Additive Manufacturing

Heat Treatment of Additive Manufactured Parts

Retort Furnaces
Chamber Furnaces
Forced Convection Furnaces
Annealing Furnaces
Protective Gas Boxes
Furnaces for Debinding
Sintering Furnaces
High-Temperature Furnaces
Ovens
Chamber Ovens

www.nabertherm.com
Made in Germany
Nabertherm with 500 employees worldwide have been developing and producing industrial furnaces for many different applications for 70 years. As a manufacturer, Nabertherm offers a very wide and deep range of furnaces. 150,000 satisfied customers in more than 100 countries offer proof of our commitment to excellent design, quality and cost efficiency. Short delivery times are assured due to our complete inhouse production and our wide variety of standard furnaces.

Setting Standards in Quality and Reliability
Nabertherm does not only offer a wide range of standard furnaces. Professional engineering in combination with in house manufacturing provide for individual project planning and construction of tailor-made thermal process plants with material handling and charging systems. Complete thermal processes are realized by customized system solutions.

Innovative Nabertherm control technology provides for precise control as well as full documentation and remote monitoring of your processes. Our engineers apply state-of-the-art technology to improve the temperature uniformity, energy efficiency, reliability and durability of our systems with the goal of enhancing your competitive edge.

Global Sales and Service Network – Close to you
Nabertherm’s strength is one of the biggest R&D departments in the furnace industry. In combination with central manufacturing in Germany and decentralized sales and service close to the customer we can provide for a competitive edge to live up to your needs. Long term sales partners in all important world markets ensure individual on-site customer service and consultation. There are certainly reference customers who are using similar furnaces or systems close to you.

Large Customer Test Center
What furnace is the right choice for this specific process? This question cannot always be answered easily. Therefore, we have set up our modern test center which is unique in respect to size and variety. A representative number of furnaces is available for tests for our customers.

Customer Service and Spare Parts
Our professional service engineers are available for you worldwide. Due to our complete inhouse production, we can despatch most spare parts from stock over night or produce with short delivery time.

Experience in Many Fields of Thermal Processing
In addition to furnaces for additive manufacturing, Nabertherm offers a wide range of standard furnaces and plants for many other thermal processing applications. The modular design of our products provides for customized solutions to you individual needs without expensive modifications.
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Additive manufacturing allows for the direct conversion of design construction files into fully functional objects. With 3D-printing objects, from metals, plastics, ceramics, glass, sand or other materials are built-up in layers until they have reached their final shape.

Depending on the material, the layers are interconnected by means of a binder system or by laser technology.

Many methods of additive manufacturing require subsequent heat treatment of the manufactured components. The requirements for the furnaces for heat treatment depend on the component material, the working temperature, the atmosphere in the furnace and, of course, the additive production process.

Apart from the choice of the right model and process parameters the previous processes before the heat treatment also have an influence on the overall result. One important criteria for a good surface quality is that the components are cleaned properly before the heat treatment.

This is particularly important for the processes that are carried out under vacuum or in furnaces that have a high requirement for a low residual oxygen content. Minor leaks or contamination can lead to insufficient results. For this reason, regular cleaning and maintenance of the furnace is important.

In additive manufacturing, a distinction is made between printing with and without binder. Depending on the manufacturing process, different furnace types are used for the subsequent heat treatment.
Binder-Free Systems

In binder-free additive manufacturing, in most cases, the components are produced with the powder-based laser melting process on a printing platform. In the meantime, other manufacturing processes have also become established on the market, which likewise require a corresponding heat treatment after the production process.

The tables below show typical materials and construction platform sizes of laser-based systems that are available on the market with suggestions with respect to furnace sizes, required temperature and atmosphere in the furnace.

**Aluminum Components**

Generally, aluminum is heat treated in air at temperatures between 150 °C and 450 °C.

Due to the very good temperature uniformity, forced convection chamber furnaces are suitable for processes such as tempering, aging, stress-relieving or preheating.

<table>
<thead>
<tr>
<th>Platform sizes</th>
<th>Forced convection chamber furnaces, see page 42</th>
</tr>
</thead>
<tbody>
<tr>
<td>210 x 210 mm</td>
<td>NA 30/45</td>
</tr>
<tr>
<td>280 x 280 mm</td>
<td>NA 60/45</td>
</tr>
<tr>
<td>360 x 360 mm</td>
<td>NA 120/45</td>
</tr>
<tr>
<td>480 x 480 mm</td>
<td>NA 250/45</td>
</tr>
<tr>
<td>600 x 600 mm</td>
<td>NA 500/45</td>
</tr>
</tbody>
</table>

*Also available for 650 °C and 850 °C

**Stainless Steel and Titanium Components**

In many cases, certain stainless steels and titanium are heat treated in a protective gas atmosphere at temperatures below 850 °C.

By using a protective gas box with the corresponding process gas supply, a standard furnace can be upgraded to a protective gas furnace. Depending on the type of process gas, the preflushing rate, the process flushing rate, and the condition of the box, it is possible to achieve residual oxygen concentrations of up to 100 ppm.

The forced convection chamber furnaces with protective gas boxes described below have a working temperature range between 150 °C and 850 °C. If the protective gas boxes are removed from the furnace, aluminum or steel components can also be heat treated in air.

<table>
<thead>
<tr>
<th>Platform sizes</th>
<th>Forced convection chamber furnaces, see page 42</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 x 100 mm</td>
<td>N 30/85 HA</td>
</tr>
<tr>
<td>200 x 200 mm</td>
<td>N 60/85 HA</td>
</tr>
<tr>
<td>280 x 280 mm</td>
<td>N 120/85 HA</td>
</tr>
<tr>
<td>400 x 400 mm</td>
<td>N 250/85 HA</td>
</tr>
<tr>
<td>550 x 550 mm</td>
<td>N 500/85 HA</td>
</tr>
</tbody>
</table>

The models listed in the table above are just a few examples.
Inconel or Cobalt-Chromium Components

Materials such as Inconel and cobalt-chromium are generally heat treated at temperatures from 850 °C up to between 1 100 °C and 1 150 °C. Various furnace families are used for these processes. In many cases, the chamber furnaces of the LH .. or NW .. series with protective gas boxes are sufficient to provide an outstanding price/performance ratio. Both furnace groups are suitable for temperatures between 800 °C and 1100 °C.

Examples for Chamber furnaces see page 30 and 34

<table>
<thead>
<tr>
<th>Platform sizes</th>
<th>Chamber furnaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 x 100 mm</td>
<td>LH 30/12</td>
</tr>
<tr>
<td>250 x 250 mm</td>
<td>LH 120/12</td>
</tr>
<tr>
<td>400 x 400 mm</td>
<td>LH 216/12</td>
</tr>
<tr>
<td>420 x 520 mm</td>
<td>NW 440</td>
</tr>
<tr>
<td>400 x 800 mm</td>
<td>NW 660</td>
</tr>
</tbody>
</table>

Cold-wall retort furnaces are used for processes in protective gas at temperatures above 1100 °C or under vacuum above 600 °C.

Examples for Cold-wall retort furnaces see page 22

<table>
<thead>
<tr>
<th>Platform sizes</th>
<th>Cold-wall retort furnaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 x 100 mm</td>
<td>VHT 8/..</td>
</tr>
<tr>
<td>250 x 250 mm</td>
<td>VHT 40/..</td>
</tr>
<tr>
<td>350 x 350 mm</td>
<td>VHT 70/..</td>
</tr>
<tr>
<td>400 x 400 mm</td>
<td>VHT 100/..</td>
</tr>
</tbody>
</table>

1Available with different heater materials and for different max. temperatures

With sensitive materials, such as titanium, the component may still oxidize due to the residual oxygen concentration in the protective gas box.

In these cases, hot-wall retort furnaces with a maximum temperature of 900 °C or 1100 °C are used. These gas tight retort furnaces are ideal for heat treatment processes that require a defined protective or reaction gas atmosphere. The compact models can also be designed for heat treatment under vacuum up to 600 °C. The risk of oxidation on the component is considerably reduced with these furnaces.

Examples for Hot-wall retort furnaces see page 14

<table>
<thead>
<tr>
<th>Platform sizes</th>
<th>Hot-wall retort furnaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 x 200 mm</td>
<td>NR 20/11 and NR(A) 17/..</td>
</tr>
<tr>
<td>300 x 300 mm</td>
<td>NR 80/11 and NR(A) 50/..</td>
</tr>
<tr>
<td>300 x 500 mm</td>
<td>NR 80/11 and NR(A) 75/..</td>
</tr>
<tr>
<td>400 x 400 mm</td>
<td>NR 160/11 and NR(A) 150/..</td>
</tr>
<tr>
<td>400 x 800 mm</td>
<td>NR 160/11 and NR(A) 300/..</td>
</tr>
</tbody>
</table>

Inconel or Cobalt-Chromium Components

Materials such as Inconel and cobalt-chromium are generally heat treated at temperatures from 850 °C up to between 1100 °C and 1150 °C. Various furnace families are used for these processes.
**Systems with Binder**

In 3D printing, organic binders, which evaporate during heat treatment, are used to build-up the part. The printed parts can be made of ceramic, metal, glass or sand. Depending on the evaporation volume, furnaces with graduated safety systems for debinding and sintering are used.

On pages 10 and 11 the different concepts are presented in a decision matrix and explained on the following pages.

<table>
<thead>
<tr>
<th>Printing dimensions up to (w x d x h)</th>
<th>Debinding furnaces(^1)</th>
<th>Sintering furnaces(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>see catalog Advanced Materials</td>
<td>see catalog Advanced Materials</td>
</tr>
<tr>
<td>100 x 100 x 100 mm</td>
<td>L 9/11 BO</td>
<td>LHT 4/16</td>
</tr>
<tr>
<td>200 x 200 x 150 mm</td>
<td>L 9/11 BO</td>
<td>HT 40/16</td>
</tr>
<tr>
<td>300 x 400 x 150 mm</td>
<td>L 40/11 BO</td>
<td>HT 64/17</td>
</tr>
</tbody>
</table>

\(^1\) Values for debinding like max. organic content, or evaporation rate have to be considered

\(^2\) The furnaces are available with different max. furnace chamber temperatures

---

**Debinding and Sintering in Protective or Reaction Gas or under Vacuum**

To protect metal components that were printed using a binder-based system against oxidation, two process steps, debinding and sintering, are carried out in an oxygen-free atmosphere.

Depending on the material and the binder system, debinding is carried out either in a non-flammable protective gas (IDB), under hydrogen (H\(_2\)), or catalytically in a mixture of nitric acid and nitrogen. Adapted safety systems are used to ensure the safety of these processes.

The table contains examples of furnaces which can be equipped with suitable safety technology. Hot-wall retort furnaces are used as debinding furnaces and cold-wall retort furnaces as sintering furnaces. Under certain circumstances, depending on the application, it is possible to use the same furnace for both processes.

<table>
<thead>
<tr>
<th>Printing dimensions up to (w x d x h)</th>
<th>Hot-wall retort furnaces(^1)</th>
<th>Cold-wall retort furnaces(^2,3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>see page 14</td>
<td>see page 22</td>
</tr>
<tr>
<td>100 x 180 x 120 mm</td>
<td>NRA 17/..</td>
<td>VHT 8/..</td>
</tr>
<tr>
<td>180 x 320 x 170 mm</td>
<td>NRA 17/..</td>
<td>VHT 25/..</td>
</tr>
<tr>
<td>230 x 400 x 220 mm</td>
<td>NRA 50/..</td>
<td>VHT 40/..</td>
</tr>
<tr>
<td>300 x 450 x 300 mm</td>
<td>NRA 50/..</td>
<td>VHT 70/..</td>
</tr>
<tr>
<td>400 x 480 x 400 mm</td>
<td>NRA 150/..</td>
<td>VHT 100/..</td>
</tr>
</tbody>
</table>

\(^1\) Safety systems see page 16 and 19, max. oven chamber temperatures see page 14

\(^2\) Available with different heater materials and for different max. temperatures

\(^3\) With inner process chamber for the residual debinding
**Which Furnace for Which Process?**

The next two double pages give an overview of which furnaces can be used in additive manufacturing for which process. This double page describes furnaces which can be used for processes in which no combustible substances escape.

<table>
<thead>
<tr>
<th>Atmosphere</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum Temperature</strong></td>
<td></td>
</tr>
<tr>
<td>300 °C</td>
<td>850 °C</td>
</tr>
<tr>
<td><strong>Requirement Oxygen Content</strong></td>
<td></td>
</tr>
<tr>
<td>21 %</td>
<td>21 %</td>
</tr>
<tr>
<td><strong>Vacuum</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
</tr>
<tr>
<td><strong>Flammable Process Gas</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
</tr>
<tr>
<td><strong>Furnace Type</strong></td>
<td></td>
</tr>
<tr>
<td>TR, page 60</td>
<td>NA, page 42</td>
</tr>
<tr>
<td>KTR, page 62</td>
<td>SAL, page 48</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Furnace Heating</strong></td>
<td>Electric</td>
</tr>
</tbody>
</table>

Chamber oven KTR 2000 for curing after 3D-printing
Chamber furnace LH 60/12 with protective gas box for heat treatment in a protective gas atmosphere
Forced convection chamber furnace NA 250/45 for heat treatment in air
### Process Gas

<table>
<thead>
<tr>
<th>Temperature</th>
<th>1100 °C</th>
<th>1150 °C</th>
<th>2400 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>0,01 %</td>
<td>0,00 %</td>
<td>0,00 %</td>
</tr>
<tr>
<td>Vacuum</td>
<td>&lt; 10⁻⁵ mbar</td>
<td>&lt; 10⁻⁵ mbar</td>
<td>&lt; 10⁻⁵ mbar</td>
</tr>
<tr>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

### Vacuum

<table>
<thead>
<tr>
<th>Temperature</th>
<th>≤ 600 °C</th>
<th>≥ 600 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>0,00 %</td>
<td>0,00 %</td>
</tr>
<tr>
<td>Vacuum</td>
<td>≤ 10⁻⁵ mbar</td>
<td>≤ 10⁻⁵ mbar</td>
</tr>
<tr>
<td></td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

**With protective gas box**
- LH, page 30
- NW, page 34
- N, page 36
- NA*, page 42
- SAL*, page 48
- NR(A), page 14
- SR(A), page 21
- LBR(A), page 20
- VHT, page 22
- LBVHT, page 27
- NR(A), page 14
- SR(A), page 21
- LBR(A), page 20
- VHT, page 22
- LBVHT, page 27

### Electric

- SAL 250/65
- Cold-wall retort furnace VHT 100/12-MO for processes in high vacuum
- Semi-automatic annealing plant with retort furnace NR 50/11 and water quenching bath on rails

*Tmax 850 °C
## Concepts for Drying, Debinding and Sintering of Parts with Binder Content

<table>
<thead>
<tr>
<th>Process</th>
<th>Drying Solvents</th>
<th>Air</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmosphere</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Temperature for Debinding</td>
<td>300 °C</td>
<td>450 °C</td>
<td>450 °C</td>
</tr>
<tr>
<td>Organic Quantity</td>
<td>Organic quantity low</td>
<td>Organic quantity low</td>
<td>Organic quantity low</td>
</tr>
<tr>
<td>Requirement</td>
<td>Low requirement for temperature uniformity</td>
<td>Increased requirement for temperature uniformity</td>
<td>Increased requirement for temperature uniformity</td>
</tr>
<tr>
<td>Concept</td>
<td>LS</td>
<td>LS</td>
<td>DB10</td>
</tr>
<tr>
<td>Furnace Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For Debinding</td>
<td>KTR, page 62</td>
<td>NA .. LS, page 42</td>
<td>NA .. 45 DB10, page 42</td>
</tr>
<tr>
<td>For Debinding and/or Sintering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Treatment of Exhaust Gases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Furnace Heating</td>
<td>Electric</td>
<td>Gas</td>
<td></td>
</tr>
</tbody>
</table>

1) Air  
2) Protective gas
Debinding

**Inert**
- 650 °C
- Organic quantity low to high
- Increased requirement for temperature uniformity
- DB100
- Monitored air exchange. Pre heated fresh air. Furnace in overpressure.
- NA .. IDB, page 42
- N .. HA IDB, page 42
- HT .. DB100, page 58
- Separate catalytic afterburning system
- Separate thermal afterburning system
- Thermal afterburning

**Reaction gas**
- 600 °C
- Organic quantity low to high
- Low residual oxygen concentration
- IDB
- Thermal debinding in inert atmosphere. Monitored safe inert gas purging.
- NRA .. IDB, page 16
- SRA .. IDB, page 21
- NR .. IDB, page 16
- SR .. IDB, page 21
- VHT .. IDB, page 22
- Thermal afterburning
- Flare

**Catalytic**
- 120 °C
- Organic quantity low to high
- High requirement for temperature uniformity
- IDB
- Thermal debinding in nitrogen/nitric acid atmosphere. Monitored safe Nitrogen purging to displace the oxygen.
- NRA .. CDB, page 19
- NR .. H2, page 16
- SR .. H2, page 21
- VHT .. H2, page 22
- Flare

**Electric**
- Increased requirement for temperature uniformity
- Monitored air exchange.
- Pre heated fresh air.
- Furnace in overpressure.
- Separate catalytic afterburning system
- Separate thermal afterburning system
- Thermal afterburning
- Flare

**Other**
- HT .. DB100, page 58
- NRA .. IDB, page 16
- SRA .. IDB, page 21
- NR .. IDB, page 16
- SR .. IDB, page 21
- VHT .. IDB, page 22
- NRA .. H2, page 16
- SR .. H2, page 21
- VHT .. H2, page 22
- Flare

**Symbols**
- IDB
- NRA
- SRA
- VHT
- HT
- DB100
During debinding e.g. from technical ceramics, hydrocarbons are released, which might generate an ignitable mixture depending on their concentration in the furnace chamber. Nabertherm offers tailor-made passive and active safety packages depending on the process and the amount of binder, which enable safe operation of the furnace.

I. Debinding in Air

Debinding in an Electrically Heated Furnace

For debinding in air with electric heating Nabertherm offers various debinding packages tailored to the individual process requirements. All debinding packages have professional integrated safety technology. Passive or active safety concepts are available, depending on the specific requirements. The passive safety concepts differ upon the requirements for the quantity of organic materials, process reliability, and temperature distribution.

Passive Safety Concept

Nabertherm debinding furnaces are generally equipped with a passive safety concept to allow for a slow vaporization of flammable substances. The electrically heated furnaces work according to the dilution principle by introducing fresh air to reduce the degassing from the charge to a non-ignitable atmosphere in the furnace. The customer has to define the quantity of organic materials as well as the temperature curve, to make sure that the maximum permissible rate of vaporization is not exceeded. Thus, the customer is responsible for the function of the safety concept. The furnace DB safety package monitors all safety-relevant process parameters and initiates a respective emergency program in case of a malfunction. The passive safety concept has proven itself in practice based to its good price performance ratio. Depending on the process requirements, the following equipment packages are available.

DB10 Debinding Package for Air Circulation Furnaces (Convection Heating) up to 450 °C

The DB10 debinding package is the basic option for safe debinding in air circulation furnaces up to 450 °C. The furnace is equipped with an exhaust gas fan providing for a defined volume of air which is extracted from the furnace, thus allowing the volume of fresh air required for the debinding process to enter the furnace. The furnace is operated with negative pressure, which prevents an undefined emission of vaporization products.

Debinding Package for Laboratory Furnaces

The ashing furnaces have a passive safety system and integrated exhaust gas post combustion. An exhaust gas fan extracts flue gases from the furnace and simultaneously supplies fresh air to the furnace atmosphere with the result that sufficient oxygen is always available for the incineration process. The incoming air is guided behind the furnace heating and preheated to ensure good temperature uniformity. Exhaust gases are led from the furnace chamber to the integrated post combustion system, where they are postburned and catalytically cleaned. Directly after the incineration process (up to max. 600 °C) a subsequent process up to max. 1100 °C can take place.
II. Safety Concept EN 1539 (NFPA 86) to Dry Liquid Solvents in Ovens

The safety technology of furnaces and dryers used for processes in which solvents or other flammable substances are released and vaporized relatively quickly is regulated throughout Europe in EN 1539 (or NFPA 86 in the USA).

Typical applications are drying of mold varnish, surface coatings, and impregnating resins. Users include the chemical industry as well as many other areas, such as the automotive, electric, plastic processing and metalworking industries.

The safety concept relates to preventing the formation of explosive mixtures through continuous air exchange in the entire vapor space.

III. Debinding or Pyrolysis under Non-Flammable or Flammable Protective or Reaction Gases

IDB Safety Concept for Debinding in Protective Gas Boxes under Non-Flammable Protective Gases with Low Residual Oxygen

The IDB safety concept with an inert atmosphere in protective gas boxes is ideal for debinding processes under protective gas where a small amount of residual oxygen for the materials is permitted. The furnace technology in combination with a protective gas box made from heat-resistant stainless steel has a very good price performance ratio.

A monitored inert gas pre-flushing and conservation flushing during the process ensure that a residual oxygen concentration of 3% is not exceeded in the protective gas box. The customer must check this limit value with regular measurements.

IDB Safety Concept in Retort Furnaces for Debinding under Non-Flammable Protective Gases or for Pyrolysis Processes

The retort furnaces in the NR(A) and SR(A) series are ideal for debinding under non-flammable protective gases or for pyrolysis processes. With the IDB option, the furnace chamber is flushed with protective gases. Exhaust gases are incinerated in an exhaust gas torch. The flushing and the torch function are monitored to ensure safe operation.

Safety Concept for Heat Treatment under Flammable Process Gases

If flammable process gases, such as hydrogen, are used, the retort furnace is also equipped and delivered with the required safety technology. Only components with the corresponding certification are used as safety-relevant sensors. The furnace is controlled by a failsafe PLC control system (S7300/safety control).

CDB Safety Package for Catalytic Debinding with Nitric Acid

The safety concept prevents explosive gas mixture forming when the furnace is operated with nitric acid. For this purpose, the gastight retort is automatically flushed with a controlled flow of nitrogen which displaces the atmospheric oxygen before nitric acid is introduced. During debinding, the monitored mixing ratio between the nitrogen and acid prevents an excess acid dosis and, or consequently, the formation of an explosive atmosphere.
These gas tight retort furnaces are equipped with direct or indirect heating depending on temperature. They are perfectly suited for various heat treatment processes requiring a defined protective or a reaction gas atmosphere. These compact models can also be laid out for heat treatment under vacuum up to 600 °C. The furnace chamber consists of a gas tight retort with water cooling around the door to protect the special sealing. With the corresponding safety technology, retort furnaces are also suitable for applications under reaction gases, such as hydrogen or, in combination with the IDB package, for inert debinding or for pyrolysis processes.

Different model versions are available depending on the temperature range:

Models NRA ../06 with Tmax 650 °C
- Heating elements located inside the retort
- Temperature uniformity up to +/- 5 °C inside the work space see page 68
- Retort made of 1.4571
- Gas circulation fan in the back of the retort provides for optimal temperature uniformity
- Insulation made of mineral wool

Models NRA ../09 with Tmax 900 °C
Design like models NRA ../06 with following differences:
- Outside heating with heating elements around the retort
- Retort made of 1.4828
- Exclusive use of insulation materials without categorization according to EC Regulation No 1272/2008 (CLP). This explicitly means that alumino silicate wool, also known as "refractory ceramic fiber" (RCF), which is classified and possibly carcinogenic, is not used.

Models NR ../11 with Tmax 1100 °C
Design like models NRA ../09 with following differences:
- Retort made of 1.4841
- Without gas-circulation

Short and long-term durability of retort materials
Vacuum pump for cold evacuation of the retort

Process control H3700 for automatic version

Basic version
- Compact housing with removable stainless steel sheets
- Controls and gas supply integrated in the furnace housing
- Welded charging supports in the retort resp. air-baffle box in the furnaces with atmosphere circulation
- Swivel door hinged on right side
- Open cooling water system
- Depending on furnace volume for 900 °C- and 1100 °C-models the control system is divided in one or more heating zones
- Furnace temperature control with measurement outside the retort
- Gas supply system for one non-flammable protective or reaction gas with flow meter and magnetic valve
- Port for vacuum pump for cold evacuation
- Operation under vacuum up to 600 °C with optional single-stage rotary vane pump
- Defined application within the constraints of the operating instructions
- NTLog Basic for Nabertherm controller: recording of process data with USB-flash drive
- Controls description see page 72

Additional equipment
- Upgrade for other non-flammable gases, H₂ version for flammable gases see page 16
- Automatic gas injection, including MFC flow controller for alternating volume flow, controlled with process control H3700, H1700
- Vacuum pump for evacuating of the retort up to 600 °C, attainable vacuum up to 10⁻⁵ mbar subject to selected pump and furnace type
- Indirect cooling see page 29
- Direct cooling see page 29
- Heat exchanger with closed-loop cooling water circuit for door cooling
- Measuring device for residual oxygen content
- Door heating
- Temperature control as charge control with temperature measurement inside and outside the retort
- Retort, made of 2.4633 for Tmax 1150 °C
- Process control and documentation via VCD software package or Nabertherm Control Center (NCC) for monitoring, documentation and control see page 72
Hot-Wall Retort Furnaces up to 1100 °C

**H₂ Version for Operation with Flammable Process Gases**

When a flammable process gas like hydrogen is used, the retort furnace is additionally equipped with the required safety technology. Only certified and industry proven safety sensors are used. The furnace is controlled by a fail-safe PLC control system (S7-300F/safety controller).

- Process control under monitored overpressure
- Process control H1700 with PLC controls and graphic touch panel for data input
- Monitored gas pre-pressure of the process gas
- Bypass for safe flushing of furnace chamber with inert gas
- Thermal post combustion of exhaust gases

IDB Version for Debinding under Non-flammable Protective Gases or for Pyrolysis Processes

The retort furnaces of the NR and NRA product line are perfectly suited for debinding under non-flammable protective gases or for pyrolysis processes. The IDB version of the retort furnaces implements a safety concept by controlled inerting the furnace chamber with a protective gas. Exhaust gases are burned in a thermal post combustion. Both the purging and the torch function are monitored to ensure a safe operation.

- Supply of flammable process gas at controlled overpressure of 50 mbar relative
- Certified safety concept
- PLC controls with graphic touch panel H3700 for data input
- Redundant gas inlet valves for hydrogen
- Monitored pre-pressures of all process gases
- Bypass for safe flushing of furnace chamber with inert gas
- Thermal post combustion of exhaust gases
- Emergency flood container for purging the furnace in case of failure

<table>
<thead>
<tr>
<th>Model</th>
<th>Outer dimensions1 in mm</th>
<th>Work space dimensions in mm</th>
<th>Useful volume in l</th>
<th>Connected load in kW*</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR(A) 20/..</td>
<td>1100/1600 1700</td>
<td>225 400 225</td>
<td>20</td>
<td>34</td>
</tr>
<tr>
<td>NR(A) 40/..</td>
<td>1200/1600 1900</td>
<td>325 400 325</td>
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<td>34</td>
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<tr>
<td>NR(A) 80/..</td>
<td>1200/1600 1900</td>
<td>325 750 325</td>
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<tr>
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<td>1400/2000 2100</td>
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<td>NR(A) 300/..</td>
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<td>157</td>
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<tr>
<td>NR(A) 400/..</td>
<td>2200/3400 2600</td>
<td>590 1200 590</td>
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<tr>
<td>NR(A) 500/..</td>
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<td>720 1000 720</td>
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<td>217</td>
</tr>
<tr>
<td>NR(A) 700/..</td>
<td>2300/3500 2700</td>
<td>720 1350 720</td>
<td>700</td>
<td>287</td>
</tr>
<tr>
<td>NR(A) 1000/..</td>
<td>2300/3600 2800</td>
<td>870 1350 870</td>
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</tr>
</tbody>
</table>

1Outer dimensions and connected load of models NR ../11
2Outer dimensions plus separate switchgear with gas supply package for flammable gases or PLC control
3Outer dimensions plus separate switchgear

*Please see page 73 for more information about supply voltage
With their high level of flexibility and innovation, Nabertherm offers the optimal solution for customer-specific applications.

Based on our standard models, we develop individual solutions also for integration in overriding process systems. The solutions shown on this page are just a few examples of what is feasible. From working under vacuum or protective gas via innovative control and automation technology for a wide selection of temperatures, sizes, lengths and other properties of retort furnaces – we will find the appropriate solution for a suitable process optimization.
Processes such as hardening of titanium or hardening/carburization, carburizing of steel, which require a controlled gas atmosphere with a subsequent quenching process, can be carried out with protective gas quenching and tempering plants. Such a system consists of a hot-wall retort furnace and an external quenching bath. Depending on the arrangement and design of the components, quenching delay times of up to 10 seconds can be achieved, so that the components are exposed to air for a short time only.

Chamber retort furnaces or pit-type retort furnaces can be offered for heavy components, where the batch is removed by crane after heat treatment and transferred to the quenching bath.

Depending on the requirements, the degree of automation can range from a purely manual version to a fully automated system with manipulator.

The quenching medium shall be selected taking into account the material to be treated and may be water, polymer, oil or a salt.

Additional equipment required for the process, such as cooling or heating or circulation of the medium, can be offered as well.

In a manual quenching and tempering plant, the process control is carried out by means of a Nabertherm controller. For more complex requirements, the controller is replaced by a PLC control. Process documentation in accordance with current standards such as the AMS2750F (NADCAP) is also possible.
Retort Furnaces for Catalytic Debinding
also as Combi Furnaces for Catalytic or Thermal Debinding

The retort furnaces NRA 40/02 CDB and NRA 150/02 CDB are specially developed for catalytic debinding of ceramics and metallic powder injection molded parts. They are equipped with a gastight retort with inside heating and gas circulation. During catalytic debinding, the polyacetal-containing (POM) binder chemically decomposes in the oven under nitric acid and is carried out of the oven by a nitrogen carrier gas and burned in an exhaust gas torch. Both retort furnaces have a comprehensive safety package to protect the operator and the surrounding.

Executed as combi furnace series CTDB these retort furnace can be used for either catalytic or thermal debinding incl. presintering if necessary and possible. The presintered parts can be easily transferred into the sintering furnace. The sintering furnace remains clean as no residual binder can exhaust anymore.

- Retort made of acid-resistant stainless steel 1.4571 with large swiveling door
- Four-side heating inside the retort through chromium steel tube heating elements for good temperature uniformity
- Horizontal gas circulation for uniform distribution of the process atmosphere
- Acid pump and acid vessel (to be provided by the customer) accommodated in the furnace frame
- Gas-fired exhaust gas torch with flame monitoring
- Extensive safety package with redundantly operating safety PLC for safe operation with nitric acid
- Large, graphic process control H3700 for entering data and for process visualization
- Emergency tank for flushing in case of a failure
- Defined application within the constraints of the operating instructions

Version NRA .. CDB
- Tmax 200 °C
- Automatic gas supply system for nitrogen with mass flow controller
- Adjustable acid volume and correspondingly adjusted gas supply volumes

Version NRA .. CTDB
- Available for 600 °C and 900 °C with atmosphere circulation

Additional equipment
- Scale for the nitric acid vessel, connected to the PLC monitors the acid consumption and visualizes the fill level of the acid vessel (NRA 150/02 CDB)
- Lift truck for easy loading of the furnace
- Cupboard for acid pump
- Process control and documentation via Nabertherm Control Center (NCC) for monitoring, documentation and control see page 72

<table>
<thead>
<tr>
<th>Model</th>
<th>Tmax  °C</th>
<th>Inner dimensions in mm</th>
<th>Volume in l</th>
<th>Outer dimensions3 in mm</th>
<th>Heating power in kW²</th>
<th>Electrical connection*</th>
<th>Weight in kg</th>
<th>Acidic quantity (HNO₃)</th>
<th>Nitrogen (N₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRA 40/02 CDB</td>
<td>200</td>
<td>300 450 300 40</td>
<td>1400 1600 2400</td>
<td>2 3-phase¹</td>
<td>800</td>
<td>max. 70 ml/h</td>
<td>1000 l/h</td>
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<td></td>
</tr>
<tr>
<td>NRA 150/02 CDB</td>
<td>200 350  700 450 150</td>
<td>1650 1960 2850</td>
<td>20</td>
<td>3-phase¹</td>
<td>1650</td>
<td>max. 180 ml/h</td>
<td>max. 400 l/h</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹Heating only between two phases
²Depending on furnace design connected load might be higher
³External dimensions vary when furnace is equipped with additional equipment. Dimensions on request.
Bottom Loading Retort Furnaces up to 1100 °C

The bottom loading retort furnaces of the LBR series are suitable for production processes that are carried out in protective/reaction gas atmosphere. With regard to the basic performance data, these models are constructed like the SR models. Their size and design with electro-hydraulically driven lifting bottom make it easier to load heavy duties. The retort furnaces are available in different sizes and designs.

Basic version (all models)
- Tmax 650 °C, 900 °C or 1100 °C
- Frame-mounted housing with stainless steel sheets
- Charging from the front
- Electro-hydraulically driven furnace bottom
- Gas supply system for a non-flammable protective gas or reaction gas with flow meter and solenoid valve
- Temperature control designed as furnace chamber control, see control alternative page 71
- Connection possibility for an optional vacuum pump (cold evacuation or operation up to 600 °C under vacuum)
- Defined application within the constraints of the operating instructions
- NTLog Basic for Nabertherm controllers: recording of process data with USB flash drive

Additional equipment, H₂ version and IDB version see models NR and NRA
The retort furnaces SR and SRA (with gas circulation) are designed for operation under non-flammable or flammable protective or reaction gases. The hot-wall retort furnaces are loaded from above by crane or other lifting equipment provided by the customer. In this way, even large charge weights can be loaded into the furnace chamber.

Depending on the temperature range in which the furnace be used, the following models are available:

Models SRA ../06 with Tmax 650 °C
- Heating inside the retort
- Gas-circulation with powerful fan in the furnace lid
- Temperature uniformity up to +/- 5 °C inside the work space see page 68
- Single-zone control
- Retort made of 1.4571
- Insulation made of high-grade mineral wool

Models SRA ../09 with Tmax 900 °C
Design like models SR…/06 with following differences:
- All-around heating from outside of the retort
- Exclusive use of insulation materials without categorization according to EC Regulation No 1272/2008 (CLP). This explicitly means that aluminosilicate wool, also known as “refractory ceramic fiber” (RCF), which is classified and possibly carcinogenic, is not used.
- Retort made of 1.4828

Models SR …/11 with Tmax 1100 °C
Design like models SR…/09 with following differences:
- Without gas-circulation
- Top down multi-zone control of the furnace heating
- Retort made of 1.4841

Standard Equipment (all models)
Design like standard equipment of models NR and NRA with following differences:
- Compact housing in frame construction with inserted stainless steel sheets
- Charging from above with crane or other lifting equipment from customer
- Hinged lid with opening to the side
- Welded charging frame resp. gas-guiding box for furnaces with circulation
- Gas-supply system for one non-flammable protective or reactive gas with flowmeter and magnetic valve
- Furnace temperature control see control alternative page 71
- Possible connection of an optional vacuum pump (for cold evacuation or for processes up to 600 °C under vacuum)
- Defined application within the constraints of the operating instructions
- NTLog Basic for Nabertherm controller: recording of process data with USB-flash drive

Additional equipment, H₂ version or IDB version see models NR and NRA

<table>
<thead>
<tr>
<th>Model</th>
<th>Tmax °C</th>
<th>Inner dimensions of alloy retort</th>
<th>Volume in l</th>
<th>Outer dimensions in mm</th>
<th>Electrical connection</th>
<th>Weight in kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR(A) 17/..</td>
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<td>17</td>
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<td>1900</td>
<td>1800</td>
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<td>50</td>
<td>1400</td>
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<td>200</td>
<td>1600</td>
<td>2200</td>
<td>2200</td>
</tr>
<tr>
<td>SR(A) 300/..</td>
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<td>1000</td>
<td>300</td>
<td>1600</td>
<td>2200</td>
<td>2500</td>
</tr>
<tr>
<td>SR(A) 500/..</td>
<td>800</td>
<td>1000</td>
<td>500</td>
<td>1800</td>
<td>2400</td>
<td>2700</td>
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<td>SR(A) 600/..</td>
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<td>3100</td>
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<tr>
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<td>1300</td>
<td>1500</td>
<td>2200</td>
<td>2800</td>
<td>3300</td>
</tr>
</tbody>
</table>

*Please see page 73 for more information about supply voltage

*External dimensions vary when furnace is equipped with additional equipment. Dimensions on request.
The compact retort furnaces of the VHT product line are available as electrically heated chamber furnaces with graphite, molybdenum, tungsten or MoSi$_2$ heating. A wide variety of heating designs as well as a complete range of accessories provide for optimal retort furnace configurations even for sophisticated applications.

The vacuum-tight retort allows heat treatment processes either in protective and reaction gas atmospheres or in a vacuum, subject to the individual furnace specs to $10^{-5}$ mbar. The basic furnace is suited for operation with non-flammable protective or reactive gases or under vacuum. The H$_2$ version provides for operation under hydrogen or other flammable gases. Key of the specification up is a certified safety package providing for a safe operation at all times and triggers an appropriate emergency program in case of failure.

**Alternative Heating Specifications**

In general the following variants are available with respect to the process requirements:

**VHT ../..-GR with Graphite Insulation and Heating**
- Suitable for processes under protective and reaction gases or under vacuum
- Tmax 1800 °C, 2200 °C or 2400 °C (VHT 40/.. - VHT 100/..)
- Max. vacuum up to $10^{-4}$ mbar depending on pump type used
- Graphite felt insulation

**VHT ../..-MO or VHT ../..-W with Molybdenum or Tungsten Heating**
- Suitable for high-purity processes under protective and reaction gases or under high vacuum
- Tmax 1200 °C, 1600 °C or 1800 °C (see table)
- Max. vacuum up to $10^{-5}$ mbar depending on pump type used
- Insulation made of molybdenum rsp. tungsten radiation sheets

**VHT ../..-KE with Fiber Insulation and Heating through Molybdenum Disilicide Heating Elements**
- Suitable for processes under protective and reaction gases, in air or under vacuum
- Tmax 1800 °C
- Max. vacuum up to $10^{-2}$ mbar (up to 1300 °C) depending on pump type
- Insulation made of high purity aluminum oxide fiber
- Exclusive use of insulation materials without categorization according to EC Regulation No 1272/2008 (CLP). This explicitly means that aluminosilicate wool, also known as “refractory ceramic fiber” (RCF), which is classified and possibly carcinogenic, is not used.
### Basic version
- Standard furnace sizes 8 - 500 liters
- Water-cooled retort made of stainless steel
- Frame made of stable steel profiles, easy to service due to easily removable stainless steel panels
- Housing of the VHT 8 model on castors for easy repositioning of furnace
- Cooling water manifold with manual tap, automatic flow monitoring, open-loop cooling water system
- Adjustable cooling water circuits with flowmeter and temperature indicator and overtemperature protection
- Switchgear and controller integrated in furnace housing
- Process control with controller P570
- Over-temperature limiter with adjustable cutout temperature as temperature limiter to protect the oven and load
- Manual operation of the process gas and vacuum functions
- Manual gas supply for one process gas (N₂, Ar or non-flammable forming gas) with adjustable flow
- Bypass with manual valve for rapid filling or flooding of furnace chamber
- Manual gas outlet with overflow valve (20 mbar relative) for over-pressure operation
- Single-stage rotary vane pump with ball valve for pre-evacuating and heat treatment in a rough vacuum to 5 mbar
- Pressure gauge for visual pressure monitoring
- Defined application within the constraints of the operating instructions

### Schematic presentation of a cold-wall retort furnace with additional equipment

<table>
<thead>
<tr>
<th>1</th>
<th>Retort</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Heating</td>
</tr>
<tr>
<td>3</td>
<td>Insulation</td>
</tr>
<tr>
<td>4</td>
<td>Gas management system</td>
</tr>
<tr>
<td>5</td>
<td>Vacuum pump</td>
</tr>
<tr>
<td>6</td>
<td>Cooling water distribution</td>
</tr>
<tr>
<td>7</td>
<td>Controls</td>
</tr>
<tr>
<td>8</td>
<td>Integrated switchgear</td>
</tr>
<tr>
<td>9</td>
<td>Heating transformer</td>
</tr>
<tr>
<td>10</td>
<td>Charging frame inside the inner process chamber</td>
</tr>
</tbody>
</table>

Retort furnace VHT 8/16-MO with automation package

Retort furnace VHT 100/16-MO with automation package
Additional equipment:
- Housing, optionally divisible, for passing through narrow door frames (VHT 8)
- Lift door
- Individual heating concepts

Additional equipment gas management system:
- Manual gas supply for second process gas ($N_2$, Ar or non-flammable forming gas) with adjustable flow and bypass
- Mass flow controller for alternating volume flow and generation of gas mixtures with second process gas (only with automation package)
- Inner process box made of molybdenum, tungsten, graphite or CFC, especially recommended for debinding processes. The box is installed in the furnace with direct gas inlet and outlet and provides for better temperature uniformity. Generated exhaust gases will be directly lead out the inner process chamber during debinding. The change of gas inlet paths after debinding results in a clean process gas atmosphere during sintering.

Retort furnace VHT 40/22-GR with motorized lift door and front frame for connection to a glovebox

Additional equipment vacuum:
- Two-stage rotary vane pump with ball valve for pre-evacuating and heat-treating in a fine vacuum (up to $10^{-2}$ mbar) incl. electronic pressure sensor
- Turbo molecular pump with slide valve for pre-evacuation and for heat treatment in a high vacuum (up to $10^{-5}$ mbar) including electronic pressure sensor and booster pump
- Other vacuum pumps on request
- Partial pressure operation: protective gas flushing at controlled underpressure (only with automation package)

Heat treatment of copper bars under hydrogen in retort furnace VHT 8/16-MO

Additional equipment cooling:
- Heat exchanger with closed-loop cooling water circuit
- Direct cooling see page 29

Additional equipment for controls and documentation:
- Charge thermocouple with display
- Temperature measurement at 2200 °C models with pyrometer in the upper temperature range and thermocouple, type C with automatic pull-out device for precise control results in the low temperature range (VHT 40/...-GR and larger)
- Automation package with process control H3700
  - 12" graphic touch panel
  - Input of all process data like temperatures, heating rates, gas injection, vacuum at the touch panel
  - Display of all process-relevant data on a process control diagram
  - Automatic gas supply for one process gas ($N_2$, argon or non-flammable forming gas) with adjustable flow
  - Bypass for flooding and filling the chamber with process gas controlled by the program
  - Automatic pre- and post programs, including leak test for safe furnace operation
  - Automatic gas outlet with bellows valve and overflow valve (20 mbar relative) for over-pressure operation
  - Transducer for absolute and relative pressure
- Process control and documentation via VCD software package or Nabertherm Control Center (NCC) for monitoring, documentation and control see page 72

Turbo-molecular pump
Single-stage rotary vane pump for heat treatment in a rough vacuum to 5 mbar

Two-stage rotary vane pump for heat treatment in a vacuum to $10^{-2}$ mbar

Turbo-molecular pump with booster pump for heat treatment in a vacuum to $10^{-5}$ mbar

**Process Box for Debinding in Inert Gas**

Certain processes require charges to be debinded in non-flammable protective or reactive gases. For these processes we fundamentally recommend a hot-wall retort furnace (see models NR .. or SR ..). These retort furnaces can ensure that the formation of condensation will be avoided as thoroughly as possible.

If there is no way to avoid the escape of small amounts of residual binder during the process, even in the VHT furnace, the retort furnace should be designed to meet this contingency.

The furnace chamber is equipped with an additional process box that has a direct outlet to the exhaust gas torch through which the exhaust gas can be directly vented. This system enables a substantial reduction in the amount of furnace chamber contamination caused by the exhaust gases generated during debinding.

Depending on the exhaust gas composition the exhaust gas line can be designed to include various options.

- Exhaust gas torch for burning off the exhaust gas
- Condensation trap for separating out binding agents
- Exhaust gas post-treatment, depending on the process, via exhaust gas washers
- Heated exhaust gas outlet to avoid condensation deposits in the exhaust gas line

<table>
<thead>
<tr>
<th>Model</th>
<th>Inner dimensions of process box in mm</th>
<th>Volume in l</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHT 2/..</td>
<td>80 x 125 x 150</td>
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</tr>
<tr>
<td>VHT 8/..</td>
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<td>VHT 70/..</td>
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<td>425 x 500 x 425</td>
<td>90.0</td>
</tr>
<tr>
<td>VHT 250/..</td>
<td>575 x 700 x 575</td>
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<tr>
<td>VHT 500/..</td>
<td>725 x 850 x 725</td>
<td>445.0</td>
</tr>
</tbody>
</table>

**Models**

<table>
<thead>
<tr>
<th>Model</th>
<th>Inner dimensions in mm</th>
<th>Volume in l</th>
<th>Max. charge weight/kg</th>
<th>Outer dimensions in mm</th>
<th>Heating power in kW</th>
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<tbody>
<tr>
<td>VHT 2/..</td>
<td>110 x 125 x 150</td>
<td>150</td>
<td>2</td>
<td>2</td>
<td>1250 (800)</td>
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<tr>
<td>VHT 8/..</td>
<td>170 x 240 x 200</td>
<td>200</td>
<td>8</td>
<td>5</td>
<td>1250 (800)</td>
</tr>
<tr>
<td>VHT 25/..</td>
<td>250 x 400 x 300</td>
<td>300</td>
<td>40</td>
<td>30</td>
<td>1500</td>
</tr>
<tr>
<td>VHT 40/..</td>
<td>300 x 450 x 300</td>
<td>300</td>
<td>40</td>
<td>30</td>
<td>1600</td>
</tr>
<tr>
<td>VHT 70/..</td>
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<td>375</td>
<td>50</td>
<td>50</td>
<td>1800</td>
</tr>
<tr>
<td>VHT 100/..</td>
<td>450 x 550 x 450</td>
<td>450</td>
<td>70</td>
<td>70</td>
<td>1900</td>
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<td>VHT 250/..</td>
<td>600 x 750 x 600</td>
<td>600</td>
<td>100</td>
<td>75</td>
<td>1900</td>
</tr>
<tr>
<td>VHT 500/..</td>
<td>750 x 900 x 750</td>
<td>750</td>
<td>150</td>
<td>150</td>
<td>1900</td>
</tr>
</tbody>
</table>

1With separated switching system unit
2Depending on furnace design connected load might be higher
3Dimensions may be smaller depending on the heater type
4External dimensions vary when furnace is equipped with additional equipment. Dimensions on request.
**H₂ Version for Operation with Hydrogen or other Reaction Gases**

In the H₂ version the retort furnaces can be operated under hydrogen or other reaction gases. For these applications, the systems are additionally equipped with the required safety technology. Only certified and industry proven safety sensors are used. The retort furnaces are controlled by a fail-safe PLC control system (S7-300F/safety controller).

- **Certified safety concept**
- **Automation package (additional equipment see page 24)**
- **Redundant gas inlet valves for hydrogen**
- **Monitored pre-pressures of all process gases**
- **Bypass for safe purging of furnace chamber with inert gas**
- **Pressure-monitored emergency flooding with automated solenoid valve opening**
- **Electric or gas-heated exhaust gas torch for H₂ post-combustion**
- **Atmospheric operation: H₂-purging of retort starting from room temperature at controlled over pressure (50 mbar relative)**

**Additional equipment**

- **Partial pressure operation: H₂ flushing at underpressure in the retort starting from 750 °C furnace chamber temperature**
- **Inner process hood in the retort for debinding under hydrogen**
- **Process control and documentation via Nabertherm Control Center (NCC) for monitoring, documentation and control see page 72**
The LBVHT model series with bottom loading specification are especially suitable for production processes which require either protective or reaction gas atmosphere or a vacuum. The basic performance specifications of these models are similar to the VHT models. Their size and design with electro-hydraulically driven table facilitate charging during production. The retort furnaces are available in various sizes and designs. Similar like the VHT models, these furnaces can be equipped with different heating concepts.

- Standard furnace sizes between 100 and 600 liters
- Designed as bottom loading retort furnace with electro-hydraulically driven table for easy and well-arranged charging
- Prepared to carry heavy charge weights
- Different heating concepts using
  - Graphite heating chamber up to Tmax 2400 °C
  - Molybdenum heating chamber up to Tmax 1600 °C
  - Tungsten heating chamber up to Tmax 2000 °C
- Frame structure filled with textured stainless steel sheets
- Standard design with gassing system for non-flammable protective or reaction gases
- Automatic gas supply system which also allows for operation with several process gases as additional equipment
- Gas supply systems for operating with hydrogen or other combustible reaction gases incl. safety package as additional equipment
- Switchgear and control box as well as gassing system integrated into the furnace housing
- Further product characteristics of the standard furnace as well as possible additional equipment can be found in the description of the VHT furnaces from Page 22
Indirect cooling (hot-wall retort furnaces)
- Ambient air is blown onto the outer retort surface to cool it down. The waste heat is removed via the exhaust air outlet of the furnace.
- The charge is cooled indirectly, which means that the atmosphere in the retort is not affected by the cooling
- The charge cannot be quenched with the cooling system

Direct cooling (cold-wall and hot-wall retort furnaces)
- Rapid gas cooling in the retort. For this purpose, the furnace atmosphere is circulated through a heat exchanger.
- The system pressure is not increased by the cooling; there is no gas quenching at high pressure
- Not available for processes with flammable furnace atmospheres

Cooling Behavior of Hot-Wall Retort Furnace with Charge
(Example: NRA 50/09 with charge of 40 kg)

Cooling Behavior of Cold-Wall Retort Furnace with Charge
(Example: VHT 8/06-MO with charge of 10 kg)
Chamber Furnaces with Brick Insulation or Fiber Insulation

The chamber furnaces LH 15/12 - LF 120/14 have been trusted for many years as professional chamber furnaces for the laboratory. These furnaces are available with either a robust insulation of light refractory bricks (LH models) or with a combination insulation of refractory bricks in the corners and low heat storage, quickly cooling fiber material (LF models). With a wide variety of optional equipment, these chamber furnaces can be optimally adapted to your processes.

- Tmax 1200 °C, 1300 °C, or 1400 °C
- Dual shell housing with rear ventilation, provides for low shell temperatures
- High furnace chamber with five-sided heating for very good temperature uniformity
- Heating elements on support tubes ensure free heat radiation and a long service life
- Controller mounted on furnace door and removable for comfortable operation
- Protection of bottom heating and flat stacking surface provided by embedded SiC plate in the floor
- LH models: multi-layered insulation of light refractory bricks and special backup insulation
- LF models: high-quality fiber insulation with corner bricks for shorter heating and cooling times. Exclusive use of insulation materials without categorization according to EC Regulation No 1272/2008 (CLP). This explicitly means that alumino silicate wool, also known as “refractory ceramic fiber” (RCF), which is classified and possibly carcinogenic, is not used.
- Door with brick-on-brick seal, hand fitted
- Short heating times due to high installed power
- Self-supporting arch for high stability and greatest possible protection against dust
- Quick lock on door
- Motorized exhaust air flap
- Freely adjustable air inlet integrated in furnace floor
- Base included
- Defined application within the constraints of the operating instructions
- NTLog Basic for Nabertherm controller: recording of process data with USB-flash drive
- Controls description see page 72
Chamber furnace LF 60/14 with fresh air fan to accelerate the cooling times

**Additional equipment**
- Parallel swinging door, pivots away from operator, for opening when hot
- Lift door with electro-mechanic linear drive
- Separate wall-mounting or floor standing cabinet for switchgear
- Cooling fan for shorter cycle times
- Protective gas connection to purge with non-flammable protective or reaction gases
- Manual or automatic gas supply system
- Scale to measure weight reduction during annealing
- Process control and documentation via VCD software package or Nabertherm Control Center (NCC) for monitoring, documentation and control see page 72

### Model Specifications

<table>
<thead>
<tr>
<th>Model</th>
<th>Tmax °C</th>
<th>Inner dimensions in mm</th>
<th>Volume in l</th>
<th>Outer dimensions a in mm</th>
<th>Connected load kW</th>
<th>Electrical connection b</th>
<th>Weight in kg</th>
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<tr>
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<td>30</td>
<td>710 x 930 x 1290</td>
<td>7.0</td>
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<tr>
<td>LH 60/12</td>
<td>1200</td>
<td>400 x 400 x 400</td>
<td>60</td>
<td>790 x 1080 x 1370</td>
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<td>890 x 1180 x 1470</td>
<td>12.0</td>
<td>3-phase</td>
<td>410</td>
</tr>
<tr>
<td>LH 216/12</td>
<td>1200</td>
<td>600 x 600 x 600</td>
<td>216</td>
<td>990 x 1280 x 1590</td>
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<td>120</td>
<td>890 x 1180 x 1470</td>
<td>15.0</td>
<td>3-phase</td>
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</tr>
<tr>
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<td>7.0</td>
<td>3-phase</td>
<td>150</td>
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<td>LF 30/13</td>
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<td>710 x 930 x 1290</td>
<td>8.0</td>
<td>3-phase</td>
<td>180</td>
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<tr>
<td>LF 60/13</td>
<td>1300</td>
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<td>60</td>
<td>790 x 1080 x 1370</td>
<td>11.0</td>
<td>3-phase</td>
<td>270</td>
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<tr>
<td>LF 120/13</td>
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<td>120</td>
<td>890 x 1180 x 1470</td>
<td>15.0</td>
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<td>LF 15/14</td>
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<td>680 x 860 x 1230</td>
<td>8.0</td>
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<tr>
<td>LF 30/14</td>
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<td>30</td>
<td>710 x 930 x 1290</td>
<td>10.0</td>
<td>3-phase</td>
<td>180</td>
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<tr>
<td>LF 60/14</td>
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<td>270</td>
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<tr>
<td>LF 120/14</td>
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<td>120</td>
<td>890 x 1180 x 1470</td>
<td>18.0</td>
<td>3-phase</td>
<td>370</td>
</tr>
</tbody>
</table>

*a Heating only between two phases  
*b Please see page 73 for more information about supply voltage  
*c External dimensions vary when furnace is equipped with additional equipment. Dimensions on request
**Protective Gas Boxes for Models LH 15/.. - LH 216/..**

Due to the cubic interior of the LH chamber furnaces and the corresponding protective gas boxes, these furnaces are ideally suited for higher batches. Gassing boxes for the LH models have a standard charge thermocouple, which can be used, for example, for charge control. The protective gas inlet and outlet is routed through the furnace collar in the case of a furnace with a swivel door on the left and through the lower furnace collar in the lift-door configuration.

These boxes have a lid for charging from above, protective gas inlet and outlet.

- Tmax 1100 °C
- For non-combustible protective and reactive gases argon, nitrogen and forming gas (observe national regulations)
- Protective gas box with fiber seal and cover with locks, inert gas introduction via a pipe into the bottom of the box
- Protective gas connection via quick coupling with hose connector (inner diameter 9 mm)
- Piping for gas inlet and outlet through the furnace collar
- Heat-resistant alloy 314 (AISI)/(DIN material no. 1.4841)
- Charge thermocouple type K for temperature display or charge control

**Additional equipment**

- Starting from LH 30/.. a charging cart is recommended see page 54
- Digital temperature display see page 51
- Gas supply systems see page 52
- Extended gas piping for the use of smaller boxes in larger furnace models
- Draw hook
- Charging stacker see page 55

---

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Furnace</th>
<th>Inner dimensions in mm</th>
<th>Outer dimensions in mm¹</th>
<th>Charging method of the box</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>w d h</td>
<td>W D H</td>
<td></td>
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<tr>
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<td>415 411 441</td>
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<tr>
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<td>LH 216/..</td>
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<td>514 535 554</td>
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</tr>
<tr>
<td>601655055</td>
<td>1 set of fiber insulation cord, 5 strips of 610 mm each</td>
<td>1 Without piping</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Work space = box inner dimensions: - 30 mm to all sides
Larger boxes and custom dimensions available upon request

---

**Protective Gas Boxes with Charging from the Front**

Design as the described protective gas boxes, but with charging from the front. These protective gas boxes remain in the oven and are equipped with a lid that can be opened to the front. After the lid has been opened, the batch can be removed directly.

---

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Furnace</th>
<th>Inner dimensions in mm</th>
<th>Outer dimensions in mm¹</th>
<th>Charging method of the box</th>
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<td>W D H</td>
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<td>240 218 264</td>
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<td>631001312</td>
<td>LH 60/..</td>
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<td>320 298 344</td>
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<td>LH 120/..</td>
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<td>420 398 444</td>
<td>-</td>
</tr>
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<td>1 set of fiber insulation cord, 5 strips of 610 mm each</td>
<td>1 Without piping</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Work space = box inner dimensions: - 30 mm to all sides
Larger boxes and custom dimensions available upon request

---

*¹ Without piping*
Protective Gas Boxes with Evacuation Lid for Models LH 15/.. - LH 216/..

Design as the described protective gas boxes, but with an additional evacuation lid. In order to reduce the residual oxygen in the box, protective gas boxes with evacuation lids can be used. These boxes have a lid for top loading, a protective gas inlet and outlet, and an evacuation cover with rubber gasket. The gas piping and the handling in the warm state corresponds to the gassing boxes on page 32. In addition, a connection for a vacuum pump via three-way ball valve is provided.

In combination with a vacuum pump, the oxygen is evacuated from the box in cold state and afterwards flushed with protective gas. Repeating the process once or several times will significantly improve the results. After this process, the evacuation cover is removed and the actual heat treatment process is started under protective gas. After the heat treatment, the box is pulled out of the furnace and can be cooled in air or opened for batch removal.

- Protective gas box with fiber sealing and lid with locks, recess for evacuation lid, gas inlet via a pipe into the bottom of the box
- Evacuation lid with rubber sealing (Elastomer) and manometer
- Protective gas connection via three-way ball valve and quick coupling with hose connector (inner diameter 9 mm)

Additional equipment
- Starting from LH 30/.., a charging cart is recommended see page 54
- Digital temperature display see page 51
- Vacuum pump see page 53
- Gas supply systems see page 52
- Extended gas piping for the use of smaller boxes in larger furnace models
- Draw hook
- Charging stacker see page 55

Charging Plates for Models LH 15/.. - LH 216/..

Charging plates are recommended to protect the furnace floor. The charging plates are particularly suitable for heat treatment with protective gas boxes in order to minimize wear during charging.

- Tmax 1100 °C
- Threeside upstand
- Heat-resistant alloy 314 (AISI)/(DIN material no. 1.4841)
- With spacer on the rear heating elements

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Furnace</th>
<th>Inner dimensions in mm</th>
<th>Outer dimensions in mm</th>
<th>Charging method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>w x d x h</td>
<td>W x D x H</td>
<td>of the box</td>
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<td>LH 216/..</td>
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<td>506 x 535 x 540</td>
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</table>

Article no. 601655055, 1 set of fiber insulation cord, 5 strips of 610 mm each
Work space = box inner dimensions: - 30 mm to all sides
Larger boxes and custom dimensions available upon request

Without piping and evacuation lid

Charging Plate

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Furnace</th>
<th>Outer dimensions in mm</th>
</tr>
</thead>
<tbody>
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<td>628002016</td>
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<tr>
<td>628002017</td>
<td>LH 216/..</td>
<td>540 x 600 x 30</td>
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</table>
Chamber Furnaces with Drawer Bottom or as a Bogie

The NW chamber furnaces enable simple charging for cold-cold processes. The heat treatment can take place under air or under non-flammable protective gases with a protective gas box or protective gas hood. With a drawer mechanism (NW 150 - NW 300/H) the furnace table can be easily pulled out of the chamber furnace. The larger models NW 440 - NW 1000/H are designed as shuttle furnace with completely free traversing bogie. Free access in front of the furnace allows for a simplified and clear charging.

- Tmax 1300 °C, 1100 °C with protective gas box (additional equipment)
- Dual shell housing, galvanized steel sheets
- Double-walled door with front made of textured stainless steel
- Controller mounted on furnace door and removable for comfortable operation (up to model NW 440)
- Heating from five sides with special arrangement of heating elements for optimum temperature uniformity

Exclusive use of insulation materials without categorization according to EC Regulation No 1272/2008 (CLP). This explicitly means that alumino silicate wool, also known as “refractory ceramic fiber” (RCF), which is classified and possibly carcinogenic, is not used.
- Vaulted ceiling
- Furnace table can be pulled-out as drawer (NW 150 - NW 300)
- From chamber furnace NW 440 bogie on four castors (two with brakes) which can be pulled out completely.
- Accession assistance and removable drawbar for bogie
- SiC-floor plate protects floor elements and provides a level setting surface
- Door sealing ground by hand (brick on brick); NW 150 - NW 300
- Semi-automatic air inlet flap closes the air inlet at a temperature which can be set in the controller for NW 150 - NW 300
- Exhaust air outlet in the ceiling, motorized exhaust air flap for chamber furnaces NW 440 - NW 1000
- Comfortable charging height with base of 800 mm (chamber furnaces NW 440 - NW 1000 = 500 mm)
- Defined application within the constraints of the operating instructions
- NTLog for Nabertherm controller: recording of process data with USB-flash drive

Controls description see page 72

Additional equipment
- Protective gas boxes and hoods
- Manual or automatic gas supply system
- Process control and documentation via VCD software package or Nabertherm Control Center (NCC) for monitoring, documentation and control see page 72

<table>
<thead>
<tr>
<th>Model</th>
<th>Tmax °C</th>
<th>Inner dimensions in mm</th>
<th>Volume in l</th>
<th>Outer dimensions in mm</th>
<th>Connected load kW</th>
<th>Electrical connection*</th>
<th>Weight in kg</th>
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<tbody>
<tr>
<td>NW 150</td>
<td>1300</td>
<td>430 530 620 150</td>
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<tr>
<td>NW 200</td>
<td>1300</td>
<td>500 530 720 200</td>
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<tr>
<td>NW 300</td>
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<td>3-phase 970</td>
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<td>NW 660</td>
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<td>57.0</td>
<td>3-phase 1800</td>
<td></td>
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</tr>
</tbody>
</table>

*Please see page 73 for more information about supply voltage

1External dimensions vary when furnace is equipped with additional equipment. Dimensions on request.
Protective Gas Boxes

These protective gas boxes have a cover with a sealing profile as well as a protective gas inlet and outlet. They are pulled out of the furnace in cold condition and charged from above.

- Tmax 1100 °C
- For non-combustible protective and reactive gases argon, nitrogen and forming gas (observe national regulations)
- Protective gas box with fiber seal and cover with locks, inert gas introduction via a pipe into the bottom of the box
- Protective gas connection via quick coupling with hose connector (inner diameter 9 mm)
- Piping for gas inlet and outlet through the furnace collar
- Forklift receptive
- Heat-resistant alloy 314 (AISI)/(DIN material no. 1.4841)
- Charge thermocouple type K for temperature display or charge control

Protective Gas Hoods

Protective gas hoods consist of a a and a bottom with a sealing profile as well as protective gas inlet and outlet. After charging the bottom in front of the oven in cold condition, the hood is put on and the drawer or the car is pushed back into the oven.

Design as protective gas boxes, but

- Gassing hood with eye for raising the hood by crane
- Hood bottom with sealing
- Piping for gas inlet and outlet at the hood through the furnace collar

Additional equipment for protective gas boxes and hoods

- Digital temperature display see page 51
- Gas supply systems see page 52

---

### Protective Gas Boxes and Protective Gas Hoods for Chamber Furnaces NW 150 - NW 1000

<table>
<thead>
<tr>
<th>Furnace</th>
<th>Article no.</th>
<th>Inner dimensions in mm</th>
<th>Protective gas box</th>
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</thead>
<tbody>
<tr>
<td>NW 150</td>
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<td>NW 660</td>
<td>631001333</td>
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<td>NW 1000</td>
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<td>on request</td>
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<table>
<thead>
<tr>
<th>Article no.</th>
<th>Inner dimensions in mm</th>
<th>Protective gas box</th>
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<td>631001334</td>
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<td>631001335</td>
<td>370 390 450</td>
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<td>631001336</td>
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<td>631001338</td>
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</tbody>
</table>

Article no. 601655055, 1 set of fiber insulation cord, 5 strips of 610 mm each
Work space = box inner dimensions: - 30 mm to all sides
Larger boxes and custom dimensions available upon request

---

Two automatic gas supply systems, connected with each other

Chamber furnace NW 200 with protective gas box

Protective gas box for similar furnace

For non-combustible protective and reactive gases argon, nitrogen and forming gas.

- Forming gas (observe national regulations)
- Protective gas box with fiber seal and cover with locks, inert gas introduction via a pipe into the bottom of the box
- Protective gas connection via quick coupling with hose connector (inner diameter 9 mm)
- Piping for gas inlet and outlet through the furnace collar
- Forklift receptive
- Heat-resistant alloy 314 (AISI)/(DIN material no. 1.4841)
- Charge thermocouple type K for temperature display or charge control

Heat-resistant alloy 314 (AISI)/(DIN material no. 1.4841)
Charge thermocouple type K for temperature display or charge control
These universal chamber furnaces with radiation heating have been specifically designed to withstand heavy-duty use in the tool shop. They are particularly useful for processes such as tool making or for hardening jobs, e.g., annealing, hardening and forging. With help of various accessories, these furnaces can be customized to your application requirements.

- Compact, robust design
- Deep furnace chamber with three-sides heating: from both side walls and bottom
- Heating elements on support tubes ensure free heat radiation and a long service life
- Bottom heating protected by heat conducting SiC tiles
- Stainless steel upper door jamb protects furnace structure when furnace is opened hot
- Base frame included in the delivery, N 7/H - N 17/HR designed as table-top model
- Exhaust opening in the side of the furnace, or on rear wall of chamber furnace in the N 31/H models and higher
- Temperature uniformity up to +/- 10 °C according to DIN 17052-1 see page 68
- Low energy consumption due to multi-layer insulation
- Gas spring dampers provide for easy door opening and closing
- Heat resistant zinc paint for protection of door and door frame (for model N 81 and larger)
- Defined application within the constraints of the operating instructions
- NTLog Basic for Nabertherm controller: recording of process data with USB-flash drive
- Controls description see page 72

For additional features see separate catalog „Thermal Process Technology I“

<table>
<thead>
<tr>
<th>Model</th>
<th>Tmax °C</th>
<th>Inner dimensions in mm</th>
<th>Volume in l</th>
<th>Outer dimensions in mm</th>
<th>Heating power in kW</th>
<th>Electrical connection</th>
<th>Weight in kg</th>
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<tbody>
<tr>
<td>N 7/H</td>
<td>1280</td>
<td>250 250 140</td>
<td>9</td>
<td>800 650 600</td>
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<tr>
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<td>11</td>
<td>800 750 600</td>
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<td>800 900 600</td>
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<td>350 500 250</td>
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<td>80</td>
<td>1140 1900 1790</td>
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<td>1180 1930 1980</td>
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<tr>
<td>N 321</td>
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<td>750 1100 400</td>
<td>320</td>
<td>1400 2270 2040</td>
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<td>640</td>
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</tr>
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<td>80</td>
<td>1220 1960 1840</td>
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<td>160</td>
<td>1260 1990 2030</td>
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</tr>
<tr>
<td>N 321/13</td>
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<td>750 1100 400</td>
<td>320</td>
<td>1480 2330 2090</td>
<td>60.0</td>
<td>3-phase</td>
<td>1500</td>
</tr>
<tr>
<td>N 641/13</td>
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<td>1000 1300 500</td>
<td>640</td>
<td>1770 2730 2290</td>
<td>80.0</td>
<td>3-phase</td>
<td>2500</td>
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</tbody>
</table>

1Table-top model 2Heating only between two phases 3Depending on furnace design connected load might be higher
4External dimensions vary when furnace is equipped with additional equipment. Dimensions on request.
Protective Gas Boxes for Models N 7/H - N 641/13

The annealing boxes for heat treatment under protective gas are equipped with a protective gas inlet and outlet. A box with protective gas is advisable for larger workpieces requiring defined heat treating. We would be pleased to carry out Trials at our technical center can be carried out on request. Up to furnace model N 61/H with downward door opening the gas ductway is laid through the upper section of the door collar, for larger furnaces with upward door opening the supply line is laid through the lower furnace collar.

The box is pressurized with non flammable protective and reactive gases such as argon, nitrogen or forming gas via the protective gas tube. There are manual and automatic systems available for protective gas. See pages 52 - 53. for more information about protective gases which can be used as well as manual and automatic protective gas systems.

After charging the box it is closed and preflushed outside the furnace. Afterwards the box is placed in the preheated furnace. The quantity of gas can be reduced to the process flush quantity. After the heat treatment the box is pulled out of the furnace, the charge taken from the box and placed in the quenching medium. We recommend using binding wire on the parts so that they can easily be grasped by tongs.

A flexible type K thermocouple is installed in the box for measuring the temperature; we recommend connecting it to a digital display device or to a temperature recorder.

The box can also be cooled down on a cooling platform while closed. Be sure that the protective gas flowrate is increased for this application.

- Tmax 1100 °C
- For non-combustible protective and reactive gases argon, nitrogen and forming gas (observe national regulations)
- Protective gas box with fiber sealing and lid, gas supply via a tube into the bottom of the box
- Protective gas connection via quick coupling with hose connector (inner diameter 9 mm)
- Piping for gas inlet and outlet through the furnace collar
- Heat-resistant alloy 314 (AISI)/(DIN material no. 1.4841)
- Charge thermocouple type K for temperature display or charge control

Additional equipment
- Starting from N 31/H a charging cart is recommended see page 54
- Digital temperature display see page 51
- Gas supply systems see page 52
- Charging forks see page 39
- Draw Hook

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Furnace</th>
<th>Inner dimensions in mm</th>
<th>Outer dimensions in mm</th>
<th>Preflush rate l/min</th>
<th>Process flush rate l/min</th>
<th>Charging method of the box</th>
</tr>
</thead>
<tbody>
<tr>
<td>631000963</td>
<td>N 7/H</td>
<td>180 190 90</td>
<td>216 226 116</td>
<td>15 - 20</td>
<td>5 - 8</td>
<td>charging fork</td>
</tr>
<tr>
<td>631000968</td>
<td>N 11/H, N 11/HR</td>
<td>180 290 90</td>
<td>216 326 116</td>
<td>15 - 20</td>
<td>5 - 8</td>
<td>charging fork</td>
</tr>
<tr>
<td>631000973</td>
<td>N 17/HR</td>
<td>180 440 90</td>
<td>216 476 116</td>
<td>15 - 20</td>
<td>5 - 8</td>
<td>charging fork</td>
</tr>
<tr>
<td>631000978</td>
<td>N 31/H</td>
<td>280 230 200</td>
<td>316 304 226</td>
<td>20 - 25</td>
<td>10 - 15</td>
<td>draw hook</td>
</tr>
<tr>
<td>631000983</td>
<td>N 41/H</td>
<td>280 380 200</td>
<td>316 454 226</td>
<td>20 - 25</td>
<td>10 - 15</td>
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</tr>
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<td>631000987</td>
<td>N 51/H, N 87/H</td>
<td>280 500 200</td>
<td>316 574 226</td>
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<td>10 - 15</td>
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<tr>
<td>631000892</td>
<td>N 81, N 81/13</td>
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<td>462 530 212</td>
<td>20 - 30</td>
<td>10 - 20</td>
<td>charging stacker</td>
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<tr>
<td>631000939</td>
<td>N 161, N 161/13</td>
<td>450 550 250</td>
<td>515 596 355</td>
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<td>10 - 20</td>
<td>charging stacker</td>
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<td>631000607</td>
<td>N 321, N 321/13</td>
<td>470 850 185</td>
<td>580 960 330</td>
<td>20 - 30</td>
<td>10 - 20</td>
<td>charging stacker</td>
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<tr>
<td>631000608</td>
<td>N 641, N 641/13</td>
<td>720 1050 270</td>
<td>830 1160 414</td>
<td>20 - 30</td>
<td>10 - 20</td>
<td>charging stacker</td>
</tr>
</tbody>
</table>

Article no. 601655055, 1 set of fiber insulation cord, 5 strips of 610 mm each

Work space = box inner dimensions: - 30 mm to all sides

Larger boxes and custom dimensions available upon request
Protective Gas Boxes with Evacuation Lid for Models N 7/H - N 161/13

For heat treatment of bulk goods and hollow parts under protective gas atmosphere we recommend the usage of protective gas boxes with an additional evacuation lid.

These boxes are equipped with a lid for top charging, protective gas inlet and outlet as well as an evacuation lid with rubber sealing gasket. Gas ductwork and handling while hot is the same as the protective gas boxes described on page 37. In addition, these boxes also feature a connection for a vacuum pump with a shut-off valve.

After charging the box in a cold state it is evacuated and afterwards flushed with protective gas. By repeating this process once or several times the results are considerably improved. After the box was flushed with protective gas the last time, the evacuation lid is removed and the box is placed into the preheated furnace. Protective gas is used for heat treatment. Thus traces of oxygen in the box can be reduced by a considerable amount which improves the quality of the components accordingly.

After the heat treatment the box is taken out of the furnace and can be cooled in air or be opened to remove the charge.

The box can also be force-cooled on a cooling platform while closed. Be sure that the protective gas flowrate is increased for this application.

- Tmax 1100 °C
- For non-combustible protective and reactive gases argon, nitrogen and forming gas (observe national regulations)
- Protective gas box with fiber sealing and lid with locks, recess for evacuation lid, gas inlet via a pipe into the bottom of the box
- Evacuation lid with rubber sealing (Elastomer) and manometer
- Protective gas connection via three-way ball valve and quick coupling with hose connector (inner diameter 9 mm)
- Piping for gas inlet and outlet through the furnace collar
- Heat-resistant alloy 314 (AISI)/(DIN material no. 1.4841)
- Charge thermocouple type K for temperature display or charge control

Additional equipment
- Starting from N 31/H a charging cart is recommended see page 54
- Digital temperature display see page 51
- Vacuum pump see page 53
- Gas supply systems see page 52
- Charging forks see page 39
- Draw Hook

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Furnace</th>
<th>Inner dimensions in mm</th>
<th>Outer dimensions in mm</th>
<th>Preflush rate</th>
<th>Process flush rate</th>
<th>Charging method of the box</th>
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</thead>
<tbody>
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<td>170 x 170 x 70</td>
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<td>170 x 270 x 70</td>
<td>212 x 312 x 106</td>
<td>15 - 20</td>
<td>5 - 8</td>
<td>charging fork</td>
</tr>
<tr>
<td>631000976</td>
<td>N 17/HR</td>
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<td>5 - 8</td>
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<td>N 31/H</td>
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<td>10 - 15</td>
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<td>N 41/H</td>
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<td>292 x 392 x 178</td>
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<td>10 - 15</td>
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</tr>
<tr>
<td>631000989</td>
<td>N 61/H, N 87/H</td>
<td>250 x 500 x 150</td>
<td>292 x 542 x 178</td>
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<td>10 - 15</td>
<td>draw hook</td>
</tr>
<tr>
<td>631000526</td>
<td>N 81, N 81/13</td>
<td>354 x 494 x 185</td>
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<tr>
<td>631000527</td>
<td>N 161, N 161/13</td>
<td>400 x 550 x 250</td>
<td>468 x 965 x 350</td>
<td>20 - 30</td>
<td>10 - 20</td>
<td>charging stacker</td>
</tr>
</tbody>
</table>

1 Without piping and evacuation lid

Larger boxes and custom dimensions available upon request

Article no. 601655055, 1 set of fiber insulation cord, 5 strips of 610 mm each

Work space = box inner dimensions: ± 30 mm to all sides
Charging Plates for Models N 7/H - N 641/13

We recommend these accessories for applications up to 1100 °C to protect the furnace floor, especially if a charging cart is used.

- Tmax 1100 °C
- Three raised edges
- Heat-resistant alloy 314 (AISI)/(DIN material no. 1.4841)
- Larger plates and custom dimensions available upon request

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Furnace</th>
<th>Outer dimensions in mm</th>
</tr>
</thead>
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Charging Forks

- Charging forks to charge and remove protective gas boxes up to model N 17/H

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<tr>
<td>631001017</td>
<td>N 17/HR</td>
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</table>

Charging plate
Tool Shop Hardening Systems MHS 31, MHS 41 and MHS 61

These toolshop hardening systems are suitable for components in air or under a protective gas atmosphere. They can be assembled from a chamber furnace, a forced convection gas box with a gas supply via a solenoid valve, a charging plate to protect the furnace floor, and a quenching bath with heating element. During the heat treatment under protective gas, the process starts with the flushing of the batch in the protective gas box by means of protective gas. Subsequently, annealing is carried out in the chamber furnace at a lower process flushing rate. The chamber furnace is opened after the annealing process and the batch is removed from the protective gas box to be quenched in the preheated quench bath. The final annealing process takes place in the forced convection furnace. For easier charging, we recommend the use of optional charging aids such as pull hooks and charging trolleys.

The toolshop hardening systems are an assembly of furnaces and accessories from our standard range. All components can also be ordered separately.

Additional equipment
- Draw hook
- Charging cart see page 54

<table>
<thead>
<tr>
<th>Model</th>
<th>Tmax °C</th>
<th>Inner dimensions in mm</th>
<th>Charging height in mm</th>
<th>Outer dimensions in mm</th>
<th>Heating power in kW</th>
<th>Electrical connection</th>
<th>Weight in kg</th>
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<td>-</td>
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<td>- 316 454 226</td>
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<td></td>
</tr>
</tbody>
</table>

¹Heating only between two phases
²Depending on furnace design connected load might be higher

*Please see page 73 for more information about supply voltage
Protective Gas Hardening System SHS 41

This compact, semi-automatic system is suitable for hardening in a protective gas atmosphere followed by quenching of the workpiece in oil. In this way, even larger parts can be annealed under a protective gas and quenched. It consists of a chamber furnace N 41/H hardening furnace with a pneumatic door opening and charging plates as well as an oil quench bath on rollers with an integrated pneumatic lowering unit, a floor grid with gas hood, a holding unit for the gas hood as well as a rim exhaust with flame trap.

The workpiece is placed on the floor grid and covered with the gas hood. After preflushing with protective gas, the gas hood is pushed with the floor grid into the chamber furnace. After the heat treatment is completed, the workload is pulled out of the furnace onto the lowering unit. The hood remains above the quenching bath while the charging floor grid is lowered pneumatically. In order to obtain best quenching results, the pneumatic lowering unit is moved up and down in the oil quench bath. After completion, the workload is moved into unloading position.

This low cost system can be used for hardening processes which otherwise could only be handled in complex furnace systems.

- Chamber furnace N 41/H
- Pneumatic pedal switch operated door opening
- Charging plate
- Oil quench bath on rollers
- Pneumatic lowering unit
- Heating of oil quench bath
- Oil temperature display
- Charging floor grid and gas hood
- Holding unit for gas hood
- Manual protective gas unit see page 52
- Draw hook
- Safety equipment consisting of rim exhaust with flame trap and oil steam separator

Additional equipment
- Suction hood
- Water bath

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Protective gas hardening system</th>
<th>W</th>
<th>D</th>
<th>H</th>
<th>Oil quench bath size in liters</th>
<th>max. load Weight</th>
<th>max. quench yield/h</th>
<th>Preflush rate</th>
<th>Process flush rate</th>
<th>Heating power oil bath kW</th>
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<td>360</td>
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<td>20 kg</td>
<td>20 - 25</td>
<td>10 - 15</td>
<td>6.0</td>
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*Please see page 73 for more information about supply voltage

<table>
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<th>Furnace Model</th>
<th>Tmax °C</th>
<th>Inner dimensions in mm</th>
<th>Volume in l</th>
<th>Outer dimensions in mm</th>
<th>Heating power in kW 2</th>
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<th>Weight in kg</th>
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</tbody>
</table>

¹ Furnace description see page 36
² Depending on furnace design connected load might be higher

*Please see page 73 for more information about supply voltage
Chamber furnaces with air circulation are characterized particularly by their very good temperature uniformity. As a result, they are well suited for processes such as calcination and drying e.g. ceramic materials. The design as a debinding furnace for safe debinding in air or in an inert atmosphere is possible. When used for debinding in air the exhaust gases are diluted by fresh air to reliably prevent an inflammatory atmosphere in the furnace chamber. For debinding processes that have to take place under inert gas, the IDB passive safety concept with a residual oxygen content of max. 3 % is recommended.

- **Tmax** 450 °C, 650 °C, or 850 °C
- Stainless steel air-baffles in the furnace for optimum air circulation
- Swing door hinged on the right side
- Base frame included in the delivery, NA 15/65 designed as table-top model
- Horizontal air circulation
- Temperature uniformity up to +/- 4 °C according to DIN 17052-1 (model NA 15/65 up to +/- 5 °C) see page 68
- Optimum air distribution enabled by high flow speeds
- One frame sheet and rails for two additional trays included in the scope of delivery (NA 15/65 without frame sheet)
- Defined application within the constraints of the operating instructions
- NTLog Basic for Nabertherm Controller: Recording of process data with USB-flash drive (NA 30/45 - N 675/85 HA)
- Controls description see page 72

Additional equipment (not for model NA 15/65)
- Optimization of the temperature uniformity up to +/- 3 °C according to DIN 17052-1 see page 68
- Air inlet and exhaust air flaps when used for drying
- Controlled cooling with fan
- Manual lift door (up to model N(A) 120/.. (HA))
- Pneumatic lift door
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<thead>
<tr>
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<th>Heat-up time to Tmax in minutes</th>
<th>Cool-down time from Tmax to 150 °C in minutes</th>
<th>Flaps</th>
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<td>255 1636 1860 20.0</td>
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<td>900</td>
<td>210</td>
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</table>

*Table-top model see page 42
Heating only between two phases
Depending on furnace design connected load might be higher

1. Air circulation with speed control, recommendable for processes with light or sensitive charge
2. Roller conveyor in furnace chamber for heavy charges
3. Designed for Tmax 950 °C
4. Safety technology according to EN 1539 (NFPA 86) (models NA .. LS) for charges containing solvents
5. Inlets, measuring frames and thermocouples for TUS measurements charge or comparative measurements
6. Process control and documentation via VCD software package or Nabertherm Control Center (NCC) for monitoring, documentation and control see page 72

Air circulation chamber furnace N 250/65 HA IDB with gas supply box for debinding and protective gases

Air circulation chamber furnace N 500/65 HA DB200 for debinding in air with catalytic afterburner system

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Additional frame sheet
Roller conveyor in furnace chamber for heavy charges
Safety technology according to EN 1539 (NFPA 86) (models NA .. LS) for charges containing solvents
Inlets, measuring frames and thermocouples for TUS measurements charge or comparative measurements
Process control and documentation via VCD software package or Nabertherm Control Center (NCC) for monitoring, documentation and control see page 72

Air circulation with speed control, recommendable for processes with light or sensitive charge
Air circulation with speed control, recommendable for processes with light or sensitive charge
Air circulation with speed control, recommendable for processes with light or sensitive charge
Air circulation with speed control, recommendable for processes with light or sensitive charge
Air circulation with speed control, recommendable for processes with light or sensitive charge
Air circulation with speed control, recommendable for processes with light or sensitive charge
Air circulation with speed control, recommendable for processes with light or sensitive charge
Air circulation with speed control, recommendable for processes with light or sensitive charge
Protective Gas Boxes for Models
NA 30/45 - N 500/85HA

For the heat treatment, workpieces are placed in the box, the lid is locked using the sealing locks and flushed with protective gas outside the furnace for some time and then placed in the furnace. Depending on the weight, a charging cart (page 30) is recommended.

Basic Version

- For non-combustible protective and reactive gases argon, nitrogen and forming gas (observe national regulations)
- Protective gas box with fiber seal and cover with locks, inert gas introduction via a pipe into the bottom of the box
- Protective gas connection via quick coupling with hose connector (inner diameter 9 mm)
- Piping for gas inlet and outlet through the furnace collar
- Models N 250/..HA, NA 250/.., N 500/..HA und NA 500/.. will be delivered without bottom frame sheet
- Heat-resistant alloy: 309 (AISI)/(DIN material no. 1.4828)
- Charge thermocouple type K for temperature display or charge control

Additional equipment

- Digital temperature display see page 51
- Gas supply systems see page 52
- Extended gas piping for the use of smaller boxes in larger furnace models
- Draw hook
- Charging cart see page 54

| Article no. 601655055 | 1 set of fiber insulation cord, 5 strips of 610 mm each |

| Larger boxes and custom dimensions available upon request |

| Article no. (Furnace with hinged door) (Furnace with lift door) | Furnace | Inner dimensions in mm w d h | Outer dimensions in mm\(^2\) W D H | Charging method of the box |
|---|---|---|---|---|---|
| 6310000410 | 631000763 | NA 30/.., N 30/..HA | 220 | 320 | 160 | 282 | 376 | 242 | draw hook |
| 6310000411 | 631000764 | NA 60/.., N 60/..HA | 270 | 420 | 260 | 336 | 460 | 340 | draw hook |
| 6310000412 | 631000765 | NA 120/.., N 120/..HA | 350 | 520 | 340 | 436 | 560 | 430 | draw hook |
| 6310000413 | 631000766 | NA 250/.., N 250/..HA | 480 | 630 | 460 | 546 | 680 | 600 | charging stacker |
| 6310000414 | 631000767 | NA 500/.., N 500/..HA | 630 | 780 | 610 | 696 | 836 | 760 | Charging cart |

Without piping
Design as the boxes described above, but with additional evacuation lid and connection. Before the box is placed in the furnace, in a cold state an evacuation and protective gas atmosphere are alternately generated to force out the oxygen and achieve a pure atmosphere.

- Protective gas box with fiber sealing and lid with locks, recess for evacuation lid, gas inlet via a pipe into the bottom of the box
- Evacuation lid with rubber sealing (Elastomer) and manometer
- Protective gas connection via three-way ball valve and quick coupling with hose connector (inner diameter 9 mm)
- Piping for gas inlet and outlet through the furnace collar

Additional equipment
- Digital temperature display see page 51
- Vacuum pump see page 53
- Gas supply systems see page 52
- Extended gas piping for the use of smaller boxes in larger furnace models
- Draw hook
- Charging cart see page 54

### Protective Gas Boxes with Evacuation Lid for Models NA 30/45 - N 500/85HA

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Furnace with hinged door</th>
<th>Furnace with lift door</th>
<th>Furnace</th>
<th>Inner dimensions in mm</th>
<th>Outer dimensions in mm&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Charging method of the box</th>
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<td>631000806</td>
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<td>NA 30/... N 30/... HA</td>
<td>170 300 130</td>
<td>258 388 222</td>
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<td>631000807</td>
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<td>draw hook</td>
</tr>
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<td>631000561</td>
<td>631000808</td>
<td></td>
<td>NA 120/... N 120/... HA</td>
<td>330 480 320</td>
<td>418 568 412</td>
<td>draw hook</td>
</tr>
<tr>
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<td>631000809</td>
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<td>NA 250/... N 250/... HA</td>
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<td>631000810</td>
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<td>NA 500/... N 500/... HA</td>
<td>560 810 530</td>
<td>648 898 692</td>
<td>charging stacker</td>
</tr>
</tbody>
</table>

Article no. 601655055, 1 set of fiber insulation cord, 5 strips of 610 mm each
Work space = box inner dimensions: ± 30 mm to all sides
Larger boxes and custom dimensions available upon request

<sup>1</sup> Without piping and evacuation lid
Protective Gas Boxes According to AMS2750F, Instrumentation Type D for Forced Convection Furnaces

These boxes are based on the standard protective gas boxes for furnaces with hinged door. To fulfill AMS2750F, instrumentation, type D requirements the boxes are equipped with necessary measuring ports.

- Temperature uniformity class 2: +/- 5 °C in useful space
- Additional port for customers flexible SAT thermocouple with max. 1,5 mm diameter
- Thermocouple, overtemperature protection, metal clad thermocouple, type N with plug

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Furnace (with swinging door)</th>
<th>Furnace (with lift door)</th>
<th>Inner dimensions in mm</th>
<th>Outer dimensions in mm¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Furnace with swinging door)</td>
<td>(Furnace with lift door)</td>
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<td>d</td>
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<td>631001029</td>
<td>NA 500/...N 500/...HA</td>
<td>630</td>
<td>780</td>
</tr>
</tbody>
</table>

Article no. 601655055, 1 set of fiber insulation cord, 5 strips of 610 mm each
Without piping

Work space = box inner dimensions: - 30 mm to all sides
Larger boxes and custom dimensions available upon request

Protective Gas Boxes with Evacuation Lid According to AMS2750F, Instrumentation type D

These boxes are based on the standard protective gas boxes with evacuation lid for furnaces with hinged door. Before the box is placed in the furnace, in a cold state an evacuation and protective gas atmosphere are alternately generated to force out the oxygen and achieve a pure atmosphere.

- Temperature uniformity class 2: +/- 5 °C in useful space
- Additional port for customers flexible SAT thermocouple with max. 1,5 mm diameter
- Thermocouple, overtemperature protection, metal clad thermocouple, type N with plug

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Furnace with hinged door</th>
<th>Furnace with lift door</th>
<th>Inner dimensions in mm</th>
<th>Outer dimensions in mm¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Furnace with hinged door)</td>
<td>(Furnace with lift door)</td>
<td>w</td>
<td>d</td>
</tr>
<tr>
<td>631001049</td>
<td>631001054</td>
<td>NA 30/...N 30/...HA</td>
<td>170</td>
<td>300</td>
</tr>
<tr>
<td>631001050</td>
<td>631001055</td>
<td>NA 60/...N 60/...HA</td>
<td>220</td>
<td>380</td>
</tr>
<tr>
<td>631001051</td>
<td>631001056</td>
<td>NA 120/...N 120/...HA</td>
<td>330</td>
<td>480</td>
</tr>
<tr>
<td>631001052</td>
<td>631001057</td>
<td>NA 250/...N 250/...HA</td>
<td>430</td>
<td>580</td>
</tr>
<tr>
<td>631001053</td>
<td>631001058</td>
<td>NA 500/...N 500/...HA</td>
<td>560</td>
<td>810</td>
</tr>
</tbody>
</table>

Article no. 601655055, 1 set of fiber insulation cord, 5 strips of 610 mm each
Without piping

Work space = box inner dimensions: - 30 mm to all sides
Larger boxes and custom dimensions available upon request

Protective Gas Boxes for Automotive (CQI-9) and Aeronautic (AMS7NADCAP) Norms

![Diagram of protective gas box with evacuation lid]

Larger boxes and custom dimensions available upon request
Sealed Forced Convection Chamber Furnaces NA-I and NA-SI

Sealed forced convection chamber furnaces are suitable if a heat treatment process up to 650 °C requires a protective gas atmosphere that does not have to be completely oxygen free.

The difference between the two variants is that the I-model only has a sealed outer housing while the SI-model has a welded inner box, which further reduces the residual oxygen concentration.

NA-I design
Like forced convection chamber furnaces < 675 l (page 42) with the following changes
- Tmax 450 °C and 650 °C
- Silicone door seal
- Furnace housing sealed with silicone
- Protective gas connection in the back wall
- Defined application within the constraints of the operating instructions
- Residual oxygen concentration < 1 % depending on the volume and type of protective gas
- For non-flammable protective and reaction gases such as argon, nitrogen, and forming gas (national regulations must be considered)

NA-SI design
Additional features
- Tmax 650 °C
- Welded inner housing
- 2-sided heating and air circulation
- Door sealed with seal gas
- Sealed connection to circulation motor
- Gas inlet via circulator shaft
- Defined application within the constraints of the operating instructions
- Residual oxygen concentration to 0.1 % depending on the volume and type of protective gas
- For non-flammable protective and reaction gases such as argon, nitrogen, and forming gas (national regulations must be considered)

---

<table>
<thead>
<tr>
<th>Model</th>
<th>Tmax °C</th>
<th>Inner dimensions in mm</th>
<th>Volume in l</th>
<th>Outer dimensions* in mm</th>
<th>Heating power in kW</th>
<th>Electrical connection*</th>
<th>Weight in kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA 20/45 I</td>
<td>450</td>
<td>290 420 260</td>
<td>30</td>
<td>1040 1290 1385</td>
<td>3.0</td>
<td>1(3)-phase</td>
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</tr>
<tr>
<td>NA 60/45 I</td>
<td>450</td>
<td>350 500 350</td>
<td>60</td>
<td>1100 1370 1475</td>
<td>6.0</td>
<td>3-phase</td>
<td>350</td>
</tr>
<tr>
<td>NA 120/45 I</td>
<td>450</td>
<td>450 600 450</td>
<td>120</td>
<td>1250 1550 1550</td>
<td>9.0</td>
<td>3-phase</td>
<td>460</td>
</tr>
<tr>
<td>NA 250/45 I</td>
<td>450</td>
<td>600 750 600</td>
<td>250</td>
<td>1350 1650 1725</td>
<td>12.0</td>
<td>3-phase</td>
<td>590</td>
</tr>
<tr>
<td>NA 500/45 I</td>
<td>450</td>
<td>750 1000 750</td>
<td>500</td>
<td>1550 1900 1820</td>
<td>18.0</td>
<td>3-phase</td>
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</tr>
<tr>
<td>NA 675/45 I</td>
<td>450</td>
<td>750 1200 750</td>
<td>675</td>
<td>1550 2100 1820</td>
<td>24.0</td>
<td>3-phase</td>
<td>900</td>
</tr>
<tr>
<td>NA 15/65 l*</td>
<td>650</td>
<td>295 340 170</td>
<td>15</td>
<td>470 790 460</td>
<td>2.8</td>
<td>1-phase</td>
<td>60</td>
</tr>
<tr>
<td>NA 30/65 l*</td>
<td>650</td>
<td>350 420 260</td>
<td>30</td>
<td>870 1290 1385</td>
<td>5.0</td>
<td>3-phase</td>
<td>285</td>
</tr>
<tr>
<td>NA 60/65 l (SI)</td>
<td>650</td>
<td>450 600 450</td>
<td>120</td>
<td>990 1470 1550</td>
<td>9.0</td>
<td>3-phase</td>
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</tr>
<tr>
<td>NA 120/65 l (SI)</td>
<td>650</td>
<td>600 750 600</td>
<td>250</td>
<td>1170 1650 1680</td>
<td>12.0</td>
<td>3-phase</td>
<td>460</td>
</tr>
<tr>
<td>NA 250/65 l (SI)</td>
<td>650</td>
<td>750 1000 750</td>
<td>500</td>
<td>1290 1890 1825</td>
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<td>3-phase</td>
<td>590</td>
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<tr>
<td>NA 500/65 l (SI)</td>
<td>650</td>
<td>750 1200 750</td>
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<td>900</td>
<td></td>
</tr>
</tbody>
</table>

1Table-top model
2Heating only between two phases

*Please see page 73 for more information about supply voltage
Depending on furnace design connected load might be higher

*External dimensions vary when furnace is equipped with additional equipment. Dimensions on request.
Forced Convection Pit-Type Furnaces
Electrically Heated

Forced convection pit-type furnaces offer the advantage of easy charging, for heat treatment of heavy parts or loads in charge baskets. With maximum application temperatures available from 450 °C to 850 °C, these compact pit-type furnaces are particularly useful for processes such as tempering, solution annealing, artificial ageing, and soft annealing.

- Tmax 450 °C, 650 °C, 850 °C
- Air circulation fans in the furnace bottom, high circulation rate
- Vertical air circulation with square air heating chamber
- Temperature uniformity up to +/- 4 °C according to DIN 17052-1 see page 68
- Interior walls from stainless steel
- Switchgear with solid-state relays
- Defined application within the constraints of the operating instructions
- NTLog Basic for Nabertherm controller: recording of process data with USB-flash drive
- Controls description see page 72

Addition equipment
- Charging hoist with swivel arm and charge basket
- Optimization of the temperature uniformity up to +/- 2 °C according to DIN 17052-1 see page 68
- Integrated fan for rapid cool down or separate cooling station for annealing box cooling outside of the furnace
- Annealing box with protective gas inlet and outlet for production in a defined atmosphere
- Manual or automatic gas supply systems for non-flammable protective or reaction gases
- Process control and documentation via VCD software package for monitoring, documentation and control see page 72

<table>
<thead>
<tr>
<th>Model</th>
<th>Tmax °C</th>
<th>Inner dimensions in mm</th>
<th>Volume in l</th>
<th>Max. charging weight in kg</th>
<th>Outer dimensions in mm</th>
<th>Heating power in kW</th>
<th>Electrical connection*</th>
<th>Weight in kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAL 30/45</td>
<td>450</td>
<td>300</td>
<td>250</td>
<td>400</td>
<td>30</td>
<td>120</td>
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<td>950</td>
</tr>
<tr>
<td>SAL 120/45</td>
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<td>450</td>
<td>450</td>
<td>600</td>
<td>120</td>
<td>120</td>
<td>900</td>
<td>1050</td>
</tr>
<tr>
<td>SAL 250/45</td>
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<td>1200</td>
</tr>
<tr>
<td>SAL 500/45</td>
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<td>750</td>
<td>750</td>
<td>900</td>
<td>500</td>
<td>400</td>
<td>1200</td>
<td>1350</td>
</tr>
<tr>
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<td>300</td>
<td>250</td>
<td>400</td>
<td>30</td>
<td>120</td>
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<td>450</td>
<td>600</td>
<td>120</td>
<td>120</td>
<td>900</td>
<td>1050</td>
</tr>
<tr>
<td>SAL 250/65</td>
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<td>750</td>
<td>250</td>
<td>400</td>
<td>1050</td>
<td>1200</td>
</tr>
<tr>
<td>SAL 500/65</td>
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<td>750</td>
<td>900</td>
<td>500</td>
<td>400</td>
<td>1200</td>
<td>1350</td>
</tr>
<tr>
<td>SAL 30/85</td>
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<td>250</td>
<td>400</td>
<td>30</td>
<td>80</td>
<td>600</td>
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</tr>
<tr>
<td>SAL 60/85</td>
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<td>500</td>
<td>60</td>
<td>80</td>
<td>800</td>
<td>950</td>
</tr>
<tr>
<td>SAL 120/85</td>
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<td>450</td>
<td>450</td>
<td>600</td>
<td>120</td>
<td>80</td>
<td>900</td>
<td>1050</td>
</tr>
<tr>
<td>SAL 250/85</td>
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<td>600</td>
<td>600</td>
<td>750</td>
<td>250</td>
<td>250</td>
<td>1050</td>
<td>1200</td>
</tr>
<tr>
<td>SAL 500/85</td>
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<td>750</td>
<td>900</td>
<td>500</td>
<td>250</td>
<td>1200</td>
<td>1350</td>
</tr>
</tbody>
</table>

*Heating only between two phases
*Please see page 73 for more information about supply voltage
*External dimensions vary when furnace is equipped with additional equipment. Dimensions on request.
### Protective Gas Boxes for Models SAL 30/45 - SAL 500/85

For tempering and bright annealing, workpieces are laid in the box, the lid is pressed firmly shut using the sealing locks and flushed with protective gas outside the box for some time and then placed in the furnace. Due to weight reasons we recommend to use a charging aid for charging.

- For non-combustible protective and reactive gases argon, nitrogen and forming gas (observe national regulations)
- Protective gas box with fiber seal and cover with locks, inert gas introduction via a pipe into the bottom of the box
- Protective gas connection via quick coupling with hose connector (inner diameter 9 mm)
- Piping for gas inlet and outlet through the furnace collar
- Heat-resistant alloy: 450 °C - 304 (AISI)/(DIN material no. 1.4301), 650 °C - 321 (AISI)/(DIN material no. 1.4541) or 850 °C - 309 (AISI)/(DIN material no. 1.4828)
- Charging aid lifting eyes
- Charge thermocouple type K for temperature display or charge control

### Additional equipment

- Digital temperature display see page 51
- Gas supply systems see page 52

---

### Table: Furnace Dimensions

<table>
<thead>
<tr>
<th>Furnace</th>
<th>Total height in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAL 30/.. - SAL 120/..</td>
<td>2400</td>
</tr>
<tr>
<td>SAL 250/..</td>
<td>2600</td>
</tr>
<tr>
<td>SAL 500/..</td>
<td>3010</td>
</tr>
</tbody>
</table>

---

Article no. 601655055, 1 sales unit of fiber insulation cord, 5 strips of 610 mm each

1 Without piping
Forced Convection Pit-Type Retort Furnaces up to 850 °C

The forced convection pit-type furnaces of the SAL series (technical data see page 48) can be upgraded by the use of gas tight retorts for processes with defined atmospheres.

These systems are very well suited for the heat treatment of bulk materials.

By means of an additional retort and cooling station, the retort can be removed after completion of the heat treatment process and cooled in a cooling station. In the case of sensitive components, further flushing with protective gas can also be carried out during the cooling phase.

The cooling station can be designed with or without forced cooling by means of a powerful fan.

When equipped with a vacuum pump, the retort is evacuated outside the furnace in cold state and then flushed with protective gas. This procedure is particularly suitable for heat treatment of bulk solids as well as for non-ferrous and precious metals. Residual oxygen is much better and faster removed by means of pre-evacuation.

Up to a maximum working temperature of 600 °C, the furnaces can also be operated under vacuum by connecting a vacuum pump depending on the type of pump, a vacuum of up to $10^{-5}$ mbar can be achieved.

The furnaces can be equipped with gas supply systems for non-flammable protective and reaction gases, as described on pages 52 - 53.

A gas supply system for operation under hydrogen, including safety technology, is also available as an additional equipment.
Temperature Measurement in Gas Supply Systems

The use of a thermometer with thermocouple is recommended for determining the exact heat treatment temperature in protective gas boxes or gas feed annealing bags with holders. The thermocouple is permanently mounted on the respective protective gas boxes or gas feed annealing bag holder. A simple manual thermometer with LCD display or a temperature indicator with LED display can be supplied, mounted in a separate metal housing. Both are equipped with a two-pole plug unit for connecting to the thermocouple. The temperature can be determined in this way and, if necessary, readjusted on the controller.

Upon request, the furnace can be operated by charge control with a thermocouple attached to the workpiece.

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>402000057</td>
<td>Temperature indicator with digital display, 230 V 1/N connection, in metal housing</td>
</tr>
<tr>
<td>542100028</td>
<td>Temperature indicator with digital display, battery-operated, manual device</td>
</tr>
<tr>
<td>V000808</td>
<td>Connecting cable between heat treatment with charge thermocouple and Article no. 402000057, 5 m</td>
</tr>
<tr>
<td>V000801</td>
<td>Connecting cable between heat treatment with charge thermocouple and Article no. 542100028, 3 m</td>
</tr>
</tbody>
</table>

To carry out the temperature uniformity measurement (TUS) the protective gas box will be equipped with a second lid. The TUS measuring frame is fixed to the lid and it is equipped with measuring port for thermocouples.

- Tmax 1100 °C
- Useful for all relevant TUS norms
- Under the assumption that the furnace is equipped with a measuring port for thermocouples
- Heat-resistant alloy 314 (AISI)/(DIN material no. 1.4828)
- Thermocouples not included
Gas Supply Systems

Protective Gases
Protective gases are used to force oxygen out of the gas feed boxes mentioned above. Make sure to use protective gases behaving neutrally toward the heat treated part. The protective gases should be inert, meaning no chemical bonding should occur with the workpiece or the furnace and no reactions should be endured.

In many cases, nitrogen is used as protective gas (lighter than air). Our experience shows that nitrogen does not always lead to sufficient results. A longer preflush time must also be used.

Better results are achieved by adding a mixture of nitrogen and adding some hydrogen. Hydrogen acts as a reducing constituent and reacts with the oxygen. This gas mixture is known as forming gas and available in stores. Experience has shown that adding 5% hydrogen to the nitrogen leads to good results. According to the EU material safety data sheet this mixture is considered as not flammable. National regulations, however, must be observed. This gas can be obtained in premixed form. No measures must be taken in advance to prevent explosions.

If the workpiece has an affinity to hydrogen, argon used as protective gas can lead to good results.

Argon is a gas which is heavier than air. This makes it relatively easy to fill the protective gas containers. Forming gas with added hydrogen (depending on the country law up to a ration of 98/2) is lighter, but it has the advantage of burning at higher temperatures and therefore binds with the oxygen. Even in a cold state, the leaking hydrogen transports the oxygen very easily out of the container.

For gas mixtures with hydrogen or other combustible gases, the valid safety regulations must always be observed. If the mixture is declared as combustible, the furnace, provided it is a gas tight version, can be fitted with a corresponding safety system.

Always make sure that the room is properly ventilated when working with protective gases. Country-specific safety regulations must also be followed.

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Type of gas</th>
<th>Flow rate l/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>631000309</td>
<td>Ar</td>
<td>0 - 30</td>
</tr>
<tr>
<td>631000310</td>
<td>N₂</td>
<td>0 - 30</td>
</tr>
<tr>
<td>631000311</td>
<td>Non-flammable forming gas</td>
<td>0 - 30</td>
</tr>
</tbody>
</table>

Manual Gas Feed Fitting for Bottles
- Pressure reducing valve with assembled flow meter and attached pressure gauge indicating the bottle pressure. The assembled variable area flow meter ensures good readability of the amount used.
- Connection: screw connection for bottle.
- Exit: hose connection (inner diameter 9 mm).
- 200 bar intake pressure, 4 bar outlet pressure.
- Incl. 4 m connecting hose to the furnace.

Alternative connection threads on request.
Automatic Gas Supply System for two different Flushing Quantities, e.g. high Volume Preflushing and low Volume for ongoing Operation

Consisting of:

- Switching system with 3-step switch for gas inlet Off/Manual/Automatic via “Extra” function of respective controller, timer for switching from large gas quantity to small gas quantity. Gas feed stops at when program quits.
- Automatic gas feed panel with pressure reducer, two adjustable flow meters and two solenoid valves, preinstalled conduit and wiring attached to furnace from the side on an assembly plate.
- Connection: hose connection (inner diameter 9 mm)
- Exit: hose connection (inner diameter 9 mm)
- Max. 10 bar intake pressure, max. 300 mbar outlet pressure
- Incl. connecting hose between furnace and protective gas box or gas connection
- Available only in combination with furnace or switchgear

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Type of gas</th>
<th>Flow rate l/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>631000379</td>
<td>Ar</td>
<td>0 - 30</td>
</tr>
<tr>
<td>631000380</td>
<td>N₂</td>
<td>0 - 30</td>
</tr>
<tr>
<td>631000381</td>
<td>Non-flammable forming gas</td>
<td>0 - 30</td>
</tr>
</tbody>
</table>

Alternative connection threads on request

Automatic Gas Feed Fitting with Solenoid Valve

- Solenoid valve mounted on the furnace, controlled using the controller “Extra” function
- Connection: screw connection for bottle
- Exit: hose connection (inner diameter 9 mm)
- 200 bar intake pressure, 4 bar outlet pressure
- Incl. 4 m connecting hose to the furnace
- Available only in combination with furnace or switchgear

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Type of gas</th>
<th>Flow rate l/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>631000379</td>
<td>Ar</td>
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</tr>
<tr>
<td>631000200</td>
<td>N₂</td>
<td>0 - 30</td>
</tr>
<tr>
<td>631000380</td>
<td>Non-flammable forming gas</td>
<td>0 - 30</td>
</tr>
</tbody>
</table>

Automatic gas feed panel with Solenoid Valve

- Solenoid valve mounted on the furnace, controlled using the controller “Extra” function
- Connection: screw connection for bottle
- Exit: hose connection (inner diameter 9 mm)
- 200 bar intake pressure, 4 bar outlet pressure
- Incl. 4 m connecting hose to the furnace
- Available only in combination with furnace or switchgear

Vacuum Pump

Oil sealed rotary vane vacuum pump for universal use within the low vacuum range. Highly compact and low noise construction. Manometer included in delivery.

- Sliding vane rotary pump with sucking capacity of max. 16 m³/h
- 0.5 mbar absolute
- Connection hose made of stainless steel 2000 mm
- Connector KF16
- Manometer (-1/0.6 bar)

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Outer dimensions in mm</th>
<th>Connections on suction side</th>
<th>Connected load</th>
<th>Supply voltage*</th>
<th>Nominal suction power m³/h</th>
<th>Suction capacity m³/h-h</th>
</tr>
</thead>
<tbody>
<tr>
<td>60140305/7</td>
<td>280 x 315 x 200</td>
<td>3/4“ 1/2” inner thread</td>
<td>0.55 kW</td>
<td>230 V</td>
<td>16</td>
<td>15</td>
</tr>
</tbody>
</table>

*Article no. for other possible supply voltages on request
Cooling Platforms for Models N 17/HR, N 61/H, N 161

Storage platforms are used for forced cooling of mechanical components or annealing boxes outside of the furnace. The platform can also be used for charging the box in front of the furnace.

- Fan with 25 m³/min ambient air

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Furnace</th>
<th>Outer dimensions in mm</th>
<th>Connected load kW</th>
<th>Supply voltage</th>
<th>Comments</th>
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<tr>
<td>631000528</td>
<td>up to N 17/HR</td>
<td>550 610 760</td>
<td>0.2</td>
<td>230 V</td>
<td>The same as forced cooling system MHS 17</td>
</tr>
<tr>
<td>631000529</td>
<td>up to N 61/H</td>
<td>335 1100 880 - 920</td>
<td>0.2</td>
<td>230 V</td>
<td>The same as CWK1 charging trolley see page 54</td>
</tr>
<tr>
<td>63100294</td>
<td>up to N 161</td>
<td>700 800 900</td>
<td>0.9</td>
<td>230 V</td>
<td></td>
</tr>
</tbody>
</table>

*Article no. for other possible supply voltages on request

Charging Devices with and without Cooling Fan for Models N 31/H - N 641/13, N 30/45 HA - N 500/85 HA, LH (LF) 15/... - LH (LF) 216/...

Charging Cart CW(K) 1, CW(K) 15 and CW(K) 16

For charging larger workpieces and annealing boxes.
- 4 casters, freely movable
- Equipped with a rack at working height for temporary storage
- Fixing lock for annealing bags (CWK)
- CWK version with cooling fan (0.2 kW, 230 V)

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Designation</th>
<th>Furnace</th>
<th>Outer dimensions in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>631000528</td>
<td>CW 1</td>
<td>N 31/H, N 41..., N 61..., N 30/..HA, N 60/..HA</td>
<td>330 1100 880 - 920</td>
</tr>
<tr>
<td>631001320</td>
<td>CW 15</td>
<td>LH(LF) 15/... - LH(LF) 60/...</td>
<td>370 1100 760 - 800</td>
</tr>
<tr>
<td>631001321</td>
<td>CW 16</td>
<td>LH(LF) 120/... - LH(LF) 216/...</td>
<td>470 1000 760 - 800</td>
</tr>
<tr>
<td>631000529</td>
<td>CWK 1</td>
<td>N 31/H, N 41..., N 61..., N 30/..HA, N 60/..HA</td>
<td>330 1100 880 - 920</td>
</tr>
<tr>
<td>631001322</td>
<td>CWK 15</td>
<td>LH(LF) 15/... - LH(LF) 60/...</td>
<td>370 + 100 1100 760 - 800</td>
</tr>
<tr>
<td>631001323</td>
<td>CWK 16</td>
<td>LH(LF) 120/... - LH(LF) 216/...</td>
<td>470 + 80 1100 760 - 800</td>
</tr>
</tbody>
</table>

Art.-No. for NA 30/... and NA 60/... on request

Charging Cart CW 2 - CW 4 and CWK 2 - CWK 4

For charging larger workpieces and annealing boxes.
- 2 casters, 2 fixed rollers for heavy loads
- Equipped with a grid at working height for temporary storage
- Furnace locking via pedal lever
- CWK version with cooling fan (0.9 kW, 230 V)

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Designation</th>
<th>Furnace</th>
<th>Outer dimensions in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>631000530</td>
<td>CW 2</td>
<td>N 81..., N 161..., N 120/..HA</td>
<td>500 1100 880 - 920</td>
</tr>
<tr>
<td>631000531</td>
<td>CW 3</td>
<td>N 321...</td>
<td>800 1490 880 - 920</td>
</tr>
<tr>
<td>631000468</td>
<td>CW 4</td>
<td>N 641...</td>
<td>1040 1950 880 - 920</td>
</tr>
<tr>
<td>631000469</td>
<td>CWK 2</td>
<td>N 81..., N 161..., N 120/..HA</td>
<td>500 + 80 1120 880 - 920</td>
</tr>
<tr>
<td>631000470</td>
<td>CWK 3</td>
<td>N 321...</td>
<td>800 + 80 1490 880 - 920</td>
</tr>
<tr>
<td>631000471</td>
<td>CWK 4</td>
<td>N 641...</td>
<td>1040 + 80 1950 880 - 920</td>
</tr>
</tbody>
</table>

Art.-No. for NA 120/... on request

*Please see page 73 for more information about supply voltage

1 Side switch
2 Without holding grip
Charging Cart WS 1

For charging of protective gas and annealing boxes.
- 2 casters, 2 fixed rollers for heavy loads
- With parallel guided lifting mechanism
- Only for boxes with preparation for charging device (standard since 07.2018)
- Will be delivered with drive-in aid for the relevant furnace model
- Guiding track and charging cart can be also ordered separately

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Designation</th>
<th>Furnace</th>
</tr>
</thead>
<tbody>
<tr>
<td>60000004965</td>
<td>WS 1</td>
<td>N 61/H, N 81, N 60/..HA, N 120/..HA, NA 60/.., NA 120/.., LH 60/.., LH 120/..</td>
</tr>
</tbody>
</table>

Charging Stacker WS 25 - WS 321

- Lifting device with hand winch
- Compact construction with push bar and manual lifting device for easy and safe lifting
- 2 casters, 2 fixed rollers
- Adjustable loading fork width
- Max. charging weight 500 kg
- Guiding track, mounted at the furnace base frame
- Guiding track and forklift can be also ordered separately

<table>
<thead>
<tr>
<th>Article no.</th>
<th>Designation</th>
<th>Furnace</th>
</tr>
</thead>
<tbody>
<tr>
<td>631000425</td>
<td>WS 161</td>
<td>N 161/..</td>
</tr>
<tr>
<td>631000370</td>
<td>WS 321</td>
<td>N 321/..</td>
</tr>
<tr>
<td>631000299</td>
<td>WS 25</td>
<td>N 250/..HA</td>
</tr>
<tr>
<td>631000532</td>
<td>WS 50</td>
<td>N 500/..HA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>on request</td>
</tr>
</tbody>
</table>

Art.-No. for NA 250/.. and NA 500/.. on request

WS 641 Charging Stacker

Design as charging stacker WS 25 - WS 321, but
- Lifting device with manual hydraulic
- Max. charging weight 700 kg

<table>
<thead>
<tr>
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<th>Designation</th>
<th>Furnace</th>
</tr>
</thead>
<tbody>
<tr>
<td>631000426</td>
<td>WS 641</td>
<td>N 641/..</td>
</tr>
</tbody>
</table>
Ashing Furnaces with Integrated Exhaust Gas Cleaning

The ashing furnace L .. /1 1 BO is specially designed for processes in which larger sample quantities have to be incinerated. Fields of application are e.g. the ashing of food, thermal cleaning of injection molding tools or the determination of annealing loss. Another application is the debinding of ceramic products, e.g. after additive production.

The ashing furnaces have a passive safety system and integrated exhaust gas post combustion. An exhaust gas fan extracts flue gases from the furnace and simultaneously supplies fresh air to the furnace atmosphere with the result that sufficient oxygen is always available for the incineration process. The incoming air is guided behind the furnace heating and preheated to ensure good temperature uniformity. Exhaust gases are led from the furnace chamber to the integrated post combustion system, where they are postburned and catalytically cleaned. Directly after the incineration process (up to max. 600 °C) a subsequent process up to max. 1100 °C can take place.

- Tmax 600 °C for the incineration process
- Tmax 1100 °C for the subsequent process
- Three-side heating (both sides and bottom)
- Ceramic heating plates with embedded heating wire

- Exclusive use of insulation materials without categorization according to EC Regulation No 1272/2008 (CLP). This explicitly means that alumino silicate wool, also known as “refractory ceramic fiber” (RCF), which is classified and possibly carcinogenic, is not used.
- Dual shell housing made of structured stainless steel provides for low outer temperature and high stability
- Steel collecting pan protects the bottom insulation
- Spring-assisted closing of the furnace door (flap door) with mechanical locking against unintentional opening
- Thermal/catalytic post combustion, integrated in the exhaust channel, up to 600 °C in function
- Temperature control of post combustion can be set up to 850 °C
- Monitored exhaust air
- Inlet-air preheated through the bottom heating plate
- Over-temperature limiter with adjustable cutout temperature as temperature limiter to protect the oven and load
- Defined application within the constraints of the operating instructions
- NTLog Basic for Nabertherm controller: recording of process data with USB-flash drive
- Controls description see page 72

Additional equipment
- Process control and documentation via VCD software package for monitoring, documentation and control see page 72

<table>
<thead>
<tr>
<th>Model</th>
<th>Tmax °C</th>
<th>Inner dimensions in mm</th>
<th>Outer dimensions in mm</th>
<th>Max. weight of hydrocarbons in g</th>
<th>Max. evaporation rate g/min</th>
<th>Connected load kW</th>
<th>Electrical connection</th>
<th>Weight in kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>L 9/11 BO</td>
<td>1100</td>
<td>230</td>
<td>240</td>
<td>170</td>
<td>9</td>
<td>415</td>
<td>575</td>
<td>750</td>
</tr>
<tr>
<td>L 24/11 BO</td>
<td>1100</td>
<td>280</td>
<td>340</td>
<td>250</td>
<td>24</td>
<td>490</td>
<td>675</td>
<td>800</td>
</tr>
<tr>
<td>L 40/11 BO</td>
<td>1100</td>
<td>320</td>
<td>490</td>
<td>250</td>
<td>40</td>
<td>530</td>
<td>825</td>
<td>800</td>
</tr>
</tbody>
</table>

1Including exhaust tube (Ø 80 mm)
2External dimensions vary when furnace is equipped with additional equipment. Dimensions on request

*Please see page 73 for more information about supply voltage
High-Temperature Furnaces with MoSi₂ Heating Elements up to 1800 °C

Designed as tabletop models, these compact high-temperature furnaces have a variety of advantages. The first-class workmanship using high-quality materials, combined with ease of operation, make these furnaces all-rounders in research and the laboratory. These high-temperature furnaces are also perfectly suited for the sintering of technical ceramics, such as zirconium oxide dental bridges.

- Tmax 1600 °C, 1750 °C, or 1800 °C
- High-quality molybdenum disilicide heating elements
- Dual shell housing made of textured stainless steel sheets with additional fan cooling for low surface temperature
- Exclusive use of insulation materials without categorization according to EC Regulation No 1272/2008 (CLP). This explicitly means that alumino silicate wool, also known as “refractory ceramic fiber” (RCF), which is classified and possibly carcinogenic, is not used.
- Compact design with lift door, opening upwards
- Adjustable air inlet
- Exhaust air opening in the roof
- Type B thermocouple
- Defined application within the constraints of the operating instructions
- NTLog Basic for Nabertherm controller: recording of process data with USB-flash drive
- Controls description see page 72

Additional equipment
- Over-temperature limiter with adjustable cutout temperature as temperature limiter to protect the oven and load
- Square saggars for charging of up to three layers
- Protective gas connection to purge with non-flammable protective or reaction gases
- Manual or automatic gas supply system
- Process control and documentation via VCD software package for monitoring, documentation and control see page 72

<table>
<thead>
<tr>
<th>Model</th>
<th>Tmax °C</th>
<th>Inner dimensions in mm</th>
<th>Volume in l</th>
<th>Outer dimensions in mm</th>
<th>Connected load kW</th>
<th>Electrical connection</th>
<th>Weight in kg</th>
<th>Minutes to Tmax</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHT 02/16</td>
<td>1600</td>
<td>90  150  150</td>
<td>2</td>
<td>470  630  760 + 260</td>
<td>3.0</td>
<td>1-phase</td>
<td>75</td>
<td>30</td>
</tr>
<tr>
<td>LHT 03/16</td>
<td>1600</td>
<td>150 150 150</td>
<td>4</td>
<td>470  630  760 + 260</td>
<td>5.2</td>
<td>3-phase</td>
<td>85</td>
<td>25</td>
</tr>
<tr>
<td>LHT 03/17 D</td>
<td></td>
<td>150  150 150</td>
<td>8</td>
<td>470  810  760 + 260</td>
<td>8.0</td>
<td>3-phase</td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>LHT 01/17 D</td>
<td>1650</td>
<td>110 120 120</td>
<td>1</td>
<td>385  425  525 + 195</td>
<td>2.2</td>
<td>1-phase</td>
<td>28</td>
<td>10</td>
</tr>
<tr>
<td>LHT 03/17 D</td>
<td>1650</td>
<td>135 155 200</td>
<td>4</td>
<td>470  630  760 + 260</td>
<td>3.0</td>
<td>1-phase</td>
<td>75</td>
<td>60</td>
</tr>
<tr>
<td>LHT 02/17</td>
<td>1750</td>
<td>90  150 150</td>
<td>2</td>
<td>470  630  760 + 260</td>
<td>3.0</td>
<td>1-phase</td>
<td>75</td>
<td>60</td>
</tr>
<tr>
<td>LHT 04/17</td>
<td>1750</td>
<td>150 150 150</td>
<td>4</td>
<td>470  630  760 + 260</td>
<td>5.2</td>
<td>3-phase</td>
<td>85</td>
<td>40</td>
</tr>
<tr>
<td>LHT 08/17</td>
<td>1750</td>
<td>150 300 150</td>
<td>8</td>
<td>470  810  760 + 260</td>
<td>8.0</td>
<td>3-phase</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>LHT 02/18</td>
<td>1800</td>
<td>90  150 150</td>
<td>2</td>
<td>470  630  760 + 260</td>
<td>3.6</td>
<td>1-phase</td>
<td>75</td>
<td>75</td>
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<tr>
<td>LHT 04/18</td>
<td>1800</td>
<td>150 150 150</td>
<td>4</td>
<td>470  630  760 + 260</td>
<td>5.2</td>
<td>3-phase</td>
<td>85</td>
<td>60</td>
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<tr>
<td>LHT 08/18</td>
<td>1800</td>
<td>150 300 150</td>
<td>8</td>
<td>470  810  760 + 260</td>
<td>9.0</td>
<td>3-phase</td>
<td>100</td>
<td>60</td>
</tr>
</tbody>
</table>

1Heating only between two phases
2If connected at 230 V 1/N/PE resp. 400 V 3/N/PE
4External dimensions vary when furnace is equipped with additional equipment. Dimensions on request
5Including opened lift door

Please see page 73 for more information about supply voltage
Due to their solid construction and compact stand-alone design, these high-temperature furnaces are perfect for processes in the laboratory where the highest precision is needed. Outstanding temperature uniformity and practical details set unbeatable quality benchmarks. For configuration for your processes, these furnaces can be extended with extras from our extensive option list.

- Tmax 1600 °C, 1750 °C, or 1800 °C
- Recommended working temperature 1750 °C (for models HT ..18), increased wear and tear must be expected in case of working at higher temperatures
- Dual shell housing with fan cooling for low shell temperatures
- Heating from both sides via molybdenum disilicide heating elements
- High-quality fiber insulation backed by special insulation
- Side insulation constructed with tongue and groove blocks provides for low heat loss to the outside
- Long-life roof insulation with special suspension
- Exclusive use of insulation materials without categorization according to EC Regulation No 3272/2008 (CLP). This explicitly means that alumino silicate wool, also known as “refractory ceramic fiber” (RCF), which is classified and possibly carcinogenic, is not used.
- Chain-guided parallel swivel door for defined opening and closing of the door
- Two-door design (front/back) for high-temperature furnaces > HT 276/..
- Labyrinth sealing ensures the least possible temperature loss in the door area
- Reinforced floor as protection for bottom insulation as standard from models HT 16/16 upwards
- Vapor vent in the furnace roof
- Heating elements switched via thyristors
- Defined application within the constraints of the operating instructions
- NTLog Basic for Nabertherm controller: recording of process data with USB-flash drive
- Controls description see page 72
<table>
<thead>
<tr>
<th>Model</th>
<th>Tmax °C</th>
<th>Inner dimensions in mm</th>
<th>Volume in l</th>
<th>Outer dimensions in mm</th>
<th>Connected load kW</th>
<th>Electrical connection*</th>
<th>Weight in kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>HT 04/16</td>
<td>1600</td>
<td>150 150 150 4</td>
<td>730 490 1400</td>
<td>5.2 3-phase 150</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>HT 08/16</td>
<td>1600</td>
<td>150 300 150 8</td>
<td>730 640 1400</td>
<td>8.0 3-phase 200</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>HT 16/16</td>
<td>1600</td>
<td>200 300 150 16</td>
<td>810 700 1500</td>
<td>12.0 3-phase 270</td>
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</tr>
<tr>
<td>HT 29/16</td>
<td>1600</td>
<td>275 300 150 29</td>
<td>975 740 1620</td>
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<tr>
<td>HT 40/16</td>
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<td>300 350 150 40</td>
<td>1000 800 1620</td>
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</tr>
<tr>
<td>HT 64/16</td>
<td>1600</td>
<td>400 400 150 64</td>
<td>1130 900 1670</td>
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<tr>
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<td>1600</td>
<td>400 800 150 128</td>
<td>1130 1290 1670</td>
<td>26.0 3-phase 750</td>
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<tr>
<td>HT 160/16</td>
<td>1600</td>
<td>500 550 150 160</td>
<td>1250 1050 1900</td>
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<tr>
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<td>1750</td>
<td>150 150 150 4</td>
<td>730 490 1400</td>
<td>5.2 3-phase 150</td>
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<td>HT 08/17</td>
<td>1750</td>
<td>150 300 150 8</td>
<td>730 640 1400</td>
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<td>HT 29/17</td>
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<td>275 300 150 29</td>
<td>975 740 1620</td>
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<td>300 350 150 40</td>
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<td>1130 900 1670</td>
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<td>26.0 3-phase 750</td>
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<td>1750</td>
<td>500 550 150 160</td>
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<tr>
<td>HT 276/17</td>
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<td>500 1000 150 276</td>
<td>1300 1600 1900</td>
<td>36.0 3-phase 1100</td>
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<tr>
<td>HT 450/17</td>
<td>1750</td>
<td>500 1150 780 450</td>
<td>1350 1740 2120</td>
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<td>150 150 150 4</td>
<td>730 490 1400</td>
<td>5.2 3-phase 150</td>
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<td>HT 08/18</td>
<td>1800</td>
<td>150 300 150 8</td>
<td>730 640 1400</td>
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<td>HT 16/18</td>
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<td>200 300 150 16</td>
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<td>400 800 150 128</td>
<td>1130 1290 1670</td>
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<tr>
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<td>500 550 150 160</td>
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<td>1800</td>
<td>500 1000 150 276</td>
<td>1300 1600 1900</td>
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<td></td>
</tr>
<tr>
<td>HT 450/18</td>
<td>1800</td>
<td>500 1150 780 450</td>
<td>1350 1740 2120</td>
<td>64.0 3-phase 1500</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Please see page 73 for more information about supply voltage

Uncontrolled or controlled cooling system with frequency-controlled cooling fan and motorized exhaust air flap

Furnace in DB design featuring fresh air preheating, exhaust gas ventilation and an extensive safety package for debinding and sintering in one process, i.e. without transferring the material from the debinding furnace to the sintering furnace

Stainless steel exhaust gas top hats

Special heating elements for zirconia sintering provide for longer service life with respect to chemical interaction between charge and heating elements

Protective gas connection to purge with non-flammable protective or reaction gases

Manual or automatic gas supply system

Inner process box to improve the gas tightness and to protect the furnace chamber against contamination

Lift door

Motorized exhaust air flap, switchable via the program

Thermal or catalytic exhaust cleaning systems see page 66

Process control and documentation via VCD software package or Nabertherm Control Center (NCC) for monitoring, documentation and control see page 72

Additional equipment

- Uncontrolled or controlled cooling system with frequency-controlled cooling fan and motorized exhaust air flap
- Furnace in DB design featuring fresh air preheating, exhaust gas ventilation and an extensive safety package for debinding and sintering in one process, i.e. without transferring the material from the debinding furnace to the sintering furnace
- Stainless steel exhaust gas top hats
- Special heating elements for zirconia sintering provide for longer service life with respect to chemical interaction between charge and heating elements
- Protective gas connection to purge with non-flammable protective or reaction gases
- Manual or automatic gas supply system
- Inner process box to improve the gas tightness and to protect the furnace chamber against contamination
- Lift door
- Motorized exhaust air flap, switchable via the program
- Thermal or catalytic exhaust cleaning systems see page 66
- Process control and documentation via VCD software package or Nabertherm Control Center (NCC) for monitoring, documentation and control see page 72
With their maximum working temperature of up to 300 °C and air circulation, the ovens achieve a perfect temperature uniformity which is much better than in ovens of most competitors. They can be used for various applications such as e.g. drying, sterilizing or warm storing. Ample warehousing of standard models provides for short delivery times.

- Tmax 300 °C
- Working temperature range: + 5 °C above room temperature up to 300 °C
- Ovens TR 30 - TR 240 designed as tabletop models
- Ovens TR 450 and TR 1050 designed as floor standing models
- Horizontal, air circulation results in temperature uniformity better than +/- 5 °C (oven TR 30 up to +/- 4 °C) with closed exhaust flap in the empty workspace according to DIN 17052-1 see page 68
- Stainless steel chamber, alloy 304 (AISI)/(DIN material no. 1.4301), rust-resistant and easy to clean
- Exclusive use of insulation materials without categorization according to EC Regulation No 1272/2008 (CLP). This explicitly means that alumino silicate wool, also known as "refractory ceramic fiber" (RCF), which is classified and possibly carcinogenic, is not used.
- Large handle to open and close the door
- Charging in multiple layers possible using removeable grids (number of removeable grids included, see table to the right)
- Large, wide-opening swing door, hinged on the right with quick release for models TR 30 - TR 450
- Double swing door with quick release for TR 1050
- TR 1050 equipped transport rollers
- Infinitely adjustable exhaust at the rear wall with operation from the front
- PID microprocessor control with self-diagnosis system
- Solid state relays provide for low noise operation
- Defined application within the constraints of the operating instructions
- NTLog Basic for Nabertherm controller: recording of process data with USB-flash drive
- Controls description see page 72
Oven TR 1050 with double door

Additional equipment

- Over-temperature limiter with adjustable cutout temperature as temperature limiter to protect the oven and load
- Infinitely adjustable fan speed of the air circulation fan
- Window for charge observing
- Further removable grids with rails
- Side inlet
- Stainless steel collecting pan to protect the furnace chamber
- Door hinges on the left side
- Reinforced bottom plate
- Safety technology according to EN 1539 for charges containing liquid solvents (TR .. LS) up to model TR 240 LS, achievable temperature uniformity +/- 8 °C see page 68
- Transport castors for model TR 450
- Various modifications available for individual needs
- Upgrading available to meet the quality requirements of AMS2750F or FDA
- Process control and documentation via VCD software package for monitoring, documentation and control see page 72

---

<table>
<thead>
<tr>
<th>Model</th>
<th>T_max in °C</th>
<th>Inner dimensions in mm</th>
<th>Volume in l</th>
<th>Outer dimensions in mm</th>
<th>Connected load in kW</th>
<th>Electrical connection*</th>
<th>Weight in kg</th>
<th>Minutes to Tmax²</th>
<th>Grids included</th>
<th>Grids max.</th>
<th>Max. total load³</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR 30</td>
<td>300</td>
<td>360 300 300</td>
<td>30</td>
<td>610 570 665</td>
<td>2.1</td>
<td>1-phase</td>
<td>45</td>
<td>25</td>
<td>1</td>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>TR 60</td>
<td>300</td>
<td>450 390 350</td>
<td>60</td>
<td>700 610 710</td>
<td>3.1</td>
<td>1-phase</td>
<td>90</td>
<td>25</td>
<td>1</td>
<td>4</td>
<td>120</td>
</tr>
<tr>
<td>TR 60 LS</td>
<td>260</td>
<td>450 360 350</td>
<td>60</td>
<td>700 820 710</td>
<td>5.3</td>
<td>3-phase</td>
<td>120</td>
<td>25</td>
<td>1</td>
<td>4</td>
<td>120</td>
</tr>
<tr>
<td>TR 120</td>
<td>300</td>
<td>650 390 500</td>
<td>120</td>
<td>900 860 870</td>
<td>3.1</td>
<td>1-phase</td>
<td>3-phase</td>
<td>120</td>
<td>25</td>
<td>7</td>
<td>150</td>
</tr>
<tr>
<td>TR 120 LS</td>
<td>260</td>
<td>650 360 500</td>
<td>120</td>
<td>900 820 870</td>
<td>6.3</td>
<td>3-phase</td>
<td>3-phase</td>
<td>120</td>
<td>45</td>
<td>7</td>
<td>150</td>
</tr>
<tr>
<td>TR 240</td>
<td>300</td>
<td>750 550 600</td>
<td>240</td>
<td>1000 970 870</td>
<td>3.1</td>
<td>1-phase</td>
<td>1-phase</td>
<td>165</td>
<td>45</td>
<td>7</td>
<td>150</td>
</tr>
<tr>
<td>TR 240 LS</td>
<td>260</td>
<td>750 530 600</td>
<td>240</td>
<td>1000 990 970</td>
<td>6.3</td>
<td>3-phase</td>
<td>1-phase</td>
<td>180</td>
<td>45</td>
<td>8</td>
<td>150</td>
</tr>
<tr>
<td>TR 420</td>
<td>300</td>
<td>1300 550 600</td>
<td>420</td>
<td>1550 815 970</td>
<td>6.3</td>
<td>3-phase</td>
<td>2-phase</td>
<td>250</td>
<td>60</td>
<td>8</td>
<td>200</td>
</tr>
<tr>
<td>TR 450</td>
<td>300</td>
<td>750 550 1100</td>
<td>450</td>
<td>1000 780 1470</td>
<td>6.3</td>
<td>3-phase</td>
<td>3-phase</td>
<td>250</td>
<td>60</td>
<td>3</td>
<td>150</td>
</tr>
<tr>
<td>TR 450 LS</td>
<td>260</td>
<td>750 530 1100</td>
<td>450</td>
<td>1000 990 1470</td>
<td>12.6</td>
<td>3-phase</td>
<td>3-phase</td>
<td>250</td>
<td>60</td>
<td>15</td>
<td>180</td>
</tr>
<tr>
<td>TR 800</td>
<td>300</td>
<td>1200 670 1000</td>
<td>800</td>
<td>1470 970 1520</td>
<td>6.3</td>
<td>3-phase</td>
<td>3-phase</td>
<td>360</td>
<td>80</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>TR 1050</td>
<td>300</td>
<td>1200 670 1400</td>
<td>1050</td>
<td>1470 970 1920</td>
<td>9.3</td>
<td>3-phase</td>
<td>3-phase</td>
<td>450</td>
<td>80</td>
<td>4</td>
<td>250</td>
</tr>
</tbody>
</table>

¹External dimensions vary when furnace is equipped with additional equipment. Dimensions on request
²In the empty and closed oven, connected to 230 V 1/N/PE resp. 400 V 3/N/PE
³Max load per layer 30 kg

*Please see page 75 for more information about supply voltage
Chamber Ovens
Electrically Heated or Gas-Fired

The chamber ovens of the KTR range can be used for complex drying processes and heat treatment of charges to an application temperature of 260 °C. The high-performance air circulation enables optimum temperature uniformity throughout the work space. A wide range of accessories allow the chamber ovens to be modified to meet specific process requirements. The design for the heat treatment of flammable materials in conformance with EN 1539 (NFPA 86) is available for all sizes.

- Tmax 260 °C
- Electrically heated (via a heating register with integrated chrome steel heating elements) or gas-fired (direct or indirect gas-fired including injection of the hot air into the intake duct)
- Temperature uniformity up to +/- 3 °C according to DIN 17052-1 (for design without track cutouts) see page 68
- High-quality mineral wool insulation provides for outer temperatures of < 25 °C above room temperature
- Exclusive use of insulation materials without categorization according to EC Regulation No 1272/2008 (CLP). This explicitly means that alumino silicate wool, also known as “refractory ceramic fiber” (RCF), which is classified and possibly carcinogenic, is not used.
- High air exchange for fast drying processes
- Double-wing door for furnaces KTR 3100 and larger
KTR 3100/S for curing of composites in vacuum bags incl. pump and necessary connections in the oven chamber

Over-temperature limiter with adjustable cutout temperature as temperature limiter to protect the oven and load

Incl. floor insulation

Defined application within the constraints of the operating instructions

NTLog Basic for Nabertherm controller: recording of process data with USB-flash drive

Controls description see page 72

Additional equipment

- Track cutouts for level drive-in of charging cart
- Base frame to charge the oven via a charging forklift
- Additional door in the back for charging from both sides or to use the oven as lock between two rooms
- Fan system for faster cooling with manual or motorized control of the exhaust flaps
- Programmed opening and closing of exhaust air flaps
- Air circulation with speed control, recommendable for processes with light or sensitive charge
- Observation window and furnace chamber lighting
- Safety technology according to EN 1539 (NFPA 86) (models KTR .. LS) for charges containing solvents
- Charging cart with or without rack system
- Design for clean room heat treatment processes
- Rotating systems for tempering processes
- Process control and documentation via VCD software package or Nabertherm Control Center (NCC) for monitoring, documentation and control see page 72
Chamber Ovens
Electrically Heated or Gas-Fired

Charging cart with pull-out trays

Chamber oven KTR 6250 with double doors in the front and in the back as well as guide-in tracks for use as sluice oven

Drive-in tracks with sealing shoes

Accessories
- Adjustable plate shutters to adapt the air guide to the charge and improve temperature uniformity
- Guide-in tracks and shelves
- Shelves with 2/3 extraction with evenly distributed load on the whole shelf surface
- Platform cart in combination with drive-in tracks
- Charging cart with rack system in combination with drive-in tracks
- Sealing shoes for ovens with drive-in tracks to improve temperature uniformity in the work space

All KTR-models are also available with Tmax 300 °C.

<table>
<thead>
<tr>
<th>Model</th>
<th>Tmax °C</th>
<th>Inner dimensions in mm</th>
<th>Volume in l</th>
<th>Outer dimensions in mm²</th>
<th>Heating power in kW ¹</th>
<th>Electrical connection*</th>
</tr>
</thead>
<tbody>
<tr>
<td>KTR 1000 (LS)</td>
<td>260</td>
<td>1000 1000 1000</td>
<td>1000</td>
<td>1900 1430 1815</td>
<td>18/on request</td>
<td>3-phase</td>
</tr>
<tr>
<td>KTR 1500 (LS)</td>
<td>260</td>
<td>1000 1000 1500</td>
<td>1500</td>
<td>1900 1430 2315</td>
<td>18/36</td>
<td>3-phase</td>
</tr>
<tr>
<td>KTR 3100 (LS)</td>
<td>260</td>
<td>1250 1250 2000</td>
<td>2000</td>
<td>2400 1530 2905</td>
<td>27/45</td>
<td>3-phase</td>
</tr>
<tr>
<td>KTR 4500 (LS)</td>
<td>260</td>
<td>1500 1500 2000</td>
<td>2000</td>
<td>2400 1530 2905</td>
<td>45/54</td>
<td>3-phase</td>
</tr>
<tr>
<td>KTR 6125 (LS)</td>
<td>260</td>
<td>1750 1750 2000</td>
<td>2000</td>
<td>2650 2200 3000</td>
<td>45/63</td>
<td>3-phase</td>
</tr>
<tr>
<td>KTR 6250 (LS)</td>
<td>260</td>
<td>1750 2500 2000</td>
<td>2000</td>
<td>2650 2200 3000</td>
<td>54/90</td>
<td>3-phase</td>
</tr>
<tr>
<td>KTR 9000 (LS)</td>
<td>260</td>
<td>1500 3000 2000</td>
<td>2000</td>
<td>2900 2450 3000</td>
<td>108/on request</td>
<td>3-phase</td>
</tr>
<tr>
<td>KTR 12300 (LS)</td>
<td>260</td>
<td>1750 3500 2000</td>
<td>2000</td>
<td>2900 4900 3000</td>
<td>108/on request</td>
<td>3-phase</td>
</tr>
<tr>
<td>KTR 16000 (LS)</td>
<td>260</td>
<td>2000 4000 2000</td>
<td>2000</td>
<td>2900 4900 3000</td>
<td>108/on request</td>
<td>3-phase</td>
</tr>
</tbody>
</table>

¹Depending on furnace design connected load might be higher
²Outer dimensions from chamber ovens KTR .. LS are different

*Please see page 73 for more information about supply voltage
To ensure safe operation of the oven when tempering silicone, the fresh air supply of the oven must be monitored. A fresh air volume flow of 100 - 120 l/min/kg silicone (6-7.2 m³/h/kg silicone) has to be considered. The graph shows the maximum amount of silicone depending on the operating temperature for various KTR models at a fresh air supply of 120 l/min/kg silicone. The oven will be carried out in accordance with the requirements of the standard EN 1539 (NFPA 86).
Catalytic and Thermal Afterburning Systems, Exhaust Gas Washer

For exhaust gas cleaning, in particular in debinding, Nabertherm offers exhaust gas cleaning systems tailored to the process. The afterburning system is permanently connected to the exhaust gas fitting of the furnace and accordingly integral part of the control system and the safety matrix of the furnace. For existing furnaces, independent exhaust gas cleaning systems are also available that can be separately controlled and operated.

Catalytic afterburning systems (KNV)
Catalytic exhaust cleaning is recommended due to energetic reasons when only pure hydrocarbon compounds must be cleaned during the debinding process in air. They are recommended for small to medium exhaust gas amounts.

- Perfectly suited for debinding processes in air with only organic exhaust gases
- Decomposition of gases in carbon dioxide and water
- Integrated in a compact stainless steel housing
- Electric heating provides for preheating of the exhaust gas to the optimal reaction temperature for catalytic treatment
- Cleaning in different layers of catalytic honeycombs within the system
- Thermocouples for measuring the temperatures of raw gas, reaction honeycombs and discharge
- Over-temperature limiter with adjustable cutout temperature protects the catalyst
- Tight connection between the exhaust gas outlet of the debinding furnace and the exhaust gas fan with corresponding integration into the overall system with respect to control and safety technology
- Catalyst dimensioned in relation to the exhaust gas flow
- Measuring port for clean gas measurements (FID)
Thermal afterburning systems (TNV)
Thermal afterburning systems are used if large volumes of exhaust gas from the debinding process in air must be cleaned and/or if there is a risk that the exhaust gases might damage the catalyst. Thermal afterburning is also used for debinding applications under non-flammable or flammable protective or reaction gases.

- Optimally suited for debinding processes in air with large exhaust gas flow, erratic large exhaust gas volumes, large volume flow or for debinding processes under non-flammable or flammable protective or reaction gases
- Gas-fired to burn the exhaust gases
- Burn-off at temperatures up to 850 °C provides for thermal decomposition of the exhaust gases
- Heating with compact gas burner with automatic firing device

Exhaust Gas Washer
An exhaust gas washer will be often used if the generated gases cannot be effectively treated with a thermal afterburner system or with a torch. To clean, detox or decontaminate the exhaust gas stream a liquid us used to wash or neutralize unwanted pollutants. The exhaust gas washer can be adapted to the process by designing its liquid distribution and contact area and by selecting the most suitable washing liquid. Liquids may simply be water or special reagents or even suspensions to successfully remove unwanted gases, liquids or particles from the exhaust gas.
Temperature Uniformity and System Accuracy

Temperature uniformity is defined as the maximum temperature deviation in the work space of the furnace. There is a general difference between the furnace chamber and the work space. The furnace chamber is the total volume available in the furnace. The work space is smaller than the furnace chamber and describes the volume which can be used for charging.

**Specifying Temperature Uniformity in +/− K in the Standard Furnace**

In the standard design the temperature uniformity is specified in +/− K in the empty work space. In order to make a temperature uniformity survey the furnace should be calibrated accordingly. As standard our furnaces are not calibrated upon delivery.

**Calibration of the Temperature Uniformity in +/− K**

If an absolute temperature uniformity at a reference temperature or at a defined reference temperature range is required, the furnace must be calibrated appropriately. If, for example, a temperature uniformity of +/− 5 K at a set temperature of 750 °C is required, it means that measured temperatures may range from a minimum of 745 °C to a maximum of 755 °C in the empty work space.

**System Accuracy**

Tolerances may occur not only in the work space, they also exist with respect to the thermocouple and in the controls. If an absolute temperature uniformity in +/− K at a defined set temperature or within a defined reference working temperature range is required, the following measures have to be taken:

- Measurement of total temperature deviation of the measurement line from the controls to the thermocouple
- Measurement of temperature uniformity within the work space at the reference temperature or within the reference temperature range
- If necessary, an offset is set at the controls to adjust the displayed temperature at the controller to the real temperature in the furnace
- Documentation of the measurement results in a protocol

**Temperature Uniformity in the Work Space incl. Protocol**

In standard furnaces, temperature uniformity is guaranteed as +/− K without measurement of temperature uniformity. However, as an additional feature, a temperature uniformity measurement at a target temperature in the work space compliant with DIN 17052-1 can be ordered. Depending on the furnace model, a holding frame which is equivalent in size to the work space is inserted into the furnace. This frame holds thermocouples at up to 11 defined measurement positions. The measurement of the temperature uniformity is performed at a target temperature specified by the customer after a static condition has been reached. If necessary, different target temperatures or a defined target working temperature range can also be calibrated.
Standards such as the AMS2750F (Aerospace Material Specifications) are applicable for the industrial processing of high-quality materials. They define industry-specific requirements for heat treatment. Today, the AMS2750F and derivative standards such as AMS2770 for the heat treatment of aluminum are the guidelines for the aerospace industry. After the introduction of the CQI-9, the automotive industry has also committed to submit heat treatment processes to stricter rules. These standards describe in detail the requirements applicable to thermal processing plants.

AMS2750F, NADCAP, CQI-9

- Temperature uniformity in the work space (TUS)
- Instrumentation (definition of measurement and control systems)
- Calibration of the measurement system (IT) from the controller via the measurement line to the thermocouple
- Inspections of system accuracy (SAT)
- Documentation of the inspection cycles

Norm compliance is necessary to ensure that the required quality standard of the manufactured components can also be reproduced in series. For this reason, extensive and repeated inspections as well as controls of the instrumentation, including the relevant documentation, are required.

Furnace Class and Instrumentation Requirements of the AMS2750F

Depending on the quality requirements of heat treatment job the customer specifies instrumentation type and the temperature uniformity class. The instrumentation type describes the necessary combination of the applied control, recording media as well as thermocouples. The temperature uniformity of the furnace and the class of the selected instrumentation are defined based on the required furnace class. The higher the requirements are set for the furnace class the more precise the instrumentation must be.

Regular Inspections

The furnace or the heat treatment plant must be designed so that the requirements of the AMS2750F can be met and be reproduced. The standard also requires the inspection intervals for the instrumentation (SAT = System Accuracy Test) and the temperature uniformity of the furnace (TUS = Temperature Uniformity Survey). The SAT/TUS tests must be performed by the customer with measuring devices and sensors which operate independently of the furnace instrumentation.

<table>
<thead>
<tr>
<th>Instrumentation</th>
<th>Type</th>
<th>Furnace class</th>
<th>Temperature uniformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each control zone has a thermocouple connected to the controller</td>
<td>x x</td>
<td>1</td>
<td>+/- 3 +/- 5</td>
</tr>
<tr>
<td>Recording of the temperature measured by the control thermocouple</td>
<td>x x</td>
<td>2</td>
<td>+/- 6 +/- 10</td>
</tr>
<tr>
<td>Sensors for recording the coldest and hottest spots</td>
<td>x x</td>
<td>3</td>
<td>+/- 8 +/- 15</td>
</tr>
<tr>
<td>Each control zone has a charge thermocouple with recording system</td>
<td>x x</td>
<td>4</td>
<td>+/- 10 +/- 20</td>
</tr>
<tr>
<td>One additional recording sensor, distance &gt; 76 mm to control sensor, of a different sensor type</td>
<td>x</td>
<td>5</td>
<td>+/- 14 +/- 25</td>
</tr>
<tr>
<td>Each control zone has an over-temperature protection unit</td>
<td>x x</td>
<td>6</td>
<td>+/- 28 +/- 50</td>
</tr>
</tbody>
</table>

Measurement set-up in a high-temperature furnace

Measurement set-up in an annealing furnace

Measuring protocol

Measurement range calibration
AMS2750F, NADCAP, CQI-9

The suitable furnace model for the corresponding heat treatment can be designed based on the process, the charge, the required furnace class and the type of instrumentation. Depending on the required specs, alternative solutions can be offered.

- Furnace designs, which meet standards, following customer specifications regarding furnace class and instrumentation, incl. gauge connections for repeated customer inspections at regular intervals. No consideration of requirements with respect to documentation
- Data recording devices (e.g., temperature recorder) for TUS and/or SAT measurements see page 12
- Data recording, visualization, time management via the Nabertherm Control Center (NCC), based on Siemens WinCC software see page 13
- Commissioning at site, incl. the first TUS and SAT inspection
- Connection of existing furnace plant to meet norm requirements
- Documentation of the complete process chain in line with the corresponding norm

Implementation of AMS2750F

Basically, two different systems are available for control and documentation, a proven Nabertherm system solution or instrumentation using Eurotherm controllers/temperature recorders. The Nabertherm AMS package is a convenient solution that includes the Nabertherm Control Center for control, visualization, and documentation of the processes and test requirements based on PLC control.

Instrumentation with Nabertherm Control Center (NCC)

The attractive feature of the instrumentation with Nabertherm Control Center in combination with PLC controls of the furnace is the convenient data input and visualization. The software programming is structured in a way that both the user and the auditor can navigate it without difficulty.

- Very easy to navigate and straight-forward presentation of all the data in plain text on the PC
- Automatic saving of the charge documentation at the end of the program
- Administration of the calibration cycles in the NCC
- Results of the measurement distance calibration are entered in the NCC
- Schedule management of the required testing cycles including a reminder function. The testing cycles for TUS (Temperature Uniformity Survey) and SAT (System Accuracy Test) are entered in days and monitored by the system and the operator or tester is informed in time about up-coming tests. The measurements have to be done with separate calibrated measuring equipment.
- Option of transferring the measurement data to a customer’s server

In daily use, the following product characteristics stand out:

- Option of transferring the measurement data to a customer’s server

The Nabertherm Control Center can be extended to enable a complete documentation of the heat treatment process apart from just the furnace data. For example, when heat-treating aluminum, in addition to the furnace, the temperatures in the quenching basin or a separate cooling medium can also be documented.
Alternative Instrumentation with Temperature Controllers and Recorders from Eurotherm

As an alternative to instrumentation with the Nabertherm Control Center (NCC) and PLC controls, instrumentation with controllers and temperature recorders is also available. The temperature recorder has a log function that must be configured manually. The data can be saved to a USB stick and be evaluated, formatted, and printed on a separate PC. Besides the temperature recorder, which is integrated into the standard instrumentation, a separate recorder for the TUS measurements is needed (see page 12).

Furnace Chamber Control

Only the furnace chamber temperature is measured and controlled. Regulation is carried out slowly to avoid out-of-range values. As the charge temperature is not measured and controlled, it may vary a few degrees from the chamber temperature.

Charge Control

If the charge control is switched on, both the charge temperature and furnace chamber temperature are measured. By setting different parameters the heat-up and cooling processes can be individually adapted. This results in a more precise temperature control at the charge.

1. Furnace setpoint value
2. Actual value furnace chamber, 1-zone
3. Actual value furnace chamber, 3-zone
4. Actual value furnace chamber
5. Actual value load/bath/muffle/retort
6. Charge setpoint value
The controller series 500 impresses with its unique scope of performance and intuitive operation. In combination with the free "MyNabertherm" smartphone app, the operation and monitoring of the furnace is even easier and more powerful than ever before. The operation and programming takes place via a high-contrast, large touch panel, which shows exactly the information that is relevant at the moment.

Standard Equipment

- Transparent, graphic display of the temperature curves
- Clear presentation of the process data
- 24 operating languages selectable
- Consistent, attractive design
- Easily understandable symbols for many functions
- Precise and accurate temperature control
- User levels
- Program status display with estimated end time and date
- Documentation of the process curves on USB storage medium in .csv file format
- Service information can be read out via USB stick
- Clear presentation
- Plain text display
- Configurable for all furnace families
- Can be parameterized for the different processes
Highlights

In addition to the well-known and matured controller functions, the new generation offers you some individual highlights. Here is an overview of the most important ones for you:

**Modern Design**
Colored display of temperature curves and process data

**Easy Programming**
Simple and intuitive program entry via touch panel

**Integrated Help Function**
Information on various commands in plain text

**Program Management**
Temperature programs can be saved as favorites and in categories

**Segment Player**
Detailed overview of process information including setpoint, actual value and switched functions

**Wi-Fi-Capable**
Connection with the MyNabertherm app

Intuitive touch screen  Easy program entry and control  Precise temperature control  User levels  Process documentation on USB

Further information on Nabertherm controllers, process documentation and tutorials on operation can be found on our website: https://nabertherm.com/en/series-500
MyNabertherm App for Mobile Monitoring of Process Progress

MyNabertherm app – the powerful and free digital accessory for Nabertherm 500 Series Controllers. Use the app for convenient online progress monitoring of your Nabertherm furnaces – from your office, while on the way or from wherever you wish. The app always keeps you in the picture. Just like the controller itself, the app is also available in 24 languages.

App-Functions

- Convenient monitoring of one or multiple Nabertherm furnaces simultaneously
- Clear presentation as a dashboard
- Individual overview of a furnace
- Display of active/inactive furnaces
- Operating status
- Current process data

Display of Program Progress for Each Furnace

- Graphical representation of the program progress
- Display of furnace name, program name, segment information
- Display of start time, program run time, remaining run time
- Display of additional functions such as fresh-air fan, exhaust air flap, gassing, etc.
- Operating modes as symbol

Push Notifications in Case of Malfunctions and at Program End

- Push notification on the lock screen
- Display of malfunctions with an associated description in the individual overview and in a message list

Contact with Service Possible

- Stored furnace data facilitate rapid support for you

Requirements

- Connection of the furnace to the Internet via the customer’s Wi-Fi
- For mobile devices with Android (from version 9) or iOS (from version 13)
Monitoring of Nabertherm furnaces with 500 series touch panel controller for Arts & Crafts, laboratory, dental, thermal process technology, advanced materials and foundry applications.

Available in 24 languages

Push notifications in case of malfunctions

Clear contextual menu

Any addition of Nabertherm furnaces

Everything on display in the new Nabertherm app for the new controller series 500. Get the most out of your furnace with our app for iOS and Android. Don’t hesitate to download it now.
Functions of the Standard Controllers

<table>
<thead>
<tr>
<th>Controller</th>
<th>R7</th>
<th>3216</th>
<th>3208</th>
<th>B500/ B510</th>
<th>C540/ C350</th>
<th>P570/ P580</th>
<th>3508</th>
<th>3504</th>
<th>H600</th>
<th>H1700</th>
<th>H3700</th>
<th>NCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of programs</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>10</td>
<td>50</td>
<td>1/10/</td>
<td>1/10/</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>Segments</td>
<td>1</td>
<td>8</td>
<td>4</td>
<td>20</td>
<td>40</td>
<td>500³</td>
<td>500³</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Extra functions (e. g. fan or autom. flaps) maximum</td>
<td>2</td>
<td>2</td>
<td>2-6</td>
<td>0-4¹</td>
<td>2-8¹</td>
<td>3²</td>
<td>6/2²</td>
<td>8/2²</td>
<td>16/4³</td>
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<tr>
<td>Maximum number of control zones</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2 ² ²</td>
<td>2 ² ²</td>
<td>1-3³</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
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<tr>
<td>Drive of manual zone regulation</td>
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<tr>
<td>Charge control/bath control</td>
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<td>Auto tune</td>
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<td>Real-time clock</td>
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<td>Graphic color display</td>
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<tr>
<td>Graphical display of temperature curves (program sequence)</td>
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<tr>
<td>Status messages in clear text</td>
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<tr>
<td>Data entry via touchpanel</td>
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<tr>
<td>Entering program names (i.e. “Sintering”)</td>
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<td>Keypad lock</td>
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<td>User levels</td>
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<tr>
<td>Skip-button for segment jump</td>
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<tr>
<td>Program entry in steps of 1 °C or 1 min.</td>
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<td>Start time configurable (e. g. to use night power rates)</td>
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<tr>
<td>Switch-over °C/°F</td>
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<td>Operating hour counter</td>
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<td>Set point output</td>
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<tr>
<td>NTLog Comfort for HiProSystems: recording of process data on an external storage medium</td>
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<td>NTLog Basic for Nabertherm controller: recording of process data with USB-flash drive</td>
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<td>Interface for VCD software</td>
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<td>Malfunction memory</td>
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<td>Number of selectable languages</td>
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<tr>
<td>Wi-Fi-capable („MyNabertherm“ app)</td>
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</tbody>
</table>

¹ Not for melt bath control
² Control of additional separate slave regulators possible
³ Depending on the design

Assignment of Standard Controllers to Furnace Families

<table>
<thead>
<tr>
<th>Controller</th>
<th>NRA17/06 - NRA1 1500/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5 / S208</td>
<td>14, 16, 16, 19, 19, 21, 22, 26, 27, 30, 34, 36, 42, 42, 47, 48, 56, 57, 58, 60, 62</td>
</tr>
</tbody>
</table>

Mains Voltages for Nabertherm Furnaces

1-phase: all furnaces are available for mains voltages from 110 V - 240 V at 50 or 60 Hz.
3-phase: all furnaces are available for mains voltages from 200 V - 240 V or 380 V - 480 V, at 50 or 60 Hz.
The connecting rates in the catalog refer to the standard furnace with 400 V (3/N/PE) respectively 230 V (1/N/PE).
There are various options for evaluation and data input the processes for optimal process documentation and data storage. The following options are suitable for data storage when using the standard controllers.

Data Storing of Nabertherm Controllers with NTLog Basic

NTLog Basic allows for recording of process data of the connected Nabertherm Controller (B500, B510, C540, C550, P570, P580) on a USB stick. The process documentation with NTLog Basic requires no additional thermocouples or sensors. Only data recorded which are available in the controller. The data stored on the USB stick (up to 130,000 data records, format CSV) can afterwards be evaluated on the PC either via NTGraph or a spreadsheet software used by the customer (e.g. Excel™ for MS Windows™). For protection against accidental data manipulation the generated data records contain checksums.

Visualization with NTGraph for MS Windows™ for Single-Zone Controlled Furnaces

The process data from NTLog can be visualized either using the customer’s own spreadsheet program (e.g. Excel™ for MS Windows™) or NTGraph for MS Windows™ (Freeware). With NTGraph Nabertherm provides for an additional user-friendly tool free of charge for the visualization of the data generated by NTLog. Prerequisite for its use is the installation of the program Excel™ for MS Windows™ (from version 2003). After data import presentation as diagram, table or report can be chosen. The design (color, scaling, reference labels) can be adapted by using prepared sets. NTGraph is available in eight languages (DE/EN/FR/ES/IT/CN/RU/PT). In addition, selected texts can be generated in other languages.

Software NTEdit for MS Windows™ for Entering Programs on the PC

By using the software NTEdit for MS Windows™ (Freeware) the input of the programs becomes clearer and thus easier. The program can be entered on customers PC and then be imported into the controller (B500, B510, C540, C550, P570, P580) with a USB stick. The display of the set curve is tabular or graphical. The program import in NTEdit is also possible. With NTEdit Nabertherm provides a user-friendly free tool. A prerequisite for the use is the client installation of Excel™ for MS Windows™ (from version 2007). NTEdit is available in eight languages (DE/EN/FR/ES/IT/CN/RU/PT).
Documentation and reproducibility are more and more important for quality assurance. The powerful VCD software represents an optimal solution for single multi furnace systems as well as charg documentation on the basis of Nabertherm controllers.

The VCD software is used to record process data of the series 500 and series 400 as well as various further Nabertherm controllers. Up to 400 different heat treatment programs can be stored. The controllers are started and stopped via the software at a PC. The process is documented and archived accordingly. The data display can be carried-out in a diagram or as data table. Even a transfer of process data to Excel™ for MS Windows™ (.csv format *) or the generation of reports in PDF format is possible.

### Features
- Available for controllers series 500 - B500/B510/C540/C550/ P570/P580, series 400 - B400/B410/C440/C450/P470/P480, Eurotherm 3504 and various further Nabertherm controllers
- Suitable for operating systems Microsoft Windows 7/8/10/11
- Simple installation
- Setting, Archiving and print of programs and graphics
- Operation of controllers via PC
- Archiving of process curves from up to 16 furnaces (also multi-zone controlled)
- Redundant saving of archives on a server drive
- Higher security level due to binary data storage
- Free input of charge date with comfortable search function
- Possibility to evaluate data, files exportable to Excel™ for MS Windows™
- Generation of a PDF-report
- 24 languages selectable

### Extension Package 1
- Connection of an independent thermocouple, type S, N or K with temperature display on a supplied C6D display, e. g. for documentation of charge temperature
- Conversion and transmission of measured values to the VCD software
- For data evaluation, please see VCD-software features
- Display of measured temperature directly on the extension package

### Extension Package 2
- Connection of three thermocouples, type K, S, N or B to the included connecting box
- Possible extension of up to two or three connecting boxes with up to nine measuring points
- Conversion and transmission of measured values to the VCD software
- Data evaluation, see VCD features
PLC Controls
HiProSystems

This professional process control with PLC controls for single and multi-zone furnaces is based on Siemens hardware and can be adapted and upgraded extensively. HiProSystems control is used when process-dependent functions, such as exhaust air flaps, cooling fans, automatic movements, etc., have to be handled during a cycle, when furnaces with more than one zone have to be controlled, when special documentation of each batch is required and when remote service is required. It is flexible and is easily tailored to your process or documentation needs.

Alternative User Interfaces for HiProSystems

Process Control H500
This basic panel accommodates most basic needs and is very easy to use. Firing cycle data and the extra functions activated are clearly displayed in a table. Messages appear as text. Data can be stored on a USB stick using the „NTLog Comfort“ option.

Process Control H1700
Customized versions can be realized in addition to the scope of services of the H500. Display of basic data as online trend on a color 7“ display with graphically structured interface.

Process Control H3700
Display of functions on a large 12“ display. Display of basic data as online trend or as a graphical system overview. Scope as H1700.

Remote Maintenance Router – Fast Support in Case of a Malfunction

For fast failure diagnosis in case of a malfunction, remote maintenance systems are used for HiProSystems-plants (depending on the model). The plants are equipped with a router, which will be connected to the internet by the customer. In case of a malfunction, Nabertherm is able to get access to the furnace controls via a secured connection (VPN tunnel) and to perform a malfunction diagnosis. In most cases, the problem can be directly solved by a technician on site according with supervision from Nabertherm.

If no Internet connection can be provided, we offer optionally the remote maintenance via LTE network as additional equipment.
The following options are available for industrial process documentation and the recording of data from several furnaces. These can be used to document the process data for the PLC controls.

### Data Storing of HiProSystems with NTLog Comfort

The extension module NTLog Comfort offers the same functionality of NTLog Basic module. Process data from a HiProSytems control are read out and stored in real time on a USB stick. The extension module NTLog Comfort can also be connected using an Ethernet connection to a computer in the same local network so that data can be written directly onto this computer.

### Temperature Recorder

Besides the documentation via the software which is connected to the controls, Nabertherm offers different temperature recorders which can be used with respect to the application.

<table>
<thead>
<tr>
<th></th>
<th>Model 6100e</th>
<th>Model 6100a</th>
<th>Model 6180a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data input using touch panel</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Size of colour display in inch</td>
<td>5.5&quot;</td>
<td>5.5&quot;</td>
<td>12.1&quot;</td>
</tr>
<tr>
<td>Number of thermocouple inputs</td>
<td>3</td>
<td>18</td>
<td>48</td>
</tr>
<tr>
<td>Data read-out via USB-stick</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Input of charge data</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Evaluation software included</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Applicable for TUS-measurements acc. to AMS2750F</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Temperature recorder

NTLog Comfort for data recording of a Siemens PLC via USB stick

NTLog Comfort - Data recording via USB stick

NTLog Comfort - Data recording online on the PC
Nabertherm Control Center NCC
PC-based control, process visualization and process documentation software

The Nabertherm Control Center as PC-supported furnace controls offers an ideal extension for furnaces with PLC based HiProSystem controls. The system has proven itself in many applications with increased demands on documentation and process reliability and also for convenient multi-furnace management. Many customers from the automotive, aviation, medical technology or technical ceramics sectors have been working successfully with this powerful software.

**Standard Equipment**

- Central furnace management
- Graphical furnace overview of up to 8 furnaces
- Tabular, clear program entry (100 program locations)
- Charge administration (article, quantity, additional information)
- Connection to the company network
- Adjustable access rights
- Online monitoring of the heat treatment
- Tamper-proof documentation
- Malfunction message list, adapted to the furnace model
- Archive function
- Delivery incl. PC and printer
- Measuring range calibration of up to 18 temperatures per measurement point. Multi-stage calibration is possible for applications with normative requirements.

**Additional Equipment**

- Reading in charge data via barcode
  - Simple data acquisition, ideal for frequently changing charges
  - Defined charge data ensures data quality
  - Recipe storage with charge comparison
  - Comparison of charge and recipe to increase process reliability
- Adaptable access rights or access rights via employee cards
- Software extension to fulfill documentation requirements according to norms like AMS2750F (NADCAP), CQI9 or Food and Drug Administration (FDA), Part 11, EGV 1642/03
- Interface for connection to overriding systems
- SQL connection
- Redundant data storage
- Cellular connection or network connection for notification via SMS, e.g. in the event of malfunctions
- Control from different PC workstations
- Configuration as industrial PC or virtual machine
- PC cabinet
- UPS for PC
- Customization according to individual requirements

Retort furnace NR 300/08 for treatment in high vacuum

Retort furnace NR 80/11 with IDB safety concept for debinding under non-flammable protective gases

System overview

Furnace overview

Measurement range calibration
The whole World of Nabertherm: www.nabertherm.com

Please visit our website www.nabertherm.com and find out all you want to know about us - and especially about our products.

Besides news and our current calendar of trade fairs, there is also the opportunity to get in touch directly with your local sales office or nearest dealer worldwide.

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- Arts & Crafts
- Glass
- Advanced Materials
- Laboratory
- Dental
- Thermal Process Technology for Metals, Plastics and Surface Finishing
- Foundry

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