
Rio Grande PMC® Kilns #703-117 & #703-118 Instruction Handbook



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SHIPPING LOSS OR DAMAGE

When your Rio PMC® kiln is delivered, note any external evidence of loss or damage on the freight way bill or express receipt and have it signed by the carrier's agent. Failure to adequately describe such external evidence of loss or damage may result in the carrier's refusal to honor your damage claim. The form required to file such a claim will be supplied by the carrier.

Concealed loss or damage means loss or damage which does not become apparent until the merchandise has been unpacked and inspected. Please examine your kiln carefully as you unpack it. If there is any visible damage, do not attempt to operate it.

Should either external or concealed damage occur, make a written request for inspection by the carrier's agent within 15 days of the delivery date. File a claim with the carrier for any damage that is caused by the carrier.

Save your shipping carton; it is carefully designed to provide maximum protection during shipping. Repack the kiln in the carton to take it to seminars or on vacation, or to send it for repairs.

Please Note:

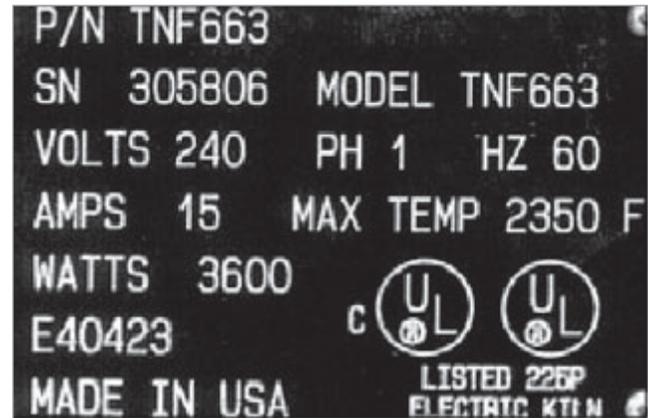
Tremendous stresses are generated within the kiln. The ceramic fiber firing chamber actually expands and contracts with each firing, so do not be concerned if small cracks appear in the fiber as this is normal. These are surface cracks that close tightly when the heated fiber expands. You may find a small pin-hole in the center of the firing chamber. It is from the manufacturing process and will not affect the kiln's performance.

Also note that paint around the door will eventually discolor from heat. Again, this will not affect the kiln's performance.

During firing, you will hear an intermittent, distinct clicking. This is the sound of the relay(s) sending power to the heating elements. Do not be concerned with this sound.

THE ELECTRICAL DATA PLATE

Important information about your kiln is recorded on its electrical data plate. Please include this information when ordering parts or calling Rio Grande with questions about your kiln.



SAFETY PRECAUTIONS

Read Your Handbook

Read each page of this handbook carefully before operating your kiln. The warranty does not cover damage caused by failure to follow instructions.

Safety Rules

An electric kiln is extremely safe to operate provided you follow these basic safety rules:

- **DANGEROUS VOLTAGE!** Do not touch the heating elements with anything.
- Disconnect the power when the kiln is not in use.
- Install your kiln at least 12" away from walls and any potentially combustible surfaces.
- Fire only in a well-ventilated, covered and protected area.
- Never fire tempered glass inside the kiln; this type of glass could explode.
- Never fire toxic materials, such as styrofoam (used as a core for hollow beads), inside the kiln.
- Keep any combustible materials away from the kiln at all times.
- Wear properly rated safety glasses when looking into the firing chamber of a hot kiln or when cutting glass.
- Do not leave the kiln unattended while firing, especially near the expected shut-off time.
- Do not touch the hot kiln case; keep unsupervised children away.
- Keep the cord-set away from the hot kiln case.
- Do not open the lid or door until the kiln has cooled and all switches are off.
- Keep food away from your work area.
- Disconnect the kiln before servicing.

Over-Firing

The warranty on your Rio PMC® kiln does not cover damage from over-firing, regardless of the circumstances. It is the operator's responsibility to make sure the kiln turns off at the proper time.

The Ceramic Fiber

Avoid touching the firing chamber surface with sharp or pointed objects that can damage the fiber surface.

Food or Drink Containers

Some decorative materials may be unsafe or toxic on surfaces that will be in contact with food or drink.

When you make food or drink containers, select a glaze or glass that has been formulated, tested and labeled as approved for surfaces that will be in contact with food or drink. Follow the glaze or glass manufacturer's instructions exactly, without any variations.

SETTING UP THE KILN

ELECTRICAL INSTALLATION

Important: Provide your kiln with a circuit that no other appliance uses while the kiln is firing. To check the circuit, turn off the circuit breaker (or unscrew the fuse) for the circuit that your kiln will use. Check to see if any other appliances shut off too. If that circuit powers appliances that must remain on while the kiln is firing, choose a different circuit.

Please Note: With 120-volt kilns, avoid using an extension cord if possible. If you must use one, never use one smaller than 12-gauge or longer than 20 feet.

Important: Never plug the kiln or extension cord into a ceiling outlet!

Voltage fluctuation can vary firing time from as little as half the average time to more than twice the average time. If the voltage is too low, the kiln may never reach full temperature.

The receptacle for the kiln must have a separate safety grounding wire. This protects you from serious electrical shock. Changing the cord plug configuration in any way will void your warranty.

PLACING THE KILN

1. Place your kiln in a well-ventilated, covered and protected

area such as a garage, basement, utility or hobby room.

Please Note: Some people keep their kiln outside on a covered patio. This is acceptable so long as the kiln is not subjected to excessive humidity and has good ventilation.

2. Remove gasoline, paint and all other flammable materials from the kiln room.
3. Provide a minimum of 12" of clearance between the kiln and the nearest wall; keep the kiln away from curtains or other combustible materials.
4. Never allow the temperature of your firing room to exceed 100°–110°F. Measure the temperature about three feet from the kiln. If necessary, use fans to reduce room temperature.
5. Position the kiln on a level, fire-proof surface such as an 18" x 18" sheet of metal or a large ceramic kiln shelf.
6. Keep unsupervised children away.
7. Keep the power supply cord away from the kiln case.



Place the kiln on a fire-proof surface.

There is little danger of a serious burn from accidental contact if you exercise the same caution you would use with an electric iron.

TRANSPORTING THE KILN

You may want to take your kiln to seminars. The best way to transport the kiln is to use the original packing materials.

If you no longer have the packing materials, transport the kiln on its back (with the door facing up). Place a thin sheet of foam cushioning between the door and the firing chamber to prevent rubbing. Avoid subjecting the kiln to excessive vibration during travel.

BASIC OPERATION

ACCESSORIES

Ceramic Fiber Shelf

The soft ceramic fiber shelf, provided with the kiln, cradles PMC® pieces. Four ceramic feet raise the shelf off the kiln floor. This shelf is not suitable for enameling or firing glass or ceramics. **Do not** coat the fiber shelf with glass separator or kiln wash.



Ceramic Fireclay Shelf & Posts

A ceramic fireclay shelf, available in your *Rio Grande Tools & Equipment* catalog, protects the firing chamber bottom and provides a smooth firing surface. Use a ceramic shelf to fire ceramics, glass and enamels. Firing glass, enamel or ceramic glaze directly on the firing chamber bottom will ruin the bottom. Shelves can be stacked using posts.



Insulating Firebrick Piece

Insulating firebricks are porous, light-weight and can be shaped to support delicate clay designs. Shape the firebrick with a knife or hacksaw.



Ceramic Bowl

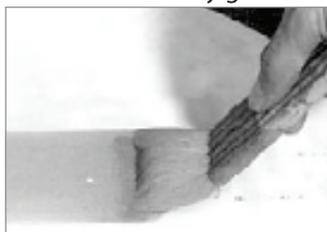
You can purchase a clay/silica melting crucible from Rio Grande (#704-120) that will last through many firings. Use it to hold alumina hydrate.

Please Note: Ceramic shelves and bowls and insulating firebricks may slow the firing. They absorb more heat than the ceramic fiber shelf and cool more slowly.

Glass Separator & Kiln Wash

Glass separator and kiln wash are mixtures of finely ground minerals that will not melt and fuse together at high temperatures. They prevent glass and ceramic glaze from sticking to fireclay shelves.

The difference between glass



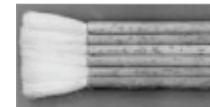
separator and kiln wash is that the separator is ground more finely to leave a smooth back on glass pieces laid on the shelf.

As powders, glass separator and kiln wash have an unlimited shelf life. **Warning:** Do not inhale the powder when mixing.

Caution: If glass separator or kiln wash contact a heating element, that element will burn out during the next firing. Never apply glass separator or kiln wash to the ceramic fiber firing chamber.

Haik Brush

The haik brush is used to apply glass separator to the kiln shelf in a smooth, thin layer. The smoother the glass separator, the smoother the underside of the glass will be.



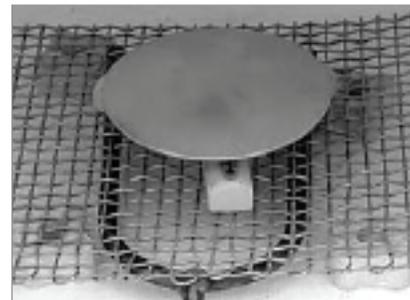
Alumina Hydrate

Delicate PMC® shapes may need extra support during firing to prevent warping. Place these shapes in a thin layer of alumina hydrate inside a small clay/silica melting crucible.

Warning: Do not inhale alumina hydrate.

Stilt

A stilt is a point embedded in a ceramic base. The point separates enameling and glazed ceramics from the shelf.



The wire mesh is referred to as an enameling rack. An enameling fork lifts the rack out of the kiln. A stilt separates the piece from the rack.

Enameling Rack

Enameling is the art of firing glass onto metal. The metal shapes are arranged on a high temperature wire rack. The enameled pieces and wire rack are loaded into a hot kiln, fired for just a few minutes, and removed red-hot. To load and unload the racks safely, use an enameling fork.

Fiber Repair Filler

Filler is a permanent, high-temperature refractory cement used to repair holes or cracks in the ceramic fiber firing chamber.

Safety Glasses

Wear safety glasses when cutting or chipping glass and when looking into a hot kiln. See your *Rio Grande Tools & Equipment* catalog for safety glasses. **Caution:** Always wear firing glasses when viewing the oven's interior.



IMPORTANT GUIDELINES

EMBEDDED HEATING ELEMENTS

The heating elements of your kiln are embedded into the ceramic fiber firing chamber. The firing chamber surface is hardened to a depth of 1/4". This makes the fiber more durable. It is important that you do not touch the firing chamber with sharp objects. These can penetrate the fiber surface and contact the heating element, creating a severe shock hazard.

THE CLICKING NOISE

Do not be concerned if your kiln makes a clicking sound during firing. Your kiln contains a relay which sends power to the element. The relay clicks as it cycles on and off to maintain the correct temperature.

THERMOCOUPLE INSPECTION

The small rod protruding into the firing chamber is the temperature sensor or thermocouple. The digital controller senses temperature by reading a voltage from the thermocouple. Be sure the rod extends into the firing chamber before firing the kiln. **Please Note:** If this rod is bumped out of the firing chamber, the kiln will assume that the firing chamber is cold. This will result in over-firing. The controller does not contain an alarm to detect this kind of failure. Always check placement before firing.

- A 1/8"-diameter thermocouple should extend into the firing chamber 1/2"–5/8".
- A 1/4"-diameter thermocouple should extend into the firing chamber 1" or more.
- Keep shelves, posts and objects being fired 1"–1 1/2" away from the thermocouple.

KILN CLEANING

Clean the kiln before firing glass, enamels or ceramic glaze (cleaning is not necessary when firing PMC®). Use a soft brush nozzle on a vacuum cleaner to remove dust from inside the kiln.

HOT ITEM REMOVAL

To remove hot items from the kiln, turn off the kiln. Wearing thick work gloves, carefully slide an enameling fork under the shelf. Lift out the shelf and place the hot shelf on a large ceramic kiln shelf in front of the kiln.



FIRING LOG BOOK

Record the following information in a firing log book:

- Date
- Firing temperature, speed and hold time; or Ramp/Hold program
- Starting time
- Total firing time
- Type of pieces
- Firing results

As you gain experience, you will find a wealth of useful information in your firing logs.

LOW-TEMPERATURE HOLD

A low-temperature hold (e.g.: 200°F–300°F) is more difficult to maintain than a higher temperature hold (1400°F–1700°F). At low temperatures, turning on the heating element affects firing temperature to a greater degree than at high temperatures.

When holding at a low temperature, heat the kiln slowly to avoid overshooting the hold temperature before the element turns off.

HEATING ELEMENT CONTAMINATION

Contact with silica or silica-bearing compounds (such as kiln wash, glass separator, alumina hydrate, glass, enameling powder or ceramic glaze), will ruin the heating element. This type of damage is not covered by warranty. Never fire glazed ceramic ware, glass or enameling directly on the firing chamber bottom. Use a ceramic shelf on short posts to protect the bottom from glaze drips, glass and enameling powder.

Please Note: If a contaminant such as dripping glass or glaze becomes embedded in the firing chamber, unplug the kiln. Gently scrape off the contaminant with a knife, being careful not to damage the heating element. Vacuum the kiln.

THE EFFECT OF SILVER RESIDUE ON GLASS

Firing PMC® leaves traces of silver in the pores of the firing chamber. Sometimes there is enough silver residue in the kiln to affect colors of glass. For instance, green might turn yellow. Before firing an important glass piece in a kiln used for silver clay, perform color tests. Fire small samples of each glass color on a base sheet of clear glass. Place the glass on a fireclay shelf (not the soft fiber shelf).

LOADING THE KILN

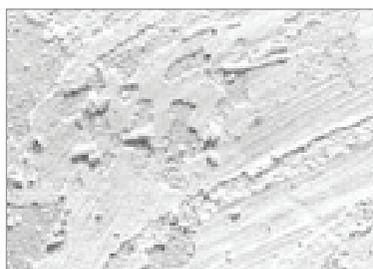
Place Items on a Protective Shelf

Always protect the firing chamber by firing your pieces on a shelf or in a bowl. Do not place the pieces directly on the bottom of the firing chamber. See types of shelves and containers on page 4.

Apply Glass Separator or Kiln Wash

Glass and ceramics are fired on a fireclay kiln shelf and not directly on the kiln bottom. You can also slump glass over a mold, such as a bowl. The kiln shelf and sagging mold must be coated with glass separator to keep glass or ceramic glaze from sticking to them.

A coat of glass separator or kiln wash will usually last through several firings. The lower the fusing temperature, the more firings you can get from one application of separator.



Apply a new coat of separator when the old coat begins to flake.

When the shelf coating begins to crack or chip, apply a fresh coat.

Before re-coating a shelf, remove as much of the old coating as possible with a grit cloth so that you start with a smooth surface. The abrasive mesh of the cloth allows residue to pass through. Re-coat the shelf using the directions below.

Please Note: Both glass separator and kiln wash are referred to as “separator.”

Important: Do not apply glass separator or kiln wash to the ceramic fiber firing chamber or to the bottom of the shelf! Contact with glass separator or kiln wash can ruin the embedded heating element.

Please Note: Do not coat the soft ceramic fiber shelf with separator. When firing glass with or without PMC®, above 1110°F, fire the piece on a hard fireclay shelf coated with separator.

1. Follow the directions on the bag to mix the separator with water.

2. Use a haik brush or a soft paint brush to apply the separator to the shelf. The haik brush is recommended because it lays down a more even coating.
3. Each time you dip your brush into the separator mixture, swirl the brush around the bottom of the container to re-mix the separator.
4. Use two or three thin coats, changing the direction of your brush strokes 90° with each coat.
5. Dry the shelf before firing. To speed drying, place the shelf on three or four 1/2" posts inside the kiln. Heat at full rate to 300°F/148°C and hold for five minutes. Then turn off the kiln and leave the shelf inside.
6. After the separator has dried and your shelf is cool, you can smooth the separator further by rubbing your hand lightly over the shelf. The smoother the separator, the smoother the underside of your glass will be.

Use Ceramic Fireclay Posts

- Place three or four 1/2" posts under the hard ceramic fireclay shelf to help air circulate, preventing heat built-up under the shelf.
- You can fire two or more ceramic fireclay shelves in the Rio PMC® kiln. Separate the shelves with taller posts. The length of the posts and the number of shelves you can fire depends on the size of the kiln.



VENTING THE KILN

Some types of pieces, such as glass and ceramics, contain impurities that burn off during firing. These impurities must be released from the kiln; otherwise, they can affect the quality of the piece.

PMC® needs no venting unless you are firing it with a material that burns out for a hollow shape, or are combining it with another material such as glass.

Open the vent hole by removing the ceramic plug in the top of the kiln.

Please Note: When the kiln is first turned on, the numbers on the display will show the software package that is installed in your kiln—this is a normal operation.

Temperature Display
No Display Dot:
Temperature display, °F.

Temperature Display
Right Display Dot:
Temperature display, °C.

Time Display
Center Display
Dot: Separates
hours & minutes.

START/STOP
HIGHER
LOWER

Program
Review
Run

°F When Off
°C When Lit

Pro1 = PMC+ Fast
Pro2 = PMC+ Slow
Pro3 = PMC3 Slow
Pro4 = PMC Original
Pro5 = PMC Gold
Pro6 = User Defined
Pro7 = User Defined
Pro8 = User Defined
Pro9 = User Defined

RIO GRANDE
Since 1944

The Rio Grande micro processor is manufactured by the Orton Ceramic Foundation and displays the CE mark.

Start/Stop Key
1) **On/Off:** Starts and stops a firing.
2) **Enter Data:** Press after each programming step.

Up Arrow Key
1) **Increases** values during programming.
2) **Select Mode:** from **IdLE** press **start**. Press **up arrow** key to select PMC or Ramp/Hold mode.
3) **Skip Segment:** During Ramp/Hold firing, skips to the next segment. After pressing **up arrow** key, **SStP** will appear. To skip, press **up arrow** key again.

Down Arrow Key
1) **Decreases** values during programming.
2) **Review:** From **IdLE** or during firing, press **down arrow** key. The program will appear one step at a time.
3) **Delay:** From **Start** press **down arrow** key.

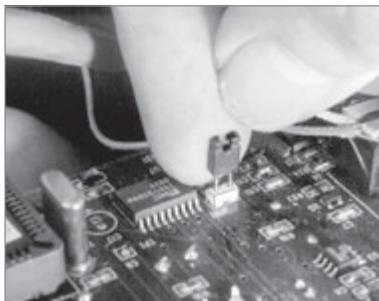
Rio PMC® kiln control panel descriptions

SELECTING °F OR °C DISPLAY

If your controller shows a small dot in the lower right corner of the display, the temperature shown is °C. If there is no dot, the temperature shown is °F.

To change the temperature display:

1. Unplug kiln or disconnect power.
2. Remove the four screws from the controller on the front of the kiln, and carefully remove it, leaving the wires attached to the controller.
3. At the back of the controller, on the circuit board, you will see a set of connector pins labeled "C/F". When a jumper connects the two pins, the display will read in °F. When the jumper is removed, the display will read in °C. Remove or insert the jumper as desired (jumpers are available from any computer supply store).
4. Re-install the controller, being careful not to jar components on the back of the controller against the kiln case.



CONTROLLER PROGRAMMING

TWO MODES OF OPERATION: PRE-SET PMC® PROGRAMS AND RAMP/HOLD

For your convenience, five programs for firing PMC®, PMC+® and PMC3® are pre-set into the Rio PMC® controller:

Program 1: PMC+® Fast

Ramp — Full

Temperature — 1650°F

Hold — 10 minutes

Program 2: PMC+® Slow

Ramp — 1500°F

Temperature — 1470°F

Hold — 30 minutes

Program 3: PMC3® Slow

Ramp — 1500°F

Temperature — 1110°F

Hold — 45 minutes

Program 4: Original PMC®

Ramp — Full

Temperature — 1650°F

Hold — 2 hours

Program 5: PMC® 22KY Gold

Ramp — Full

Temperature — 1290°F

Hold — 1½ hours

You can customize programs to fire materials other than PMC®, such as glass and enamel. Enter custom programs using any of the four user-defined settings.

HOW TO DISPLAY "IdLE"

IdLE must appear before you can fire the kiln.

- If **CPLt**, **STOP** or other messages appear instead of **IdLE** when you turn the kiln on, press the **start/stop** key. **IdLE** will appear.
- If you press the **start/stop** key during a firing, **STOP** will appear. To get back to **IdLE**, press the **start/stop** key again.
- If the display shows an error message such as **FAIL** instead of **IdLE**, see page 12.
- **CPLt** (firing complete) appears at the end of a firing. To make **IdLE** appear, press the **start/stop** key.

SCROLLING NUMBERS

The **up arrow** and **down arrow** keys change number settings during programming. Ordinarily, you would press the **up arrow** key to raise a number and the **down arrow** key to lower it. But sometimes it's faster to press the opposite key because the numbers scroll below 0000 to the maximum setting and vice versa.

Examples:

- To program a 99.59-hour Hold when the display shows "00.00," press the **down arrow** key once.
- To program a Full rate when the display shows "0000," press the **down arrow** key once.
- To program a temperature of 200°F when the display shows "1800°F," press the **up arrow** key.

PROGRAM REVIEW AND REPEAT FIRING

Program review allows you to confirm that the program in the controller is correct. It is a good habit to use program review before every firing.

- **Program Review During Firing:** Press the **down arrow** key. The rate, temperature, hold, etc. will display one after the other; firing will continue.
- **Program Review and Repeat Firing From IdLE:** Press the **down arrow** key. After rate, temperature, hold, etc., **Strt** will appear. Press the **start/stop** key. **-On-** will appear and the kiln will begin firing the program just reviewed.

HOLD

Hold maintains a steady temperature for the length of time you specify. In the pre-set PMC® programs, **Hold** has already been determined for you. In **Ramp-Hold**, you can use **Hold** in both heating up and cooling down segments.

When **Hold** is set to 99.59 hours, the controller will remain at that temperature indefinitely, until you press the **start/stop** key. To enter a 99.59-hour **Hold**, press the **Down Arrow** key once from "00.00" during programming in **Ramp-Hold** (see page 9). **Please Note:** During firing, the **Hold** temperature alternates with the remaining **Hold** time.

DELAY

Delay is a count-down timer. The kiln begins firing when the timer runs out of time. Use **Delay** to control firing schedule.

Caution: For safety, do not leave the kiln unattended during a delay or a firing. You must be present to ensure that the kiln turns off at the proper time.

1. After you have programmed the controller and it is ready to begin firing, **Strt** will appear.
2. Press the **down arrow** key once. **dELA** will appear, alternating with **00.00**.

3. Use the **arrow** keys to enter the delay time (e.g.: 1 hour, 10 minutes = 01.10), then press the **start** key. **dELA** will appear, alternating with time remaining before firing begins.

POWER FAILURES

After a power failure, the controller will continue firing provided that:

- the temperature dropped no more than 104°F/40°C while the power was down.
- the kiln temperature is above 212°F/100°C when the power is restored.

POWER FAILURE MESSAGES:

PF 1 — Power failed during a cooling segment, and the kiln cooled past the target temperature while the power was off.

PF 2 — Power failed during firing and the kiln temperature was below 212°F/100°C when the power came back on.

PF 3 — Power failed during firing and the temperature dropped more than 104°F/40°C by the time the power came back on.

THUNDERSTORMS AND POWER SURGES

Unplug the kiln or disconnect the power when the kiln is not in use, especially during thunderstorms and in areas with frequent power surges. If the kiln is partially through a firing when a storm begins, it is probably safe to continue the firing. Do not leave the kiln unattended.

FIRING IN A HOT KILN

After a temporary power failure, or when the kiln has shut off too soon, it may be necessary to turn the kiln back on. After you press the **start/stop** key, the controller will begin firing from the current temperature to the target temperature. In **Ramp/Hold**, the firing will begin from the first segment that encompasses the current temperature. **Please Note:** If the kiln is already hotter than the programmed target temperature when you begin firing, **CPLt** will flash.

FIRING PROFILES

The controller needs three pieces of information to fire:

- Rate or Ramp
- Temperature
- Hold time (if any) at that temperature

This information has already been programmed into the controller for PMC®, gold and silver. The PMC programs are shown in the display window during program selection as Programs 1, 2, 3, 4 and 5. The chart on page 7 shows the firing rate, temperature and hold time for each PMC program. The display prompt column shows the program number to select for each type of PMC.

GENERAL FIRING INSTRUCTIONS

1. From **IdLE**, press the **start/stop** key
2. Use the **up arrow** key (not the **down arrow** key) to select PMC® program 1, 2, 3, 4, 5 or **PrOG (Ramp-Hold** mode programming: see next section). Then press the **start/stop** key.
3. **Strt** will appear. Press the **start/stop** key to begin firing. **-On-** will appear and the kiln will begin firing.

To stop a firing before completion, press the **start/stop** key. **StOP** will appear, alternating with the kiln temperature.

When the kiln fires to completion, the controller will beep for 30 seconds. The display will show the following:

- Firing time
- Present temperature
- **CPLt**

To return to **IdLE**, press the **start/stop** key.

RAMP-HOLD MODE

DEFINITION OF A SEGMENT

A segment is the most basic part of a firing in **Ramp-Hold** mode. A segment includes a target temperature and a firing rate (or ramp) to reach that temperature. The firing rate is figured in degrees of temperature per hour. Shown in **Diagram 1** is a segment with a target temperature of 750°. Since, according to the chart, the temperature will take two hours to reach 750°, the rate is $750 \div 2 = 375^\circ$ per hour.

Diagram 2 (at right) illustrates three different rates. A rate of 1000°/hr will reach 1000° in one hour. A rate of 500°/hr will reach 1000° in two hours. A rate of 333°/hr will reach 1000° in three hours.

A segment (a target temperature and a rate of heating to reach that temperature) can include a hold as shown in **Diagram 3**. Hold means maintaining the target temperature for a length of time. Firing to a temperature at a single rate would need only one segment. Reasons to add segments include:

- To have more than one heating rate
- To add a hold somewhere below the shut-off temperature (see Segment 1 in diagram below)
- To control the cooling rate

Diagram 4 shows a 3-segment firing. The first two segments are used to bring the temperature up to a target temperature. The last segment represents a controlled cooling.

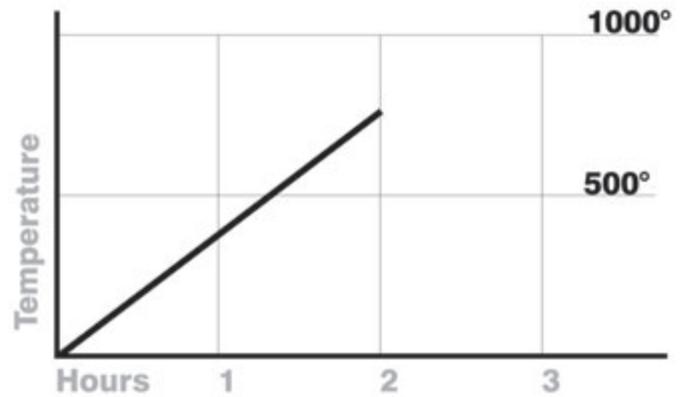


Diagram 1: A single segment with a rate of 375°.

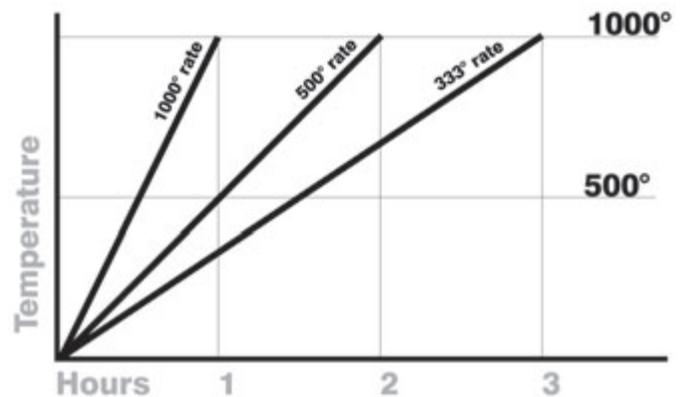


Diagram 2: Rate is degrees per hour.

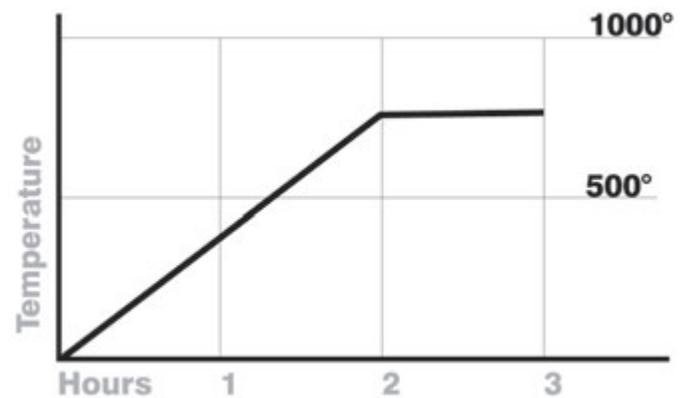


Diagram 3: A single segment with a one-hour hold.

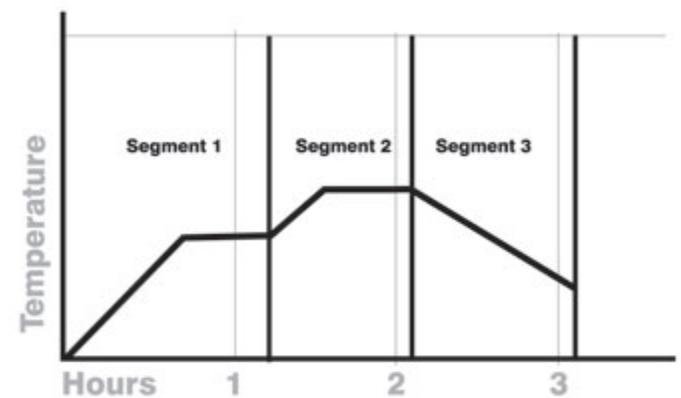


Diagram 4: A 3-segment firing with controlling cooling.

RATE

Each segment must include a rate, which is degrees of temperature change per hour.

The kiln will fire at full power when the rate is 1799°F/999°C. Full power displays as **FULL**.

Please Note: To enter full power from **0000**, press the **down arrow** key once.

EDITING THE TARGET TEMPERATURE

While the kiln is firing in **Ramp-Hold**, you can change the target temperature for any segment during its firing sequence. If the segment is in hold, it will come out of hold and fire to the new temperature at the original rate. **Please Note:** You cannot adjust the firing rate during firing. If you wish to change the target temperature of a segment not currently firing, simply wait until that segment begins and then make your change. To edit the target temperature:

1. Press the **Up Arrow** repeatedly until **CHGt** appears.
2. Press **START**. The target temperature for the current segment will appear in the display.
3. Use the arrow keys to change the target temperature.
4. Press **START**. The normal kiln temperature will appear.

Example of Editing Target Temperature:

You program the kiln to fuse glass at a temperature of 1450°F. At 1445°F, you check on its progress and realize that the glass will need at least another 50° to fuse fully. You can change the target temperature to 1560°F without having to turn off the kiln to reprogram it.

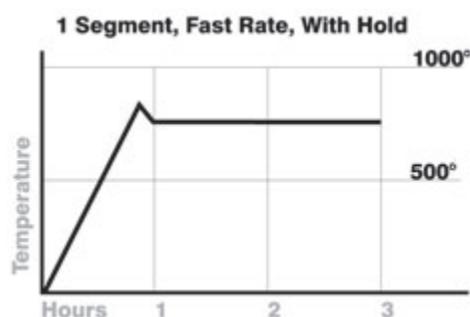
ADDING HOLD TIME IN RAMP-HOLD

While the kiln is firing in **Ramp-Hold**, you can add five-minute increments of hold time to any segment during its firing sequence (even if the segment has no hold time programmed to begin with). This feature is designed for ceramists who use witness cones and for glass artists who inspect the glass near the end of firing.

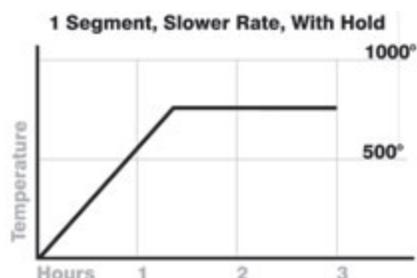
1. Press the **Up Arrow** repeatedly until **HLdt** appears.
2. Press **START**. The hold time for the current segment will appear in the display.
3. Press the **Up Arrow** once for each five-minute increment of time you wish to add.
4. Press **START**. The normal kiln temperature will appear.

TEMPERATURE OVER-SHOOT

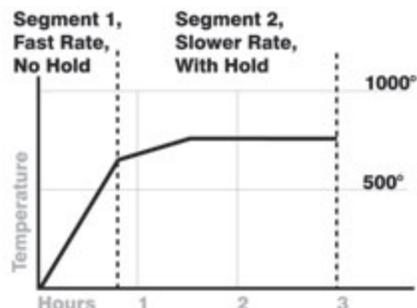
Heating a kiln at a fast rate (diagram at top right) may cause the temperature to over-shoot the target temperature, especially in small kilns at lower temperatures. To avoid this, add an extra segment in **Ramp-Hold** to slow the firing near the target temperature.



You can avoid temperature over-shoot by slowing the rate as shown below.



You can also avoid a temperature over-shoot by adding a segment with a slower rate, to begin approximately 40°–



60° below the target temperature.

SKIPPING A SEGMENT IN RAMP-HOLD

While the kiln is firing in **Ramp-Hold**, you can skip from the current segment to the following segment in a sequence.

1. During a **Ramp-Hold** firing, press the **Up Arrow**. **SStP** will appear.
2. Press **START**. The current segment ramp or hold number will appear. (If you change your mind and don't want to skip after all, simply don't press **START** after **SStP** appears. The firing will continue in the same segment and the temperature will appear after one minute.)
3. Press **START** again.

Please Note: The skip-segment feature does nothing during the final segment. To end the final segment, press **STOP**.

Example of Skipping A Segment:

You have programmed a target temperature of 1425°F for fusing glass, followed by a segment for controlled cooling. When you check on its progress, you see that the glass edges have rounded nicely at 1315°. Use the skip-segment

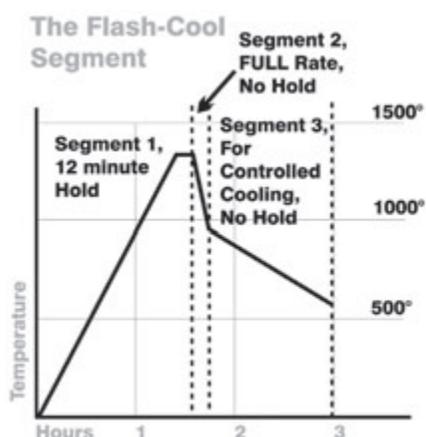
feature to end the firing segment and start the controlled cooling segment.

CONTROLLED COOLING IN RAMP-HOLD

Use the **Ramp-Hold** mode to program a slow cooling. Slow cooling enhances the quality of some ceramic glazes; it also encourages crystal development, deeper gloss and sometimes startling color shifts. Iron red glazes seem to respond well to slow cooling.

For controlled cooling, program a segment to a lower target temperature than that of the preceding segment. The controller, of course, cannot speed cooling beyond the kiln's natural cooling rate.

Glass artists sometimes flash-cool glass after it has fused. They open the door slightly for a few minutes to allow heat to escape. To flash-cool the glass, you will need to add a segment with a rate of **FULL**. Otherwise, after the flash-cool, the controller will raise the temperature again.



Caution: During fast cooling, do not open the lid or door

Segment	Rate °F/°C	Temp. °F/°C	Hold
1	950°/527°	1350°/732°	00.12
2	FULL	950°/510°	00.00
3	300°/166°	550°/287°	00.00

all the way. Do not flash-cool the kiln with a fan.

The above firing would be programmed as follows:

RAMP-HOLD PROGRAMMING/FIRING

Please Note: If you don't need all eight segments available in **Ramp-Hold**, enter zero for each of the unused segments (see step 6, below).

1. From **IdLE**, press the **start/stop** key.
2. Using the **up arrow** key (not the **down arrow** key), bypass **PrO1**, **PrO2**, **PrO3**, **PrO4** and **PrO5**. Select **ProG** then press the **start/stop** key.
3. **ra 1** will appear. Enter firing rate (temperature change per hour) for segment 1.

1° = slowest rate.

1799°F/999°C = full power.

Then press the **start/stop** key.

4. **°F 1** (or **°C 1**) and segment 1 target temperature from the last firing will appear. Use the **up** and **down arrow** keys to change the temperature. Press the **start/stop** key.
5. **Hld 1** and segment 1 hold time from the last firing will appear (e.g.: 1 hour 10 minutes = 01.10). Use the **up** and **down arrow** keys to change the hold time. Then press the **start/stop** key.
6. Continue entering values for the segments needed. When **ra _** appears for the first segment you don't need, select **0000**. Then press the **start/stop** key to enter. This will enter zero for any remaining segments.
7. **Strt** will appear. Press the **start/stop** key to begin firing. **-On-** will appear and the kiln will begin firing.

To stop a firing before completion, press the **start/stop** key. **StOP** will appear, alternating with kiln temperature.

Please Note: The actual firing rate may be less than the rate you programmed, depending on the kiln model, available voltage and the density of the load you are firing.

When the kiln fires to completion, it will beep for 30 seconds. The display will show the following:

- Firing time
- Present temperature
- **CPLt**

To return to **IdLE**, press the **start/stop** key.

THE ALARM FEATURE

You can set an alarm to sound when the kiln reaches the set temperature during any **PMC®** or **Ramp-Hold** program. Use the alarm, for example, to alert you to check the fusing or slumping of glass.

Only one alarm temperature can be set at any one time; however, after the alarm beeps, you can re-set the alarm for another temperature. Re-set the alarm as many times as you need during a firing program. Entering an alarm temperature automatically overwrites the previous alarm temperature.

Please Note: The alarm temperature you set during a firing must be higher than the current display temperature. The alarm is designed for rising temperatures, not for cooling temperatures.

1. During the firing mode, press the **Up Arrow** repeatedly until **ALAr** appears.
2. Press **START**. The current alarm temperature will appear.
3. Use the arrow keys to set the alarm temperature.
4. Press **START**. The normal kiln temperature will appear.

To silence the alarm, press any key. An alarm temperature of 32°F/0°C will turn off the alarm.

ERROR MESSAGES

BAdP (bad programming) — The kiln will not fire because 1) the **Ramp-Hold** program entered has a rate of 0000 in segment one, or 2) the target temperature in segment one of **Ramp-Hold** is lower than the current temperature.

EtH — The temperature of the electronic circuit board is above 158°F/70°C. This could damage the controller, so the firing has been stopped. To correct and/or prevent this, keep the firing room cooler. Increase ventilation.

Fail (thermocouple failure) — The thermocouple (temperature sensor) failed during firing. Possible causes include:

- Defective thermocouple or disconnected/loose wires
- Defective controller
- Electrical noise

Thermocouple Paper Clip Test

Check the thermocouple wire connections (see page 5). If connections are tight, perform this test:

1. Unplug the kiln or disconnect the power. Remove the controller (“Selecting,” step #2, page 7). Remove the two thermocouple wires from the back of the controller.
2. Clip off the U-shaped end of the paper clip. Insert it (or another piece of thin wire) into the thermocouple receptacles.
3. Plug in the kiln. If the controller displays room temperature, replace the thermocouple. If it shows **Fail**, replace the controller.



FE-5 — This signal appears when the controller senses an inability to communicate, either within the controller or with the oven. This can be caused by power fluctuations. Press the keypad to reset the controller.

FtL (fired too long) — This message appears when both of the following conditions occur:

- The temperature rise is less than 27°F/15°C per hour.
- The firing is four hours longer than programmed.

See “Controller display turns on. No heat in kiln,” page 13.

PF 1 (power failure 1) — The power failed during a cooling segment, and the kiln cooled past the target temperature while the power was off. The kiln will not resume firing. To return to the **IdLE** display, press any key.

PF 2 (power failure 2) — The power failed during firing and the kiln temperature was below 212°F/100°C when the power came back on. The kiln will not resume firing. To return to the **IdLE** display, press any key.

PF 3 (power failure 3) — Power failed during firing and the temperature dropped more than 104°F/40°C by the time the

power came back on.

tC (thermocouple failure) — The thermocouple failed during the **IdLE** display. See the “Paper clip Test” under **Fail**, above.

tCL (thermocouple lag) — The heating rate is slower than 9°F/5°C per hour and the kiln temperature is more than 100°F/56°C away from the programmed temperature. To return to the **IdLE** display, press any key. Causes include:

- On kilns with a portable controller, the thermocouple may have fallen out of the firing chamber.
- A bare spot on the thermocouple lead wires has touched a grounded object inside the kiln switch box causing the thermocouple to short out.
- **tCL** will flash if you program a cooling segment temperature that is below room temperature.

Check for worn or burned-out elements, defective relays, low voltage and a defective thermocouple.

tCr (thermocouple reversed) — Thermocouple lead wires are reversed. Check that the thermocouple lead wires are connected to the correct terminals (see kiln wiring diagram).

DISPLAY MESSAGES

Abrt — Firing was stopped.

ALAr — Ready for you to enter an alarm temperature. When the kiln reaches that temperature, the alarm will sound.

CHGt — Ready for you to edit the target temperature of the current **Ramp-Hold** segment during firing.

CPLt/COE — Fired to completion.

dELA — Delay is a count-down timer that starts the kiln when the time runs out.

°F or °C (with numerals) — The controller is ready for you to enter the target temperature (the temperature that the kiln will fire to). Each segment in **Ramp-Hold** has a target temperature.

FULL — Full power firing rate. At this setting, the kiln will fire at its fastest rate. To select full power, program a rate of 1799°F/999°C at the **ra_** prompt in **Ramp-Hold**. A fast way to do this is to press the **down arrow** key once from 0000. **FULL** will appear.

Hld 1 (with numerals) — Hold time of a segment. Shown in hours and minutes. (example: 2 hrs., 15 mins. = 02.15).

HLdt — Add hold time. During a firing, you can extend the hold time of a segment without having to first stop the firing to reprogram the controller.

IdLE — The controller is ready for you to enter a program or to begin a repeat firing.

-On- — Firing has begun. A moment after **-On-** appears, you will hear the relay(s) clicking.

Pr (with numeral 01–05) — Pre-programmed PMC® firing sequences. Scroll through these prompts with the **up arrow** key. Press the **start/stop** key to select the desired PMC program.

ProG — Program. Select this option to manually program a

Ramp-Hold firing.

rA 1, rA 2, etc. — Rate. Appears in **Ramp-Hold** programming for each segment. The 1, 2, etc., are segment numbers. Enter the rate of temperature change for that segment. Rate is figured in degrees of temperature change per hour. **Examples:**

- A temperature rise of 100° in two hours = 50° rate.
- A temperature drop of 200° in one hour = 200° rate.

SStP — Skip step. This message appears when you press the **up arrow** key during a **Ramp-Hold** firing. If you press the **up arrow** key again, the firing will skip to the next segment.

StOP — The firing was stopped by pressing the **start/stop** key.

Strt — The “Ready to Start” message appears after programming a firing. Press the **start/stop** key to begin firing. Controller calibration (press the **Up Arrow**) and delay (press the **Down Arrow**) functions are accessed from the **START** message.

TCOS — Calibrate the controller to fire hotter or cooler.

TROUBLESHOOTING

PROBLEM: CONTROLLER DISPLAY IS BLANK; NO HEAT IN KILN.

- Is the kiln connected to the power?
- Has the circuit breaker tripped or is a fuse blown?
- Is power reaching the wall receptacle? Test with a voltmeter or a test light if you are not sure.
- Has the kiln switch box 1/2-amp fuse blown?

The kiln's 1/2-amp fuse is located in the kiln switch box. Remove it by pressing the fuse holder and turning counter-clockwise half a turn. Check the fuse by placing the probes of an ohmmeter on the ends of the fuse. If the ohmmeter reads less than one ohm (digital meter) or reads 0 ohms (analog meter), the fuse is working. If the reading is OPEN (digital meter) or infinity/no needle movement (analog meter), the fuse is defective. Replacement fuse: AGC 1/2 A 250V AC.



- Is the controller receiving power? Test the power input connections on the back of the controller with a voltmeter.

Controller Power Input Test #1

1. Unplug the kiln. Remove the four screws holding the controller faceplate to the switch box. Lift the faceplate out of box and let the board hang on the box with the back of the board facing you.
2. Plug the kiln back in. Touch voltmeter probes (in AC mode) to both input connections (the white and



orange wires).

Caution: Do not let the back of the board touch a grounded object. Make sure the voltmeter is in the AC mode when placing the probes on input connections.

• Controller Power Input Test Result: No voltage

Unplug kiln. Check the switch box for disconnected wires between the cord, transformer and controller. If the wiring is sound, replace the transformer.

• Controller Power Input Test Result: 20–24 volts AC

Correct current is reaching the board from the transformer. Since the board is not lighting up, it is probably defective. Return the controller for repair or replacement.

• Controller Power Input Test Result: Less than 20 volts

Did you recently replace the transformer? It may be the wrong voltage. The voltage is below 20, which is not enough to power the controller. To find out the cause of low voltage, continue below:

Controller Power Input Test #2

The back of the board is still facing you and the kiln is plugged in. Remove the input plug (the white, orange and blue wires) from the back of the controller. Touch a voltmeter probe to the white wire and the other probe to the orange wire.



• Input Test #2 Result: Less than 20 volts AC

There are two possible reasons: 1) Low voltage at the wall receptacle; 2) a defective transformer. If wall receptacle voltage is correct, replace the transformer.

• Input Test #2 Result: 20–24 volts AC

The transformer is sending correct voltage to the controller. Yet when the input plug was connected to the controller, the voltage was less than 20. This means the controller is draining the voltage and is defective. Return the controller for repair or replacement.

PROBLEM: CONTROLLER DISPLAY TURNS ON; NO HEAT IN THE KILN

- Is the relay making its normal clicking sound? If **yes**, test the elements with an ohmmeter.

Element Resistance Test

1. Unplug the kiln/disconnect the power. Open the kiln switch box. Make sure the wires connecting the relay to the elements are secure. If the connections are sound, continue to step 2.
2. Touch the ohmmeter leads to the two element connectors of each element. A no-needle-movement reading on an analog meter (or OPEN on a digital meter),



Replac
is done

indicates a broken element.

If the elements check out, replace the relay (see page 23 to replace relay).

If **no**:

We know the controller is receiving voltage because the display is lit. But the voltage from the transformer may be too low to power the relays. Perform the “Controller Power Input Test #1” (page 13). If your controller passes the input test, perform the “Controller Power Output Test” below.

Controller Power Output Test

1. Unplug the kiln/disconnect the power. Remove the four screws holding the controller faceplate to the switch box. Lift faceplate out of box and let the controller hang on the outside of the box with the back of the board facing you. Then plug the kiln back in. Program the controller to fire to 1000°F at **FULL** rate in **Ramp-Hold** mode. Press the **start/stop** key.

2. Put the voltmeter in DC mode (it must be in DC mode when testing output voltage). Touch probes to the red wire and black wire connections. Measure the voltage when the relay clicks on.

• **Output Test Result: No voltage at red and black wires**

The controller is not sending power to the relay. Return the controller for repair or replacement.

• **Output Test Result: 10–14 volts at red and black wires**

The controller is sending correct power to the relay. Unplug the kiln/disconnect the power. Remove the kiln switch box. Look for disconnected wires between the controller, relay and elements. Check the wiring diagram to be sure wires are connected to the correct terminals. Be sure connections are tight. If the wiring is sound, replace the relay. To replace relay, see page 23.

PROBLEM: KILN SWITCH BOX 1/2-AMP FUSES KEEP BLOWING.

- What size fuse are you using? Correct fuse: AGC 1/2 A 250V AC.
- If the fuse is the correct size, perform the following test:

Kiln Switch Box 1/2-Amp Fuse Power Test

1. Unplug the kiln/disconnect the power. Remove the four screws holding the controller board faceplate to the switch box. Lift the faceplate out of box and let the board hang on the out side of the box with the back of the board facing you. Then plug the kiln back in. Disconnect both wire plugs from the back of the controller. Apply power to kiln.



If the fuse blows, replace the transformer. If the fuse does not blow, the problem is a board or relay. Go to step 2.

2. Connect the input plug (orange, blue and white wires) to the board again. Leave off the output wire plug (red, green and black wires). Program the controller to fire to 1000°F at **FULL** rate in **Ramp-Hold** mode. Press the **start/stop** key. If the fuse blows, replace or service the board. If the fuse does not blow, the problem is caused by a short in the coil of a relay. Go to step 3.

3. Unplug the kiln/disconnect the power. Reconnect the output wire plug. Reinstall the board in the switch box. Replace the relay (see page 23).

Ramp-Hold Shorthand Instructions

Re-read the safety guidelines on page 2. After you press

Keys to Press	Display
<input type="radio"/> PrO1–ProG	IdLE
<input type="triangle-up"/> select ProG	ProG
<input type="radio"/> rA 1	
<input type="triangle-up"/> <input type="triangle-down"/> enter segment 1 rate	500 (sample rate)
<input type="radio"/> °F 1 or °C 1	
<input type="triangle-up"/> <input type="triangle-down"/> enter temperature you want to fire at	1900 (sample temp.)
<input type="radio"/> Hld1	
<input type="triangle-up"/> <input type="triangle-down"/> enter hold time	00.00 (or hold time)
First segment not needed: enter a rate of 0000.	
<input type="radio"/>	
<input type="radio"/> Strt	

the keys in the left column, the message in the center will appear. For more detailed instructions, see pages 9–11.

PMC® Shorthand Instructions

Keys to Press	Display
<input type="radio"/> PrO1 - ProG	IdLE
<input type="triangle-up"/> select 1–3	PrO1 = PMC+ Fast
	PrO2 = PMC+ Slow
	PrO3 = PMC3 Slow
	PrO4 = PMC Original
	PrO5 = PMC Gold
<input type="radio"/> Strt	
<input type="radio"/> -On- (the kiln is	now firing)

Re-read the safety guidelines on page 2. After you press the keys in the left column, the message in the center will appear. For more detailed instructions, see page 9.

PRECIOUS METAL CLAY®

With PMC®, it is possible to shape intricate, free-form silver or gold jewelry in minutes—even as a beginner.

PMC looks and feels like modeling clay. It is formed with simple tools such as a toothpick, small knife and razor blade. Its surface is pliable and accepts impressions from objects such as leaves, coins and coarse fabrics. After PMC is formed, it is fired in a kiln. The recommended temperatures and hold times are included with PMC.

PMC is made of micron-size silver (or gold) particles held in an organic binder. During firing, the binder burns away. The silver particles then fuse together forming pure silver. Since the binder disappears, there is a certain amount of shrinkage during firing. Shrinkage varies depending on the type of PMC you use.

DRYING TIME

Small, thin PMC® pieces can be placed into the kiln and fired while still moist. Thicker pieces need time to dry or they may warp during firing.

To be on the safe side, give PMC plenty of time to dry. As you gain experience, you will know just how much drying time each type of piece needs. You can speed drying with a hair dryer.

LOADING THE KILN

PMC® pieces that have a flat side can be placed inside the kiln directly onto a shelf.

- PMC pieces can be close together, but they must not touch.
- The soft ceramic fiber shelf can be placed directly onto the firing chamber bottom. Four ceramic feet are included to raise the shelf off the kiln floor.
- Do not coat the ceramic fiber shelf with kiln wash or glass separator.
- You can also place PMC on a piece of ceramic fiber batting.

ALUMINA HYDRATE

Rounded, hollow or other delicate shapes may need support to prevent collapsing. You can lay these pieces onto a mound of alumina hydrate.

If the piece needs only shallow support (1/4" depth or less), pour the alumina hydrate onto a ceramic fireclay shelf. Support the fireclay shelf on three or four feet to aid heat flow under the shelf.

If the PMC® shape needs deeper support, pour the alumina hydrate into an unglazed ceramic bisque bowl.

- NEVER use a glazed bowl to hold the alumina hydrate. If the glaze runs, it can embed into the firing chamber.

Caution: Avoid inhaling alumina hydrate dust.

Caution: Alumina hydrate can destroy the heating element on contact. If it spills into the firing chamber, remove with a vacuum cleaner.

VENTING THE KILN

PMC® by itself needs no venting. Load the kiln, close the door and leave it closed until the PMC is ready to remove.

The kiln needs venting if you fire ceramics or glass with the clay silver, or if you make hollow objects that contain a core of organic materials.

Cork clay is a good core material. Do not use wax or styrofoam as a core; they emit harmful fumes. When using cores, vent the kiln by removing the plug from the top.

RATE, TEMPERATURE, HOLD

Each type of silver clay fires to a specific temperature and hold time. This information is available from your silver clay supplier (see page 7 for PMC® information).

Please Note: Do not fire longer than the recommended hold, or the silver will begin to over-fire.

Besides selecting a temperature and hold time on the digital controller, you will also need a firing rate. Select a full power rate if you are firing PMC alone. If you fire glass or ceramics with the PMC, select a rate best suited for the glass or ceramics.

Do not place PMC into a kiln that is already hot unless the clay is completely dry. The kiln should be no hotter than 500°F/260°C when loading the PMC.

Once the kiln begins firing, leave the door closed. Do not open the door until it is time to remove the clay. Visual inspection of the clay is unnecessary. If you are firing glass with PMC, you may need to check the fusing progress of the glass by opening the door

1/2" and looking inside (always wear safety glasses). Look for just a second or two. As you gain experience, you will be able to program the correct temperature for your PMC



Always wear safety glasses when looking at hot glass.

and glass combination, eliminating the need to visually check the glass.

COOLING TIME

After the clay silver has fired to completion, you can open the door an inch to speed cooling. If you are firing stones, glass or other materials with PMC®, it is safer to allow the kiln to cool slowly with the door closed. Remove the piece when the kiln reaches room temperature. PMC pieces that contain no other materials can be removed from the kiln at 1100°F/593°C. Use tongs to remove them and drop them into water.

Caution: Turn the kiln off before inserting tongs into the firing chamber. Wear protective gloves.

COMBINING PMC® WITH OTHER MATERIALS

There are two ways to fire PMC® with other materials such as glass:

- Fire PMC first by itself. After you have cleaned and polished the PMC, fire it a second time with the other material.
- Fire PMC and other materials, such as a stone, together in a single firing.

Enameling powder is easier to fire with PMC in a second firing (see page 18). Glass is often fired with PMC in a single firing. Many types of glass will melt to the point of over-fire at PMC temperatures. Before combining glass and PMC in a single firing, test a small sample of the glass. To do this, fire the glass during a PMC firing, keeping the glass separate from the PMC (this way you won't ruin the PMC piece). Place the glass pieces on a ceramic fireclay shelf. You must coat the shelf with glass separator, or the glass sample will embed into the shelf.

If the glass sample withstands the firing, you can fire that type of glass with PMC in a single firing. Note, however, that different types of glass fire to different temperatures. Every time you fire a different type of glass, be sure to test.

GLASS FUSING AND SLUMPING

You will probably fire primarily stained glass, but you can also fire standard float (window) glass. Some types of float glass devitrify (form a dull, frosty surface) when fired. **Caution:** Never fire tempered glass; it could explode if heated inside a kiln.

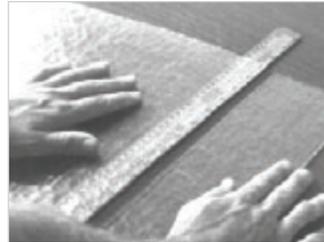
Basic Glass Tools

- **Reservoir glass cutter** uses a reservoir of oil to lubricate the cutter wheel.
- **Running pliers** cut large pieces of glass.
- **Breaking pliers** cut small strips.
- **Grozing pliers** shape the glass by chipping away the edges. They are often used when the score line doesn't break cleanly. Note that rough edges will become smooth when fired to fusing temperature.

Cutting Glass

IMPORTANT! Always wear safety glasses when cutting or chipping glass.

1. Lay the glass on a clean surface. Mark the cut with a grease pencil or felt-tip pen. A small mark on each end of the glass will do. Lay a wood straight-edge over the glass and line it up with the marks you made.
2. Hold the straight-edge firmly and score the glass with the glass cutter. Press just hard enough so that the scoring sound is steady and unbroken.
3. Place the straight-edge under the glass so that an edge is lined up with the score line you made. Press down on the glass. It will break cleanly.



Fusing Compatibility of Glass

When the temperature of glass changes, it expands and contracts. The rate at which this occurs is called the "coefficient of thermal expansion." If you fuse two glass pieces together and one changes size faster or slower than the other, the fused piece may crack—even several months after fusing.

When different glasses have similar enough coefficients of expansion to fuse successfully, they are called "fusing compatible." Buy glass labeled "fusing compatible," or fuse glass that has been cut from the same sheet, which guarantees compatibility.

Fusing Compatibility Test

1. To test glass for compatibility, fuse small 1/2"-square sample pieces of different glasses onto a larger base piece of clear transparent. The base should extend beyond the small sample pieces by half an inch on each side. One of the sample pieces should be cut from the base piece.
2. Heat the glass to a temperature that completely rounds the edges of the small sample pieces.
3. After the glass cools, place a polarizing filter under the

glass and another filter over the glass. Look at the glass with light shining through it (hold it over a lamp). Turn one of the filters until the filters are at their darkest.

Results of the Test

A halo around the edges of the small glass samples usually means the glass is not compatible. If you don't see a halo, the glass is fusing compatible.

The sample square cut from the base transparent glass tests for annealing. A halo around that piece means the glass was not annealed properly. Perform the test again, this time cooling more slowly through the annealing range.

The Annealing Range

Each type of glass has a temperature range that it must pass through slowly as it cools. This is called the "annealing range." This slow cooling gives hot glass time to release the stress of cooling. If you cool the glass too fast through the annealing range, it will break.

The larger and thicker the glass, the slower it must pass through its annealing range. You cannot over-anneal, so err on the side of caution if you aren't sure how long to anneal. Small projects such as earrings rarely need annealing time as they cool.

Cleaning and Gluing the Glass

Grease, dirt and fingerprints etch permanently into glass during firing. Clean glass with glass cleaner (the type without silicones), rubbing alcohol or even plain water just before assembling the pieces on the kiln shelf.

Use white glue (such as Elmer's) diluted 1:1 with water to hold the glass pieces together after you place them on the kiln shelf. Use the glue sparingly. Glue

is especially important when fusing wire into the glass. The glue prevents the glass or wire from moving out of place before they fuse. The glue disappears during firing.

Avoid using glue on the coated side of dichroic glass.

If you lay dichroic glass carefully onto the piece, glue is unnecessary, so avoid it altogether if you do not know which side of the dichroic glass is coated.

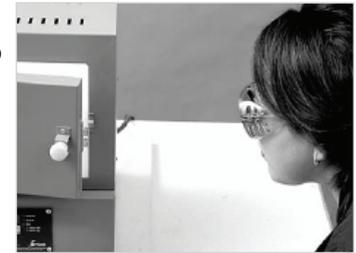


Loading the Kiln

Ensure that air circulates between the shelf and the bottom of the kiln by placing three or four 1/2" posts in the kiln. Lay the shelf over the posts.

Firing the Glass

1. Vent the kiln by removing the vent plug from the top of the kiln. Venting allows the gases released to escape. When the kiln reaches 500°–800°F/260°–426°C, replace the plug.
2. The first time you fire a particular brand or type of glass, program the controller for a higher temperature than the estimated fusing temperature. Watch the glass by opening the door 1/2" for several seconds at a time. Shut the kiln off when the glass fuses the way you want. Make a note of the shut-off temperature. For future firings, program the kiln for that temperature and rate.



Always wear firing safety glasses when looking at hot glass.

Please Note: With every firing, be sure you are near the kiln before the expected shut-off time.

3. After you shut the kiln off, vent the kiln by opening the door 1" for five minutes. Then close the door.

Please Note: Some glass artists flash-cool the glass after it fuses. To do this, vent the kiln until the temperature drops to 1000°F. Then close the door again. This speeds cooling.

4. The annealing range for most glass is between 950°F/510°C and 700°F/371°C. Cool slowly through this annealing range. Leaving the door closed will slow the cooling enough for most projects. If you need even slower cooling, program a separate segment for cooling.



Please Note: For safest cooling, leave the piece inside the kiln until the kiln cools to room temperature.

If you remove the piece too soon, the sudden temperature change can crack the piece.

To remove small pieces, such as glass jewelry, before they have cooled completely, remove the entire shelf. Leave the pieces on the shelf until they reach room temperature. The heat in the shelf will help prevent them from cooling too quickly.

Caution: Before removing a shelf, turn off power to the kiln.

ENAMELING ON METAL

Preparing the Copper

Enamels come in transparent or opaque varieties. Start with one of the many pre-shaped copper forms available, or shape and trim copper to your own design.

1. Heat the copper on an enameling rack to about 1400°F/760°C to burn off any oil or grease. Heat the copper just until smoke from oil or grease stops coming off the metal and its color has changed to a purple/ red/ pale green iridescence that extends across the copper. This indicates that the grease has vaporized. Do not fire the copper any longer than this point, or excess firescale will form, making the cleaning step difficult.
2. After the copper cools, brush any loose scale from the copper. Use a brush or paper towel, being sure that you do not put any grease or oil, such as fingerprints, onto the copper. Clean the copper with a 3M ScotchBrite® pad. This pad does such a good job that in most cases, no further cleaning will be required. Additional copper cleaning products like Rio Pickle™ are available in the *Tools & Equipment* catalog.



It is best to clean the copper just before you decorate it. If you wait too long to decorate after cleaning, the copper will become dirty again.

Decorating the Copper

Counter-Enameling

Counter- or backing-enamel, a mixture that gives a mottled effect, can be used for counter-enameling, or you can use regular enamel.

Most enameled pieces should be counter-enameled on the back side.

This gives the piece a much more finished look, eliminates a great deal of fire-scale cleaning, and controls the chipping and cracking that can result from the different rates of expansion and contraction in copper and enamel after the enamel has been fired.

When firing counter-enamel, under-fire it so that the firescale on the front of the piece isn't too difficult to remove. You can purchase a masking preparation from your supplier to help prevent fire scale. You must place the piece on a stilt when firing the front side of the piece. The stilt prevents the back of the counter-enameled piece from sticking to the



enameling rack.

Applying Enamels

Apply enamel over a clean sheet of paper so you can pour the excess back into the bottle for re-use. Transparent enamels should be applied in several thin coats. Transparent enamels can be mixed with fairly good results. Mixing opaque enamels results in a grainy effect. The two basic methods of applying enamels are *sifting* and *spatula*.

Sifting Enamel

Spray or brush Thompson holding agent onto the copper. Then sift a 1/32" layer of enamel onto the copper. Use a #60 mesh sifter. If the coat is too thin, you can easily add another coat after firing, but a coat that is too thick will bubble and crack. The enamel must dry completely before firing.

Spatula or Inlaid Method

You can use this method to decorate a small area with many different colors. Using a diluted solution of Thompson holding agent, dampen the enamels just to the saturation point, and maintain this moisture while working with the enamels. Apply the enamels onto the copper with a small spatula, and spread them out to a thickness of about 1/32" thick with a spreader. Lines of contact can be formed by the spatula blade. Then spray the enamels with the holding agent to keep the grains of enamel in place. Allow the enamel to dry completely before firing.



Firing Enamel

1. Heat the kiln to 1450°F/787°C for most enameling. Use a single segment.

Segment	Rate °F/°C	Temp. °F/°C	Hold
1	1799°/999°	1450°/787°	01.00

2. Lay the copper form on an enameling rack. If the part that touches the rack is enameled, place a stilt under the copper. Some bowls or other shapes have enameled sides that might run during firing. These should be fired with a stilt even if the piece has a plain bottom. Use an enameling fork or, if the rack is small, a 6" putty knife, to place the rack into the kiln on top of 1/2" ceramic posts.

Please Note: Firing the piece at enameling temperature should take about three minutes and requires your undivided attention!

3. Look at your piece every 15 seconds by briefly opening the door 1/2". Remove the rack when the copper piece

appears a rosy red and the enamel is smooth. Place the rack on a steel pad or large ceramic kiln shelf and let it cool completely.

- After counter-enameling, clean the firescale off the front of the piece. A 3M ScotchBrite® pad works well for this. Then clean it with Rio Pickle™.



A self-supporting cone fired to maturity (do not be concerned if the tip is slightly higher or lower than shown).

CERAMIC OVERGLAZE Pyrometric Cones

Pyrometric cones are small pyramids of clay and mineral oxide that soften and bend when exposed to heat. They indicate when ceramic has fired to maturity.

Pyrometric cones come in 1 1/8" and 2 1/2" lengths; use the 2 1/2" cones. Cones mounted on the kiln shelf must be slanted 8° from vertical. They will not bend accurately if they are

slanted to the wrong angle. Self-supporting large cones have the correct slant built into their bases. Standard cones must be mounted in a clay or wire plaque.

The temperature equivalents chart at right shows the temperatures of pyrometric cones. Program your controller for the cone recommended for the ceramic ware that you are firing.

For small ceramic pieces, such as figurines, program a rate of 400°F/222°C. Fire to the temperature shown in the 108°F column of the temperature equivalents chart for the cone number you are firing.

Before selecting a firing speed for important pieces, test-fire sample clay pieces.

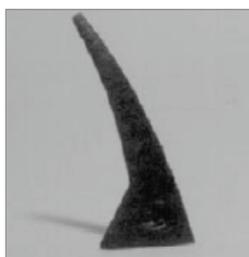
Please Note: Do not fire beyond the maximum temperature. Doing so will void your warranty.

Loading and Firing Overglaze

Overglaze is decoration applied over fired glaze or polished porcelain bisque. Overglazes include china paints, gold and luster, which fire from cone 022 to 014. Load overglazed ware the same way you would load ceramic glaze. Use a



An over-fired cone with "puddled" appearance.



An under-fired cone.

still and make sure no piece is touching any other piece. Ware must be completely dry before firing.

China paints will crack or peel if applied heavily. Apply several light coats instead, firing after each, until you get the shade you want. Not all china paint colors reach maximum color saturation at the same temperature—even when fired on the same piece—so you must know which colors you should fire first at higher temperatures to prevent



Open the door 1/2" to vent the kiln if your kiln does not have vent holes.

Temperature Equivalents for Orton Self-Supporting Pyrometric Cones

Cone Number	Self-Supporting Cones			Pre-Fire Cone Color
	Heated at: 27°F/hr.	108°F/hr.	70°F/hr.	
022	—	1087	1094	green
021	—	1112	1143	fuschia
020	—	1159	1180	orange
019	1213	1252	1283	yellow
018	1267	1319	1353	white
017	1301	1360	1405	pink
016	1368	1422	1465	light blue
015	1382	1456	1504	violet
014	1395	1485	1540	gray
013	1485	1539	1582	green
012	1549	1582	1620	fuschia

**Rate of temperature increase during last 90–120 minutes of firing. Tables courtesy of the Edward Orton, Jr. Ceramic Foundation.*

burning out other colors in later firings. For example, reds mature at a lower temperature than other colors and are fired after the other colors have been fired. Reds and yellows should not be fired side by side.

Colors also mature at a lower temperature on ceramic pieces than on porcelain or hard china. Check the literature from your overglaze manufacturer for information on which cone to use with each color and type of ceramic ware.

Vent the kiln during the first hour of firing by leaving the vent hole open during the entire firing. Allow kiln to cool to room temperature before opening the door.

LOST-WAX BURNOUT

Caution:

- Only kilns with vent holes are designed for lost-wax burnout. You can use a kiln without the vent hole provided that you open the door 1/2" during firing.
- Always use a wax tray.
- If your kiln heating element is embedded in the floor of the firing chamber, place the metal wax tray on three or four 1/2" posts inside the kiln to prevent any possibility of the element shorting out against the tray.

Please Note: These instructions apply to injection wax that melts at 200°F, not pattern waxes and plastics that melt at higher temperatures. If smoke appears during wax elimination, turn off the kiln. Smoking wax means the kiln fired hotter than 300°F/148°C.

Overview

Lost-wax casting is the process of carving a shape in wax, then casting that shape in metal. After the wax has been carved, a mold is made of the wax shape. The mold is a negative image of the wax. The wax is later melted out of the mold through hollow channels called sprues. Lost-wax burnout is the process of preparing a casting mold for the melted metal that will be poured into it. The steps in lost-wax burnout:

1. Melt the wax from the mold.
2. Remove wax from the kiln before raising the temperature higher than 300°F/148°C.
3. Harden the mold at high temperature.
4. Maintain the mold at the casting temperature recommended for the type of metal that will be poured into the mold.

Caution: Prevent wax or carbon from contacting the kiln walls and elements. Carbon build-up inside a kiln ruins the interior. Carbon conducts electricity and causes elements to short-circuit. Damage to elements from contact with foreign materials is not covered by warranty.

A Sample Program

Segment	Rate °F/°C	Temp. °F/°C	Hold
1	500°/277°	300°/148°	01.00
2	500°/277°	1350°/732°	01.00
3	450°/250°	800°/426°	02.00

- Segment 1 heats the wax to 300°F/148°C and holds it for one hour, allowing it to drip from the mold.
- Segment 2 hardens the mold.

- Segment 3 lowers temperature to 800°F/426°C, the typical casting temperature for silver. Most types of gold cast at 900°F/482°C.

Note: Casting temperature depends on the size of the mold. The temperatures above are only a guide. See your jewelry supply dealer for temperature recommendations.

Burnout Instructions

1. Place a metal tray inside the kiln on three or four 1/2" posts. Place the mold (sprue hole down) on a wire mesh screen on top of the tray. The tray will catch melting wax as it drips from the sprue hole.
2. Keep the kiln vent hole(s) open during wax elimination. This allows fumes to escape from the kiln. Heat the kiln to 300°F/148°C and hold it at that temperature for at least one hour.
Please Note: During this hour, the wax will melt from the mold and drip into the tray. If the kiln gets hotter than 300°F/148°C, the wax may smoke and deposit carbon inside your kiln, causing expensive damage.
3. After one hour at 300°F/148°C, open the kiln. Remove the mold and wax tray. Pour the wax from the tray and leave the tray out of the kiln until your next wax elimination.
IMPORTANT! Do not leave the tray in the kiln!
4. Heat the mold to the temperature recommended by the jeweler's supply house where you purchased the mold material. This is usually around 1350°F/732°C.
5. Lower the temperature to the casting temperature of the metal. Hold at that temperature until you are ready to begin casting. Remove the mold with tongs. Wear protective gloves and safety glasses.

Saving a Carbon-Damaged Kiln

If you follow the above directions, your kiln should be safe from wax damage. In some cases, a small amount of carbon may form on the walls over a period of time. This is due to the burning of wax residue that was left in the mold. For this reason we recommend that you periodically fire the kiln to 1500°F/815°C as follows:

1. Open the vent cover(s) or leave the door ajar 1/2".
2. Fire the empty kiln to 1500°F/815°C at a rate of 300°F/166°C with a one-hour hold (01.00).

FIRING MISTAKES

PMC® Cracks

Cracks that appear in fired PMC® may be due to too much water in the PMC before it was fired. Another cause is careless handling of a dried, unfired piece. To repair, fill the crack with silver clay and fire again.

Brittleness

PMC® will not reach full strength if under-fired. You may be able to save the piece by firing again to the correct temperature and hold.

Too Much Shrinkage

When PMC® is over-fired, it shrinks too much and loses detail. If the kiln is firing hotter than the temperature programmed, check the position of the thermocouple (see page 5). Replace the thermocouple if necessary.

Glass

Glass Cracking

Probable causes:

- Heating the kiln too fast
- Cooling the kiln too fast
- Fusing incompatible glass
- Not enough glass separator on shelf

Most problems in fusing are caused by rushing the firing. The

glass must change temperature slowly during the critical temperature range of 100°–500°F/37°–260°C. This critical range applies to both heating and cooling.

The second critical temperature range is annealing, which is the cooling range of 950°–700°F/510°–371°C on the average. Cool the glass slowly during this range so the stress in the glass will have time to dissipate.

If you become impatient after the glass has fused and you crack open the door of the kiln for a few seconds to peek inside, you may hear a “ping,” which is the sound of glass cracking. Avoid the temptation to open the door. Wait until the kiln has cooled to room temperature. Some artists schedule their fusing so that it is completed before they go to bed. That way they will be asleep while the glass cools and won't be tempted to open the door.

After each firing, examine the shelf. Recoat if the kiln wash is chipped. When glass sticks to a bare section of shelf, the glass cracks.

Glass Bubbles

Probable causes:

- Heating the kiln too fast
- Air trapped between layers of glass
- Grease or dirt between layers of glass
- Uneven glass volume
- Moisture or trapped air between the glass and shelf

Make sure the shelf is completely dry before firing. If you have applied fresh glass separator, leave the shelf in the kiln at 300°F/148°C for 20 minutes before placing glass on it.

One way to eliminate bubbles is to hold the temperature at

100°F/55°C below fusing temperature for 15 minutes. This gives the shelf time to heat up to match the temperature of the glass.

Glass Devitrification (Frosty Surface)

Probable causes:

- Impurities in glass
- Kiln not vented long enough during initial heating

Devitrification is a frosty surface on the glass; with some glass, it is unavoidable. To lessen devitrification, some artists vent the door of the kiln slightly after fusing is completed, then close the door when the temperature reaches 1000°F/537°C.

Glass Separator Sticks To Glass

Probable causes:

- Firing too hot
- Overglaze on the back of the piece

Instead of firing to a full-fuse temperature, try firing 50°F/28°C cooler and holding at that temperature for several minutes.

Ceramic Overglaze

Breaking in Overglaze Firing

Probable cause:

- Poorly fired bisque

A slow bisque fire is always better for ware that is to be china painted. The greenware should be completely dry before being placed in the kiln.

Purple Spots in Gold

Probable cause:

- A thin application of gold or too much thinner

If gold is applied accidentally to an area it will show purple after being fired unless cleaned with a good gold remover.

Broken Lines in Gold

Probable cause:

- Over-firing or too heavy an application

However, this can be very attractive when gold is crackled over a dark-color fired glaze.

Peeling China Paint

Probable cause:

- Applying the paint too heavily

Loss of Color in China Paints

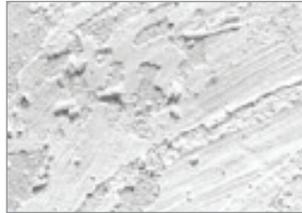
Probable cause:

- Over-firing or thinning your paint with too much medium when applying

Faded Colors in Overglaze Decals

Probable cause:

- Either under-firing or over-firing



Flaking glass separator can cause the glass to crack. This is because the glass sticks to the shelf.

If pinks and reds are drab, re-fire to a hotter cone. When used with a china paint background, apply and fire the decals first, then china paint and fire again. Check the recommendations of decal supplier. If decal was under-fired, re-fire to proper firing cone. If decal was over-fired, the design may be repainted in china paints and re-fired.

Weakening of Luster Colors

Probable cause:

- Over-firing

White Spots in Lustres or Metals

Probable causes:

- Moisture on the ware before it was placed in the kiln
- Was fired at the same time as other overglazes

Please Note: Apply lustres only on a dry day.

Powdering of Luster Colors

Probable cause:

- Too heavy an application



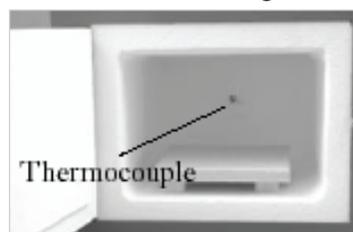
KILN

MAINTENANCE

TROUBLE-SHOOTING

Kiln Does Not Turn On, Display is Blank

- Make sure the circuit breaker is in the "on" position.
- If the circuit breaker is on, check the kiln fuse. Remove the fuse by pressing on the fuse holder and turning counter-clockwise half a turn. Check the fuse by placing the probes of an ohmmeter on the ends of the fuse. If the ohmmeter reads less than one ohm (digital meter) or reads 0 ohms (analog meter), the fuse is bad. Replacement fuse: AGC 1/2 A 250V AC



Please Note: If you do not

have an ohmmeter, look closely at the fuse. You will see a thin strand of unbroken wire in a good fuse. The wire usually appears broken in a bad fuse.

Circuit Breaker Trips

- If the circuit breaker trips after the kiln has fired for a while, make sure no other appliances are operating on the same circuit as the kiln.
- If the circuit breaker trips immediately after the kiln is turned on, the kiln may have a short-circuit. Unplug the kiln. Remove the bottom cover and look for a loose wire touching the case.



Temperature is Inaccurate

- Make sure the thermocouple is pushed 1/2"–3/4" into the firing chamber.
- If the thermocouple is pushed into the firing chamber, and the temperature is inaccurate, replace the thermocouple.



KILN REPAIRS

Door Latch Adjustment

Adjust the two screws on the door latch to change the spring tension.

Please Note: Do not loosen the screws too far or they may fall out.



Ceramic Fiber Repair

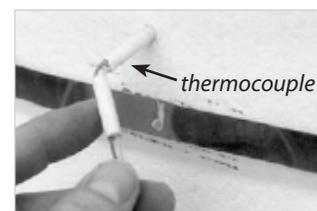
If glass, ceramic glaze or other materials drip into the firing chamber, repair before the next firing, otherwise the glaze will re-melt and embed deeper into the fiber.

1. Unplug the kiln.
2. Cut or scrape the ceramic fiber to remove contaminant. Remove as little fiber as possible. Avoid touching any heating element.

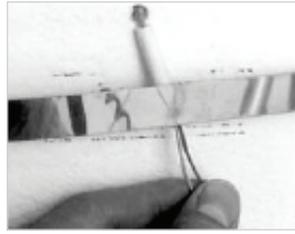


Replacing the Thermocouple

1. Unplug the kiln.



- Remove the four screws holding the controller to the front of the kiln. Carefully remove the controller.



- Remove the two thermocouple wires from the back of the controller. They are held in place by button- or lever-type connectors. To remove the wires, lift the levers (or press the connector buttons) and pull the wires out.

To prevent over-firing, the band must secure the thermo-

- Remove the back cover of the kiln.
- The thermocouple is located in the back of the firing chamber, held in place by a metal band. Remove the thermocouple from the kiln.
- Bend the new thermocouple between the two porcelain insulators. After bending, the thermocouple end should be two insulators long.

- Push the new thermocouple into the hole in the firing chamber. The twisted end must extend into the firing chamber by $1/2$ "– $3/4$ ". Make sure the band holds the thermocouple; otherwise, the thermocouple can be pushed out, resulting in an over-fire.
- Thread the thermocouple wires down to the controller opening at the front of the kiln. Keep the thermocouple



The relay being replaced; the transformer is the part in the foreground.

wires away from electrical components and other wires.

- Strip $1/2$ " of insulation from the ends of the thermocouple wires.

- Attach the wires to the back of the controller. One wire is yellow, the other red. Make sure the wires connect to the correct color-coded terminals.



- Install the controller and back cover of the kiln.

Replacing a Relay or Transformer

- Unplug the kiln.
- Place the kiln on its back.
- Remove the screws holding the sheet metal bottom to the kiln. Tilt the bottom forward reach the relay and transformer.
- Hold the new part next to the one you are replacing, aligned in the same direction. Remove and transfer one wire at a time from the old part to the new one. Make sure each connection is tight.
- Replace push-on connectors and wires damaged by heat from a burned terminal. If wire connectors do not fit snugly on terminals, gently squeeze the end of the terminal with pliers.
- As you move the sheet metal bottom back into place, make sure the thermocouple wire attached to the back of the board is away from the other wires.
- Install the screws holding the bottom to the kiln.

Replacing the Temperature Controller

- Unplug kiln.
- Remove the four corner screws holding the controller faceplate to the switch box. Carefully lift out faceplate.
- Disconnect the wires from the back of the board. You will find two plugs and two single wires.
- Connect the wires to the new board. Reinstall faceplate.

Calibrating the Controller

You can calibrate the controller to fire up to $20^{\circ}\text{F}/11^{\circ}\text{C}$ higher or lower than the zero factory setting.

WARRANTY

Rio Grande warrants the Rio Kiln and controller to be free from manufacturer's defects for a period of one (1) year from the date of purchase. If the product fails to work due to materials or workmanship at any time during this period, Rio Grande will, at its option, repair or replace this product as set forth below.

The liability of Rio Grande is limited to replacement and/or repair at its factory of a kiln that does not remain in good working order under normal operating conditions. Rio Grande reserves the right to repair at their facility or to send the oven to the factory for warranty repairs.

Limited warranty service may be obtained by delivering the unit within the warranty period to RIO GRANDE; 7500 BLUEWATER RD. NW; ALBUQUERQUE, NEW MEXICO, USA 87121-1962. Provide proof of purchase and a written description of defect or problem.

Service may also be obtained on units no longer under warranty by returning the unit, pre-paid, to Rio Grande with a description of the problem, and the buyer's name, address and telephone number. The customer will be contacted with an estimate of the service charges before any work is performed.

Rio Grande PMC® Kiln with Bead Door & Mandrel Holder #703-118

Introduction

The Rio Grande PMC® kiln with bead door gives beadworkers an easy and efficient way to anneal flame-worked beads while greatly reducing the cracking and splitting that can occur when using standard kilns. Because of its small size, the bead door allows very little cool outside air to enter into the kiln, helping to maintain the correct temperature for annealing beads. An attachable rack conveniently holds bead mandrels inside the kiln.

Installing the Bead Mandrel Holder

When placing the beads inside the kiln, the mandrel holder supports the bead mandrels.

1. Open the door. You will find two screws on the bottom edge of the door. Loosen the screws with a 1/4" nut driver.
2. Slide the two slots in the bead mandrel holder under the two screws in the door. Tighten the screws.

Annealing Flame-Worked Glass Beads

Glass is sensitive to breakage as it cools through the annealing range (approximately 950°F/510°C–700°F/371°C). The larger the piece, the slower it must cool to prevent breakage.

To safely cool flame-worked glass beads, anneal them in your kiln using the bead door.

Programming the Kiln

Program the controller in **Ramp-Hold (ProG display)** for the following two segments (see page 7 for programming instructions). If your bead-making session will be longer than 3 hours, program a longer hold time in segment 1. Start the kiln. When the temperature reaches 1000°F/537°C, it will maintain that temperature for three hours.



Annealing the Beads

1. When the kiln reaches 1000°F/537°C, it is ready for loading with hot beads on the bead mandrels. Allow a freshly made bead to cool slightly before placing it into the kiln to prevent the bead from flattening on one side when it is placed inside the kiln.
2. Open the bead door and insert the mandrels as you complete the beads. Leave the door ajar with the end of the bead mandrel extending outside the kiln. **Please Note:** The bead door is not intended to close entirely, there will always be a slight gap along the bottom.
3. When you have finished the batch of beads, perform a skip segment (see page 7, item 3, under **Up Arrow** key). This will end the temperature hold and begin segment 2. The kiln will cool through the annealing range.

After the kiln shuts off, leave the beads in place. Do not remove them until the kiln has reached room temperature.

Segment	Rate or Ramp	Temp.	Hold
1	1799°F/999°C	1000°F/537°C	3 hours
2	400°F/222°C	700°F/371°C	0
3	0	—	—



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