High-Temperature Tube Furnaces for Horizontal or Vertical Operation up to 1800 °C

The high-temperature tube furnaces are available in either horizontal (type RHTH) or vertical (type RHTV) designs. High-quality insulation materials made of vacuum-formed fiber plates enable energy-saving operation due to low heat storage and heat conductivity. By using different gas supply systems, operations can be performed under non-flammable or flammable protective or reactive gases or under vacuum.

Tube furnace RHTV 50/150/17 with stand and gas supply system 2

Standard Equipment

- Tmax 1600 °C, 1700 °C, or 1800 °C
- Single-zoned design
- Insulation with vacuum-formed ceramic fiber plates
- Tube furnaces RHTV with frame for vertical operation
- Type B thermocouple
- Ceramic working tube C 799 including two fiber plugs for operation under air see page 56
- Hanging and easy to change $MoSi_2$ heating elements
- Power unit with low-voltage transformer and thyristor
- Over-temperature limiter with adjustable cutout temperature as temperature limiter to protect the oven and load and with selectable maximum temperature gradient as tube protection
- Switchgear and control unit separate from furnace in separate floor standing cabinet
- Controller P470 (50 programs with each 40 segments), alternative controllers see page 75

RHTH 80/300/18 tube furnace with water-cooled flanges and charge control

Additional Equipment

- Charge control with temperature measurement in the working tube see page 62
- Three-zone control for optimization of temperature uniformity (only horizontal tube furnaces RHTH) see page 62
- Alternative working tubes see page 56
- Gas supply system 2 for non-flammable protective or reactive gas operation see page 58
- Gas supply packages 3 or 4 for hydrogen operation see page 60
- Vacuum package to evacuate the working tube see page 61

RHTH 120/600/18 with gas supply system 4 for operation with hydrogen

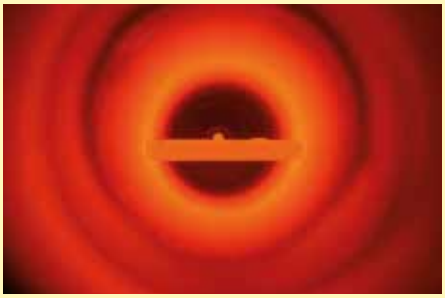
Model Horizontal design	Tmax[1]	Outer dimensions[3] in mm			Max. outer tube Ø	Heated length	Length constant temperature[1] +/– 5 K in mm		Tube length	Connected load	Electrical	Weight
	in °C	W[2]	D	H	in mm	in mm	single zoned	three zoned	in mm	in kW	connection*	in kg
RHTH 50/150/..	1600 or	470	480	640	50	150	50	70	380	5.4	3-phase[4]	70
RHTH 80/300/..	1700 or	620	550	640	80	300	100	150	530	9.0	3-phase[4]	90
RHTH 120/600/..	1800	920	550	640	120	600	200	300	830	14.4	3-phase[4]	110

Model Vertical design	Tmax[1] in °C	Outer dimensions[3] in mm W	D	H[2]	Max. outer tube Ø in mm	Heated length in mm	Length constant temperature[1] +/– 5 K in mm	Tube length in mm	Connected load in kW	Electrical connection*	Weight in kg
RHTV 50/150/..	1600 or	500	650	510	50	150	30	380	5.4	3-phase[4]	70
RHTV 80/300/..	1700 or	580	650	660	80	300	80	530	10.3	3-phase[4]	90
RHTV 120/600/..	1800	580	650	960	120	600	170	830	19.0	3-phase[4]	110

[1]Values outside the tube. Difference to temperature inside the tube up to + 50 K
[2]Without tube
[3]External dimensions vary when furnace is equipped with additional equipment. Dimensions on request.
[4]Heating only between two phases

*Please see page 75 for more information about supply voltage

Tube furnace RHTH 120/600/17



Sintering under hydrogen in a tube furnace of RHTH product line

Example of over-temperature limiter

Working Tubes

There are various working tubes available, depending on application and temperatures. The technical specifications of the different working tubes are presented in the following table:

Various working tubes as option

Material	Tube outside Ø in mm	Max. heat-up ramp in K/h	Tmax in air[3] in °C	Tmax in vacuum operation in °C	Gas tight
C 530 (Sillimantin)[1]	< 120 from 120	unlimited 200	1300	not possible	no
C 610 (Pythagoras)[1]	< 120 from 120	300 200	1400	1200	yes
C 799 (Alsint 99.7 %)[1]	< 120 from 120	300 200	1800	1400	yes
Quartz glass[2]	all	unlimited	1100	950	yes
FeCrAl-Alloy[2] (APM)	all	unlimited	1300	1100	yes

[1]Tolerances with respect to form and position acc. to DIN 40680
[2]All dimensions are nominal dimensions, tolerances on request
[3]The max. allowed temperature might be reduced operating under aggressive atmospheres

Measurements	Article No.[4]		Rotary tube furnace, continuous operation RSRC										Batch operation RSRB				
outer Ø x inner Ø x length	work tube	spare tube	1100 °C					1300 °C					1100 °C				
			80-500	80-750	120-500	120-750	120-1000	80-500	80-750	120-500	120-750	120-1000	80-500	80-750	120-500	120-750	120-1000
Ceramic tube C 530																	
80 x 65 x1540 mm	6000058702	691404536	○					●									
80 x 65 x 1790 mm	6000058701	691404537		○		○			●		○						
80 x 65 x 2040 mm	6000058700	691404538					○					○					
110 x 95 x 1540 mm	6000058704	691404539			○					●							
110 x 95 x 1790 mm	6000058703	691403376				○					●						
110 x 95 x 2040 mm	6000058216	691404540					○					●					
Ceramic tube C 610																	
80 x 65 x1540 mm	6000058707	691404541	○					○									
80 x 65 x 1790 mm	6000058706	691404542		○		○			○		○						
80 x 65 x 2040 mm	6000058705	691404543					○					○					
110 x 95 x 1540 mm	6000058709	691404544			○					○							
110 x 95 x 1790 mm	6000058708	691404561				○					○						
110 x 95 x 2040 mm	6000052969	691403437					○					○					
Quartz glass tube																	
76 x 70 x 1540 mm	6000058947	691404545	●					○		○							
76 x 70 x 1790 mm	6000054644	691404546		●		○			○		○						
76 x 70 x 2040 mm	6000058946	691404547					○					○					
106 x 100 x 1540 mm	6000058949	691403519			●					○							
106 x 100 x 1790 mm	6000058948	691403305				●					○						
106 x 100 x 2040 mm	6000030741	691404548					●					○					
Quartz glass tube with pimple																	
76 x 70 x 1540 mm	6000058953	691404549	○					○									
76 x 70 x 1790 mm	6000058952	691404550		○		○			○		○						
76 x 70 x 2040 mm	6000058951	691404551					○					○					
106 x 100 x 1540 mm	6000058956	691404552			○					○							
106 x 100 x 1790 mm	6000058955	691403442				○					○						
106 x 100 x 2040 mm	6000058954	691404553					○					○					
CrFeAl-Alloy																	
75 x 66 x 1540 mm	601405296	691405357	○		○			○		○							
75 x 66 x 1790 mm	601405297	691405231		○		○			○		○						
109 x 99 x 1540 mm	601405298	691403682			○					○							
109 x 99 x 1790 mm	601405299	691403607				○					○						
109 x 99 x 2040 mm	601405300	691405122					○					○					
Quartz glas reactor																	
76 x 70 x 1140 mm	601402746	691402548											●		○		
76 x 70 x 1390 mm	601402747	691402272												●		○	
106 x 100 x 1140 mm	601402748	691402629													●		
106 x 100 x 1390 mm	601402749	691402638														●	
106 x 100 x 1640 mm	600048571	600032705															●
Quartz glass reactor with pimples																	
76 x 70 x 1140 mm	601404723	691402804											○		○		
76 x 70 x 1390 mm	601404724	691403429												○		○	
106 x 100 x 1140 mm	601404725	691403355													○		
106 x 100 x 1390 mm	601404726	691403296														○	
Quartz glass mixing reactor																	
76 x 70 x 1140 mm	601404727	691403407											○				
76 x 70 x 1390 mm	601404728	691404554												○		○	
106 x 100 x 1140 mm	601404732	691404557													○		
106 x 100 x 1390 mm	601404733	691404558														○	

● Standard working tube
○ Working tube available as an option

[4]Tubes/reactors incl. mounted sleeves for connection to the rotary drive. Spare tubes come without sleeves.

Working tube outer Ø x inner Ø x length	Article No.	Model																				
		R					RSH/RSV								RHTC			RHTH			RHTV		
		50-250	50-500	120-500	170-750	170-1000	50-250	50-500	80-500	80-750	120-500	120-750	120-1000	170-750	170-1000	80-230	80-450	80-710	50-150	80-300	120-600	50-150	80-300	120-600
C 530																								
40 x 30 x 450 mm	692070274	○					○																	
40 x 30 x 700 mm	692070276		○	○				○	○		○													
50 x 40 x 450 mm	692070275	●					●																	
50 x 40 x 700 mm	692070277		●	○				●			○													
60 x 50 x 850 mm	692070305			○					○		○													
60 x 50 x 1100 mm	692070101				○									○										
80 x 70 x 850 mm	692070108			○					●		○													
80 x 70 x 1100 mm	692070109				○					●		○												
120 x 100 x 850 mm	692070110			●							●													
120 x 100 x 1100 mm	692070111				○							●		○										
120 x 100 x 1350 mm	692070131					○							●											
170 x 150 x 1100 mm	692071659				●									●										
170 x 150 x 1350 mm	692071660					●									●									
Vacuum tube[1] C 610																								
50 x 40 x 650 mm	692070207	○					○																	
50 x 40 x 900 mm	691405352		○					○																
60 x 50 x 1230 mm	692070180			○					○		○													
60 x 50 x 1480 mm	692070181				○					○		○		○										
80 x 70 x 1230 mm	692070182			○					○		○													
80 x 70 x 1480 mm	692070183				○					○		○		○										
120 x 100 x 1230 mm	692070184			○							○													
120 x 100 x 1480 mm	692070185				○							○		○										
120 x 100 x 1730 mm	692070186					○							○		○									
170 x 150 x 1480 mm	692070187				○									○										
170 x 150 x 1730 mm	692070188					○									○									
C 799																								
50 x 40 x 380 mm	692071664																		●			●		
50 x 40 x 450 mm	691403622	○																						
50 x 40 x 530 mm	692071665																			○			○	
50 x 40 x 690 mm	692071714		○																					
50 x 40 x 830 mm	692070163																				○			○
80 x 70 x 530 mm	692071669																			●			●	
80 x 70 x 600 mm	692070600															●								
80 x 70 x 830 mm	692071670																●				○			○
80 x 70 x 1080 mm	692071647																	●						
120 x 105 x 830 mm	692071713																				●			●
Vacuum tube[1] C 799																								
50 x 40 x 990 mm	692070149																		○			○		
50 x 40 x 1140 mm	692070176																			○			○	
50 x 40 x 1440 mm	692070177																				○			○
80 x 70 x 990 mm	692070190															○								
80 x 70 x 1140 mm	692070148																			○			○	
80 x 70 x 1210 mm	692070191								○		○						○							
80 x 70 x 1470 mm	692070192									○		○		○				○						
80 x 70 x 1440 mm	692070178																				○			○
120 x 105 x 1440 mm	692070147																				○			○
APM vacuum tube[2] with grinded ends																								
51 x 38 x 650 mm	691406358	●					●																	
51 x 38 x 900 mm	691406359		●					●																
51 x 38 x 1480 mm	691406360				○					○				○										
51 x 38 x 1730 mm	691406361					○							○		○									
60 x 52 x 1230 mm	691406362			○					○		○													
60 x 52 x 1480 mm	691406363				○					○		○		○										
60 x 52 x 1730 mm	691406364					○							○		○									
75 x 66 x 1230 mm	691406206			○					●		○													
75 x 66 x 1480 mm	691406365				○					●		○		○										
75 x 66 x 1730 mm	691406366					○							○		○									
115 x 104 x 1230 mm	691406367			●							●													
115 x 104 x 1480 mm	691406325				○							●		○										
115 x 104 x 1730 mm	691406368					○							●		○									
164 x 152 x 1480 mm	691406339				●									●										
164 x 152 x 1730 mm	691406370					●									●									
Vacuum quartz glass tube																								
50 x 40 x 650 mm	691403182	○					○																	
50 x 40 x 900 mm	691406024		○					○																
60 x 54 x 1030 mm	691404422																							
60 x 54 x 1230 mm	691404423			○					○		○													
60 x 54 x 1480 mm	691404424				○					○		○		○										
80 x 74 x 1230 mm	691404425			○					○		○													
80 x 74 x 1480 mm	691404426				○					○		○		○										
120 x 114 x 1230 mm	691404427			○							○													
120 x 114 x 1480 mm	691404428				○							○		○										
120 x 114 x 1730 mm	691404429					○							○		○									
170 x 162 x 1480 mm	691404430				○									○										
170 x 162 x 1730 mm	691404431					○									○									

● Standard working tube
○ Working tube available as an option

[1]With ground tube ends for connection of water-cooled flanges
[2]With attached holder for gas tight flange

Gas Supply Systems/Vacuum Package for Tube Furnaces

When equipped with different gas supply systems, most tube furnace product lines can be adapted for operation with non-flammable or flammable gases or for vacuum operation.

Fiber plug with protective gas connection, suitable for many laboratory applications (gas supply system 1)

Gas Supply System 1

For Non-Flammable Protective or Reactive Gases in Static Tube Furnaces, not Gas-Tight

Gas supply system 1 is a basic version for static tube furnaces, for operation with non-flammable protective or reactive gases. This system is not completely gas-tight and can therefore not be used for vacuum operation.

Standard Equipment

- Available for RD, R, RT, RHTC, RSH and RSV tube furnaces
- Two plugs made of porous, non-classified ceramic fiber incl. protective gas connections
- The standard working tube supplied with the furnace can be used
- Gas panel for one non-flammable protective or reactive gas (N_2, Ar, He, CO_2, air, forming gas*)
- Shut-off valve and flow meter with manual valve
- Supply of gas with 300 mbar required

Additional Equipment

- Additional gas panels for further non-flammable gases
- Automatic segment-related switching on/off by a magnetic valve
- Bottle pressure reducer for use with bottled gas

Flange with heat radiation protection insert (gas supply system 15)

Gas Supply Systems 15 and 2

for Non-Flammable Protective or Reactive Gases in Static Tube Furnaces, Gas-Tight

For increased atmospheric purity requirements in the working tube in static tube furnaces we recommend one of these gas-tight gas supply systems with stainless steel flanges on the end of the tube is recommended.

The less expensive gas supply system 15 for furnaces up to 1300 °C and working tubes to 120 mm diameter is available for R, RSH and RSV tube furnaces. It includes contact protection on the flange and a stainless steel type 1.4301 heat radiation protection insert for the tube ends to protect the seals. A heat radiation protection package cools the flanges and a water connection is thus not required. With this variant, the tube must not be opened while it is hot. It is also not suitable for applications with a turbomolecular pump to achieve high vacuum. Gas supply system 2 is the correct choice for this type of application.

Water-cooled vacuum flange (gas supply system 2)

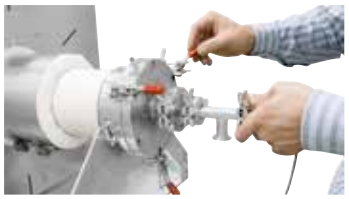
Gas supply system 2 with water-cooled flanges is available for R, RHTC, RHTH, RHTV, RSH and RSV furnaces. Cooling water supply with NW9 hose connector to be provided by the customer.

Standard Equipment

- Extended gas-tight working tube made of C 610 for furnaces up to 1300 °C or C 799 for temperatures above 1300 °C
- Two vacuum-tight stainless steel flanges with KF flange on the outlet side
- Mounting system on furnace for the flanges

* Country-specific regulations for permissible mixture ratios must be observed.

- Gas panel for one non-flammable protective or reactive gas(N_2, Ar, He, CO_2, air, forming gas*)
- Shut-off valve and flow meter with manual valve
- Supply of gas with 300 mbar required
- Check valve in the gas outlet to prevent air entering



Water-cooled stainless steel flanges with quick locks as additional equipment

Additional Equipment for Gas Supply Systems 15 and 2

- Additional gas panels for further non-flammable gases
- Automatic segment-related switching on/off by a magnetic valve
- Bottle pressure reducer for use with bottled gas
- Vacuum package for a maximum final pressure of up to 5 x 10^{-5} mbar

Other Additional Equipment only for Gas Supply System 2

- Quick-locks for water-cooled flanges
- Air-water heat exchanger for closed loop water circuit
- Window for charge observation

Window as additional equipment for gas-tight flanges

Gas Supply Systems 25 and 26

for Non-Flammable Protective or Reactive Gases in Rotary Tube Furnaces, Gas-Tight

Gas supply systems for non-flammable protective and reactive gases are also available for RSRB and RSRC rotary tube furnaces.

Standard Equipment

- Gas panel for one non-flammable protective or reactive gas (N_2, Ar, He, CO_2, air, forming gas*)
- Shut-off valve and flow meter with manual valve
- Supply of gas with 300 mbar required

Gas supply system 25 for rotary tube furnaces for batch operation (RSRB) also includes gas-tight rotary lead-outs on the gas inlet and outlet as well as a gas cooler at the outlet. A check valve is also installed at the gas outlet to prevent air entering the tube.

For gas supply system 26 for rotary tube furnaces for continuous processes (RSRC) the furnace must also be equipped with a feeding system.

Gas panel for one non-flammable protective or reactive gas
(N_2, Ar, He, CO_2, air, forming gas*)

Additional Equipment

- Additional gas panels for further non-flammable gases
- Automatic segment-related switching on/off by a magnetic valve
- Bottle pressure reducer for use with bottled gas
- Vacuum package for a maximum final pressure of up to 5 x 10^{-2} mbar

* Country-specific regulations for permissible mixture ratios must be observed.

Gas Supply System 3

for Hydrogen Applications in Tube Furnaces above 750 °C

Gas supply system 3 allows for the operation in a hydrogen atmosphere at temperatures above 750 °C. From 750 °C, hydrogen can be introduced into the working tube. At program end or when the temperature falls below 750 °C , the working tube is purged with nitrogen to prevent the formation of an explosive hydrogen/oxygen atmosphere. The purging volume is at least five times the volume of the tube. Surplus hydrogen is burnt off in an exhaust gas torch.

Example of an over-temperature limiter

Standard Equipment

- Available for R, RHTC, RHTH, RHTV, RSH, RSV, RSRB and RSRC tube furnaces
- Gas panel for hydrogen and nitrogen
- Automatic segment-related switching on/off by a magnetic valve
- Nabertherm Controller to regulate the temperature curve and switch the gas supply system
- Additional safety controls with touch panel to monitor hydrogen gassing only above 750 °C
- Exhaust gas torch with temperature monitoring
- Over-temperature limiter with digital display as over-temperature protection for the furnace and charge
- Temperature monitoring at the gas inlet
- Emergency purge container for nitrogen

Gas panels with mass flow controllers

Additional Equipment

- Additional gas panels for further non-flammable gases
- Gassing via program-related controllable mass flow controllers
- Bottle pressure reducer for use with bottled gas
- Air-water heat exchanger for closed loop water circuit (not for RSRB and RSRC)

Gas Supply System 4

for Hydrogen Applications in Tube Furnaces from Room Temperature

Gas supply system 4 allows operation with a hydrogen atmosphere starting at ambient temperature. During hydrogen operation, a pressure of approx. 30 mbar is ensured in the working tube. At the gas outlet the hydrogen is burnt off in an exhaust gas torch. Equipped with a safety PLC control system, pre-purging, hydrogen inlet, operation, fault monitoring and purging at the end of the process are carried out automatically (with at least five times the volume of the tube). If a malfunction occurs, the tube is immediately purged with nitrogen and the system is automatically switched to a safe status.

Example of a torch

Standard Equipment

- Available for R, RHTC, RHTH, RHTV, RSH, RSV, RSRB and RSRC tube furnaces
- Gas panel for hydrogen and nitrogen
- Automatic segment-related switching on/off by a magnetic valve
- Control via safety PLC control system with touch panel
- Exhaust gas torch with temperature monitoring
- Over-temperature limiter with digital display as over-temperature protection for the furnace and charge
- Excess pressure monitoring
- Emergency purge container for nitrogen

Additional Equipment

- Additional gas panels for further non-flammable gases
- Operation with other flammable gases
- Gassing via program-related controllable mass flow controllers
- Bottle pressure reducer for use with bottled gas
- Air-water heat exchanger for closed loop water circuit (apart from RSRB and RSRC)

Furnace-unrelated measuring device for a pressure range of 10^{-3} mbar or 10^{-9} mbar

Assignment of Gas Supply Systems to Furnace Models

Model	Gas supply system						
	1	15	2	25	26	3	4
RD	●						
R	●	●	●			●	●
RT	●						
RHTC	●		●			●	●
RHTH			●			●	●
RHTV			●			●	●
RSH	●	●	●			●	●
RSV	●	●	●			●	●
RSRB				●		●	●
RSRC					●	●	●

Single-stage rotary vane pump

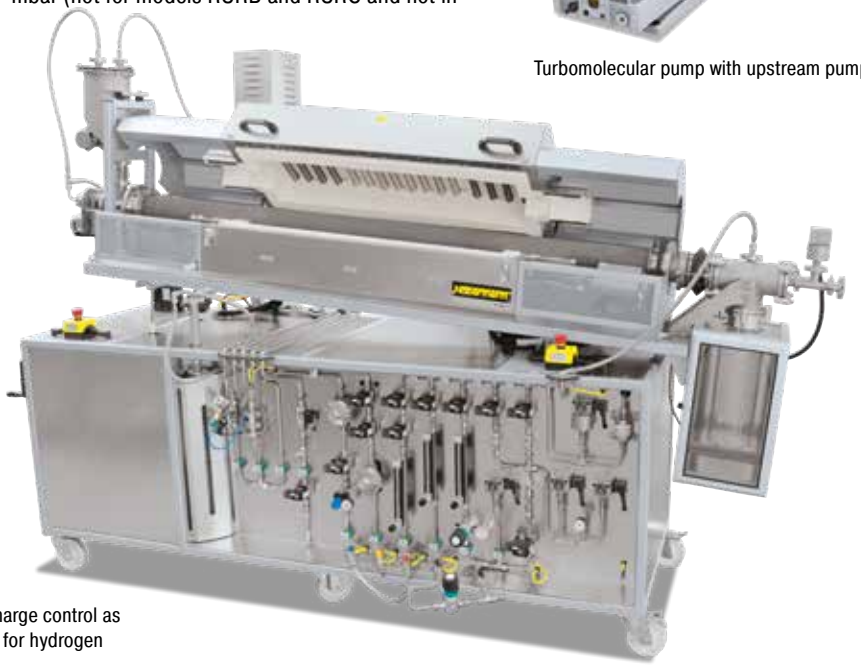
Vacuum Package

The vacuum package enables the working tube to be evacuated for vacuum operation in tube furnaces. It consists of an intermediate component for the gas outlet, a ball valve, a pressure gauge and a manually operated vacuum pump that is connected to the gas outlet by a corrugated stainless steel hose. A gas-tight furnace system is required for the use of a vacuum package, e.g. with the gas-supply packages 15, 2, 25 or 26. To protect the vacuum pump, only cold stage evacuation is allowed. The pump can then remain switched during the running program. The maximum ultimate pressure in the working tube depends on the type of pump.

Two-stage rotary vane pump

- Single-stage rotary vane pump for an achievable ultimate pressure of approx. 20 mbar
- Two-stage rotary vane pump for an achievable ultimate pressure of approx. 5 x 10^{-2} mbar
- Turbomolecular pump system, consisting of a diaphragm pump with downstream turbomolecular pump for an achievable ultimate pressure of up to approx. 5 x 10^{-5} mbar (not for models RSRB and RSRC and not in combination with gas supply package 15)

Turbomolecular pump with upstream pump



Rotary tube furnace RSRC 120/1000/11 H_2 with three-zone control, charge control as well as FeCrAl working tube, feeding system and gas supply system 4 for hydrogen operation