CARBOLITE® GERO 30-3000°C

LEADING HEAT TECHNOLOGY

ENABLING THE WORLD OF HEAT TREATMENT

part of VERDER scientific

VERDER scientific

ENABLING PROGRESS.

HEAT TREATMENT
ELEMENTAL ANALYSIS
MATERIALOGRAPHY & HARDNESS TESTING
MILLING & SIEVING
PARTICLE CHARACTERIZATION
PHARMACEUTICAL TESTING

Under the roof of VERDER SCIENTIFIC we support thousands of customers worldwide in realizing the ambition we share. As their technology partner behind the scenes, we deliver the solutions they need to make progress and to improve the everyday lives of countless people. Together, we make the world a healthier, safer and more sustainable place.

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BUSINESS AREAS


Additive Manufacturing


Aerospace


Annealing

Applications


Automotive


Carbonization

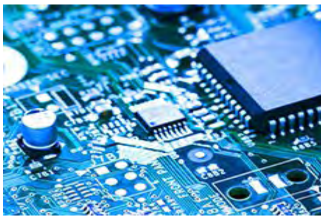

Ceramics / Glass

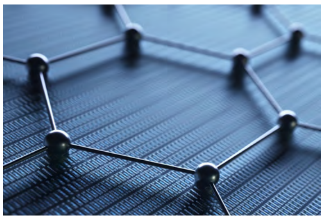

Chemistry / Plastics

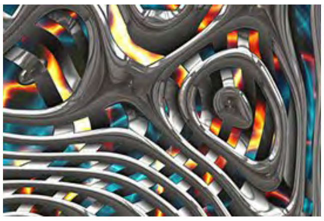

Crystal Growth


Debinding

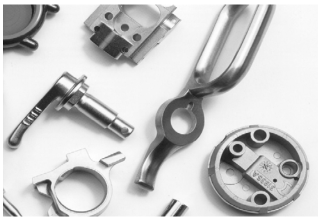

Drying


Electronics


Graphitization

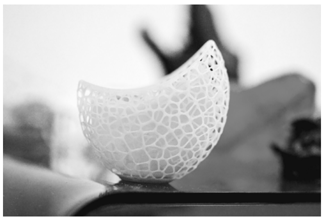

Material Research


Medical Devices / Pharmaceuticals


Metal Injection Moulding


Pyrolysis


Research / University


Sintering


Steel / Metallurgy


Technical Ceramics


Vacuum Soldering & Brazing

Industries

DIRECT AND INDIRECT AM METHODS

Additive methods can be divided into two categories. Direct methods, such as SLM and EBM, are very well known and have reached a broad market acceptance in the industrial environment.

However, indirect methods have become more important in recent years. With these methods a green part is produced in the first process step, which is debinded and sintered in the second step.

AM OF METALS

DIRECT METHODS

SELECTIVE LASER MELTING
SLM / L-PBF

SELECTIVE ELECTRON BEAM
EBM

INDIRECT METHODS

BINDER JETTING
BJ

FUSED FILAMENT FABRICATION/ METAL EXTRUSION
M-FDM

COLD METAL FUSION
CMF

	Direct AM Methods	Indirect AM Methods
Method	L-PBF, EBM One-step process Direct production of components through welding processes	BJ, CMF, M-FDM Two-step process First step: Production of green parts Second step: Debinding and sintering of the green parts
Advantages	• Material can be applied to existing structures • High degree of development • High reproducibility	• Wide variety of materials possible, materials can be processed that are also not weldable • Component properties comparable to MIM components • Highest ratio of the volume of all printed parts to printer volume (even stacking is possible)
Disadvantages	• Rough surfaces • High thermal stresses are introduced into the components as a result of the process • Support structures are required for complex geometries • Surface porosity • Reworking of components required, removal of support structures always necessary • High heat input • Powder handling	• Sintering distortion of the components possible • More complex process chain compared to direct AM methods

Model	Dimensions Internal retort H x W x D [mm]		Atmosphere**
Stress relieving up to 1150 °C under inert gas (Direct AM)			
GPCMA/37	205 x 337 x 538		Nitrogen, Argon, Forming Gas
GPCMA/56	229 x 400 x 610		
GPCMA/117	279 x 500 x 840		
GPCMA/174	428 x 500 x 815		
GPCMA/208	428 x 500 x 970		
GPCMA/245	650 x 700 x 1050		
Stress relieving up to 1150 °C under vacuum (Direct AM)			
V-L 180-300	300 X 125 x 125	page 18	High Vacuum, Nitrogen, Argon, Forming Gas
V-L 450-600	600 X 315 x 315		
Thermal debinding and pre-sintering up to 1100 °C (1300 °C) (Indirect AM)			
GLO 8-13	125 x 125 x 300	page 6	Vacuum, Nitrogen, Argon, Forming Gas, Hydrogen, Partial Pressure
GLO 40	200 x 200 x 600		
GLO 120	300 x 300 x 700		
GLO 260*	400 x 400 x 800		
Catalytic debinding up to 130 °C (Indirect AM & MIM)			
EBO 120	380 x 400 x 770		Nitrogen, Nitric Acid
EBO 250	500 x 500 x 1000		
Sintering & graphitisation up to 3000 °C			
LHTG 100-200			Vacuum, Nitrogen, Argon, Forming Gas, Hydrogen, Partial Pressure
LHTG 200-300		page 24	
Rest debinding and sintering up to 1600 °C (Indirect AM & MIM)			
HTK 8	170 x 190 x 190		Vacuum, Nitrogen, Argon, Forming Gas, Hydrogen, Partial Pressure
HTK 25	250 x 250 x 410	page 12	
HTK 80	400 x 420 x 520		
HTK 120*	400 x 420 x 790		
Debinding and sintering up to 1800 °C (Indirect AM)			
HTF 27 & 64		page 36	Air
HB 80 & 160		page 40	

*Larger sizes on request **other atmospheres on request

SOLUTIONS FOR ADDITIVE MANUFACTUING & POWDER INJECTION MOULDING

SAFETY is one of the most important aspects in our daily life. CARBOLITE GERO not only protects its furnaces but also the load and application of our customers.

Many furnaces are equipped with a so-called safety system whereas prior to each run, the furnace checks its health conditions and gas tightness to securely run the chosen program. This is a huge advantage over other products so that failures are minimised, damages to the load prevent-ed, and money saved in the long term. Our intelligent furnaces are supplied with a PLC observing each step in the process.

By incorporating hydrogen, we achieve SIL2 compliance. Our safety system is TÜV certified, and our products undergo weeks of rigorous testing prior to release and delivery, ensuring consistent, high-quality results.

As your reliable partner in HEAT TREATMENT, we offer solutions for the whole range of materials within the AM & MIM market, both now and in the future.

HTK Metallic Chamber Furnace for Powder Injection Moulding and Additive Manufacturing

- Debinding & sintering under H_2, Ar, N_2, partial pressure
- Switchable gas flow for processing of sensitive materials
- Fully automatic control system
- Low energy consumption

www.carbolite-gero.com

1300 °C

GLO 8/13

LEADING HEAT TECHNOLOGY

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ADDITIVE MANUFACTURING

GLO 8/13 - ALL-IN-ONE DEBINDING & SINTERING SOLUTION

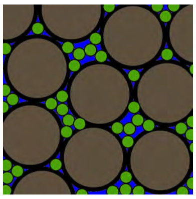
Carbolite Gero offers the GLO 8/13 furnace, a compact and versatile debinding and sintering solution for additive manufacturing. This furnace features rotationally symmetrical heating elements that encompass a 180 mm iD cylindrical retort, providing even heating throughout its length. It is suitable for all additive manufacturing processes that require either nitrogen, argon, or forming gas (N_2/H_2 95/5% or Ar/H_2 98/2%). With a maximum temperature of 1300 °C, this furnace can accommodate nearly 80% of printed metals.

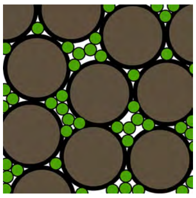
Annealing

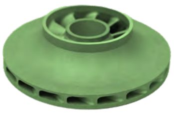
Stress-Relieving

Debinding

Sintering







< 600 °C

DEBINDING

< 1400 °C

SINTERING

GREEN PART

BROWN PART

FINAL PART

In the 3D printing of metal or ceramic components using techniques such as binder jetting, lithography, or metal extrusion, a binder is typically used to maintain the integrity of the structure. It's essential to eliminate this binder from the green part to enable the sintering of the powder particles. A multi-stage debinding process is often employed, commencing with an initial debinding step at low temperatures up to 250 °C (which may only involve drying). Following this, the complete removal of organic materials occurs at temperatures ranging from 400 to 600 °C, resulting in the formation of the brown part.

During this process, off-gases and volatiles are handled using a binder trap or afterburner, which can be powered thermally or catalytically. After a final debinding step the part is sintered at approximately 80% of the metal's melting temperature. At this stage, all particles soften and begin to form interconnecting bridges, leading to a solid-state reaction and fusion. The complete removal of the binder is critical to ensure a low carbon content and to prevent a reduction in the material's melting point due to the formation of a eutectic phase.

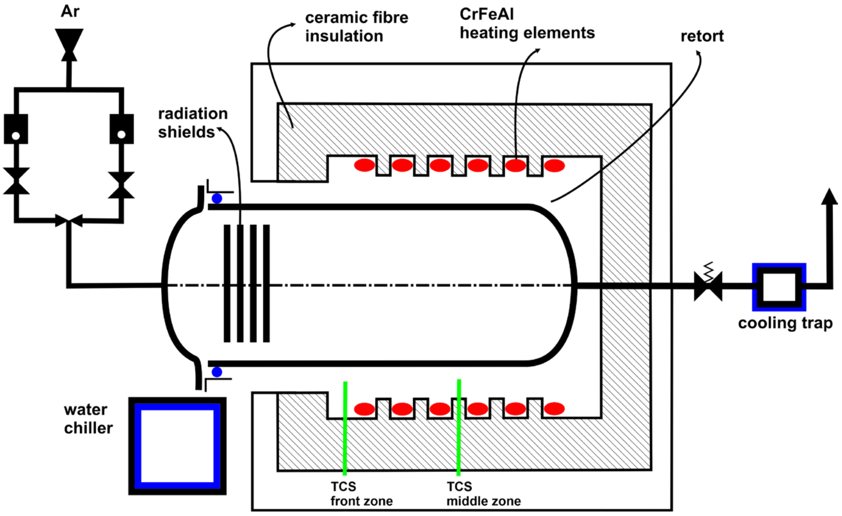
MORE INFORMATION ON AM & MIM FURNACES

WEBPAGE

BROCHURE

WHY CHOOSE A GLO?

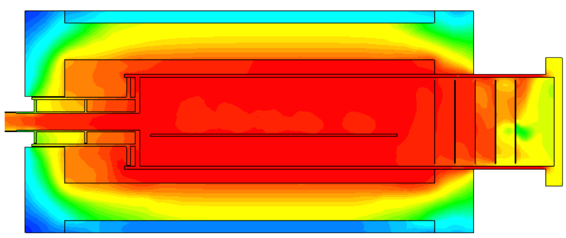
1. Versatile furnace with a small footprint, ideal for areas with constrained space
2. Robust design for temperatures at the sample of approx. 1280 °C
3. Separate front zone with offsets to adjust and improve the temperature uniformity
4. Low energy consumption due to multiple insulation layers and intelligent design
5. Optimized gas outlet for efficient binder removal
6. Covers approx. 80% of AM metals and enables a cost effective solution, opening doors into the AM world



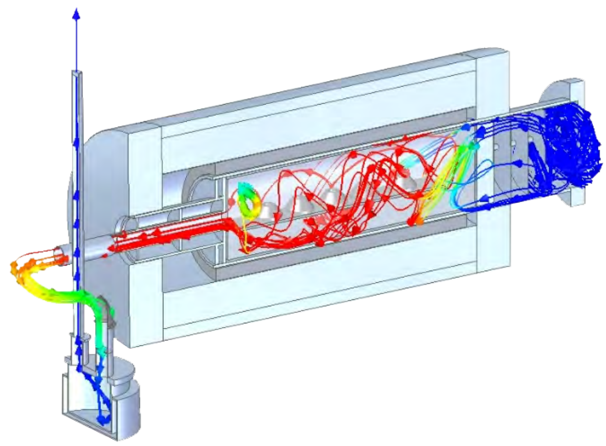
ADVANCED STANDARD FEATURES

- Rotameter (flow controller) for process and purge gas
- 2-zone control with thermocouple type S
- Built in water cooling chiller
- Designed to withstand 1300 °C
- Placed on castor rollers for easy movement
- Plug & play power and gas connections

A combination of an over pressure valve and cooling trap ensures the condensation of binder. Almost all condensables with a condensation point above 20 °C are trapped. It is easy to clean and maintain.



Temperature uniformity during debinding step @ 600 °C with 10 small plane Ø 80 mm samples placed on the rack.

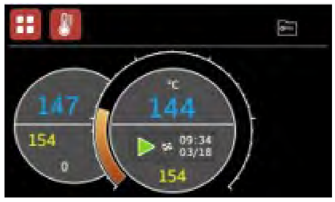


Red arrows indicate the removal of the binder @ 600 °C. The high turbulent gas flow efficiently removes organics.

TOUCH CONTROL SYSTEM

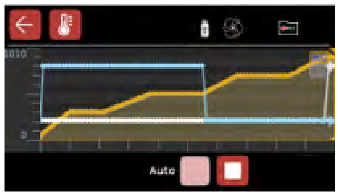
TOUCH PANEL

CC-T touch controller (4.3" 480x272 Pixel)
Resistive colour display
Eurotherm EPC2000
Single setpoint and program file control
Real-time clock and program scheduler
Ethernet & USB connections
Storage of 10 programs
24 Segments (steps, dwell times) per program
All working setpoints and process values stored in .csv file format
Automatic & manual batch file saving
Recording time resolution of 10 seconds
3 different user levels as standard
English, German, Chinese, Japanese, French, Italian, Spanish, Russian
Accessible via Eurotherm iTools software



OVERVIEW SCREEN

INTUITIVE PROGRAM TABLE



DATA LOGGING & TREND VIEW

FULLY MANUALLY ADJUSTABLE

Please note: This unit is intented for debinding and sintering processes with maximum binder content of 750 g (5 mass% @ 15 kg load). Regular cleaning of the condensate trap is mandatory.

★★★★★ **USER FEEDBACK**

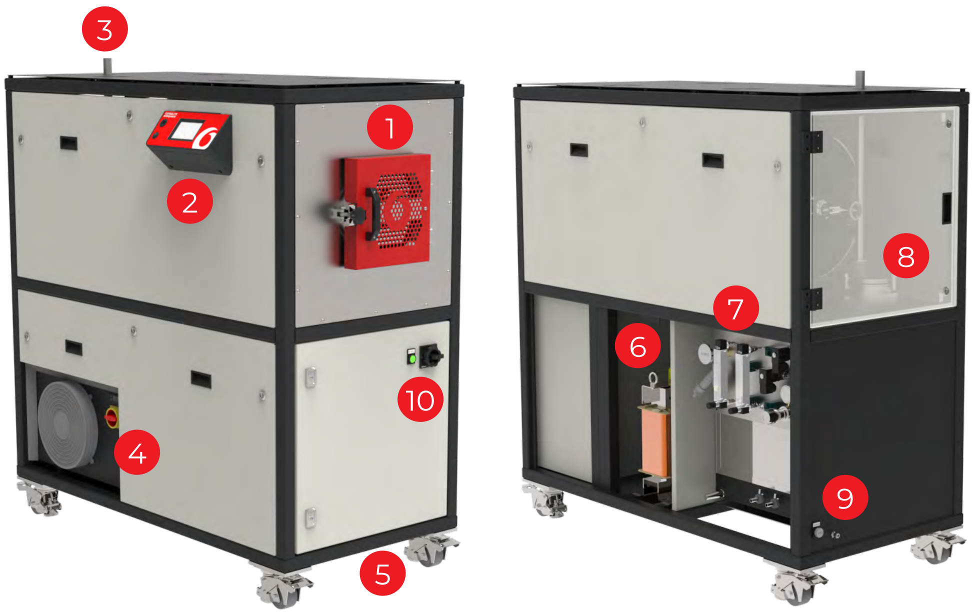
"Acquiring the GLO 8/13 has allowed us to perform debinding and sintering of 3D printed parts with ease and at a low cost without requiring significant infrastructure investment. Once the process is established, our next move would be to transition to a vacuum furnace to scale up our production."

2023, Headmade Materials

OVERVIEW & FOOTPRINT

PART IDENTIFICATION

1) Door with lock
2) Touch panel controller
3) Gas exhaust pipe
4) Cooling water chiller
5) Wheels with stopper
6) Transformer
7) Process & purge gas
8) Condensation trap
9) Mains & gas connection
10) Main & power switch



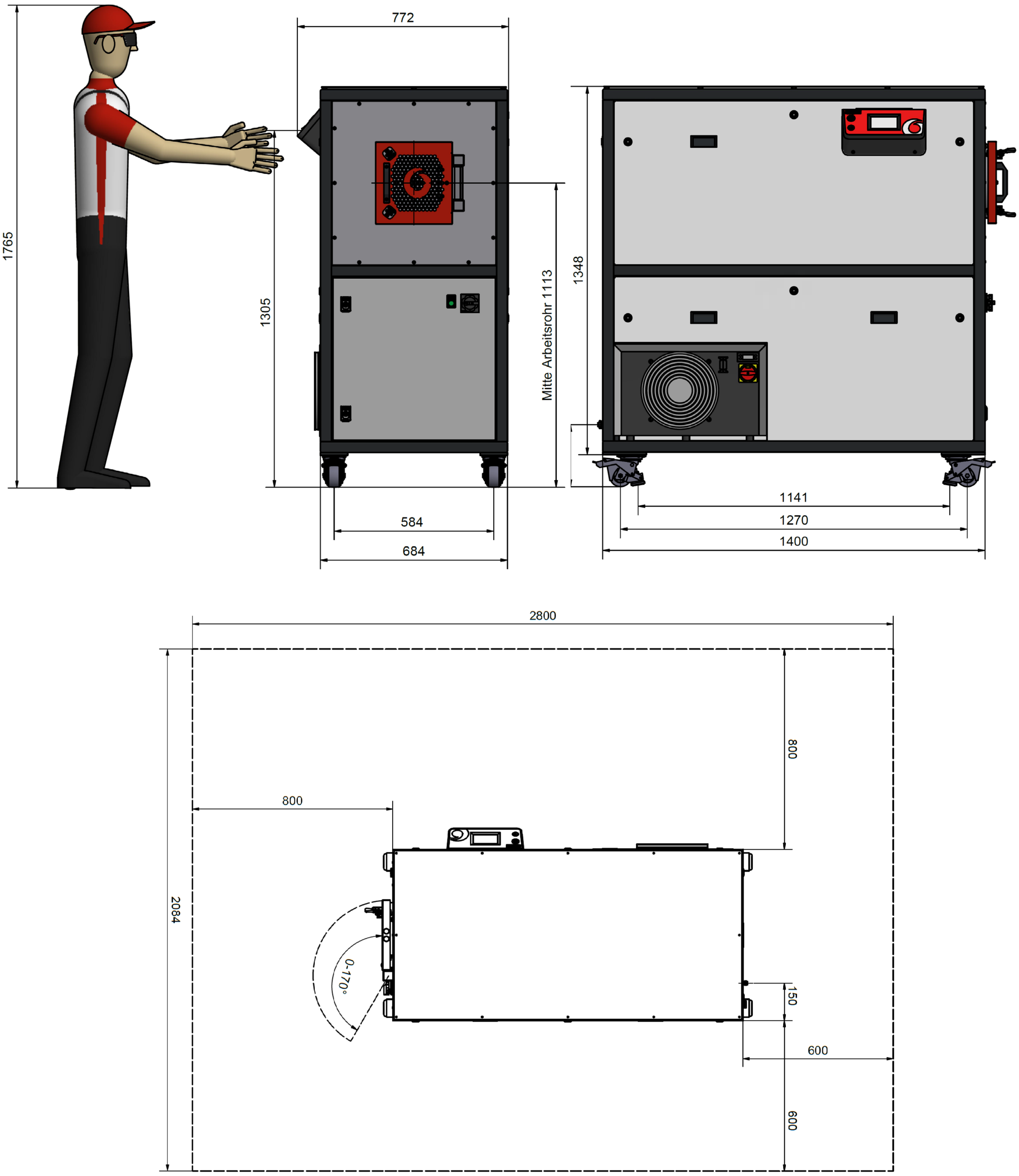
TECHNICAL DATA

WHAT YOU GET !	
Tmax furnace incl. tube	1300 °C
Tmax at sample	1280 °C
Gas flow rate	35 - 370 L/h
Pressure	Atmospheric +40 mbar, rel.
Furnace dimensions (HxWxD)	1460 x 780 x 1500 mm
Total furnace weight	500 kg
Volume retort	iD 180 x L 500 mm
Maximum sample weight	15 kg
Certification	Machinery directive / CE

REQUIRED INFRASTRUCTURE

WHAT YOU NEED !	
Cooling water (Chiller) (requires separate power supply)	1 kW chiller incl. 0.8 kW, 230 V, 4.1 A 1 Ph + N + E, 50 Hz
Extraction system above furnace	5 m^3/h
Compressed Air	7 bar abs.
Argon	7 bar abs.
Power supply	15 kW
Voltage	3 x 400 V + N + E, 50 Hz
Pre-fuse	3 x 32 A
Plug Chiller Plug Furnace incl. 3 m cable	Schuko 32 A CEE

OVERVIEW & FOOTPRINT



CARBOLITE®
GERO 30-3000°C

1600 °C

HTK 25

LEADING HEAT TECHNOLOGY

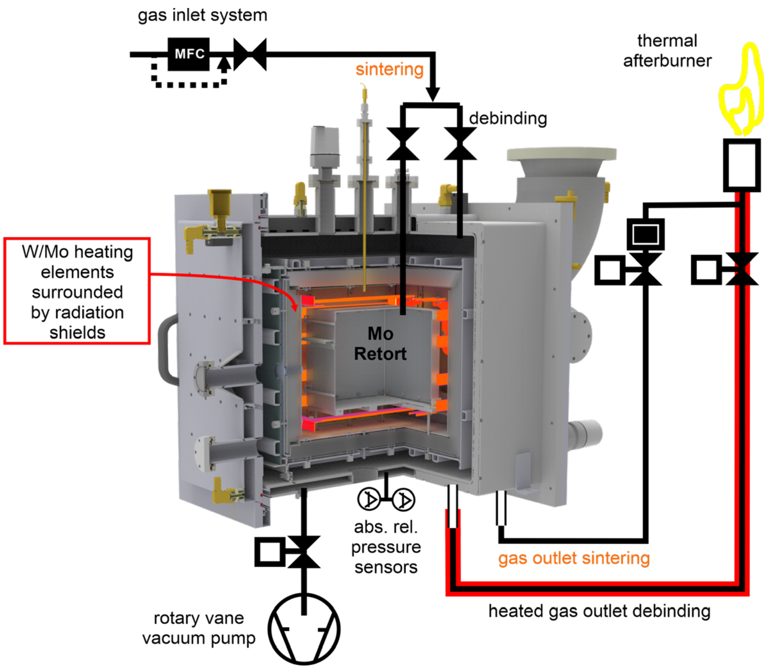
ENABLING THE WORLD OF ADDITIVE MANUFACTURING

FURNACES FOR (RESIDUAL) DEBINDING AND SINTERING FOR LABORATORY AND INDUSTRY

	HTK 8 MO/16-3G	HTK 25 MO/16-3G	HTK 80 MO/16-3G	HTK 120 MO/16-3G	HTK 200 MO/16-3G	HTK 320 MO/16-3G
T_{max} atmosphere [°C]	1600	1600	1600	1600	1600	1600
$T_{max, work}$ atmosphere [°C]	1500	1500	1500	1500	1500	1500
HxBxT Useful space with retort [mm]	170x190x190	250x250x410	400x430x520	400x420x790	520x520x1000	520x520x1500
HxBxT Useful space with retort [mm]	160x180x180	240x240x400	380x410x500	380x400x770	500x500x800	500x500x1300
Number of stacks	-	1	2	3	4	6
Loading Method	Manual	Manual	Loading Trolley			
Gas Outlet	At the bottom	At the bottom	At the rear	At the rear	At the rear	At the bottom
Loading	One-sided					On both sides
Number Heating Zones	1	1	4	4	4	6
Uniformity	<±5	<±5	<±5	<±5	<±10	<±15
Cooling time without fast cooling with typical load [h]	3	4	6	7	13	18
Cooling time with fast cooling with typical load [h]	-	-	2.5	<4	<7	<9
Total number of plates with 30 mm spacing	Laboratory unit	6	20	33	56	84
Installed power [kW]	30	84	167	200	300	400
Holding power at 1380 °C under H_2 [kW]	20	45	80	100	160	260
Cooling water consumption [L/min]	25	80	150	170	260	350
Total loading area [mm²]	-	437,760	1,459,200.00	2,407,680.00	4,085,760.00	66,128,640.00
Typical total running time [h]	Laboratory Units		16	22	30	40

WHY CHOOSE AN HTK?

1. Two separate gas in and outlets allows for optimal debinding & sintering
2. Trace heated gas outlet minimizes condensation during debinding
3. Heaters and ratiation shields made of either molybdenum, tungsten or graphite reduces cross-contamination
4. Standard safety features such as evacuating the furance prior to each run, over-temperature and overpressure protection, and precise control systems for gas and cooling water
5. Heating elements are positioned 360° around the retort allowing for improved temperature uniformity
6. Cross-contamination free debinding and sintering



HEATING-COOLING CONDENSATION TRAP as an advanced option to condense or release binder efficiently from the condensation trap. Depending on the set temperature of a special chiller the reversed ability is achievable.

ADVANCED STANDARD FEATURES

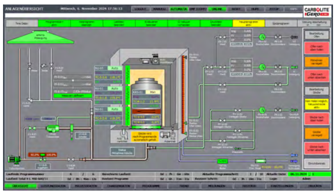
- Mass flow controller **MFC** with integral bypass for fast refill after evacuation
- Separate control for gas inlet into the retort and vacuum vessel
- Relative, absolute and Pirani vacuum gauge
- Double stage rotary vane pump reduces cycle times and oxygen content

CARBOLITE GERO enables contamination-free sintering of highly sensitive materials through a switchable gas flow. During debinding, the gas flows from the top through the right inlet ("debinding") above the retort. Since the retort is not fully sealed and the pressure outside is slightly higher than inside the retort, the gas flows into the retort. By flowing through the retort, the carrier gas takes the gaseous binder into the gas outlet at the bottom of the retort. Those gases are then directed through the heated gas outlet to the thermal afterburner. After the debinding step, the gas flow can be changed to provide the purest atmosphere for the parts. The gas flows through the upper left inlet ("sintering") directly into the retort and from there to the outside of the retort, where it passes through the lower right gas outlet into the afterburner. Since there is no more binder present, the outlet no longer needs to be heated. The improved gas flow prevents binder residues that might be outside the retort from getting back onto the samples during sintering resulting into cleaner samples and higher quality.

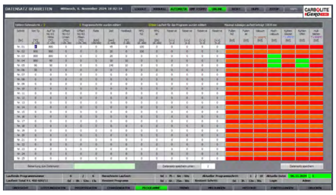
AUTOMATIC CONTROL SYSTEM

TOUCH PANEL

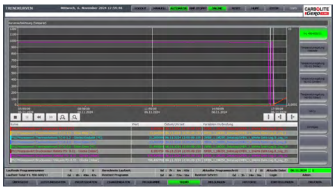
Siemens TP1900 Comfort (19" 1280x800 Pixel)
Resistive incl. pen
Windows CE
Siemens S7 - 1500
Ethernet & USB connection
Storage of 20 programs with 25 segments (steps, dwell times) each
Error message handling with history
All working setpoints and process values (temperature, gas flow, pressure, errors) stored in .csv file format
Automatic & manual batch file saving for each furnace run
Recording time resolution of 5 – 600 seconds
3 different user levels as standard
English & German as standard languages
Accessible and controllable via remote connection (e.g. VNC Viewer) from any device
Mounted in Rittal® control cabinet with IP-class 54



OVERVIEW SCREEN



INTUITIVE PROGRAM TABLE



DATA LOGGING & TREND VIEW

FULLY MANUALLY ADJUSTABLE

FEATURES AFTERBURNER

- 3.4 kW power to convert volatiles in H_2O, CO_2, NO_2 etc.
- Trace heated to approx. 250 °C to minimize condensation during debinding / pyrolysis

Please note: This unit is supposed to be for off-gassing processes including a small quantity of condensables (50 g at most). Volatiles such as hydrocarbons, carbon monoxide are combusted within 3.4 kW torch. However, regular cleaning of the gas outlet is unavoidable.

★★★★★ **USER FEEDBACK**

"We bought the HTK to debind & sinter printed glass. It enables us to achieve great quality parts and reliable heat treatment."

2024, Glassomer

OVERVIEW & FOOTPRINT

PART IDENTIFICATION

1) 19" touch panel
2) Rittal® control cabinet
3) Adjustable feet
4) Mass flow controller
5) Afterburner
6) Hydrogen sensor
7) Rotary vane pump
8) Safety purging tank
9) Gas outlet
10) Cooling water circuits

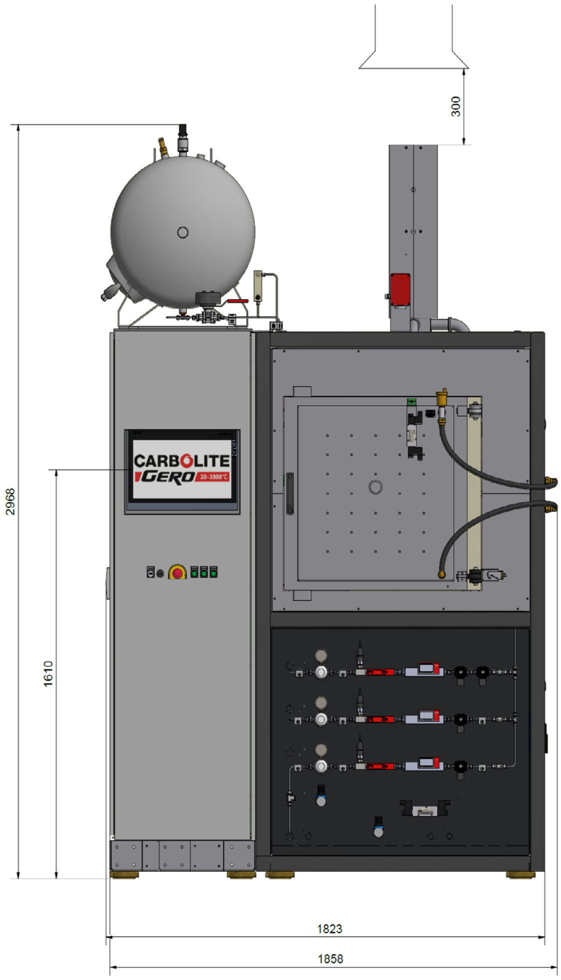
TECHNICAL DATA

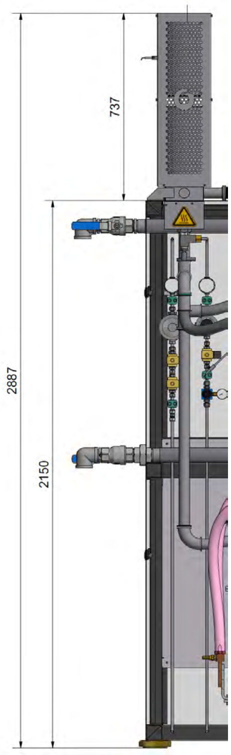
WHAT YOU GET !	
Tmax in argon (we recommend a dwell <30 min)	1600 °C
Tmax in vacuum	1600 °C
Gas flow rate	20 - 2000 L/h
Vacuum level	10^{-1} - 10^{-2} mbar
Furnace dimensions (HxWxD)	2970 x 2150 x 1850 mm
Total furnace weight	1600 kg
Volume retort (HxWxD)	250 x 250 x 250 mm
Maximum sample weight	20 kg
Certification	Machinery directive / CE

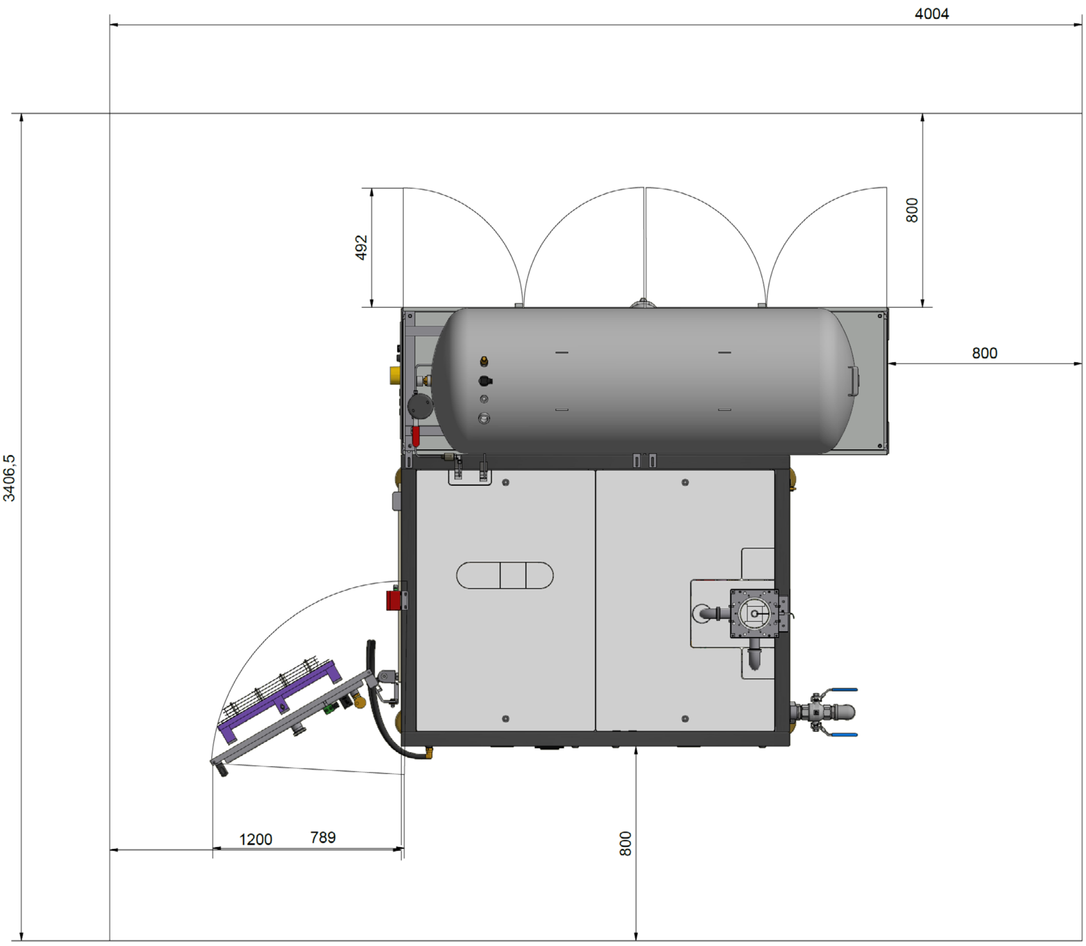
REQUIRED INFRASTRUCTURE

Cooling water (Chiller) (requires separate power supply)	60 L/min 2x¾" connection 2 – 4 bar abs.
Extraction system above furnace	200 m³/h
Compressed Air	2470 L/h 7 bar abs.
Argon / Nitrogen	9 bar abs.
Propane	130 L/h 50 – 100 mbar
Hydrogen	20 – 2000 L/h 7 bar abs.
Power supply	84 kW
Voltage	3 x 400 V + N + E
Pre-fuse	3 x 125 A

OVERVIEW & FOOTPRINT







1100 °C

V-L 450 – 600

LEADING HEAT TECHNOLOGY

ENABLING THE WORLD OF HIGH VACUUM HEAT TREATMENT

V-L TOP HAT FURNACE

Carbolite Gero reports on a study where the oxygen concentration was measured by EDX analysis of samples which were heat treated in either atmospheric pressure or in high vacuum. The samples were manufactured by Laser-Powder-Bed Fusion (L-PBF) technology, where and subsequent heat treatment is required. In theory and in practice, it could be shown, that oxygen in high vacuum is always lower than at atmospheric pressure. This results in a reduction in oxidation by 38% on the titanium (Ti-6Al-4V) samples used in this report.

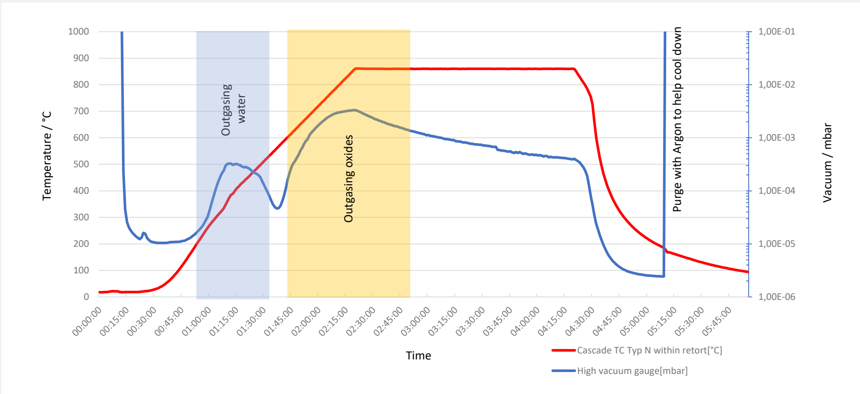
Stress Relieving

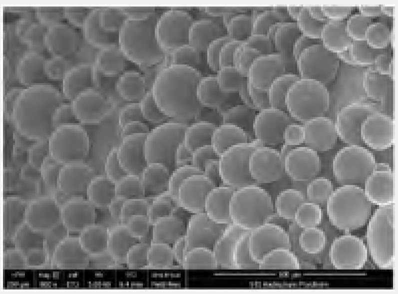
Vacuum Soldering

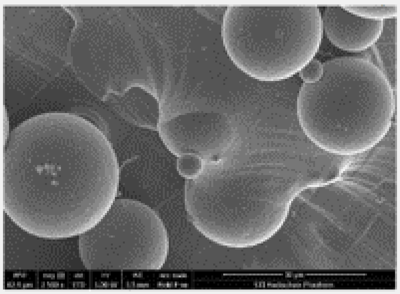
Vacuum Brazing

Degassing

When heating titanium and its alloys in an inert gas or vacuum, they remain highly reactive to residual oxygen. In a vacuum, the surface water and oxides are more readily released from the metal, thanks to the disruption of adhesive forces and the formation of metal oxides. The amount of material released strongly depends on the temperature and pressure, or what is known as vapor pressure.







Oxide particles formed during heat treatment in either inert gas atmoshpere (left) or vacuum (right)

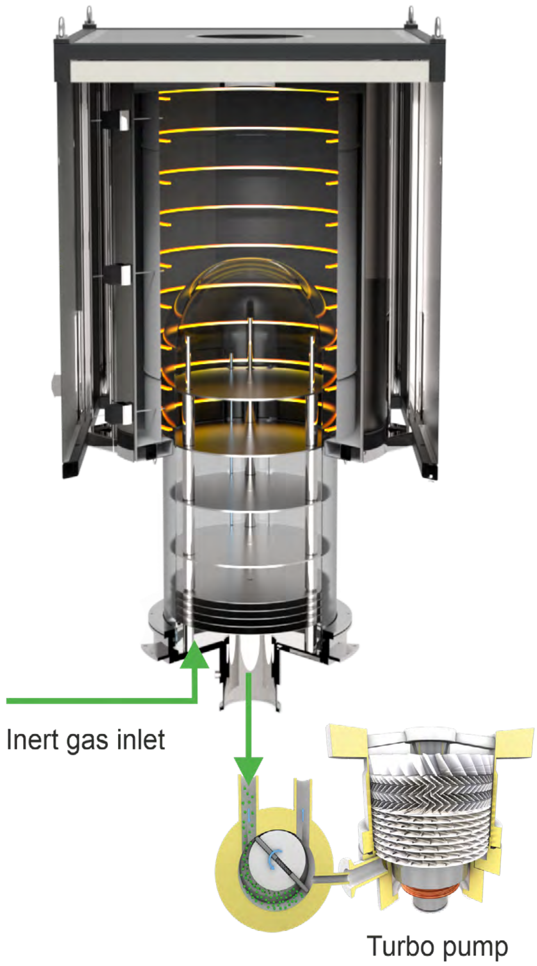
The diagram shows that the read pressure decreases due to outgassing of water between 200 – 500 °C. From 600 to approximately 850 °C, the pressure drops further due to the outgassing of metal monoxides. After completing the heat treatment, the vacuum, created by the turbomolecular pump, stabilizes because no desorption processes occur at cooler temperatures. The EDX measurements validate this physicochemical effect. Scientific investigations and experiments conducted by Ellingham and Richardson, which were published in 1944 and the subsequent years, have documented these findings for the first time.

The Ellingham-Richardson diagram indicates that to completely prevent the oxidation of titanium at 700 °C, the pressure must be maintained below <5.88×10^{-42} mbar. However, achieving such a pressure is unrealistic in practice; therefore, attaining the minimal achievable pressure is desired. It is also important to avoid and minimize any gas impurities containing oxygen in argon.

OPTIMIZING THE ATMOSPHERE FOR STRESS RELIEF ANNEALING OF L-PBF SAMPLES BY SEM-EDX METHOD

WHY CHOOSE A V-L?

1. Precise temperature control at low and high temperatures
2. Load thermocouples for precise temperature reading directly at the sample
3. Very low oxygen content achieved with turbomolecular pump system and special seal arrangement
4. Standard safety features such as evacuating the furance prior to each run, over-temperature and overpressure protection, and precise control systems for gas and cooling water
5. Quartz hood, molybdenum or inconel rack for robust and clean heat treatment
6. Samples accessible from all sides for easy positioning



ADVANCED STANDARD FEATURES

- Inert gas inlet with integral bypass for fast refill after evacuation
- Quartz hood for clean high vacuum operation
- Relative, absolute and Pirani vacuum gauge
- Turbomolecular pump reduces oxygen content to values below << 30 ppm
- Heating elements and insulation withstands continuous temperatures of 1300 °C enabling an almost maintenance free heat treatment

ADVANCED OPTIONS

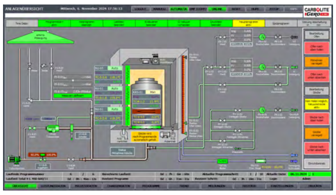
- Hydrogen safety package for reactive atmospheres
- Bar code / QR code scanner for furnace users providing batch no., temperature profile and many other important pre-configured parameters
- Fast cooling by lifting the furnace and flushing the quartz retort from outside with cold air
- 9-point thermocouple access port

Requirements for different heights? Our rack systems allows for different adjustments due to a flexible design. Any combination of the 4 levels with 145 mm each is possible. This advantage is your key for R&D and production. Either smaller or larger parts can be heat treated simultaneously and the rack adjusted to their size. In addition rack materials like SiC, molybdenum or stainless steel are available.

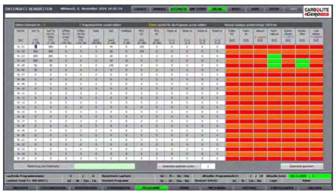
AUTOMATIC CONTROL SYSTEM

TOUCH PANEL

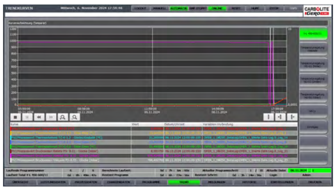
Siemens TP1900 Comfort (19” 1280x800 Pixel)
Resistive incl. pen
Windows CE
Siemens S7 - 1500
Ethernet & USB connection
Storage of 20 programs with 25 segments (steps, dwell times) each
Error message handling with history
All working setpoints and process values (temperature, gas flow, pressure, errors) stored in .csv file format
Automatic & manual batch file saving for each furnace run
Recording time resolution of 5 – 600 seconds
3 different user levels as standard
English & German as standard languages
Accessible and controllable via remote connection (e.g. VNC Viewer) from any device
Mounted in Rittal® control cabinet with IP-class 54



OVERVIEW SCREEN

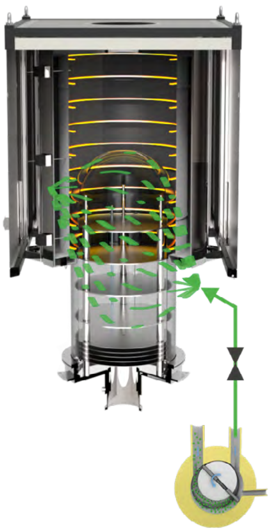


INTUITIVE PROGRAM TABLE



DATA LOGGING & TREND VIEW

FULLY MANUALLY ADJUSTABLE



An efficient solution for FORCED COOLING of the V-L quartz retort is by lifting the furnace and blowing room temperature air around the quartz hood. This simple technology allows for faster process cycle times or quick temperature drop for vacuum soldering and brazing. Furthermore a motorized flap on the top of the V-L can create a chimney effect cooling the whole system immediately when heating elements are turned off.

★★★★★ **USER FEEDBACK**

“We purchased the V-L with a turbomolecular pump to guarantee clean heat treatment under vacuum for very pure samples. This equipment offers us the opportunity to achieve excellent results.”

2022, PR

OVERVIEW & FOOTPRINT

PART IDENTIFICATION

1) 19” touch panel
2) Rittal® control cabinet
3) Adjustable feet
4) Mass flow controller
5) Radiation shields & rack
6) Quartz retort
7) Gas inlet thermocouple
8) Movable cover & furnace
9) Forced cooling
10) Cooling water circuits

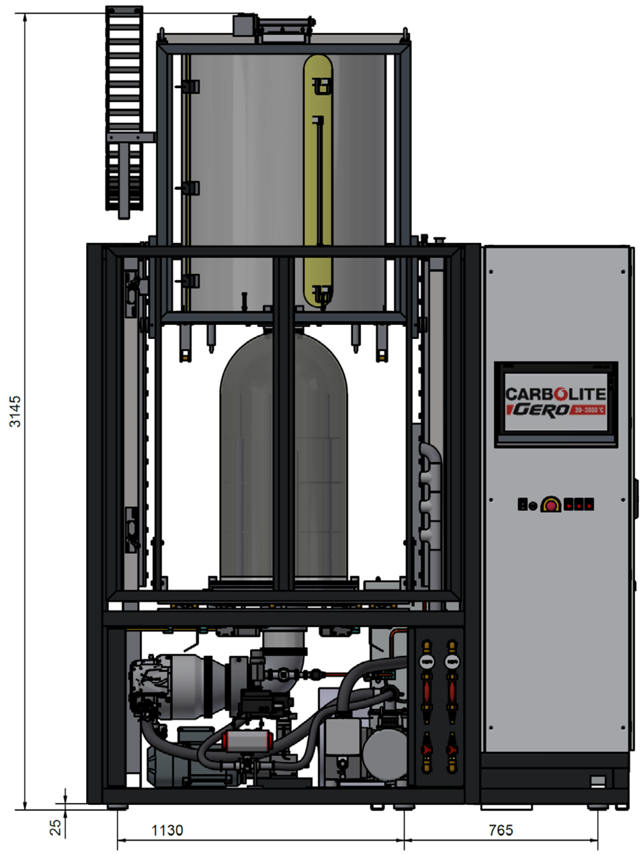
TECHNICAL DATA

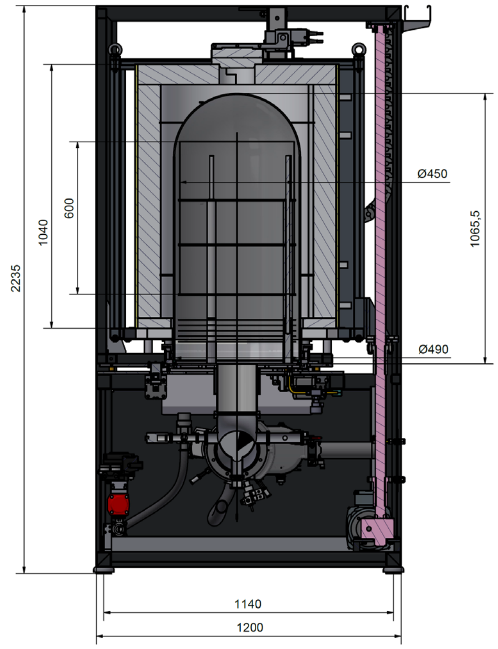
WHAT YOU GET !	
Tmax in argon (we recommend a dwell <30 min)	1100 °C
Tmax in vacuum	1100 °C
Gas flow rate	30 - 1000 L/h
Vacuum level	10^{-2} - 10^{-6} mbar
Furnace dimensions (H(open)xWxD)	2300 (3200) x 2200 x 1200 mm
Total furnace weight	2000 kg
Volume retort	iD 450 x h 600 mm
Maximum sample weight (per shelf)	80 kg (20 kg)
Certification	Machinery directive / CE

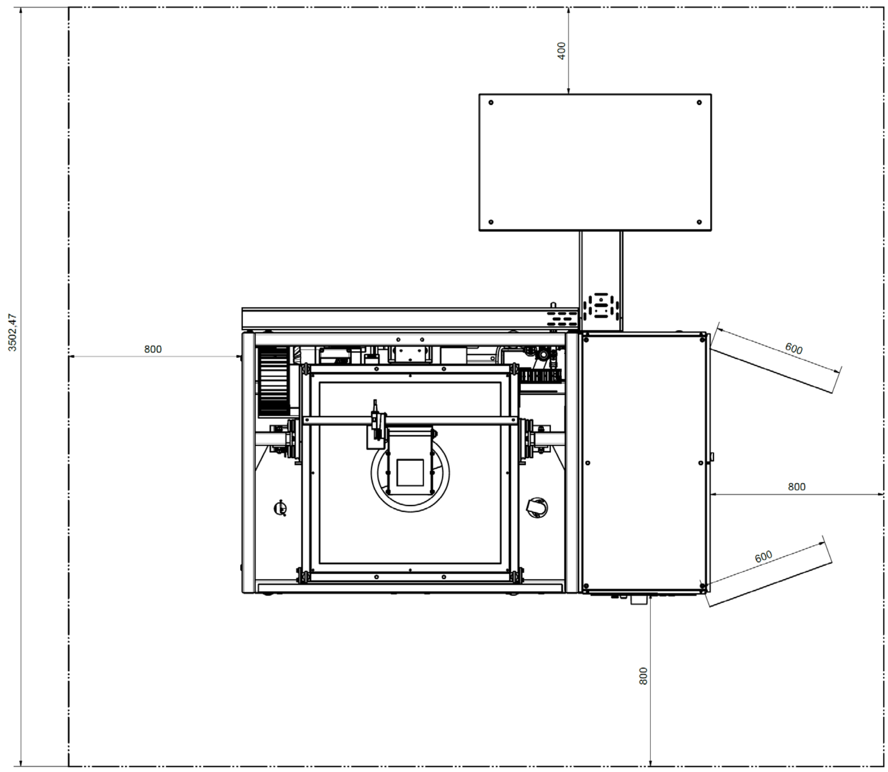
REQUIRED INFRASTRUCTURE

WHAT YOU NEED !	
Cooling water (Chiller) (requires separate power supply)	8 L/min 2 x 1/2“ connection 2 – 4 bar abs.
Extraction system above furnace (with forced cooling)	10 m³/h (500 m³/h)
Compressed Air	7 bar abs.
Argon	7 bar abs.
Power supply	58 kW
Voltage	3 x 400 V + N + E
Pre-fuse	3 x 125 A

OVERVIEW & FOOTPRINT







CARBOLITE GERO 30-3000°C

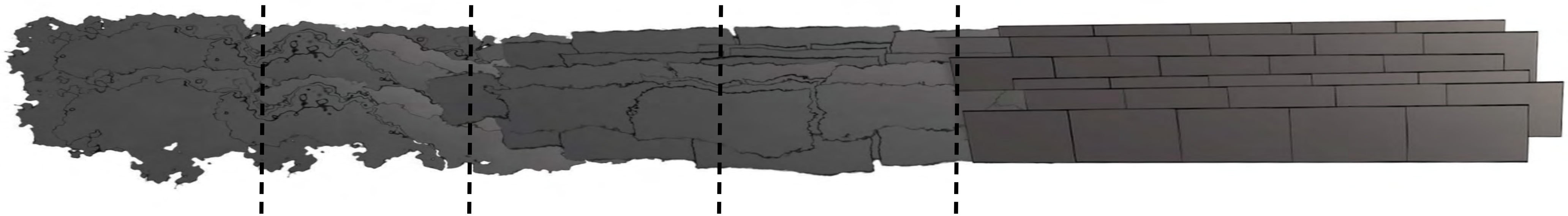
3000 °C

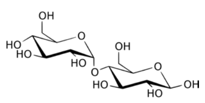
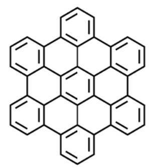
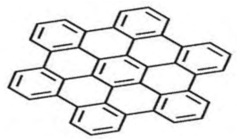
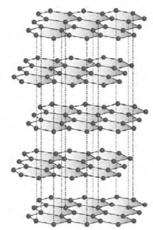
LHTG 200 - 300/30 AUTOMATIC

LEADING HEAT TECHNOLOGY

ENABLING THE WORLD OF GRAPHITIZATION

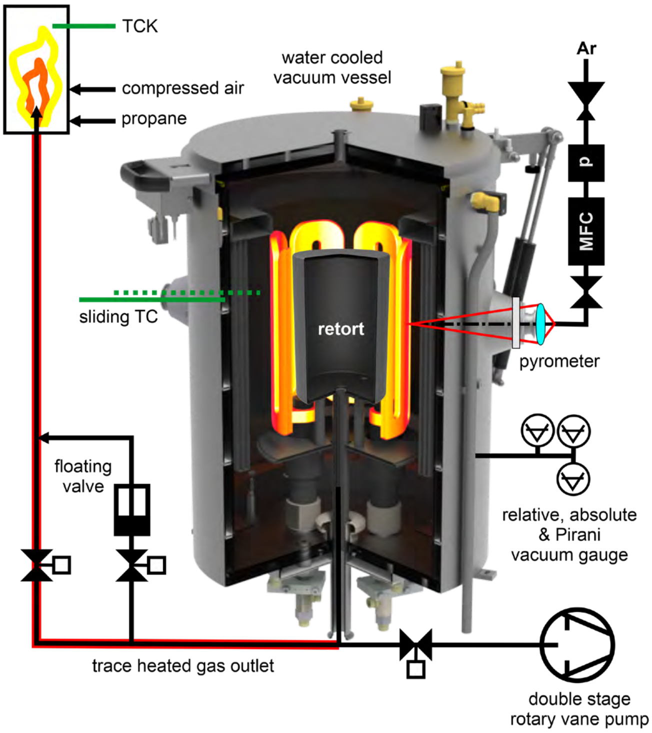
OVERVIEW PYROLYSIS, CARBONIZATION, GRAPHITIZATION



Temperature		600 °C	1000 °C	1500 °C	2000 °C – 3000 °C
Reaction	Pyrolysis		Carbonization		Graphitization
	Aromatization	Polycondensation	Graphene Layer Formation	Graphene Layer Growth	Graphene Layer Growth & Stacking Order
State of Residue	Solid →	Solid, Liquid or Gas →		Carbonaceous Solid	
Nanostructure					
Main Outgassed Component	Aliphatic	Aromatic, CO_2, CH_4	H_2	$C(N)_2, N_2$	

WHY CHOOSE AN LHTG?

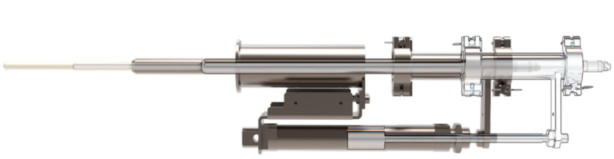
1. Precise temperature control at low temperatures with sliding thermocouple
2. Precise temperature control at high temperatures up to 3000 °C with pyrometer
3. Very low energy consumption due to our special design - WE AVOID PLASMA! It increases the furnace lifetime and lowers your energy costs
4. Standard safety features such as evacuating the furance prior to each run, over-temperature and overpressure protection, and precise control systems for gas and cooling water
5. Compact design and small footprint makes this furance ideal for your laboratory
6. Meander shaped heater design allows almost 360° heating



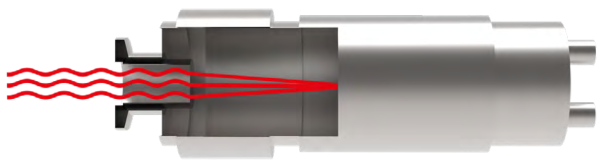
ADVANCED STANDARD FEATURES

- Mass flow controller **MFC** with integral bypass for fast refill after evactuation
- Pressure switch **P** monitors gas availability
- Relative, absolute and Pirani vacuum gauge
- Double stage rotary vane pump reduces cycle times and oxygen content

The cylindrical GRAPHITE RETORT prevents the samples from direct radiation and ensures a great temperature uniformity. Additionally, it guides gases through the gas outlet to the exhaust.



The SLIDING THERMOCOUPLE (sTC) controls perfectly at low temperatures. Between 900 and 1100 °C the sTC and pyrometer work simultaneously to double check its accuracy. Above 1100 °C the sTC slides out the hot zone and hands over the lead to the pyrometer.

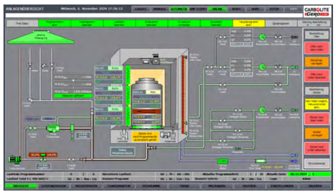


The PYROMETER receives radiation and senses it very well at high temperatures. To ensure optimum functionality an additional protection is offered by a small sapphire window. This prevents dust or dirt from condensing at the pyrometer lens.

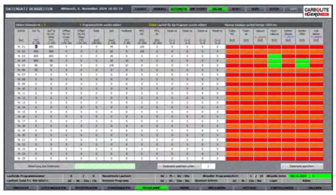
AUTOMATIC CONTROL SYSTEM

TOUCH PANEL

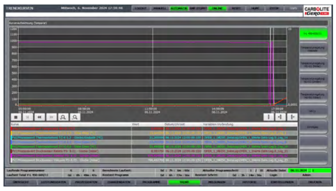
Siemens TP1900 Comfort (19” 1280x800 Pixel)
Resistive incl. pen
Windows CE
Siemens S7 - 1500
Ethernet & USB connection
Storage of 20 programs with 25 segments (steps, dwell times) each
Error message handling with history
All working setpoints and process values (temperature, gas flow, pressure, errors) stored in .csv file format
Automatic & manual batch file saving for each furnace run
Recording time resolution of 5 – 600 seconds
3 different user levels as standard
English & German as standard languages
Accessible and controllable via remote connection (e.g. VNC Viewer) from any device
Mounted in Rittal® control cabinet with IP-class 54



OVERVIEW SCREEN



INTUITIVE PROGRAM TABLE



DATA LOGGING & TREND VIEW

FULLY MANUALLY ADJUSTABLE

FEATURES AFTERBURNER

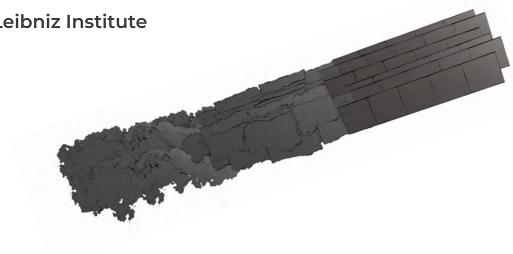
- 3.4 kW power to convert volatiles in H_2O, CO_2, NO_2 etc.
- Trace heated to approx. 250 °C to minimize condensation during debinding / pyrolysis

Please note: This unit is supposed to be for off-gassing processes including a small quantity of condensables (50 g at most). Volatiles such as hydrocarbons and carbon monoxide are combusted within the 3.4 kW torch. However, regularly cleaning of the gas outlet is unavoidable.

★★★★★ **USER FEEDBACK**

“We bought the LHTG with afterburner to ensure full combustion of the by-products of our processes. It has enabled a safe all-in-one solution for our R&D lab.”

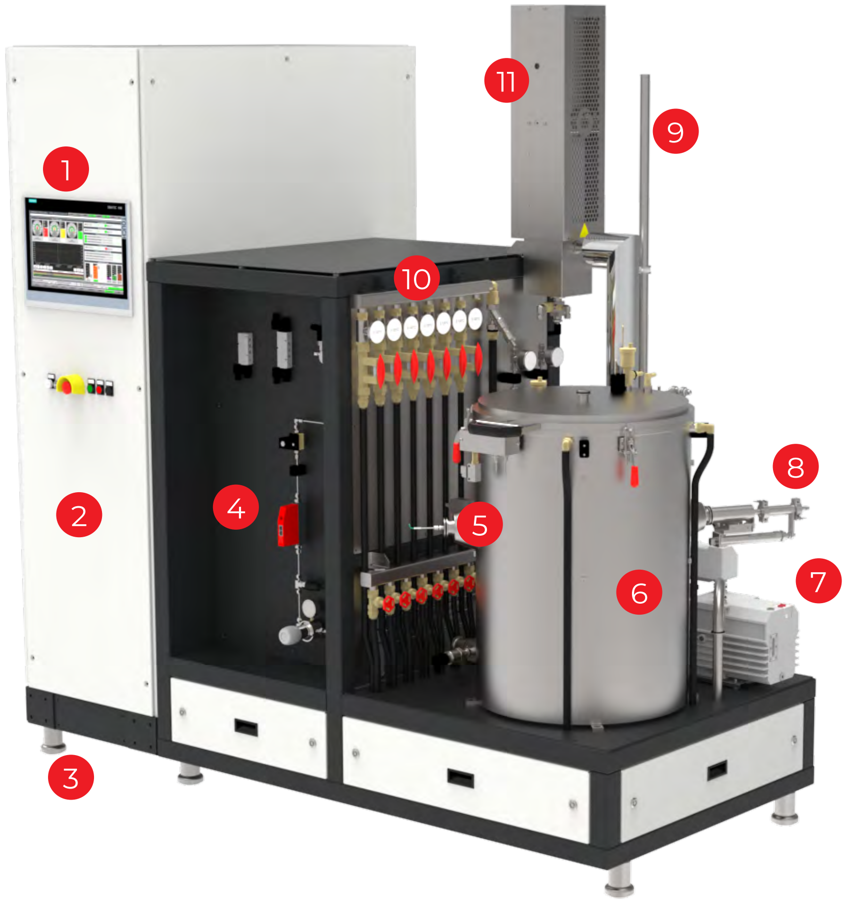
2018, Leibniz Institute



OVERVIEW & FOOTPRINT

PART IDENTIFICATION

1) 19" touch panel
2) Rittal® control cabinet
3) Adjustable feet
4) Mass flow controller
5) Over-temperature thermocouple
6) Vacuum vessel
7) Rotary vane pump
8) Sliding thermocouple
9) Gas outlet
10) Cooling water circuits
11) Afterburner



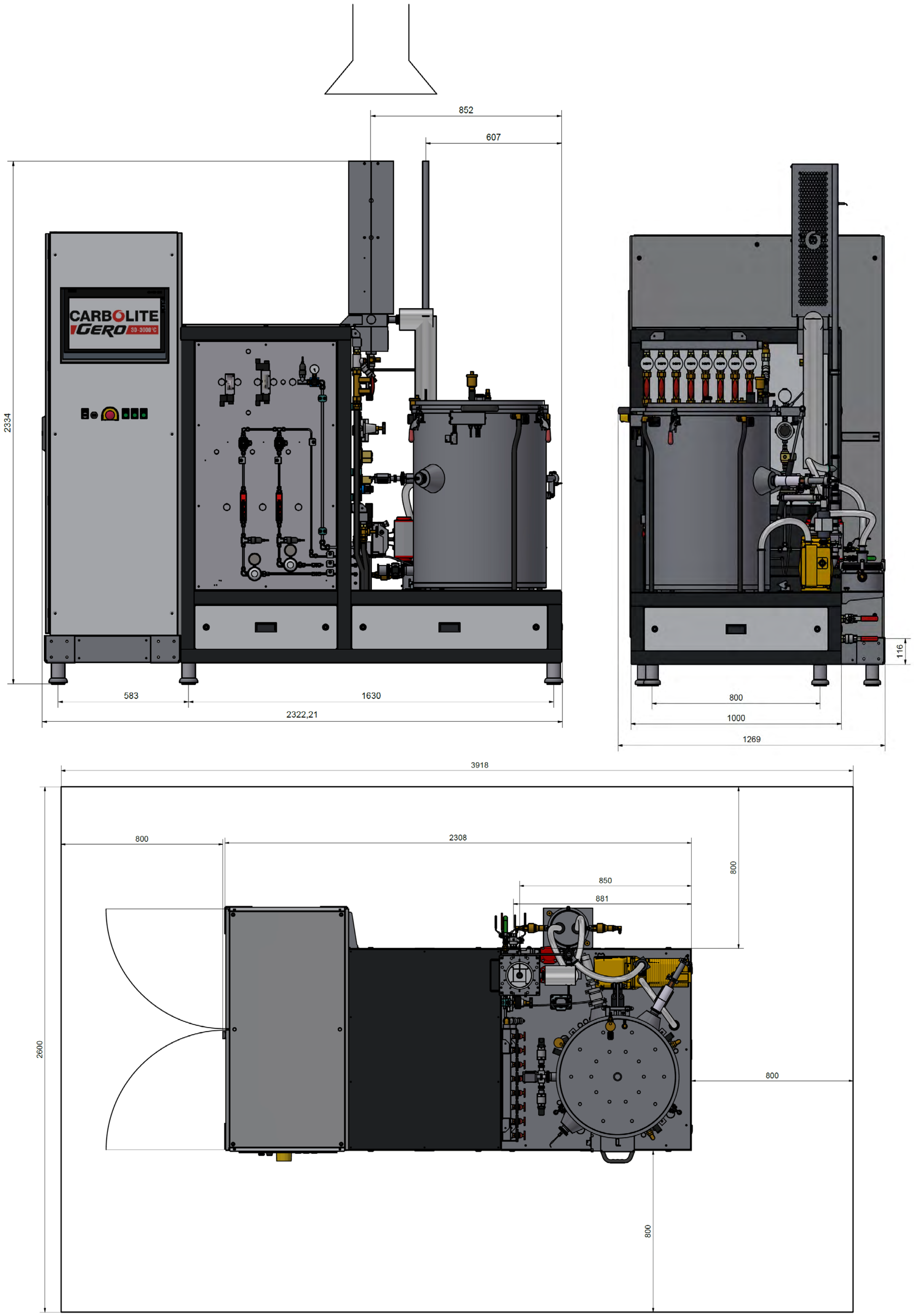
TECHNICAL DATA

WHAT YOU GET !	
Tmax in argon (we recommend a dwell <30 min)	3000 °C
Tmax in vacuum	2200 °C
Gas flow rate	100 - 1000 L/h
Vacuum level	10^{-1} – 10^{-2} mbar
Furnace dimensions (HxWxD)	2350 x 2350 x 1300 mm
Total furnace weight	1500 kg
Volume retort	iD 190 x L 290 mm
Maximum sample weight	5 kg
Certification	Machinery directive / CE

REQUIRED INFRASTRUCTURE

WHAT YOU NEED !	
Cooling water (Chiller) (requires separate power supply)	60 L/min 2x¾" connection 2 – 4 bar abs.
Extraction system above furnace	200 m^3/h
Compressed Air	2470 L/h 7 bar abs.
Argon	7 bar abs.
Propane	130 L/h 50 – 100 mbar
Power supply	63 kW
Voltage	3 x 400 V + N + E
Pre-fuse	3 x 125 A

OVERVIEW & FOOTPRINT



CARBOLITE GERO 30-3000°C

2800 °C

LHTG 200 - 300/28 SMART

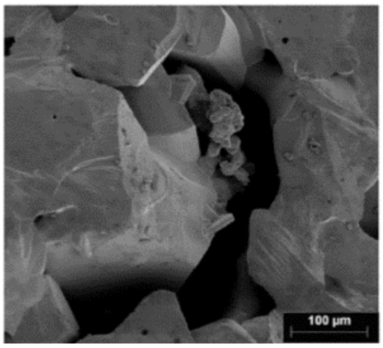
LEADING HEAT TECHNOLOGY

ENABLING THE WORLD OF BLACK CERAMICS

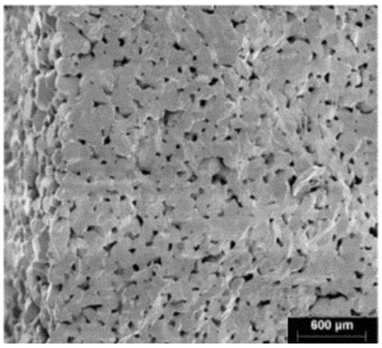
LHTG – HIGH TEMPERATURE GRAPHITE FURNACE

The LHTG graphite furnace is the perfect choice for laboratories, research facilities and industrial applications. Due to advanced heating technology, the high temperature furnace offers a superior performance and a precise temperature control. LHTG smart furnace is capable of achieving temperatures up to 3000 °C, making it ideal for a variety of applications.

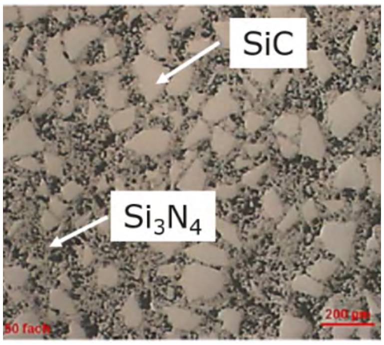
Graphitization
Sintering of Silicon Carbide (SiC)
Tungsten Carbide (WC)
Carbon Nanotubes & Graphene
Ceramic Matrix Composite (CMC)



The SEM image depicts an undersintered R-SiC microstructure. Here, unlike the larger grains, the smaller grains failed to recrystallize. LHTG ensures precise temperature control and uniformity throughout the sintering process to prevent an incomplete crystallization process.



The SEM image showcases the ideal R-SiC microstructure where the grains are tightly interconnected, and there are no fine grains visible. This high-performance material exhibits exceptional hardness, making it an excellent choice for a wide range of industrial applications.



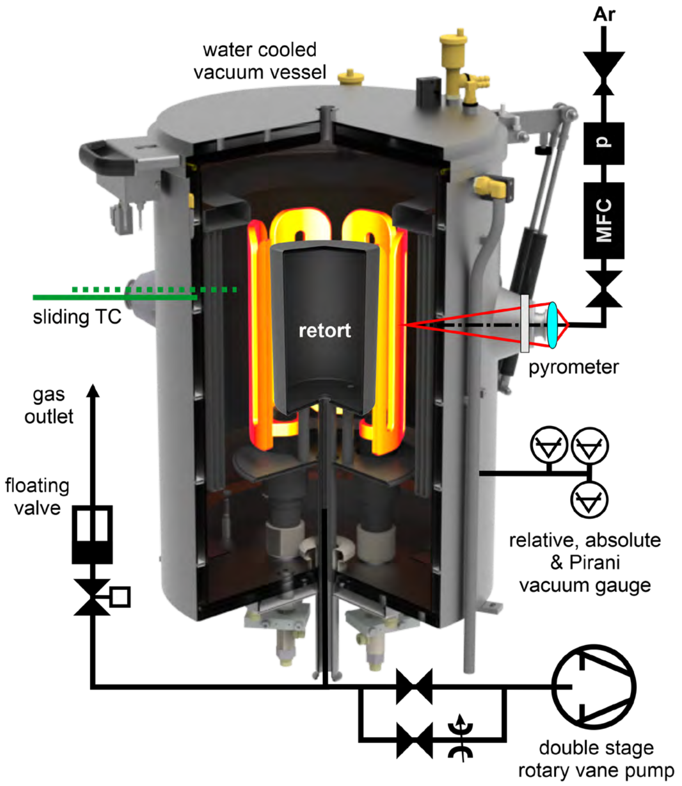
The light microscope image displays the microstructure of N-SiC, where SiC grains are embedded within a Si_3N_4 matrix. The material exhibits a porosity of 10%, which makes it an ideal choice for applications that require high mechanical strength and excellent thermal shock resistance.

LIQUID SILICON INFILTRATION

GRAPHITIZATION

WHY CHOOSE AN LHTG?

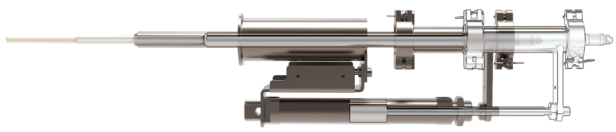
1. Precise temperature control at low temperatures with sliding thermocouple
2. Precise temperature control at high temperatures up to 2800 °C with pyrometer
3. Very low energy consumption due to our special design - WE AVOID PLASMA! It increases the furnace lifetime and lowers your energy costs
4. Standard safety features such as evacuating the furnace prior to each run, over-temperature and overpressure protection, and precise control systems for gas and cooling water
5. Compact design and small footprint makes this furnace ideal for your laboratory
6. Meander shaped heater design allows almost 360° heating



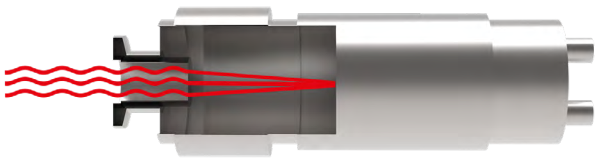
The cylindrical GRAPHITE RETORT prevents the samples from direct radiation and ensures a great temperature uniformity. Additionally, it guides gases through the gas outlet to the exhaust.

ADVANCED STANDARD FEATURES

- Mass flow controller **MFC** with integral bypass for fast refill after evactuation
- Pressure switch **P** monitors gas availability
- Relative, absolute and Pirani vacuum gauge
- Double stage rotary vane pump reduces cycle times and oxygen content



The SLIDING THERMOCOUPLE (sTC) controls perfectly at low temperatures. Between 900 and 1100 °C the sTC and pyrometer work simultaneously to double check its accuracy. Above 1100 °C the sTC slides out the hot zone and hands over the lead to the pyrometer.

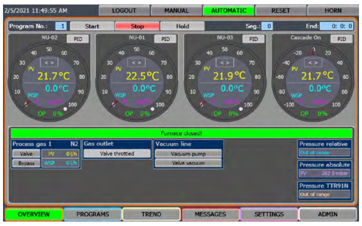


The PYROMETER receives radiation and senses it very well at high temperatures. To ensure optimum functionality an additional protection is offered by a small sapphire window. This prevents dust or dirt from condensing at the pyrometer lens.

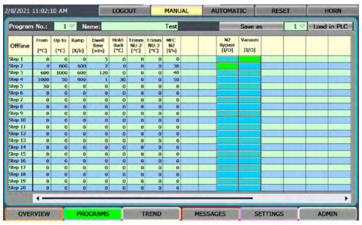
SMART CONTROL SYSTEM

TOUCH PANEL

- Siemens TP1200 Comfort (12.1" 1280x800 Pixel)
- Resistive incl. pen
- Windows CE
- Siemens S7 - 1200
- Ethernet & USB connection
- Storage of 12 programs
- 20 segments (steps, dwell times) per program
- All working setpoints and process values (temperature, gas flow, pressure, errors) stored in .csv file format
- Automatic & manual batch file saving for each furnace run
- Recording time resolution of 5 – 600 seconds
- 3 different user levels as standard
- English & German as standard languages
- Accessible and controllable via remote connection (e.g. VNC Viewer) from any device
- Mounted in Rittal® control cabinet with IP-class 54

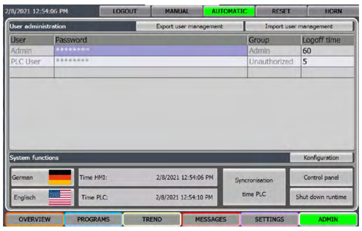


OVERVIEW SCREEN



INTUITIVE PROGRAM TABLE

DATA LOGGING & TREND VIEW



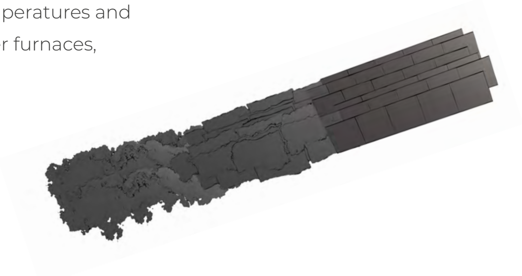
USER LEVEL MANAGEMENT

Please note: This unit is supposed to be for clean processes, that includes samples which do not release condensable volatiles. Any off-gasses would need further modifications to the furnace. We have experts and many different solutions in our portfolio to consult and guide you to the right choice.

★★★★★ **USER FEEDBACK**

"We bought the LHTG since it enables highest temperatures and lowest energy consumption compared to any other furnaces, which makes it perfect for our laboratory."

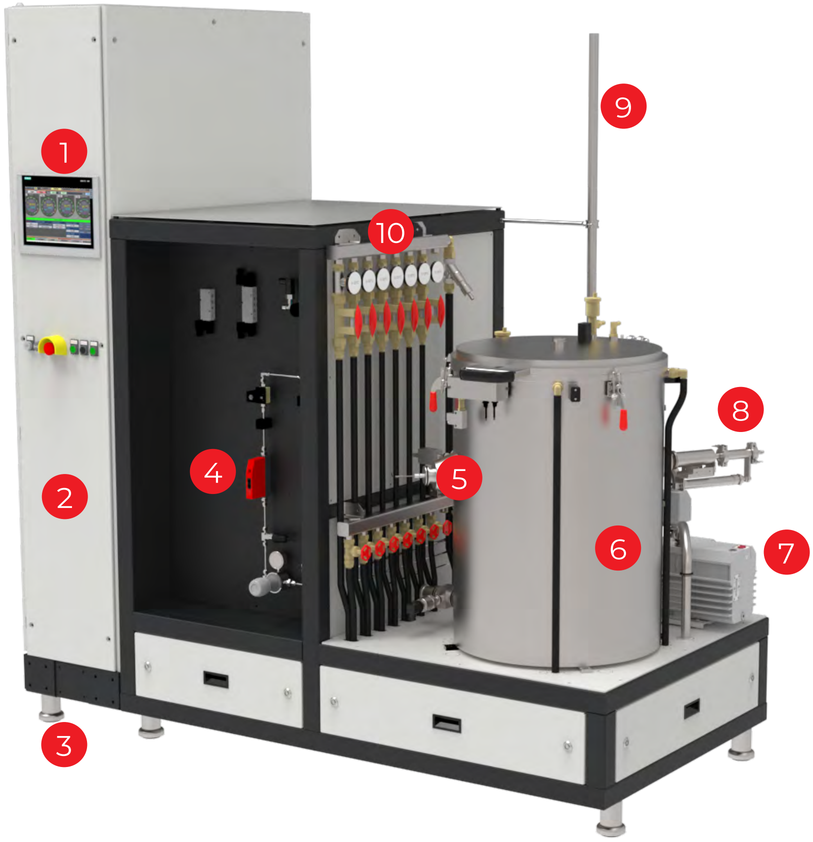
2023, University of Queensland



OVERVIEW & FOOTPRINT

PART IDENTIFICATION

1) 12” touch panel
2) Rittal® control cabinet
3) Adjustable feet
4) Mass flow controller
5) Over-temperature thermocouple
6) Vacuum vessel
7) Rotary vane pump
8) Sliding thermocouple
9) Gas outlet
10) Cooling water circuits



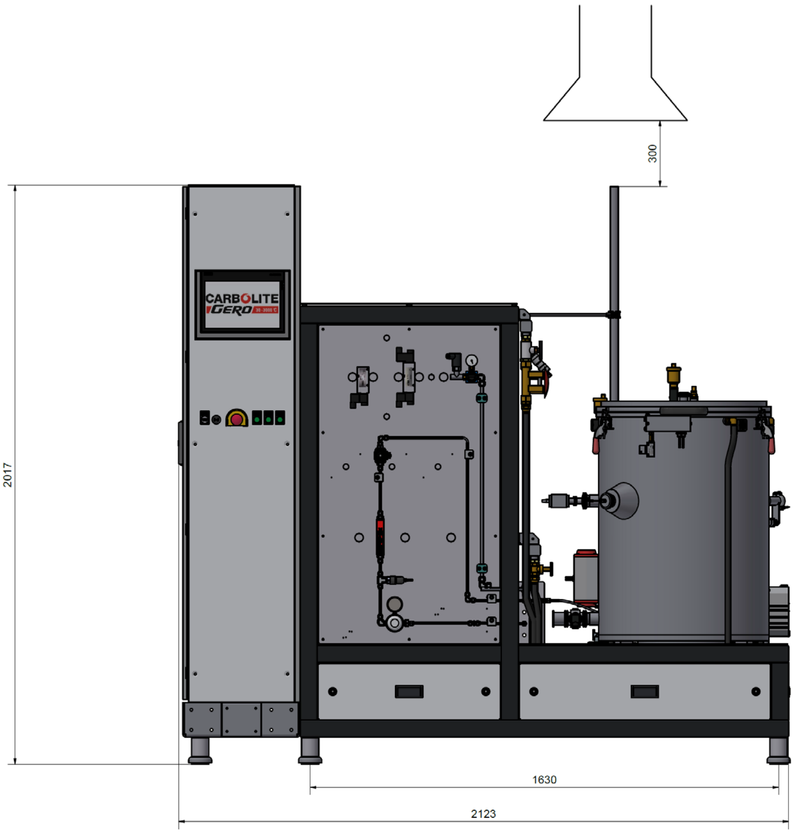
TECHNICAL DATA

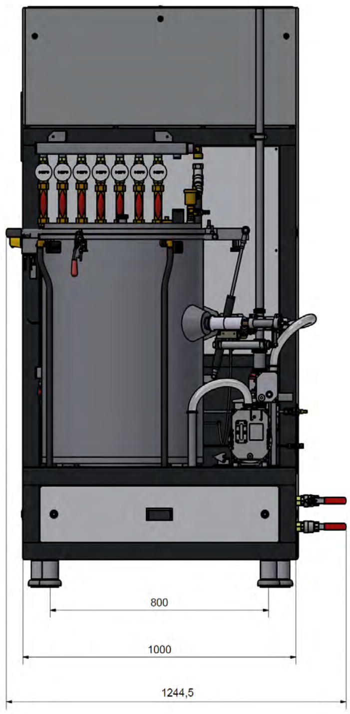
WHAT YOU GET !	
Tmax in argon (we recommend a dwell <30 min)	2800°C
Tmax in vacuum	2200°C
Gas flow rate	20 - 1000 L/h
Vacuum level	10^{-1} – 10^{-2} mbar
Furnace dimensions (HxWxD)	2250 x 2150 x 1250 mm
Total furnace weight	1100 kg
Volume retort	iD 190 x L 290 mm
Maximum sample weight	5 kg
Certification	Machinery directive / CE

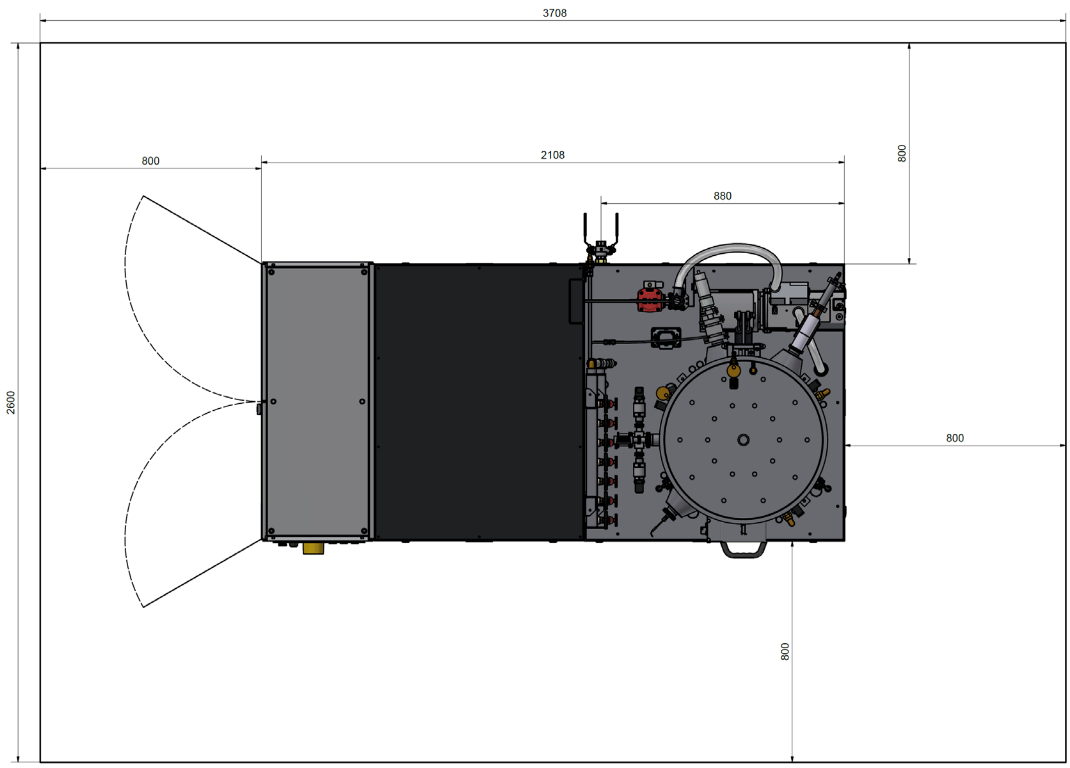
REQUIRED INFRASTRUCTURE

WHAT YOU NEED !	
Cooling water (Chiller) (requires separate power supply)	60 L/min 2x¾“ connection 2 – 4 bar abs.
Extraction system above furnace	200 m³/h
Compressed Air	7 bar abs.
Argon	7 bar abs.
Power supply	63 kW
Voltage	3 x 400 V + N + E
Pre-fuse	3 x 125 A

OVERVIEW & FOOTPRINT







1800 °C

HTF 27

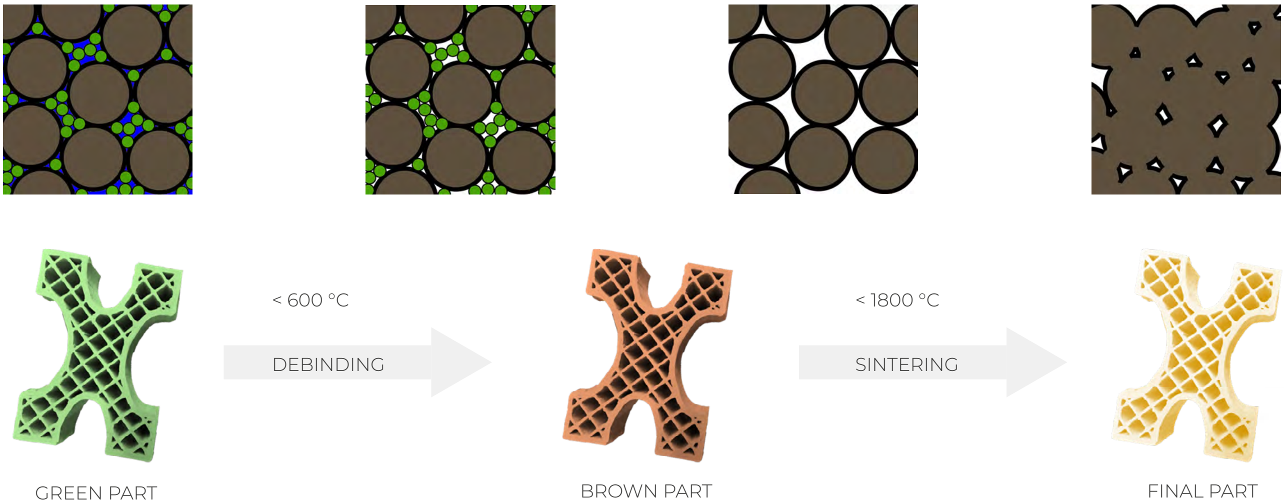
LEADING HEAT TECHNOLOGY

ENABLING THE WORLD OF TECHNICAL CERAMICS

HTF – ALL-IN-ONE DEBINDING & SINTERING

Carbolite Gero offers the HTF 18/27 furnace, a compact and versatile debinding and sintering solution for additive manufacturing. This furnace provides even heating by an arrangement of high-quality U-shaped molybdenum disilicide elements working up to a maximum temperature of 1800 °C.

Debinding
Sintering
CIM



In the 3D printing of metal or ceramic components using techniques such as binder jetting, lithography, or metal extrusion, a binder is typically used to maintain the integrity of the structure. It's essential to eliminate this binder from the green part to enable the sintering of the powder particles. A multi-stage debinding process is often employed, commencing with an initial debinding step at low temperatures up to 250 °C (which may only involve drying). Following this, the complete removal of organic materials occurs at temperatures ranging from 400 to 600 °C, resulting in the formation of the brown part.

During this process, off-gases and volatiles are handled using a binder trap or afterburner, which can be powered thermally or catalytically. After a final debinding step the part is sintered at approximately 80% of the metal's melting temperature. At this stage, all particles soften and begin to form interconnecting bridges, leading to a solid-state reaction and fusion. The complete removal of the binder is critical to ensure a low carbon content and to prevent a reduction in the material's melting point due to the formation of a eutectic phase.

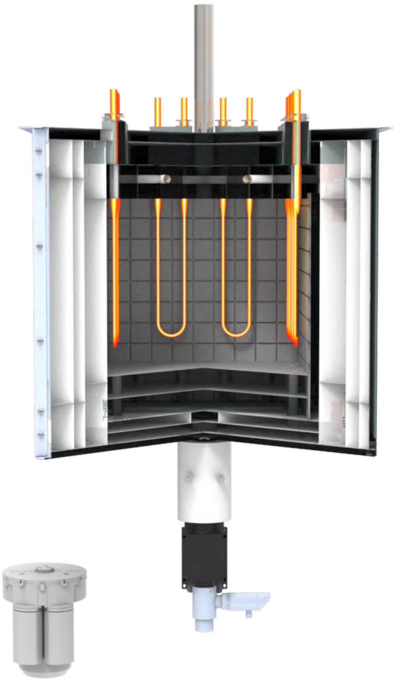
MORE INFORMATION ON TECH CERAMIC FURNACES

WEBPAGE

BROCHURE

WHY CHOOSE AN HTF?

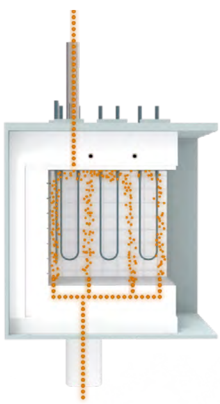
1. Versatile furnace with a small footprint, ideal for areas with space constraints
2. Robust design for temperatures at the sample of up to 1800 °C
3. Low energy consumption due to multiple insulation layers and intelligent design
4. Optimised pre-heated airflow for efficient binder removal



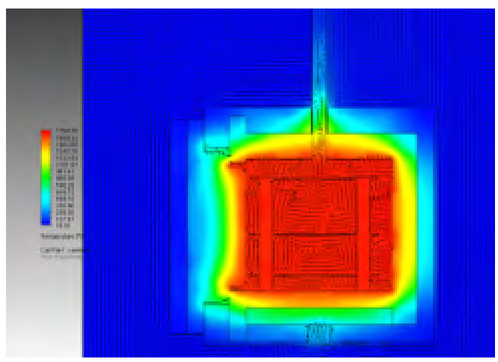
For safe combustion of binder gases and active propane gas after-burner or catalytic oxidizer can be provided.

ADVANCED STANDARD FEATURES

- Designed to withstand 1800 °C
- Plug & Play power and gas connections
- Gridded surface ensures the insulation tears in the right place
- High quality molybdenum disilicide heating elements
- Type B control thermocouple
- Motorised exhaust vent
- Reinforced hearth for loads up to 500 kg/m²



Optimised pre-heated air flow in the chamber of the HTF ensures that a continous airflow is maintained throughout the whole chamber, even when a rack is placed inside the furnace.

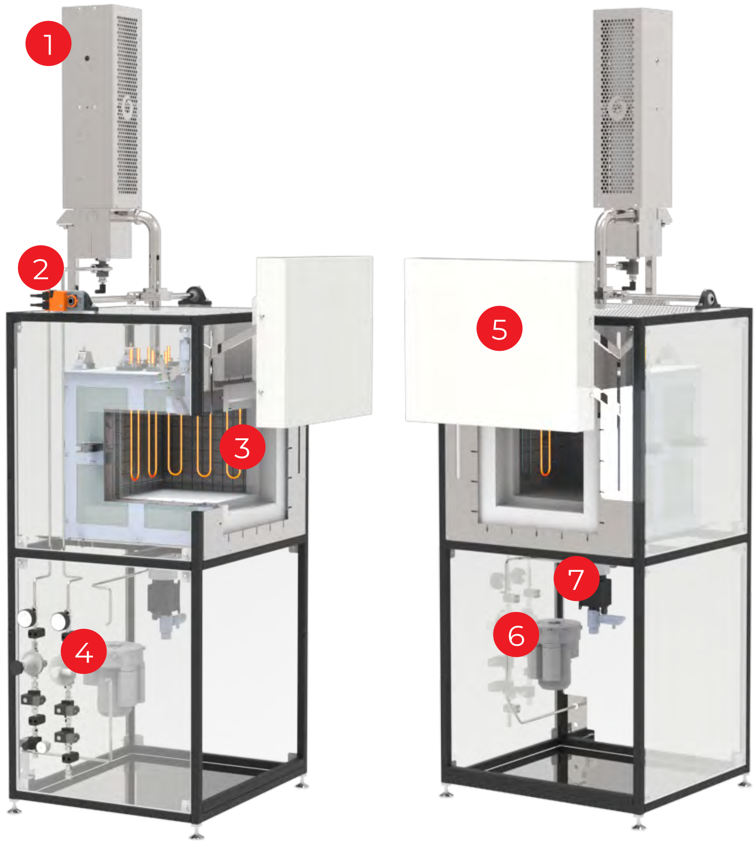


The HTF furnace has great temperature uniformity due to the advanced design and control systems which feature high quality elements and superior thermal insulation.

OVERVIEW & FOOTPRINT

PART IDENTIFICATION

1) Gas fired afterburner
2) Motorised damper
3) Molybdenum disilicide elements
4) Gas controls
5) Automatic door
6) Side channel blower
7) Air preheater



TECHNICAL DATA

WHAT YOU GET !	
Tmax furnace	1700 °C, 1800 °C
Tmax at sample	1700 °C, 1800 °C
Useable Chamber dimensions	300 x 300 X 300 mm
Furnace dimension (HxWxD) Debind option	1945 x 1290 x 1000 mm
Furnace dimension (HxWxD) Debind + Afterburner option	2790 x 1380 x 1135 mm
Total furnace weight	400 kg
Maximum sample weight	45 kg
Certification	CE & UKCA

REQUIRED INFRASTRUCTURE

WHAT YOU NEED !	
Extraction system above furnace Debind options	5 m³/h
Compressed Air	2470 L/h 7 bar abs.
Propane	130 L/h 50 – 100 mbar
Power supply 27 L / 64 L	10 kW / 16kW
Voltage	3 x 400 V + N + E, 50 Hz
Pre-fuse	3 x 32 A
Plug Furnace incl. 3 m cable	32 A CEE

CARBOLITE GERO 30-3000°C

1800 °C

HB 80

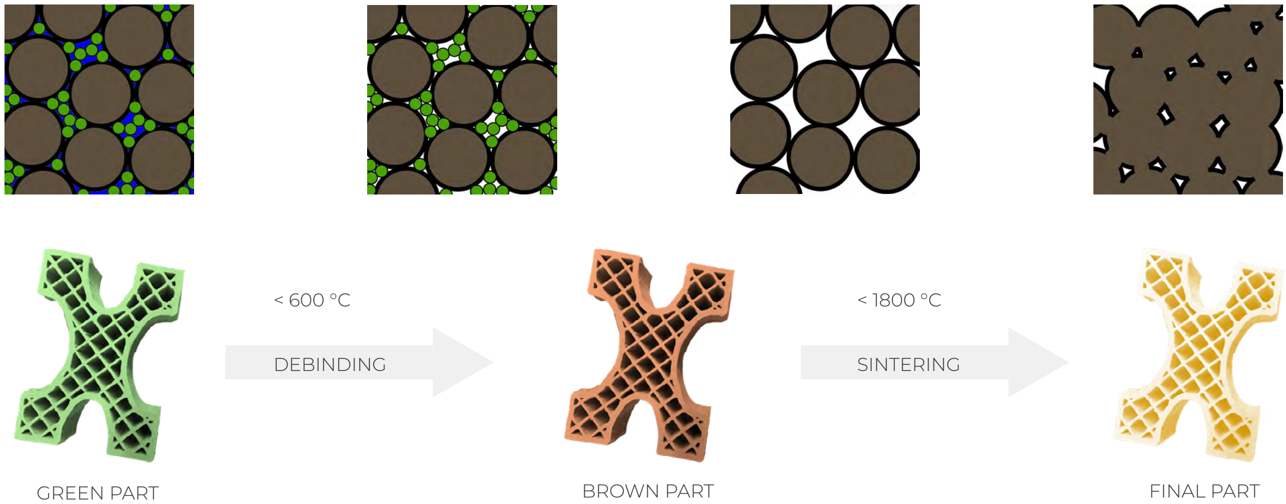
LEADING HEAT TECHNOLOGY

ENABLING THE WORLD OF TECHNICAL CERAMICS

HB – TOP HAT FURNACE

Carbolite Gero offers the HB furnace, a versatile debinding and sintering solution for technical ceramics. This furnace utlilises an optimized heating element arrangement that provides unique uniformity at high temperatures. For safe combustion of binder gases an active propane gas afterburner or catalytic oxidizer can be provided. The reinforced base plate allows for a surface load of 500 kg/m² which can be accessed from three sides by virtue of an automatically operated vertically moving hood.

CIM
Debinding
Sintering
Heat Treatment



In the 3D printing of metal or ceramic components using techniques such as binder jetting, lithography, or metal extrusion, a binder is typically used to maintain the integrity of the structure. It's essential to eliminate this binder from the green part to enable the sintering of the powder particles. A multi-stage debinding process is often employed, commencing with an initial debinding step at low temperatures up to 250 °C (which may only involve drying). Following this, the complete removal of organic materials occurs at temperatures ranging from 400 to 600 °C, resulting in the formation of the brown part.

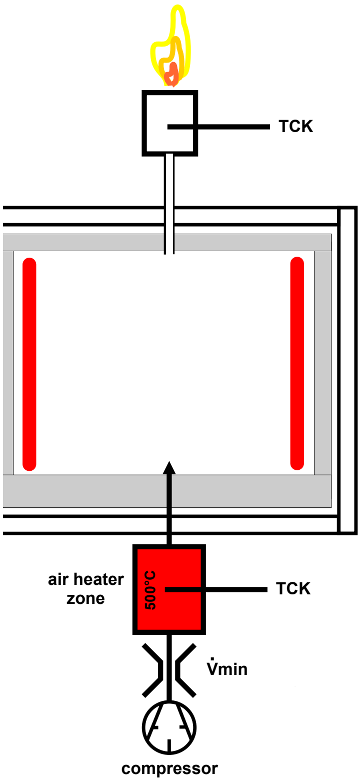
During this process, off-gases and volatiles are handled using a binder trap or afterburner, which can be powered thermally or catalytically. After a final debinding step the part is sintered at approximately 80% of the metal's melting temperature. At this stage, all particles soften and begin to form interconnecting bridges, leading to a solid-state reaction and fusion. The complete removal of the binder is critical to ensure a low carbon content and to prevent a reduction in the material's melting point due to the formation of a eutectic phase.

MORE INFORMATION ON TECH CERAMIC FURNACES

WEBPAGE

BROCHURE

WHY CHOOSE AN HB?

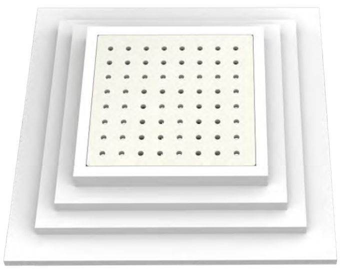


1. Versatile furnace with a small footprint, ideal for areas with space constraints
2. Robust design for temperatures at the sample of approx. 1700 & 1800 °C
3. Gridded surface ensures that the insultion tears at the right places
4. Low energy consumption due to multiple insulation layers and intelligent design
5. Advanced refractory interior used in combination with energy efficient low thermal mass insulation

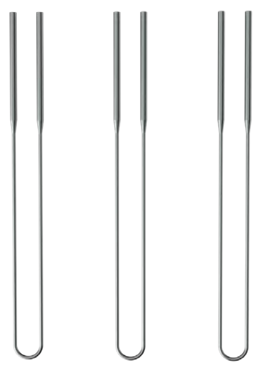
An active propane gas afterburner enhances safety in the combustion of volatile organic compounds released during debinding applications.

ADVANCED STANDARD FEATURES

- Vertically moving furnace hood for sample access from three sides
- $MoSi_2$ heating elements for models up to 1800 °C
- Plug & Play power connections
- Reinforced base for heavier loads



The reinforced hearth option of the HB ensures a stable hearth for heavy loads. This durability reduces the need for frequent repairs and replacements, extending the furnace's operational lifespan.

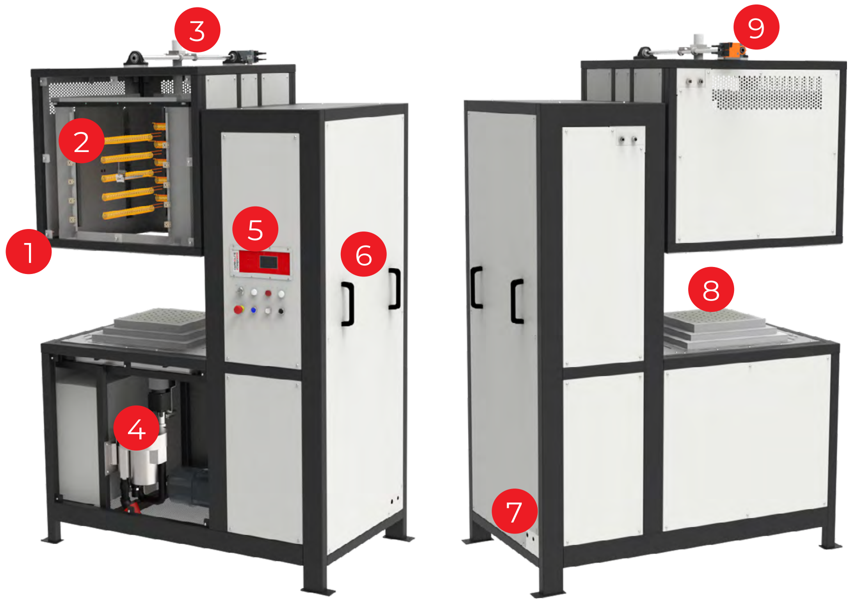


High-quality molybdenum disilicide ($MoSi_2$) elements for HTF form a protective silicon dioxide (SiO_2) layer at high temperatures, enhancing longevity and reliability in oxidizing atmospheres.

OVERVIEW & FOOTPRINT

PART IDENTIFICATION

1) Vertically moving hood
2) $MoSi_2$ heating elements
3) Gas exhaust pipe
4) Hot air blower
5) Touch panel controller
6) Removable back panel
7) Mains connections
8) Hearth
9) Motorised damper



TECHNICAL DATA

WHAT YOU GET !	
Tmax furnace	1700 °C, 1800 °C
Tmax at sample	1700 °C, 1800 °C
Furnace dimension (H x W x D) 8L 160 L	2580 x 1045 x 1650 mm 2525 x 1475 x 1650 mm
Total furnace weight 80 L 160 L	750 kg 1000 kg
Usable space (H x W x D)	500 x 400 x 400 mm
Maximum sample weight 80 L 160 L	100 kg 200 kg
Certification	CE / UKAS

REQUIRED INFRASTRUCTURE

WHAT YOU NEED !	
Extraction system above furnace	300 m³/h
Power supply 80 L / 160 L	18 kW / 30 kW
Voltage	3 x 400 V + N + E, 50 Hz
Pre-fuse 80 L / 160 L	3 x 25 A / 3 x 64 A

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