KSL-1700X-KA

1750°C BENCH-TOP MUFFLE FURNACE

6"x6"x6", 3.6L Chamber with Kathal Super-1800 Heating Elements

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 operating and utilizing 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 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 PREVENT ELECTRICAL SHOCKS:

- Always consult a certified electrician to perform the electrical connections in order to ensure proper power requirements and safety conditions are met or satisfied.
- Use a properly grounded electrical outlet of correct voltage and current handling capacity and away from sources of electromagnetic interference.
- Connect the equipment to a dedicated / separate power outlet and make sure that the electrical loads on the power supply system are distributed evenly.
- Equipment must be disconnected from the power supply before servicing.

⚠ TO AVOID BURNS:

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

⚠ 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 or cleaning, the product is not being used for a long period of time, and when the unit is being moved.
- Do not place the instrument too close to the wall or obstruct the air vents. Keep the instrument at least 1 meter in distance from the wall.
- Always operate the equipment in the company of others and do not operate it alone so that accidents can be addressed quickly.

WARRANTY

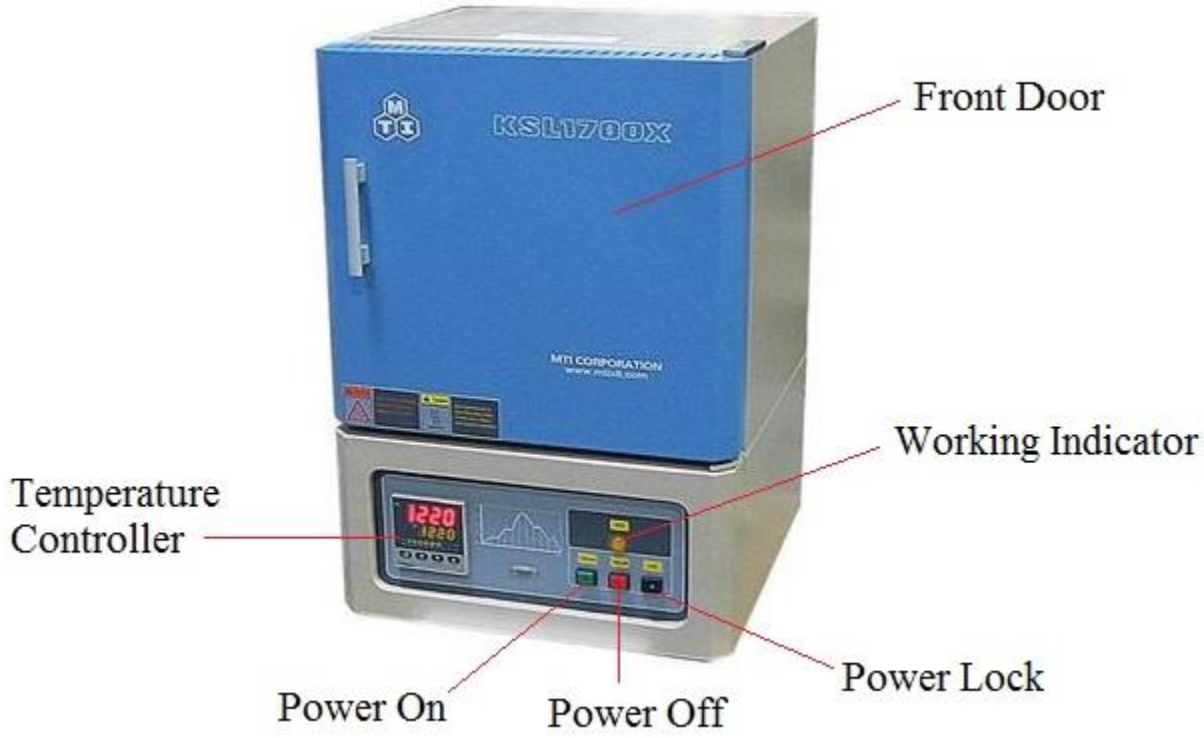
MTI Corporation provides one year limited warranty for equipment (consumable accessories and parts not covered) from date the product is shipped out. Any defective part(s) will be replaced free of charge during the warranty period. However, the warranty does NOT cover any equipment damage caused by misuse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

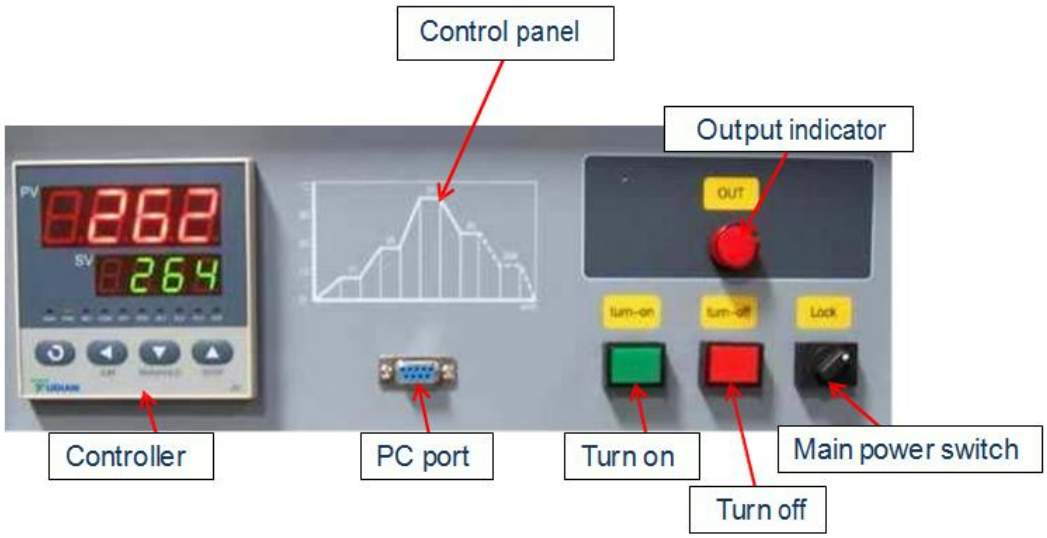
EQUIPMENT INFORMATION

INTRODUCTION

KSL-1700X-KA is a CE certified bench-top ultra-high temperature muffle furnace with a max. working temperature up to 1750°C. The furnace uses Kathal HT (1830 grade) MoSi2 heating elements and is controlled by a high precision SCR (Silicon Controlled Rectifier) digital controller with +/-1 °C accuracy and 30 segments that are programmable up to 1750 °C. It is an ideal box furnace for sintering high purity ceramic materials at high temperatures.

FURNACE STRUCTURE





Controller: Use to set up the heating sequence (heating procedures) and modify the parameters.
PC port: Connects to a computer for enabling the furnace to be controlled by the computer. (Note: A temperature control system - EQ-MTS02 must be purchased to enable the PC control function.)
Turn on: Turns on the relay for allowing the controller to work with heating elements
Turn off: Turns off the relay and stops communication between controller and heating elements
Main power switch: Controls the power supply.
Output indicator: Lights on when the furnace is heating; usually blinks intermittently during under normal settings.

SPECIFICATIONS

Power	4KW, AC 208 - 240 Single Phase 50/60 Hz
Max. Temperature	1750 ^{o}C (< 3 hours)
Working Temperature	1700 ^{o}C (Continuous)
Max. Heating Rate	≦ 20 ^{o}C /min
Chamber Dimensions	160 x 150 x 150mm (6.3" x 5.9" x 5.9"), 3.6L
Temperature Uniformity	• +/- 5°C over 120 mm (5") @ 1700°C • +/- 2°C over 80 mm (3") @ 1700°C
Heating Elements	Kanthal Super-1800 grade $MoSi_2$ (4 pcs U shape)
Thermocouple	B Type (Pt-Rh to Pt-Rh) with Alumina tube
Overall Dimensions	515 x 500 x 730 mm (20.28" x 20" x 28.75")
Warranty	• One year limited warranty with life time support. (Consumable parts such as sample plates and heating elements are not covered by the warranty, please order the replacement at related products below.) • ***ATTENTION: Any damages caused by the use of corrosive and acidic gases are not under the coverage of MTI One Year Limited Warranty.***

Application Notes	• For preserving the longevity of the furnace components, we recommend the heating rate not to exceed 10 °C /min. • Cooling rate shall also not exceed 10 °C /min. • This furnace lacks vacuum sealing, toxic or explosive gases are not recommended for use with this furnace without necessary safety controls and supervision. • Small cracks may appear on the surface of the refractory ceramics over extended use. This is a normal occurrence and the cracks may be repaired with alumina coating. • Please click here to learn how to DIY gas purging system. • Refractory block must be inserted before closing door.

ASSEMBLY & OPERATION 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.

⚠ **WARNING:**

Prior to connecting power to the furnace, please open up the top lid of the furnace and remove the shock absorbent foam covering the heating elements. Put the top lid back in place afterwards.




OPERATING ENVIRONMENT

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

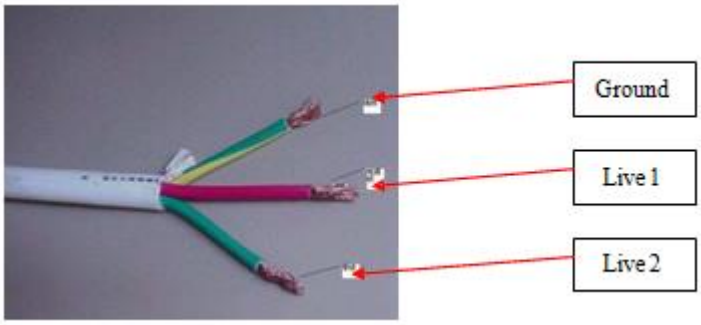
- The furnace should be placed on a dry, hard and flat surface that is free of vibration
- Use should be limited to indoor only with adequate ventilation and away from direct sunlight
- Environment should be dust-free and without explosive and corrosive gases
- Relative humidity (non-condensing): 10%～85%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

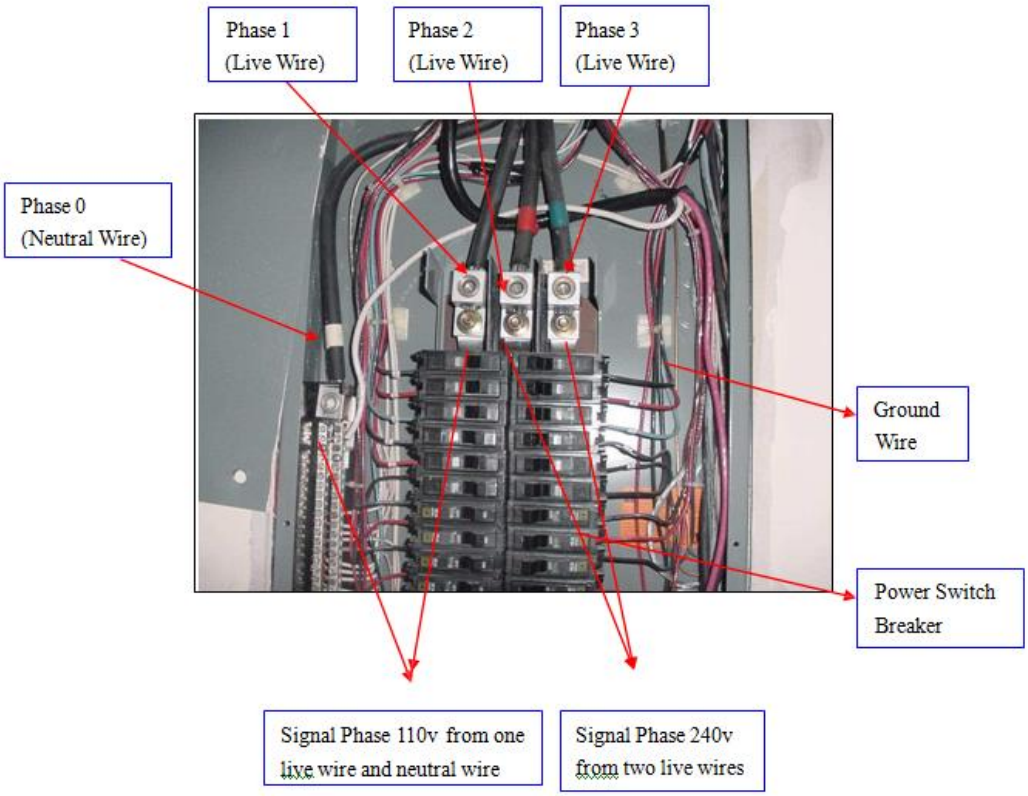
⚠ **Attention:**

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.

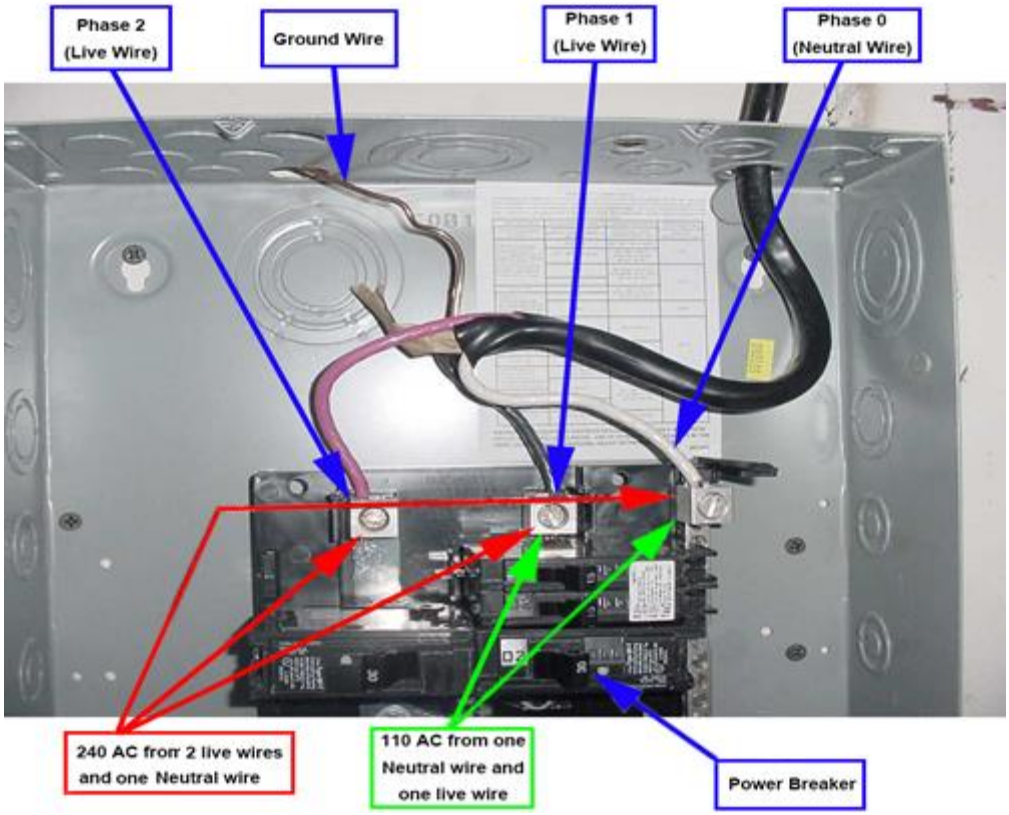
The following knowledge may be useful for configuring a single phase 208~240V power line from various electrical panels. A three phase 240V AC electrical panel generally found in most laboratories can be configured to output a single phase 208~240V power line. To do this, two of the three live wires 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

THERMOCOUPLE INSTALLATION

The thermocouple has been tested on the furnace to ensure proper function prior to shipping. However, some furnaces have special thermocouples that had to be removed prior to shipping to protect against damage. If your furnace does not come with the thermocouple already being installed, please use the following instructions to install it.

- Insert the thermocouple (ceramic tube) from the backside of the furnace and make sure that the tip of the thermocouple is fully protruded in the chamber for accurate temperature readings.

⚠ **Attention:**

A clearance of 1mm (millimeter) between tip of the thermocouple and the tube surface should be given to prevent damage to the thermocouple.

- Tighten screw to fix the thermocouple in position.
- Connect the wires coming out from the furnace to the terminals on the thermocouple block according to the labels and markings. It is very important that the positive and negative polarities are connected correctly or else the thermocouple will not work. Please refer to pictures C and D for more details.

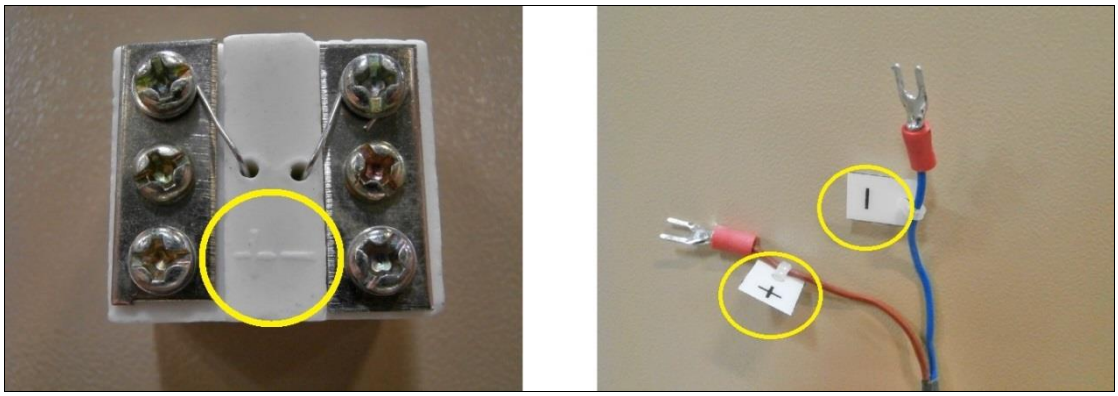


Figure C

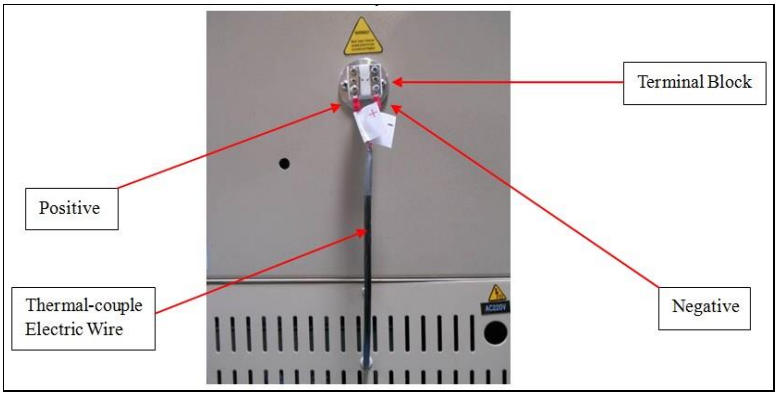


Figure D

Attention:

The polarity marking on the terminal block

Once the furnace setup is finished, we strongly recommend reading the handbook and follow the instructions listed in the "HEATING PROFILE SETTING EXAMPLE" section to perform a quick test and check the heating condition of the furnace.

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℃ for at least 2 hours to remove moisture inside the chamber. This helps to prevent the furnace refractory ceramics from cracking.

1) Place the test sample inside the Chamber (Crucible may be used as material container, please visit: http://www.mtixtl.com/ceramiccrucibles.aspx), slightly close the front door.
2) Power on the instrument by turning the the "**Power Lock**" to the right and the temperature control LCD will start to blink.
3) 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.
4) 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.

TEMPERATURE CONTROL INSTRUCTIONS

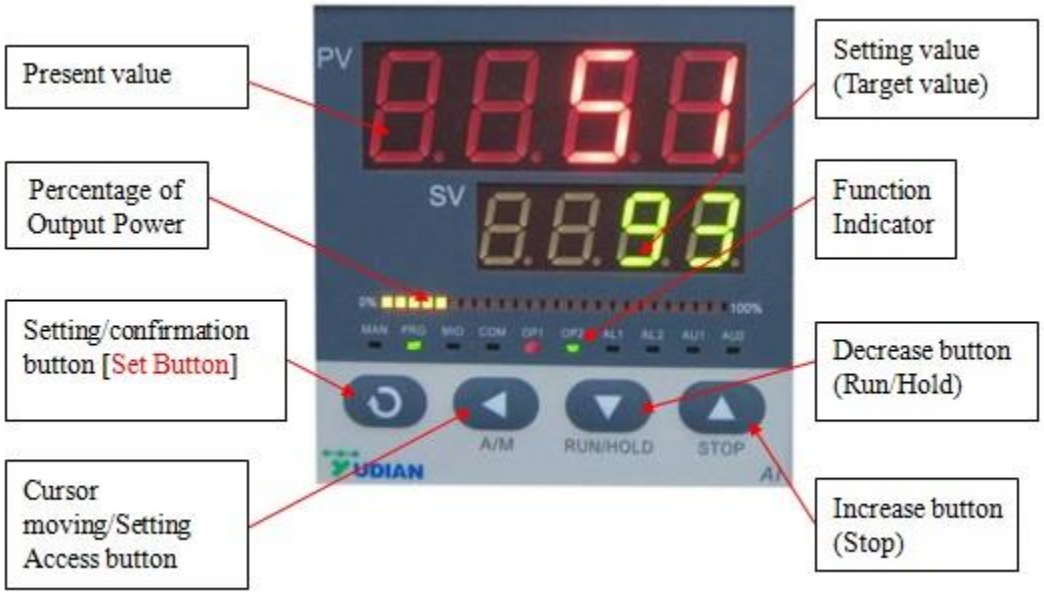
TEMPERATURE CONTROLLER

1. Specifications
   a. Compatible Thermocouple: K、S、R、E、J、T、N;
   b. Measurement Accuracy: 0.3;
   c. Power Input: Single phase 220V AC (±10%) / 50~60Hz;
   d. Power: ≤5W;
   e. 30 Programmable Segments.
   f. 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".

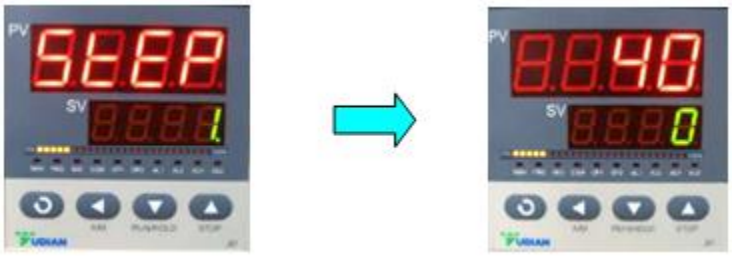
Meter type & Program version Normal state

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 ^{o}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;

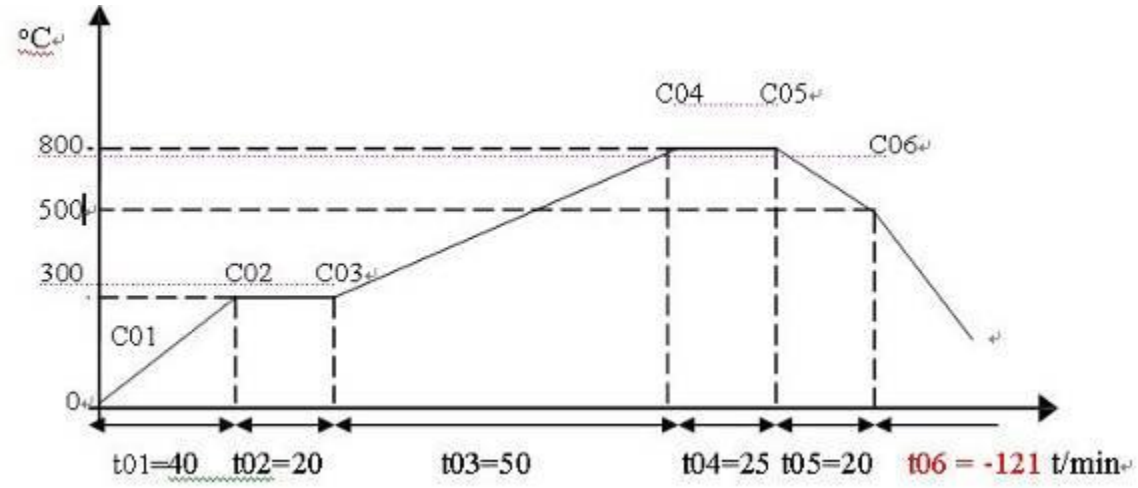
⚠ **Attention:**

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 firstly change the value of parameter "Loc" to "808" 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℃/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 deceasing), 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 ℃ 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 ℃/min heating or cooling rate is suggested.

- Please refer to parameters “M5, P and t” if the temperature offset cannot be eliminated and the difference between PV and SV increases at 300 ℃.
- 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 ℃ 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_2, Cl_2 and SO_2, will cause damage to the heating elements. Customer should use them at their own risk.
- Before operating the furnace, you must place the alumina insulation block (see Fig.a and.b) behind the front door of the furnace for good insulation performance.

Fig. a, Alumina insulation block

Fig. b, Alumina insulation block

- Please don‟t open the front door of the furnace above 300℃ to prevent insulation inside furnace from cracking.
- MoSi2 heating element is only suitable for using in air or inert gas environment. Other active gas, such as H2, Cl2 and SO2 will damage heating element.
- Please don‟t use the furnace at 400 – 700 oC temperature range for long time because MoSi2 heating element will be easy to be oxidized in the temperature range.
- MoSi2 heating element is very brittle. Please pay a great attention during moving and handling.
- Please check heating element for every three months to see if they are in good connecting condition. If the connection gets loose, please open case and tighten them properly.
- Please always keep inside clean before operation to avoid contamination to your sample.

HEATING ELEMENTS REPLACEMENT

1) Remove the 4 screws on top of furnace, and then open the cover as shown in Fig. 1
2) Take off the screws on the clips for heating elements as shown in Fig. 2
3) Disassemble the aluminum plates connecting the heating elements as shown in Fig. 3


Fig. 1


Fig. 2


Fig. 3

4) Unfasten the screws on the metal clips used for fixing the ceramic blocks as shown in Fig. 4
5) Remove the ceramic block between rods of U type heating elements as shown in Fig. 5
6) Take out the U type heating elements that need to be replaced as shown in Fig. 6
7) Insert a new heating element together with the ceramic block positioned in between the heating rods as shown in Fig. 7


Fig. 4


Fig. 5


Fig. 6


Fig. 7

8) When tighten the screw of metal clip for heating element, please make sure the bottom of the U heating element does not touch the bottom of furnace chamber. Usually the bottom of the U element shall rise 5 mm high from the bottom of furnace chamber
9) Then, follow the procedure 4, 3, 2, 1 to tighten the screws and finish the exchange of heating elements

⚠ **Attention:**

Heating elements are brittle and need to be handled with care at all times.

To avoid breaking, do NOT over-tighten the aluminum connecting plates between the rods of heating elements. However, a loose connection could cause a higher contact resistivity and increase the temperature on the top of furnace dramatically.

If the temperature on top of furnace is too high during heating, please shut down the power and remove the cover to further tighten the screws between heating element rods and aluminum plates.

TROUBLESHOOTING FOR TYPICAL PROBLEMS

Problems	Reason	Solution
Open Power Lock, no power indication	Circuit breaker on the furnace is flipped	Check circuit breaker and flip it back
Controller display panel SV shows " OraL"	Thermal Couples broken	Replace Thermal couples (B type)
Controller display panel SV shows " HI AL"	Furnace temperature > 1750℃, Protection from Alarm	Cool furnace down, and find reason why temperature is so high (program setting may be wrong)
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
Program running, but furnace cannot be heated, or real temperature is far behind the setting value	oPL or oPH value is too low due to lower local voltage or frequency difference	Increase oPL and oPH value till current meter shows "0 and 100" respectively
During heating below 300℃, 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℃.	Let the furnace heat to 300℃, then thermocouple will function stably with program. If the PV value at 300℃ 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 for additional information about the instrument
- Contact us by Tel: 510-525-3070 or email: info@mtixtl.com