

***VBF-1200X-H8***

***1100°C COMPACT VACUUM CHAMBER FURNACE***

**With UL Recognized Electric Components & Eurotherm 3504 Temperature Controller**

**OPERATION MANUAL**



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## **IMPORTANT NOTES**

Thank you for purchasing from Materials Technology International Corporation. This manual contains important operation and safety information prepared for those intending on using the equipment. The prospective user is responsible for carefully reading and understanding the contents of this manual prior to operating the equipment.

MTI reserves the right to update or upgrade the product without informing customers of the data change(s) in this manual. Please visit [www.mtixtl.com](http://www.mtixtl.com) frequently for the latest information and manual.

## **GENERAL WARNINGS**

MTI will not be responsible for equipment damage, accidents leading to minor or fatal injuries, and etc. caused by the user's negligence or lack of knowledge. Always read the manual fully beforehand and exercise the best judgment when handling the equipment.

### **To avoid electrical shock:**

- Use a properly grounded electrical outlet of correct voltage and current handling capacity.
- Disconnect equipment from the power supply before servicing.
- Always double check the wiring and consult a licensed electrician for installation.

### **To avoid burns:**

- Do not touch the exterior or interior surface of the furnace during operation or after use (cooling time depends on temperature set by the user).

### **Tube Replacement or Installation:**

- Use extreme cautions and be aware of the surroundings when replacing or installing a tube.
- Read the installation instructions listed in the dedicated section prior to installing.

### **To avoid Physical Injuries:**

- Do not put this equipment near flammable or explosive environments and substances.
- Do not leave the internal circuit exposed after disassembly.
- Power should be cut off when performing external maintenance like cleaning.

## **WARRANTY**

MTI Corporation provides one year limited warranty from date the product is shipped out. Any defective part(s) will be replaced free of charge during warranty period. However, the warranty does NOT cover any equipment damage caused by misuse or negligence. After the expiration of warranty, MTI will continue to provide technical support and spare parts at a reasonable cost.

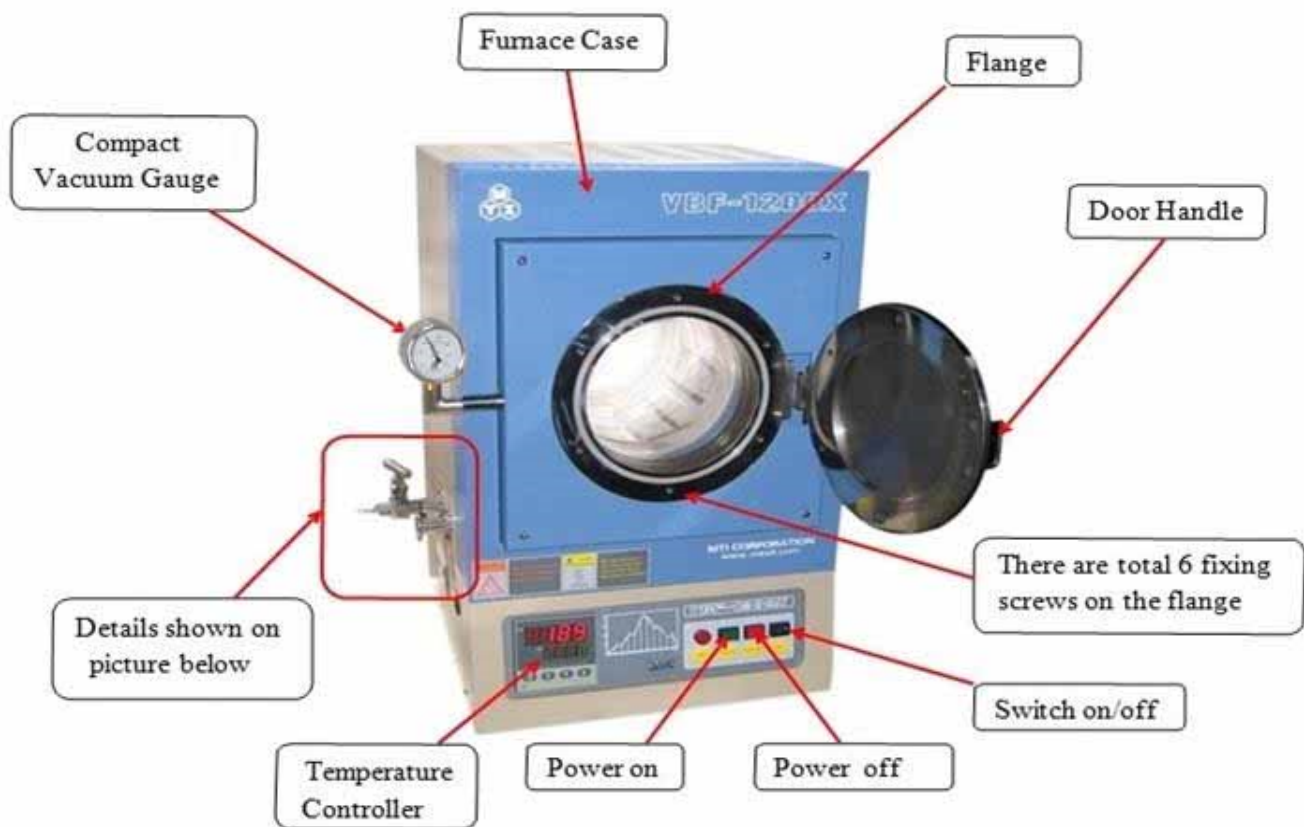


## EQUIPMENT INFORMATION

### INTRODUCTION

VBF-1200X-H8 is a **CE certified** vacuum furnace with a 7.5" ID x 13.4"L quartz tube chamber placed horizontally. Water-cooled stainless steel vacuum flanges with valves are installed to achieve a vacuum of  $10^{-2}$  to  $10^{-5}$  torr through the use of a mechanical or molecular vacuum pump. It is designed for calcining or annealing semiconductor wafers (up to 6") under vacuum or various other gas atmospheres with a temperature up to 1100°C. It also can also be used as vacuum brazing furnace for fusing small parts.

### FURNACE STRUCTURE





## SPECIFICATIONS

<b>Working Temperature</b>	<ul style="list-style-type: none"> <li>• 1000°C , continuous</li> <li>• Max. 1100°C, &lt; 30 minutes</li> </ul>
<b>Heating Elements</b>	High quality Ni-Cr-Al resistance wires
<b>Heating Chamber Size</b>	7.5" ID x 8.5" Depth (7.6Liter)
<b>Liner</b>	High purity quartz liner: 8" O.D. x 7.5" I.D x 13.4" L.
<b>Temperature Controller</b>	Programmable digital temperature controller provides precise control of heating, cooling and dwelling with up to 50 segments per program.
<b>Uniformity</b>	+/- 2°C
<b>Vacuum Flange</b>	<ul style="list-style-type: none"> <li>• Stainless steel vacuum flange with dual high temperature silicone O-rings.</li> <li>• One ¼" hose barb fitting with needle valve built into the flange for gas inlet.</li> <li>• KF-25D port on furnace left can be used for vacuum pump connection.</li> <li>• A water cooling jacket has been installed in the flange to protect the vacuum sealing assembly from melting at over 300°C.</li> <li>• One bored Al<sub>2</sub>O<sub>3</sub> foam refractory block is included to prevent heat radiation and dissipation.</li> </ul>
<b>Vacuum Pressure</b>	<p>Vacuum Level is dependent on the vacuum pump used, connected pipe, interior refractory block's materials etc. By using KF-25D port, vacuum bellows, MTI two stage mechanical pump and KF25 Ball valve, the furnace can achieve vacuum levels below:</p> <ul style="list-style-type: none"> <li>• 10 m-torr (<math>10^{-2}</math> torr) via two stages mechanical pump within 30 minutes without refractory block.</li> <li>• 60 m-torr (<math>6 \times 10^{-2}</math> torr) via two stages Mechanical pump within 60 minutes with fibrous alumina refractory block at 900 °C.</li> </ul>
<b>Gas Flow and Pressure</b>	<ul style="list-style-type: none"> <li>• Inert gas and oxygen gas flow can be achieved via two valves. (Attention: MTI does not recommend using our products under hazardous conditions. We are not liable for any damage incurred under hazardous conditions. For using hydrogen gas, it is prudent to place the furnace under fume hood.)</li> <li>• Max. gas pressure shall be less than 1.2 atm.</li> <li>• A <b>flow meter</b> may be used to monitor the flow rate of gases.</li> </ul>
<b>PC Control</b>	PC control software and interface are available upon request at extra cost
<b>Power Supply</b>	Single phase 208 - 240 VAC / 50/60Hz, 3000 W max. (20 A breaker required)
<b>Overall Dimensions</b>	700 L x 440 W x 435mm H
<b>Net Weight</b>	80 kg
<b>Warranty</b>	One year limited warranty with lifetime support



## ASSEMBLY INSTRUCTIONS

### EQUIPMENT INSPECTION

Once receiving the furnace, please inspect the equipment and all accessories for damage incurred from shipping and check the packing list for missing items. If anything is damaged or missing, please inform us at [info@mtixtl.com](mailto:info@mtixtl.com).

### OPERATING ENVIRONMENT

The operating environment information listed below may be helpful for safely operating the instrument:

- The furnace should be placed on a dry, hard and flat surface that is free of vibration
- Use should be limited to indoor only with adequate ventilation and away from direct sunlight
- Environment should be dust-free and without explosive and corrosive gases
- Relative humidity (non-condensing): 10% ~ 85%
- Circumstance temperature: -10~75 °C

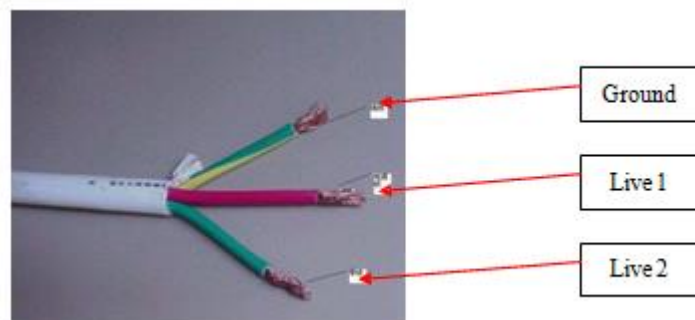


#### **WARNING:**

To reduce the possibility of heat-related injuries or of overheating the instrument, do not place the instrument too close to the side wall or obstruct the air vents. Keep the instrument at least 1 meter in distance from the side wall.

### POWER CONNECTION

Please make sure that the power source in your lab is sufficient to meet the power requirement listed for the equipment. The following picture shows the three wires of the power cable: Ground, Live 1, and Live 2. **We strongly suggest consulting a professional or licensed electrician to perform the power connections.** For more information, please refer to the “AC Power” section below.



### AC POWER

For power connection, a licensed electrician should be consulted to meet and comply with the local electrical codes and requirements. Proper electrical power handling and knowledge are crucial for both safety and thorough application of the equipment.



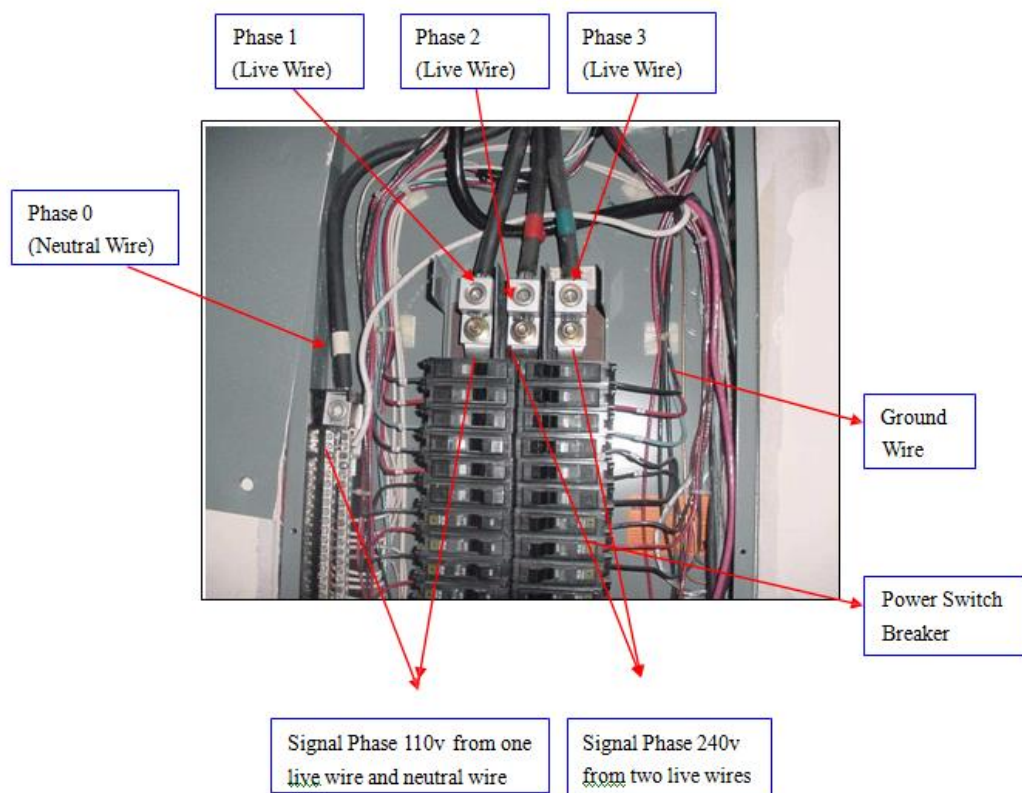
**⚠ Attention:**

For countries that use 220V, the furnace's power supply is already configured to work with this input voltage. However, in countries that use 110V, a 208~240V single phase AC power line needs to be setup.

The following knowledge may be useful for configuring a single phase 208~240V power line from various electrical panels. A three phase 240V AC electrical panel generally found in most laboratories can be configured to output a single phase 208~240V power line. To do this, two of the three live wires from the panel need to be configured with the neutral wire. Please refer to the illustrations below to get an idea of the connections for the three phase and as well as the single phase 208~240V AC.

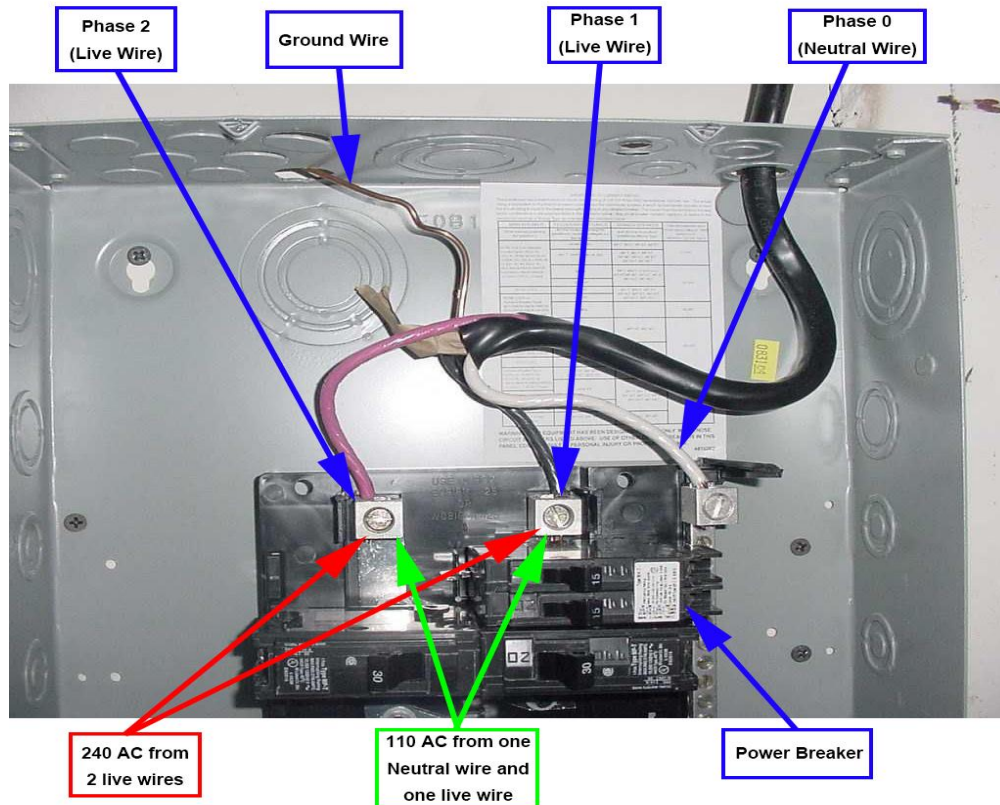
**⚠ Attention:**

MTI Corporation will not be responsible for any equipment or property damage that results from improper or incorrect power connections.



**Typical Three Phases AC Power in US**





**Typical Single Phase AC Power In US**

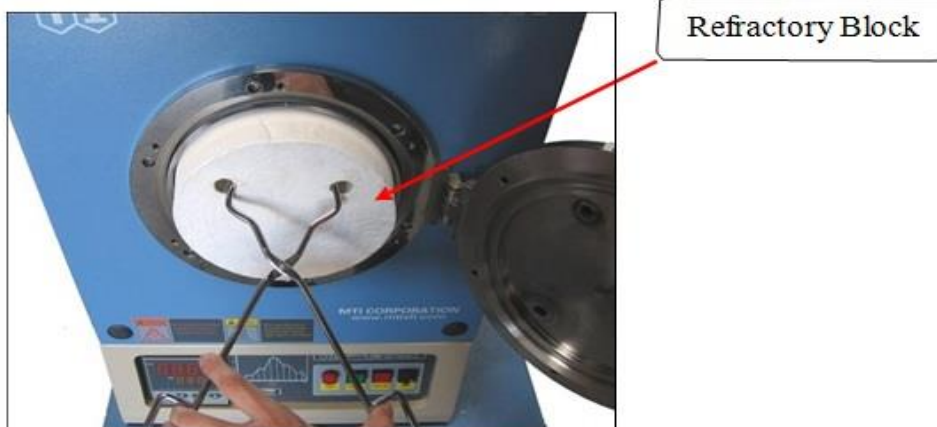
## GENERAL OPERATION

If the furnace is being used for the first time (or use again after a long period of inactivity), please pre-heat the furnace to 300°C for at least 2 hours for removing moisture inside the chamber to prevent cracking of the furnace refractory ceramics.

Properly setting up the tube and vacuum flanges prior to heating will ensure the furnace to work under the most ideal conditions. This will insulate the heat from the flanges while simultaneously preventing the dissipation of heat from the furnace chamber. The insulation of heat stabilizes the heating zone which in turn expends less energy and places less wear on the heating elements.

- Unscrew the 6 tighten screws on the flange and then open the flange.
- Use the clamp to insert the refractory block.

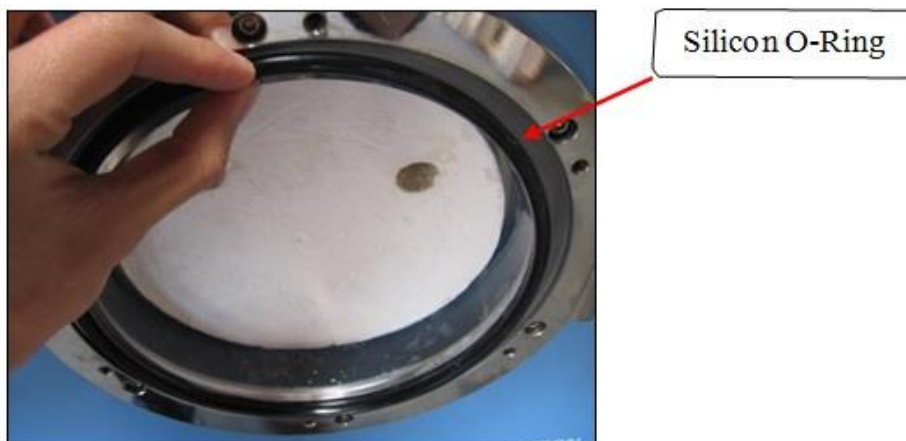




- Place the test sample inside the tube chamber (crucibles or boats may be used as material containers, please visit: <http://www.mtixtl.com/ceramiccrucibles.aspx>) to order.



- Insert the O-Ring into the slot between the quartz tube and the flange.



- Seal the chamber by tightening the 6 fixing screws on the flange.



**Attention:**

A optional Quartz Thermal Block (Alumina fiber filled) with carrying handle can be purchased at extra cost for easy handling and better vacuum efficiency. Please always wear gloves when handling this block and do not touch it when hot!

**Attention:**

In order to achieve the best vacuum level, please follow the following instructions.

1. Clean high temperature silicone O-ring before installing the flange and then apply vacuum grease on the O-ring. Please order it at:

<http://www.mtixtl.com/highvacuumsiliconegreaseforsealinggloveboxeq-gb-vg.aspx>



2. Tighten the six fixing screws evenly and gradually.
3. Place the refractory block inside the chamber and preheat the furnace at 1000 C for least an hour since the refractory block will be a major factor influencing the vacuum level.
4. You may order a quartz heat block at extra cost from MTI Corp when a replacement is needed for the refractory block.



5. Please be advised that you must implement cooling water during operation, please visit: <http://www.mtixtl.com/recirculatingwaterchiller.aspx> for more information about the Compact Recirculation Water Chiller (4 Liter Tank, 4L/min Flow).



*Compact Recirculation Water Chiller*

- Limit the pressure regulator attached to the gas tank to below 1.2 atm before filling the tube with gas. Keep the vacuum valve(s) open during gas filling to avoid high pressure from building up inside tube.
- When the installation is finished, please do a test for gas leaks to check if the sealing parts were assembled well. You may locate the leaking part(s) by using soap suds and apply vacuum grease on the part(s).



**WARNING:**

- Tube furnaces are designed to be used under vacuum with low pressure gases. **NEVER** inject gas into the tube with pressure higher than 1.2 atm. Pressure build up inside the tube may cause the flange(s) to be catapulted which may cause injury or death.
- Also, do not pour any liquid or molten substances into the tube to keep its interiors clean.
- After an inspection has been performed to make sure there are no gas leaks, power on the instrument by turning the “**Power Lock**” to the right and the temperature control LCD will start to blink.
- Press the “**Turn On**” button and a “clunk” sound should be heard. This switch activates the relay switch inside the furnace to establish power connection to the heating elements. If the sound is not heard, please do not proceed with operating the furnace. The furnace must be powered down and get inspected.
- Please refer to the “[TEMPERATURE CONTROL INSTRUCTIONS](#)” sections to learn how to setup and run the heating profile.



**Attention:**

A small to medium heating rate with a small temperature difference between the adjacent segments should be set when the furnace is being heated up from room temperature. Please take the characteristics of the material being sintered into consideration when setting the heating rate.

Also, please avoid using rapid heating and cooling rates as doing so will render shock and damage to the heating elements. Using the heating or cooling rates listed in the specifications is recommended.



## VACUUM AND GAS FLOW SYSTEMS

When used in conjunction with vacuum pumps, vacuum furnaces can heat samples with a cleaner environment that greatly reduces oxidation and contamination of materials or samples.

The flanges on MTI furnaces can be readily configured to accept various fittings for vacuum pump connections. Typically, connection to the pump is made by securing stainless steel bellows to either side of the flange by quick locking clamps. For medium vacuum ( $25 \sim 10^{-3}$  Torr), the **EQ-YTP550** vacuum pump is an ideal option. Turbo-molecular pumps such as the **EQ-PV-HVS** or **EQ-MT-HVS** are ideal for achieving high vacuum levels ( $10^{-3} \sim 10^{-5}$  Torr).

Gas mixing/ delivery systems allow for mixing of various reactive gases for inducing chemical reactions as well delivering inert gases into the chamber for sample treatment. For making the connections to these systems, the flanges regularly come standard with barbed hose fittings to accept gas tubes bridging the gas source and furnace. Moreover, this fitting can easily be removed and re-configured to more secured gas connections or for adding gas flow meters to monitor gas flow rates.

All of the components mentioned above can be found at the *Furnace Accessories* section below:

<http://mtixtl.com/furnaceaccessories.aspx>



### WARNING:

- For safety concerns, never charge any noxious, explosive or flammable gas into ceramic tubes. Please remember that pressures  $> 0.12$  Mpa (absolute pressure value) inside the tube chamber are strictly forbidden at high temperatures when using quartz or corundum tubes.

Please choose from MTI's various types of vacuum pumps in the link below based on the experiment needs:

<http://www.mtixtl.com/vacuumpumpandhighvacuumstation.aspx>

## TEMPERATURE CONTROL INSTRUCTIONS

### TEMPERATURE CONTROLLER

#### 1. Specifications

- Compatible Thermocouple: K, S, R, E, J, T, N;
- Measurement Accuracy: 0.3;
- Power Input: Single phase 220V AC ( $\pm 10\%$ ) / 50~60Hz;
- Power:  $\leq 5W$ ;
- 30 Programmable Segments.

- MET Certified



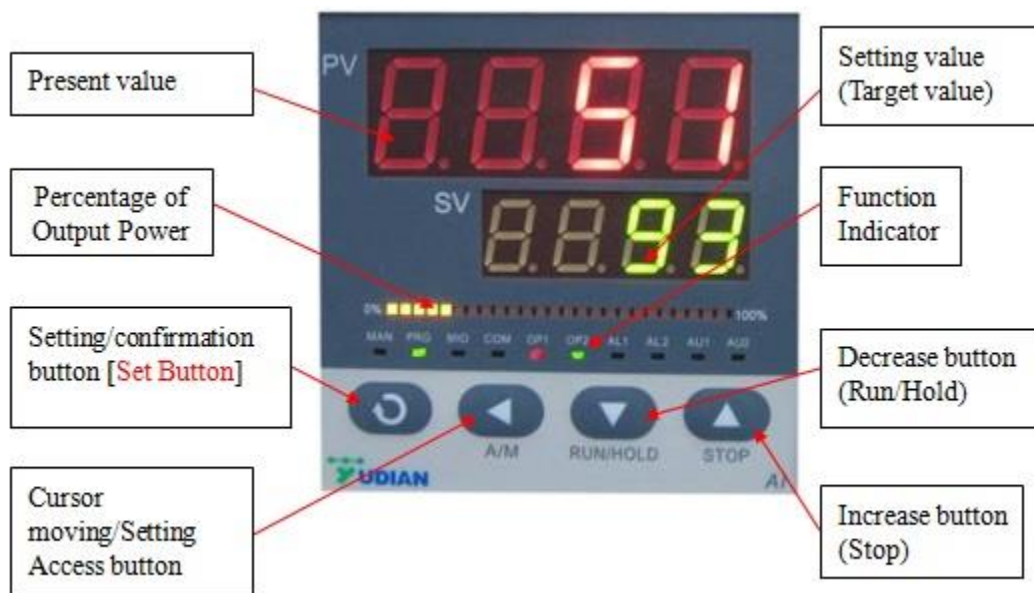
#### 2. Structure

Below are the three variants of controllers commonly found on the furnaces. Though with different looks, they all share similar features and functions.





### 3. Functions and Indicators



## SETTING THE TEMPERATURE CONTROLLER

### Start Up State

When starting the device, the meter type and program version will display for a few seconds, and then enter the normal state. Blinking “stop” indicates the program is in “normal state”.



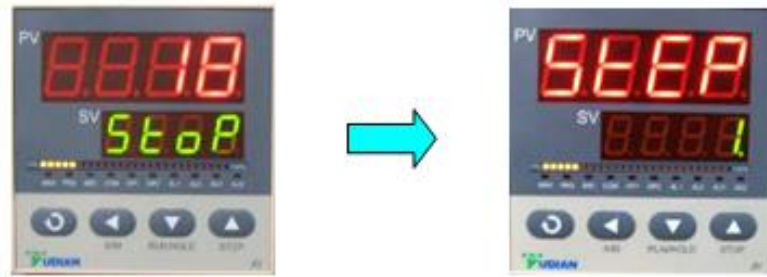
Meter type & Program version

Normal state

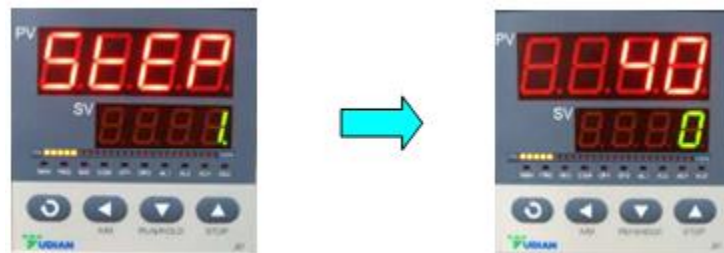


## Displaying Switch

- a. In the “normal state” or “program running state”, press “SET” key (Button 2) for 1 second to switch to “executing program segment” (to set executing segments or display the ongoing temperature segment).



- b. Press “SET” key (Button 2) again for 1 second to switch to “running time state” (to display the total running time PV xxxx min. and the elapsed time SV xxxx min.)
- c. Press “SET” key again (Button 2) for 1 second to go back to “normal state”.



## HEATING PROFILE SETTING EXAMPLE

Programmable smart instrumentation auto-controller allows you to set the temperature profile up to 30 segments. To process this function, follow these steps:

- Power on the furnace, blinking “STOP” on the SV window indicates the Normal State;
- Press “←” once to display “C01” on PV window;
- Set initial temperature to 0 °C by using Keystrokes : “←”, “↑” or “↓” ;



- Press “Set” to display “t01” on PV window;





- Set heat-up time (Usually beyond 30 minutes for this segment in case of temperature overshooting) from initial temperature to target temperature by using Keystrokes :“←”, “↑” or “↓”;
- Press “Set” to display “C02” on PV window; Set the actual working temperature for the second segment by using Keystrokes :“←”, “↑” or “↓”;



- Press “Set” to display “t02” on PV window; Set heat-up time from initial temperature to target temperature by using Keystrokes :“←”, “↑” or “↓”;
- By pressing “Set”, you can get into the remaining segments (C03&t03;C04&t04;C05&t05...) and set their target temperature and duration time values;
- Press “Set” to display “Cxx” on PV window (xx could be any values among 01~30);
- Press“←”, “↑” or “↓” to set “-121” in the last segment in order to shut down the furnace;



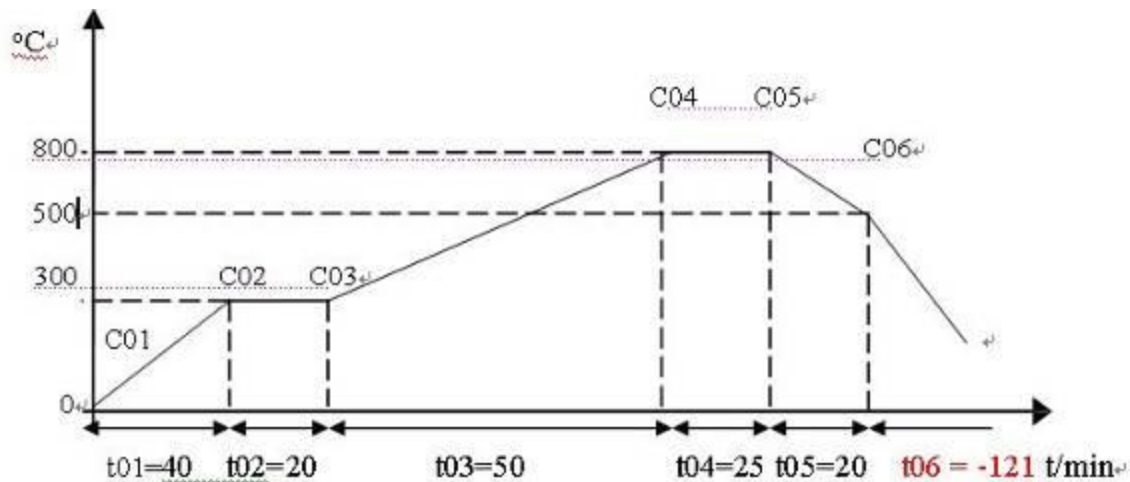
#### Attention:

The heating profile will stop at the first segment that contains “-121” regardless of whether or not the latter segments have values set in them.

## ILLUSTRATION OF HEATING PROFILE SETTING

### Setting Example: Temperature Control Program with 6-segments





According to figure I above, all segments were recorded in the following:

Prompt	Input Data	Description
C01	0	Initial Temperature
T01	40	Heat-up time 40 minutes from 0-300 °C in the first segment
C02	300	Target temperature of the first heat-up stage
T02	20	Keep 20 minutes at 300 °C in the second segment
C03	300	Target temperature of the third stage
T03	50	Heat-up time 50 minutes from 300-800°C in the third segment
C04	800	Target temperature of the fourth stage
T04	25	Keep 25 minutes at 800°C in the fourth segment
C05	800	Target temperature of the fifth cooling stage
T05	20	Cooling time 20 minutes from 800-500°C
C06	500	Beginning temperature of the sixth stage
T06	-121	Program end, Out-put power off. Furnace cooling down naturally.(t06 = -121 is an order to stop running)

## RUNNING THE PROGRAM

- When all the data is input into the temperature program, press both “Set” and “←” together, and “STOP” will show on SV window again as an indication of the controller returning to the “Normal State”. Then press “↓” and hold for two seconds to display “Run” on SV window;





- Furnace will run segment by segment automatically according to the program setting;
- PV window then displays the present temperature inside the chamber;

## HOLDING THE PROGRAM

- If you need to hold the furnace at certain temperature **when the program is running**, press “↓” for 2 sec to hold the program and press it again to continue.
- You can stop the program either from the running or holding states by pressing “↑” for 2 seconds.



### Attention:

It is not suggested to modify any parameters during the execution if the operator is not familiar with the furnace operations. If it is absolutely necessary, please first stop the program first and then do the modification.

## STOPPING THE PROGRAM/ FURNACE SHUT DOWN

- Press the “↑”key to make sure the controller is at its “STOP “ state
- Push the red “ Turn-Off” button to deactivate the furnace relay
- Turn the lock switch in counter clockwise direction to cut off power from the control panel
- If possible, shut off the power switch from the power cable

## TEMPERATURE CONTROLLER PARAMETERS

### Introduction of Main Parameters

Parameter Name	Parameter Function	Setting Range	Unit
M5	Maintain parameter	1 – 9999	° C or definable unit
P	Speed	1 – 9999	
t	Delay time	1 – 2000	second
Ctrl	Control type	2, 3	
LOC	Parameter lock	0 or 808	



### Attention:



Whenever you want to change the parameters referred below, please change the value of parameter "Loc" to "808" first in order to unlock the parameter settings.



## FUNCTIONS OF MAIN PARAMETERS

### Maintain parameter M5:

Like integral time of PID calibration, this parameter is mainly in charge of the integral work during the adjustment process. For instance, the smaller the M5 is set, the stronger the system integral effect is, vice versa. When M5=0, the system will cancel integral and intelligent adjustment, leave only proportion and differential (PD) function.



### Speed parameter P:

Parameter P has nothing to do with integral function. The bigger the P value is, the stronger the proportion and differential function are, vice versa.





### Delay time t:

It is defined as the time spent when the heating rate reaches to 63.5% of the maximum value with assumption that there is no heat dissipation. Remember, this parameter affects the three functions such as integral, proportion and differential, the smaller t is, the stronger proportion and integral function are but weaker differential, after all, the system feedback is promoted, vice versa. If  $t \leq 1$ , the differential function will be off.



### Control type Ctrl:

(Do follow the default setting, or the system may be unable to work)

When Ctrl=2, startup auto-tune function, after that, system will go to 3.

When Ctrl=3, adopts advanced AI adjustment. After auto-tune, the system goes to this setting mode. Note that in this mode, you cannot startup auto-tune function from the panel by holding button, for a protection of repeating auto-tune.



### Parameters lock - LOC:

Please set LOC to "808" in order to unlock the parameter settings. Otherwise, please keep it at default: "0".





## PARAMETER SETTING

- In the “normal state”, press the “SET” key for 2 seconds, you will see the parameter “M5” pop up and press “←”, “↑” or “↓” to modify the parameters.
- Press the “SET” key for 1 second to go to next parameter and press “←” for 2 seconds to return to preceding parameter.
- Press “←” and then press “SET” to return to “normal state”. Alternatively, not using the keys for about 30 seconds will automatically cause the meter to exit from “parameter setting state” and return to the “normal state”.

## AUTO - TUNE

In order to obtain precise temperature control, customers should pay more attention to the parameters of M5, P and t. Actually, MTI’s engineers have already made a strict high temperature pre-heating test (rate: 5°C/min) and fine-tuned on these three parameters according to each furnace’ condition before shipping it out. Therefore, we have a confidence of satisfying over 95% customers.

**However**, the diversity of environment and the distinction in manufacturing for each customer, may seriously affect the operation, so, using auto-tune function to decide these parameters for a perfect result **when the temperature is not stable and the error is large:**

- Run the program and wait until the furnace temperature reaches to 80% of your desired temperature. For example, if your desired target temperature was set to 800C, the Auto-tune should be started when the chamber temperature reaches 640C
- Press and hold the “SET” key for 2 seconds to enter the parameter setting menu
- Press the “SET” key repeatedly until “Ctrl” appears on the PV screen
- Set the “Ctrl” to 2 and then press “←” and “SET” key simultaneously to switch back to “Running State”
- You will see the SV screen flashes with “AT”, which indicates that the controller has entered the “auto-tune state”. Then, system begins to oscillate 2-3 times and the controller automatically analyzes the furnace’s heating behavior and yields the optimal parameters of M5, P and t.
- Press and hold “←” for 2 seconds to stop Auto-tune at any time you need
- Due to different temperature, the time spent for “auto-tune” may vary

**Note:** the parameter ‘Ctrl’ will be set as 3 by the system after “auto-tune”. So, if customer needs more “auto-tune” operation for the furnace, please reset the ‘Ctrl’ to 2.

## MANUAL - TUNE

- Short oscillating period, you can decrease P (priority), increase M5 and t.
- Long oscillating period, you can increase P (priority) as well as M5 and t.
- No oscillating but offset is large, decrease M5 (priority), increase P.
- Stable controlling but time-consume is too long, decrease t (priority) as well as M5, increase P.

Increase (or decrease) one of the three parameters by 30%-50%, if the controlling becomes better, continue increasing (or decreasing), otherwise, decrease (or increase) it till get the qualified adjustment. Commonly, M5 possesses the priority, if not enough, try P and t.



## **EQUIPMENT MAINTENANCE & TROUBLESHOOTING**

### **MAINTENANCE AND EQUIPMENT CARE**

- If the furnace is being used for the first time (or use again after a long period of inactivity), please pre-heat the furnace to 300 °C for at least 2 hours for removing moisture inside the chamber to prevent cracking of the furnace refractory ceramics. Do not pour any liquid or molten substances onto the furnace heating chamber to keep it clean.
- A small to medium heating rate with a small temperature difference between the adjacent segments should be set when the furnace is being heated up from room temperature. Please take the characteristics of the material being sintered into consideration when setting the heating rate.
- Avoid using rapid heating and cooling rates as doing so will render shock and damage to the heating elements. A 10 °C/min heating or cooling rate is suggested.
- Please refer to PID parameters: “Proportional band, Integral time constant, and Derivative time constant” if the temperature offset cannot be eliminated and the difference between PV (Process Variable) and the SP (Set Point) variables increases at 300 °C.
- When powering the furnace on, do not continue to operate if you cannot hear the sound from cooling fans. Shut down the furnace and check or replace the cooling fans.
- While furnace is running, please do not touch furnace to avoid burns from high temperature.
- Do not open the furnace when it is being heated above 300 °C to prevent its insulation materials from cracking.
- MTI furnaces are only suitable for using with air or inert gas environments. Other flammable or toxic gases, such as H<sub>2</sub>, Cl<sub>2</sub> and SO<sub>2</sub>, will cause damage to the heating elements. Customer should use them at their own risk.



## TROUBLESHOOTING FOR TYPICAL PROBLEMS

Problems	Reason	Solution
Open Power Lock, no power indication	Fuse (4A) in control panel is broken	Check control panel, and replace fuse
Green Power indicator is off, but Red open circuit indicator is On	Fuse in main power circuit is broken	Open the cover of front panel and replace the fuse
No current shows in meter, but has Max. Voltage	Broken Heating Element(s)	Find broken heating rod, and replace it
PV remains the same but furnace is producing heat	Thermal Couple is broken	Replace Thermal couples (K type)
Power and heating element are OK, but furnace cannot be controlled by program.	Controller or related; circuit may be damaged	Check controller. If not, please inform manufacturer to check what the real problem is
During heating below 300°C, the temperature value (PV) is not stable, and does not match with setting program (SV)	It is normal because the furnace comes with a high temperature thermocouple, which is not as sensitive at temperature below 300°C.	Let the furnace heat to 300°C, then thermocouple will function stably with program. If the PV value at 300°C is still less than that of SV, you may need to increase OPL value a little.

## TROUBLESHOOTING RESOURCES

- Visit MTI web site link: [WWW.MTIXTL.COM](http://WWW.MTIXTL.COM) for additional information about the instrument through Help and Support
- Contact us by Tel: [510-525-3070](tel:510-525-3070) or email: [info@mtixtl.com](mailto:info@mtixtl.com)