection enclosure according to DIN EN 60825, the LBM research system corresponds to a laser system of the laser safety class 1.

- Operation of the LBM research equipment for laser protection class 1 systems is not permitted without corresponding use of the laser proof protection, bridging of safety switches, or failure to integrate into a facility safety concept (restricted access area with interruption contact and warning signal at the door).

- The laser system shall be installed or fixed, including devices located in the beam path, in such a way as to avoid any unintentional change in its position and beam direction.

DANGER!

Danger caused by laser safety class 4 laser radiation!

Without the optional laser proof protection enclosure, according to DIN EN 60825, the LBM research system corresponds to a laser system of the laser safety class 4.

Irradiation of the eye or skin by direct or scattered laser radiation leads to serious injuries.

- The system may only be used when integrated into a facility safety concept.
- Operation of the laser safety class 4 system is only allowed for in a restricted room with equipped with a laser emission indicator lamp.
- The interlock safety circuit of the research equipment must be connected to the entrance door of the room via the interface provided on the control cabinet.
- Directional and diffuse laser beam reflections must be avoided as they are highly energetic and invisible.
- The operator must ensure that all safety measures used are adapted to the corresponding laser protection class, the wavelength, the laser system and the emitted laser beam power.
- Indicate the used laser beam (wavelength, laser regime, average output power) at the entrance door of the research facility in which the research equipment is placed.
- Never operate the research equipment without suitable laser protection goggles according to DIN EN 207 (DIN 58215) for the applied wavelength range.
- Wear suitable personal protective equipment such as gloves and protective apparel made of flame and heat resistant material.

5.3.5 Pyrometry (Optional)

Table 12 defines ambient requirements and technical specifications for pyrometry (dimensions, weight and power consumption are contained in monitor-processing specifications).

Technical Data Pyrometry	
Dimensions (W x D x H)	Optical mount 1200 x 700 x 200 mm³
Weight	Optical mount 6 kg
Measuring wavelengths	λ = 1200 nm – 1700 nm
Frame rate	< 100 kHz

Ambient Requirements Pyrometry	
Range of temperatures in relative ambient humidity and switched off machine without powder	10 – 40 °C at 20 – 80 %
Range of temperatures in relative ambient humidity operational mode	15 – 20 °C at max. 80 % 20 – 25 °C at max. 60 % 25 – 30 °C at max. 45 %

Power Pyrometry* *Pyrometry is power supplied via LBM Research Equipment	
Voltage supply	24 VDC
Connection	Terminal block
Fuse	3 A
Connection value	30 W

Power consumption	1,2 A

Cooling Pyrometry	
Type	Air cooled

Emissions Pyrometry	
Sound pressure	≤ 63 dB(A)
Waste heat	30 W

Table 12: Ambient requirements and technical specifications for pyrometry

IMPORTANT!

Pyrometric measurements decisively depend on alignment of pyrometer fiber heads. For alignment of pyrometers, Aconity3D advises to use specific measurement system to be provided by Aconity3D upon request.

5.3.6 Setup Station (optional)

Table 13 defines ambient requirements and technical specification of the setup station.

Technical Data Setup Station	
Dimensions (W x D x H)	1600 mm x 1000 mm x 2100 mm
Weight	620 kg

Ambient Requirements Setup Station	
Range of temperatures in relative ambient humidity and switched off machine without powder	10 – 40 °C at 20 – 80 %
Range of temperatures in relative ambient humidity operational mode	15 – 20 °C at max. 80 % 20 – 25 °C at max. 60 %

	25 – 30 °C at max. 45 %
Local temperature gradient	± 5 °C
Derivation inert gas temperature compared to ambient temperature	± 5 °C
Condensate formation in cooling circuits	Not permitted
EMV	Do not place devices, emitting high-frequent radiation in vicinity of machine
	Do not place any electrical installation interfering with the machine into vicinity

Power Setup Station	
Voltage supply	400 V, 50 Hz
Connection	Open ended w/o plug 3P + N + PE
Fuse	16 A
Connection value	Max. 3,2 kW
Power consumption	Max. 9 A

Inert Gas Setup Station	
Type	Argon 4.6 / Nitrogen
Pressure	Min. 4 bar Max. 6 bar
Min. Flowrate	15 l/min

Inlet Connection	JohnGuest® 12 mm
Outlet Connection	JohnGuest® 12 mm

Emission Setup Station	
EMV	ISM device class A, Group 1 according to EN55011
Waste heat	ca. 1,5 kW
Sound pressure	65 dB (A) Max. 73 dB (A)
Inert gas	Argon < 30 l/min
Connection Inertgas Outlet	JohnGuest® 12 mm

Table 13: Ambient requirements and technical specification of the setup station

IMPORTANT!

Functionality can be reduced by ambient influence or improper use of the equipment.

- Make sure that the ambient requirements and minimal space requirements (see section 5.4.2) are observed.

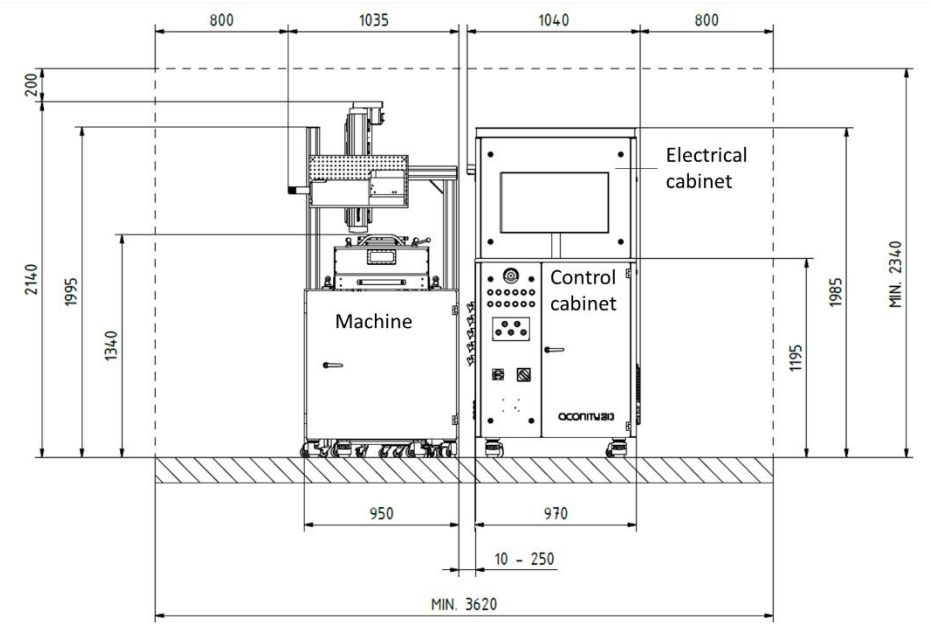
5.4 Space Requirements

5.4.1 Installation Plan Machine

Figure 6 illustrates Aconity***MIDI*** installation plan, frontal view

Figure 6 Installation Dimension Aconity***MIDI*** machine

Frontal view



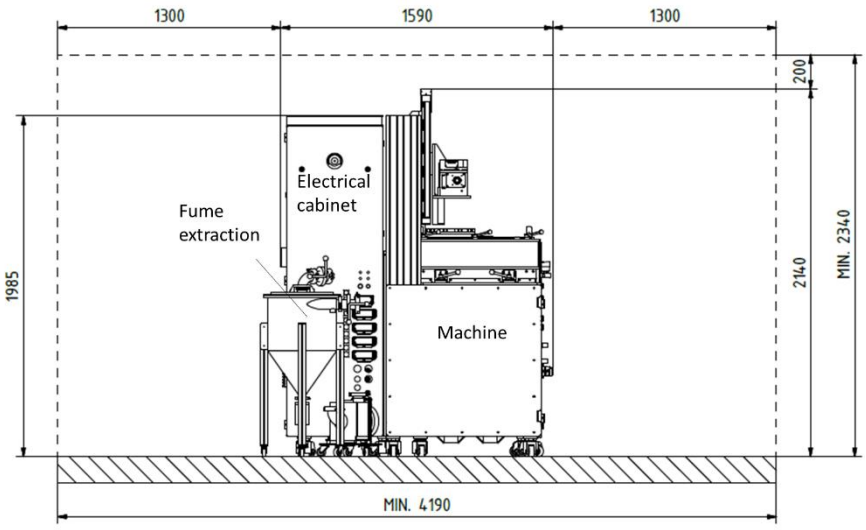
The LBM Research Equipment comprises machine and control cabinet, mounted side by side and connected via Harting plug connectors.

With doors closed, the Equipment measures 2170 mm total width. The total height measures 2140 mm. Please allow additional 200 mm height to grant movement of the optical axe covering the total travel range.

In Figure 7 the left side of the Aconity***MIDI*** system is illustrated.

Figure 7 Installation Dimension Aconity***MIDI*** machine

left side

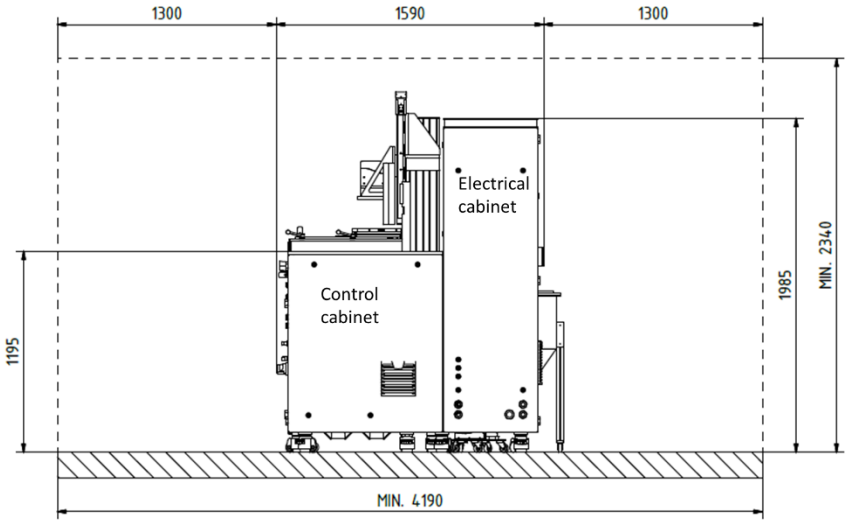


With doors closed, The Equipment measures 1590 mm total depth. You can find the fume extraction's cyclone behind the machine.

In Figure 8 the right side of the Aconity***MIDI*** system is illustrated.

Figure 8 Installation Dimension Aconity***MIDI*** machine

right side

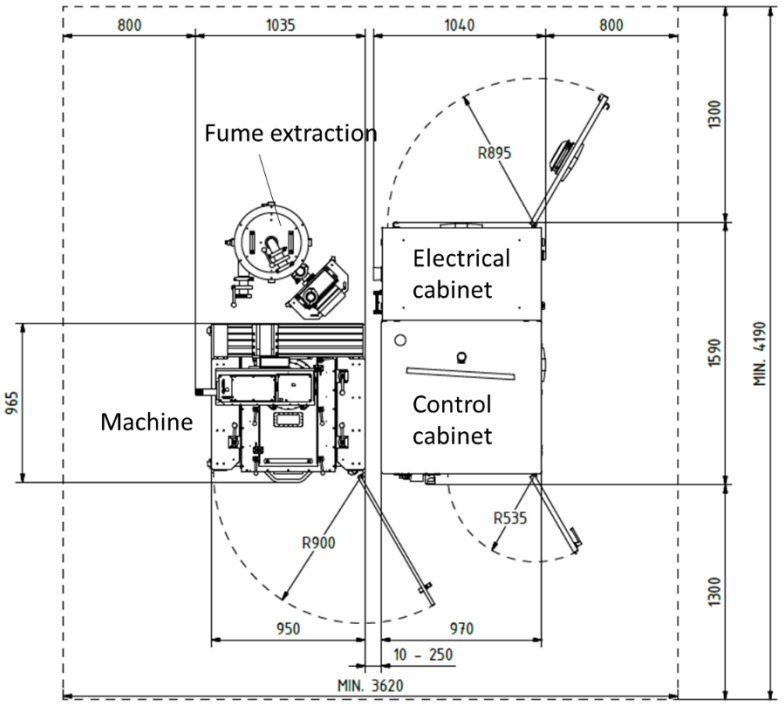


The connections for media supply are placed on the right side of the equipment.

In Figure 9 the top view of the Aconity***MIDI*** system is illustrated.

Figure 9 Installation Dimension Aconity***MIDI*** machine

top view



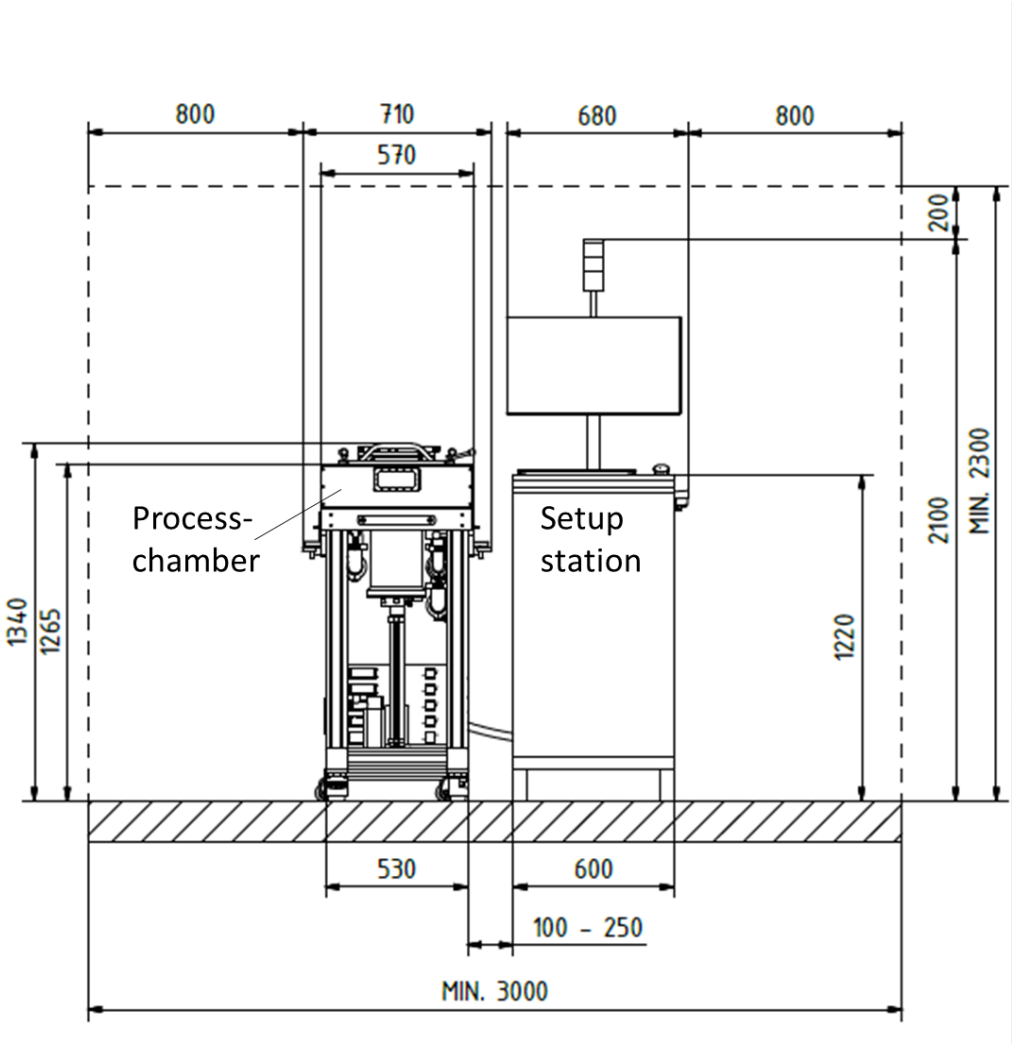
Please allow a 1300 mm gap on the left and on the rear side to the wall to grant unobstructed works of maintenance staff with equipment doors opened. As there are no doors on the right and left side of the equipment, a total gap of 800 mm to the wall is sufficient. For easy working, please allow a gap minimum of 1500 mm between wall and equipment front.

5.4.2 Installation Plan Setup Station (Optional)

Figure 10 shows the Aconity**MIDI** setup station's installation plan, frontal view.

Figure 10 Installation Dimensions of the Aconity***MIDI*** setup station

frontal view



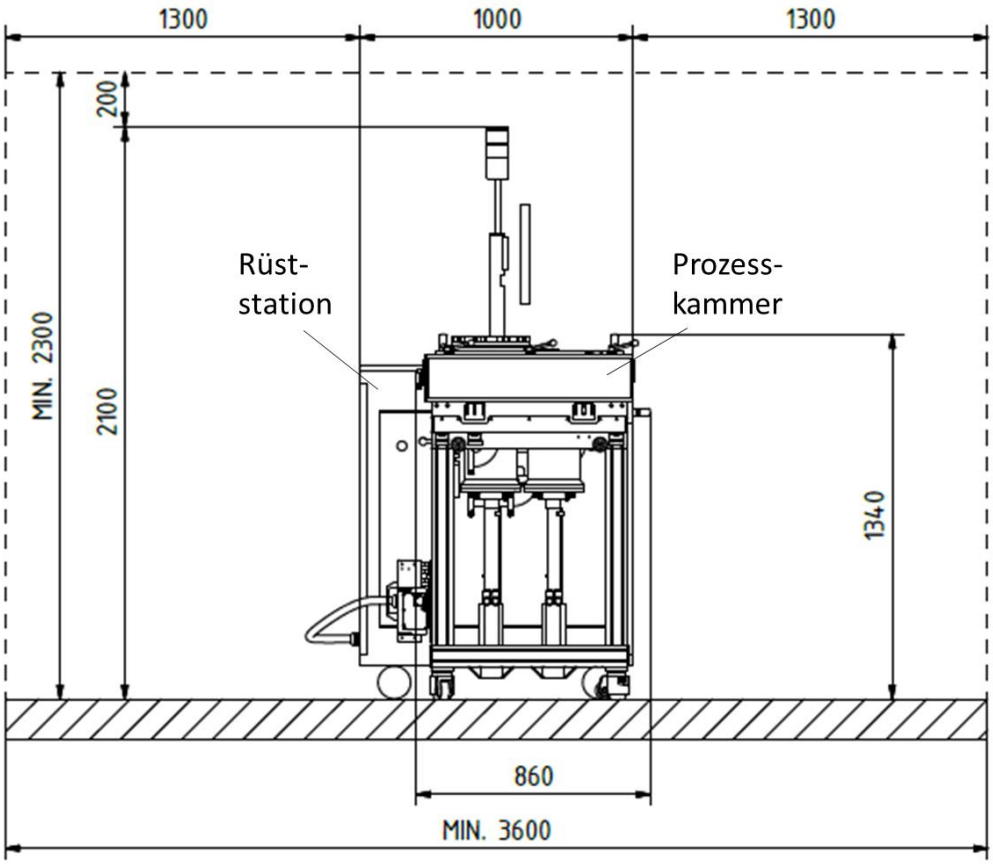
The setup station consists of the process chamber and the setup station, which are connected via quick and plug in connections.

The setup station has a total width of 1380 mm. The total height measures 2100 mm. Please allow an additional 200 mm gap to the ceiling.

Figure 11 shows the setup station's installation plan from the left side.

Figure 11 Installation Dimensions of the Aconity***MIDI*** setup station

left side view

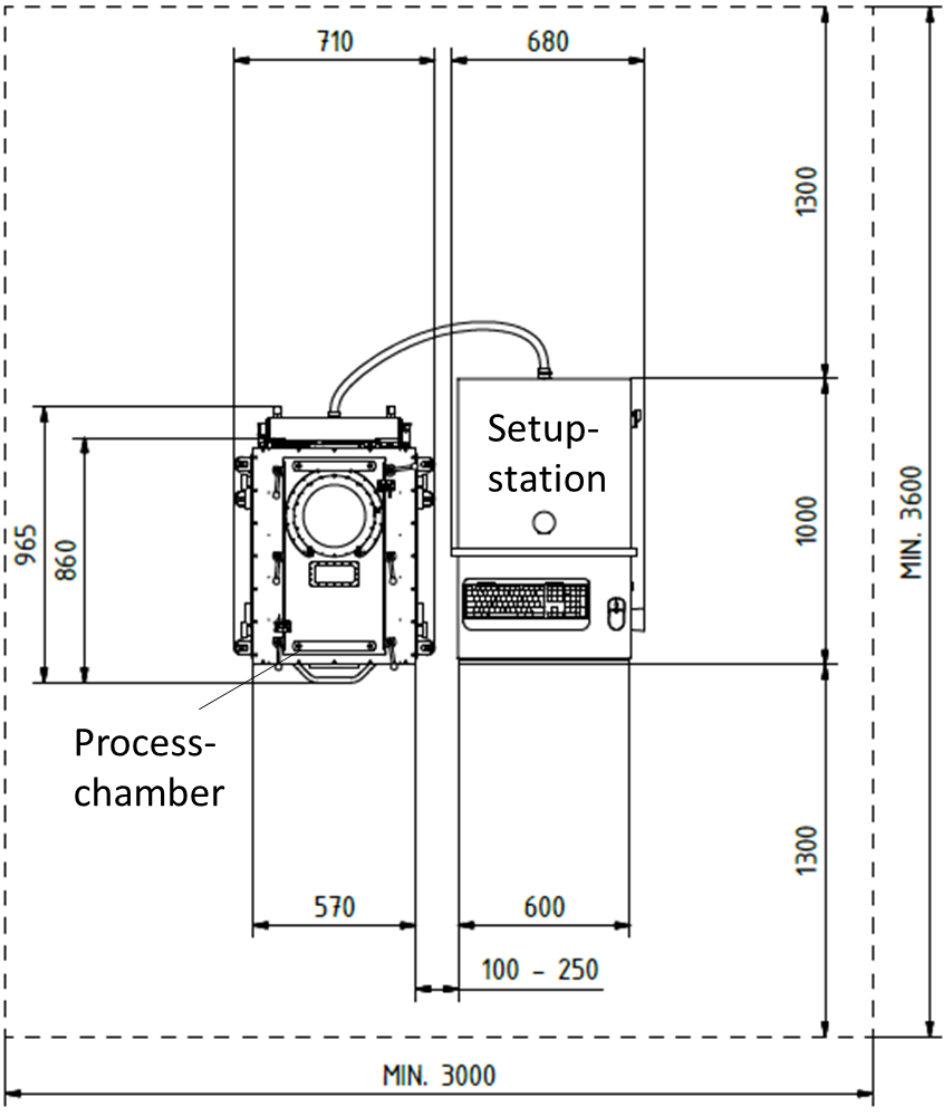


The setup station has a total depth of 1000 mm, with doors closed. The connections for media supply are located on the right side of the machine.

Figure 12 shows the Aconity**MIDI** setup station's installation plan from above.

Figure 12 Installation plan of the Aconity***MIDI*** setup station

view from above



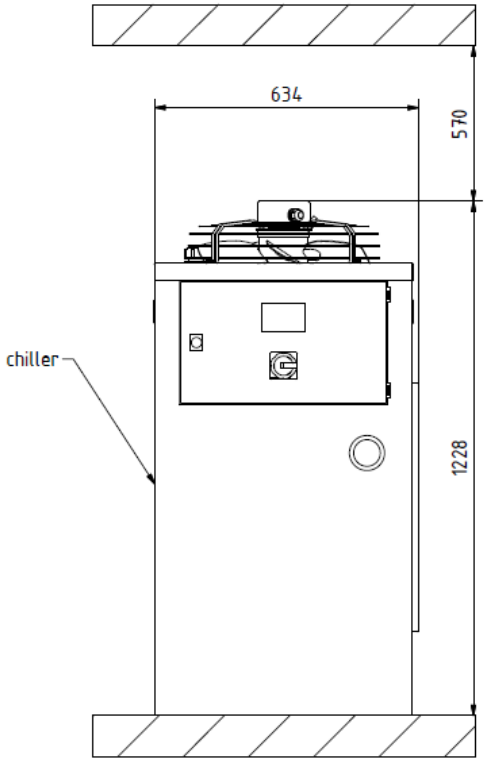
Please allow a 1300 mm gap on the rear side to the wall to grant unobstructed works of maintenance staff with equipment doors opened. As there are no doors on the right and left side of the equipment, a total gap of 800 mm to the wall is sufficient. For easy working, please allow a gap minimum of 1500 mm between wall and equipment front.

5.4.3 Installation Plan Cooling Unit (Optional)

In Figure 13 the frontal view of the optional cooling unit is illustrated.

Figure 13
Installation Dimension cooling unit

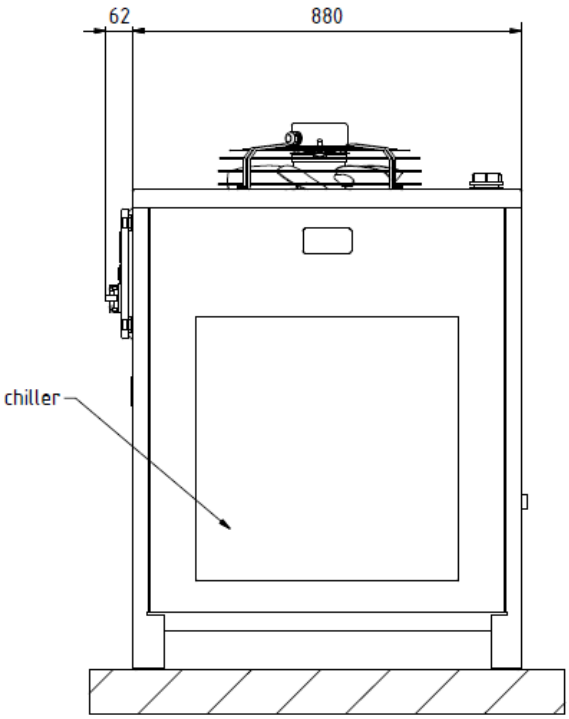
Frontal view



In Figure 14 the side view of the optional cooling unit is illustrated

Figure 14
Installation Dimension cooling unit

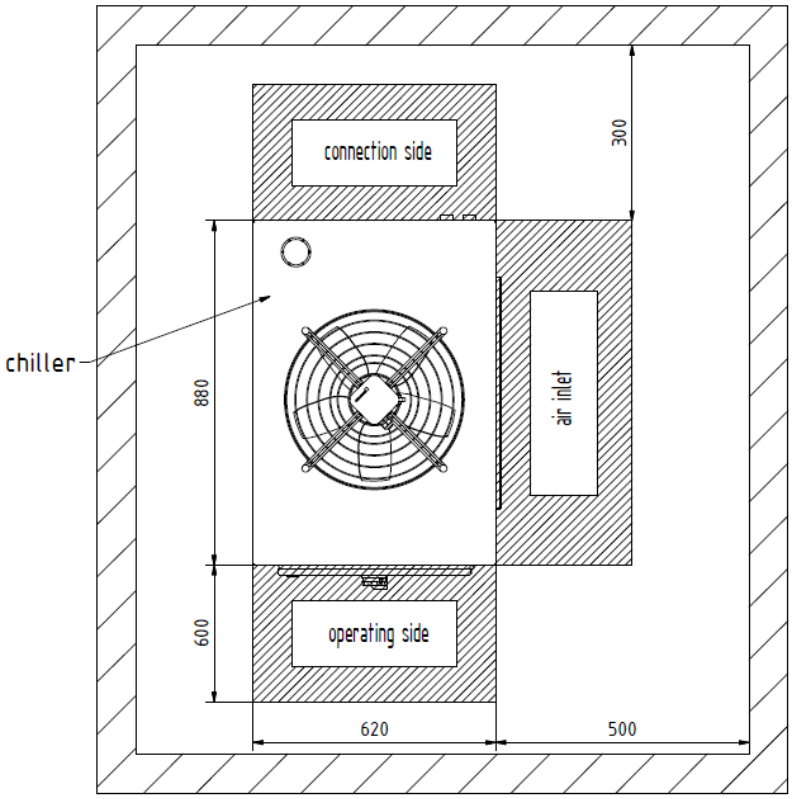
Side view



In Figure 15 the top view of the optional cooling unit is illustrated. Also, minimum clearance for air inlet is indicated. Media supply is located at the rear side of the cooling unit.

Figure 15
Installation Dimension cooling unit

Top view



For ease of operation and to ensure operability, the operating side as well as the air inlet should be kept clear.

5.4.4 Minimum Space Requirements

For set-up of LBM Research Equipment and its optional component, please consider the following:

- For evaluation of minimal space requirements, please consider the space requirements of any additional components!
- For removal and follow-up treatment of the builds and preparation of the equipment it is advisable to a supplementary work table.
- Please consider potential upgrading of the Equipment with optional accessories to avoid subsequent removal and relocation.

- Please consider the space required for inert gas supply!
- Please consider the space required for compressed air supply!
- Please consider the space required for cooling water supply!

DANGER!

Danger to life cause by obstructed escape routes!

Obstructed escape routes are a massive danger to life.

- Strictly avoid obstructing escape routes in hazardous areas!
- Please comply with domestic safety regulations and instructions.

5.5 Powder Material

Table 14 defines the ambient requirements for powder material. Please ensure storage of powder material in receptacles provided by the manufacturer and seal it airtight.

Metal powder in Original Receptacles	
Range of temperatures	15 – 25 °C
Relative humidity	Max. 40 %

Table 14: Ambient requirements for storage of metal powders

Important!

Metal powder may age due to non-compliance with ambient requirements and improper storage. Avoid damaging ambience impact of ageing powder material on build quality by using up powder materials in opened receptacles within 6 months.

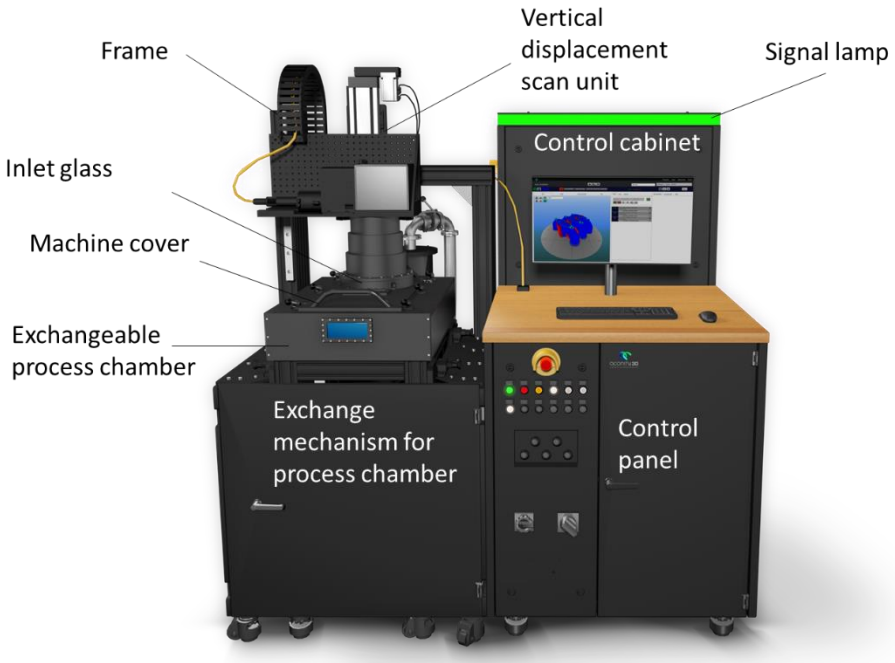
- Storage of powder material under argon increases storage period.
- Please comply with safety data sheet indications as to storage times of powder material provided by powder manufacturer, as well as the safety instructions, provided in section 3.7.

6 Design and Function

The LBM research equipment Aconity***MIDI*** consists of the main components according to Figure 16:

- Control cabinet with control panel
- Exchangeable process chamber
- Optical bench
- Vacuum option (optional)

Figure 16
Aconity***MIDI***
equipment overview

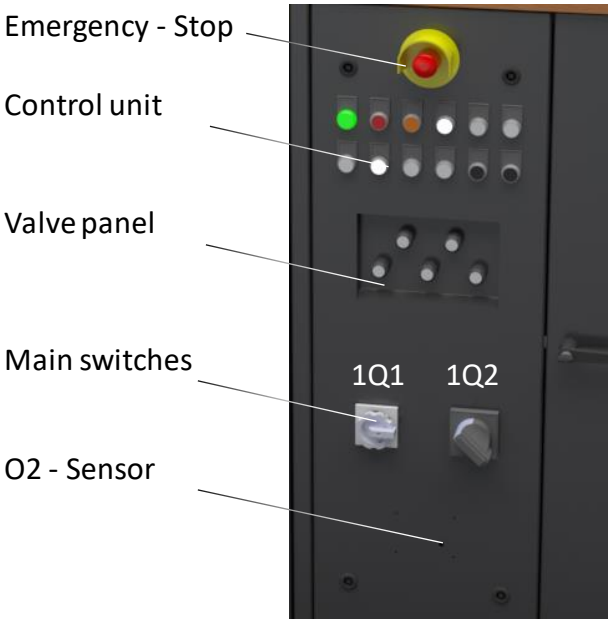


6.1 Control Cabinet

The control cabinet contains the computer for the control of the research machine, the laser, a control panel with control unit for the media supply

and all electronic components. Further optional components, such as heating unit and process monitoring, are also wired within the control cabinet. Figure 17 shows the individual control units of the control panel.

Figure 17
The control panel of the Aconity***MIDI*** system



6.1.1 Emergency – Stop

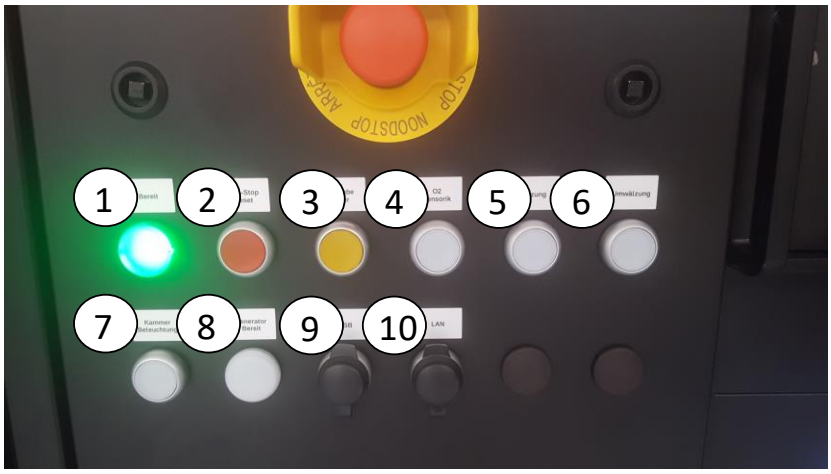
The research equipment has three electrical emergency-stop switches, which allow immediate shutdown of the entire system in case of danger. The emergency stop switches are located in the following locations:

- Control panel at front (see Figure 17)
- Control cabinet left hand side (see Figure 1)

6.1.2 Control Unit

The LBM research equipment is controlled via the control panel at the front according to Figure 18

Figure 18
The control unit of the Aconity***MIDI*** system



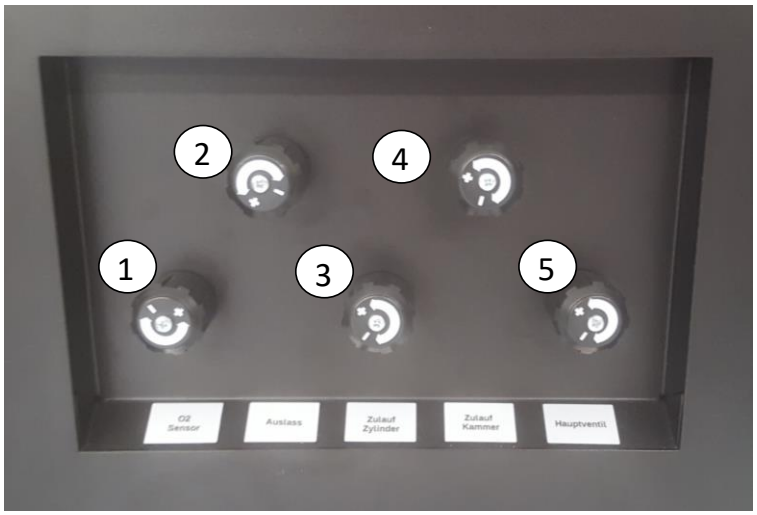
The control panel accommodates the following functions:

1. “Ready light” indicates that the system is ready. Precondition for this is a released emergency – stop as well as a closed laser proof enclosure.
2. “Release of emergency – stop”. This needs to be pressed after the emergency stop has been used.
3. “Laser ready”. This must be pressed, when the laser proof enclosure is closed and the laser ready to operate.
4. “O2 sensor”. This button allows for starting the O2 sensor.
5. “Heating” This button is used for starting the optional resistive preheating device
6. “Recirculation unit”. This button starts the recirculation unit.
7. “Chamber illumination” starts the light inside the process chamber
8. “Generator status” indicates if the optional inductive heating is powered up and emitting energy.
9. “USB” represents a spare USB connection
10. “LAN” represents a spare LAN connection

6.1.3 Valve Panel

In Figure 19 the valve panel of the Aconity***MIDI*** system is shown.

Figure 19
The valve panel of the Aconity***MIDI*** system



The valve panel accommodates the following functions:

1. “O2 Sensor” regulates the flow of the O2 Sensor.

Important!

Do not regulate the inflow of the O2 sensor above 10 l/h, otherwise the sensor will be destroyed!

- The flow rate of the O2 sensor may be observed within the Aconity***Studio*** control software (see section 7.7).
- Always keep the control valve of the O2 sensor closed after using the system in order to avoid excessive gas flow during the installation of the laboratory system.
- After the system is set up for the process, the valve can be opened carefully. Always pay attention to the indicated flow within the sensor, which may be observed via the Aconity***Studio*** control software (see section 7.7)

2. “Outlet” regulates the inert gas outlet of the system.
3. “Inlet cylinder” regulates the inert gas inlet at the bottom of the build cylinder and powder reservoir.

DANGER!

Excessive opening of the "inlet cylinder" may cause powder to be whirled up.

- When the process chamber is open, always keep the valve closed, as powder particles may get into the ambient air.
- When the process chamber is closed, whirled up powder may settle on the underside of the inlet window and pollute it. This may cause destruction of the inlet window upon laser radiation. If the process chamber is pressurized, the glass of the inlet window may splitter and cause severe harm to the operator!

4. “Inlet chamber” regulates the inert gas inlet into the process chamber. The resulting pressure and gas flow in the chamber can be read in the software Aconity***Studio***, as well as the fluidic sensors. (see section 6.1.7)

5. “Main valve” represents the main gas valve of the system which provides all other valves with gas. The “main valve” may be cleared within the software Aconity***Studio***.

Important!

If the LBM system is not used, always keep the "main valve" closed.

- When the process chamber is open, always keep the valve closed, as inert gas may enter the ambient air.

6.1.4 Main Switch

The main switch is used to supply the system (1Q1) and the optional heater (1Q2) with power. The main switches are shown in Figure 17.

6.1.5 O2 – Sensor

The operating status of the O2 sensor is indicated by the following signals:

- Red flashing → Sensor heats up
- Green light → Sensor is ready for operation

The sensor values such as flow, temperature, oxygen value and error status can be taken from the Aconity***STUDIO*** software user interface (see section7.7).

The O2 sensor has a measuring range of 210,000 ppm to < 10 ppm.

6.1.6 Computer

The research equipment is controlled by the computer integrated into the control cabinet. Controlling of the system is done via Aconity***STUDIO*** software.

IMPORTANT!

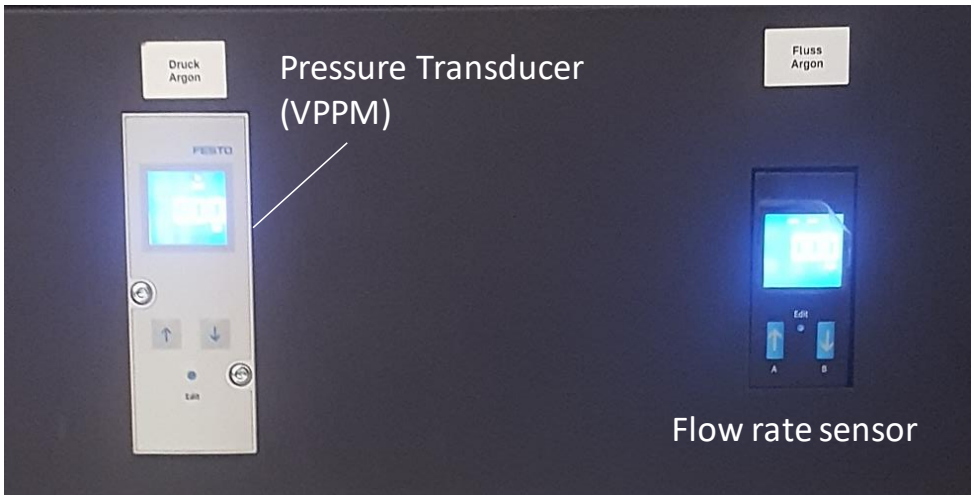
Data and network safety is only ensured by the operating system of the control computer.

- Use only password-protected access to the control computer.
- If the control computer is connected to a network, ensure that all ports (except port 9000) are closed or otherwise secured.
- Keep the operating system up-to-date by means of safety-related updates.
- Only connect the control computer to secure private networks. The http-protocol is not secure.

6.1.7 Fluid Sensors

The fluid sensors consist of a pressure transducer and a flow sensor, which are illustrated in Figure 20.

Figure 20
Fluid sensors of the Aconity***MIDI*** system



The set regulating pressure as well as the resulting gas flow can be read off both the devices as well as in the user interface of the software Aconity***STUDIO***. The setpoint of the pressure control unit can also be set within the Aconity***STUDIO*** software (see section 7.7).

6.1.8 Processing Laser

The processing laser is a 400 W (1000 W optional) single mode fiber laser provided by IPG (Figure 21), alternatively a 500 W (1000 W optional) provided by SPI. The laser radiation is brought to the SLM laboratory equipment by means of an optical fiber. Control of the processing laser is either done via machine control software Aconity***Studio*** (Key switch at front panel must be switched to remote [REM] modus) or via front panel (Key switch at front panel must be switched to [ON]).

Figure 21
Front view of the IPG 400 W processing laser

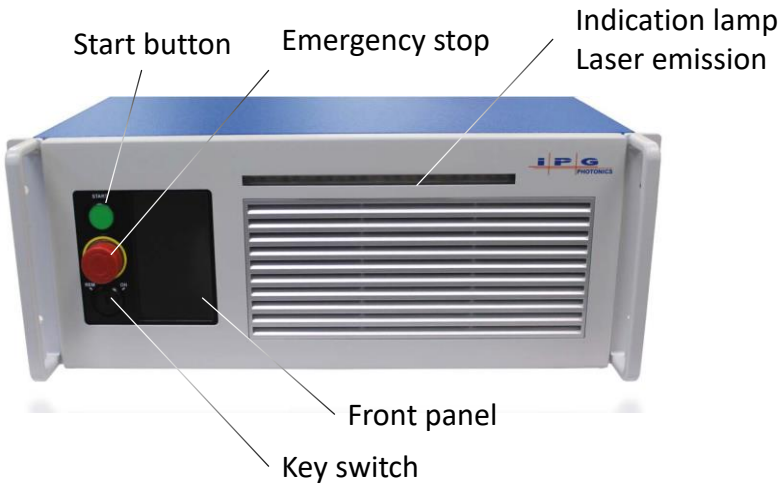
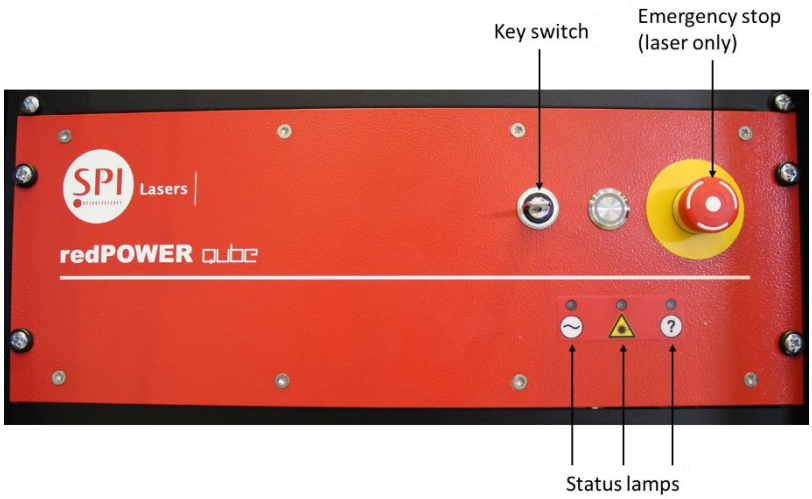


Figure 22
Front view of the SPI 500 W processing laser

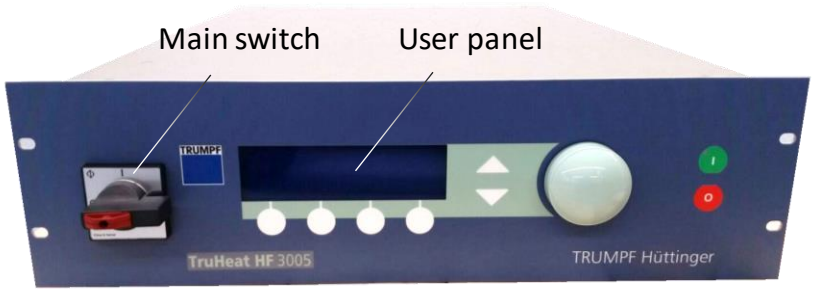


Control of the laser is performed via electrical connections at the back of the device and is further specified in the machine's wiring diagram as well as the laser's technical documentation.

6.1.9 Induction Generator (Optional)

The optional induction heating consists of a 5 kW induction generator, provided by Trumpf Hüttinger (Figure 23).

Figure 23
Front view of the Induction generator



The generator has a separate current supply (see section 5.3.2). The current supply of the generator must be switched by means of the main switch 1Q2 (see Figure 17). In addition, the main switch on the generator must be switched on for the operation of the generator. The user panel shows the emitted power during operation and allows configuration of the device. For further information please refer to the technical documentation of the induction generator and the circuit diagram of the research equipment.

6.2 Electrical Cabinet

The electrical cabinet accommodates all necessary electronics and controllers for the axis movement. The wiring is further specified in the wiring diagram of the research equipment. When opening the door of the electrical cabinet at the back of the system, the emergency – stop is enabled.

DANGER!

The electrical cabinet carries electrical currents!

Only qualified personnel are allowed to work on the control cabinet.

- Unauthorized access is to be ensured by securing the doors of the cabinet by appropriate tools.
- Unauthorized access is to be ensured by securing the doors of the cabinet by appropriate tools.
- Remain the doors closed to ensure unauthorized access to voltage-carrying components
- Only trained personnel according to Table 1 are granted access to the electrical components of the cabinet.
- When the door is open, the research facility must be disconnected from the mains power supply and secured against being switched on again.

6.3 Signal Lamp

The signal lamp is designed as a light strip and is located above the control cabinet (see Figure 16). The light indicates the following statuses:

- Red: emergency - stop is triggered (can be acknowledged with the emergency - stop reset button)
- Yellow: Laser fault
- Green: The System is operational
- Blue: The laser is ready for emitting laser radiation

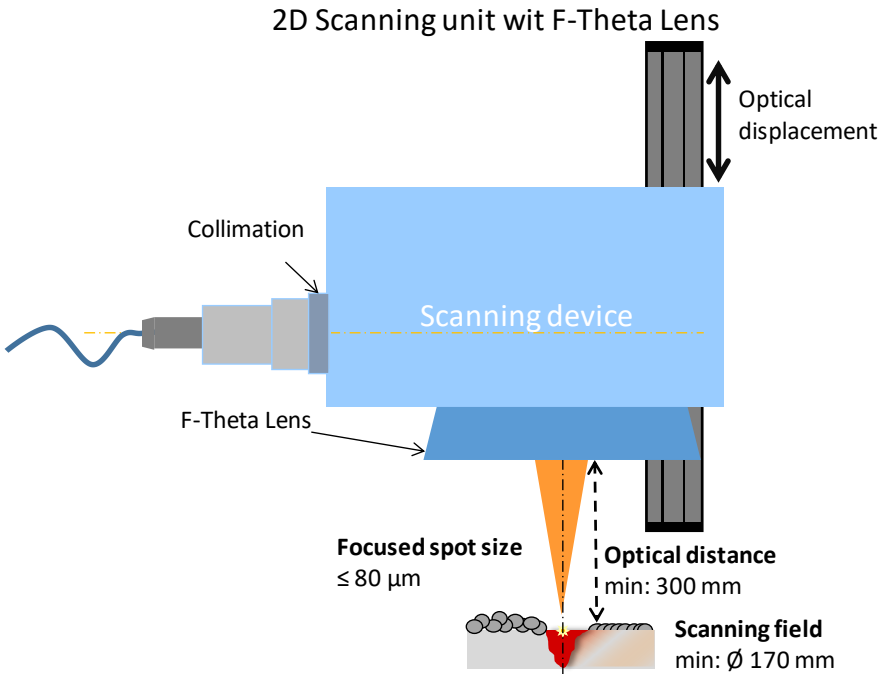
6.4 Optical Mount

All optical elements for laser beam guidance are mounted on the optical mount. The optical mount may be traversed by 400 mm in z- direction. This allows a comfortable caustics and power measurement of the laser system. Depending on the system configuration, the laser system can be operated in two different configurations.

6.4.1 F-Theta Configuration

The configuration with F-Theta lens allows the laser beam to be focused to a spot size <80 µm. The optical beam path is shown in Figure 24.

Figure 24
Schematic illustration of the F-Theta configuration



IMPORTANT!

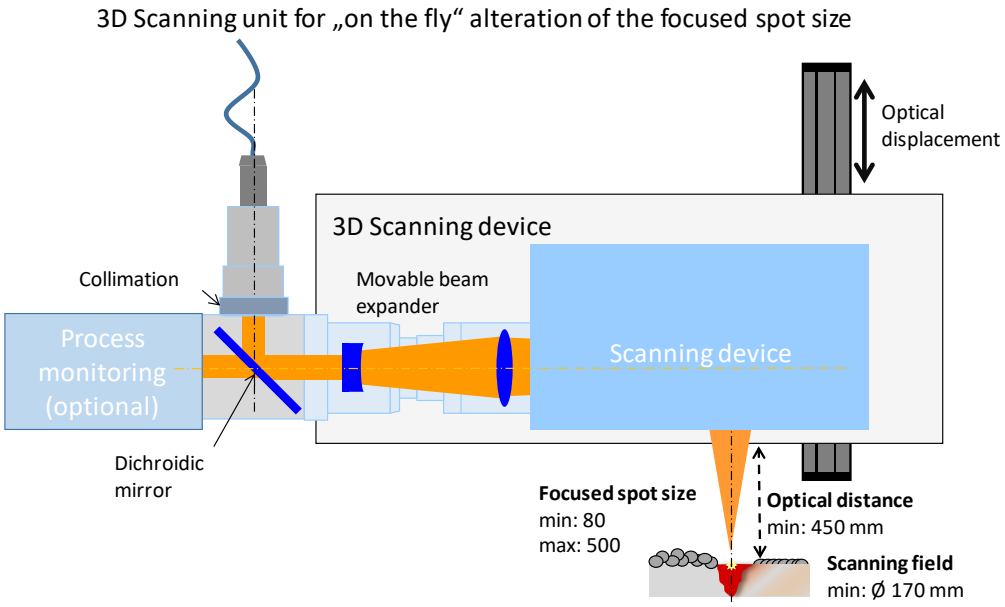
When using the F-Theta lens made of optical glass, the laser must not be operated with a power > 400W!

- If laser power > 400 W is to be used, consult Aconity3D GmbH.
- Always ensure that a suitable F-Theta optic with coating is used when using large laser powers.
- F-Theta optics can be subject to an optical shift depending on the power used, whereby the focus position can be shifted during operation.

6.4.2 3D Scanning Configuration (optional)

The configuration with a 3D scanning unit allows for the “on-the-fly” defocusing of the laser beam. The optical beam path is shown in Figure 25.

Figure 25
Schematic illustration of the 3D scanning configuration

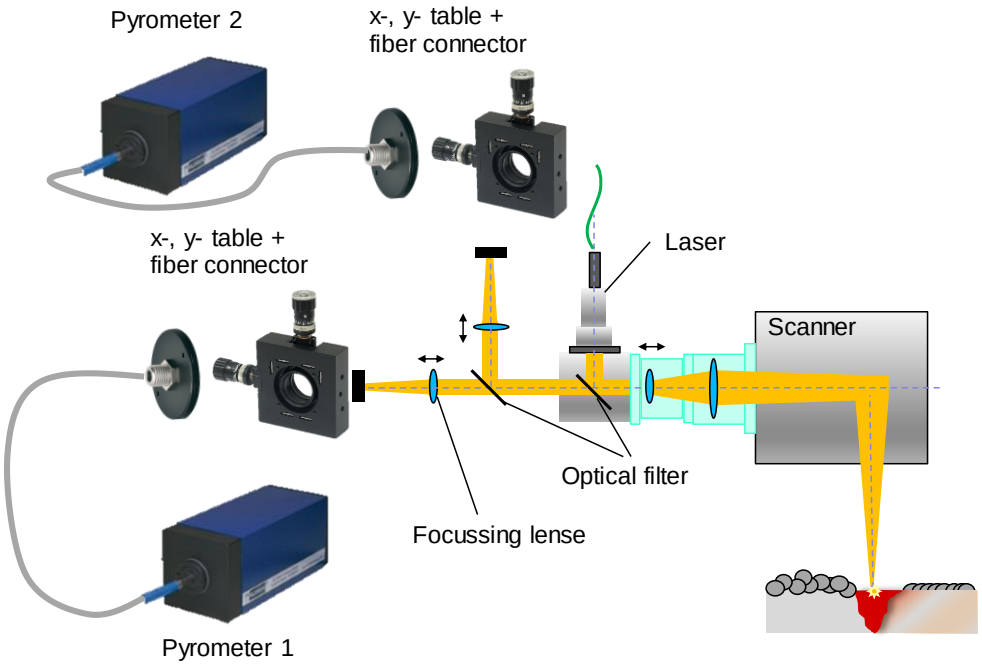


The 3D scanning unit allows for a variation of the spot size between 80 µm and 500 µm during the process, using the Aconity***Studio*** software. For details on the caustics of the laser beam, please refer to the corresponding caustic measurement in the appendix of the operating instructions.

6.4.3 Pyrometry (optional)

The optical pyrometry records the heat radiation ranging from 1500 – 1700 nm via two detector heads with the setup shown in Figure 26. The beam path of the heat radiation is split in two paths by optical filters, which are displayed on the fiber end of the detector head by different focusing lenses.

Figure 26
Schematic illustration of the pyrometer

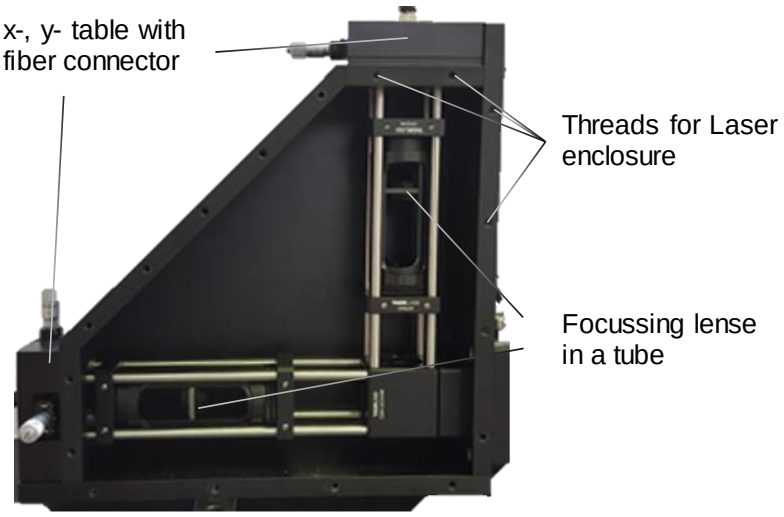


The fiber ends of the detector head are fixated by the fiber connector on the adjustable x-, y- table.

To align the pyrometers, you can focus the thermal radiation from the process zone in to the fiber end by moving the focusing lens. Adjusting the x-, y- table allows for the lateral configuration of the field of observation.

Figure 27 show a pyrometer module opened on the side – the shown module contains two beam entrances with one x-, y- table each for receiving the fiber and a lens tube with a focusing lens and a beam separator for the connection of both pyrometer beam entrances.

Figure 27
Photo of the pyrometer module



Important!

The measurement results of the pyrometry depend heavily on the correct adjustment of the pyrometer fibers.

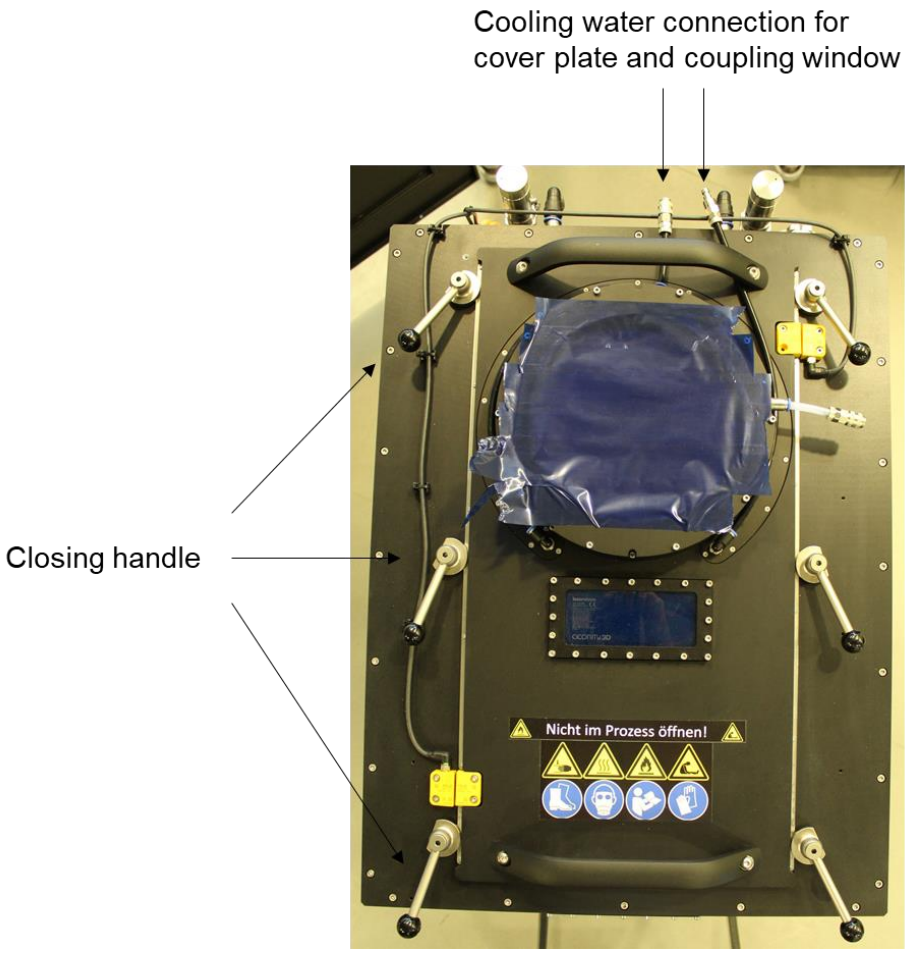
For reliable adjustment of the pyrometer fibers, Aconity3D suggest use of a special measurement system, which may be ordered separately.

The pyrometers exhibit a response time of T90 = 10 µs at a repetition rate of 100 kHz and a maximum resolution of 10 Bit.

6.5 Machine Cover

A schematic illustration of the process chamber is illustrated in Figure 30. For pre- and post- processing of a built the process chamber needs to be opened via the machine cover. For this purpose, loosen the quick-release fasteners shown in Figure 28 for the supply and return of the gas supply, the quick-release closures for the cover cooling, as well as the six closing handles on the chamber cover.

Figure 28
Opening of the process chamber



IMPORTANT!

Depending on the optical configuration the optical mount needs to be moved upwards for opening of the machine cover.

- Observe the minimum bending radius of 150 mm for the optical fiber of the laser beam source.
- Observe the length of the water-conducting connections during movement of the optical mount. If the connections are loosened, considerable water damage can occur.
- Observe the current and signal lines during movement of the optical mount.

WARNING!

Risk of Injury from moving parts!

When moving the optical mount, risk of crushing may occur.

- Do not grasp moving parts.
- Wear tight protective clothing with low tear strength.


WARNING!

Risk of injury from heat and high pressure!

The process chamber can be under high pressure and heated up after use!

- Before opening the process chamber, ensure that there is no overpressure in the chamber. Close the gas supply in the software Aconity***Studio*** and open the "outlet" valve on the fluidic panel completely (see section 6.1.3).

- Before opening the process chamber, ensure that there is no elevated temperature in the process chamber. High temperatures can cause burns or ignite the powder material in combination with oxygen. This is especially true for highly flammable metallic powder materials such as titanium, aluminum or magnesium.
- Wear appropriate heat protection gloves.

WARNING!

Risk of Injury from moving parts!

The powder deposition unit and the axes of the cylinders can be operated with an opened process chamber.

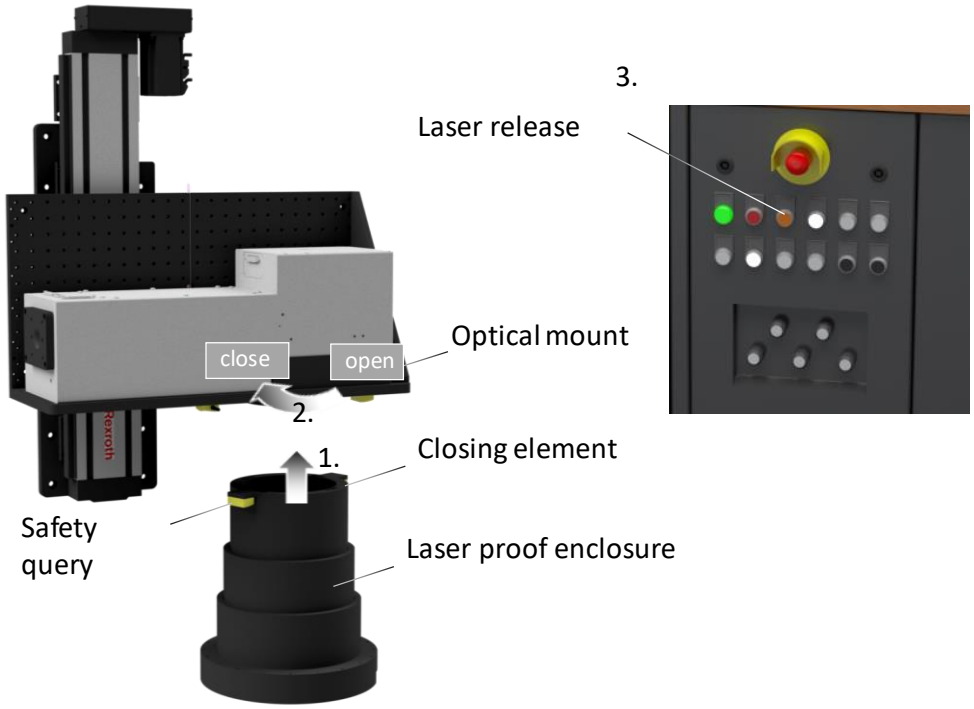
- Do not grasp moving parts.
- Wear tight protective clothing with low tear strength.

When closing the machine cover, ensure that the sealing elements are correctly positioned and check for damage.

6.6 Laser Proof Enclosure (Optional)

To close the optional laser proof enclosure, follow the steps illustrated in Figure 29.

Figure 29
Closing of the laser proof enclosure



1. Move the closing element of the laser proof enclosure in direction of the optical mount. The holes of the bayonet lock must overlap the fitting bolts.

2. Close the bayonet lock by turning the closing element. Make sure that the Safety query on the closing element aligns with its counterpart beneath the optical mount.

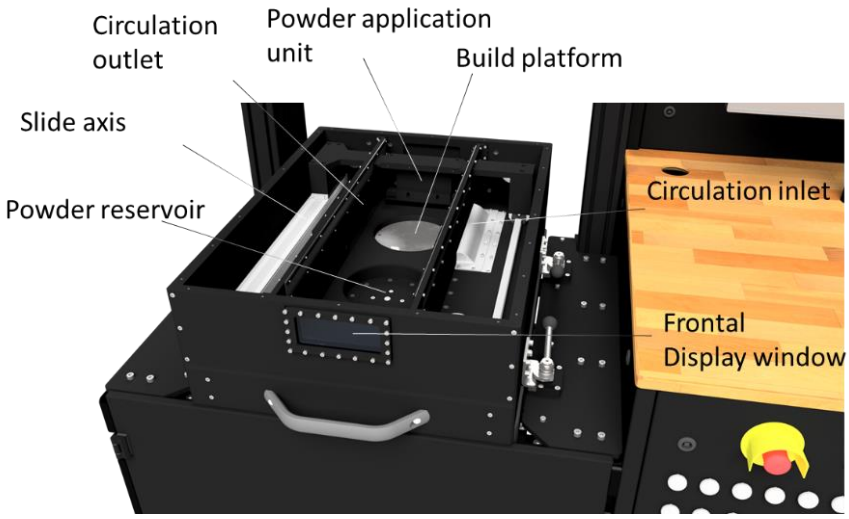
3. Push the laser ready button on the control panel (see section 6.1.2).

After successfully closing the laser proof enclosure and pushing the Laser ready button on the control panel the yellow light on the signal lamp will expire (see section 6.3). After successful lase clearance laser radiation can be emitted with the software Aconity***STUDIO*** (see section 7.8.2).

6.7 Process Chamber

Within the process chamber the following components are arranged: Build platform, powder overflow for excess powder, powder deposition unit and nozzles for inert gas supply. Figure 30 shows the process chamber with corresponding components.

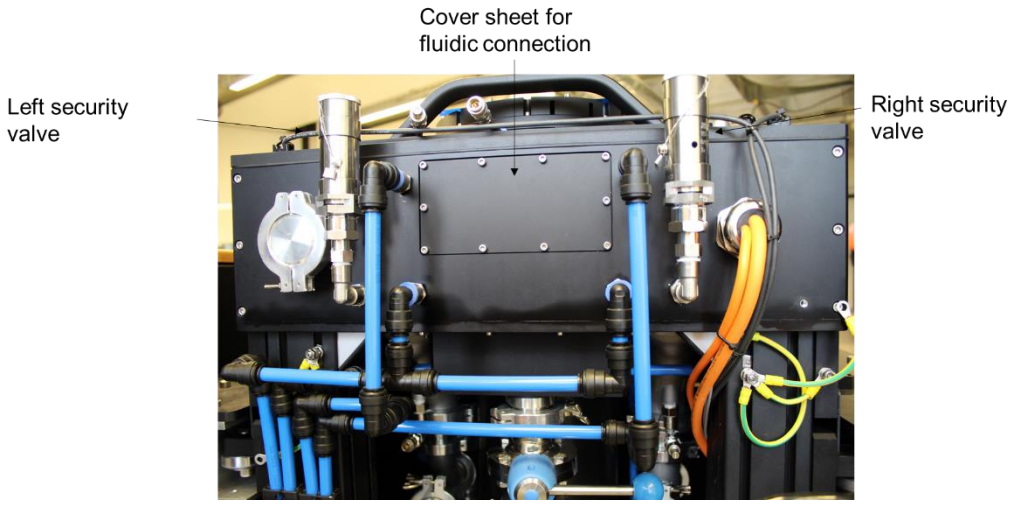
Figure 30 Schematic illustration of the process chamber



The process chamber is designed to be gas tight when the machine cover is attached. Viewing windows at the front and within the machine cover are designed to allow for an open view directly into the interaction zone between laser and the applied material.

The back of the process chamber is equipped with an interchangeable cover for diverse gas in- and outlets as well as two redundant overpressure valves, which are triggered at a pressure of 100 mbar above ambient pressure. Above the cover sheet for fluidic inlets the powder dosing unit (see section 6.7.5) is located as shown in Figure 31.

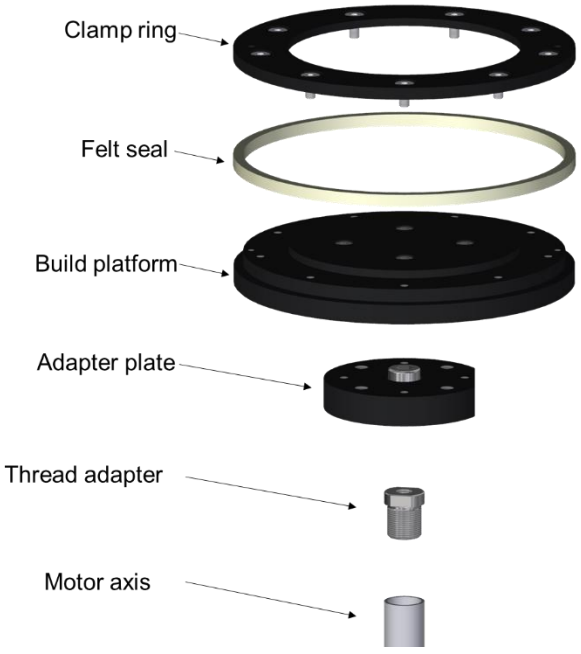
Figure 31
Illustration of the back of the process chamber



6.7.1 Build Platform

The build platform yields a diameter of Ø 170 mm. The substrate plates are mounted with 2 x M4 screws on the build platform. The technical drawings for the substrate plates are to be found in the appendix. Figure 32 shows a schematic representation of the build platform.

Figure 32
Schematic representation of the build platform



Thus, the build platform is fixed to the axis of the build platform by means of a connection flange. The whole construction is mounted by means of a centering nut beneath the cover.

When installing the build platform, it is important to ensure that the fastening screws of the substrate plate are aligned parallel to the powder deposition unit before the centering nut is tightened. To ensure free running of the build platform within the cylinder, the build platform should be moved into the cylinder, using the Aconity***STUDIO*** control software before the fastening screws are tightened. Two felt seals seal the construction platform and the cylinder.

IMPORTANT!

When installing the felt seals, make sure that the seals extend beyond the edge of the construction platform.

- After each built, clean the felt seals and inspect them for defects. Defective felt seals must be replaced (see section 11.5).

6.7.2 Resistive Heating Unit (optional)

The build platform may be replaced by a heating unit, which is capable of reaching up to 500 °C.

WARNING!

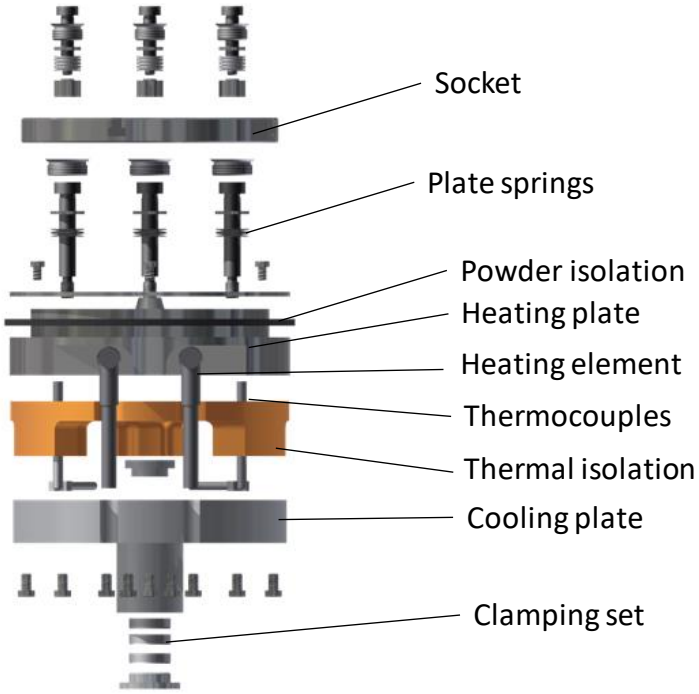
Risk of burns!

Process chamber and component surfaces heat heavily up during operation.

- Risk of skin burns when in contact with hot components and build platform.
- Risk of skin burns when in contact with heating elements.
- Prior to any works please ensure cooling down of all surfaces to ambient temperatures.
- Wear appropriate heat-resistant gloves and protective clothing for all work with hot surfaces.

In Figure 33 an explosive view of the heating unit is shown.

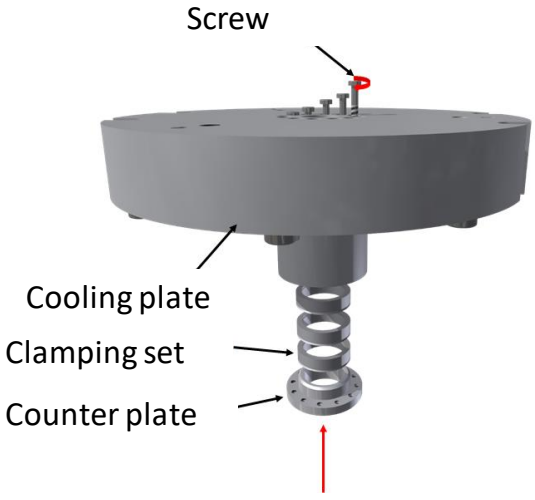
Figure 33
Explosive view of the resistive heating unit



Thus, the heating unit consist of a clamping set for radial fixation onto the axis, a cooling plate, thermal isolation, thermocouples and heating elements, thermal isolation, a heating plate, powder isolation, some plate springs and a socket for fixation of the substrate plate.

For mounting of the resistive heating element, in step 1 the cooling plate must be installed according to Figure 34.

Figure 34
Mounting of heating unit
Step 1: Cooling plate



For this the clamping set must be pre-assembled by loose tightening of the screws to the counter plate. Then the connections for the cooling water can be connected to the connections at the bottom of the cylinder before the cooling plate is set onto the axis.

IMPORTANT!

If the cooling water connections are incorrectly installed, water damage can occur on the system.

- Please always check the water hoses for porosity before they are connected.
- Please make sure that the quick connections are properly connected and locked.
- Please check the cooling water circuit before complete installing of the resistive heating unit.
- When removing the heater, please remove the cooling hoses within the cylinder to prevent them from bursting under excessive pressure.


DANGER!

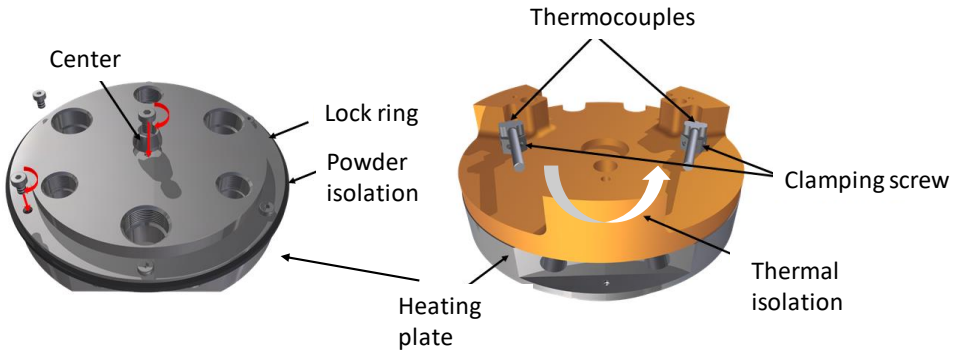
Leaking water can lead to short circuits and an explosive reaction with powder.

- Current-carrying components can be affected by leaking water, causing short-circuits.
- Leaking water can react with certain powders and form a dangerous fuel gas (H2). This can lead to an explosion in the event of a short circuit.

Before fixing the cooling plate by tightening the screws on the upper side, the electrical lines for the thermo- and heating elements must be passed through the holes provided in the cooling plate for this purpose.

In step 2 the preparation of the heating plate is performed, as indicated in Figure 35.

Figure 35
Mounting of heating unit
Step 2: Preparation of heating plate



Thus, the lock ring is tightly connected to the heating plate with the black powder isolation in between. Subsequently the heating plate is turned around and the thermal isolation is placed on top of it. The thermocouples are guided through the according holes and fixed with the clamping screws, making sure that they are touching the heating plate. Subsequently, the thermocouples and heating elements are connected with the connections provided for this purpose.

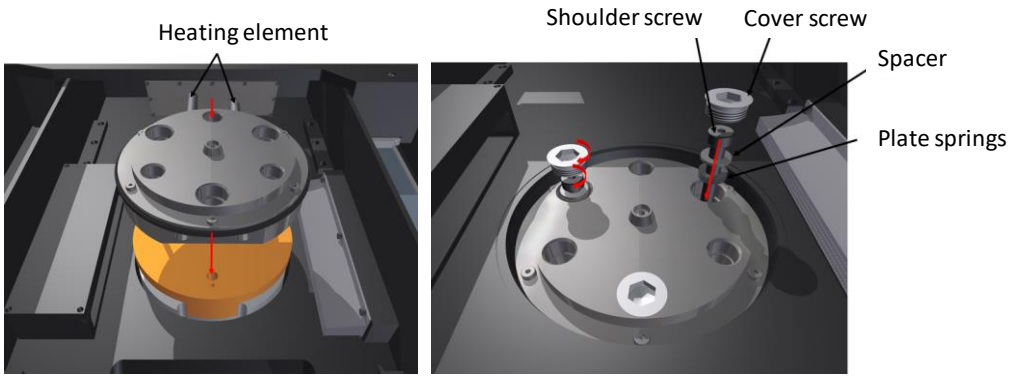
IMPORTANT!

If the thermocouples are installed incorrectly, overheating and damage can occur.

- Ensure proper signal transmission after connecting the thermocouple.
- When installing the thermocouples, always make sure that they must always touch the heating plate, otherwise no contact-related measurement can be carried out.

Subsequently, the heating plate is connected onto the cooling plate as illustrated in Figure 36.

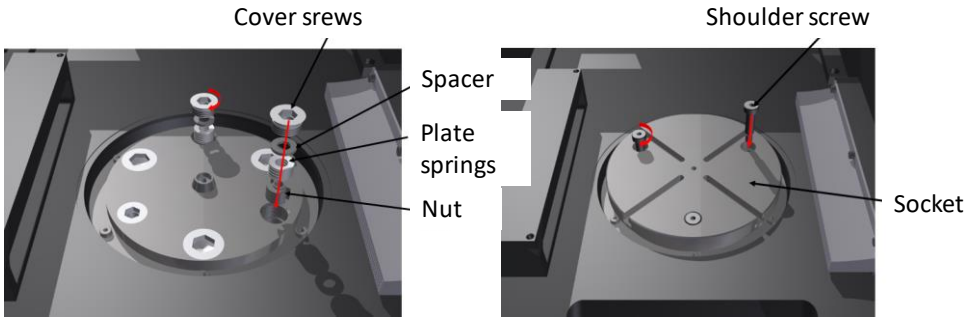
Figure 36
Mounting of heating unit
Step 3: Connection of heating plate onto cooling plate



Accordingly, the heating elements must be placed into the according holes inside the heating plate before heating plate and thermal isolation are fixed onto the cooling plate. Then 3 x 4 plate springs (outside diameter 20 mm, inside diameter 10,2 mm) and the spacers are tightened onto the cooling plate before the cover screws are attached.

The final step for final fixation of heat plate and attachment of socket is illustrated in Figure 37.

Figure 37
Mounting of heating unit
Step 4: Final fixation of heat plate and attachment of socket



Thus, the nuts for fixation of the socket is placed under 3 x 16 plate springs with an outer diameter of 16 mm and inside diameter of 8,2 mm before the socket is tightened onto the heat plate with shoulder screws.

Placing sliding blocks within the four grooves of the socket allow for fixation of substrate plates. The heating unit is designed to cover the whole diameter of the build platform of Ø = 170 mm. However, the applicable substrate plates differ from the ones used without any preheating. Technical drawings of the substrate plate can be found in the appendix.

6.7.3 Inductive Heating (optional)

The build platform can be replaced by an optional inductive heating unit, which allows heating temperatures of up to 1200 ° C with a reduced build space of Ø = 70 mm.

Risk of burns!

Process chamber and component surfaces heat heavily up during operation.

- Risk of skin burns when in contact with hot components and build platform.
- Risk of skin burns when in contact with heating elements.
- Prior to any works please ensure cooling down of all surfaces to ambient temperatures.
- Wear appropriate heat-resistant gloves and protective clothing for all work with hot surfaces.

Danger caused by electromagnetic fields!

In the vicinity of the induction coil strong electromagnetic fields exist. These may have detrimental effects on active and passive body aids, such as pacemakers, implants, etc.

The inductor generates an electromagnetic field. This induces eddy currents in a metallic workpiece, which is thereby heated by induction. The extent of the fields goes beyond the inductor and beyond the workpiece (stray field). Strength and extent of the stray field are strongly dependent on the size of the inductor and the magnitude of the alternating current flowing in the inductor.

Stray fields can have disturbing effects on the environment:

- Heating of metallic objects in the immediate vicinity of the inductor. For example, Implants, jewelry made of metal.
- Disturbing of electrical equipment in the immediate vicinity of the inductor. For example, heart

pacemakers or other electronic devices in the human body.

Only use the induction heater when the chamber lid is closed, as the EMC radiation is absorbed by forming a Faraday cage.

DANGER!

Acute danger to life due to high voltages!

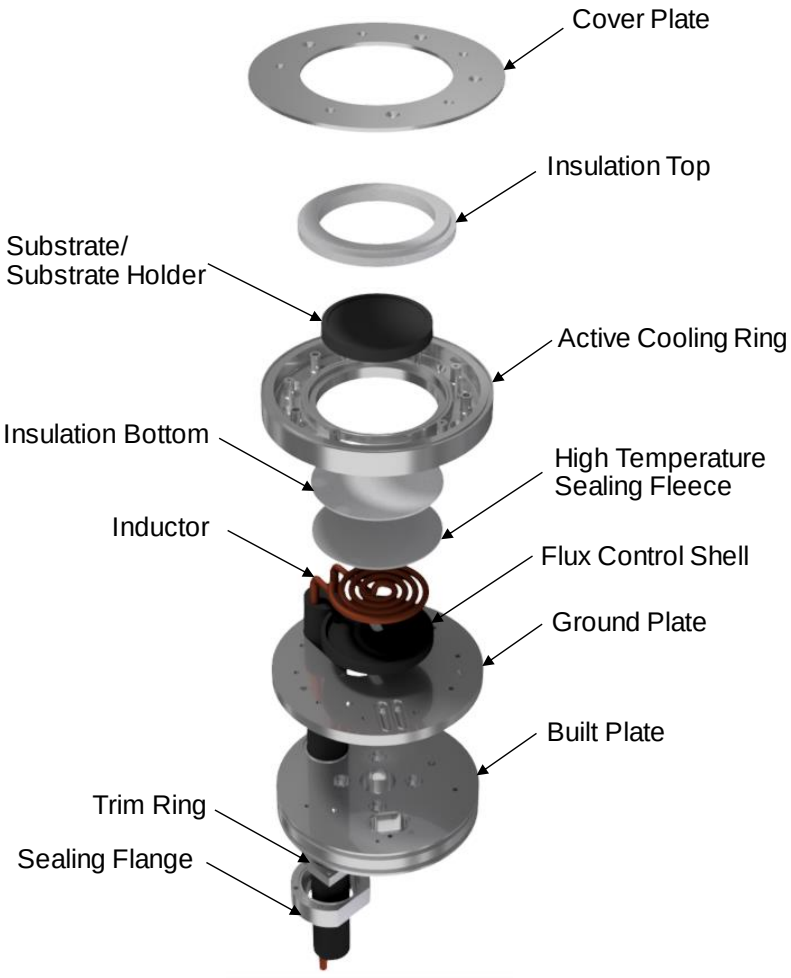
The high voltages occurring in both, generator and inductor represent an acute danger to life!

To generate the electro-magnetic fields required for induction, the generator generates voltages, constituting a high risk to human life or health impairment. These voltages occur equally within the generator, the outer circle, in the inductor and the terminal jaws. Operators or any other individuals in close vicinity to the generator under operation risk personal injuries when coming in contact with inductor voltages.

- Strictly never open generator when connected to power supply!
- Strictly never remove plastic enclosure of inductor and outer circle when connected to power supply!
- Strictly never touch inductor coil under operation!
- Exclusively operate induction heating with closed chamber lid!
- Strictly install all plastic covers of powered lines after maintenance in order to avoid accidental touching of these during operation.

In Figure 38 and explosive view of the inductive heating unit is given.

Figure 38
Explosive view of the inductive heating unit



The ground plate, flux control shell, inductor and cooling ring can be pre-assembled to ease installation into the process chamber. For this the following steps should be followed:

1. Place the flux control shell coaxially on the ground plate. Please ensure the grooves of the flux control shell face upwards.

2. Guide the inductor along with the black supply channel through the hole within the ground plate.

3. Place the inductor coil inside the grooves of the flux control shell.

4. Place the active cooling ring carefully around the inductor onto the ground plate. Please ensure that the sealing of the water supply fits

into the grooves provided within the ground plate. Please also ensure that the induction coil lays flat on the flux control shell.

5. The pre-assembled heating unit should now look as indicated in Figure 39

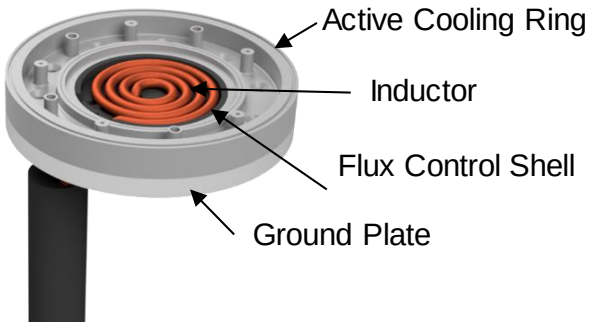


Figure 39 Schematic illustration of the pre-assembled heating unit

6. Fix the inductor to the trim ring beneath the ground plate.

7. Connect the cooling hoses to the couplings at the bottom of the build cylinder.

8. Connect the thermocouple with the plug inside the build cylinder.

9. Mount the base build plate onto the axis. To do this, go to the upper limit of the axis within the Aconity***STUDIO*** user interface. Ensure that the cooling hoses and the thermocouple are routed through the holes provided in the built plate, as shown in Figure 40. Please ensure that the through hole for the black supply channel of the inductor is concentric with the through hole in the cylinder bottom.

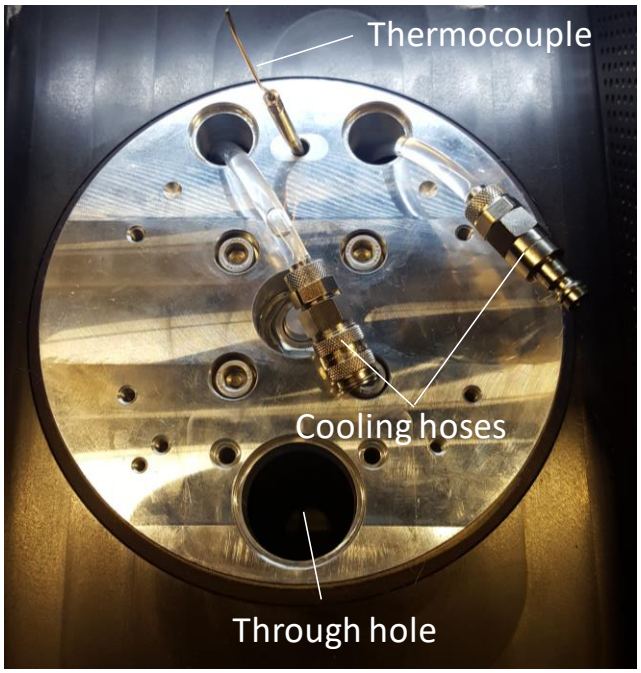


Figure 40
Mounted build plate with routed thermocouple and cooling hoses

10. Guide the pre-assembled heating unit through the through hole. Please ensure that the black supply channel for the inductor is guided through the according opening at the bottom of the build cylinder.

11. Guide the thermocouple through the opening in the active water cooling ring and connect the cooling hoses with the cooling ring.

IMPORTANT!

If the cooling water connections are incorrectly installed, water damage can occur on the system.

- Please always check the water hoses for porosity before they are connected.
- Please make sure that the quick connections are properly connected and locked.
- Please check the cooling water circuit before complete installing of the resistive heating unit.
- When removing the heater, please remove the cooling hoses within the cylinder to prevent them from bursting under excessive pressure.

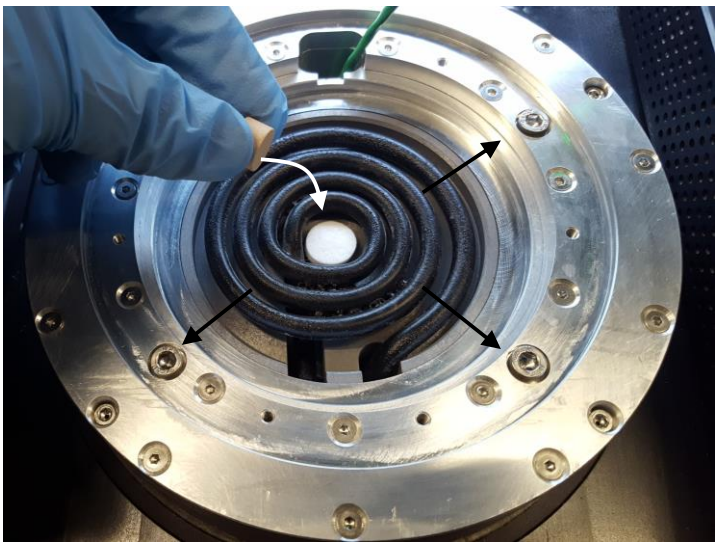
DANGER!

Leaking water can lead to short circuits and an explosive reaction with powder.

- Current-carrying components can be affected by leaking water, causing short-circuits.
- Leaking water can react with certain powders and form a dangerous fuel gas (H2). This can lead to an explosion in the event of a short circuit.

12. Connect the pre-assembled heating unit with the build plate, by tightening the highlighted screws as shown in Figure 41.

Figure 41
Mounted heating unit on build plate

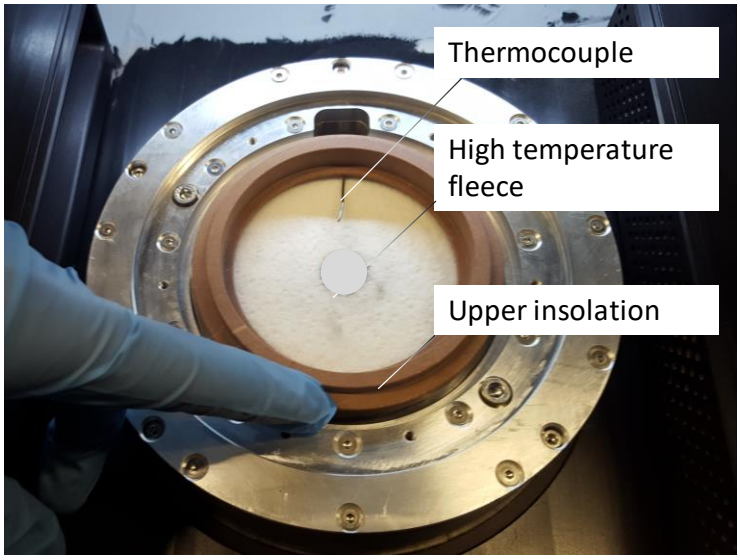


13. Mount the sealing flange beneath the bottom of the cylinder and ensure that it seals tightly with the supply channel of the inductor. Please apply grease to the sealing surfaces to ensure a gastight sealing. In case the vacuum option is applied in combination with the inductive preheating, please apply special vacuum grease.

14. Place the little isolating cylinder between the convolutions of the induction coil as shown in Figure 41.

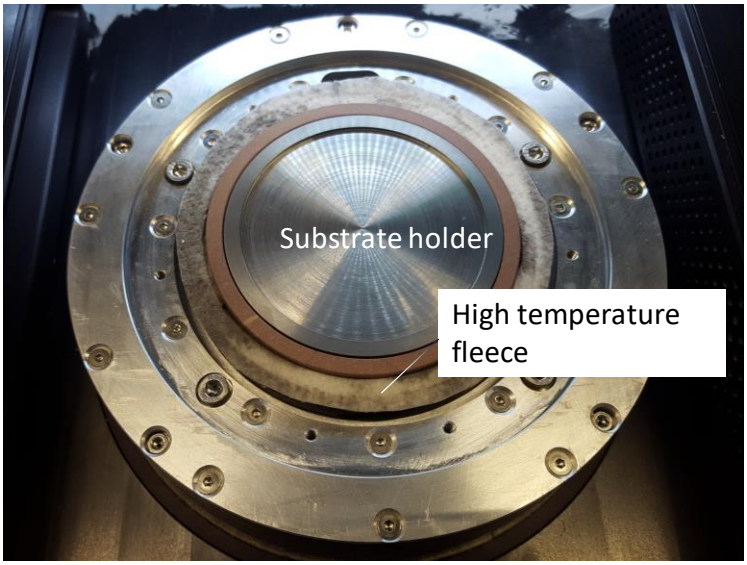
15. Subsequently, place the high temperature sealing fleece onto the induction coil. Then, bend the thermocouple downwards before placing the upper insulation on top of it as shown in Figure 42.

Figure 42
Alignment of thermocouple and upper insulation



16. Subsequently, the substrate holder can be carefully put into the upper insulation and a high temperature fleece can be applied as a powder seal around the flanks of the upper insulation, as shown in Figure 43.

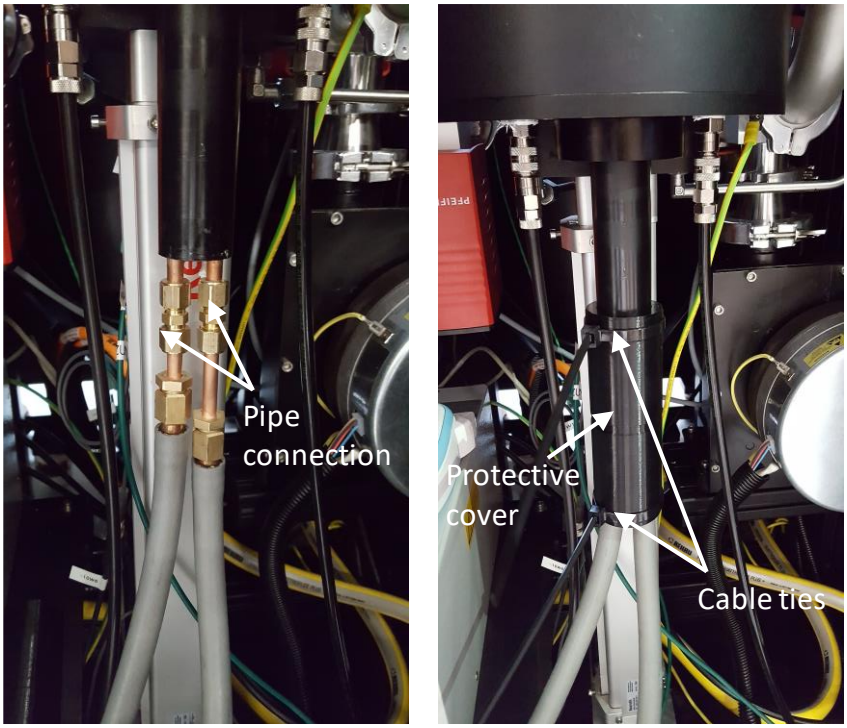
Figure 43
Installation of the substrate holder



17. For installation of the cover plate, a ring of high-temperature fleece is put around the upper insolation in order to seal off the inductive heating from entering powder particles.

18. As a next step, the supply channel of the inductor is connected to the flexible cables of the outer circle beneath the build cylinder. To do so, tighten the pipe connections as shown in Figure 44.

Figure 44
Connecting the inductor to the outer circle

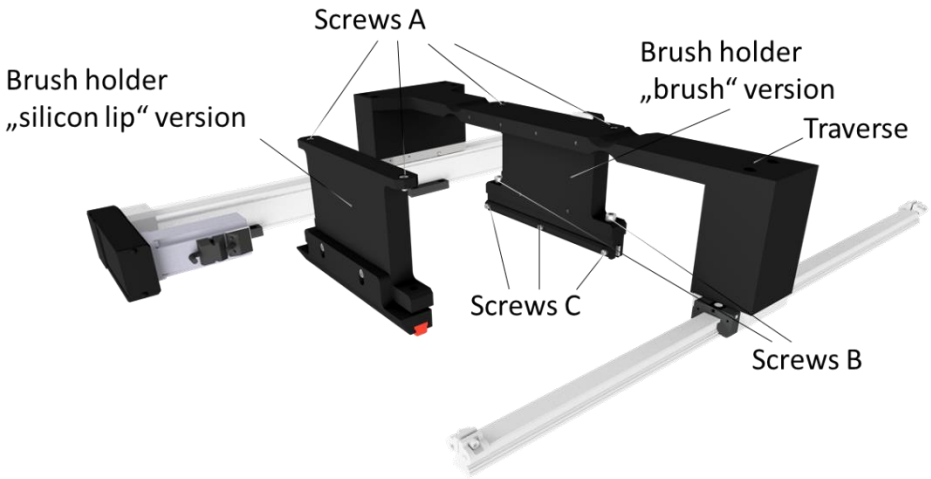


19. As last step, all contacts are protected against unintentional touching. For this the protective plastic covers are put in place and secured with cable ties.

6.7.4 Powder Deposition Unit

The powder material is applied via a carbon fiber brush (Blades, silicone lips, etc. can be additionally purchased). Powder material is supplied by the powder supply and spread evenly over the substrate plate by the powder deposition unit (see Figure 45). Excess powder is conveyed to the powder overflow by the powder deposition unit (see section 6.7.5).

Figure 45 Schematic of the powder deposition unit



The powder deposition unit consists of a traverse, a mount and the brush holder. The traverse is propelled by a linear unit and guided on a sliding carriage. The brush holder can be separated from the traverse to check or exchange the brush, by loosening screws A. The brush holder is connected to its mount by the screws B. The brush is aligned with the build platform by means of screws C (see section 8.3.2).

WARNING!

Danger of personal injuries caused by moving parts!

Rotating and/ or linearly moving parts may cause severe injuries.

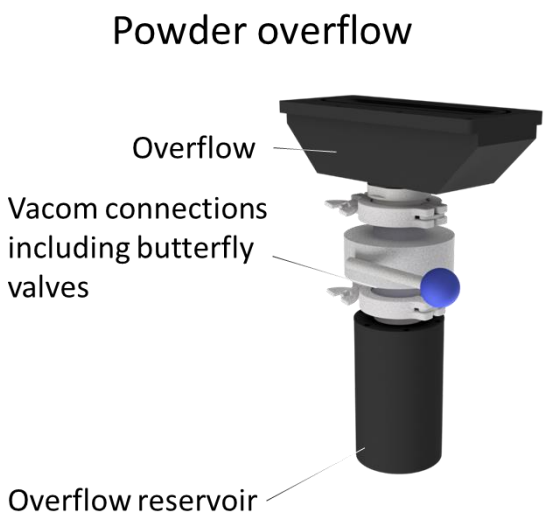
- Strictly avoid getting within reach of moving parts or touching them during operation.
- Please check for follow-up time and ensure complete stop of moving parts prior to removal of covers.
- Wear appropriate gloves and protective mask when removing the powder contaminated brush holder.
- Please wear only tight-fitting protective apparel with low resistance to tearing within hazardous areas.

6.7.5 Powder Supply and Powder Overflow

A schematic of the powder supply and powder overflow is shown in Figure 46. The powder necessary for the whole building process is poured into the powder reservoir. The powder in the reservoir is conducted into the process chamber in front of the powder deposition unit by means of the dosing unit and spline shaft. After the powder is applied on the build platform by the powder deposition unit the excess powder falls through the overflow funnel into the overflow reservoir.

The powder reservoir and the powder overflow are connected to the process chamber by a gas-tight Vacom flange system, including a disc valve, which allows filling and emptying in an inert process atmosphere.

Figure 46
Schematics of the powder overflow



WARNING!

Risk of injury by contact with or by inhalation of hazardous dusts!

Skin and eye contact with, as well as inhaling and swallowing of powder materials may cause severe health impairment

- Please refer to safety data sheets of the powders used.
- Powder material must only be handled by trained personnel.
- Only use powder materials in well-ventilated rooms.
- Always wear personal protective equipment, such as powder-tight gloves, protective clothing, safety goggles and respiratory protection.
- Change and wash the safety clothing at regular intervals to prevent excessive dust contamination.
- Please ensure that all personal protective gear is removed after completion of the work to not carry dust that is within the textile fabric beyond the working area.

WARNING!

Risk of injury while handling the powder containers

A fully filled powder container is very heavy.

- Please wear safety shoes while working on the powder containers.

6.8 Media Supply

6.8.1 Water Cooling

The LBM machine must be supplied with cooling water. The cooling water connector is located at the right side of the control cabinet (feed and return flow).

The following components of the machine are continuously supplied with cooling water:

- Scanner
- 3D scanner unit (optional)
- Laser beam source (optional at laser power > 400 W)
- Induction generator (optional)

Optionally an additional circuit can be connected via valves, at which the distributor is located under the process chamber (see Figure 47). The following components may be connected:

- Build platform with heating element (optional with usage of a heater)
- Cooling plate of the process chamber lid (optional with usage of a heater)

Cooling water can be tapped from this distributor for additional peripheral devices like a water-cooled power measurement device.

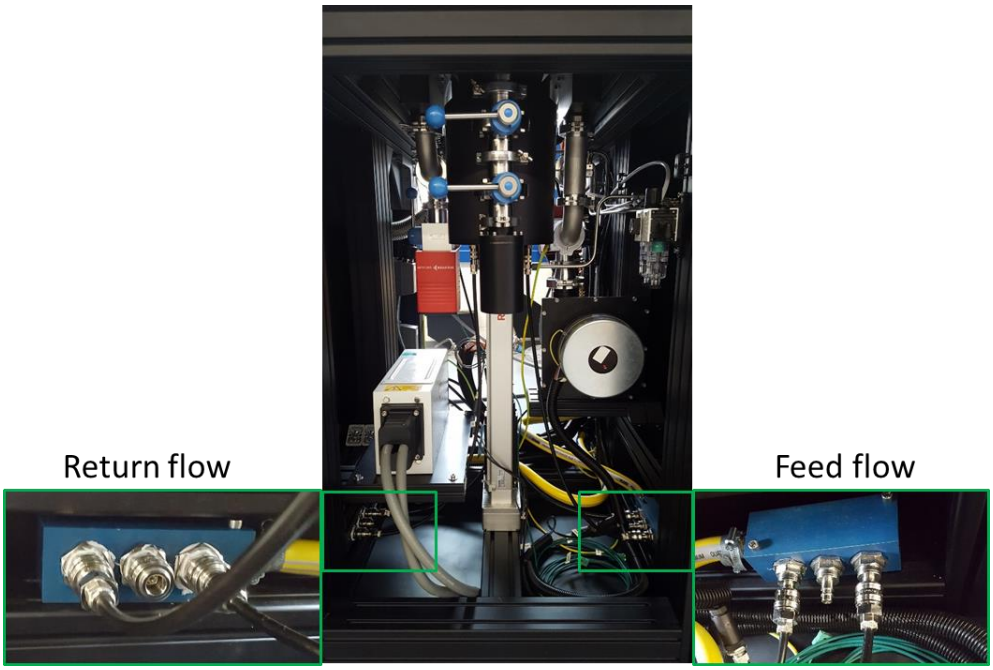


Figure 47 Photo of the water distributor under the process chamber

The main pipe of the water supply at the in- and outlet should be connected via additional valves, which can be closed for temporal shutdown or possible fitting work to prevent leakage of greater amount of water und resulting damages. For the operation of the research machine both valves (in- and outlet) must be opened.

Important!

When *opening* the water supply, first open the water outlet and subsequently the inlet. This prevents pressure build-up in the water circuit.

When *closing* the water supply, first close the water inlet and subsequently the outlet. This prevents pressure build-up in the water circuit

DANGER!

Danger caused by electrical voltage!

Check the whole cooling system for leakage before activating the water supply.

- Strictly avoid moisture in the vicinity of the research equipment, as it causes short circuits.

6.8.2 Air cooling

Compressed air is necessary for cooling some scanners and for usage of the preheating to cool the inlet glass. Prior to entering the scanner, the compressed air must be cleaned by a filtration unit and the pressure for the inlet must be lowered by a manometer. The filtration unit with the manometer (Figure 48) is located at the right side above the optical mount.

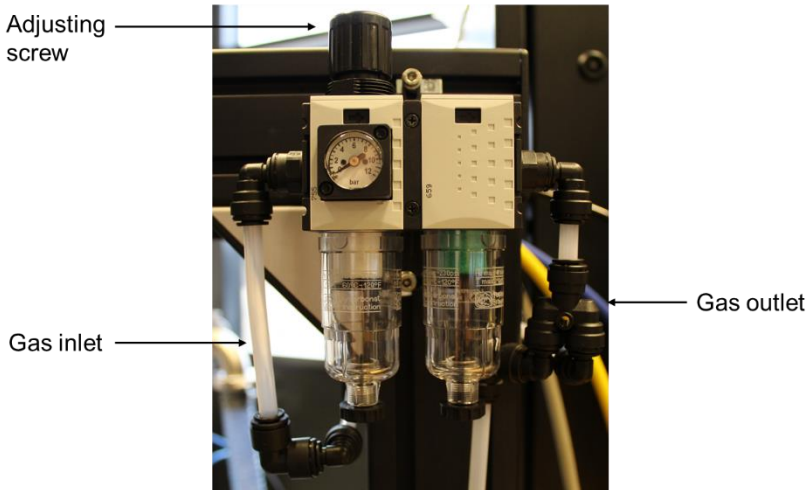
Important!

The scanner can be destroyed by too high air pressure or unfiltered, compressed air.

- Via the manometer at the side of the machine, make sure that the pressure of the complete system does not exceed 1,6 bars.
- Make sure that the compressed air for the complete system is conducted through a filtration unit. Change the filter if it is heavily contaminated.

Figure 48 shows the filtration unit for filtering the compressed air.

Figure 48 Photo of the filtration unit and manometer for compressed air supply



The pressure for the whole machine can be regulated via the adjusting screw and read on the manometer. The pressure at the gas outlet must not exceed the pressure on the gas inlet. A maintenance unit is located under the two-staged filtration unit, which allows dumping of residue like condensed water or oil by opening the screw.

6.8.3 Inert Gas Supply

To prevent oxidation of molten metal material the LBM machine is operated under an atmosphere of protective gas. The machine is supplied with argon via the right side (see section 5.2.3), whereby it is to be made sure that the argon supply (see section 5.2.5) is within the given parameters.

WARNING!

Suffocation risk due to exposure to argon!

When in high concentration, leaking out argon displaces oxygen in the ambient air, thus causing loss of consciousness or even suffocation when inhaled.

- Strictly consult safety data sheet provided by manufacturer.
- Provide readily available self-contained breathing apparatus in case of emergency.
- Always lead the exhaust gases into the open air directly or via an exhaust system of the facility.
- When using an exhaust air system, make sure exhaust gases are completely and permanently sucked off.
- Ensure there are no pits, shafts, or other bumps in the ground where argon might accumulate.
- Ensure that the installation site is equipped with an oxygen monitor.
- When Argon is flowing into the surrounding, always ensure fresh air supply.
- In case of accidental inhalation, take affected person immediately to fresh air in a stable side position. If breathing is stopped, seek medical attention immediately and initiate first aid measures.

When purging (purge mode, see section 7.8.2) the process chamber, a high gas flow up to 30 l/min can occur. During purging the process chamber is automatically regulated to < 50 mbar above ambient pressure. Observe the flow through the O_2 -sensor. To prevent damaging the sensor the flow must not exceed 10 l/h (see section 6.1.5). After reaching an O_2-value of

< 1000 ppm the gas supply can be switched to operating mode by clicking the “atmospheric pressure button” within the Job-Editor: View and Control Section (see section 7.8.2).

In operating mode, the inlet gas flow is automatically regulated to 3 – 5 l/min depending on the gas outlet valve, set within the valve panel (see section 6.1.3). The further the gas outlet is opened, the larger the inlet flow. The amount of gas flow influences the quality of the protective gas atmosphere.

DANGER!

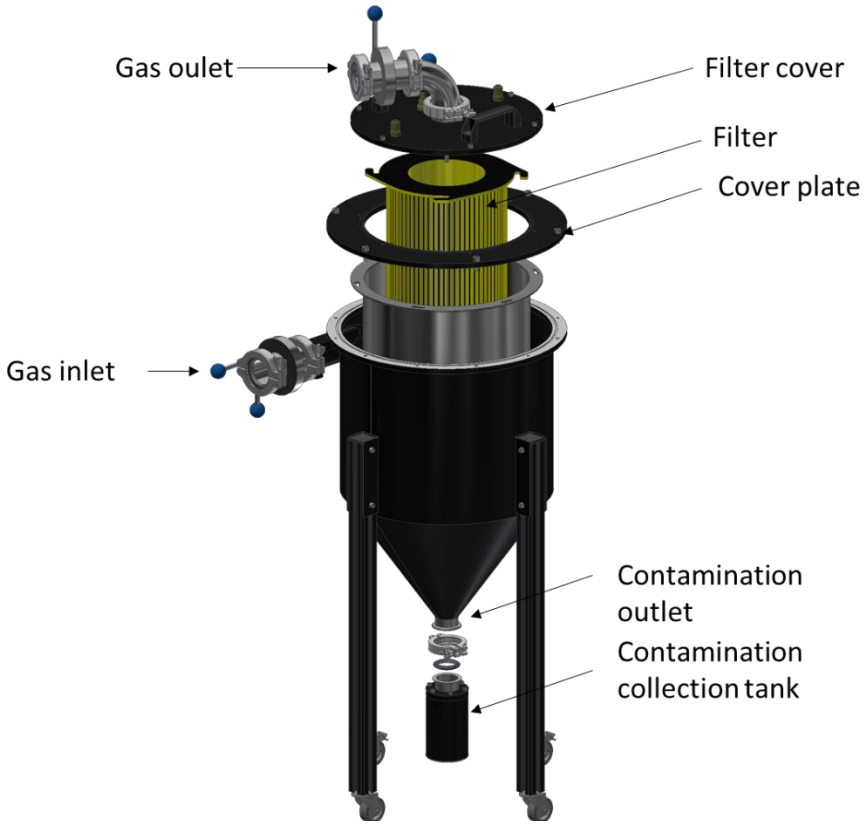
Danger via high pressure in the process chamber!

Check the pressure relief valve for functional capability. The process chamber can burst due to high pressure.

- Make sure that the pressure in the process chamber does not exceed 100 mbar above ambient atmosphere.
- If necessary increase the outlet flow on the valve panel (see section 6.1.3)
- If necessary increase the outlet flow by regulating the automated outlet valve (see section 7.8.2)

During a build job, contaminants which are produced in the interaction zone of laser beam and powder material, are filtered out by means of a cyclone filter (Figure 49).

Figure 49
Schematics of the cyclone filter



The power of the circulation pump can be regulated via the software Aconity**STUDIO** (see section 7.8.2).

Important!

The circulation pump operates at 35 % of the maximum power, independently from the settings in the software Aconity*STUDIO.*

With a dynamic pressure sensor, the contamination grade of the cyclone filter can be measured and displayed in the software Aconity***STUDIO*** (see section 7.7). At high grade of contamination, the filter has to be changed (see section 11.2).

After activating the circulation pump the concentration of oxygen in the process chamber is elevated for a short time, until the cyclone filter is completely filled with inert gas.

DANGER!

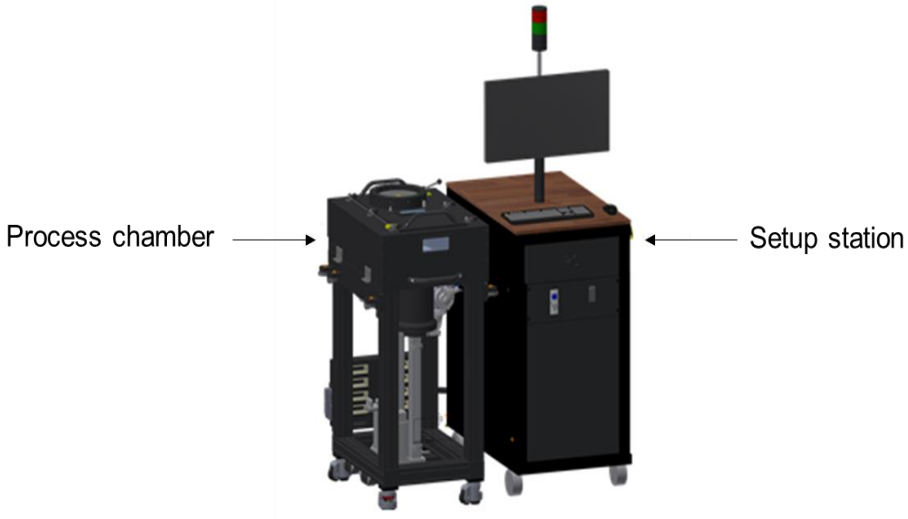
Danger to life via ignition and explosion of powder material and powder residue!

- Only start the circulation pump when a protective gas atmosphere with an oxygen content of < 1000 ppm is established.
- Exchange the filter unit after working with highly reactive powder material (titanium, aluminum, magnesium, etc.)
- Consult safety data sheet provided by powder manufacturer when disposing of powder and filter.
- Contaminated filters are highly flammable and must be stored and disposed of in gas-tight, lockable metal containers

6.9 Setup station (optional)

To increase the research equipment's efficiency, an additional process chamber can be prepared in the optional setup station (see Figure 50Figure 50) independently from the control cabinet and optical mount.

Figure 50
Setup station with additional process chamber

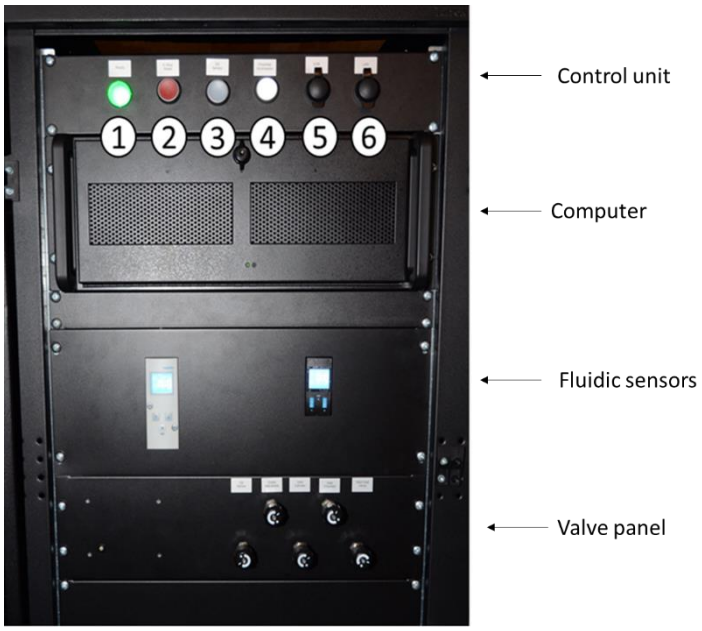


The additional process chamber can be filled with powder and rendered inert while a build job is being manufactured in the research equipment. As

soon as the build job in the first process chamber is finished, the chambers are switched and the new build job can be started immediately.

The setup station`s control panel mostly matches the research equipment's. Operation takes place via the control unit in the upper part of the panel (see Figure 51).

Figure 51
Setup station's control panel



1. The green „ready" light shows the power supply with activated main switch and released emergency-stop

2. The red "release emergency-stop" shows the closed emergency-stop chain. It must be pressed after activating the setup station and after every activation of any emergency-stop button

3. The "O2 sensor" button activates the power for the O2 sensors (see section 6.1.5)

4. The button "chamber light" activates the chamber illumination

5. USB port

6. LAN port

The Computer (see section 6.1.6), the fluid sensors (see section 6.1.7) and the valve panel (see section 6.1.7) are located underneath the control unit.

7 Aconity*STUDIO*

7.1 General Remarks

7.1.1 Control Elements and Switches

All central elements and switches are accompanied by concise descriptions. With the cursor resting on a control element or switch, the descriptions are shown next to it.

The following recurrent control elements are made used of:

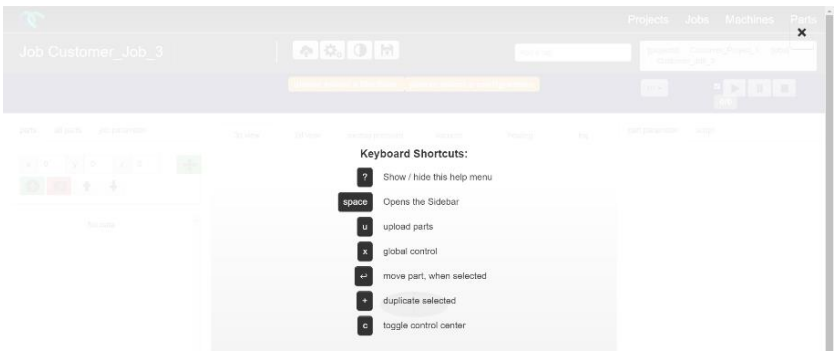
- Display (): If display is asked, then this control element is used.
- Settings (): If setting is asked, then this control element is used.
- Delete (): If deletion is asked, then this control element is used.
- Add-on (): If add-on is asked, then this control element is used.

Switches are displayed the same way as control elements. With the machine not yet started, the switch will be either not displayed or shaded grey, thus indicating locked functionality. Further locked states may arise in dependence of switch functionality. In switch-off mode switches are shaded green. After switch-on operation switches are shaded red.

7.1.2 Hotkeys

For time-saving operation, hotkeys are applied. For a list of hotkeys press “?”. The List of Hotkeys is displayed in Figure 52.

Figure 52
List of hotkeys in Job Editor

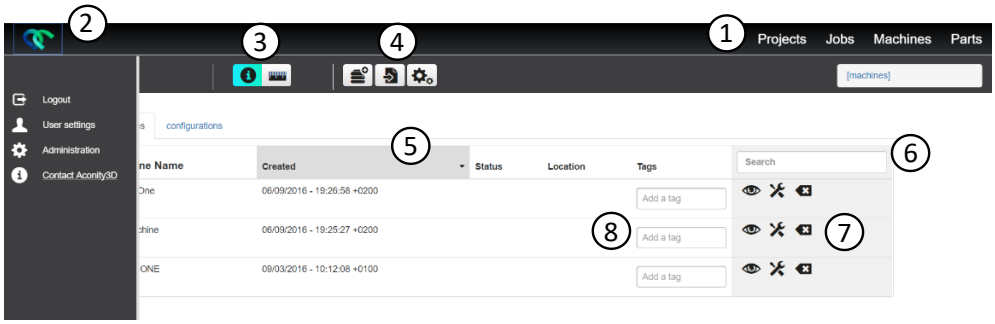


7.2 Navigation- and Control Elements

The user interface of the web application is subdivided into four main sections: **‘Projects’, ‘Jobs’, ‘Machines’** and **‘Parts’**. Each of these main sections has one overview page minimum and a detailed view of the respective instances. Each of these main sections may comprise further subsections. Recurring navigation and control bars are to simplify usability. In the following, the respective navigation and control bars are dealt with under the corresponding sections and subsections.

Figure 53 represents central navigation and control bars.

Figure 53
Display of central navigation and control elements



The following sections are designated numerically:

1. Main navigation
2. System navigation
3. Section navigation
4. Primary toolbar
5. Search field
6. Line toolbar
7. Tags

The above sections are recurrent in all four main sections and will be dealt with in more detail in the following.

7.2.1 Main Navigation

Main navigation is provided in the above right corner (1 Figure 53). The specific main section can be accessed under its name, subsequently opening the corresponding section overview page.

7.2.2 System Navigation

One click on the logo (2 in Figure 53) opens system navigation on the sidebar, left margin. The following functions are saved on the sidebar:

- Logout ( ): User logout for end of session
- User settings ( ): Opens modal for setting of user instructions and user password.
- Administration ( ): Opens overview page of administration
- Contact ( ): Opens modal providing Aconity 3D contact information

7.2.3 Section Navigation

All main sections comprise one subsection minimum. Section navigation (3 in Figure 53.) provides switch-over to the various subsections. For example: The main section Machines, displayed in Figure 59, has the subsections **‘Machines’** and **‘Machine Tests’** (see section 7.5.5).

7.2.4 Primary Toolbar

Each subsection has a primary toolbar (4 in Figure 53) This function bar accesses the subsection´s central functions. Control elements may differ and are dealt with in detail in the overviews of each main section: **‘Projects’** (see section 7.3), **‘Jobs’** (see section 7.4), **‘Machines’** (see section 7.5) and **‘Parts’** (see section 7.6).

7.2.5 Tables

Instance quantities are shown in tables, each line representing a specific instance. The columns always have a named headline (5 in Figure 53) One click on the headline sorts by instance characteristics.

7.2.6 Search Field

Tables always have a search field (6 in Figure 53) for name searching and other table fields searching. After entering the search term, the number of lines is adjusted. Search fields are equally used for long lists.

7.2.7 Line Toolbar

Each table line has a specific toolbar (7 in Figure 53).

The following recurrent switch elements can be found on the toolbar:

- Display ( ): Opens single view of the specific instance.
- Settings ( ): Opens modal, facilitating edition of sub-quantities of instance characteristics. With further detailed settings, there is a control element in the primary toolbar (4 in Figure 53) of the single view, featuring the same symbol.
- Delete ( ): Opens modal for deletion of specific instance.

7.2.8 Tags

Each instance can be tagged (7 in Figure 53). A tag is used for saving meta-information of the specific instance, e.g.: pointing out relevant jobs or parts.

7.3 Main Section Projects

‘Projects’ offers the user grouping of his jobs. Each project can comprise any number of jobs. Each project is named and offers optional description. For each project, creation date and latest date of update are saved.

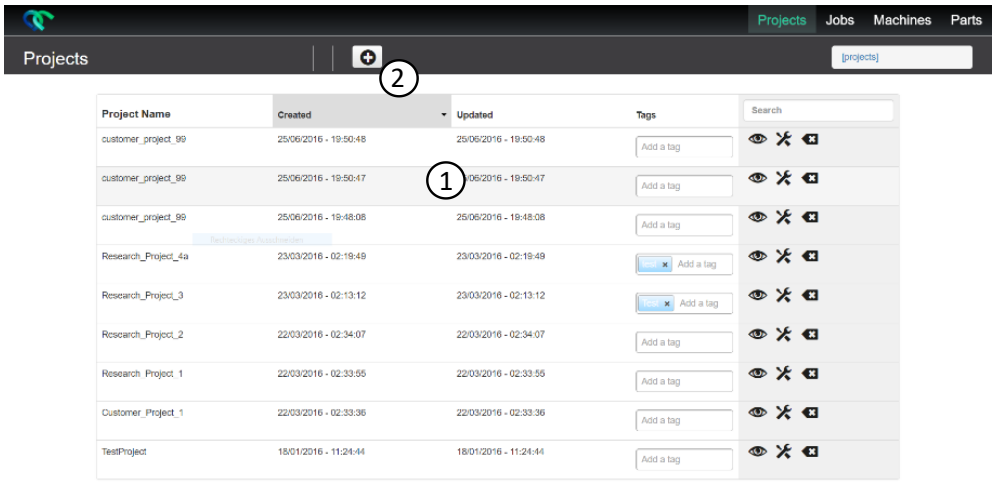
The main section **‘Projects’** allows for access to user projects.

Overview displays any projects a user has access to. Single view displays project details.

7.3.1 Overview Projects

Figure 54 displays main section **‘Projects’** overview.

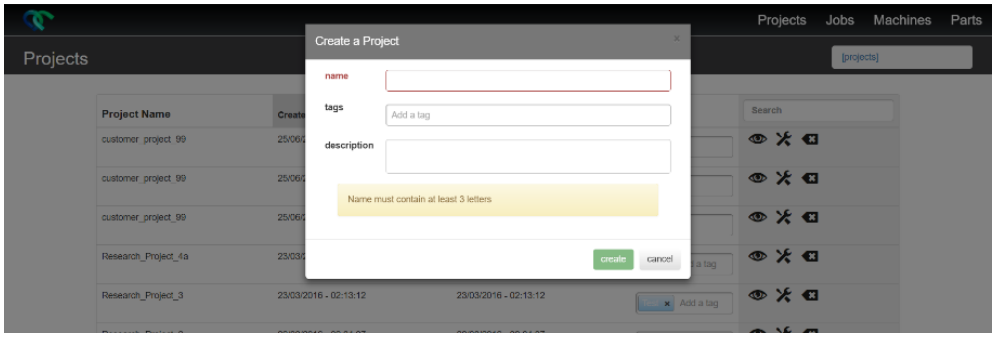
Figure 54
Main section
'Projects' overview



Central element of the main section **'Projects'** overview is the tabular display of any project the user has access to (1). Displayed are 'ProjectName', 'Created', 'Updated' and 'Tags'. One click on display ( ) opens single view Projects (see section 7.3.2).

The section toolbar (2) exclusively consists of one control element for new project add-on ( ) Figure 55 displays the modal for new project creation.

Figure 55
Modal for new
project creation

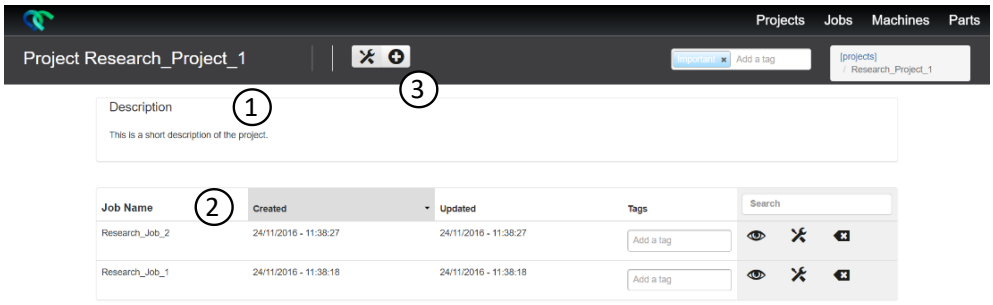


The modal for project creation requires filling in of project name minimum, any other characteristic is optional.

7.3.2 Single View Projects

Single view Projects displays any number of jobs connected to a project. Figure 56 displays the corresponding window.

Figure 56
Single view
'Projects'



(1) Displays optional project characteristics. (2) Displays any jobs attributed to the project in tabular form. Jobs display is analogue to the one, stated in main section Jobs (see section 7.4) with information about creation date, modification date, optional tags and line toolbar for display (), opening of settings () and deletion () of the specific job.

The section toolbar (3) contains the following control elements:

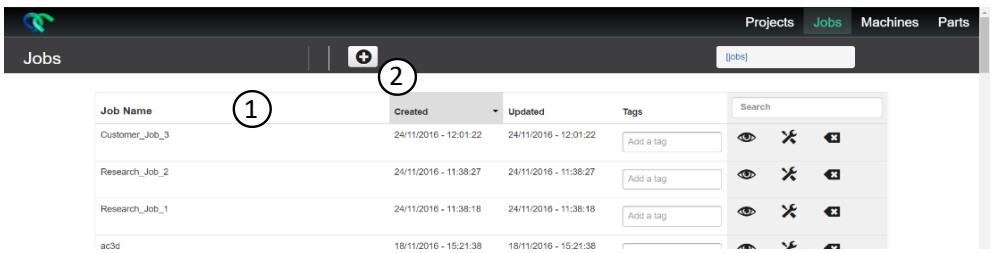
- Add-on (): Opens modal for creation of new job. It is mandatory to add one project and one name minimum. Any other characteristics are optional.

- Settings (): Opens modal for editing name, tags and details for the specific project.

7.4 Main Section Jobs

Main section '**Jobs'** opens access to any user's build jobs, regardless of project affiliation. Figure 57 displays overview of main section '**Jobs'**.

Figure 57
Overview **'Jobs'**



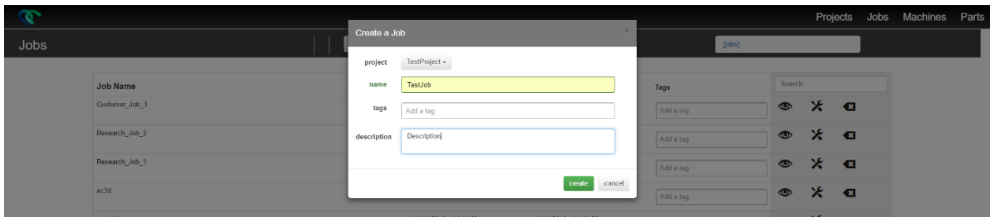
Central element of overview **'Jobs'** is the view of jobs in tabular form (2). Displayed are 'Job Name', 'Created', 'Updated' and 'Tags'. One click on display () opens single view jobs.

Single view displays job details, the so-called Job Editor (see section 7.8). Job Editor is the central tool for job parameterization, preparation and execution. As the Job Editor represents the main section for process

information the remaining sections **‘Machines’** and **‘Parts’** are dealt with first.

The section toolbar (2) exclusively consists of only one control element for new job add-on (⊕). The modal for a new job creation is displayed in Figure 58.

Figure 58
Modal for new job creation



The modal for job add-on is to be at least filled in with name and affiliated project. Any other characteristics are optional.

7.5 Main Section Machines

Main section **‘Machines’** allows for total machine configuration to be modified, thus permitting integration of new components or sensors into the machine and operation via Aconity***Studio***.

Important!

Interference with machine configuration allows for manipulation of any system components.

Deficient machine configuration may result in malfunction and damage of single system components.

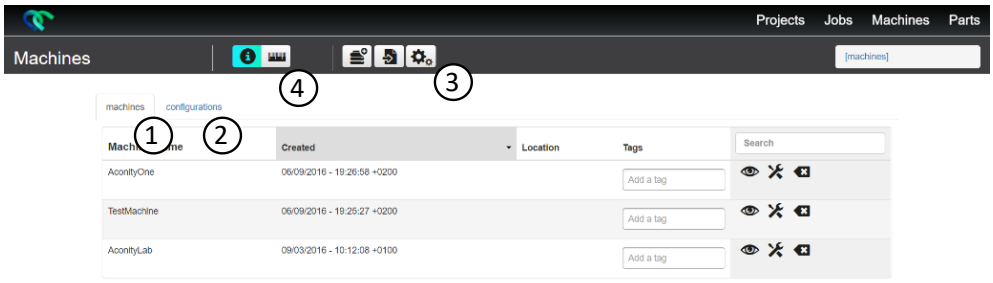
Manipulation of machine configuration therefore is to be strictly done in accordance with Aconitiy3D and not to be executed independently.

Important!

Please observe that any configuration modification is effective only after saving and restarting of the specific configuration (see section 7.7)

Figure 59 displays main section **‘Machines’**

Figure 59
Main section
‘Machines’



Selection of overview machines (see section Overview Machines7.5.1) and overview configurations (see section 7.5.3) is done via tabs **‘machines’** (1) and **‘configurations’** (2).

The section toolbar (3) consists of the following control elements:

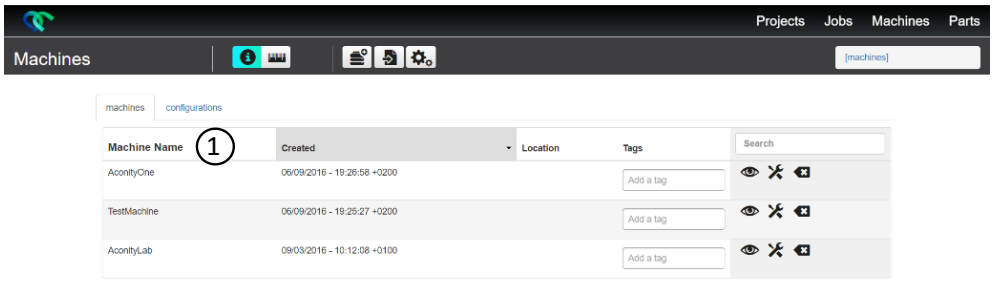
- Create machine (): Opens modal for new machine creation. This function can be used for creation of specific pre-defined groups of configurations.
- Import configuration (): Opens modal for configuration import. This requires machine selection and name assignment. Optional tags can be assigned for configuration. The configurations are imported in form of a password-locked text.
- Control Center (): Opens Control Center (see section 7.7)

Section navigation (4) facilitates alternating between overview **‘Machines’** (see section 7.5.1) and **‘Machine Tests’** (see section 7.5.5)

7.5.1 Overview Machines

Figure 60 displays overview **‘machines’**.

Figure 60
Overview
‘Machines’



Central element of main section **'machines'** overview is the tabular display of any machine a user has access to (1). Displayed are: **'Machine Name'**, '**Created'**, **'Location'** and **'Tags'**.

As with all tables, there are search functions and options for tag assignment displayed together with line toolbar for view (), opening of settings () and deletion () of the respective machines.

In case of deletion of a machine, the respective affiliated configurations (see section 7.5.3) are kept intact with the help of duplicating; these can be used for any other machine.

7.5.2 Single View Machines

Single View **'machines'** displays the configurations affiliated to a machine and basically corresponds in structure to the overview configurations, dealt with in section 7.5.3.

7.5.3 Overview Configurations

Figure 61 displays overview **'configurations'**.

In addition to name and creation date of the configuration, the affiliated machine and the respective configuration content are displayed.

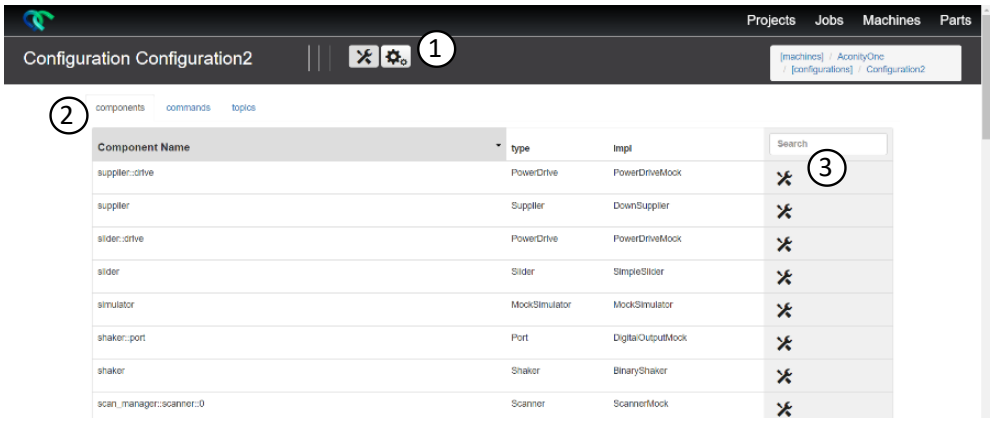
Figure 61
Overview
configurations

The line toolbar (2) facilitates opening () of single view configuration (see section 7.5.4) as well as deletion () of the specific configuration.

7.5.4 Single View Configuration

Figure 62 displays single view **'Configuration'**

Figure 62
Single view
‘Configuration’



The section toolbar (1) consists of the following control elements:

- Settings (🛠): Opens a modal for editing configuration characteristics. This equally puts the entire machine configuration at disposal in form of a locked text, to be either imported as new configuration or secured.

- Control Center (⚙): Opens Control Center (see section 7.7)

Machine **Configuration** consists of a graph, respectively network of basic components to be selected from with the help of tabs (2):

- ‘components’

- ‘commands’

- ‘topics’

Each basic component has a quantity of parameters and a status. Co-operation between machine elements is facilitated via referencing to other basic components. Name, type and implementation of all basic components are displayed in tabular form under the respective tabs (2).

A component represents implementation of a logical, respective hardware component. E.g. the component *platform* references at least one drive component. Figure 63 displays a modal for a single component. Hardware components have, to the largest extent, the same names and definitions as in the respective manufacturers manual. Details as for individual hardware components are to be taken from the respective manufacturers’ manuals.

A command defines the execution of an action with the help of an assigned component. E.g. the *expose* command activates laser and scanner to scan

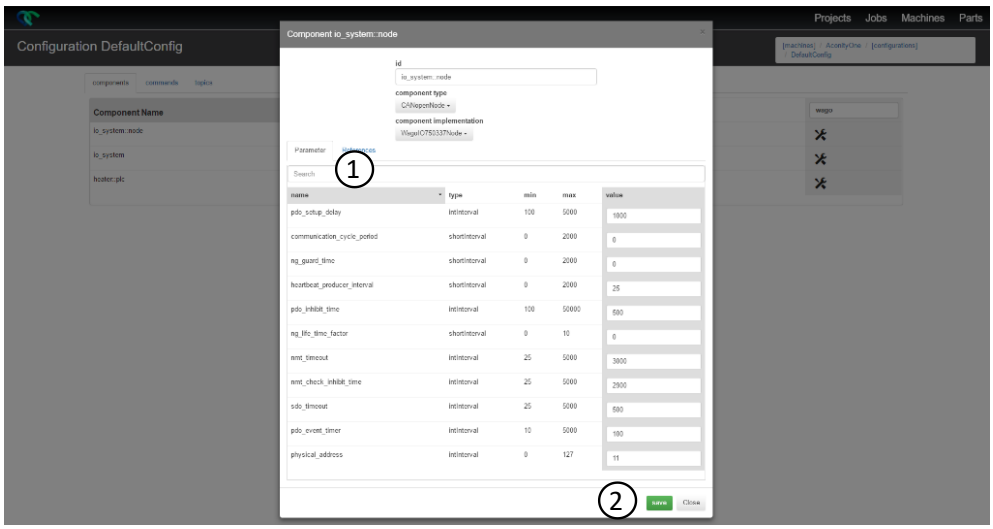
part data. Command parameters always overwrite default settings in the components.

Components do not only have parameters, but equally provide data. A sensor component provides e.g. the current value for the hardware sensor. These data can be read and forwarded with the help of topics. A topic can collect and simultaneously read selected data from random components. The data features are used for data, respectively status display, controlling and saving in the log file (C:\ac3d_studio\log).

For basic components manipulation, the respective toolbar permits opening of settings (🛠) in the specific line toolbar (3 in Figure 62).

Figure 63 Figure displays modal **‘Component’** settings.

Figure 63
Modal **‘Component’**



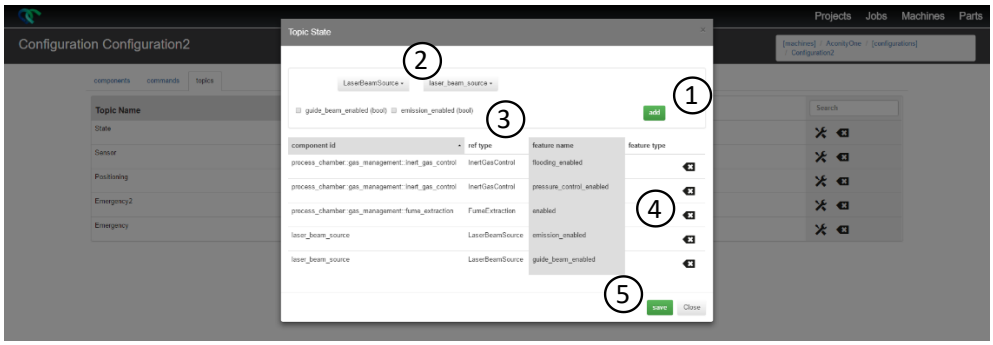
All adjustable parameters are listed within this modal (1). For all parameters name, type and current value are listed. With interval parameters, value minimum and maximum are equally displayed. One parameter exceeding the defined interval results in blocking start of configuration (see section 7.7).

Parameter configurations are to be secured (2). Modifications will only be applied after restart of configuration (see section 7.7).

The display **‘commands’** configuration is identical with **‘components’** configuration.

‘Topics’ configuration is the only one to deviate and is displayed in Figure 64.

Figure 64
Modal **'Topic'**

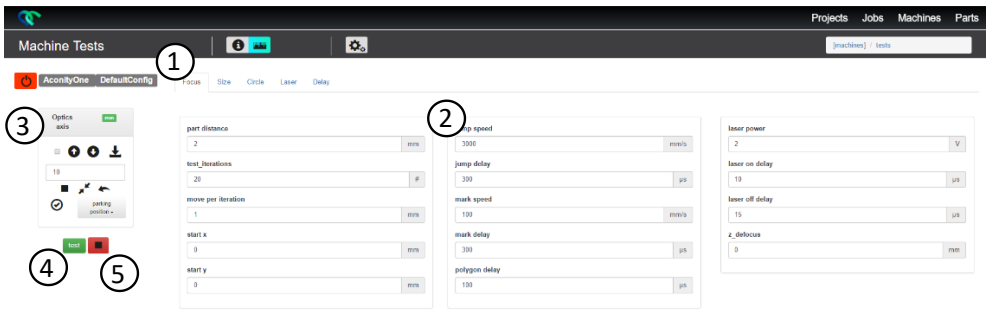


For new Topics (1) add-on, components (2) and data (3) required are to be selected. Deletion of one date (4) results in deletion of all component dates in question. Saved modifications (5) are only put into action after restart of configuration (see section 7.7).

7.5.5 Machine Tests

'Machine Tests' are designed for simplifying machine setup and for finding appropriate parameters. Focus tests, for instance, demonstrate the recurrent control elements (Figure 65). Basic control elements in all tests are repetitive.

Figure 65
'Machine Tests'
'Focus'



'Machine Test' provides selection between the specific tests via corresponding tabs (1):

- **'Focus'**: search focus level
- **'Size'**: Building part size setup
- **'Circle'**: Roundness securing
- **'Laser'**: Control for laser output power measurement
- **'Delay'**: Scan delay setting

For any test, specific parameters can be selected and modified (2). The focus test is for simplifying finding focus. To accomplish this, a quantity of 10 mm-length vectors is subject to exposure at a spacing to be specified. Between the vectors, the optical Z-axis travels a path to be specified. In this way, initial state position can be defined and exposure parameters specified.

In addition to the parameters to be selected, Control Center characteristics (see section 7.7), such as configuration start as well as optical axis movement can be operated (3).

With setting of all parameters, the test can be executed via pressing test button (4). In case of test interruption, the test can be stopped, if required (5).

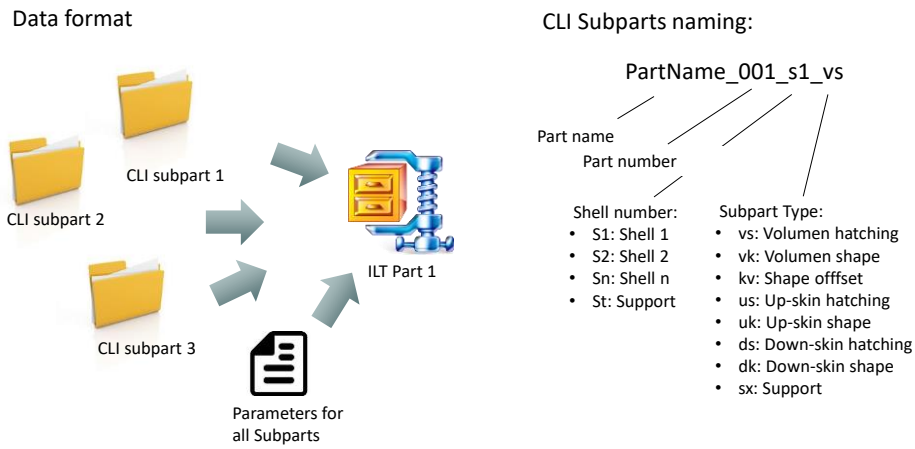
7.6 Parts

The main section **'Parts'** allows for administration and add-on of building part data.

7.6.1 Data Processing and Supported File Formats

Building part data in ILT or CLI (Common Layer Interface Version 2.0) format can be added-on or processed. An ILT file is a zipped, uncompressed file, comprising individual CLI files for contour, hatch etc. and one file containing parameter information. The file structure is displayed in Figure 66.

Figure 66
Data format & file naming

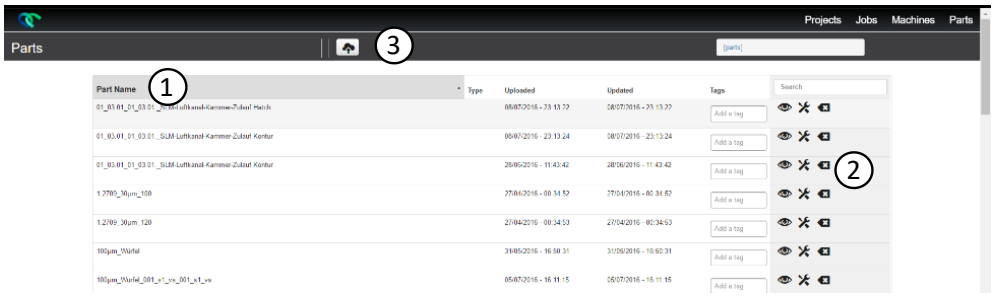


Parameter information of ILT files are not taken into account yet. Any parameters are required to be defined in Job Editor (see section 7.8.3).

7.6.2 Overview Parts

Figure 67 displays overview **‘Parts’**

Figure 67
Overview **‘Parts’**



The overview **‘Parts’** central element consists of tabular display of all build parts, the user has access to (1). It displays ‘Part Name’, ‘Type’, ‘Uploaded’, ‘Updated’ and ‘Tags’.

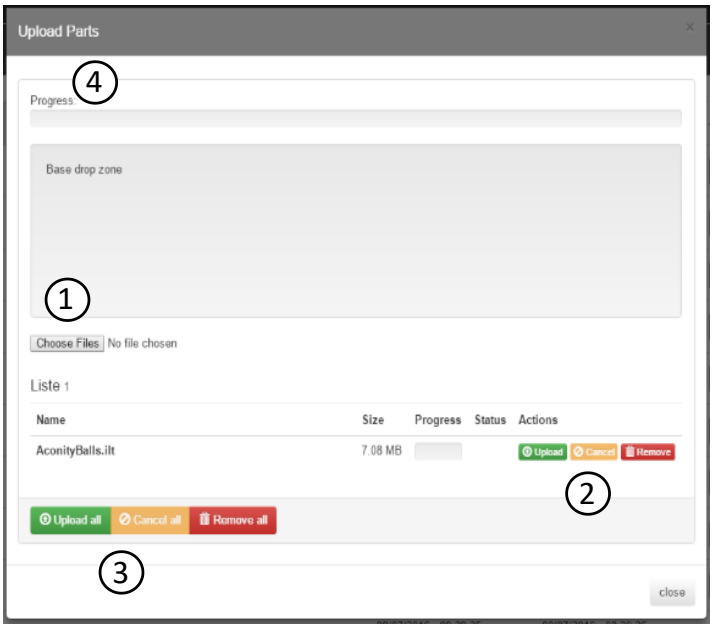
As with any tables, it displays search functions, tag options and line toolbar for view (), opening of settings () and deletion () of the respective build parts.

The section function bar (3) consists of only one control element:

- Add-on (): Opens the modal for add-on of new build parts

Figure 68 displays modal for build parts add-on.

Figure 68
Modal for build parts add-on



Build parts can be either added-on from local data system or via Drag & Drop (1). Build parts can be either added individually (2) or in total (3). Add-on may be interrupted any time. The progress bar (4) displays progress for all building parts selected. In case of non-valid file loading, an error message is displayed.

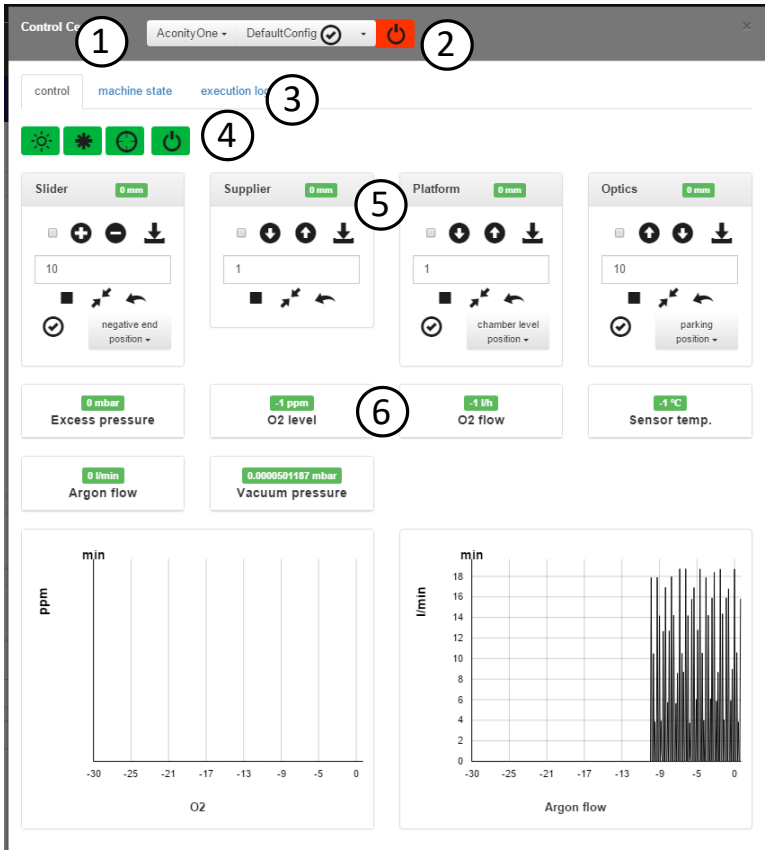
7.6.3 Single View Parts

Single view Parts displays the building part within the machine environment. Single view Parts is similar to the build part view in the Job Editor (see section 7.8), and thus is not dealt with here in detail.

7.7 Control Center

Control Center facilitates manual operation of system components and displays central sensor data and status information. The ‘Control Center’ is displayed in Figure 69.

Figure 69
Modal **'Control Center'**



Control Center makes the following basic functions available:

1. Machine and configuration selection
2. Start and stop of configuration selected
3. Subsection 'control', 'machine state' and 'execution log':
    - 'control' provides function bar, position control and display of central sensor data.
    - 'machine state' is characterized by status of all basic components. A red mark indicates component deficiency and a yellow mark indicates a warning.
    - 'execution log' displays all commands executed. A red mark indicates execution error and a yellow mark indicates a warning.

4. The toolbar provides access to the switches selected, such as Switch on/ Switch off lights, laser and guide beam.

5. When the configuration is started, all of the process chamber's axes (slider, supplier, platform) must be referenced first so they can move with relative as well as absolute values. Enter the referencing menu by clicking the gear symbol. To start referencing the axis click the compass symbol (see Figure 70). The axis will then start moving into its limit switch where it is getting referenced.

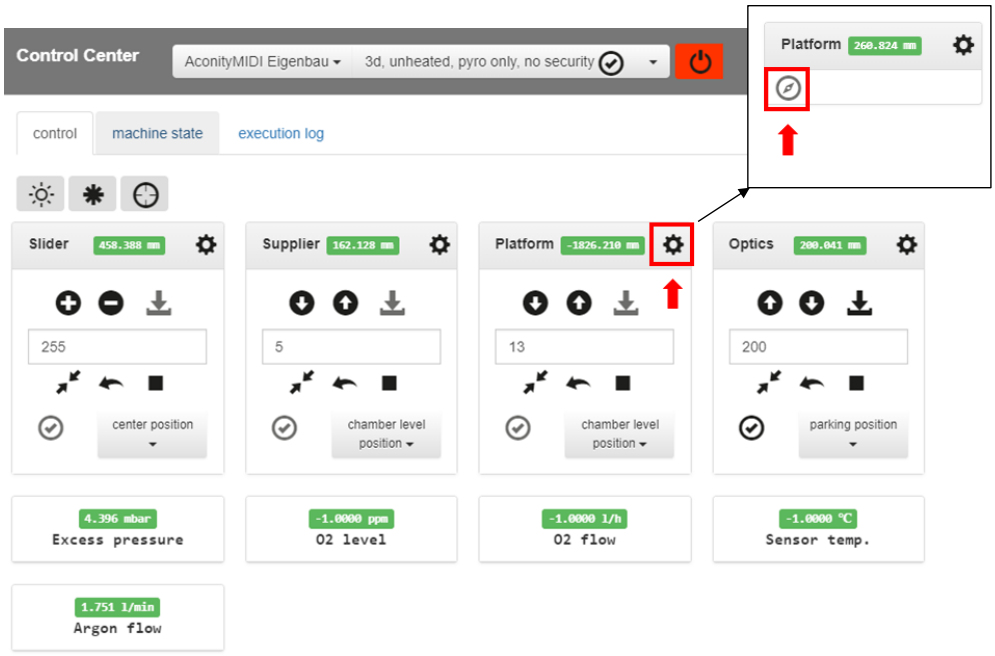
WARNING!

Danger of personal injuries caused by moving parts!

Rotating and/ or linearly moving parts may cause severe injuries.

- Strictly avoid getting within reach of moving parts or touching them during operation.
- Strictly do not open covers during operation.
- Please check for follow-up time and ensure complete stop of moving parts prior to removal of covers.
- Please wear only tight-fitting protective apparel with low resistance to tearing within hazardous areas.

Figure 70
Axis referencing via the control center



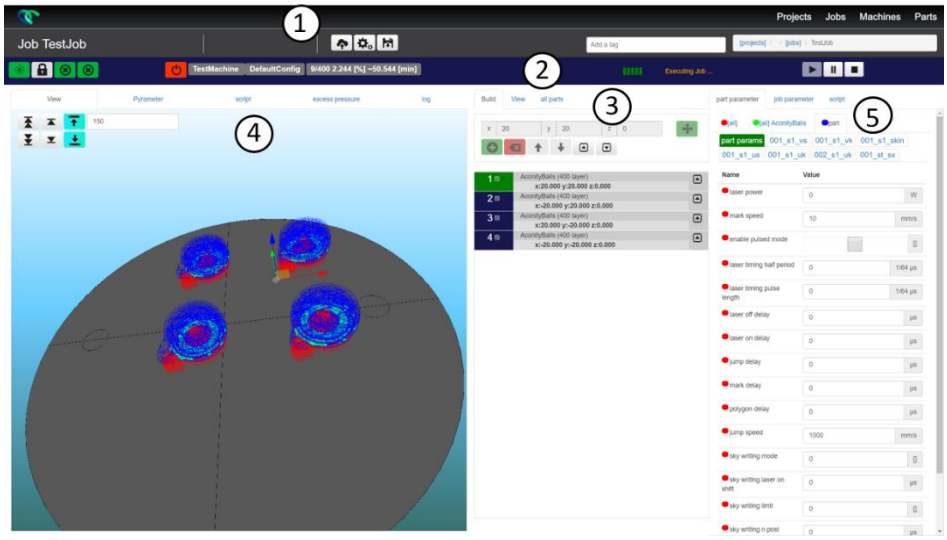
6. The controllable axis positions are displayed and are ready for travel, using relative or absolute values. The input field defines travel or absolute axis position. The buttons on top of the input field (⬇/⬆) provoke relative travel, the button (⤓) allows for axis travel into absolute position. The checkbox (☑) on top of the input field activates / deactivates type mode. Activation of type mode provokes continuous travel, when holding the travel button pressed. With button release, travel is stopped. The stop button (■) underneath the input field stops any axis travel. The switch button (↩) facilitates travelling from current to latest position. Travel to saved positions is equally made available (⇲).

7. Sensor data contain information on chamber pressure, protective gas flow, O2 sensor values. Further values are displayed in Job-Editor (see section 7.8.2).

7.8 Job Editor

Figure 71 displays Job Editor, single view of main section **'Jobs'** (see section 7.4) and the central window for building part setup and parameters.

Figure 71
Display of **'Job Editor'**



The section toolbar (1) contains the following control elements:

- Upload (): Opens modal for building part uploading (see Figure 68, section 7.6.2).
- Control Center (): Opens Control Center (see section 7.7)
- Save as (): Opens modal for saving the job under a different name, requiring selection of a project and a new name.

The primary toolbar (2) provides the following switches, according to machine configuration and machine type:

- Light (/): Switches Light on/off.
- Lock (/): Locks/ unlocks crane or process chamber (optional)
- Guide Beam (/): Activates/ deactivates guide beam
- Laser emission (/): Activates/ deactivates laser emission
- Mirror (): Adjusts mirror position (optional).

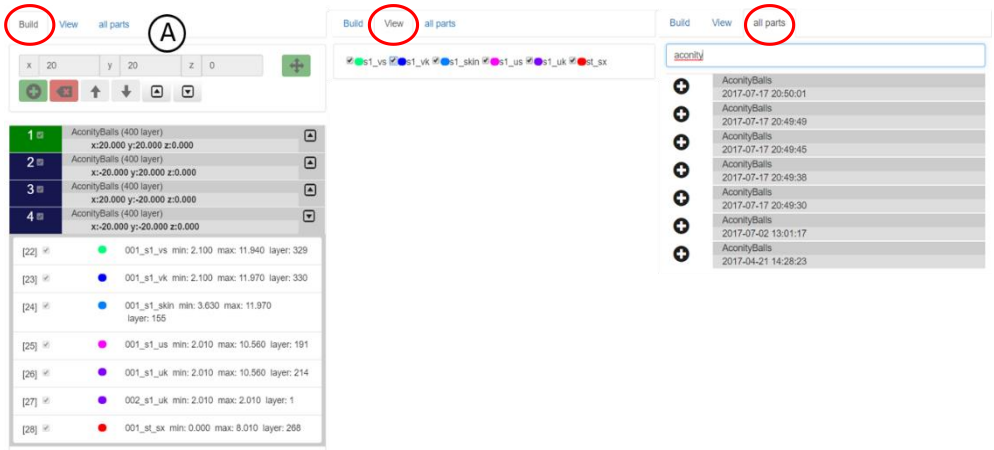
Furthermore, control elements for script execution are provided on the right side. Script can be started (▶), paused (⏸) or stopped (■). With restart of paused build job, modifications of parameters and exposure sequence become effective.

The bottom part of Job Editor displays building part section (3) (see section 7.8.1), view and control section (4) (see section 7.8.2) and parameter section (5), (see section 7.8.3).

7.8.1 Job Editor: Building Part Section

Figure 72 displays building part section (3) in Figure 71.

Figure 72
Building part section within Job Editor



The top part (A) provides selection from tabs for building parts view within the Job (Build), viewing options (View) and illustration of all parts (all parts).

- The tab **'Build'** displays the referenced building part data in tabular form, with each entry forming a group of building part data. Particularly, building part data taken from ILT files can comprise multiple subparts. Position and layer quantities are displayed. One click on building part group provokes activation, shaded green. Activated building parts can be shifted (), deleted () or duplicated (). Double click or use of the symbols (/) extends view. With duplication of building parts, all building part parameters are transferred. The sequence of subparts can be modified by Drag & Drop. With the help of check boxes (), sub-parts or complete building part groups can be selected or deselected. Once a subpart has been deselected, its data will not be used for next script execution. The sequence of building part groups can be adjusted by arrows (/).

- The tab **'View'** allows the selection/ deselection display of single subparts by using of the check boxes ().

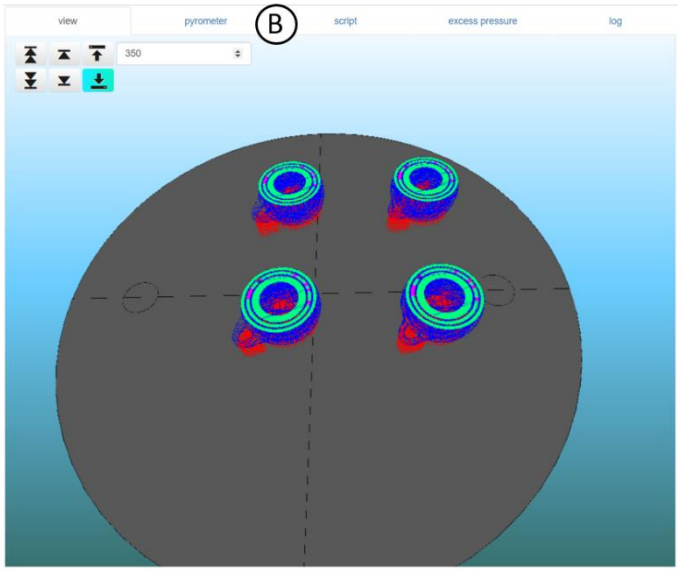
- The tab **'all parts'** displays all building parts the user has access to. Search grants easier access to building parts. The control element

“add-on” ( ) adds a new reference for the building part data to the job.

7.8.2 Job Editor: View and Control Section

Figure 73 displays the viewing section of the Job Editor (4 in Figure 71).

Figure 73
Job Editor View and Control Section

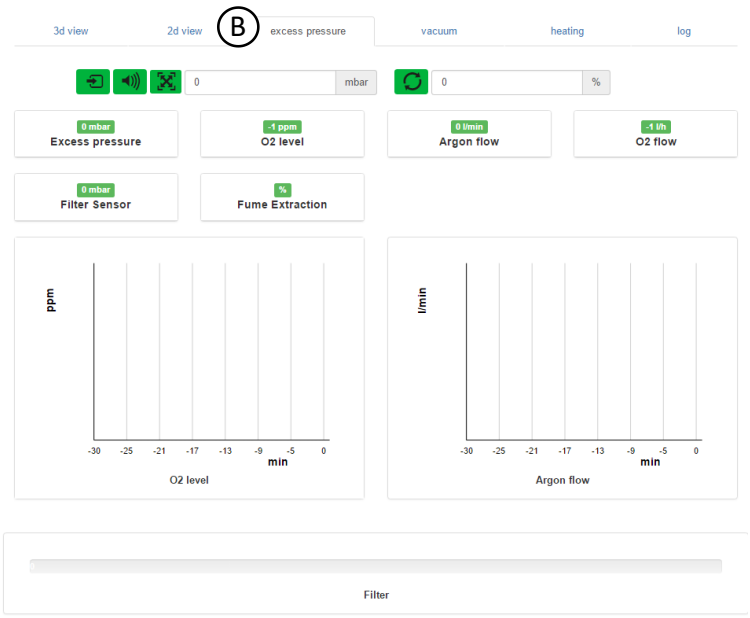


The top section (B) the tabs for 3D building part display, sensor data with excess pressure, optional display of sensor data with vacuum, optional heating use, optional pyrometry and log:

- **View:** Displays single layer of the selected part. Ansicht zeigt jeweils eine Schicht des Bauteils an. It can be iterated either quickly or slowly through all layers. The left mouse button allows you to rotate the view and the right mouse button to move the view. The control element (/) allow to display the contour of the layer that is set in the input field up to the first layer ( ) or up to the last layer ( ).

- **Excess Pressure:** With job execution to be done under protective gas atmosphere, the machine is operated under this tab. Figure 74 displays the adequate window.

Figure 74
excess pressure window in Job Editor

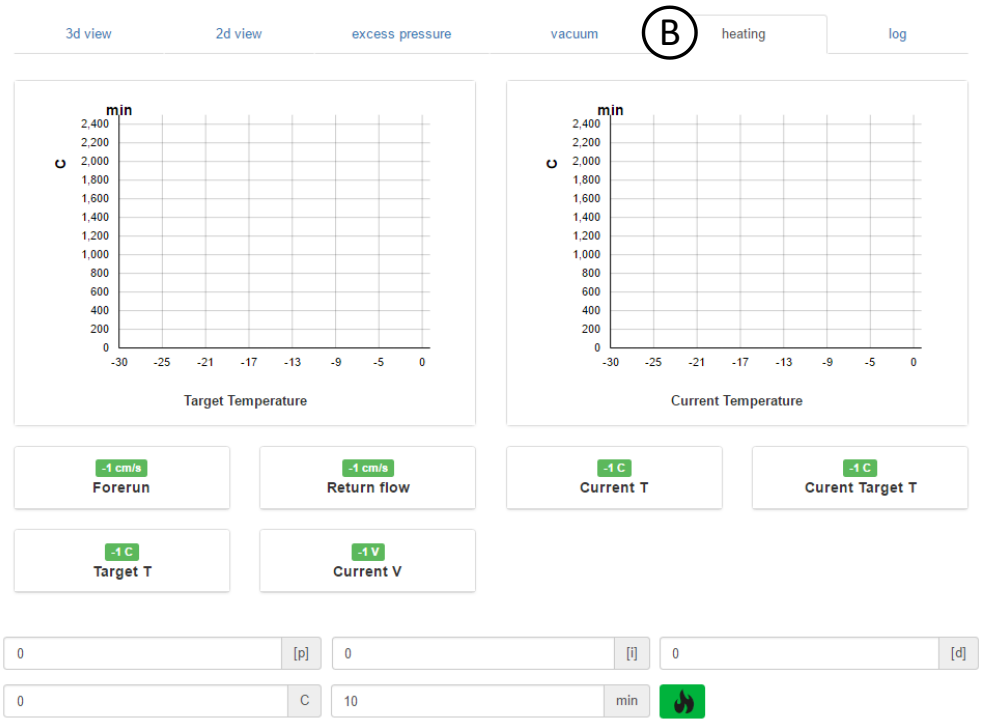


This window displays any sensor information required in form of value or diagram, such as oxygen level, atmospheric pressure and filter status. The function bar provides the following switch and control elements:

- Purging (/): Start/ stop of process chamber purging with the atmospheric pressure preset in the machine configuration (see section 7.5). To maximize the purge rate of inert gas, the additional automated outlet valve is opened.
- Outlet valve (/): Automatic outlet valve open/ close.
- Atmospheric pressure (): Atmospheric pressure set (in mbar). This function cancels purging and closes the automated outlet valve.
- Circulation (): Circulation pump performance set (in percentage) Please see section 7.7 for setting of minimum pump power.

- **Heating:** With a job to be executed with preheating (optional), the machine can be operated under this tab.

Figure 75
Heating window in Job Editor



This window displays any sensor information required in value or diagram form, such as actual and target temperature.

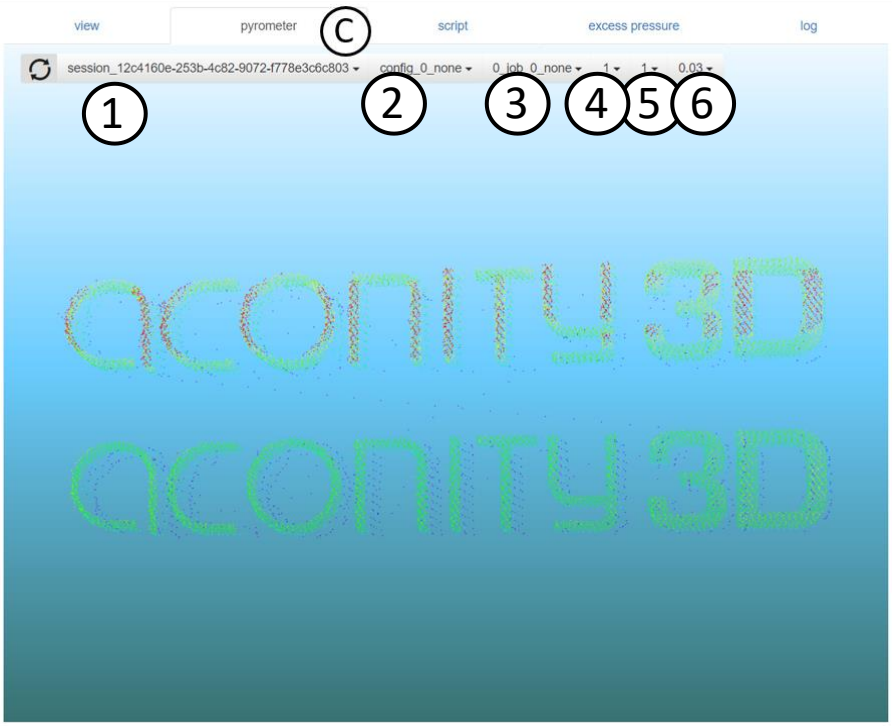
Control parameters seen as proportional [p], integral [i] and differential [d] for heating control can be set in the bottom section. Additionally, target temperature and heating ramp period in minutes are to be set. One click on heating button ( ) activates heating ramp.

The function bar provides the following further control elements:

- Water supply (/): Water supply start / stop
- Secondary cooling (/): Secondary cooling start / stop
- Power (/): Heating performance add-on / switch off

- **Pyrometer:** The tab **'pyrometer'** displays the data of the two optional Pyrometer.

Figure 76
Pyrometer window in Job Editor



The organization of the data is shown in the following:

1. **Session ID:** With every start of the Server, a new session is created.

2. **Configuration index + ID:** With every start of a configuration a consecutively numbered file with the respective Id is created.

3. **Job index + ID:** With every start of a script a consecutively numbered file with the respective Job Id is created.

4. **SensorID:** The default configuration of the pyrometry consists of two pyrometers. By choosing of one Sensor the receptive data is selected.

5. **SubpartID:** The data can either be logged for one layer (no SubpartId) or for the part.

6. **Z:** The data is for saved for every layer by using PCD-extension (Point Cloud Data).

The respective commands for recording pyrometer data are written directly into the script (see section 7.8.3):

- Recording start / stop of the layer:
  (start: $m.record_sensor($s[2Pyrometer]),
  stop:$m.stop_record_sensor($s[2Pyrometer]))

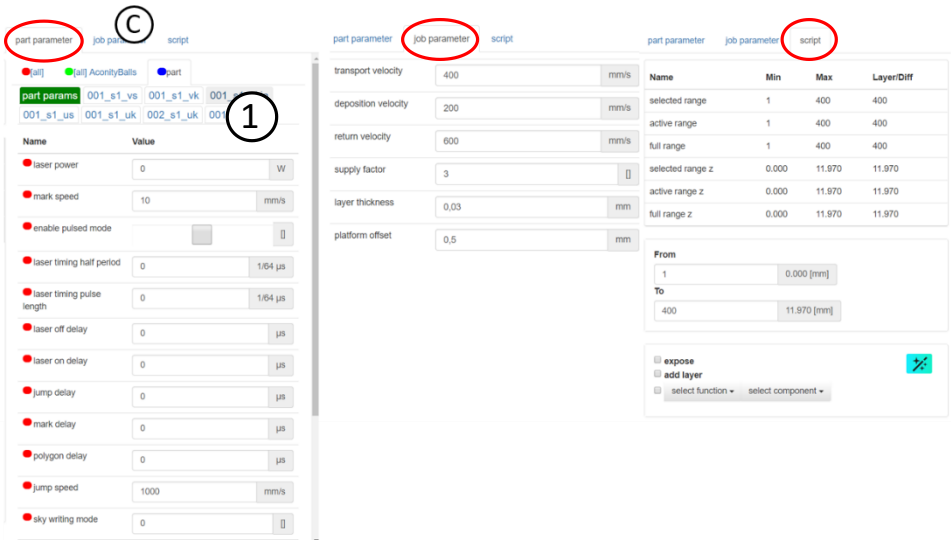
- Recording start / stop of the part:
  (**start:** $m.record_sensor($s[2Pyrometer],p),
  stop:$m.stop_record_sensor($s[2Pyrometer],p))

- **Log:** The tab log displays any layers applied and the time required for each application.

7.8.3 Job-Editor: Parameter Section & Script Section

The Parameter Section is on the right side of Job Editor, marked with (5) in Figure 71, and illustrated in Figure 77.

Figure 77
Parameter Section
in Job Editor



The upper part (C) is for selection between the tabs for configuration part parameter, job parameter and script:

- **Part parameter:** Sets specific parameters for subparts. The subparts are shown and can be changed by selecting the respective tab (1 in Figure 77). By acknowledging a value with the enter key this value will be accepted. Parameters for all Parts, can be set [all] for all parts from the same source [PartID] or for every single part and subpart [part].

- In the [all] tab generally predefined parameters from the started configuration can be selected (see section 7.7). Alternatively, parameters for all subparts can be defined here.

- In the source-specific tab [partID] parameters from the original source file can be imported from the original file if they are stored in the ILT format

- In the [part] tab, the parameters of all subparts are assigned manually.

The color marking of the parameters indicates the specific origin [all] / [partID] / [part].

- In the tab **'job parameter'** global parameters can be set. These parameters overwrite the default-values from the config. The job parameters apply for the entire job and consist of the following parameters:

  - Transport velocity: Defines the slider velocity during the powder transport to the building-platform.

  - Deposition velocity: Defines the slider velocity during the powder deposition on the building-platform.

  - Return velocity: Defines the slider velocity during the travel back to the powder supply.

  - Supply factor: Defines the amount of powder with respect to the selected layer thickness.

  - Layer thickness: Defines the layer thickness for the job.

  - Platform offset: Defines the stroke that travel platforms down during the slider travels back to the powder supply.

- **Script:** This tab allows the configuration of the job. Predefined script blocks are available for facilitating the creation of execution scripts. A common job is created by selecting the script blocks *expose* and *add-layer* through the respective check boxes (☑).

  The layer selection determines the amount of layers used. The respective layer always refers to all parts.

- **Range:** A range (From - To) the layers is used.

Adding of predefines components is possible by using the selection via drop down menu and marking of the respective Check Box (☑). By clicking on the magic wand (🪄) the script is added to 'Job Script'.

Each function of the component is added into the script at the position of the cursor.

8 Preparation for Operation

8.1 Starting the Research Equipment

Before using the research equipment, check the filters of the inert gas supply and change them if contaminated

Danger!

Danger of personal injury and damage!

When handling powders always observe the safety instructions for use of powder material and metallic condensates (see section 3.7)

WARNING!

Danger of personal injuries caused by moving parts!

Rotating and/ or linearly moving parts may cause severe injuries.

- Strictly avoid getting within reach of moving parts or touching them during operation.
- Strictly do not open covers during operation.

- Please check for follow-up time and ensure complete stop of moving parts prior to removal of covers.
- Please wear only tight-fitting protective apparel with low resistance to tearing within hazardous areas.

Below, the steps for starting the research equipment are described.

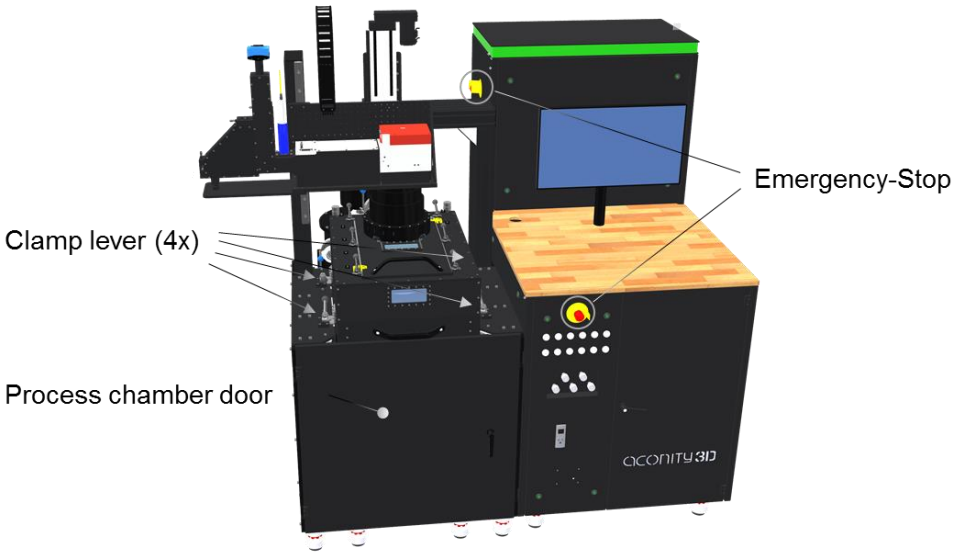
1. Push the process chamber into the research equipment's optical frame
2. Lock the process chamber in place using the four clamp levers (see Figure 78).
3. Activate the research equipment's main switch on the control cabinet (see section 6.1)
4. Wait until all electronical components of the machine have started, then press the "release of emergency-stop" button on the control unit (see section 6.1)

Important!

Make sure that all doors and interlocks are closed/locked before releasing the emergency-stop

5. Start the research equipment's control computer and screen, if they were not started automatically.
6. Lock the process chamber with the machine cover (see section 6.5)
7. Start the batch file "ac3d_studio.bat" on the control computer's desktop
8. Log into Aconity***Studio*** and start your machine's configuration in the control center
9. If necessary, manually activate the O2 sensor by pressing the "O2 sensor" button on the control panel (see section 6.1.2).

Figure 78
Schematic display of the research equipment



Important!

Make sure that all safety relevant components are initialized, configurated and started correctly.

8.2 Preparing the Laser System

DANGER!

Danger of personal injury and damage!

For preparation of the laser system observe the corresponding safety information for the use of laser radiation (see section 3.2).

1. Make sure that the key position of the laser source is set to „REM“ (see section 6.1.8).
2. The laser source is started by loading the appropriate machine configuration in the Aconity***Studio*** control software (see section 7.7).
3. Wait until the laser source is booted up completely.

4. If available, close the laser proof enclosure.

5. Afterwards press the “Laser ready” button on the control panel of the control cabinet (see section 6.1.2).

6. Make sure that the yellow status light extinguishes (see section 6.1).

7. Activate the laser source in the control software Aconity***STUDIO*** (see section 7.7).

8. The laser source clearance is indicated by the blue color on the signal lamp (see section 6.3). The laser system is now ready for operation.

8.2.1 Preparing the Optical Bench

1. Remove the protective cover of the scanner or lens.

2. Check the mirrors of the scanner with a flashlight. If necessary, carefully clean the mirrors with an optical towel and isopropanol. The mirrors are extremely sensitive, observe the maintenance instructions in the manufacturer’s manual.

3. Check the inlet window (see section 6.4.3) for contamination. If necessary, clean the glass with optical towels and isopropanol. If the inlet window shows deep scratches or weld penetrations it must be exchanged immediately.

4. Slowly open the compressed air flow for the scanner and control the air pressure at the manometer of the filtration unit for compressed air (see section 6.8.2).

5. Start the chiller (optional) and open the valves of the in- and outlet. First open the outlet, then the inlet. Check the water circuit for leakage.

6. Check the functional capability of the cooling circuit. Check if the components exhibit a decreased temperature compared to non-cooled metal parts.

8.2.2 Focus Search

The focal plane is determined with the aid of anodized aluminum plates. To do so, weld penetrations are scanned in different heights onto the aluminum plate by means of moving the vertical displacement of the optical bench (optional). Then the track width of the weld penetrations is measured and the finest track width is determined. If the minimal track with is not

located between two wider weld penetrations, the focus level is not yet reached. In this case, an extended area of movement for the vertical displacement of the optical bench needs to be selected. Consider that the width of the aluminum plate must be compensated in order to set the determined focal plane onto the build plane.

A predefined sequence program for the focus search via weld penetrations is deposited in the software Aconity***STUDIO*** (see section 7.5.5).

8.2.3 Power Measurement

The power measurement is performed with a power measurement instrument (optional). The measurement is done in 10% steps. Further power values can be determined by linear interpolation. Measurements should be conducted in regular intervals, documented and be present for inspection at the research equipment. A pre-defined machine test for execution of a power measurement of the laser output is given within the Aconity***STUDIO*** control software (see section 7.5.5)

Important!

Always measure a heavily defocused laser beam. The power measurement instrument is damaged when used within the focal plane with excessive intensities of the laser radiation. See the safety datasheet and manual of the manufacturer.

8.2.4 Aligning the Pyrometer (Optional)

The measurement results of the optional pyrometers are significantly connected to the alignment of the pyrometer detector heads and the process laser. For alignment, Aconity3D recommends a measurement device, which can be purchased additionally. The alignment can be done with a closed process chamber and installed laser proof enclosure. The schematics of the measurement device for pyrometer alignment is shown in Figure 79 and the real setup is given in Figure 80.

Figure 79
Schematic illustration of the setup for alignment of the pyrometer

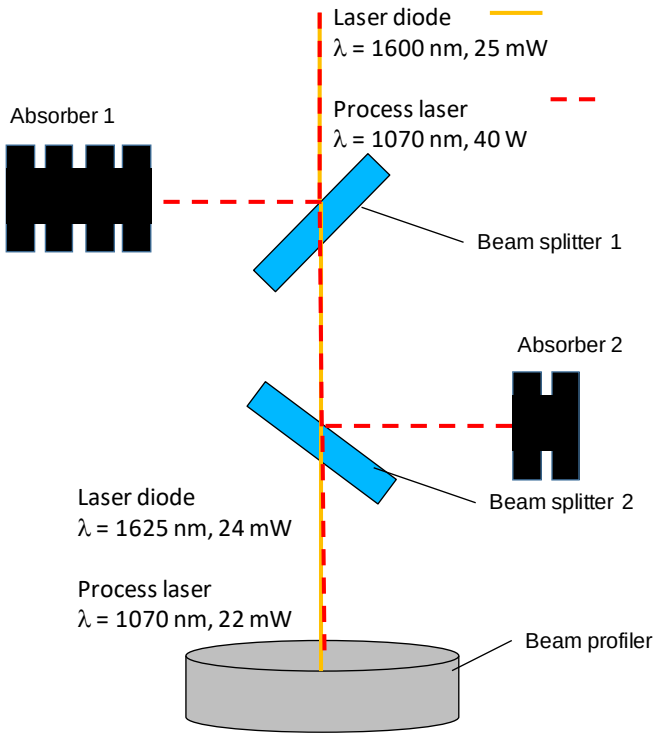


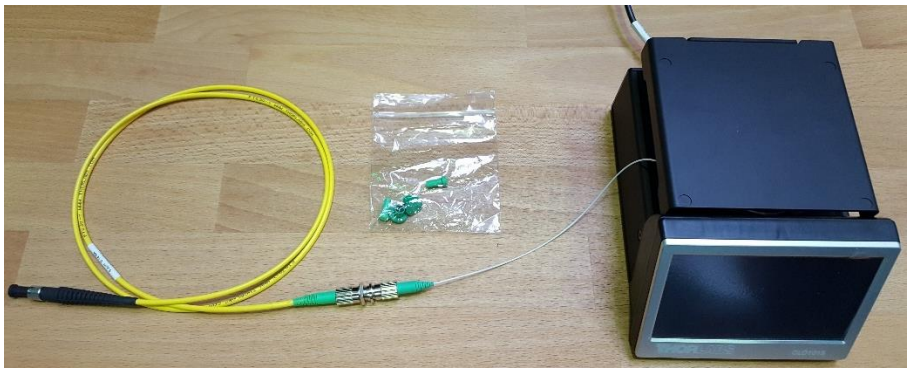
Figure 80
setup for alignment of the pyrometer

The measurement setup is based on a decrease of the process lasers from 40 W to ~ 22 mW via 2 beam splitters. In doing so the intensity is matched to the non-decreased referential laser beam of the laser diode and the destruction threshold of the beam profiler is not exceeded.

The measurement setup consists of the following components.

1. Laser diode in spectral range of the pyrometer of ~1600 nm (see Figure 81)
2. Slit-based caustic measurement device (beam profiler) and software for displaying laser radiation
3. Beam splitter for seperating process laser and the diode laser beam.
4. Absorber for absorbing excess laser power of the process laser source.

Figure 81
Laser diode, control unit and fiber adapter



Risk of burns!

The absorber for alignment of the pyrometry heat heavily up during operation.

- Risk of skin burns when in contact with hot components and build platform.
- Before all work, please make sure that all surfaces are cooled down to ambient temperatures.
- Only work with close build chamber.

To align the pyrometer, follow these steps:

1. Loosen the fiber ends of the pyrometer which is to be aligned from the fiber plugs (see section 6.4.3).
2. Connect the fiber end of the laser diode to the fiber plug of the respective pyrometer receiver (see section 6.4.3).

3. For alignment, place the measurement setup on the build platform (see Figure 82). Make sure that the power cable is routed through a free vacom connection on the chamber front and is opaquely sealed.

Figure 82
Placement of beam profiler within the process chamber

4. Next, install the beam separator and absorber as shown in Figure 83 and move the build platform down, so the absorber does not collide with the chamber cover.

Figure 83
Installation of beam splitter and absorber

5. In Aconity***STUDIO***, in the tab for laser power measurement, choose a x- and y-offset of 0 to ensure the process laser hits the sensor vertically (see section 7.5.5).

6. In Aconity***STUDIO***, activate the guide beam to align the process laser on the crosshairs of the first beam separator.

7. Take off the protective cap of the first beam separator

8. Close the machine cover
9. Close the laser proof enclosure
10. Activate the laser ready button
11. In Aconity***STUDIO***, set the laser power to 40 W in the laser power measurement tab (see section 7.5.5).
12. In Aconity***STUDIO***, set a sufficiently long measurement time in the laser power measurement tab (see section 7.5.5).
13. Start the software Thorlabs Beam and follow the instructions for recording a measurement
14. Search the focus of the process laser by vertical movement of the optical axis (see section 7.7)
15. Then deactivate the process laser again
16. Activate the laser diode (see Figure 84)

Figure 84
Clearance of the laser diode

17. Display the focus of the laser diode in Thorlabs Beam

18. Deactivate the laser diode

19. Open the laser proof cover of the pyrometry zo adjust the focusing lens. Make sure that the laser source is deactivated.

DANGER!

Danger caused by laser safety class 4 laser radiation!

Without the optional laser proof protection enclosure, according to DIN EN 60825, the LBM research system corresponds to a laser system of the laser safety class 4.

Irradiation of the eye or skin by direct or scattered laser radiation leads to serious injuries.

- The laser source must not be activated with deinstalled laser proof enclosure.

20. Move the respective focusing lens in the pyrometer's beam way (see section 6.4.3) to iteratively set the pyrometry's focus to the focal plane of the process laser. Make sure that the laser proof enclose is always installed when activating the laser source.

21. Set the desired lateral position of the pyrometry's measurement spot by adjusting the x-, y-table on the fiber plug (see section 6.4.3).

22. Loosen the laser diode's fiber ends from the fiber plug (see section 6.4.3).

23. Connect the pyrometer's fiber ends to the fiber plugs' (see section 6.4.3).

24. Repeat step 1-19 for the second measurement arm.

8.3 Preparing the Process Chamber

8.3.1 Installation of the Substrate Plate

For standard processes up to 500 °C, substrate plates with a diameter of Ø < 170 mm are used, which are mounted on the build platform by M4 screws.

For processes with optional inductive high-temperature-preheating, substrate plates with a diameter of Ø = 70 mm are used, which are placed on the heating element.

Important!

An uneven heat transfer from substrate plate to heating element can damage the heating element!

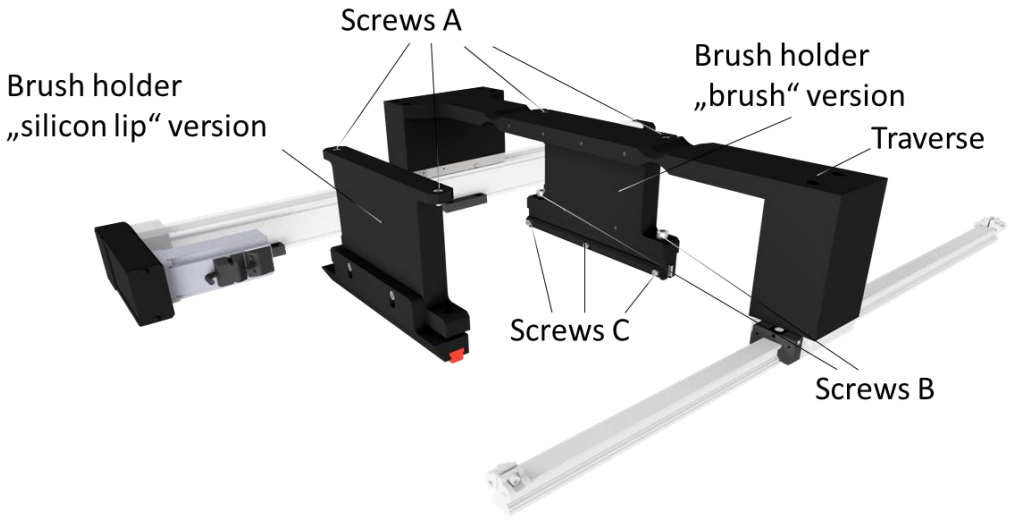
- Thoroughly clean the contact surface of substrate plate and heating element before placing the substrate plate!
- Check that there is no powder or other residue on the contact surface
- Do not let the substrate plate fall on the heating element

8.3.2 Installing the Powder Deposition Unit

Before every build job check the brush/deposition medium for damage and exchange it if needed. To install a new brush, follow these steps (See Figure 85):

1. Loosen screws “A” on the powder deposition unit.
2. Take out the brush holder and loosen screws “C”.
3. Insert a new brush and fixate it at the stopper with screws “C”.
4. Reinsert the brush holder and tighten the screws “A”

Figure 85
Display of the powder deposition unit



5. Move the build cylinder so that the substrate plate’s surface rests between 100 µm and 300 µm over the process chamber’s ground

6. Position the powder deposition unit in the center of the substrate plate. Make sure that brush holder and build platform do not collide.

7. Loosen screws “C” until the brush rests on the substrate plate. Tighten screws “C” evenly and make sure the brush stays in this position.

For diverging powder deposition medium (for example silicon lips), different adapters can be mounted with screws “B”

8.3.3 Filling the Research Equipment with Powder Material

Lower the powder reservoir’s platform and fill the cylinder with powder. Avoid raising the powder and keep an appropriate vacuum cleaner at hand to clean up any risen powder.

DANGER!

Danger of personal injury and damage!

When handling powders always observe the safety protocol for use of powder material and metallic condensates (see section 3.7)

8.3.4 Purging the Process Chamber

WICHTIG!

The gas flow is adjusted iteratively under consideration of sensor data of the gas flow, oxygen content and chamber pressure.

1. Close the process chamber (See section 6.4.3).
2. If not already done, activate the O2 sensor on the control panel (see section 6.1.2). A red blinking light at the O2 sensor under the control panel indicates that the sensor is heating up.
3. Fully open the outlet valve at the valve panel (see section 6.1.3).
4. Completely close the needle valve “O2 sensor” on the valve panel (see section 6.1.3).
5. Completely close the needle valve „inlet cylinder“ on the valve panel (see section 6.1.3).
6. Control the argon gas supply for the machine via a flow rate sensor (see section 6.1.7), or the Aconity***STUDIO*** control software (see section 7.8.2).
7. Activate the purge mode in the job-editor of the Aconity***STUDIO*** software by clicking on the corresponding button (⮕/⮕) (see section 7.8.2).

8. Open the needle valve ”Inlet cylinder“ (see section 6.1.3) slightly to refrain from whirling up powder at the build platform during the process.

9. Wait until the LED of the O2 sensor under the control panel shows a green light (see section 6.1.5).

10. Check the gas flow display of the O2 sensor in the Aconity***STUDIO*** control software (see section 7.8.2).

11. Regulate the gas flow with the needle valve “O2 sensor“ (see section 6.1.3) to a maximum of ca. 10 l/h.

12. When the O2 value falls below 1000 ppm, activate the circulation pump in the job editor of the software Aconity***STUDIO*** (see section 7.8.2).

13. Now set the desired chamber pressure in the software Aconity***STUDIO***. An operating pressure of 50 mbar is recommended. After setting the target pressure the purge mode is stopped automatically.

14. The process can be started now.

8.3.5 Starting the Preheating (Optional)

DANGER!

Danger of personal injury and damage!

When handling the optional heating unit observe the safety instructions for electrical (see section 3.4) and thermal danger (see section 3.8)

Important!

Before using the inductive heating, read and understand the operation manual of the generator

Further information can be found in section 6.7.3.

The heating is regulated via a PID element by a PLC which is activated in the software Aconity***STUDIO***. After loading the preconfigured machine configuration, a tab for controlling the preheating is accessible in the control center of the software, where more values for the PID element and the temperature value, also as time ramp function, can be entered.

Important!

The power release can only occur if the optional cooling circuit for the heating is activated in advance and all values for the regulation are set.

Important!

Only deactivate the induction generator power when the heating element has reached a temperature of < 80°C. Deactivation at higher temperatures can destroy the heating element.

Important!

Never deactivate the cooling of the heating components at temperatures > 80°C! Otherwise the cooling water around the heating element may start to boil, which leads to damages due to rising pressure.

Important!

Only use the heating element under an established protective gas atmosphere. High temperatures of the heating element in connection with oxygen can destroy the heating element

The heating is only regulated by operating personnel without any correction or safety measures by the control software. The operational safety is only ensured by the operating personnel.

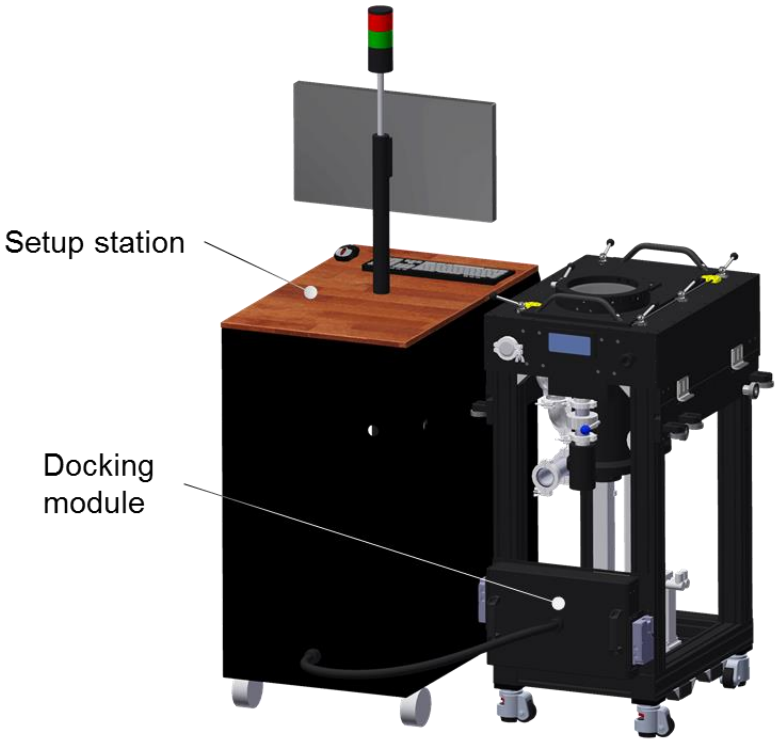
8.4 Preparing the setup station's process chamber (optional)

Please observe the safety instructions regarding the dangers caused by electricity and handling moving parts, powder materials and metallic condensate in section 3.

In the following, the steps for starting the setup station are described.

1. Make sure that the setup station's main switch is deactivated
2. Insert the setup station's docking module in the corresponding part on the process chamber's back (see Figure 86).
3. Activate the setup station's main switch.
4. Wait until all electronical components of the machine have started, then press the "release of emergency-stop" button on the control unit (see section 6.1)
5. Start the research equipment's control computer and screen, if they were not started automatically.
6. Lock the process chamber with the machine cover (see section 6.5)
7. Start the batch file "ac3d_studio.bat" on the control computer's desktop
8. Log into Aconity***Studio*** and start your machine's configuration in the control center
9. If necessary, manually activate the O2 sensor by pressing the "O2 sensor" button on the control panel (see section 6.1.2).

Figure 86
Schematic display of the setup station's docking module



9 Setup of the Research Equipment

9.1 Applying the first Layer

Before applying the first layer, check the carbon fiber brush for damages and make sure that it is installed correctly. (see section 6.7.3).

Important!

Due to thermal expansion of the build platform the clearance between platform and guiding cylinder is lowered.

With optional heating device, avoid powder in the gap before heating the build platform. This can lead to deadlock.

The substrate plate height for the first layer is adjusted by visual control of the applied powder layer on the substrate plate. To do so, first move the substrate plate ca. 1 mm under the working plane. Apply powder until the substrate plate is completely covered. Now move the substrate plate up in steps of < 0,2 mm. After each step, move the deposition unit over the substrate plate in direction of the powder overflow. Repeat this process until the substrate plate is visible under the powder layer.

Important!

Thermal expansion of the substrate plate can lead to a collision between substrate plate and powder deposition medium.

- Only align the substrate plate and deposition medium after reaching the final preheating temperature.
- Always begin the alignment process with a sufficiently thick layer (> 1 mm).
- Move the build platform upwards in small steps (0,1 mm) until you have reached the desired layer thickness for the start of the building process.

9.2 Monitoring the Process

Important!

During the first layers of building the process must be monitored carefully.

With parameter studies, it is recommended to monitor the first 30 layers.

Unstable processes must be monitored the whole time, because they can lead to damages of the research equipment.

9.3 Starting the Process

The following directions presume that the first powder layer is adjusted correctly, the process atmosphere is established and the laser system is ready for operation

1. Open or create a new job in the job editor (see section 7.8).
2. Configurate the process parameters for the first part.
3. Set the order of exposure for the parts.
4. Set the layer range which is to be exposed (see section 7.8.3).
5. Set the global parameters for the parts (see section 7.8.3).
6. Insert the scripting elements “expose” and “add layer” (see section 7.8.3).
7. If necessary, edit the script.
8. Click on the “play” button (see section 7.8).

Parameter changes during a running process are only adopted if the process is paused by the „pause“ button and then resumed.

10 Postprocessing

10.1 Part Removal

The part removal is carried out manually. The process chamber must be opened to remove the parts (see section 6.4.3). Before opening the process chamber make sure that the laser is deactivated and observe the following safety instructions:

DANGER!

Danger of personal injury and damage!

When handling powders always observe the safety protocol for use of powder material and metallic condensates (see section 3.7)

DANGER!

Danger of personal injury and damage!

When handling the heating unit observe the safety instructions for electrical (see section 3.4) and thermal danger (see section 3.8)

Important!

Remove the machine cover before moving the build platform. Components of sufficient height will otherwise collide with the inlet window when fully moved upwards!

Important!

Only move the build platform in small steps, otherwise the powder can get into the openings of the recirculation unit on the side of the build platform

Important!

Work in slow, calm movement, in order to keep whirled-up powder material to a minimum. Vacuum the whirled-up powder with an appropriate vacuum cleaner.

Before the substrate plate can be dismounted, excess powder must be moved from the building cylinder into the powder overflow. To do so, gradually move the build platform upwards and move the excess powder into the powder overflow using a brush or spatula. Empty the powder overflow container immediately and put the powder in the powder processing.

Carefully clean the components of remaining powder using and explosion-tight vacuum cleaner, then take out the substrate plate.

10.2 Cleaning of the Research Equipment

DANGER!

Risk of injury by contact with or by inhalation of hazardous dusts!!

When opening the process chamber hazardous dusts and reaction products can be discharged into the environment with high pressure.

- Please refer to safety data sheets of the powders used.
- Powder material must only be handled by trained personnel.
- Only use powder materials in well-ventilated rooms.
- Always wear personal protective equipment, such as powder-tight gloves, protective clothing, safety goggles and respiratory protection.
- Change and wash the safety clothing at regular intervals to prevent excessive dust contamination.
- Please ensure that all personal protective gear is removed after completion of the work in order to not carry dust that is within the textile fabric beyond the working area.

Always keep the whole working environment clean. When cleaning the research equipment work thoroughly and responsibly.

When cleaning the research equipment follow these steps:

1. Move excess powder out of the process chamber into the powder overflow. Make sure that the overflow container is not overfilled, otherwise the disc valve in front of the container does not close properly.
2. Close the disc valve and separate the overflow container at the vacom clamp under the disc valve. Empty the powder in an appropriate metal container
3. Disassemble the overflow container and clean it thoroughly.

4. Clean and check the sealing ring and replace it if necessary.

5. Loosen the carbon fiber brush from the powder deposition unit

6. Clean the brush and check for any damages. Safely store the brush and document the material used, so you may reuse the brush.

7. Move the build platform and the powder supply platform step-by-step upwards, until the felt seal is visible. Clean the felt seal (see section 11.5).

8. Clean the process chamber with an appropriate vacuum cleaner. Subsequently clean the surfaces with ethanol. Contaminated cleaning cloths must be disposed in designated, air-tight sealable, metal containers.

9. Clean the powder deposition unit and grease axle and sliding carriage if necessary (see section 6.7.4).

10. Move the build platform and the powder supply platform in the lowest possible position and clean the building cylinder

11. Thoroughly clean the rest of the process chamber with an appropriate vacuum cleaner and clean up the last residue with ethanol.

12. Mount all components again and check for correct functioning.

11 Maintenance

Observe the listed time intervals for the adjustment, maintenance and inspection works.

Input media like compressed air, protective gas and cooling water must be secured against accidental activation.

For all adjustments, maintenance and inspection works observe the following instructions:

- Make sure that the machine exhibits zero potential and secure the main switch against activation.
- Disconnect the machine from the power supply.
- Indicate maintenance work with a warning sign.

During assembly, secure heavy or large components with a crane or lifting gear.

After the maintenance work is completed, thoroughly check all safety relevant components for faultless function. Check all bolted connections, unfastened during maintenance for a tight and secure fit.

11.1 Disposing of Cleaning Material

Make sure that the used cleaning materials are properly handled and disposed of. This is especially important for:

- Use of lubricants
- Use of solvents
- Cleaning of powder residue
- Cleaning soot and process residue

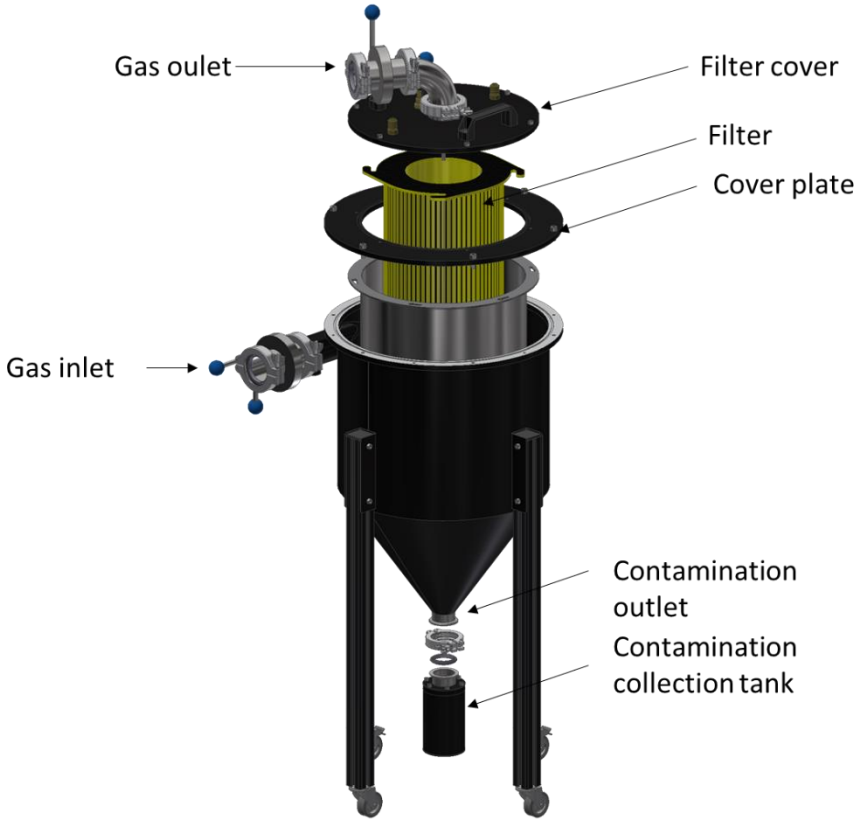
11.2 Changing Filters

Filters must be changed on a regular basis, at the latest after a runtime of 1000 hours maximum. When highly contaminated, the filter must be exchanged earlier.

The filter status is indicated within Aconity***STUDIO*** as a partial pressure “filter sensor” (see section 7.8.2). Depending on the processed material, different filter sensor values may imply a full filter.

A schematic of the cyclone filter unit is shown in Figure 87. To change the filtration unit in the cyclone filter, the filter case must be opened. Unfasten the screws on the filter cover and remove it carefully. Dispose of the filter in an appropriate, sealable metal container. The filter elements are fastened to the filter cover by means of a bayonet lock. Remove the filter element from the filter cover by turning it towards the unlock position of the bayonet lock.

Figure 87
Schematics of the cyclone filtration unit



For a complete cleaning of the cyclone unit, remove the cyclone cover plate for better accessibility. Also clean the components of the quick fasteners and disc valves.

DANGER!

Danger of personal injury and damage!

When handling powders always observe the safety protocol for use of powder material and metallic condensates (see section 3.7)

11.3 Cleaning the Process Chamber

The process chamber must be cleaned of soot and process residue after every finished process.

DANGER!

Danger of personal injury and damage!

When handling powders always observe the safety protocol for use of powder material and metallic condensates (see section 3.7)

11.4 Powered Axes

The spindle of the powered axes and the guide sled of the powder deposition unit should be greased every month. If heavily used, please grease weekly. Observe the maintenance notes in the manufacturer's manual. If necessary, components must be cleaned before greasing.

11.5 Sealing Rings

The felt seals of the platform and powder reservoir should be changed after every 10 build jobs. Follow this procedure:

1. Move up the platform until the felt seals are visible,
2. Loosen the clamp rings nine M5 countersunk screws.
3. Take out the old felt seal
4. Trim the new felt seal accordingly. For an optimal seal, make sure that the ends of the felt seal are cut at a 45° angle.
5. Insert the new felt seals into the groove of the platform. The felt strips have a measurement of ca. 5 x 6 mm. The wider side must be placed vertically into the groove, the more narrow one horizontally. While the clamp ring is loosened, the felt seals should overlap less than 0,5 mm in the outside
6. Lower the build platform back into the cylinder in steps of < 1mm until the felt seals are not visible any more. When lowering the platform, make sure that the felt seals rest against the cylinder and are not damaged.
7. Tighten the clamp rings nine M5 countersunk screws in two steps in a cross-wise pattern. In doing so the felt seal is compressed and pressed outward against the wall of the build cylinder.

DANGER!

Danger of personal injury and damage!

When handling the axes observe the safety notes for mechanical dangers (see section 3.5)

Important!

Before every process the gap between build platform and cylinder must be cleaned thoroughly.

Due to thermal expansion of the build platform during the process, the clearance to the guiding cylinder is lowered. Powder located in the gap before heating can lead to deadlock of the build platform

11.6 Laser and Optical Bench

The Laser power must be checked by regular power measurements. If the laser power is verifiably lowered, the optical components (mirrors, lenses) must immediately be checked for contamination. Should a lower laser power be measured although the optical components were cleaned, contact the manufacturer's service. Maintenance and service intervals can be found in the laser manufacturer's manual.

11.7 Build Platform Cylinder

Clean the build platform cylinder in regular intervals and after every powder change of process and powder residue. To do so, disassemble the platform from the axis (see section 6.7.1) and extract powder material from within the cylinder.

DANGER!

Danger of personal injury and damage!

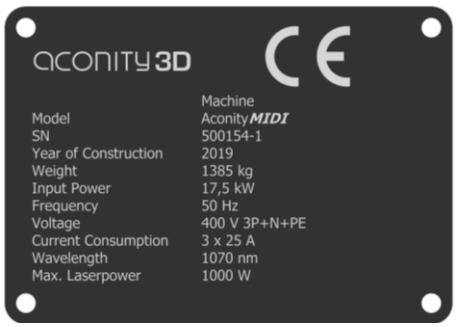
When handling powders always observe the safety protocol for use of powder material and metallic condensates (see section 3.7)

12 Product Specifications

12.1 CE Declaration of Conformity

The CE conformity marking is located on the type plate of the research equipment (see Figure 88).

Figure 88
Display of the research equipment`s type plate



The following information may be extracted here:

- Model
- Serial Number (SN)
- Year of Construction
- Weight
- Input Power of the machine and induction generator (optional)
- Frequency of the machine and induction generator (optional)
- Voltage of the machine and induction generator (optional)
- Current Consumption of the machine and induction generator (optional)
- Wavelength
- Maximum Laser Power

13 Warranty and Liability

The terms and conditions of the factory contract apply. Warranty and liability claims are excluded if caused by the following:

- Improper use of the machine.
- Faulty installation, maintenance, overhaul or use of the machine.
- Use of the research equipment with defective or limited function of safety relevant machine components.
- Disregard of instructions in the owner's manual.
- Disregard of the accident prevention regulations for handling laser radiation (VBG 93)
- Disregard of the safety information and regulations described in section 2 and 3.
- Unauthorized modifications of the machine.
- Disregard of the specified limits of the machine parameters.
- Deficient maintenance of parts subject to regular wear.
- Improper repair, maintenance and servicing.
- Damages caused by external influences and force majeure.

13.1 Constructive Changes of the Machine

Changes or modifications of the machine are strictly prohibited without explicit approval by the Aconity3D GmbH. This includes welding work on load-bearing machine components.

All Changes and modifications must be approved in writing by Aconity3D GmbH.

Immediately exchange worn, defective or functionally limited machine components.

Only use original spare parts.

14 Checklist

This checklist is meant to support a smooth installation of the LBM equipment at the customer's facility. A detailed description of all technical specifications is given in section 5 of this document.

14.1 Unloading, transport and storage

Forklift available and ready for use (Length of the lifting fork min. 1.20)	☐
Lift truck available and ready for use (Length of the lifting fork min. 1.20)	☐
Transport routes are free	☐
Transport routes are sufficiently dimensioned (see section 5.1)	☐
Transport routes are barrier free	☐
Floor weight carrying capacity sufficient for scope of delivery and means of transport	☐
Passages are sufficiently dimensioned	☐
Storage location (where applicable) corresponds to specified requirements	☐

14.2 Installation site

Floor weight carrying capacity sufficient for scope of delivery and means of transport	☐
Floor characteristics meet requirements	☐
Installation site is adequately dimensioned according to the installation plans	☐
Minimum distances between the components, the environment and accessories are taken into account	☐

Space requirements for additional storage areas are taken into account	☐
Space requirements for additional optional components for retrofitting are taken into account	☐
Access to all escape routes is ensured	☐

14.3 Site ambient requirements

Temperature range is maintained	☐
Humidity is maintained	☐
EMC requirements are maintained	☐
Local temperature gradients are maintained	☐
Other in section 5 specified site ambient requirements for machine and accessories are maintained	☐

14.4 Power supply

400 V three-phase system is present (EUROPE)	☐
208 V three-phase system (WYE) is present (USA)	☐
Mains connection machine according to section 5 is available	☐
Mains connection chiller according to section 5 is available	☐
Mains connection induction heating according to section 5 is available	☐
Mains connection wet scrubber according to section 5 is available	☐

14.5 Inert gas supply

Inert gas supply present	☐
Inert gas supply corresponds to specifications according to section 5	☐

Connection between inert gas supply and machine is in place	☐
Connection point corresponds to specifications according to section 5	☐
Deviation of inert gas temperature and ambient temperature is taken into account	☐
Sufficient amount of inert gas for acceptance testing of 8 h is available (ca. 10 m³)	☐

14.6 Pressurized air supply

Pressurized air supply present	☐
Pressurized air supply corresponds to specifications according to section 5	☐
Connection between pressurized air supply and machine is in place	☐
Connection point corresponds to specifications according to section 5	☐
Sufficient amount of inert gas for acceptance testing of 8 h is available (ca. 30 m³)	☐

14.7 Cooling water supply

Cooling water supply present	☐
Cooling water supply corresponds to specifications according to section 5	☐
Cooling water supply of accessories corresponds to specifications according to section 5	☐
Connection between cooling water supply and machine is in place	☐
Connection point corresponds to specifications according to section 5	☐

14.8 Emissions

Exhaust line in place (see section 5.1.9) ☐

- Option 1: Into the open ☐
- Option 2: Connection to the domestic exhaust air system and discharge of the exhaust gas ☐

14.9 Peripheral

Industrial explosion-tight vacuum present ☐

Wet scrubber present ☐

Computer with data preparation software for *.CLI / *.ILT is present ☐

Tools (see section 5.1.8) present ☐

14.10 Safety regulations

Suitable fire extinguishers available in sufficient number ☐

Fire extinguishers for metal fires (fire class D according to EN 3) are available ☐

Machine environment free from easily combustible materials ☐

Stationary oxygen meter with alarm function for gas monitoring is installed ☐

14.11 Personal protective equipment

Protective clothing made of flame retardant material is present ☐

Anti-static safety shoes according to EN 61340-4-3 available ☐

15 Customer Confirmation

By filling in and signed customer confirmation, we certify that all important precautions have been taken before installation.

The customer confirmation can be found on the following page. Please sign it and return it to Aconity3D GmbH at the address indicated.

Please send the completed customer confirmation to the following address:

Aconity3D GmbH
Kaiserstr. 98, 52134 Herzogenrath
Germany

Tel.: +49 2407 55292 00
Fax.: + 49 2407 55292 99

Company:	Aconity3D GmbH	Customer address:
Address:	Kaiserstr. 98	
	52134 Herzogenrath	Delivery address:
		Invoice address:
		Order number:
Your sign		Date:

Customer Confirmation

Dear Sir or Madam,

We hereby confirm the following points:

- The installation guidelines of the system have been read and understood
- For the delivery and commissioning of the system all applicable points listed in section 14 of the installation conditions are fulfilled
- We inform Aconity3D GmbH 14 days before the planned delivery about non-compliance of points specified in section 14 of the installation guidelines

In case delivery or commissioning of the system cannot be performed due to customer induced failure to comply with the installation guidelines, Aconity3D GmbH will abort all work and bill any costs incurred.

Cordially,

Name	Place	Date	Company stamp / Signature

16 Appendix

16.1 Consumables

16.1.1 Powder Deposition

The amount of spare parts needed for powder deposition depends on the applied material and on the quality of applied process parameters. A brush is more forgiving for warpage during build up but least resistant. Contrarily, a metal blade is highly resistant but least forgiving in terms of process interruptions due to warpage. Lifetime of a brush may vary between 1 day and 1 year. It is suggested to have one brush for each material.

Art.- no.	Component	Price
1001003607	**Spare Brush**	**78.- €**
	Anti-static brush • Lengths: 190 mm • Height: 10 mm • Fiber lengths: 1.7 mm	
1001003745	**Rubber Lip**	**22.- €**
	Flexible rubber • Lengths: 5 x 190 mm • Free height: 3,5 mm	
1001004732	**Metal Blade**	**140.- €**
	Metal Blade Stainless Steel • Lengths: 190 mm • Height: 11,5 mm	

16.1.2 Optical Components

If maintained properly, inlet glasses should not be subject to wear. However, in combination with the temp. preheating extensive thermal load is applied to the glasses which may cause failure in case of absent air cooling.

For laser powers of larger than 400 W use of glasses from fused silica is recommended in order to minimize thermal shifts caused by thermal gradients induced by laser radiation. The optics cleaning set should last for 6 – 12 months depending on the amount of dust accumulation at the installation site.

Art.- no.	Component	Price
1001001983	**Inlet Glass 1070 nm**	**285.- €**
	Borofloat glass • Diameter: 240 mm • Thickness: 4 mm • Anti-Reflective Coating: 1070 nm	
1001003226	**Fused Silica Inlet Glass 1070 nm**	**570.- €**
	Fused silica glass • Diameter: 240 mm • Thickness: 4,0 mm • Anti-Reflective Coating: 1070 nm	
1001005639	**Optics Cleaning Set**	**68.- €**
	Complete optics cleaning set • Brush & bellows • Textile cloth and paper towels • Cotton buds • Cleaning substance	

16.1.3 Filter Unit

Depending on the amount of material changes and weld smoke emission of the processed material filter changes are required. Typical intervals of filter change are 1 – 6 months. It is recommended to have one filter and tubing for each material to prevent contamination of the processed material.

Art.- no.	Component	Price
1001001859	**Filter Element**	**187.- €**
	Filter element • Filter class M (DIN EN 60335-2-69) • Filter area 1.5 m²	

1001003609	**Flexible Tubing**	**354.- €**
	Flexible suction/pressure PVC tube inclusive DN40 flange • 2 x 1500 mm	

16.1.4 Inductive High-Temp. Preheating

The amount of consumables for the high-temp. preheating also depends heavily on the amount of material changes and the frequency of disassembling. Due to its porous nature it is recommended to have one set of high temp. insulation for each assembly of the inductive preheating. The mid temp insulation should be replaced every 6 – 12 months, depending on usage.

For each experiment, the substrate plate requires fixation to the heated mounting plate by means of high temp. resistant glue. One container lasts for 6 – 12 months, depending on usage.

The heated mounting plate is subject to wear as traces of oxygen may persist inside the process chamber. Thus, it is required to exchange this every 12 months. Also, if the substrate plate is overheated and melts, a new heated mounting plate is required. It is therefore recommended to have 1 heated mounting plate in stock.

Art.- no.	Component	Price
1001003750	**High Temp Insulation Set (5x)**	**285,-€**
	Porous Al_2O_3 T_{max}: 1400 °C • Surrounding insulation • Sealing insulation	
1001005646	**High Temp Sealing Paper (10x)**	**110,-€**
	Sealing for induction coil • High Temp Sealing T_{max}: 1260 °C	
1001003749	**Fixation of Substrate Plate for High-Temp. Preheating**	**120,-€**
	High-temp. resistant glue 200 ml	
1001001463	**Heated Mounting Plate**	**910,-€**
	Molybdenum heating plate	

16.1.5 Substrate plates

For processing of different materials by means of LBM it is recommended to use similar materials for the substrate plates.

Aconity*LAB/MIDI* Standard		
1001001313	**Stainless steel (1.4404)**	**140,-€**
	• Diameter: Ø = 170 mm	
1001002704	**Aluminum (AlSi10Mg)**	**120,-€**
	• Diameter: Ø = 170 mm	
1001005647	**Titanium (Ti64)**	**320,-€**
	• Diameter: Ø = 170 mm	
1001005647	**Inconel (IN738)**	**340,-€**
	• Diameter: Ø = 170 mm	

Aconity*LAB/MIDI* High-Temp. Inductive Preheating		
1001003016	**Stainless steel (1.4404)**	**40,-€**
	• Diameter: Ø = 70 mm	
1001005656	**Inconel (IN738)**	**140,-€**
	• Diameter: Ø = 70 mm	

All prices are net prices and subject to applicable taxes.

16.2 Caustic measurement

Measurement protocols of the caustic measurements are delivered to the user in written form.

16.3 Blueprints

Blueprints are delivered to the user in written form.