

## Gradient Tube Furnaces

**The Carbolite Gero range of gradient tube furnaces are design to provide a temperature ramp along the length of a work tube.**

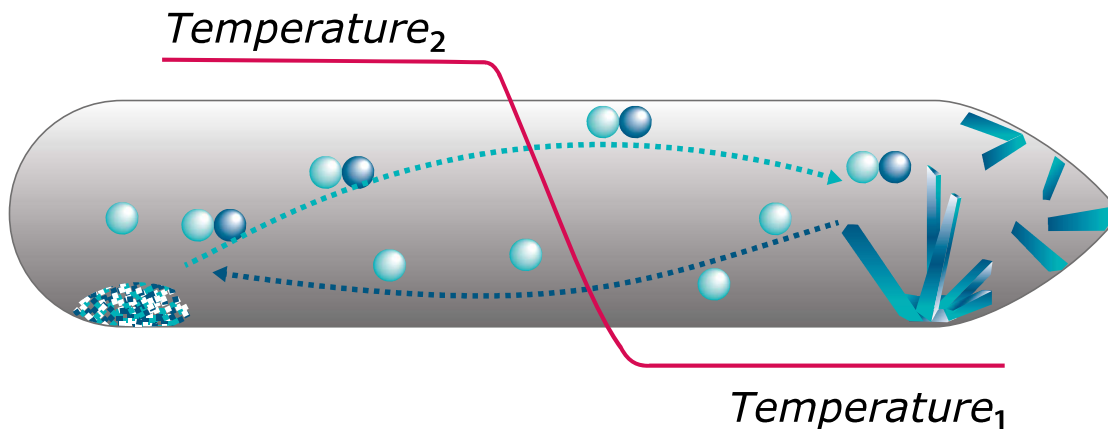
A gradient tube furnace is divided into a number of heating 'zones' along the length of the furnace. Each zone has its own individual temperature controller which can be set to independent temperatures, achieving a pre-determined temperature profile along the work tube.

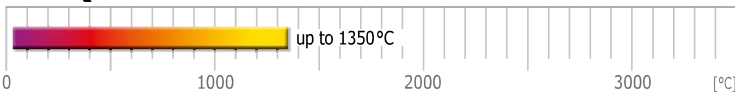
Some heat will naturally transfer between adjacent heating zones and therefore zone barriers are employed in the TG models to minimize this effect. The AZ models are not equipped with heat barriers. Examples of heating profiles are shown on each product page.

### Chemical vapour transport (CVT) and physical vapour transport (PVT) reactions

- The gradient furnace can be used to heat a reactor tube to provide the two distinct temperatures required in chemical vapour transport reactions
- Materials are vaporized in the hotter zone and condense in the cooler zone
- Extended tube furnace packages options are available to provide a sealed environment for this process
- Vacuum pump packages are also available if vacuum pressure is required
- High quality single crystals can be grown using this equipment.

Chemical vapour transport (CVT) and physical vapour transport (PVT) reactions





## AZ – 8-Zone Tube Furnaces

The AZ is an eight zone tube furnace for controlled temperature profiles. These zones can be used to generate temperature profiles along the heated length of the furnace.

With eight zones, thick insulation, and highly symmetrical winding of the heating elements throughout the entire AZ furnace, a uniformity of better than  $\pm 5^\circ\text{C}$  is achieved. A key advantage of the eight individually controlled zones is the extension of the uniform length inside the furnace. Additionally, the temperature profile can be precisely controlled for linear increases, peaks, or other user defined profiles. One process well suited for the AZ tube furnace is chemical vapour deposition as a temperature gradient can be established in the furnace for evaporation of precursor material at the high temperature end zone and



AZ 13/110/1000: This picture shows the high vacuum equipment and touch panel controller option

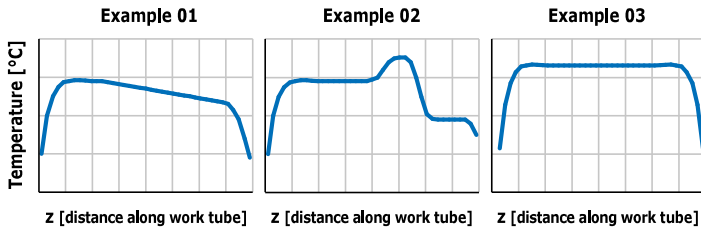
### Standard features

- Similar construction to FHA / FHC tube furnaces on pages 16 – 17
- Eight-zone control for variable heating profiles
- Gradients, linear increase/decrease etc. of temperature along the heated length
- Extended uniform temperature distribution
- Short heating and cooling rates
- Automatic operation
- Data recording for quality management
- Retransmission of setpoint
- Over-temperature controller with independent thermocouple

sublimation of the vapour on to the substrate at the cooler temperature end zone. All zones are individually controlled and monitored with thermocouples.

### Options (specify these at time of order)

- A range of sophisticated digital controllers, multisegment programmers and data loggers with digital communication options is available (see pages 36 – 40)
- Wide choice of tube diameters and materials is available. See pages 41 for tube materials
- 'L' stand for vertical usage
- Insulation plugs & radiation shields to prevent heat loss & improve uniformity (see page 45)
- Modified atmosphere and vacuum assemblies are available (see page 45)
- Vacuum packages with a choice of rotary vane pump or turbomolecular pump are available (page 46)
- Complete automation by Siemens SPS control with touch panel and mass flow controller for the gases on request
- Other diameters and heated lengths on request



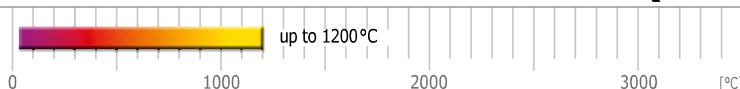
Three typical possible temperature profiles inside the furnace. The eight zones give maximum flexibility.

## Technical data

Model	Max. temp. [°C]	Dimensions: Max. Diameter accessory tube [mm]	Dimensions: Heated length [mm]	Dimensions: External H x W x D* [mm]	Transport weight** [kg]	Voltage [V]
AZ 13/32/360	1350	32	360	990 x 1800 x 500	500	400 (3P)
AZ 13/50/430	1350	50	430	990 x 1800 x 500	550	400 (3P)
AZ 13/80/810	1350	80	810	990 x 1800 x 500	600	400 (3P)
AZ 13/110/1000	1350	110	1000	1200 x 1800 x 520	650	400 (3P)

**i** Please note:  
- Maximum continuous operating temperature is 100°C below maximum temperature

\*Small models are supplied with a separate control box  
\*\*Max. weight including a high vacuum pumping station



## Compact Gradient Split Tube Furnaces

**These compact split tube furnaces are specifically design to provide a temperature gradient along the length of the heated zones. They use free radiating wire elements embedded within the insulation of the furnace body. The benefit of this design is its flexibility; with the use of tube adapters the same furnace can be used with a variety of tube diameters.**

The TG2 furnace has two independent zones and TG3 has three independent zones. They are split tube furnaces that comprise a furnace body which is hinged and split into two halves along its length. This makes exchange of work tubes easier and also enables the furnace to be used with reactors or work tubes where end flanges would make insertion into a non-split furnace difficult. The TG2 furnace includes a 25 mm long unheated zone barrier between the two heated zones and the TG3 has two 75 mm long unheated zone barriers between the three heated zones. Each heated zone has its own temperature controller and thermocouple. This range of tube furnaces does not include an integral work tube which must be selected as an additional item. Should vacuum or a modified atmosphere be required, it is necessary to use a separate slide-in work tube of adequate length needed to fit end seals. This information can be found on pages 42–43. The use of a separate work tube has the advantage of protecting the heating elements from damage or contamination.

Note: The temperature gradient achievable is influenced by work tube diameter. Larger gradients will be achieved with smaller diameter work tubes because heat transfer between zones will be less.



TG2 12/125/425



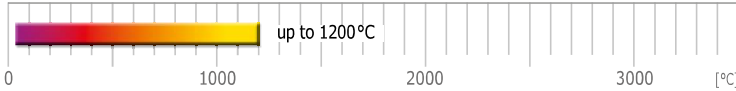
TG3 12/60/600

### Standard features

- 1200°C maximum operating temperature
- Each zone has a Carbolite Gero EPC3016P1 programmable temperature controller with 24 segments
- TG3 12/60/600. Overall heated length of 600 mm divided into three 150 mm heated zones with two 75 mm unheated zone barriers
- TG2 12/125/425. Overall heated length of 425 mm divided into two 200 mm heated zones with a 25 mm unheated zone barrier
- Wire elements in high quality vacuum formed insulation ensure fast heat up, excellent temperature control and short cool down times
- Furnace splits into two halves and accommodates tubes or samples fixed into a test rig
- Furnace body detachable from the control box to allow use of optional mounting arrangements (see pages 6–7)
- Control module with 2 metre cable to furnace with plug and socket

### Options (specify these at time of order)

- Over-temperature protection for each heated zone (recommended to protect valuable contents & for unattended operation)
- A range of additional work tubes (page 41), end seals (page 44) and work tube packages (pages 42–43) is available for use with modified atmosphere and/or vacuum
- Vacuum packages with a choice of rotary vane pump or turbomolecular pump are available (page 46)
- Wide choice of tube diameters and materials is available.
- See page 41 for tube materials
- Insulation plugs and radiation shields to prevent heat loss
- Vertical mounting stand for the furnace body including bracket for mounting the furnace body to customer's equipment
- 4 m long extension cable to give a total 6 m length of cable between furnace body and control box
- Gas packages with manual valve (page 47)
- Gas packages with electrically operated valve for up to 2 gases (page 47)



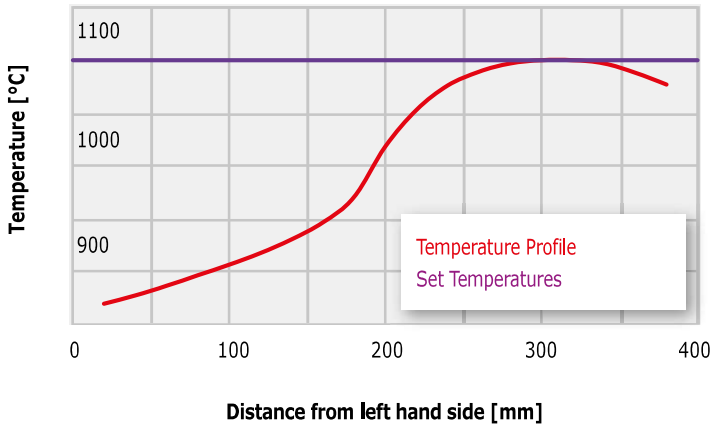
## Heat treatment

A sample could be moved between two temperature zones to achieve a desired heat cycle without waiting for a single zone furnace to heat or cool.

**Temperature Gradient, Horizontal TG2 12/125/425.**

80 mm OD worktube.

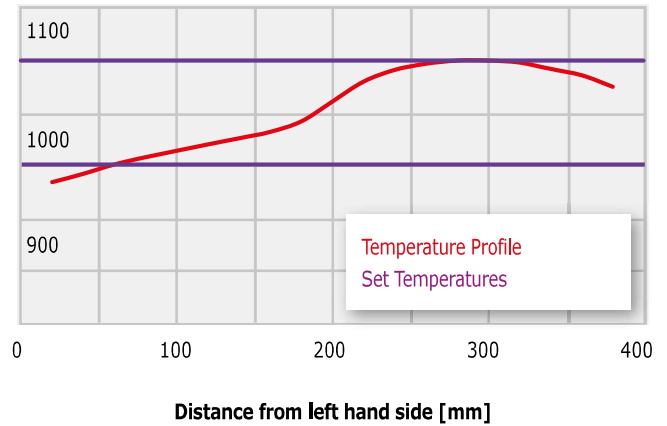
Setpoints: **zone 1: off, zone 2: 1100°C**



**Temperature Gradient, Horizontal TG2 12/125/425.**

80 mm OD worktube.

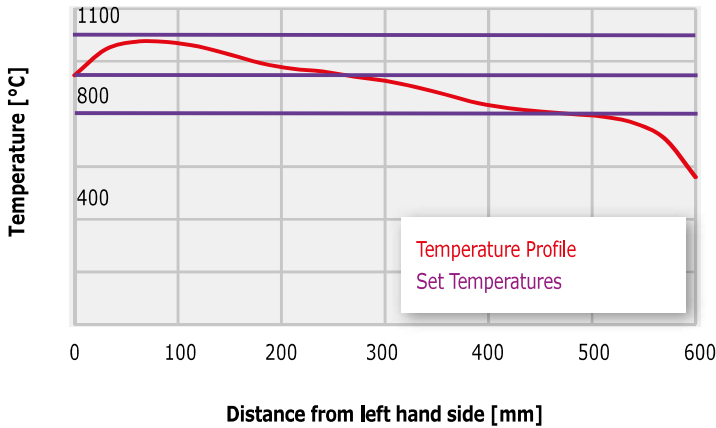
Setpoints: **zone 1: 1000°C, zone 2: 1100°C**



**Temperature Gradient, Horizontal TG3 12/60/600.**

60 mm OD worktube.

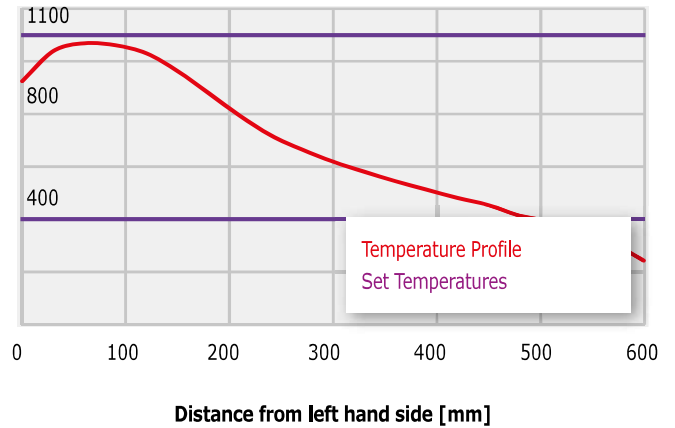
Setpoints: **zone 1: 1100°C, zone 2: 950°C, zone 3: 800°C**



**Temperature Gradient, Horizontal TG3 12/60/600.**

60 mm OD worktube.

Setpoints: **zone 1: 1100°C, zone 2: off, zone 3: 400°C**



## Technical data

Model	Max. temp. [°C]	Heat-up time [mins]	Dimensions: Max. outer Ø accessory tube [mm]	Dimensions: Overall heated length [mm]	Recommended tube length		Dimensions: External Furnace H x W x D [mm]	Dimensions: Control module H x W x D [mm]	Max. power [W]	Thermo-couple type	Weight [kg]
					for use in air [mm]	for use with modified atmosphere [mm]					
TG3 12/60/600	1200	-	60	600	880	1050	560 x 795 x 480	220 x 785 x 480	2000	N	56
TG2 12/125/425	1200	134	125	425	750	1000	645 x 665 x 575	220 x 655 x 480	1860	N	71

**i Please note:**

- Heat up time is measured to 100°C below max, using an empty quartz tube & insulation plugs
- Heat up rate when using an optional ceramic work tube must be limited to 5°C/min
- Holding power is measured at continuous operating temperature

- Temperature gradients are measured with insulation plugs fitted
- Maximum continuous operating temperature is 100°C below maximum temperature