special update equipment
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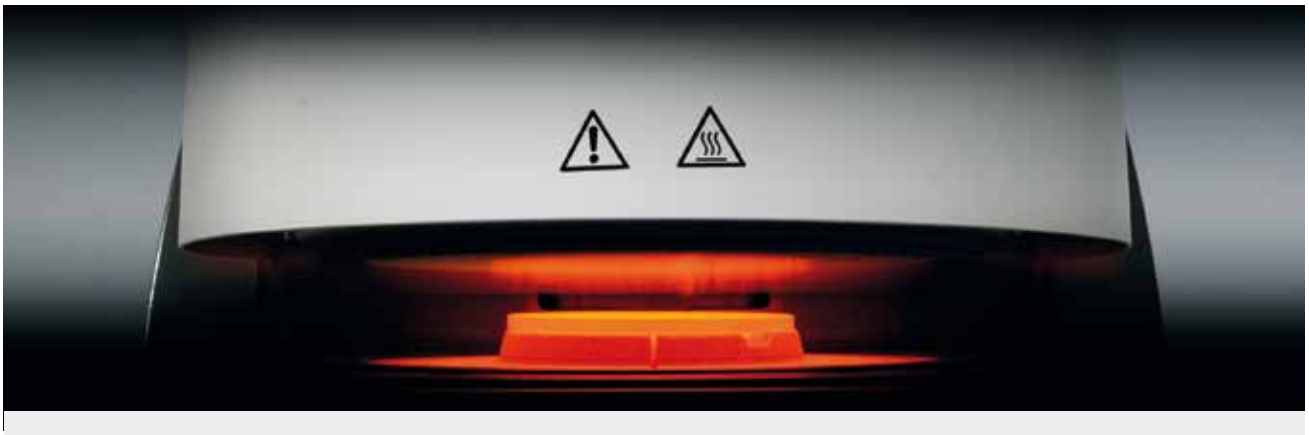
Programat® P310, P510, CS2

Ceramic furnaces featuring a new muffle technology, a special firing table and double-valve technology

The new generation of ceramic furnaces from Ivoclar Vivadent AG impresses with an attractive and functional design and intuitive operation. Additional innovations to improve routine handling complement this new furnace generation. We call it "the new physics of firing". This intelligent technology is integrated in every Programat furnace.



Topic: **Programat P310, P510, CS2 – Ceramic furnaces featuring a new muffle technology, a special firing table and double-valve technology**

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The most recent generation of furnaces from Ivoclar Vivadent includes the Programat P310, P510 and CS2. Due to their innovative heating muffle technology, the furnaces distribute heat homogeneously. This leads to excellent results when firing ceramic restorations.

Temperature and negative pressure are critical physical parameters for a controlled firing of ceramic restorations. The temperature must be consistently transferred to the firing objects even in fast firing processes (dental ceramic: temperature gradient of up to 140 K/min). A ceramic furnace should adjust the temperature in the firing area accurately and with high repeatability (from firing cycle to firing cycle). This precision is determined by a thermocouple measuring the temperature and a temperature control.

Temperature control

Irrespective of changes in the physical conditions, the temperature control should meet many different requirements. For example, the heat transfer effects vary depending on the temperature range. In the lower temperature range, heat conduction and convection play a significant role. With rising temperatures, the importance of thermal radiation increases disproportionately. Varying temperature gradients and fast changing negative pressure conditions, for example when the firing chamber is flooded immediately before reaching the holding temperature, represent a great challenge for an optimum temperature control. Simple controls meet these requirements only partially or require compromises with regard to setting times and control deviations. The new generation of Programat furnaces uses a modern and character-

istic-controlled PID control system with a pilot control feature, which selects the optimum control strategy depending on the given situation. This allows a minimum overshooting and a high control accuracy in the respective temperature range. Flooding processes, which are required for the conventional sintering technique, are taken into account by the temperature control and the control strategy is adapted correspondingly. Now, the PID control with its pilot control feature adheres even more accurately to the preset temperature gradients.

Temperature distribution

A homogeneous temperature distribution, i.e. a consistent heating of the ceramic restoration, is very important for obtaining uniform firing results especially in long-span restorations. Particularly when firing ceramic framework materials with low heat conduction, it cannot be assumed that a homogeneous temperature distribution is obtained during fast firing processes.

The amount of heat which flows through a material in a certain time period is defined as heat flow:

$$\Theta = \rho \times Cp \times \lambda \times \left(\frac{\Delta T}{\delta} \right)$$ heat flow

ρ density
Cp specific thermal capacity
λ heat conduction
ΔT temperature difference
δ wall thickness

The heat flow $\rho \times Cp \times \lambda$ depends on the material and its constants and is therefore subject to great variations. The following table shows the heat flow values of selected materials:

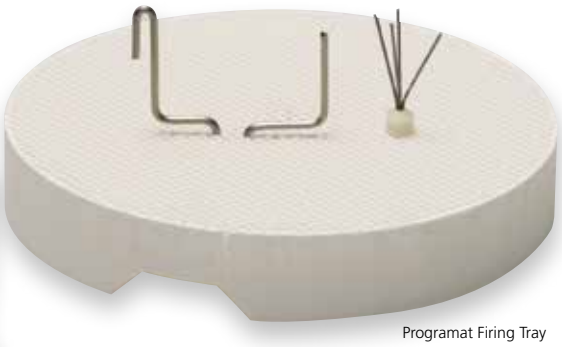
Material	$\rho \times Cp \times \lambda$
Glass-ceramic	~30
ZrO_2	~65
Gold alloy	~3000

Here, the new Programat furnaces score with a special feature. The firing table consists of high-performance ceramic material with outstanding heat conductivity and thus a high heat flow. In accordance with the above formula, this firing table demonstrates a 2000-times higher heat flow than conventional firing tables made of insulating material. The firing table made of high-performance ceramic material distributes the thermal energy that it receives from the heating coil. Similar to underfloor heating, the cooler areas underneath the firing tray are heated. The heat is generally conducted to the centre of the firing tray and thus also to the area under the firing objects which are placed on the firing tray. This is particularly important if long-span bridges or multiple restorations are positioned together at the centre or at the edge of the firing tray and fired simultaneously. In the past, the firing results often showed noticeable variations whereas, now, the results are comparable.

We recommend using the firing trays which are specified by Ivoclar Vivadent and coordinated with the individual systems.

IPS e.max CAD Crystallization Tray

IPS e.max CAD Speed Crystallization Tray



Programat Firing Tray

In addition to its physical properties, such as heat distribution and homogenization, the firing table is also characterized by its durability. This is the result of high wear and thermal shock resistance. Contamination adhering to the firing table can be easily removed by e.g. sandblasting.

The ceramic furnaces impress with many enhancements regarding the temperature input. Furthermore, a new construction and different dimensions of the heating element (QTK 2) result in an optimized service life and durability of the heating coil. The heating coil shows hardly any deformation even after use with high temperature gradients.

The guarantee of the heating element was increased to 1,500 firing hours.

For the predrying process, the proven thermo shock protection (TSP) has been adopted from the existing high-end devices. Thus, a high degree of safety during the predrying and closing process when starting firing processes outside the stand-by temperature can be ensured.
It is important to know that the temperature measured by the thermocouple in the open furnace head during the cool down processes depends on the positioning of the thermocouple. Compared to the previous models, the new furnaces need less time to cool down the temperature in the furnace head at the end of a firing cycle. In the new furnace models, the thermocouple is positioned in the furnace head instead of the furnace base (see Programat P200). The temperature measured in the open furnace head does not necessarily represent the cooling rate or the current temperature of the firing table. The cooling rate and the current temperature depend on the construction of the respective furnace, its opening position and tilt angle of the furnace head. We recommend a program start at a furnace head temperature similar to the stand-by temperature for the new Programat furnaces. To ensure even better temperature control, a special infrared technology has been developed for the Programat P510. This technology is based on an optical temperature control system. A detailed description of this special feature will not be provided in this article.

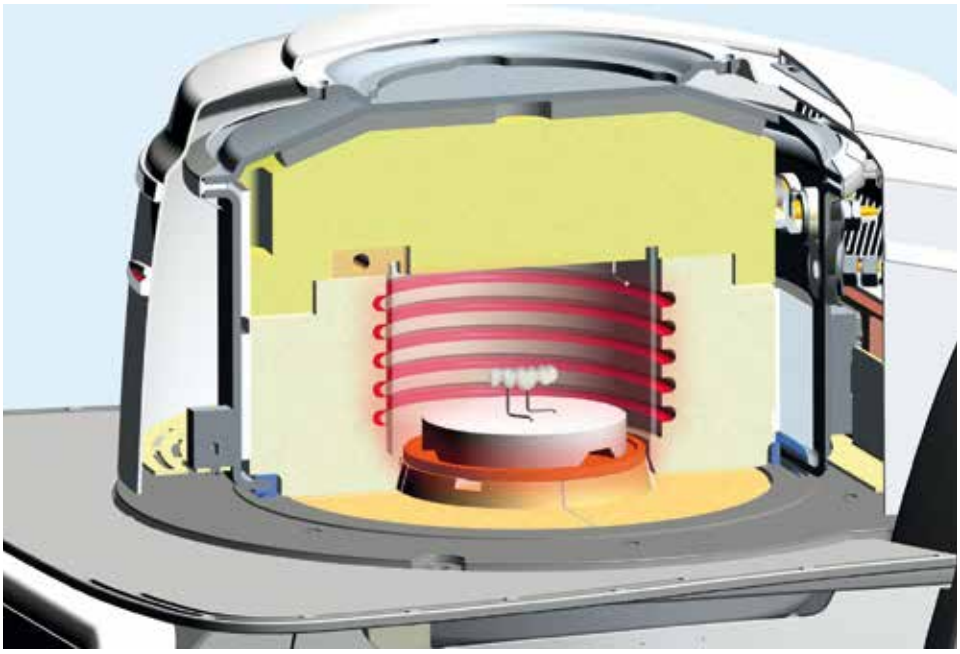
Negative pressure

The negative pressure is the second physical parameter which is critical for firing ceramic restorations. Also in this respect, the new furnaces impress with new, high-performance features: generating and holding negative pressure. Each furnace is equipped with a double-valve technology, which enables various functions. For the first time, air is evacuated directly from the firing chamber via the open furnace head, for example. In addition to enhanced cooling, this feature promotes the evacuation of combustion byproducts and improves the oxygen supply during the drying and closing process. The efficiency of the evacuation is largely dependent on the number of objects to be dried as well as on the position of the furnace head during the drying process of the liquid parts in the ceramic material. Nevertheless, residual combustion byproducts can be evacuated from the work station by means of the vacuum pump.

For an effective firing, oxygen is required, which is constantly provided by the evacuation system in the furnace head. Oxygen is critical for a thorough firing of organic components. With pumps from Ivoclar Vivadent AG, combustion byproducts and vapours can be transported from the pump output to a suction unit or to outdoor air by means of a hose assembly with a length of up to 10 m. In order to prevent excessive temperatures at the pump heads, a hose of min. 1.6 m must be inserted between the furnace and the vacuum pump.

Heat insulation materials in furnaces are hygroscopic in principle. This means that they are able to absorb moisture from the ambient air at room temperature or in changing climatic conditions. It is this kind of moisture which prevents a "good" vacuum during the firing process. The double-valve technology locks the firing chamber automatically upon switch-off. Provided that the furnace head is closed, this feature prevents air and moisture from penetrating into the firing chamber. If this happens nevertheless, for example during transport of the furnace, a special program enables the user to quickly and efficiently remove moisture from the firing chamber and the vacuum system. For this purpose, the furnace uses a valve connection in order to "rinse" the hose while the pump is running and the firing chamber is closed and evacuated. The free wheeling pump mechanism enables the efficient removal of condensed water from the vacuum system, which cannot be heated and is therefore difficult to dry outside the firing chamber.

The real advantage of the vacuum system of the new furnace line, however, is the fact that the furnace automatically sets the vacuum to the lowest vacuum level possible. The pump is automatically turned off if the lowest level and thus the best vacuum has been obtained. This reduces unnecessary running time, power consumption and noise pollution. Furthermore, the double-valve technology allows performing a vacuum self-test which checks the vacuum tightness.



Graphic: Cross-section of the firing chamber

Conclusion

"The new physics of firing" work in the background during the entire firing process. The goal of these innovations from Ivoclar Vivadent is to provide high-quality results and economic efficiency. We hope that you will enjoy working with the Programat furnaces.

NEW

Programat®

The next generation of furnaces

Efficient precision firing.

Exciting technical advancements

- **Easy handling** due to the smart combination of a colour touch screen and the tried-and-tested membrane-sealed keypad
- **Homogeneous heat distribution and excellent firing results** due to the QTK2 muffle technology with SiC bottom reflector
- **Programat infrared technology*** speeds up the predrying process by up to 20%

INFRARED TECHNOLOGY

* Only available in Programat P510

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