



EXCEL[®] KILNS OPERATING MANUAL



Thank You!

Congratulations! You've made a great choice from the proven EXCEL® kiln line.

Welcome

You have selected your kiln after much deliberation, and this booklet is planned to assist you in its installation, operation and maintenance.

All electric kilns sold by AMACO® are safe and well built. All AMACO® EXCEL® kilns are listed with Underwriters Laboratories, Inc. You can be assured that the complete unit has met their rigid standards for safety in regard to casualty and fire hazards. Most schools and institutions require the UL seal on all electrical equipment. AMACO® EXCEL® kilns are also listed with Canadian Standards Association.

Important: Read this entire manual before operating your kiln. Whether you have owned an electric kiln before or not, please take the time to read this manual from cover to cover. We think even the most experienced veteran will learn a few new tips.

Limited Warranty

All EXCEL® kilns and Select Fire™ controllers are guaranteed by AMACO® against defects in materials and workmanship to the original purchaser for a period of two years that covers parts and labor subject to these exclusions:

Exclusions

1. Damage due to misuse, including but not limited to, over-firing, improper installation, rough handling, improper stacking, malfunction of cutoffs and starters.
2. The KILN-SITTER® (if equipped) is separately warranted by its manufacturer, W.P. Dawson, Inc., 6441 S. E. Johnson Creek Blvd., Portland, OR 97206, (503) 774-6000.
3. Shipping damage.
4. The warranty period has expired.
5. Repair or service is done by an unauthorized dealer.
6. Damage or failure due to acts of God such as, fire, flood, electrical storms, etc.
7. Damage due to over-firing, reduction or salt glazing.
8. Use for other than ceramic materials.
9. Normal wear as experienced in the ceramic process.
10. Units modified in any manner.

This warranty does not cover damage caused by failure of these instruments. The buyer's sole and exclusive remedy shall be for the repair and/or replacement of defective parts as provided herein. The buyer agrees that no other remedy (including, but not limited to, lost profits, lost sales, damage to property, or any other incidental or consequential loss) shall be available to the buyer.

Warranty Repair Instructions

All warranty claims must be approved and serviced by an authorized EXCEL® dealer. If there is not an authorized EXCEL® dealer in your area, contact AMACO® directly for authorization, however labor costs will not be covered. If you experience a problem with your equipment:

1. Contact the dealer or representative from whom you made your purchase.
2. If the dealer is unauthorized to perform repair or unable to correct the problem:
 - a. Call the AMACO/Brent Technical Support Department toll free @ 1-800-374-1600 or 317-244-6871 (local).
 - b. Email the AMACO/Brent Technical Support Department at technicalsupport@amaco.com
3. Provide the following information and the Technical Support Agent will provide further assistance:
 - a. Model number of item
 - b. Serial number of item
 - c. Voltage and phase of item
 - d. Date purchased
 - e. From whom purchased
 - f. Nature of problem

AMACO® recommends that all maintenance and repairs to kilns be performed by an Authorized EXCEL® Service Technician, however if this is not possible AMACO® recommends that the owner work closely with our Technical Services representatives to ensure the diagnosis and repair are correct and performed safely. Normally, simple repairs can be made over the phone with our trained Technical Service Staff Monday–Friday 7:00 am–5:30 pm EST. If it is necessary to mail or ship parts to AMACO® for further inspection, parts must be sent prepaid. For your protection, insure all parts. The equipment and part serial number must accompany the defective item. Repair parts will be sent with a full refund on the invoice if examination confirms a defect in materials or workmanship.

If repairs must be made at the factory, it will be done at no charge for parts and labor provided all shipping costs are supplied by the purchaser. Do not return any merchandise without authorization. This warranty gives you specific legal rights. You may have other rights which vary from state to state.

Your kiln is registered. We keep a permanent record of the serial number, model number and purchaser of every kiln sold. With this information, we can supply the necessary replacement parts for your particular kiln. Keep your papers in a safe place. You will want to refer to this instruction booklet, special kiln instructions, wiring diagram and catalog. File them in a safe place for handy reference.

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Contents List/Kiln Features

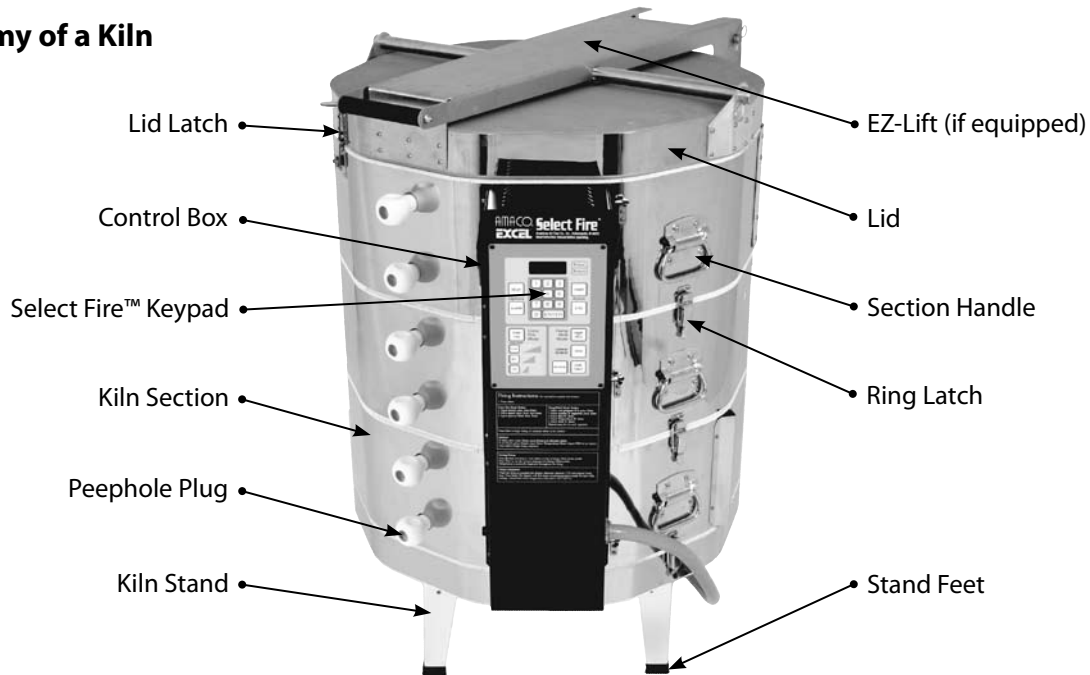
Contents List

EXCEL® Kilns should arrive fully assembled. Packed with the kiln you will find the following items:

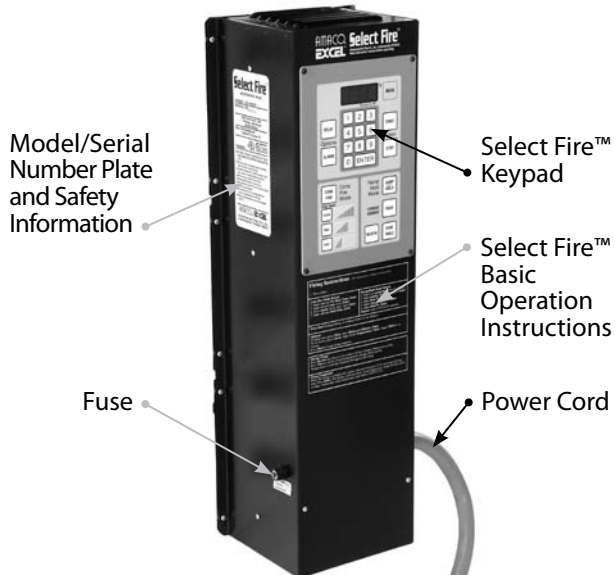
- Kiln Stand
- Instructional DVD
- Operating Manual
- Stand Feet
- Extra Thermocouple (unless Type S)
- Warranty Card
- Peephole Plugs - attached to the kiln stand, enough to fill each peephole on your particular model



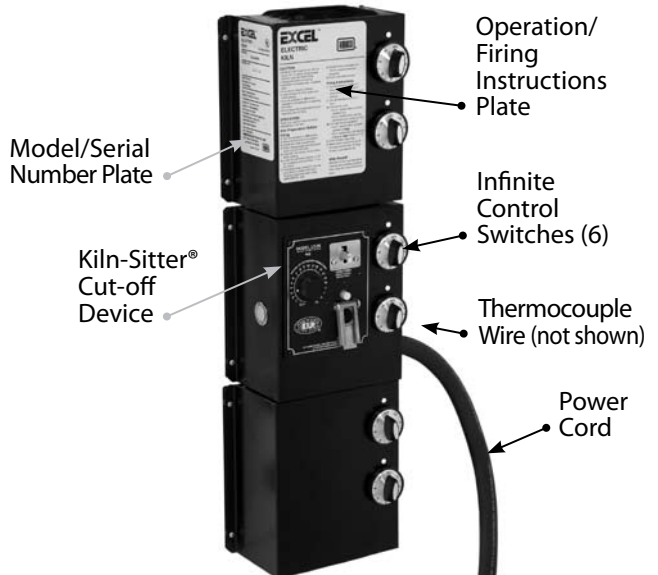
Anatomy of a Kiln



Select Fire™ Models



Manual Control Models



Quality Components That Make EXCEL® Kilns a Smart Choice

Select Fire™ Controller (if equipped)

At the heart of your new kiln is the Select Fire™ controller. This unit allows you much greater control over your kiln than ever before. It is essentially two controllers in one. You can fire by cone numbers or specify your own firing profile with multiple ramps and holds. The wall mounted Select Fire™ is an option that functions in the same manner as the built-in version with the exception that it can be moved from one kiln to another. While the wall mounted version cannot fire more than one kiln at a time, it can control any number of kilns a studio operates provided they have the same cord plug and receptacle configuration.



Brick

EXCEL® kilns are constructed of the finest insulating firebrick available today, offering strength, cleanliness and long life. All bricks are precision cut and grooved to assure tight fit, perfect element support and ease of replacement. Because of their porous composition, insulating firebrick are fragile. Always handle your kiln and its brick with care. The brick in your kiln may begin to show some fine cracks after the first few firings, especially after Cone 10 high firings. This is normal and does not harm the structural integrity of the kiln or impair its functioning.



Elements

The highest quality iron-aluminum-chromium (Kanthal-type A-1) element wire is used in all EXCEL® kilns. All multi-sided EXCEL® kilns are high fire type and are designed to reach Cone 8 or 10 except EXCEL® 399, 208V single phase (Cone 5) and EXCEL® 270, 208V single phase (Cone 6). Elements are thoroughly tested both before and after installation for assured performance and even firing.

Element life will vary depending on whether the kiln is used primarily for low firing of bisque or greenware or high firing of stoneware and porcelain. Elements will last for many firings if treated carefully. Remember these

points. 1. Keep the element grooves free of debris: bits of bisque, glaze, cones, metal, or high fire kiln wash will immediately fuse to an element and proceed to eat through it. Elements become brittle after repeated firings, so be extremely careful not to break them by scraping. 2. Do not attempt to fire beyond the rating on your kiln.

Stainless Steel Jackets

Only the finest grade stainless steel is used in EXCEL® kiln jackets, selected for its expansion qualities so that the bricks are never unduly stressed, yet are fully supported during all stages of heating and cooling. Stainless steel may discolor with repeated heating. Stainless steel cleaner is available.

EZ-Lift Spring-Assisted Hinge

Available on all 10-sided and 12-sided EXCEL® kilns (standard on EX-1266SF, EX-399/399SF, and EX-1099SF), EZ-Lift makes opening and closing the kiln lid effortless. In addition to making the lid lighter, it makes your kiln safer by reducing the risk of sudden lid drops that can cause injury.



Lid Brace

The lid brace holds the lid securely open for loading and unloading the kiln. As you open the lid, allow the lid brace to follow over the anchor pad and screw that is attached to the side of the kiln. Simply allow the notched end of the brace to engage the anchor pad and screw, allowing the lid to rest in a full upright position. Periodically test the thumbscrew for tightness. If loose, tighten.

Easy-to-Change Element Connectors

EXCEL® kilns use corrosion resistant element lug connectors which allow for easy replacement of elements without having to cut wires and solder back together. All you need is a screwdriver to remove the element and re-connect the new one!



Safety Information

Tens of thousands of kilns are used safely in homes, schools, and professional studios throughout the world. With a good understanding of your kiln and a little common sense you can avoid any accidents. Please observe the following safety recommendations:

Operation

- The stainless steel jacket and some of the other fixtures surrounding the kiln will get hot enough to burn your skin when the kiln is heated. Therefore, it is important to be extremely careful when working close to the kiln. We recommends posting warning signs of this potential hazard in the kiln room.
- Keep anyone who cannot understand warning signs such as small children and pets away from the kiln when it is firing.
- Be careful when opening the kiln door while the kiln is heated. We recommend you use fire rated gloves to protect your skin and make sure clothing is kept well away from any kiln opening or hot kiln surface.
- The elements inside the kiln chamber will cause an electrical shock if touched. Never insert metal instruments or place any part of your body into the kiln while it is firing.
- Always be sure to unplug the kiln before working on the electrical components. If the kiln is hard wired, turn off the circuit breaker.
- Plan on being with the kiln when it is scheduled to turn off.
- Long term viewing inside the kiln chamber can cause damage to your eyes, therefore it is recommended that you use IR and UV protective glasses when looking into the kiln for extended periods of time. No. 3 welders green or gray glasses will protect your eyes.
- Be cautious of intense heat around the peepholes when peephole plugs are removed.
- In the event of a severe storm, unplug your kiln. Exposure to static shock or electrical surges can damage the circuit board in the controller.
- The kiln lids on many models are heavy. Make sure the lid brace is secure before releasing the lid. Make sure the hardware that secures the lid brace is secure and not corroded.
- Do not place anything in the kiln you are unsure of. Certain items may potentially melt, explode, or release toxic fumes. Items that may be damp (i.e. greenware, kiln shelves) have the potential to crack or explode inside the kiln when the moisture trapped inside them turns to vapor when heated.
- Never allow your kiln to exceed the temperature rating listed on the serial plate.



- For your safety, the protection of your kiln, and the protection of your ware inside the kiln, we recommend that you avoid unloading the kiln when it is above 125°F (52°C).

Installation

- As with all electrical products there is danger of electrical shock. Use only properly sized and rated copper wire when installing the power supply for your kiln. We recommend this work is done by a licensed electrician.
- Kilns should always be located in a dry place to prevent electrical shock and corrosion.
- Follow all instructions for installation in this manual. Always observe fire, building and safety codes when installing any AMACO® product.
- If there are fire sprinklers located in the kiln room make sure they are rated high enough so they will not be set off when the kiln is at peak temperature. This should be tested with the kiln at peak temperature, the ventilation system turned off, and all doors and windows closed for maximum insurance.

- We recommend having a fire extinguisher rated for electrical fires easily accessible near the kiln.



- AMACO® will not assume liability for injury or damages caused by variations from the instructions put forth in this manual.

- Kilns get hot. Observe all instructions to ensure proper clearances from flammable, combustible, or temperature sensitive objects, and living things.



- Ventilation is key to maintaining a healthy work environment and proper room temperature. Proper installation of the Master KilnVent or KilnVent—Stand Version will clear potentially harmful fumes from the room. To ensure proper room temperature is maintained consult a qualified HVAC professional.

- The proper placement of thermocouples is crucial to the proper operation of all automatically controlled kilns. Check all thermocouples for damage and correct placement. Thermocouples must protrude into the kiln chamber at least 2" to ensure an accurate reading.

- Only use the stand that is provided with your particular kiln model. Other stands may not properly support the weight of your kiln, provide adequate clearance, and could pose a fire hazard.

- The power cord is sized correctly to handle the power for your particular kiln. Never use an extension cord.



- Make sure the power cord is routed in such a way as to not touch any portion of the kiln that gets hot.

- Be careful of pinch hazards when working on or assembling the kiln.
- Be sure to properly tension the springs on kilns equipped with EZ-Lift.

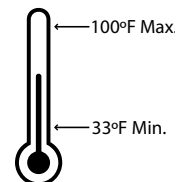
Maintenance

- Always unplug the kiln before performing any repairs or general maintenance. If your kiln is wired direct, turn off the breaker.
- Use only EXCEL® replacement parts. Improperly sourced parts pose a hazard to you and your kiln and void your warranty.
- Never modify your kiln without first consulting AMACO®. Improper modifications may pose a hazard to you and your kiln and void your warranty. Items such as alternative thermocouples, controllers, kiln coatings may ruin your kiln if improperly installed or applied.
- Replace any electrical components that are discolored, brittle, or corroded.

- Inspect all stainless steel bands to ensure they are tight. If they are loose, tighten them as much as possible to prevent the band from slipping or flexing.

Precautions for the Select Fire™ Controller

- The controller is a temperature control device. It is not a safety device.
- The maximum operating temperature is 100°F (38°C) and the minimum temperature is 33°F (1°C). This temperature refers to the room temperature while the kiln is firing and does not pertain to the internal temperature of the kiln.
- The controller contains static-sensitive parts that may be damaged by static electricity. Use caution to avoid creating static that may damage the equipment. In areas where static electricity is common, or during dry times of the year throughout the country, touch the kiln lid handle before touching the controller to discharge the static.



Electrical Requirements

Make sure the electrical information on the serial number plate matches the electrical supply. If not, consult an electrician.

Most important to the proper operation of your new kiln is to make sure it has the correct power to operate. If this is done, your kiln will provide many years of excellent service. If the correct power requirements are not met, the

first firing could be disappointing or even disastrous for your kiln. The chart below lists the recommended electrical specifications for each kiln model. If there is uncertainty about the existing outlets, have them certified by a licensed electrician. If installing new receptacles provide this information to the electrician.

Model	Volts	Amps	Kilowatts	Copper Wire Size*	Fuse/Breaker Size	NEMA Receptacle
EX-270	240 1-phase	48.0	11.5	6 gauge	60	6-50
	240 3-phase	29.3	11.5	8 gauge	40	15-50
	208 1-phase	48.0	9.9	6 gauge	60	6-50
	208 3-phase	31.7	11.0	8 gauge	40	15-50
EX-365	240 1-phase	48.0	11.5	6 gauge	60	6-50
	240 3-phase	29.3	11.5	8 gauge	40	15-50
	208 1-phase	48.0	9.9	6 gauge	60	6-50
	208 3-phase	31.7	11.0	8 gauge	40	15-50
EX-226	240 1-phase	27.8	6.7	8 gauge	50	6-50
	208 1-phase	26.1	5.5	8 gauge	50	6-50
EX-324	240 1-phase	27.8	6.7	8 gauge	50	6-50
	208 1-phase	26.1	5.5	6 gauge	50	6-50
EX-247	240 1-phase	40.0	9.5	6 gauge	60	6-50
	208 1-phase	39.4	8.3	6 gauge	60	6-50
EX-344	240 1-phase	40.0	9.5	6 gauge	60	6-50
	208 1-phase	39.4	8.3	6 gauge	60	6-50
EX-399	240 1-phase	48.0	11.5	6 gauge	60	6-50
	240 3-phase	29.3	11.5	8 gauge	40	15-50
	208 1-phase	48.0	10.0	6 gauge	60	6-50
	208 3-phase	31.7	11.0	8 gauge	40	15-50
EX-1099	240 1-phase	60.0	14.3	4 gauge	80	6-50
	240 3-phase	40.0	14.3	8 gauge	50	15-50
	208 1-phase	69.0	14.3	3 gauge	90	6-50
	208 3-phase	46.7	14.3	8 gauge	60	15-50
EX-1850	240 3-phase	66.0	23.6	3 gauge	90	15-50
	208 3-phase	76.0	23.6	3 gauge	100	15-50
EX-1266	240 1-phase	48.0	11.5	6 gauge	60	6-50
	208 1-phase	48.0	10.0	6 gauge	60	6-50
GSF-670	240 1-phase	34.7	8.3	6 gauge	50	6-50
	240 3-phase	20.0	8.3	10 gauge	30	15-50
	208 1-phase	40.0	8.3	6 gauge	60	6-50
	208 3-phase	23.1	8.3	10 gauge	30	15-50

* For runs longer than 50 feet, use heavier wire, numerically two numbers lower. For example, instead of 8 gauge wire, use 6 gauge.

Three-Phase Installation

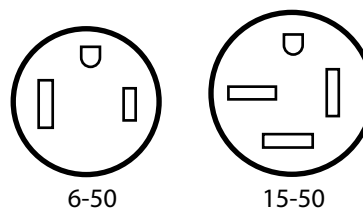
Three-phase Models EX-270SF, EX-365SF, EX-399SF and EX-1099SF can be plugged directly into a 3 phase (15-50R) wall receptacle with the exception of the EX-1099SF which is direct wired.

208 Versus 240 Supplies

As you can see from the chart on the previous page, most EXCEL® models are available in either 208 or 220/240 volt versions.

The “120/208V” supply is increasingly encountered in schools and newly-built communities because it’s more efficient for heavy 120V loads. This affects all EXCEL® models because their elements receive the full 208 (or 240) applied volts. The 240V versions of these kilns will usually low fire satisfactorily when moved to a 208V area. But the 208V versions should never be fired on a 240V supply without first installing a full set of 240V elements. Otherwise, all components will be seriously overtaxed.

NEMA Receptacle Guide



UL and CSA Listed

All EXCEL® kilns are listed with Underwriters Laboratories, Inc. (UL) and/or the Canadian Standards Association (CSA). These seals are your assurance that the complete unit (not just the switches and certain parts) has met their rigid standards of safety with regard to casualty and fire hazards. The “cUL” is given to products listed with UL that meet the safety requirements of both Underwriters Laboratories and the Canadian Standards Association. All EXCEL® kilns are re-examined regularly, part by part, by both of these well-known testing laboratories.



Kiln Venting—Why it is Important

Safer Work Areas

Successful firings and safe healthy work environments depend on clean circulated air in the kiln room as well as the firing chamber. Testing has shown that gasses generated by the use of unvented kilns exceed OSHA levels for carbon monoxide and should be removed from the kiln room. It is recommended that all EXCEL® kilns use a direct, down draft venting system like the Master KilnVent or the KilnVent—Stand Version. These systems take the hot gasses from the kiln chamber, mix them with room air and vent them outside, insuring that the gasses do not reach the work area. Cool-down time is also reduced by 2-4 hours, often allowing firing the very next day.

In addition to making the kiln room more comfortable, accidental burns and jarring of the ware are reduced because the lid stays closed throughout the firing.

Better Finished Results

Down draft, direct venting systems produce truer colors, more uniform firings, and fewer glaze flaws by:

1. Reducing carbon monoxide and increasing oxygen levels, which increases the brightness and intensity of reds, greens, golds and yellows, and allows different colors to be fired at the same time.
2. Circulating the hot gasses inside the firing chamber—the items on the bottom of the kiln receive the same heat as items on the top.
3. Increasing oxygen levels in the kiln, which helps burn out carbon and organic compounds in the clay body, thereby reducing pinholes, craters, and bubbles in the glaze.

Installation Note: While the AMACO® vents are key to creating safe work environments and better work, these systems will not reduce the kiln temperature or the ambient heat the kiln inputs into the room. It is suggested that the kiln room area be adequately sized and exhausted to keep the space under 100°F (38°) during peak temperatures and provide at least 18 inches of clearance on all sides of the kiln. Sprinkler systems in kiln area should be rated so that they will not trigger when the kiln is at peak temperature.

Vent Systems Available for Your EXCEL® Kiln



Minor modifications will need to be made to your kiln for use with either of these vent systems. For specific installation instructions, refer to the manual supplied with the vent purchased.

When Your Kiln Arrives

Be present on kiln delivery so you can inspect the carton and contents for damage due to improper handling during shipping. Located on the bottom corner of the box is the SHOCK WATCH sticker and directions are provided on the outside of the box for using this program. The freight company is required to provide you with complete instructions to report any damage that occurred during shipping. **It is important to note all damages to the kiln on arrival as the warranty will not cover damage due to shipping.**

The bill-of-lading covering this shipment is our receipt from the transportation company that the shipment was complete and in good condition when it left the factory. You should thoroughly inspect this shipment as soon as you receive it.

Shortages and/or Visible Damage to Boxes

A notation concerning any shortages of boxes or visible damage to the shipment should be made on both copies of the delivery receipt presented by the driver for the transportation company. If driver will not allow notations to be made to both copies, notify AMACO® directly.

Concealed Damage or Shortage

When your shipment is unpacked, if any item from the order was omitted you are to contact AMACO® at once.

If the merchandise was damaged in transit, report this to the delivering carrier and request an inspection of the shipment. Unless you take this action, the transportation company will dispute their liability to any claim of lost or damaged merchandise. If the inspection request is denied, make an affidavit stating that you requested an inspection on a certain date and were denied an inspection. This, with other papers, will help support the claim and should be filed immediately. The responsibility for filing claims is with the person, school or company paying the freight bill. Save all packing materials. Don't assemble or fire your kiln until your damage claim has been resolved. Fax or email a copy of the signed inspection report to AMACO®. Inspection reports MUST BE DATED NO LATER THAN 15 DAYS AFTER DELIVERY OF SHIPMENT IN ORDER FOR CLAIM TO BE VALID. When this procedure is followed AMACO® makes every effort to assist in obtaining reparation.

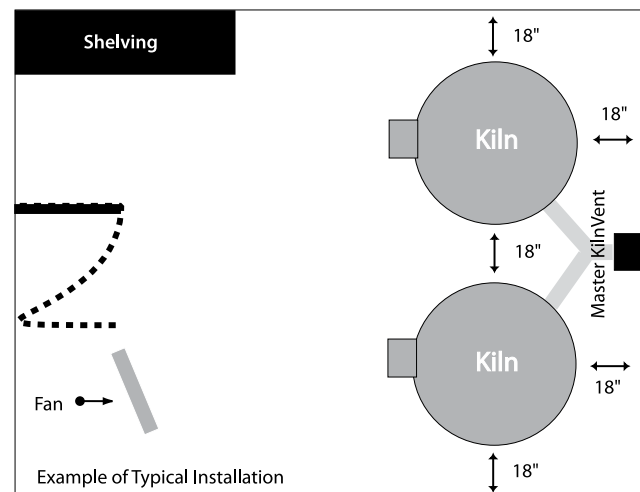
When your kiln is unpacked, check the metal nameplate to see that the voltage shown is the same as you ordered. If your electrician has not tested the power outlet to see that the specified current is available, he should do so before the kiln is installed. For example, too many appliances on a circuit will lower the input and cause slow heating. THE BEST SOLUTION IS TO RUN A DIRECT LINE TO THE KILN.

Kiln Location

- Locate your kiln near your present electrical outlet or where a new circuit can be installed. Position the kiln to the left of your electrical outlet so the cord will have an easy run and will not place a strain on the plug or outlet.
- Install it in a well ventilated, sheltered area such as a garage, utility, or hobby room. Allow a **MINIMUM 18 INCHES (46 cm)** of space between your kiln and adjacent walls, other kilns, shelving, etc. When multiple kilns will be installed in the same room, make sure the control boxes on the kilns are not facing adjacent kilns. Radiant heat from nearby kilns can damage the controller.
- For small rooms, monitor the firing so room temperature does not exceed 105°F (41°C). Do not fire if room temperatures are 32°F (0°C) or less as damage to the electronic components may result. At right is an example of a typical room layout.
- Locate the kiln in a room with a bare cement floor. If a bare cement floor is not available, the uniform mechanical code requires two inches of masonry below the kiln extending a minimum of 12" (31 cm) beyond the outside circumference of the kiln.
- When installing a kiln in a room with a fire control sprin-

kler system, do not place kilns within a 10 ft. (3m) radius below sprinkler heads. If this is not possible, contact AMACO® for alternative solutions before installing.

- All kilns are vulnerable to the highly corrosive effects of marine air. If you live near salt water, locate the kiln indoors and protect it from the damp air.



Preparation

Certain kiln models may have slightly different set-up instructions. See page 31 for special set-up instructions for kilns with manual controls and page 25 for setting up the Select Fire™ wall mount.

Save packing material until test fire is complete. The kiln comes almost completely assembled. If you need to disassemble the kiln to make it lighter or smaller to move through doorways, see page 40.

Load the EZ-Lift Springs (if equipped)

If your kiln is equipped with a spring assisted EZ-Lift, you will need to load the springs. They have been detensioned to avoid damage to the kiln during shipping. See page 11 for instructions on tensioning the springs.

Remove and Set Up Stand

- 1) Open the lid and secure the lid brace in place.
- 2) Slightly bend the stand packing cardboard to relieve the tension against the brick wall and carefully lift the stand out of the kiln, being careful not to damage the brick or the thermocouple.
- 3) Remove the cardboard and peephole plugs attached to the stand.
- 4) Install the black plastic stand feet which are located in the plastic bag with the manual.
- 5) Place the stand where the kiln will be located.

Place Slab (Kiln Bottom)

- 1) Undo the buckles that hold the kiln slab to the kiln. Lift the kiln off the slab and place on a clean flat surface. Be careful not to set the kiln on anything (watch the power cord), that will damage the bottom row of bricks.
- 2) Center the slab on the stand. Allow a minimum of 18" of spacing from walls and other kilns.
- 3) If the stand is not level or wobbles, shim legs accordingly.

Do not place shims between the stand and the slab.

Placing the Kiln

- 1) With a partner, pick the kiln up by the handles and rest it on top of the kiln slab (floor).
- 2) On models with slabs that buckle to the kiln, reattach the buckles.

Place Peephole Plugs

Place the white porcelain peephole plugs into the peepholes of the kiln. If you are not using the Master KilnVent or KilnVent—Stand Version or any other downdraft vent, be sure to leave the top peephole plug out when firing.

Clean

Vacuum the inside of the kiln to remove dust, brick chips, and other foreign matter from around the elements. Be sure not to get the hose too close to the touch pad. Static electricity built up in the hose can damage the electronics.



Kiln Wash the Shelves

Brush coat one side of each shelf with AMACO® Kiln Shelf Wash. Apply a thin coat of kiln wash in one direction, allow to dry, and apply another thin coating in the opposite direction leaving a half inch (1.3 cm) margin from the outside edge of the shelf. Allow to dry overnight. **Never kiln wash the walls or lid of your kiln!**



Test Firing

The test fire is very important and should not be skipped. It ensures the kiln is operating correctly and nothing was damaged in shipping. It burns off element oils and develops an oxide coating which will help prolong the life of the elements.

Loading

This first firing should be done with only kiln shelves. Place the first shelf layer on one-inch (2.5 cm) posts above the slab. When loading ware in the kiln, it is important to load it evenly to ensure proper ventilation. For a full description on loading, see page 12.

Place Witness Cones

A Cone 04 (1945°F/1063°C) is recommended for proper

pre-oxidation of a new element. For more about cones, see Heat Work (Cones) on page 43. If your kiln is equipped with a lid lifter, be sure to latch the lid shut.

Test Fire The Kiln

Follow the Cone Fire Mode programming instructions found in the Programming section of this manual to run a **Cone 04**, **Medium Speed** program with **No Hold** time and **No Preheat**. After the kiln has cooled to room temperature, unload the kiln and inspect the cones. If the cones are satisfactory you are ready to begin using the kiln. If there is a problem with the cones see the section on fine tuning your kiln on page 15.

Getting Started

This page is a memory aid, not a substitute to reading and understanding the manual.

Activate the power source by plugging in the kiln or controller. After plugging in the kiln, the display will read **WAIT** for approximately 10 seconds while power is restored to the kiln. It will then switch to Idle Mode. In Idle Mode the display will flash the kiln temperature alternating with **IdLE**. Begin all programming in Idle Mode.

Be sure the programmer is set to the right temperature scale before proceeding (Fahrenheit or Celsius).

Cone Fire Mode

Step 1 – Press **CONE FIRE**.

Step 2 – Input **PREHEAT** time. Press **ENTER**.

Step 3 – Input Cone number. Press **ENTER**.

Step 4 – Input a **SPEED**. Press **ENTER**.

Step 5 – Input **HOLD** time. Press **ENTER**.

Step 6 – Press **START**.

Ramp Hold Mode

Step 1 – Press **RAMP/HOLD**.

Step 2 – Input the **PROG** number. Press **ENTER**.

Step 3 – Input the number of segments. Press **ENTER**.

Step 4 – Input the first heating rate. Press **ENTER**.

Step 5 – Input the first temperature to reach. Press **ENTER**.

Step 6 – Input **HOLD** time. Press **ENTER**.

Step 7 – Repeat steps 4 through 6 until alarm flashes. Press **ENTER**.

Step 8 – Press **START**.

Important: To effectively use Ramp/Hold mode, it is imperative to understand heat-work theory. If you know the theory well, and if you have had experience with other programmable kilns or controllers, then the Getting Started instructions will be useful.

If not, please read the complete Ramp/Hold instructions beginning on page 18.

The Ramp/Hold Mode can be used for all firing applications from glass to high fire porcelain and stoneware. This option allows you to create your own profiles with up to six ramp and hold segments. A segment has three components: heating rate, temperature and hold. It is easy to program. Be sure to see page 41 for information on heat work.

EZ-Lift

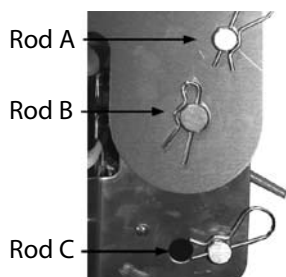
Tensioning the EZ-Lift

The EZ-Lift (if equipped) is shipped with the hinge springs de-tensioned in order to protect the lid during shipping. Please follow the instructions for tensioning the lid carefully to ensure success and avoid injury.

Step 1 - Remove the cotter pin and washer from the lid brace pad and remove the lid brace.



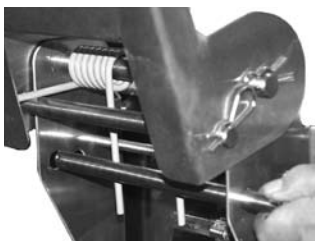
Step 2 - Remove the cotter pins on one side of Rod A and Rod C and with the lid closed slide out the rods.



Step 3 - With lid closed, insert rod A with the springs in the position pictured below. Replace cotter pin.



Step 4 - Open lid all the way. (Lid will be heavy since it is not tensioned yet). Insert rod C as pictured below. Replace cotter pin. Lid is now tensioned. Close lid and replace lid brace.



De-tensioning and Removing The Lid

To remove the lid it will be necessary to detension it first. Start by removing the lid brace and raising the lid as far as it will open. Next remove Rod C and close the lid. Be careful when lowering the lid since it is now detensioned. To remove the lid, remove Rod B and lift the lid straight up off the kiln.

Using the EZ-Lift

The lid brace has been designed with a two position setting and a stop post. The stop post is a safety feature which prevents the lid from opening too far and damaging the kiln. The lid brace provides additional safety and allows you to open the lid wider if needed for larger pieces.

The lid latch serves two purposes. The first is to make sure the lid stays in the closed position while firing. To latch the lid shut, simply close the lid and swing the latch arm over until it pops into place. Be sure to latch the lid shut prior to every firing!

There are two additional venting positions that the lid can be placed in if the kiln is not equipped with a downdraft vent. Lift the lid up and swing the Lid Latch into the desired venting slot. When the kiln reaches 1000°F (537°C), close the lid and latch it shut. Always wear fireproof protective gloves when working with any hot kiln.



Loading Tips

Balance the Load

When planning how to load your kiln, keep in mind that the center of the kiln is generally the hottest. Therefore, you will want to distribute the load with the larger, thicker pieces towards the middle and the smaller, thinner pieces towards the top and bottom. In addition, if half your load consists of small, heavy pieces and the other half is large, thin-walled pieces, don't group them all in one section. Mix them so there is a balance of each type throughout the kiln.

Allow the Kiln to Breathe

Many studios work with glazes that require oxygen to develop properly. Provide enough space between items to allow them to "breathe". Using half shelves with a ¼" space gap in the middle will also help increase the flow of oxygen within the kiln chamber, especially when used in combination with a vent system.

Allow for Proper Clearances

Kilns lose most of their heat from the lid and the slab. Ideally, there should be at least two inches of space between the lid and the closest piece. The first shelf should be posted up one inch from the bottom slab.

Nothing Directly Under the Kiln Vent Holes

Holes drilled in the lids of the kiln that have AMACO® kiln vents allow air to be drawn into the kiln chamber. If a piece of ware is sitting directly under one of these holes, it could leave a spot in the glaze. If it is not possible to cap the load with a shelf, leave a five inch radius on the shelf directly below each hole.

DO NOT Rush

Take the time to properly load and fire the kiln. Check each piece to insure that too much glaze or unsteady placement will not cause disaster during the firing. A few extra minutes can save you a lot of frustration.

DO NOT Load Damp Ware into Your Kiln

Make sure all ware is bone dry before loading into the kiln. It should feel like room temperature. If it doesn't, water is still evaporating from it.

Load Slowly

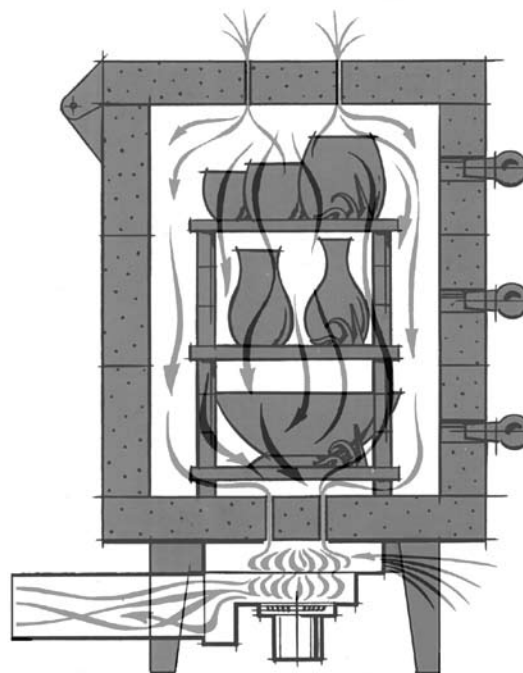
Dropped ware on shelves may damage the inside of your kiln.

DO NOT Set Pieces Directly on Kiln Floor

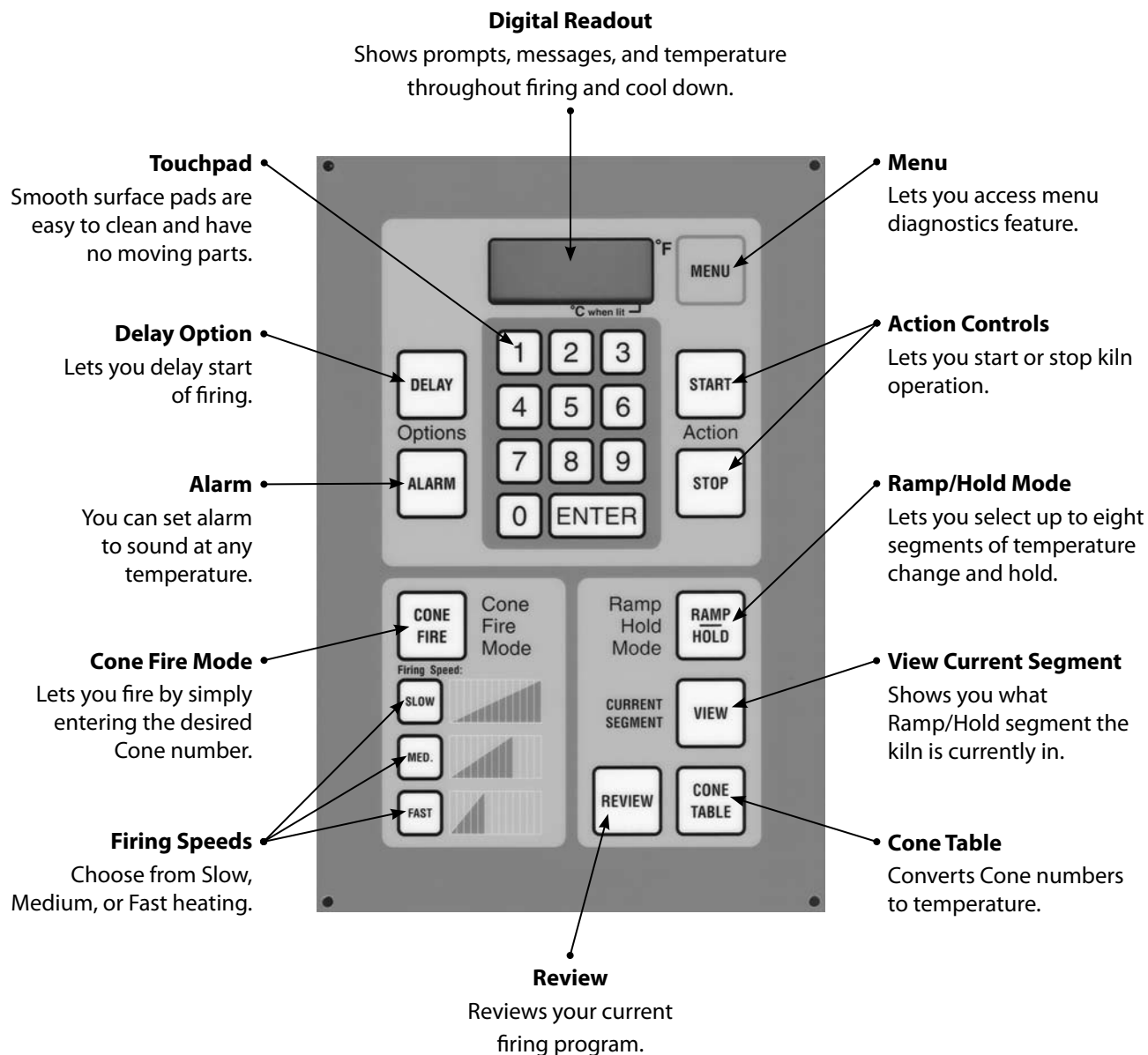
The first shelf should be 1" off the floor of the kiln. For best results, ware should not be placed within 1" of the elements. Large flat pieces like plates that demand the full width of the kiln should have their rims positioned between two elements.

DO NOT Crowd the Kiln-Sitter® or Thermocouple

Keep shelves at least ¼" from the sensing rod, and ware at least ½" away. If your load should shift during firing there will be less danger of jamming the Kiln-Sitter® or having ware resting against the thermocouple causing inaccurate temperature readings or damage to the ware.



Select Fire™ Control Features (if equipped)



General Select Fire™ Programming Information

If your kiln has manual controls and Dawson Kiln-Sitter® with Limit Timer, see page 31.

The LED Display

The display shows 4 characters and 14 segments per character. This is not always enough to exactly represent the message presented. If you find you do not understand a message, consult the Display Messages section of this manual.

The controller may be programmed in either Celsius or Fahrenheit. It is very important to know which temperature scale it is using. If there is a LED illuminated in the lower right hand corner of the display, the temperature scale is set to Celsius. Refer to the MENU section of this manual to change scales if necessary.

When prompted to enter time values, there will be an LED illuminated in the lower center portion of the display. We refer to this as a decimal point. Everything to the left of the decimal will be hours and everything to the right will be minutes.

Idle Mode

When the kiln is flashing IdLE alternately with the current temperature of the kiln chamber we refer to the controller as being in Idle Mode. This simply means that the kiln is ready to be programmed. To return to Idle mode you may press STOP at any time. If controller is programmed for Zone Control, the display will also show current thermocouple being read.

Start/Stop/Enter

The START key begins the program which is currently loaded in memory. It may only be accessed when the kiln is in Idle Mode. The STOP key will turn off the kiln at any point of a program. It may also be used to return to Idle Mode in the middle of entering a program. ENTER must be pressed after entering any time, temperature or programming speed. ENTER is also used to turn an Alarm off that has sounded during a firing.

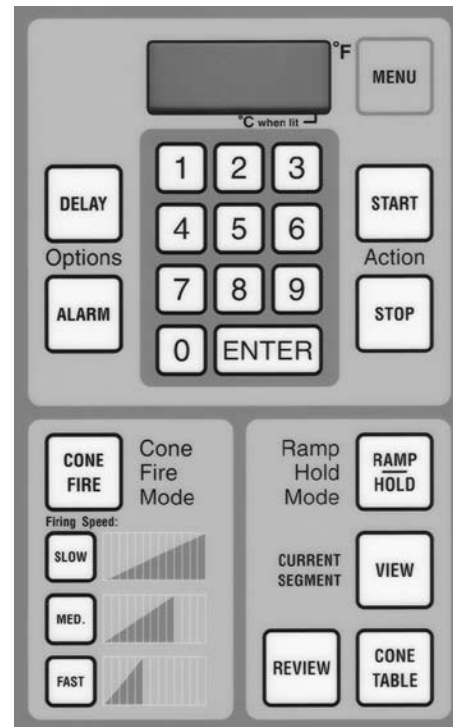
Delay

The Delay feature allows you to program the kiln to automatically start at a future time. This feature is primarily used to take advantage of better off-peak electric rates or to time the shutoff of the kiln for a time that is convenient for you to be there. It can be set for a Ramp/Hold Mode or Cone Fire Mode program and can be accessed only after the program has been entered and the controller is in Idle Mode. You can enter a delay time up to 99 hours and 99 minutes.

From Idle Mode, press **DELAY**

Input **Delay time in hours and minutes**, then press **ENTER**

When START is pressed to begin the program, the time entered for the delay will reappear on the screen and begin counting down. When it reaches 00.00 the kiln



will start the program currently loaded. The Delay time will stay in memory until it is cleared. To clear it, follow the instructions for entering a Delay and enter 00.00 for the Delay time.

Alarm

The Alarm feature is used to sound an Alarm at a specific temperature in the program. This feature is primarily used to prompt the user to lower a propped lid or for glass artists to look into the kiln at peak temperature. It can be set for a Ramp/Hold or Cone Fire program. You can enter any Alarm temperature between 0 and the maximum temperature rating of the kiln.

From Idle Mode, press **ALARM**

Input **Alarm Temperature**, then press **ENTER**

When START is pressed the program currently loaded will begin. When the temperature of the kiln reaches the Alarm temperature entered, the Alarm will sound in a series of beeps. Press **ENTER** to turn off the Alarm. DO NOT press **STOP**—this will stop the program. The Alarm temperature will stay in memory until it is cleared. To clear it, follow the instructions for entering an Alarm and enter 9999 for the Alarm Temperature. "9999" is the default for having the Alarm off.

Menu

The Menu features are discussed in depth in the Menu Features section of the manual (pages 21-24).

Review

The Review key allows the user to look at the current program loaded to make sure it is correct. We highly

suggest using this feature to check programs prior to each firing. Press **REVIEW** and the display will step through each segment of the program for a Ramp/Hold program. It will also let you know if there are Alarm temperatures or Delay times entered and whether or not the Error Codes feature is ON or OFF. Below is a sample Review of a Cone Fire program.

Sample Cone Fire Review

- | | | | |
|----|------|------|---|
| 1. | Cone | 04 | Cone Number |
| 2. | F | 1920 | Actual temperature when kiln shut off |
| 3. | SPD | FAST | Cone fire speed |
| 4. | HOLD | 0.00 | Length of hold at top temperature |
| 5. | PRHT | 0.00 | Preheat time (Will only be displayed if preheat is set to ON) |
| 6. | DELA | 0.00 | Delay Time |
| 7. | ALRM | 9999 | Alarm Temperature |
| 8. | ERCD | ON | Error Codes ON or OFF |

View

The View key allows you to determine what segment of a Ramp/Hold program the controller is currently running. While a Ramp/Hold program is firing press **VIEW**. The display will show the current segment, the traveling set point, and the circuit board temperature. The segment number is prefixed by either "RA" (Rate) or "HLd" to indicate whether the kiln is heating (or cooling) or holding temperature. The traveling set-point indicates the target temperature of that segment.

Cone Table

The Cone Table key allows the user to look up the temperature equivalent of Cone values. To use simply press **Cone Table** from Idle Mode, enter a cone value and press **ENTER**. This key may also be used to insert a Cone Value for the peak temperature of a Ramp/Hold program. This Cone Value will be automatically adjusted (Cone Correlation) based on the performance of the kiln. To use this feature press Cone Table when prompted to enter the peak temperature of your program, enter a Cone value and press **ENTER**.

During the Firing

You will see the internal temperature of the kiln displayed as the temperature increases. The options available during the firing are:

- Review program at any time.
- View Current Segment of **RAMP/HOLD** Program.
- Press **STOP** to interrupt a firing for any reason.

Note: it is common to see smoke come out of your kiln on the first firing. This is normal; the elements are burning off a coating.

After the Firing

- When completed, the display will show "CPLt" alternately with the firing time in hours and minutes and the current temperature of the kiln. Press **ENTER** to return to Idle Mode.
- When a Cone Fire Mode program (or a Ramp/Hold

program which uses the Cone Correlation feature) is run, the controller may alter the peak temperature of the program based on the kiln's ability to achieve the final temperature rate. This is done to insure the heatwork remains constant. If you are interested in knowing if that temperature changed, press **REVIEW** after the program is complete. This temperature value will only appear in a review once after the firing so be sure to pay attention.

- Allow the kiln to cool naturally. Never unplug additional peepholes or post the lid until the ware is cool enough for barehanded unloading, about 130°F (54°C).
- When unloading, be sure to examine the self-supporting cones on the shelf to determine if the kiln is firing correctly.
- It is not necessary to unplug the kiln when not in use (unless severe storms are expected). Continuous plugging and unplugging may cause components in the plug and receptacle to loosen up over time. Loose components in electrical connections create heat and can pose a fire hazard.

Fine Tuning Your Kiln

If after inspecting your witness cones you find that the kiln fired a little hot, a little cold, or a little uneven, there are certain things you can do to fine tune the kiln before your next firing. Always be sure you use self-supporting 108°F (42°C) witness cones. Cones should be placed about 2 inches (4.8 cm) from the kiln wall and or thermocouple. Never place cones directly on the bottom slab.

Too Cool

Add more Hold Time to a Cone Fire program. If the target cone did not bend at all, try adding 15 minutes to the Hold Time. If the Cone has started to bend, add time in 5 minute increments. If hold times begin exceeding 30 minutes contact AMACO® or your distributor for more information.

Too Hot

If the Cone is knuckled down on the shelf, reduce the Hold Time by 15 minutes. If the tip of the Cone has just started to touch the shelf, reduce Hold Time in 5 minute increments. If hold times are already set to zero, contact AMACO® or your distributor for more information. Thermocouples drift towards an over fire as they age so if the problem persists or requires excessive changes to correct, it may be time to change the thermocouple.

Uneven Heat Distribution

Kilns will tend to fire cooler on the top and the bottom. EXCEL® kilns compensate for this effect by putting hotter elements in these spots. If you notice a certain area consistently firing cooler, load those areas a little less dense. If areas are firing a little hot, load them a little more dense. Always be sure to post the first shelf at least 1" (2.5 cm) above the slab and if you have a small load, concentrate the mass towards the center of the kiln.

Venting systems such as the AMACO® Master KilnVent or KilnVent—Stand Version help with uneven heating by mixing the air within the kiln chamber.

Choosing a Program

The first step in programming your kiln is to decide which "Programming Mode" to use. Before making this decision it helps to have a good understanding of Firing Programs. A Firing Program consists of a series of program segments. Each segment consists of a Rate, a Temperature and a Hold Time. These segments determine the rate at which the kiln will heat up or cool down and how much Heatwork the pieces in the kiln will receive. For more information on Heatwork see page 41.

Cone Fire Mode

With Cone Fire Mode the programs are written for you. You simply give the controller some key information regarding the pieces you are firing and it accesses a program which best suites your project. This is the most commonly used mode of programming. The programs were created by Ceramic Engineers and are designed to minimize problems that can occur during critical stages in the firing process.

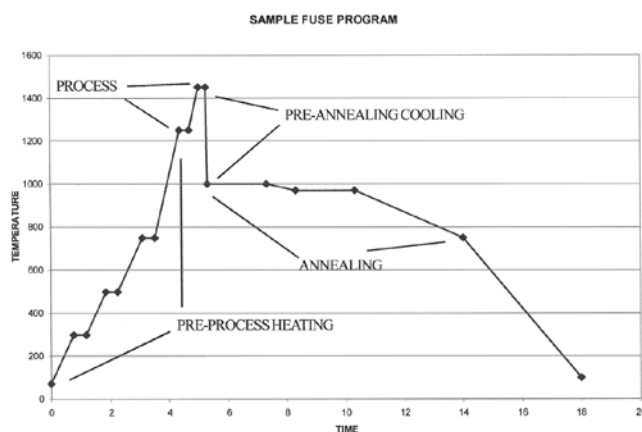
Cone Fire Mode is incredibly easy to use however, the software itself is extremely advanced. Cone Fire Mode uses complex algorithms to simulate the heatwork of a Pyrometric Cone. What is impressive is that it automatically makes adjustments to the firing profile based on your kilns performance. Cone values are based on heatwork and heatwork is a function of time and temperature. Therefore, if your kiln is firing slow due to a heavy load or aging elements, Cone Fire Mode automatically adjusts the peak temperature down so you get the perfect amount of heatwork. There are very few reasons not to use this mode of programming.

RAMP/HOLD Mode

RAMP/HOLD Mode allows you to write your own programs when the results you want cannot be achieved through Cone Fire Mode. It is a perfect tool for:

- Fusing and slumping glass
- Annealing metal and glass
- Firing Precious Metals
- Clay
- Specialized glaze formulations and techniques

Ramp/Hold is generally considered an advanced form of programming. It requires in-depth knowledge of heatwork and a good feel for how your kiln performs under a range of conditions. Below is an example of a simple glass fusing Ramp/Hold program.



Programming Cone Fire Mode

Programming Steps

Step 1 – From Idle Mode. Press **CONE FIRE**. Display will read PRHT alternately with 00.00.

Step 2 – Input a **PREHEAT TIME IN HOURS AND MINUTES**. Press **ENTER**. (See page 23 for more information on Preheat.) Display will read CONE alternately with the last Cone Value entered.

Step 3 – Input a **CONE VALUE**. Press **ENTER**. Display will read Spd alternately with the last Speed entered.

Step 4 – Press a **SPEED (SLOW, MED or FAST)**. Press **ENTER**. Display will read HOLD alternately with a Hold time value.

Step 5 – Input a **HOLD TIME** if one is desired. Press **ENTER**. Display will flash CPL, then will return to Idle

Mode. At this point the program is loaded and ready to start. Before pressing **START**, it is a good idea to press **REVIEW** to make sure the program was input correctly. Also, verify that the lid latch is engaged if your kiln is equipped with a lid lifter and check to see the area is clear of all combustible materials.

Step 6 – Press **START**. Display will read -ON- briefly and then display the current temperature of the kiln. If a delay start has been entered the display will begin counting down the time entered.

When the firing is complete the display will read CPLT alternately with the current temperature of the kiln and the time it took to complete the program. To clear this data and return to Idle Mode, press **ENTER**.

Decription

Step 1 – Cone Fire

The Cone Fire Mode runs a factory installed multi-segment program which is selected based on the Cone Value, Speed, and Hold time you choose. Below is an example of a program which is run if you choose a Cone Value of 04, a Speed of Medium and Hold time of 5 minutes.

One of the greatest features of Cone Fire Mode is Cone Correlation. It automatically measures the rate of firing during the last hour of the heating program and adjusts the final temperature based on the observed firing rate. This will insure consistent results as the kiln elements become weaker with normal wear from repeated firing. As a result the shutoff temperature may vary between firings.

Segs	Rate	Temp	Hold
1	200 °F/HR	250 °F	0
2	400 °F/HR	1000 °F	0
3	180 °F/HR	1150 °F	0
4	300 °F/HR	1694 °F	0
5	120 °F/HR	1946 °F	00.05

Step 2 – Preheat

Preheat is used to preheat the ware inside of the kiln before the temperature goes above the point when water turns to vapor. If residual water in the clay escapes as vapor too fast it can crack the ware or in extreme cases cause it to explode. Large, thick walled, pieces are more susceptible to damage caused by residual moisture.

When a Preheat time is entered and the program is started the kiln will climb in temperature at a rate of 60°F (15°C) per hour until it reaches 180°F (82°C). It will then hold at that temperature for as long as the time entered. After the hold is complete, it will begin the Cone Fire program. If you do not wish to preheat your ware, enter 00.00 for the hold time. For instructions on turning this feature off, consult the Menu section of this manual.

Step 3 – Cone Value

Every clay and glaze should have a Cone Value associated with it. A Cone Value is a measurement of the Heatwork needed for the clay or glaze to mature. The Heatwork is measured through the use of Pyrometric Cones (see page 41.) The values of these cones used by the Select Fire® controller ranges from Cone 022 through Cone 10. It will not let you enter a cone value outside of this range. **Remember that there is a big difference between values with "0"s in front of them and ones without "0"s. Example: A Cone Value of "6" is much hotter than a cone value of "06".**

Step 4 – Speed

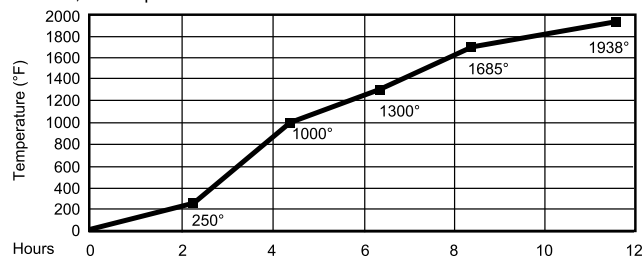
The Firing Speed you select will determine how long the kiln will take to heat up. This is important because if you

heat some pieces too quickly, they can crack or explode. There are three available speeds to choose from. Below is a description of each speed along with a graph showing the firing profile:

Cone Fire – Slow

Slow Speed will take approximately 12 hours to complete. Slow Speed is recommended for large or thick walled pieces. We recommend that most teachers use Slow Speed because it is often hard to tell how thick the walls are in a student's project. If you are unsure if the piece is completely dry, use this speed.

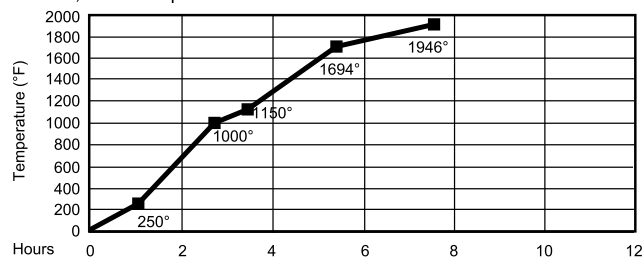
Cone 04, Slow Speed



Cone Fire – Medium

Medium Speed will take approximately 7.5 hours to fire. Medium Speed is fine for most firings. When in doubt, use the Slow Speed.

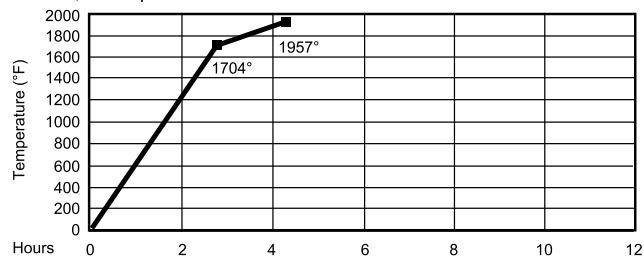
Cone 04, Medium Speed



Cone Fire – Fast

Fast Speed will take approximately 4 hours. This speed is only recommended for items such as lusters and decals which can handle the fast increase in temperature.

Cone 04, Fast Speed



Note: Firing profiles are approximate and will vary depending on load volume, density and placement of ware, and placement of kiln shelves.

Step 5 – Hold Time

HOLD is another important feature of CONE FIRE MODE. Once the kiln has achieved its peak firing temperature, HOLD can maintain that temperature for a set amount of

time. This allows the user to make fine tune adjustments to the firing process by introducing more heatwork which can help witness cones reach maturity. Additionally, a HOLD permits the kiln to equalize temperature, allowing for even firings and firings that fall between cone temperatures, for example Cone 05.5.

CAUTION: Excessive hold time can result in over firings. A common mistake is to enter ten hours when a ten

minute hold is desired. 00.10 equals ten minutes, 10.00 equals ten hours.

Step 6 – Start

Start initiates the CONE FIRE MODE firing program. If a Delay is entered the kiln will start a countdown from the amount of entered delay time. Before pressing START, verify that the lid latch is engaged, and that all combustible materials are moved out of the vicinity.

Advanced Cone Fire Menu Features

In Cone Fire Mode, the operator has the ability to modify the firing program. They can do this in one of two ways. The first method allows the user to program custom Cone Fire programs. The second involves controlling the rate in which the kiln cools down.

Writing Custom Cone Fire Programs

This new feature on the 700 Board allows you to utilize the cone correlation benefits of Cone Fire Mode coupled with the flexibility of RAMP/HOLD Mode. To use Cone Correlation to calculate your final temperature during a RAMP/

HOLD program press **CONE TABLE** instead of entering a temperature for your final heating segment. Input the Cone Value you would like to correlate and Press **ENTER**.

Slow Cooling (Cone Fire Controlled Cooling)

COOL is a feature that allows you to add a 1-segment cooling program to the end of a Cone Fire program. When COOL is toggled "ON" it will prompt you to enter a "Rate", "Temperature", and "Hold Time" after you finish entering the Hold Time for a Cone Fire program. This is helpful when trying to achieve certain glaze effects.

Programming the Ramp/Hold Mode

Programming Steps

Step 1 – From Idle Mode, press **RAMP/HOLD**. Display will show PROG alternating with a number between 1 and 6.

Step 2 – Input the **PROG Number** of the Program you wish to create or run. (This is a number between 1 and 6 that you assign to a program which will be stored in permanent memory until it is replaced.) Press **ENTER**. Display will show SEGS.

Step 3 – Input the total number of segments for your program. Press **ENTER**. Display will show RA 1.

Step 4 – Input the first heating rate in degrees per hour. Press **ENTER**. Display will show °F 1 (or °C 1 if using Celsius).

Step 5 – Input the first temperature to reach. Press **ENTER**. Display will show HLD 1.

Step 6 – Input the amount of **Hold Time** in hours and minutes. Press **ENTER**. Display will show ALRM if this is the last segment you are entering, otherwise it will show RA 2.

Step 7 – Repeat steps 4 through 6 until all segments have been completed. The display will then flash ALRM (Alarm) alternately with the current Alarm temperature. The default setting for no alarm is 9999. Enter the desired alarm setting. Press **ENTER**. Display will briefly flash CPL.

Step 8 – Prepare Venting - (See description on Page 7.)

Step 9 – The display will return to Idle mode. At this point the program is loaded and ready to start. Before pressing **START**, it is a good idea to press **REVIEW** to make sure

the program was input correctly. Be sure to check that the lid latch is secure on kilns that are equipped with lid lifters. Press **START** and the program will begin firing.

Display will briefly show ON and then will show the internal temperature of the kiln chamber unless a DELAY START has been programmed in which case it will begin counting down minutes from the designated delay time.

Description

Step 1 – RAMP/HOLD

Ramp/Hold Mode is a mode of programming that allows you to write your own firing program. When you are entering your program you will notice data already stored. Simply write over this information. If you mis-enter data you may either press zeros to clear the data and re-enter it or press STOP to start from the beginning.

Step 2 – Program Number (PROG)

You have the option of storing up to six firing programs. You may recall these programs at any time for future use. We recommend that you write down which number you have assigned each program so that you do not overwrite existing programs you have stored.

Step 3 – Segments (SEGS)

This step is prompting you to input the total number of segments you wish to use in your program. Each segment consists of a heating or cooling rate, a target temperature, and a hold time at that target temperature if one is desired. You may program up to eight segments.

Two programs may be connected to achieve 16 segment programs. See instructions below.

Step 4 – Rate (RA#)

This step is prompting you to input a Temperature Rate. The display will show RA along with the current segment number you are programming alternately with the previous data entered. You may enter any rate between 1 °F/hr (1 °C/hr) to 9999 °F/hr (9999 °C/hr). This can be a cooling rate or a heating rate. The controller distinguishes between the two by checking to see if the temperature entered in the next segment is hotter or cooler than the previous segment.

Just because you enter a rate does not mean the kiln is capable of achieving that rate. Things such as element age, load density, and temperature range will all affect the kiln's ability to heat. Conversely, the kiln's insulation will influence its ability to cool. A rate must be entered for each segment.

Step 5 – Temperature (°F#) or (°C#)

This prompt is asking you to enter a temperature to go to. When it gets to that temperature it will either hold at that temperature or switch to a new rate and aim for a new temperature. If you are programming in Celsius it will read °C instead of °F. The controller will allow you to program temperatures between 32°F (0°C) and 2400°F (1315°C). A temperature should not be entered which exceeds the kiln's temperature rating.

Step 6 – Hold Time (HOLD)

A HOLD time is generally entered to allow the kiln time to balance out and all of the pieces in the kiln to reach the input temperature before the kiln moves to the next segment. You may enter hold times of 00.00 to 99.99.

A Hold at peak temperature can be used for this reason or to gain additional heatwork to fine tune cone bends or to fire in-between cones. Remember that everything to the left of the decimal point on the display is Hours and everything to the right is Minutes. Excessive Hold times may cause over-fires.

Step 7 – Repeat

Continue to enter a rate, a temperature, and a hold time for all the segments. When the last segment has been entered the display will prompt you to enter an Alarm temperature. The default is 9999 for no alarm. Input an Alarm temperature and press ENTER. The display will briefly flash CPL for "complete" and then return to Idle Mode. The program is now loaded.

Steps 8 and 9 – Prepare venting and Start

Before starting the program it is always a good idea to press **REVIEW** and make sure the data was entered correctly. If you find an error simply press **RAMP/HOLD** and continue to press **ENTER** until you find the error and are able to correct it. If there is a Delay entered, when you press start the kiln will begin counting down from the input time. Remember to turn on your vent (or prop your lid) before pressing **START**.

Advanced Features

16-Segment

When the 16-Segment feature is toggled ON, the controller links programs #5 and #6. Now, when you run program # 5, it will automatically run program #6 to continue the firing after program #5 has completed. Due to requirements of the software, the first segment of Program #6 must be increasing in temperature. Here is how to use this feature:

Step 1 – Input a 1 to 8 segment RAMP/HOLD Program in PROG #5.

Step 2 – Input a 1 to 8 segment RAMP/HOLD Program in PROG #6.

Step 3 – Press **RAMP/HOLD**, press **5**. Press **ENTER**. Press **STOP**.

Step 4 – Press **MENU**. The Display will show SET. Press **ENTER**. The Display will show PRHT. Press **MENU** until the display shows 16-S then press **ENTER**. The display will show OFF. Toggle to ON using the 1 key, then press **ENTER**.

Step 5 – Press **REVIEW**. Press **START**. **IMPORTANT:** Program #5 must be cued prior to toggling the feature, ON. Once both programs have run, the controller automatically toggles OFF the 16-segment feature.

Skip Step

Skip any segment in a Ramp/Hold Program by pressing **VIEW** quickly followed by pressing **ENTER**. If done quick enough you will see SKIP in the display. Immediately press **ENTER** again.

Cone Correlation

The 700 Board allows you to utilize the cone correlation benefits of **CONE FIRE** Mode coupled with the flexibility of **RAMP/HOLD** Mode. To use Cone Correlation to calculate your final temperature during a RAMP/HOLD program, press **CONE TABLE** instead of entering a temperature for your final heating segment. Input the Cone Value you would like to correlate and press **ENTER**.

Running a Stored Ramp/Hold Program

Step 1 – Press **RAMP/HOLD**.

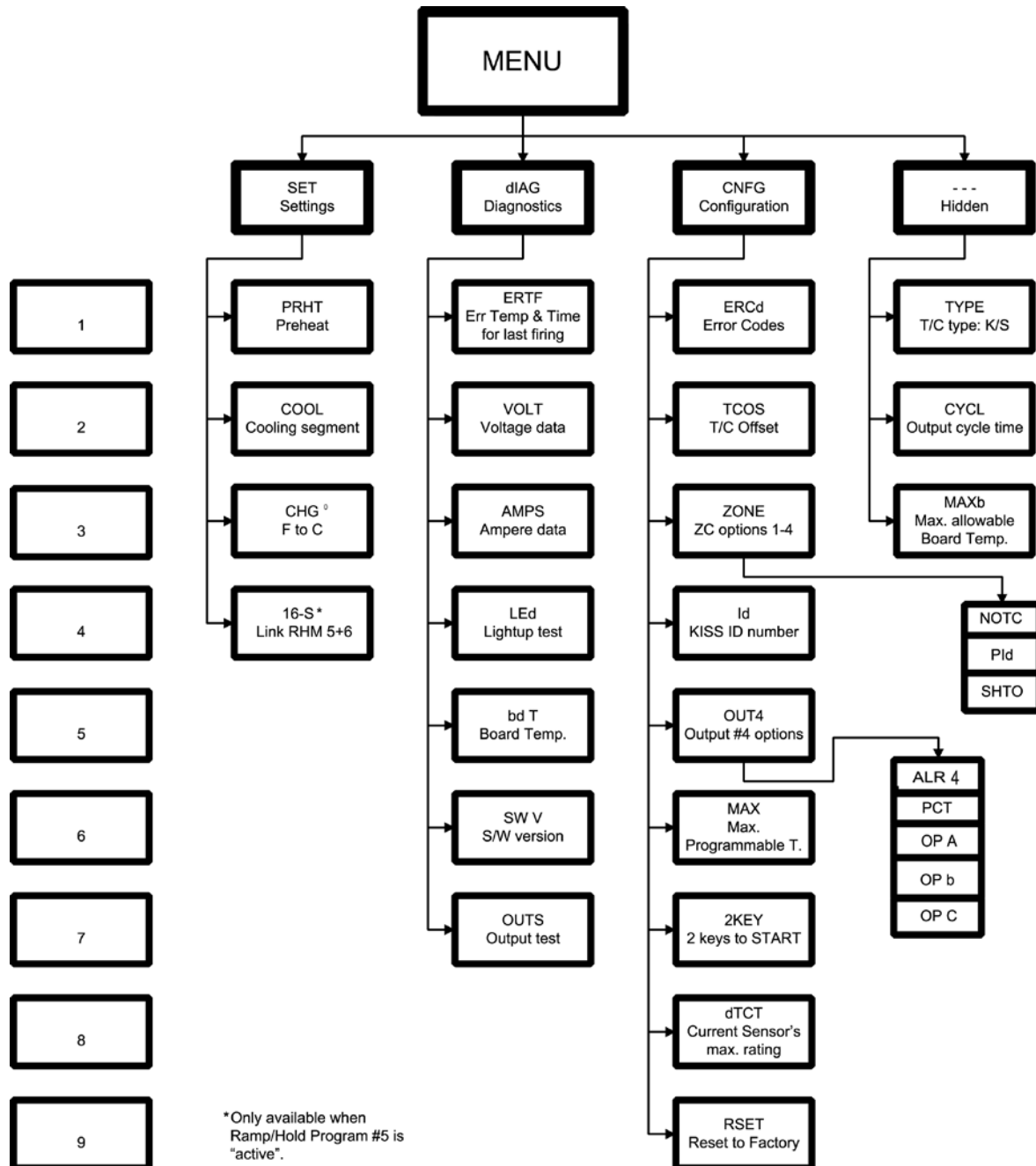
Step 2 – Input desired stored program number.

Step 3 – Press **STOP**.

Step 4 – Press **REVIEW**.

Step 5 – Press **START**.

Select Fire™ Menu Tree



New Features

Among other changes, the 700 Board in the Select Fire™ controller has the ability to do self-diagnostics. It can now show the voltage and amperage directly from the display, eliminating the need for expensive test equipment or having to hire a technician. Look through the entire MENU selection to become familiar with the options available to you.

New Menu Layout

With the exception of the new green 14-segment LED display, you will notice that the board and all of the function keys look exactly the same. All of the changes have been made in the **MENU** key.

There are now four option headings under the **MENU** key. They are:

- SET Settings
- dIAG Diagnostics
- CNFG Configurations
- Other ----

Menu Programming Tips

To access the Menu Headings, press **MENU**. You can toggle through the Menu Headings by continuing to press the **MENU** key. When you reach the one you wish to access press **ENTER**. This will take you to the first option in that submenu. As before, if you want to toggle through the various options under the selected heading, press **MENU**. When you reach the option you wish to access, press **ENTER**.

When you select an option, you are asked to either:

- Toggle the option **ON/OFF**
- Input a value
- Choose a value

To toggle options **ON/OFF**, press **1**. When you get to the desired setting, press **ENTER**.

To Input a value such as a Delay time or an Alarm temperature, input the value and press **ENTER**.

To select a value, press the **MENU** key until your selection is displayed, and then press **ENTER**.

Programming Instructions

SET (Settings)

SET, is where all of the commonly used options are located. The following options are available under the SET heading menu:

PRHT (Preheat)

This feature allows you to toggle the Preheat feature ON or OFF. The Preheat feature allows you to Input an amount of time to hold at 180°F (82°C) prior to running a CONE FIRE Program. This feature is recommended when firing large, thick-walled, or potentially damp ware. When the feature is toggled ON, it will prompt you to input a hold time value after the CONE FIRE key is pressed.

COOL (CONE FIRE Controlled Cooling)

This feature allows you to add a 1-segment cooling program to the end of a CONE FIRE program. When it is toggled "ON", it will prompt you to input a "Rate", "Temperature", and "Hold Time" after you input the Hold Time for a CONE FIRE program. This is helpful when trying to achieve certain glaze effects.

CHG ° (Change from Fahrenheit to Celsius Scale)

The controller can display temperature values in Fahrenheit or Celsius. If the scale is set to display in Celsius an LED dot will illuminate in the bottom right hand corner of the display. To select a new scale, press **ENTER**, and it will automatically toggle to the alternate scale. " °C " represents Celsius and " °F " represents Fahrenheit.

16-S (16-Segment)

This option links the RAMP/HOLD programs stored in memory positions 5 and 6 to create a 16-segment program. Normally a program is limited to 8 segments. This feature will only display when a CONE FIRE Mode program or the number 5 Ramp/Hold program is loaded. See page 19 for programming instructions.

dIAG (Diagnostics)

"dIAG" or Diagnostics, is where all of the diagnostic tools are located. The following options are available under the "dIAG" menu:

ERTF (Err Temp & Time of Last Firing)

This feature will display the temperature and the point of time in the firing at which the last Error occurred. Often times this information is helpful in troubleshooting the problem which created the error. Once "ERTF" is selected, it will first flash the temperature at which the error occurred and then the time into the firing it occurred. The ERTF information will also appear automatically when an error alarm sounds and the program is terminated. Pressing any key, will show the temperature and elapsed time at which the error occurred.

VOLT (Voltage)

This feature is used to test the voltage supply to your kiln. It tests the voltage first with the elements off, "No Load" and then again with the kiln on, or "Full Load". Select "VOLT" from the "dIAG" menu and press **ENTER**.

After the “NOLd” reading is displayed, press **ENTER** to receive the “FLLd” reading. The power to the kiln will be switched on for a brief moment when the voltage under load is checked. Our technicians can use this information to help you troubleshoot voltage related problems over the phone. When the voltage readings appear on your display, write them down. Voltage related problems can happen only at certain times of day, so try to obtain the readings at the same general time your kiln would be firing.

AMPS (Amperes)

This is probably the most useful diagnostic tool available to you. All Select Fire™ controllers produced after 3/20/2006 are equipped with a current sensor in the control box. This allows us to test the current of each output to the kiln. This is very helpful in determining if a relay or element needs replacing.

When you select “AMPS” under the “dIAG” menu, it will give you an ampere reading for each output of the kiln (except the accessory and safety output). Which elements these outputs control will vary by model. If your kiln uses only one or two outputs it will still give you three readings but the unused outputs will give a reading of zero.

LEd (LED Display)

This feature, when activated, lights up all of the segments in the LED display. This is helpful in locating any segments in the display that may have gone bad and may explain why some indicated readings are not correct.

bd T (Board Temperature)

The electronics on the controller’s circuit board may be damaged if the board exceeds 160°F (71°C). This should not occur under normal conditions. However, if the kiln is located in a small enclosure with poor ventilation or in areas where the temperatures are unusually hot, it is possible. Using this feature will tell you if your controller temperature is approaching potentially harmful levels.

If you find that your board temperature is consistently over 150°F (65°C), you may want to consider improving air circulation to the kiln room. A box fan blowing on the controller can help considerably.

SW V (Software Version)

At AMACO®, we are continually working on ways of improving our products. This feature will indicate the software version your controller is using.

OUTS (Output Test)

There are four outputs that can be used on the board. There are three designated for elements and one designated to run an accessory. This feature allows you to test each output individually to see if it is operating correctly. When activated this feature will test each output beginning with Output 1 and ending with Output 4. It will cycle each output on for approximately two minutes. You can advance to the next output at any time by

pressing **ENTER**. To see if the elements are cycling ON, you can place a small piece of paper on each element. If the paper is burned, then the element came on.

Important: *Be sure that the control box and kiln lid are closed before you use this feature in order to avoid electrical shock.*

CNFG (Configuration)

Caution: Be sure to consult with an AMACO® technician before making any configuration setting changes. Unadvised changes can cause permanent damage to your kiln and the ware inside it.

“CNFG” or Configuration, is where all of the controller configuration tools are located. The following options are available under the “CNFG” menu:

ERCd (Error Codes ON/OFF)

Error codes are designed to help protect you, your kiln, and your ware when something goes wrong with the firing. There are times however, where you may wish to try a new technique which would trigger an error code under normal conditions. When error codes are turned off, the following codes are disabled:

Error 1 - Terminate firing when kiln temperature is increasing at a rate slower than 12°F (11°C)/hr.

Error 2 - Kiln Temperature 50°F (10°C) degrees above hold temperature.

Error 3 - Kiln Temperature 50°F (10°C) degrees below hold temperature.

Error 4 - Kiln Temperature 50°F (10°C) degrees above previous hold when ramping down.

Error 5 - Kiln Temperature 50°F (10°C) degrees below traveling set point when ramping down.

Error D - Kiln Temperature 50°F (10°C) degrees above traveling set point.

TCOS (Thermocouple Offset)

This feature allows you to calibrate the thermocouple when it is reading consistently and predictably incorrect. It is extremely important to consult with an AMACO® technician before making thermocouple offset adjustments. Incorrect adjustments to the thermocouple offset can cause permanent damage to your kiln. Adjustments made to the thermocouple offset will affect all **RAMP/HOLD** and **CONE FIRE** programs.

If you are experiencing problems with CONE FIRE Mode, check to see if the ending temperature and hold time of the programs you are running have not been significantly altered from the factory programs before making thermocouple offset adjustments.

Access the TCOS setting through the CNFG menu. The display will flash °FOS alternately with the current offset setting. °FOS represents degrees Fahrenheit Offset. If the controller was programmed to display in Celsius, the “F” would be replaced by a “C”. If there is currently an offset input, this could be the problem. To be safe, make adjustments in small increments and then run a

test fire with self-supporting cones.

To Make The Kiln Fire Cooler – Input 00 followed by the number of degrees you wish to offset the thermocouple. Press **ENTER**. Example: “0010” makes the kiln fire 10 degrees cooler.

To Make The Kiln Fire Hotter – Input 90 followed by the number of degrees you wish to offset the thermocouple. Press **ENTER**. Example: “9010” makes the kiln fire 10 degrees hotter.

ZONE (Zone Control Options—if equipped)

Zone control is a feature that comes standard on the EXCEL® EX-1850SF and optional on EX-365SF and EX-1099SF. Zone Control is a feature that allows the controller to independently fire sections on multiple section kilns to ensure even temperature top to bottom.

There are three optional setting configurations for Zone Control which can be accessed through the “ZONE” feature under the “CNFG” menu:

- NOTC
- PId
- SHTO

NOTC (Number of Thermocouples—if equipped with Zone Control)

Your kiln should be properly programmed for the correct number of thermocouples before it leaves the factory. You cannot set a kiln to fire in more than one zone unless it is configured in the factory as a Zone Control kiln. If you try you will receive a “FAIL” error code.

To change the number of zones on a Zone Control kiln access the “ZONE” setting through the “CNFG” menu then use the menu key to toggle to the “NOTC” feature and press **ENTER**. The controller will display the current “NOTC” setting. Input the desired value and press **ENTER**.

PID (Proportional Integral Derivative—if equipped with Zone Control)

PID is a zone control setting that uses the center section elements to help the bottom and top sections when necessary. In most kilns the center section is usually the hottest section. The PID option is designed to help speed up the firing when the top or bottom section is cooler and lagging behind the other sections.

When the top or bottom section is on full power (it is lagging behind), then output 2 comes on as a percentage of output 1 or output 3. The middle section will fire hotter and help the top and or bottom section catch up. The percentage can be set from 0 (zero) to 150. It is factory preset at 85%.

SHTO (Shutoff—if equipped with Zone Control)

Shut off is a Zone Control feature that attempts to make firings more consistent. For 2 and 3 Zone Controllers, when shutoff is “OFF” the controller uses the average of all three thermocouples to transition from one segment to the next or to shut off the kiln. When “ON” the kiln turns off, or transitions, when any one of the thermo-

couples reaches temperature. FOR ALL DOWN RAMPS, the controller transitions from one segment to the next as if shut off “SHTO” were turned ON (i.e., when any one section reaches the next segment temperature).

Id (Control Interface System ID)

CIS is an optional accessory that allows you to program and monitor multiple kilns from a PC. Each kiln hooked up to the CIS system needs to be identified with a unique number so the software can distinguish it from the other kilns. To set the identifying CIS number for each kiln access the “Id” setting through the “CNFG” menu, select a number between 1 and 99 and press **ENTER**.

OUT4 (Output 4 Settings)

There are three standard outputs, one safety output, and one accessory output on your Select Fire™ controller. The accessory output is designated as Output 4 and can control a number of optional accessories including vents, alarms, and autodialers. Output 4 will cycle these accessories on and off at different times depending on the program you are running and the way you configure it under the “OUT4” feature setting. There are five different options for OUT4.

Note: “ALR4” is the factory default setting. When you access the Output 4 feature the feature options will appear in the order listed below. The first option listed is not necessarily the current setting.

ALR4 (Alarm 4)

This is the factory default setting. If Output 4 is not being utilized this is the setting that should be selected. This feature can also control an external alarm or auto-dialer to initiate if an Error Code is generated or if the internal temperature of the kiln reaches the temperature programmed for the **ALARM** setting of the program. To deactivate the alarm press **ENTER**.

PCT (Percent On)

Output 4 can be programmed to be on for a percent of the time output 2 is on. This option is used when output 4 controls floor or lid elements. To ensure output 4 stays off at all times, use this option and set the percentage to zero. The percent can be set from 0 to 150. There are currently no EXCEL® Kiln designs that can utilize this feature.

OP A (Option A)

When option A is selected Output 4 will turn on when a CONE FIRE Mode program is started. When the program has run and the kiln has cooled to 150°F (65°C), output 4 will turn off.

When a RAMP/HOLD program is inputted it will ask whether you want the fan (or other accessory) on for each segment you program. After you Input the hold time for each segment the display will show “FAN” along with the number of the segment you are programming. Alternately it will flash the current setting, either “OFF” or “ON”. To change the setting toggle it with the **1** key and press **ENTER** to select that setting.

OP b (Option B)

During a CONE FIRE program Output 4 will turn on when **START** is pressed. It will then turn off at 1450°F (788°C). It will turn back on when the kiln is cooling and the temperature drops below 1000°F (538°C). It will then turn off when the kiln cools to 150°F (65°C).

When a RAMP/HOLD program is inputted it will ask whether you want the fan (or other accessory) on for each segment you program. After you **Input** the hold time for each segment the display will show "FAN" along with the number of the segment you are programming. Alternately it will flash the current setting, either "OFF" or "ON". To change the setting toggle it with the 1 key and press **ENTER** to select that setting.

OP C (Option C)

When Option C is selected Output 4 does not come on during any portion of a CONE FIRE Mode program.

When a RAMP/HOLD program is inputted it will ask whether you want the fan (or other accessory) on for each segment you program. After you **Input** the hold time for each segment the display will show "FAN" along with the number of the segment you are programming. Alternately it will flash the current setting, either "OFF" or "ON". To change the setting toggle it with the "1" key and press **ENTER** to select that setting.

MAX (Maximum Programmable Temperature)

The Maximum Programmable Temperature setting is a great feature to use when other people may be programming the kiln. It helps protect against an over fire by not allowing the programmer to input any value over the designated limit. To set your firing limit access the "MAX" setting through the "CNFG" menu, Input your desired limit and press **ENTER**.

2KEY (2 Keys to Start Kiln)

The "2KEY" feature allows you to set the controller so it

takes two key presses to start the kiln. This helps protect against accidentally starting the kiln. When activated it will be necessary to press **START** then **ENTER** to start the program. To activate this feature access the "2KEY" setting through the "CNFG" menu, use the "1" key to toggle the setting to **ON** and press **ENTER**. Now when you press **START** to begin the program you will see **----** on the display. At this point press **ENTER** to begin the program.

dTCT (Detect Current Sensor Rating)

This feature indicates the maximum amperage rating for the current sensor installed in your kiln. The current sensor is the hardware installed in your kiln which allows the controller to read the current from the outputs. This feature should not be modified without consulting an AMACO® technician. Changing this setting will alter how the board interprets the current signal and will cause the board to produce erroneous current readings.

RSET (Reset To Factory Settings)

Sometimes it is difficult to diagnose a kiln problem when factory settings have been modified. To reset the factory settings access the "RSET" setting through the "CNFG" menu and press **ENTER**. The following settings will be restored:

- Error codes on
- TC offset set to zero
- Cone offset set to zero.

(Other) ----

The features contained in this menu heading are accessible only through direct contact with an AMACO® technician. If you change from a Type S thermocouple to a Type K thermocouple or vice-a-versa you will need to change a feature setting in this menu section.

The Wall-Mounted Select Fire™ Controller

The wall-mounted Select Fire® gives automatic kiln control to most modern EXCEL® or AMACO® 208/240V kilns and any other brand kiln which uses NEMA 6-50 (single phase) or NEMA 15-50 (3-phase) plugs and receptacles. It can be moved quickly from one kiln to another and can control virtually any kiln in a studio which has the proper cord plug and receptacle configuration.



Once installed, the Select Fire™ controller uses the same operating instructions as other EXCEL® Automatic kilns. Choose a location that will put the controller at least two feet from the kiln to prevent overheating the controller. To mount the controller, mark the hole positions on the wall where the controller will be installed using the paper template supplied with the controller and follow these instructions:

Mounting the Controller on Stud or Post

Use the holes marked A on the template and screw a #12 x 2 inch wood screw into the wall leaving a .25 inch gap. Repeat for the second screw.

Mounting the Controller on Sheet Rock

Using holes marked A and B on the template, drill the necessary holes to properly mount the .25 inch x 2 inch molly bolts into the sheet rock. Tighten the first bolt until there is a 1/8" gap. Repeat for the other three bolts.

Before hanging the controller on the wall, loop the cord attached to the quick reference card over a screw so that it hangs below the controller when mounted.

Connecting to the Kiln

Single-phase

(Switching capacity 48 Amps on 208-240V) To operate the wall-mounted controller, simply engage the kiln plug in the receptacle located on the back of the controller. Then plug the controller into the existing wall receptacle.

Three-phase

(Switching capacity 40 Amps on 208-240V) To connect your three-phase kiln, plug the power cord from the kiln into the receptacle mounted on the back of the controller. Plug the pilot cord (the smaller cord) into the small receptacle mounted on the underside of the controller. The controller is plugged into a wall receptacle which

provides three phase voltage. You will no longer need to use the three-phase contractor box. However, an electrician may need to wire a receptacle for the controller if a three-phase contractor box was used previously. You may need to make other changes to the supply for kilns not made by AMACO®. Other manufacturers may not use pilot cords. Please discuss this with your distributor.

Thermocouple Installation

EXCEL® kilns have a hole stamped in the stainless band where the thermocouple flange is to be installed. It is located to the right of the red switch boxes. The firebrick is visible through this hole. The thermocouple flange is a metal tube approximately 5/8" (1.59 cm) diameter and 1.5 in. (3.81 cm) long attached to a metal washer. Remove the thumbscrew from the flange. Align the thermocouple flange so that it is exactly over the hole in the stainless band. Position the flange so the thumbscrew is on the top. Attach the flange to the kiln using the two Phillips self-tapping screws provided. NOTE: To start the screws, lightly hit each screw with a hammer until the point has pierced the stainless steel band.

Insert a .5 in. (0.64 cm) twist drill or carpenter's bit through the flange holder. Slowly drill through the kiln wall brick into the kiln chamber. Insert the thermocouple into the kiln so that 1.25 in. (3.18 cm) to 1.5 in. (3.81 cm) of the tip protrudes into the kiln chamber. Tighten the thumbscrew.

Uncoil the yellow thermocouple wire that is hanging from the bottom of the controller enclosure. Plug the thermocouple ends into the receptacle coming from the controller. There is only one way the plug will engage the receptacle. The controller is now ready for use.

Thermocouple Installation in a Kiln Not Marked for a Thermocouple

Mark a .5 in. (1.27 cm) to 5/8" (1.58 cm) diameter hole on the stainless jacket in the center of the brick next to the Kiln-Sitter brick (one brick to the right of the master switch box). Be sure placement is accurate so that you do not drill through an element. Do not drill yet.

Align the flange holder accurately over the mark, positioning the thumbscrew hole on top. Mark the position of the small holes on the jacket. Push hard or tap out with a nail and hammer the small screw holes. Drill two, 3/32" (0.23 cm) holes for the smaller sheet metal screws. Drill through the metal only. Install the flange with the sheet metal screws provided.

For the remaining installation steps consult the previous section on Thermocouple Installation for an EXCEL® Kiln.

Preventative Maintenance

All Kilns

- Vacuum floor and element grooves regularly. Carefully vacuum around thermocouple and elements. Leave Select Fire™ kilns plugged in when you are vacuuming to ground any static charges that may occur at the nozzle tip of the vacuum. Try to keep the vacuum away from the touch pad area.
- Inspect plug and wall receptacle for any indication of excessive heat. Replace both plug and receptacle if necessary.

Kilns with Select Fire™

- Inspect the thermocouple for cracks or bends which could cause failure. Check and tighten thermocouple screw connections at the porcelain block. The thermocouple electronic circuitry may drift out of calibration. You can monitor the performance of your kiln with witness cone placed in the kiln. If the controller needs adjustment to fire hotter or cooler you can program a cone fire offset adjustment on the controller.
- Inspect connections at the terminal strip. If any feeder wire or thermocouple connections are loose you can tighten the screws that hold the tabs with the tabs in the most counter-clockwise position possible. If the connectors are loose, do not pinch the female connectors with pliers—instead, replace them. Pinching can distort and minimize the electrical contact area in the connector.
- The EX-1099SF has screw type element connectors at the element ends that may need tightening periodically.

Manual Control Models

- The tube assembly should be inspected and cleaned of any debris in the tube. The sensing rod should move freely in the tube.

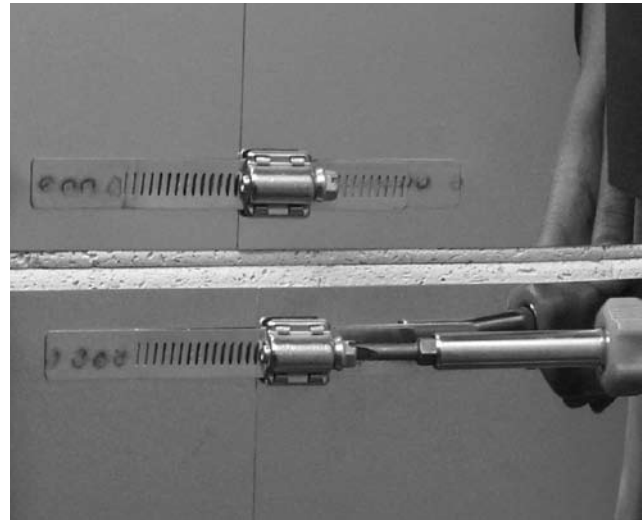
- The sensing rod should be replaced if the tip is worn too thin or otherwise damaged.
- The falling weight and claw adjustments should be checked with the gauge washer periodically.

Tightening the Stainless Steel Bands

This operation should be done while the kiln is cool and at room temperature:

Step 1 – Grasp adjusting screws in one hand with channel locks or a pair of vise grips.

Step 2 – With other hand, Use a large flat screwdriver to tighten adjusting screws.



To make bands extra tight, heat metal bands with a propane torch. Be sure to only heat the metal bands, and not the firebrick. Once the band is heated, retighten screws.

Troubleshooting Your Kiln

Warranty Work

All EXCEL® Kilns come with a Two Year Warranty which covers parts and labor. All warranty claims must be approved and serviced by an Authorized EXCEL® Distributor. If there is not an Authorized EXCEL® Representative in your area, contact AMACO® directly for authorization, however, labor costs will not be covered.

Non-Warranty Work

Once the warranty has expired, many EXCEL® owners prefer to work on their own kilns to save money. We still recommend that you work closely with an AMACO® representative to insure the diagnosis and repair are correct and done safely. There are a number of resources available to help you troubleshoot the problem efficiently and effectively.

Your Local EXCEL® Distributor

Your local EXCEL® Distributor should have a kiln repair technician on staff and replacement parts in stock. This is the best place to start since the call is local and you can often pick up parts the same day.

The AMACO® Factory

AMACO® has a well-trained staff at your disposal for technical support and information Monday through Friday from 7:00 AM to 5:30 PM EST. We will be happy to assist you with installation questions and troubleshooting of technical problems.

Error Codes

Error Codes are designed to protect your kiln and the ware inside your kiln if there is a problem with the firing. In most cases when an error is triggered the kiln will shutoff and display E followed by the Error Code that describes the error that occurred. Non-critical errors will

not stop the firing but they will display a code to notify you of the problem.

The following tables describe the error codes, their probable cause, and recommended solutions. If you run across a code that is not listed or you need help, please give AMACO® or your local distributor a call.

Error Code	Description	Cause	Correction
E- 0	Software Error.	Hardware or electrical noise, electrical spikes, surges, or arcing across the relay	Recheck the selected program and reprogram if necessary.
E- 1	The temperature is increasing less than 12 degrees per hour during a ramp segment, where the temperature is programmed to increase. This slow rate must persist for 22.5 minutes before the error is displayed.	Worn or old heating elements Low voltage to the kiln A broken heating element or faulty relay Burned or broken wires to the elements or relays Electrical noise	Check elements. Check relays. Use VOLT Menu feature to check voltage.
E- 2	During a hold segment the temperature rises to greater than 50 degrees above the hold temperature which was set. The temperature must stay 50 degrees above this set temperature for 18 seconds before the error is displayed.	Stuck relay	If only one section (or relay) remains on then it is a stuck relay. Turn off breaker to shut off power to the kiln. Replace relay.
E- 3	During a hold segment the temperature is more than 50 degrees below the hold temperature which was set. The temperature must stay 50 degrees below this set temperature for 18 seconds before the error is displayed.	Door or lid of the kiln was opened. Relay or element failed during firing.	Check relays. Check elements.
E- 4	The firing is in a ramp segment where the temperature is programmed to decrease and temperature is more than 50 degrees above the previous hold temperature. The temperature must remain 50 degrees above the hold temperature for 18 seconds before the error is displayed. E- 4 is the same as E- 2 except that E- 4 occurs during a ramp phase rather than a HOLD.	Stuck relay Skipped step feature	Check relay. If E- 4 occurs when skipping a ramp phase, press a key to clear the error. Allow the kiln to cool to within 50 degrees of the next hold temperature. Restart kiln and skip steps until you get to the segment you want.
E- 5	The temperature is more than 50 degrees below the local set-point temperature during a ramp segment where the temperature is programmed to decrease. The temperature must stay 50 degrees below this set temperature for 18 seconds before the error is displayed.	Open door or lid Bad elements Bad relay	Check elements. Check relays.

Error Code	Description	Cause	Correction
E- 6	A negative temperature is displayed. This generally indicates the thermocouple is wired incorrectly. To correct this situation, ensure the red and yellow wires are connected correctly to the controller and at all junctions. You can identify the red lead on an unmarked thermocouple with a magnet because a magnet will be attracted to the red lead.	Using the kiln in temperatures below 0°F (17°C) Thermocouple connected backwards (red and yellow leads reversed) Board has been damaged by static electricity or ESD (electro static discharge)	Check thermocouple to make sure it is connected properly. Do thermocouple bypass test. If temperature reading is still negative, the board has been damaged and needs service.
E- 8	When using the CONE FIRE mode, the temperature is decreasing during the last ramp segment. If this a Kiln-Sitter® Kiln using a Wall Mount Controller, Kiln-Sitter® may have shut off the kiln.	Faulty relay Broken element Kiln-Sitter® shut off kiln	Check relay. Check element. Check cone used in Kiln-Sitter®.
PF	Continuous PF in display.	Indicates a long-term power outage and the kiln has been shut down.	Press 1 to clear the display and restart the kiln.
Err P	A continuous Err P indicates a short term power outage has occurred and the kiln has continued with the program.	Power outage Power surge	Press 1 to clear the display. If firing was in progress, it will continue.
Err-	This code indicates there was a power loss to the controller while writing a program to the non-volatile memory chip.	Power loss	Recheck the selected program and reprogram if necessary.
E- E or E- t	A hardware error has been detected by the controller software.	Hardware error	The controller must be returned for service.
E- d	The kiln (or one of the zones in a zone control kiln) is more than 100°F (37°C) above the traveling set point.	Stuck relay	Check relay.
E- A	Invalid program variable.		Reprogram. If problem persists, have board sent in for service.
StUc	Key was held too long or was stuck.		If problem persists after releasing key, have keypad replaced.
E- bd	Controller is reading a board temperature above 160°F (71°C). Firing has stopped.	Room temperature is too hot	Lower room temperature below 100°F (37°C).
E- H	Analog to digital converter did not pass the self-check diagnostic test on reset.		Board will need to be serviced.
FAIL	Steady display indicates thermocouple has failed. If flashing, thermocouple(s) of a zone control kiln has failed.		Change thermocouple.

Select Fire™ FAQ's

How can I correct a value that's been incorrectly typed before pressing Enter?

Clear the display by pressing all zeros, then input the correct number and press **ENTER**. When a cone value has been incorrectly entered the process is slightly different. After pressing **0000**, press **ENTER**. The display will again ask for a preheat value and then a cone value.

How can I change only one value for a RAMP/HOLD firing profile without re-entering the whole program?

Follow the instructions for entering a new program and just press **ENTER** for every value that will remain the same. Make a change in the value that is incorrect, then continue.

How can I change the program after it has already started?

Press the **STOP** key. This will stop the firing. Use either the **CONE FIRE MODE** or **RAMP/HOLD** mode to input the new firing profile for the remaining portion of the firing. Press **START** to resume the firing. The controller will automatically determine where to start the program (based on the current internal temperature) and proceed with the adjusted program.

The kiln shuts off too early.

The kiln can be restarted if the cones on the shelf indicate an under-fired load. (This should be used only if you were present when the kiln shut off.) The cones are no longer accurate if they have cooled much from the time of shut off. To restart follow these steps:

- Press **CONE FIRE** or **RAMP/HOLD** to view the firing just completed.
- Press **ENTER** to accept any of the segments that are correct until the point where the cone number or final firing temperature is requested.
- Program in a hotter cone or higher firing temperature. You could also add a few minutes of hold time at the final firing temperature.
- Press **START** after the reprogramming is complete. The kiln will begin firing based on current temperature and will fire to completion using the newly programmed data.
- Helpful hint: If the firing is just slightly under fired, program five minutes of hold time at the final firing temperature. This will allow the sections of the kiln that are somewhat cooler to catch up to the hotter sections.

The kiln displays CPLt but the kiln won't cool off.

Check the elements to see if any are still glowing inside the kiln. If a whole section of the kiln is glowing, a relay is stuck. Unplug the kiln and contact your distributor for further information.

At night I see a blue flash coming out of the control box when it clicks. Is it serious?

The flash occurs when the contacts open causing a small arc. This is a normal occurrence and should not be a concern.

I programmed a RAMP/HOLD profile and when I pressed Start, the alarm sounded.

Review the program to ensure that all segments of the profile have a value entered. Also, check the alarm to see if a value has been entered that is lower than the room temperature. The default setting for no alarm to sound is **9999**.

The kiln is plugged in, but there is nothing on the display.

First check your circuit breaker to ensure it has not tripped. If the circuit breaker is okay, check the fuse. The fuse is located on the bottom of the Select Fire™ Wall Mount Controller and on the lower left side of the kiln mounted controller. Turn the knob a quarter turn counter-clockwise to remove the fuse. Check the fuse wire, and if broken, replace the fuse. If the fuse is smoky, replace it. After the fuse is replaced, if the new fuse blows, check for other possible causes. A blown fuse may be caused by a short in the circuit or a power surge.

Some segments of the display are dimmer than others.

When a few segments of the LED-display become dimmer than the others, the problem may be the result of age, indicating the circuit board may soon fail. Another possible cause is exposure of the controller to high heat. This situation needs attention. Do not use the kiln when this problem is present. Contact your EXCEL® distributor.

The thermocouple is flaking.

Flaking is normal with Type K thermocouples, especially when high fired. Use a soft bristle toothbrush to remove the flakes and vacuum them from the kiln so they do not attach to your ware. Remove the thermocouple element periodically and check it for thinning.

The end firing temperature is different now than when I first got my kiln and the results do not seem quite right. What should I do?

After about 50 Cone 6 firings, or 150 Cone 04 firings, it is necessary to replace the thermocouple element. When the temperature seems to drift, it is an indication that the thermocouple is becoming thinner and wearing out. Another possibility is a cone correlation difference. As elements age it takes longer and longer for the kiln to reach temperature. Cone Fire Mode programs will automatically lower the ending temperature to compensate for the added heat work induced by the increased time.

I pressed a number but the new cone number is not displayed.

Be sure the power is on and the touchpad is active. After entering new values for any step in programming, it is necessary to press **ENTER**.

Select Fire™ Display Messages

Messages displayed while accessing menu functions are described in the menu section of the manual. They are not listed below.

Primary Display Messages

ALRM

The controller is asking for an alarm temperature to be entered between 0° and 9999° that will alert the operator to take action.

CONE

The kiln is in CONE FIRE MODE and needs the operator to input an appropriate Cone value from 022 to 10.

CPLt

The controller has completed a firing profile. The firing time in hours and minutes is displayed along with the current internal temperature of the kiln. Press **ENTER** to return to Idle Mode.

dELA

This is a prompt to enter a time in hours and minutes to delay the firing before starting the program. Enter a time or all zeros for no delay.

E-##

A software error has occurred. Press any key to display the elapsed firing time and the temperature when the error occurred. Consult section on Error Codes for troubleshooting information.

F1, F2, F3, F4, F5, F6, F7 or F8

The controller is in RAMP/HOLD mode. The user needs to input an end temperature in °F or °C for **each** segment of the firing profile.

FAIL

The thermocouple and controller are not properly connected. Fix the connection, then press **ENTER** to display the kiln's current temperature. Press Start after the connection is fixed. The thermocouple could be damaged. Check the connections, if still no luck you may need a new thermocouple.

HOLd

Indicates a holding time in hours and minutes at the end of a CONE FIRE program.

HLd1, HLd2, HLd3, HLd4, HLd5, HLd6, HLd7 or HLd8

The controller is in RAMP/HOLD programming mode. The user needs to input a period of time in hours and minutes that the controller should maintain for **each** segment of the firing profile.

-ON-

Briefly displayed at the beginning of firing to indicate that the kiln has started.

PROG

A prompt at the beginning of a RAMP/HOLD program which allows the user to select a stored program.

RA1, RA2, RA3, RA4, RA5, RA6, RA7 or RA8

The controller is in RAMP/HOLD programming mode. The user needs to input an appropriate temperature in °F/hr or °C/hr for each segment in the profile.

SEGS

(Looks like SE65) The controller is in RAMP/HOLD mode. The user needs to Input the number of segments in the profile being programmed.

SKIP

Short for Skip Step. Can be selected during a RAMP/HOLD program when one feels that adequate heatwork has been done in the current segment. Immediately advances the program to the next segment.

SPd

The controller is in CONE FIRE MODE. The user needs to Input the appropriate speed; slow, medium or fast for this firing.

STOP

Designates the intentional termination of a program while in operation.

WAIT

Displays at the time the kiln is initially powered up. Wait for the display to return to Idle Mode.

Miscellaneous Display Messages

Flashing temperature and IdLE

The kiln is in IdLE Mode. The kiln is off and the display is showing the kiln's current temperature.

Alternating display of time and temperature

The kiln is in a RAMP/HOLD firing profile and is in the soak stage. The display is indicating the kiln's internal temperature and the remaining Hold time for that segment.

Decreasing time

The kiln is in a Delay start segment of a CONE FIRE or RAMP/HOLD mode. The display is showing the remaining time before the kiln starts to heat.

Steady temperature

The kiln is in the ramping stage of either a CONE FIRE or RAMP/HOLD fire profile.

Decimal point between 10's and 100's

Hours are to the left of the decimal and minutes are to the right.

Right hand decimal point on

Kiln is operating in Celsius temperature scale. To change back to Fahrenheit temperature scale consult the MENU Options.

Manual Kiln Operation

Preparation

Remove any brick chips or other foreign matter from around the elements. Bits of bisque and glaze will eat through elements and our warranty cannot cover such accidents. We recommend that you vacuum the inside of the kiln to remove any dust that accumulated during shipment.

Wipe all new shelves clean and apply two coats of AMACO® Kiln Shelf Wash to one side of each shelf. Apply a thin coating of Kiln Shelf Wash in one direction and allow to dry. Apply another thin coating in the opposite direction leaving a ½" margin from the outside edge of the shelf. A new coat is seldom needed—just spot-patch and sand off the surface evenly with coarse sandpaper wrapped around a wooden block. A fresh coat may be needed before a porcelain firing if glaze has dripped onto the shelf.

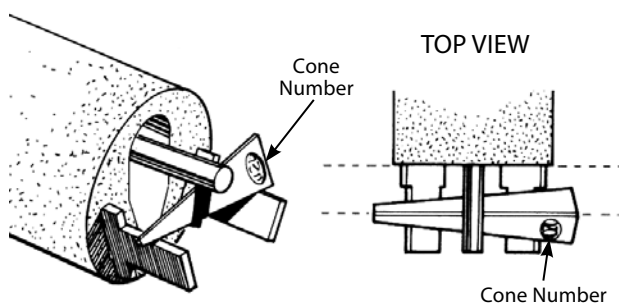
If your kiln is fitted with a Dawson® Kiln-Sitter®/Limit Timer, it has a manual cone operated shut-off system and infinite control switches.

Test Fire

Once appropriately installed, the kiln is ready for the test fire. Test firing is important to operation of the kiln as it will help to identify any installation errors that may have occurred, burn off the protective coating on the elements, and properly oxidize them to maximize their life.

1. Remove the firing gauge on the tube assembly located inside the kiln.
2. Mix a small amount of AMACO® Kiln Shelf Wash and apply a thin coat to the cone rests and the sensing rod. Do not apply wash to the end of the porcelain tube. Allow the kiln wash to dry thoroughly. Do not allow the kiln wash to accumulate.

3. Raise the weight up against the guide plate.
4. Press the claw down lightly until it engages the trigger.
5. While holding the claw down, carefully place a cone flat on the cone supports with the inside edge of the number circle even with the outside edge of the cone support. The large part of the cone should rest against the metal step of the cone support with the center of the cone parallel with the end of the tube.



CAUTION: Since the softening and bending of the cone shuts off the kiln, correct positioning of the cone is critical to proper firing. IF CONE IS DISLODGED BY ACCIDENT OR ALLOWED TO COME INTO CONTACT WITH THE PORCELAIN TUBE, AN OVER-FIRING MAY RESULT WHICH COULD CAUSE SERIOUS DAMAGE TO YOUR KILN.

The cone now holds the claw engaged so that the weight is supported and your hands are free. You are now ready to close the kiln and begin to test fire.

Note: In a new kiln, often the first few firings may be accompanied by odors of paint components and moisture from firebrick. During normal firings, moisture and gasses are driven off by the heat and carry a distinct odor from the kiln. In addition, in natural clays there are often impurities which may smoke or give off odors. The best remedy for these odors is good ventilation in your kiln room.

Temperature Indicators

Pyrometric Cones

Pyrometric cones should be used during every firing whether or not your kiln is equipped with a pyrometer or automatic cutoff. They deform progressively under advancing heat and serve as accurate indicators of firing chamber temperatures, rate of firing, atmospheric conditions, etc. Each pyramidal shaped cone is numbered, and will melt or deform at a given temperature. For general use, the tempera-



ture ranges from Cone 022 (1094°F, 590°C) to Cone 10 (2381°F, 1305°C) are sufficient.

Cones are selected in relation to the maturing temperature of the clay or glaze you are firing. Usually three cones are used for each firing—a guide cone to deform at one cone number cooler than the target temperature (A), a firing cone to deform at the cone number for the exact maturing temperature, of the clay or glaze (B), and a guard cone to deform at one cone



number higher (C). The guide cone (A) bends first and warns that the maturing temperature approaches. When the firing cone (B) bends halfway down, the kiln should be turned off. If the guard cone (C) bends, the kiln is too hot and the pieces in the kiln could be overfired.

A cone support for holding the cones is shaped of moist clay with the same or higher maturing temperature than the clay or glaze which you plan to fire. The bases of the cones are cut at an angle to guide you in placing them at the proper 80° angle. Set them in a row so they lean toward the lowest temperature cone. Embed them just enough to hold them securely, yet permit the numbers to show. AMACO® cone plaques or self standing Orton® cones are best. A clay support must be thoroughly dry before placing it in the kiln. Make cone supports up ahead of time to allow for drying. Never use cones with broken tips. Place the cones in the kiln so they can be seen easily through the peephole. Also available are reusable wire cone holders and ceramic cone holders.

Fortunately, with today's Kiln-Sitter® devices and Junior cones, three-cone firing is rarely necessary. However, always placing a single Senior firing cone at Kiln-Sitter® level is inexpensive insurance against inadvertent under-firing.

At higher temperatures, cones can be hard to see. Viewing through dark glasses helps. As an added measure, keep ware as far back from cones as possible.

Junior Cones and the Kiln-Sitter®

Junior cones are not simply miniature Senior cones. They are designed to bend under the weight of the Kiln-Sitter® sensing rod. Don't expect acceptable results using a Senior Cone in the Kiln-Sitter®. The Junior's shorter length and greater compaction make it stand longer than a Senior if placed on end, but when used horizontally in Kiln-Sitter®, the Junior will bend at approximately the same time as a Senior standing.

Because electrical power and kiln location vary, keep a complete record of every firing. You may find that you get better results with a Junior cone one step hotter than your Senior cone—that is, a Cone 6 firing may come out better with a Junior 7. If you keep accurate records, you can modify your technique to give the best results.



Pyrometers

A properly installed pyrometer indicates the firing chamber temperatures on a dial. It is not set at zero, but reads approximately room temperature. Legible markings appear every 50° on the temperature scale, making it easy to check the firing speed.

Also, a pyrometer warns that the maturing temperature approaches so you can check the pyrometric cones in the firing chamber, and thus prevent over-firing.

Check a pyrometer occasionally with cones to see if it is indicating properly. After lengthy use, if the pyrometer fails to indicate temperatures, examine the thermocouple. If a break is found in the wires, a new thermocouple must be installed.

To install a thermocouple, connect the red lead wire to the negative terminal and the other wire to the positive terminal of the pyrometer. Adjustments can be made on most models by the small screw on the lower face of the instrument dial. Be sure the pyrometer reads the same as room temperature.

To test a newly installed thermocouple, touch a lighted match to the welded tip. The needle should register an increase in temperature. If the needle moves in the opposite direction, simply reverse terminal connections.

Kiln-Sitter®

The Kiln-Sitter® is a mechanical cut-off device. A junior-size cone mounted horizontally in the kiln, bends when the maturing temperature of the cone is attained, releasing a weighted trigger which shuts off the kiln. The Kiln-Sitter® is designed to use only Junior Cones.

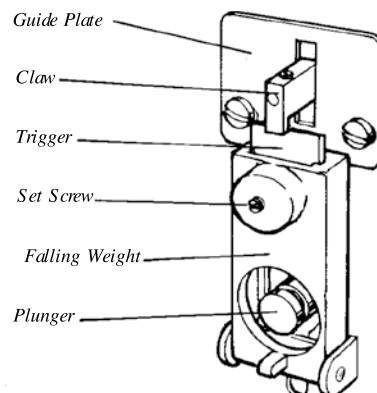


The limit timer is simply a clock mechanism which you set for a time slightly longer than your anticipated firing. By keeping an accurate record of every firing, you will soon be able to estimate the length of a firing to within a half hour or less. Then, should anything go wrong with your Kiln-Sitter®, the limit timer will turn off the kiln before over-firing can do damage.

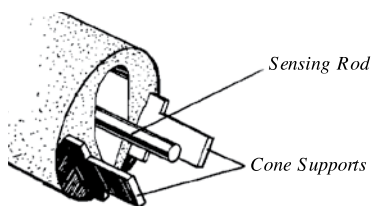
CAUTION: Automatic cut-off devices must be carefully checked and properly installed. Report any malfunction to instrument manufacturer. Since AMACO® does not manufacture these instruments, the company disclaims any liability for operational failure or resulting damage.

IMPORTANT! You must adjust and test your Kiln-Sitter® on your new or repaired kiln. As good as your Kiln-Sitter® is, you must calibrate and test it before you trust your ware solely to its control. Here's what you should do before the first firing and periodically to keep the Kiln-Sitter® in adjustment:

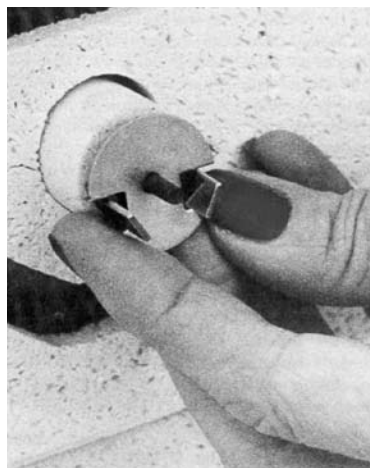
1. Turn switches off.
2. Install the firing gauge. This metal gauge fits over the sensing rod and cone supports, positioning the rod as it should be when the Kiln-Sitter® is properly adjusted.
3. Check the clearance of the trigger



and release the claw. The trigger should just clear the release claw. If it strikes the claw, or has more than a few thousandths of an inch clearance, adjust the trigger height by loosening the trigger set screw. Tighten firmly when you are finished, because repeated falling can cause the trigger plate to jar out of adjustment.

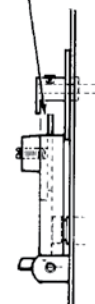


4. Check the travel of the sensing rod. Remove and save your metal firing gauge. Move the sensing rod up and down. It should travel freely without touching the sides of its tube. On the outside of the kiln, the claw should move freely within the guide plate. If there is interference, loosen the guide plate screws, and center its slot so the rod and claw move freely. Tighten screws.

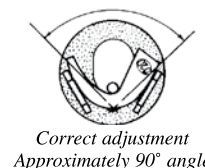
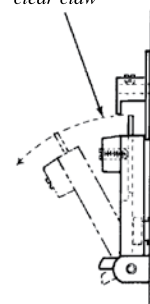


5. Make the "2 o'clock" test. To be sure your falling weight causes the plunger to pop out, press the plunger in, raise the weight to about the "2 o'clock" position, and drop it. It should cleanly trip the plunger out.

Set claw $\frac{1}{16}$ " from trigger



Set trigger to just clear claw



Additional Kiln-Sitter® Notes

Your Kiln-Sitter® is now calibrated and working properly. For trouble free operation, just remember these points:

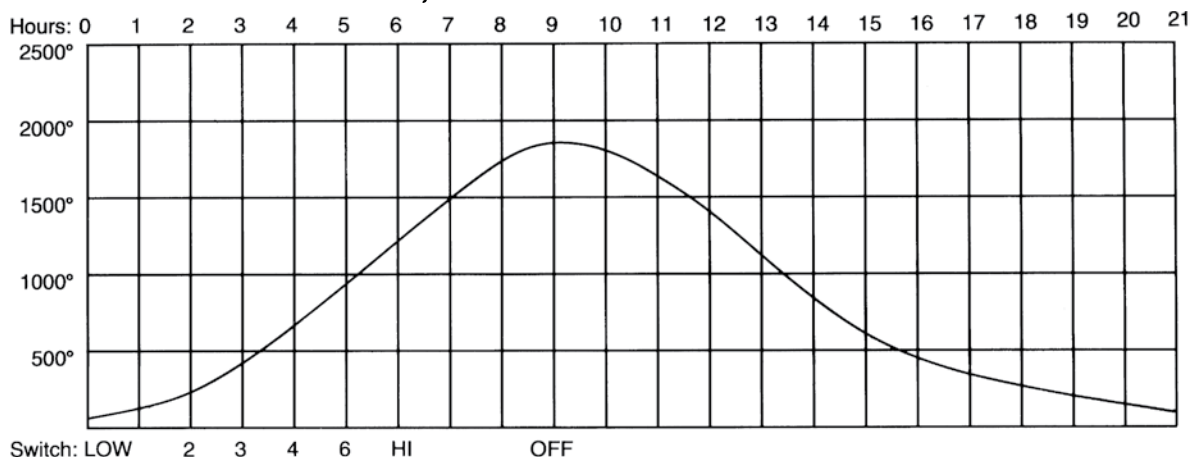
1. Never lubricate your Kiln-Sitter®. Oils will gum up the works.
2. Keep foreign objects out of the Kiln-Sitter® tubes. Bits of ware or debris can stop the sensing rod from dropping. Check frequently.
3. Keep a light coat of kiln wash on the cone support and sensing rod surfaces. This will be explained under the First Firing section.
4. Replace bent cone supports or sensing rods. After repeated firings, these may bend. For best firing accuracy, replace them when they look distorted.
5. Use only Junior cones, properly positioned as described in the Test Firing section. Tips from Senior cones will not work. After a firing, the cone should show about a 90° bend (see diagram above). Much more or less bend is a sign of incorrect adjustment, and will cause over or under-firing.

Suggested Firing Schedules

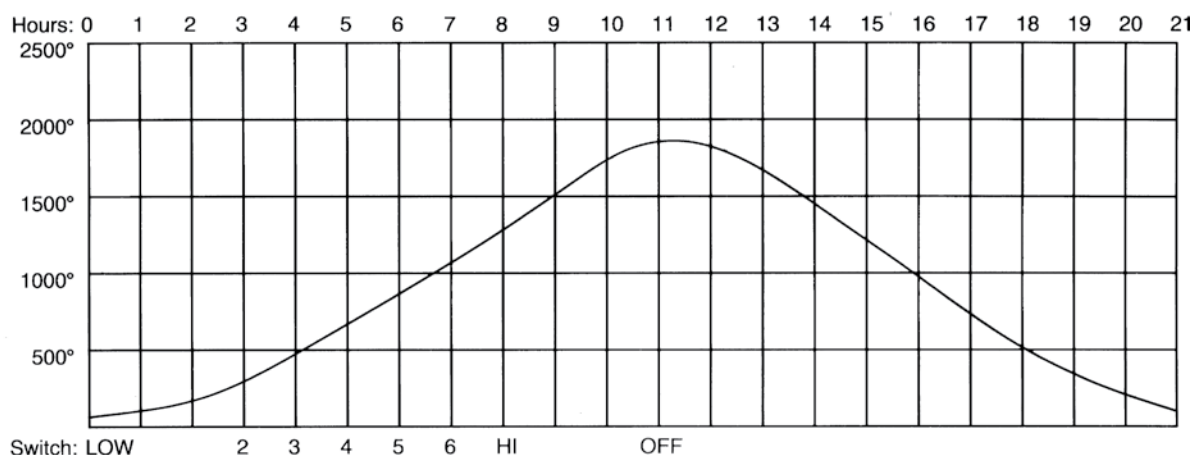
The following charts are suggested firing schedules. They vary according to the amount of ware, the dryness of ware, the way the ware is stacked, and the amount of actual voltage the kiln receives. Keep an accurate log

of firings, the time, switch adjustments made during the firing, and the results. This will help you adjust your firing schedule.

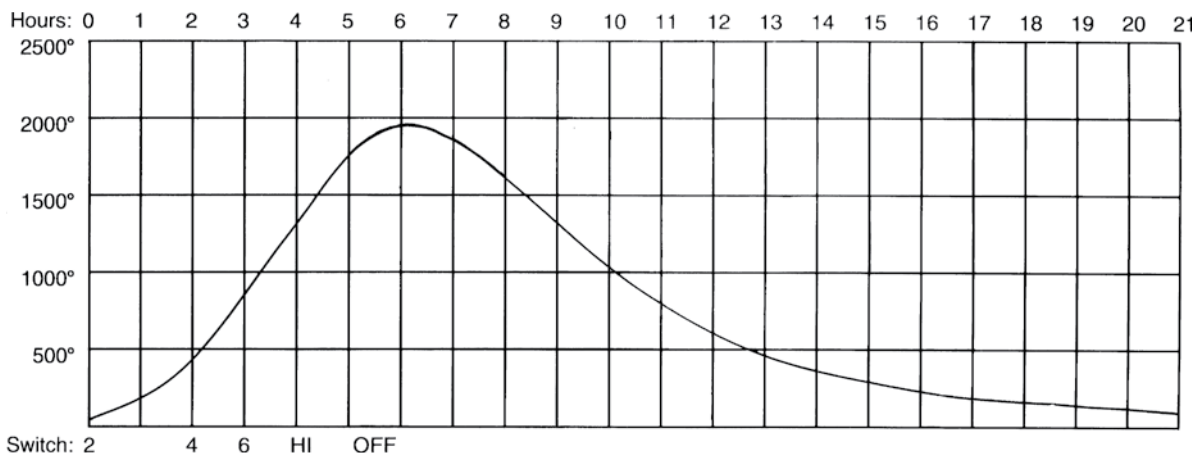
***06 BISQUE — Vent lid for first hour, then close.**



***06 BISQUE HEAVY PIECES — Vent lid for first hour, then close.**

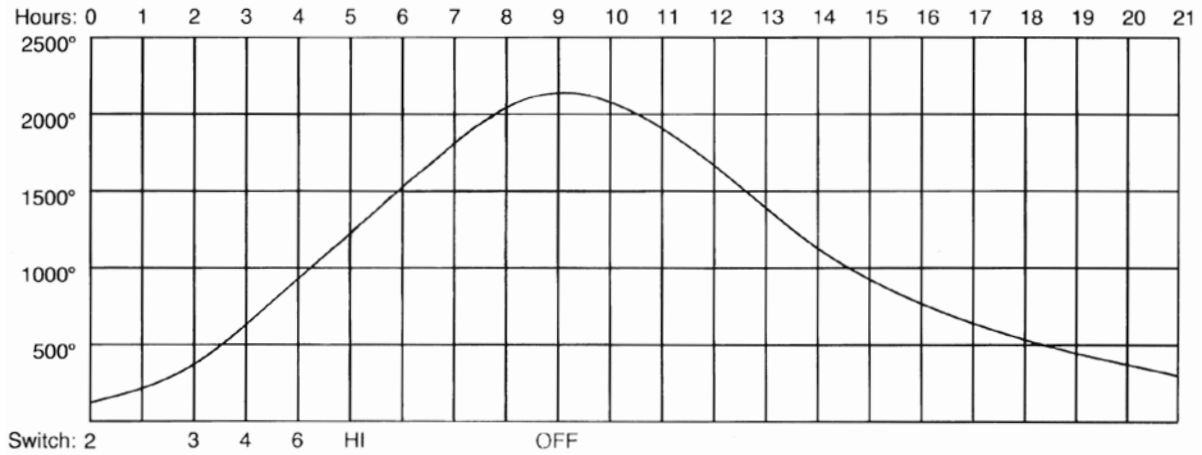


***06 GLAZE, FAST FIRE — When firing 05-06 red glazes or other bright colors, it is suggested to leave the peephole plugs out.**

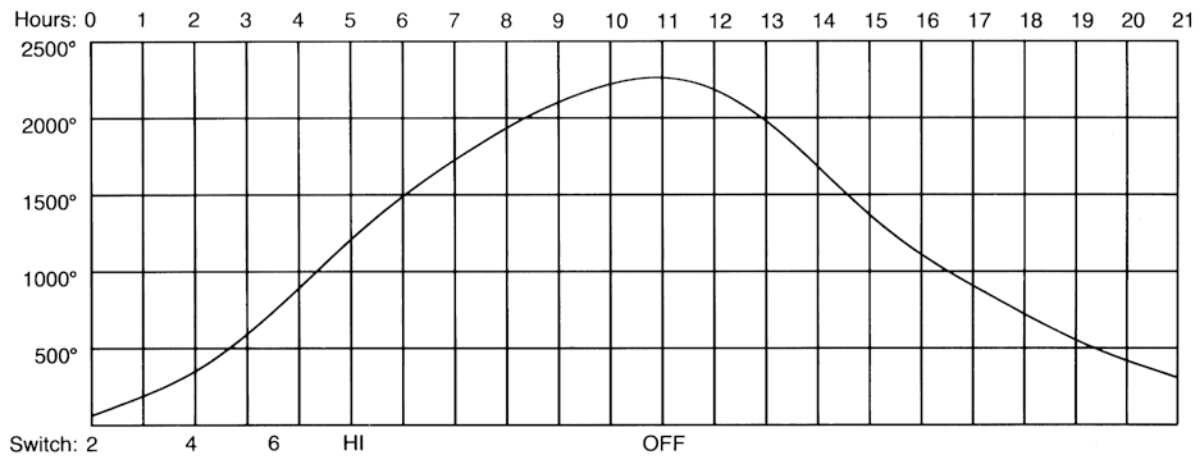


* Peephole plugs may be placed into peepholes when the kiln begins to glow a dark red, approximately 1000°F.

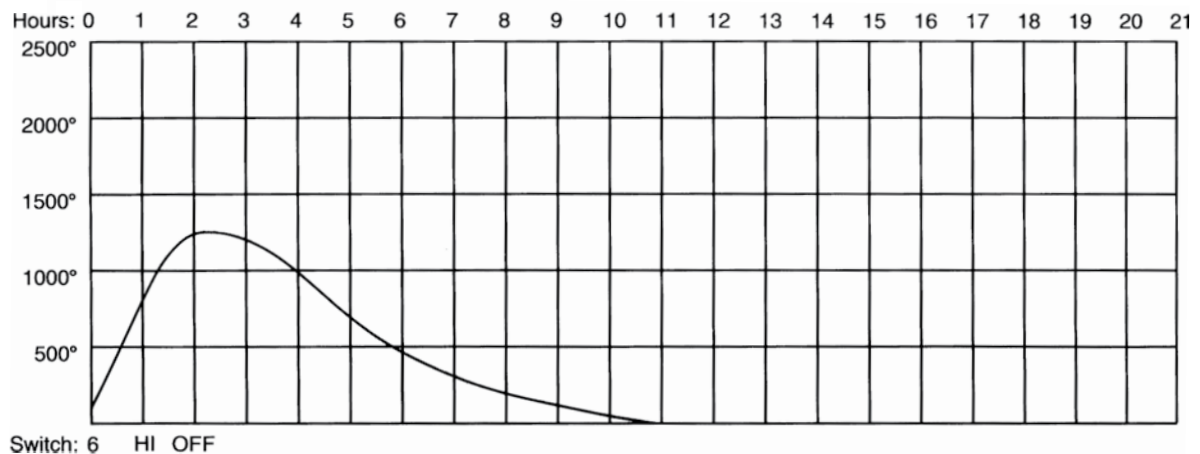
***6 GLAZE, SLOW FIRE** — When firing 05-06 red glazes or other bright colors, it is suggested to leave the peephole plugs out.



***9-10 GLAZE**



OVERGLAZES — Vent lid slightly for entire firing — **DO NOT** put in peephole plugs.



* Peephole plugs may be placed into peepholes when the kiln begins to glow a dark red, approximately 1000°F.

Troubleshooting Guide for Manually Operated Kilns

Your EXCEL® kiln is put under heavy load as it heats and cools. Like any electro-mechanical device, it may show signs of wear. For most home hobbyists, electrical work can be both confusing and dangerous. If this listing points to internal electrical trouble, we recommend you contact your EXCEL® dealer.

Kiln-Sitter®

Kiln-Sitter® consistently over or under-firing compared to a Senior check cone at Kiln-Sitter® level.

1. Check Kiln-Sitter® adjustments, page 32.
2. Bent Junior cones from Kiln-Sitter® deeply cracked across lower faces, indicating moisture problems. Buy new cones.

Consistently firing too hot or too cool in one section.

Adjust infinite switch higher or lower on Medium and High settings to compensate.

Occasional over-firing.

1. Sensing rod not accurately centered between cone rests.
2. Falling weight mounting bracket bent so weight rubs against it. Adjust per pages 32-33.
3. Overglaze oils or organic matter from native clays accumulated on inner face of guide plate. Remove plate, clean with lacquer thinner. Never plug top peephole. Vent lid longer if necessary.

Senior check cone over-fired, but Junior Kiln-Sitter® cone only normally bent.

1. Use magnifying glass to double-check numbers of both fired cones.
2. Cone drop anomalies can happen if the kiln takes more than 11 hours to reach temperature with all switches on high. Element replacement might be required—contact EXCEL® Technical Support.

Kiln found with weight fallen but pilot light and all elements still on. Cones over-fired.

1. Turn switches off. Protect hands with gloves. While kiln is still hot, perform 2 o'clock drop test, page 33, fifty times. Repeat when cooled. If plunger is released every time, you either forgot to latch the weight up when setting the cone, or the fall was impeded by the power cord or another obstruction.
2. If any cleanly made 2 o'clock drop fails to release the plunger, contact your EXCEL® dealer.

Electrical

Irregular clicking noises from models equipped with Infinite Control Switches.

Normal. These switches constantly cycle on and off at all settings other than High.

Elements hum at first, later do not.

Normal. Kanthal-type elements are magnetic only up to red heat. Humming then ceases.

Fuse blows or breaker trips more than one minute after switching to High.

1. Fuse/breaker and wire sizes improper for the kiln. See page 6.
2. Other loads on same circuit.
3. Poor quality fuses or fuses loosely screwed in sockets.
4. Tarnished or loose connections at a breaker or fuse socket. This can increase the temperature of either device, causing unwarranted interruptions. Have the circuit and breaker/fuse box checked by a qualified electrician.

Note: Your kiln will not draw more power as it ages. Aging elements can only draw less power.

Fuse blows or breaker trips almost immediately after switching to High.

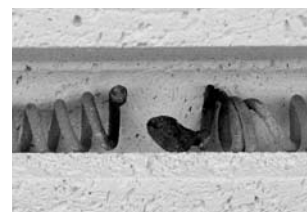
1. Examine cord and plug for breaks.
2. Have the circuit and breaker/fuse box checked by a qualified electrician.

Power interrupted during firing, kiln is still hot.

1. If still in venting stages, re-fire as if a fresh load, using original cones.
2. If venting is completed and you know the load was never within one hour of shut-off, resume firing with the same cones, and re-fire as usual, except that the lid can be left closed throughout.

Abrupt increase in firing time.

1. Check your Senior cone and shut off kiln manually if it is down. Check Kiln-Sitter® thoroughly as outlined on pages 32-33.
2. If your Senior visual cone is still standing and you're sure that it has the right number, check the fuses or breakers. If temperature then begins to rise, complete firing as usual.
3. One section not heating may mean an element has failed. When the kiln is cool, visually inspect each element for breaks. See page 38 for element replacement.
4. If no elements appear to be broken in a section that fails to heat, contact EXCEL® Technical Support.
5. If all sections are operating and firing time problems persist, ask your power company to perform a voltage test at your wall outlet with all elements on High.



Gradually increasing firing times, often accompanied by increasingly uneven temperatures within the kiln.

1. Circuit or wall receptacle is defective. Have them checked by a qualified electrician.
2. Kiln switch box connections need tightening. Contact EXCEL® Technical Support for instructions specific to your kiln model.
3. Power supply problems. Power can fluctuate during peak hours—contact your local power company or a qualified electrician.

Precautions and Maintenance Tips to Ensure Years of Trouble-Free Service

If properly cared for and fired an EXCEL® kiln will last for many years with very little maintenance but there are a few tasks that should be done regularly to ensure the kiln runs safely and effectively.

- Your kiln should only be used in well ventilated areas.
- Do not allow glaze or kiln wash to come in contact with heating elements.
- Before each firing, brush bottom of kiln shelves and underside of the kiln lid with a soft brush.
- After each bisque firing, vacuum out the element grooves, and bottom of the kiln to remove dust and stray pieces of bisque that may have broken during firing. These pieces can get caught in the elements and cause them to overheat at that point.
- Periodically check your kiln shelves for cracks that run through the entire shelf. When the shelves have become this damaged it is not recommended to use them.
- Element wire will increase in length with extended use and the coils will begin to move out of the grooves.

The wire is brittle after the first fire and should not be moved or bumped when cold. Heat kiln up until red heat (elements glow orange) for 10 minutes, disengage the power, then gently push the wire back into the grooves with a wooden tool.

- The more the kiln is fired the less efficient the elements in the kiln will become. Elements in your kiln are a wear-able part and will need to be replaced over time. If one element has burned out from age it is a good indication that the others will soon follow. When this happens replace all elements in the kiln.
- Small cracks will appear in the soft brick of the kiln walls over time. This is to be expected and will not affect the operation of the kiln.
- If it is a manual style kiln equipped with Kiln-Sitter®/ Limit Timer, scrape the kiln wash off the sensing rod and the cone supports and reapply every three to four firings to keep the cone from sticking to the sensing rod and over firing.
- Check that all electrical connections are tight and remove any oxidation that has formed on the wires or connectors.
- If it is necessary to lean over kiln while loading, be careful not to place pressure on the top inside edge of the brick. The brick is extremely fragile due to its insulating ability and can be cracked or broken easily if one's body weight is pressed against it.
- Approximately once a month, spin all switches seven times counterclockwise and seven times clockwise. This will help to keep switch contacts clean and operating properly.
- You may wish to place a kiln shelf on the base of the kiln supported by 1" posts to protect the base.

Repairs

Fortunately, your EXCEL® kiln will give you few occasions to refer to this section. But if you are not mechanically inclined, call an authorized service person, competent small appliance repairman, or other electrician. Take this owner's manual along with you. To transport your kiln, handle sections by their outer edges, and place them on a flat surface, cushioned by folded blankets.

Removing and Replacing Elements

1. Disconnect power plug from the wall.
2. Remove the screws holding the switch box on the kiln.
3. With the switch box held or pushed to one side, remove lug connectors. Select Fire™ models only: Switch box is hinged on the side. Swing the box out away from the kiln.
4. To avoid errors, work with one coil at a time. Carefully remove the lug connectors attached to the defective element.
5. Pull the twisted terminal through the kiln wall and into the firing chamber.

6. Using needle-nose pliers, remove the element staples and carefully pull the coil out of the brick groove, removing it from the kiln.



7. Inspect the element grooves, brushing out all dirt. Carefully chip away any molten material which can come in contact with the new element. Should it be necessary to ensure that the channel is clear of foreign materials, small sections of the groove may be removed without impairment to your kiln.

8. To install the new EXCEL® coil, pass the end of the coil through the kiln wall to the outside of the kiln.

9. Thread the coil around the kiln, pushing it carefully into the groove, and push the second terminal through the outer hole in the wall. Make sure the coil is resting securely in the groove and replace the element pins.

10. Cut off excess terminal wire outside of the wall, leaving sufficient wire to replace the terminal lug.

11. It is sometimes useful to strip back the insulation on the jumper wire so that it may be doubled back against itself before insertion into the lug. This will provide for a greater contact surface with the element terminal in the connection. **Note: The need to establish an absolutely tight connection cannot be over emphasized.**

12. Before fastening switch box to kiln, carefully push wires into the front corners of the switch box. Avoid contact between wires and kiln.

13. Replace element staples in corners of bricks.

CAUTION: Elements become very brittle after a few firings, so if straightening is necessary, heat the element

electrically to visible redness, unplug the kiln from the wall and immediately push the element back into position with a wooden implement, reheating whenever stiffening is detected. Place your hanging pins in a straight row and the element will serve the rest of its normal life.

Replacing Thermocouple (EXCEL® Kilns with Select Fire™ Only)

Kiln Mount Model

1. Remove the screws that secure the control panel to the kiln.
2. Swing the box open.
3. The thermocouple has a yellow, cloth wrapped lead wire attached to the terminal strip with slide on connectors marked with positive (+) and negative (-). Slide the connectors off.
4. Remove the two screws that hold the thermocouple terminal block onto the heat shield.
5. Gently pull the thermocouple assembly out of the brick.
6. Loosen the two screws that hold the thermocouple element in place and remove it from the thermocouple block.
7. Insert the new thermocouple in the same, careful manner.
8. Reattach to terminal block onto the heat shield with the two screws.
9. Reconnect the thermocouple lead wire to the terminal strip, matching the positive and negative markings.
10. Close the box.
11. Replace the screws.

Wall Mount Model

1. Gently pull the thermocouple out of the kiln.
2. Unplug the thermocouple from the receptacle at the end of the yellow wire.
3. Plug the new thermocouple into the receptacle.
4. Replace the thermocouple using the same care as when it was removed.

Select Fire™ Wall Mount Repairs

The Select Fire™ Wall Mount controller is made of solid-state parts that are not user serviceable. If repairs are necessary, contact EXCEL® Technical Services at (800) 374-1600 for instructions on how to return your unit for repair.

Brick, Floor, or Lid Repairs

Please contact your EXCEL® dealer or EXCEL® Technical Services at (800) 374-1600 for assistance with refractory repair.

Important: If you ever have the need to ship your EXCEL® Kiln, call EXCEL® Technical Support for packing instructions.

Set Up the EXCEL® EX-1099SF Kiln

The EXCEL® EX-1099SF is a heavy duty, high capacity unit designed to meet the needs of the high fire production potter, tile maker, and light industrial user. This kiln is equipped with components and wiring that will allow it to high fire extremely dense loads in a relatively short time.



Firing

The EXCEL® EX-1099SF kiln features the Select Fire™ controller as standard equipment so operation is identical to other EXCEL® Kilns with Select Fire™. Even though the earlier sections of this manual do not refer specifically to the EX-1099SF, you may follow all the instructions on programming and firing routines.

Kiln Improvements

If you are an extensive kiln user, you might find the EX-1099SF to be the appropriate choice for your next kiln purchase. Here are some of the differences from our standard kiln line:

- The EX-1099SF is designed to fire full Cone 10 loads without stalling on the high end. To do so, it is equipped with industrial gauge wiring and three types of elements for better firing balance. Because of its high rating, electrical codes require the EX-1099SF be direct wired by an electrician; therefore no plug is included.
- Mercury displacement relays are used for longer life and quieter operation.
- The hinged control box is larger, and compression connectors are used on the feeder wires for easier element replacement.

Unpacking and Moving the EX-1099SF Kiln

Follow the general instructions on kiln set-up found in this manual. You will probably want to separate the kiln into sections when you set it up or move it to a different location. These instructions are slightly different than for standard Select Fire® kilns.

CAUTION: Before disassembling the EX-1099SF kiln, be sure to turn off power to the kiln by throwing the circuit breaker or removing the fuse on its circuit. Do not restore power to the kiln until it is fully reassembled.

Note: The mercury relays in the switch box must be operated only with the switch box in a normal, vertical orientation.

Set Up the EXCEL® EX-1850SF Kiln

The EX-1850SF will be packed in three separate boxes which will include the following:

Box 1 - EX-1850SF Kiln

Box 2 - 3-Piece Fiber Slab Insert, (12) 1 inch (2.54 centimeter) Posts

Box 3 - 2-Piece Kiln Stand, Lid Prop, (6) Peephole Plugs, Operating Manual, Warranty Card, (12) Plastic Stand Feet



Follow the general instructions on kiln set-up in the Set-up section of this manual. There are three main differences that should be noted when setting up the EX-1850SF:

- Due to the weight of the EX-1850SF you will want to separate the kiln into sections when you set it up.
- The EX-1850SF has two stands that fit together for greater support. Place the stands flush together
- The EX-1850SF includes a three piece rigid fiber liner that fits inside the bottom section on top of the slab. There are holes cast in the liner which hold the 1 inch (2.54 centimeter) ceramic posts. Carefully lay the fiber insert on top of the slab after the first section is placed in position and insert the posts.

CAUTION: Before disassembling the EX-1850SF kiln, be sure to turn off power to the kiln by throwing the circuit breaker or removing the fuse on its circuit. Do not restore power to the kiln until it is fully reassembled.

Disassembling Multi-Section Kilns

Always Unplug a Kiln before Disassembly

Step 1 - Remove lid by disengaging the hinge system. If equipped, with EZ-Lift, see page 11.

Step 2 - Remove the screws from the left side of the control box that secure the box to the kiln and swing the panel to the side.

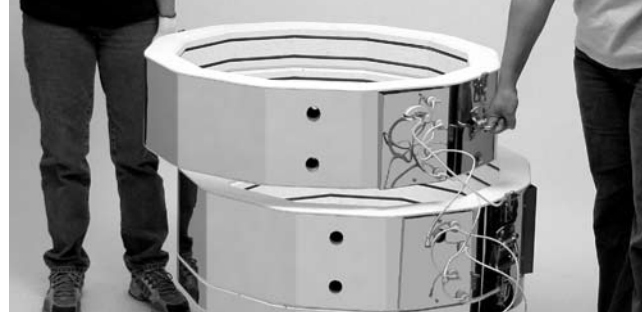
Step 3 - Disconnect the numbered feeder and thermocouple wires from the terminal strip.

Step 4 - Lift the control box up to remove it from the hinges and set it on a clean flat surface.



Step 5 - Unbuckle the draw-pull catches between each section.

Step 6 - Lift each section using the section handles and place on a flat clean surface.



Disassembling the EXCEL® 1099SF Kiln

Step 1 - Refer to page 11—*Removing the EZ-Lift*, and follow instructions to remove the EZ-Lift and lid assembly.

Step 2 - Remove the screws from the side of the control box and swing the panel to the side.

Step 3 - Number the feeder wires using tape so you can remember where they will be reconnected.

Step 4 - Loosen the terminal block lugs that hold the

feeder wires. These are located on the fiberglass lined heat baffle. Remove wires from the three terminal blocks.

Step 5 - Slide the thermocouple connectors off the terminal strip.

Step 6 - Lift the control box up and remove it.

Step 7 - Unhook the draw pull catches and lift the sections using the handles provided.

Disassembling the EXCEL® 1850SF Kiln

Step 1 - Refer to page 11—*Removing the EZ-Lift*, and follow instructions to remove the EZ-Lift and lid assembly.

Step 2 - Remove the screws from the left side of the control box and swing the panel to the side.

Step 3 - Remove the screws holding the feeder wires to the two pole blocks on the heat baffle. There are three sets with two feeder wires going to each set.

Step 4 - Remove the thermocouple wires from the terminal strip located on the baffle. They are attached with slide-on connectors and should be pulled straight off—pulling at an angle can damage the connector.

Step 5 - Lift the control box up and set it aside.

Step 6 - Unhook the draw pull catches and lift the sections using the handles provided.

Heatwork

Heatwork is the measurement of the effects of time and temperature. In ceramics, this measurement is gauged through the use of Pyrometric Cones. They are composed of materials which are carefully measured and compressed into the shape of a tetrahedron. The cones are placed in the kiln on a shelf with your ware, and when they have received the proper amount of heatwork, they bend over indicating that it is time to turn off the kiln.



Pyrometric Cones come in a variety of shapes and sizes. Each size and shape has a different temperature chart associated with it. The chart below is based on a Large Self-Supporting Cone and has become the standard for commercial clay bodies, glazes, and controller software.

All clay bodies and glazes are designed to fire to a certain cone value. In a kiln with Select Fire™ the computer calculates the heatwork and shuts the kiln off at the proper heat and time combination. This is called Cone Correlation. Cone Fire Mode programs all are controlled by Cone Correlation, Ramp/Hold Programs are not. EXCEL® Kilns are designed to fire a range of cone values from 022 to 10. As you can see by the chart at right, the temperature associated with each cone value gradually increases from 022 to 10. It is very important not to forget to add the leading zero when entering a cone value (if it is required) or the kiln will fire much hotter than you want it to.

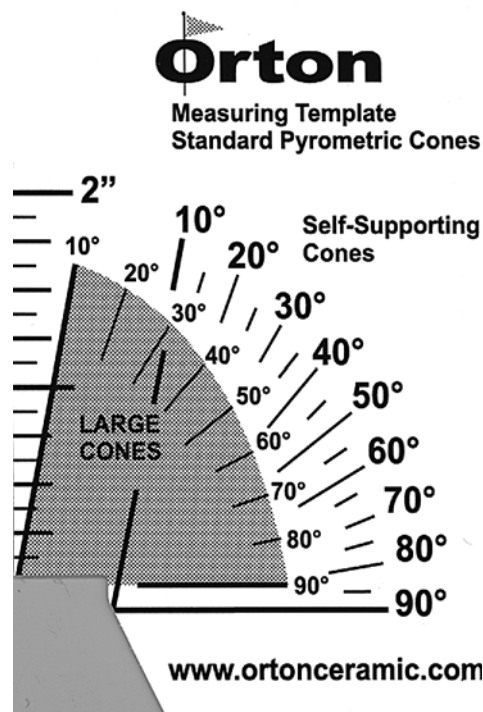
Remember that heatwork is the combination of time and temperature. This is most important during the last 200°F of the firing. If the kiln is firing very slow during this period, the controller will automatically adjust the temperature down to ensure the ware does not receive too much heatwork. The cone values listed in

Cone No.	°F	°C
022	1087	586
021	1112	600
020	1159	626
019	1252	678
018	1319	715
017	1360	738
016	1422	772
015	1456	791
014	1485	807
013	1539	837
012	1582	861
011	1607	875
010	1657	903
09	1688	920
08	1728	942
07	1789	976
06	1828	998
05 1/2	1859	1015
05	1888	1031
04	1945	1063
03	1987	1086
02	2016	1102
01	2046	1119
1	2079	1137
2	2088	1142
3	2106	1152
4	2124	1162
5	2167	1186
5 1/2	2197	1203
6	2232	1222
7	2262	1239
8	2280	1249
9	2300	1260
10	2345	1285

the chart are only valid if the kiln is firing at exactly 108°F/hr. during the last 200°F of the firing. That is why it is very important to know the capabilities of your kiln when writing Ramp/Hold Programs or entering Hold times.

We recommend that you still use Self Supporting Witness Cones on every firing to monitor the accuracy of your kiln. Place the appropriate cone on a shelf approximately 2 inches from the kiln wall and 2 inches from the tip of the thermocouple. Make sure the space between the thermocouple and cone is unobstructed.

The Cone Measuring Template shown here can be used to determine the exact bend measured in degrees of angle. A perfect bend is considered to be at 90 degrees. See *Cones and Firing* brochure from Orton included with your kiln.



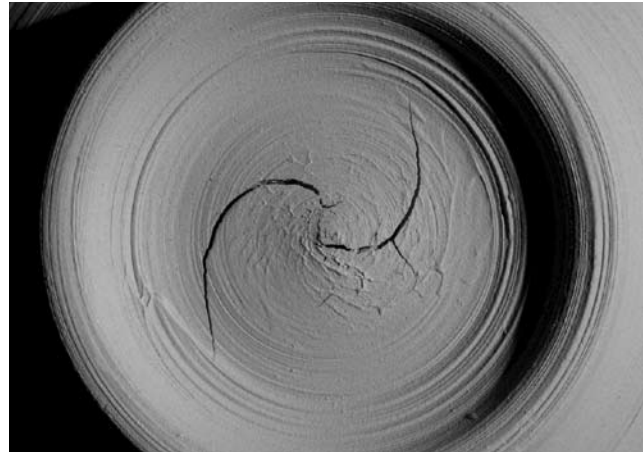
Ceramic Defects—Their Causes and How to Avoid Them

The first and most important aspect of troubleshooting defects is to be familiar with the clays, glazes, and kilns used in the studio. Completely understanding how each works, the parameters of the materials, and what the “norm” for the studio is will help figure out what went wrong when pieces do not look as expected. There are many different defects that can be caused by numerous things. This section will discuss some of the most common glaze flaws and some simple inexpensive things that can be done to help reduce the occurrence of defects.

General Concepts

1. Most defects are not seen until the piece comes out of the kiln so knowing that the kiln performed as expected is important. Even if the kiln is computer controlled, placing cone packs or self-supporting cones will allow the user to accurately know if the kiln completed the firing as programmed. Unlike pyrometers that only measure heat, cones measure both heat and time at heat which is key to how the glaze and clay will look. Knowing that the kiln fired properly is just as valuable as knowing it didn't when you are troubleshooting.
2. Know how long your kiln cycle actually takes. If the kiln cycle normally takes 6 hours to fire and now it is taking 8½, this is a sign that perhaps elements are wearing out or possibly one or more have burned out.
3. Know how the weather where you live changes by the season. These changes may be dramatic depending on locale and may affect how your clay pieces dry after forming. Drying is a function of temperature, humidity and air movement. Anything that alters these variables can cause problems. Also what works in Tampa may not work in Phoenix.
4. Keep your work area clean from dust, oils, and anything that may contaminate your ceramic pieces.
5. Keep your glaze containers clean and sealed to prevent bacterial growth. The same goes for the brushes used to apply the glaze.
6. Watch how old the glazes are and more importantly know how they apply and dry when they are new. Older glazes (especially ones that have been poorly cared for) will tend to start to dry faster and this causes issues.
7. Learn what the bisque ware pieces sound like when tapped lightly with a metal object. The sound a good piece makes is distinct and knowing that, you can determine the “clunky” dull tone of a damaged piece. Everyone can see major cracks but many cracks are small or the piece may simply have weak areas that will break when glaze fired. Knowing that a piece is not good at this point will avoid waste of decorating time, glaze and kiln space.

Drying/Forming Cracks



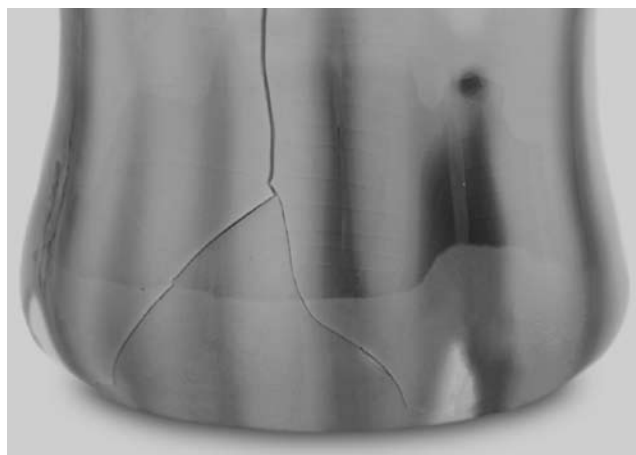
The causes for cracking are many and can be elusive. Listed here are some general tips for forming and drying pieces:

1. Do not use excess water when wheel throwing or hand-building pieces and attempt to keep the moisture level as even as possible throughout the piece.
2. Avoid areas on a piece that are thick in some areas and thin in others. If this must be done to achieve a certain look, make sure to slow the drying process way down. This can be done by loosely covering the piece with plastic. This will take trial and error to determine how much time it will take and time will vary depending on your studio conditions. But remember that drying it too long is always better than not enough.
3. Avoid sharp interior or exterior corners. Rounded corners are always better as exterior corners always dry faster than the interior of the piece. Interior corners are natural areas where stresses can be focused and start to crack.
4. Avoid sharp interior and exterior edges. Same reasoning as above.
5. Simple shapes like a 6" plate are much easier to dry than a 36" platter; the larger the piece the slower the drying time.
6. Incising may cause stresses due to variations in thickness.
7. Applied decorations need good scoring, good application of slip and slower drying to avoid cracks.
8. Be careful not to unduly flex wet shapes as clay has “memory” and it will tend to go back to the warped shape even if you smooth out the warps. This may cause stress cracks.
9. Throwing thick bases on pots can lead to “S” cracks on the bottom of the piece.
10. In general, the more complex the shape the slower the drying process needs to be.

11. Avoid drying pieces in direct sunlight, excessively arid environments, and avoid the temptation to use fans to dry pieces. Many expert potters will use all of the techniques that were suggested to avoid, learning to push the boundaries of what can be done with ceramics comes with experience and experimentation.

12. Sometimes it is important to determine if a crack occurred during the heating of a glaze firing or during the cool down phase. If a crack occurs during the heat up, it is possible to closely examine the crack to see if the glaze has run into the crack (very fluid glazes) or has at least rounded over at the edge (stiffer glazes). If it is determined that the crack has occurred during heat up of a glaze firing, one must consider slowing down the heating of the glaze firing, slowing down the cooling of the bisque firing and even looking as far back as the forming and drying of the piece.

Thermal Cracks



The causes of thermal cracks are simple; it is the rapid heating or cooling of a piece through the quartz inversion stage. The temperature at which this takes place is 1063°F (573°C). Without going into great detail, silica crystals go through a radical physical change at this temperature. If a fired piece of pottery goes through this temperature rapidly, it will not be able to adjust to the change and the piece will crack. These cracks are usually very tight and are sometimes only found by tapping on the piece to listen to the ring. In severe cases the piece will split apart into several smaller sections. It is always important when cooling the kiln to allow the temperature to fall slowly through this temperature range. When glaze and bisque firing ware, it is important to heat and cool the kiln slowly through this temperature range. Listed below are some key points to remember when firing:

1. The thicker the piece, the slower the temperature rise or fall through the quartz inversion should be. Remember that when heating the kiln, the temperature of the pieces will lag behind the temperature of the kiln that the thermocouple is measuring. When cooling the kiln the opposite holds true, the piece is actually hotter than the air inside the kiln.

2. With programmable kilns it is not a problem to change the firing speed. You can select any temperature rate you desire by simply writing your own program.

3. The more "open" a clay body is when it is fired, the less prone to these types of issues. Conversely, porcelains or denser clay bodies are much more prone to having thermal issues. The Raku process takes the ware through this stage very fast which is why Raku clays are normally very open, high grog content type bodies. Even with this quartz inversion, cracks are pretty common when firing Raku.

Glaze Fit

Glaze fit problems are simply a matter of matching the thermal expansion of the clay body and the glaze so that the glaze is slightly lower in expansion than the body. This puts the entire system into slight compression. Thermal expansion has NOTHING to do with shrinkage. All materials will expand and contract when heated and cooled. Clay bodies expand when heated and contract when cooled. We need only be concerned with glazes contracting when cooled as they are not a solid mass when heating them in the glaze firing. If the thermal fit is good the piece will be durable and stable.

Crazing



Crazing occurs when the glaze contracts more than the clay body. The glaze attempts to contract to a smaller size than the body, but the body is preventing the full contraction. Stresses build up in the system and the glaze is actually split apart to relieve the stress. These are the small thin cracks we have all seen in old china. If the mismatch is only slight, only a few large craze marks will be seen. If the mismatch is severe, many craze marks will be seen and they will be very close to each other. It is easy to see crazing on some glazes and much harder to see on others. Rubbing some India Ink onto the glaze surface will help make crazing more obvious. It should be remembered that crazing may not show up when the piece is first taken from the kiln. It may in fact take several days for crazing to appear. This is true when the mismatch is only slightly wrong. If the mismatch is severe, the crazing will happen as soon as the piece is

removed from the kiln and it may in fact have started to craze while still in the kiln.

Crazing never occurs because the piece was removed from the kiln too soon, it is just more apparent because the crazing is accelerated as the piece contracts. Crazing can have a delayed reaction and not show in a piece for years.

Shivering



Shivering is the exact opposite of crazing. During shivering, the glaze is actually put into compression as it is supposed to be, but it is put into too much compression. This is because the glaze wants to contract less than the clay body, but the clay body is preventing this. Stresses build up in the system until the glaze is in so much compression that it is forced to “pop” from the clay body to relieve the stress. If the shivering is only slight, this will cause small, very sharp places where part of the glaze is forced up and protrudes higher than the rest of the glaze surface. If the shivering is severe, small pieces of glaze will actually be pushed totally from the clay piece.

Note: See below for more information. This should not be confused with poor adhesion of the glaze to the clay.

When using commercially made products, the best way to remedy these issues is to switch clay bodies. If you have crazing, you will need a clay body with a higher thermal expansion. If you have shivering you need a body with a lower thermal expansion. As a general rule (but certainly not always true), high gloss glazes tend to have higher thermal expansions and matte glazes and underglazes tend to have lower thermal expansions. ALWAYS run test tiles of new glazes on your clay body, or if you are changing clay bodies, always test your glaze palette on it. Nothing is worse than opening the kiln to find it full of crazed and shivered pieces.

Poor Glaze Adhesion

This is a problem that most potters fail to understand fully, yet it is one of the most common problems encountered. It is important that when glazing a bisque piece or if applying an engobe or underglaze onto greenware, that the bond between the clay and the glaze be strong. Glazes are made with organic binders that help

this process by slowing the drying of the glaze to allow it to bond better to the clay and adding organic fibers to the system that helps hold the glaze to the clay. If the glaze dries too fast when applying it (especially the first layer) the bond between the glaze and the clay will be weak and it can easily be separated during the drying of the piece or in the early part of the firing schedule. The organic binders act as “food” for bacteria and mold and if the binder is all consumed by the bacteria, the drying time will speed up and glaze popping may occur. Most commercial glazes have chemicals added to keep bacteria from growing. The bacteria eat this material and it kills them. When the entire amount of chemical is gone, the bacteria will grow. One can tell that the bacteria are growing by seeing it in the glaze or the glaze starts to have a bad smell to it. Keeping the lid on your glazes when not in use, only using clean brushes, using glaze in a timely manner, etc will keep glazes working longer.

Users of glazes should mentally keep track of how their glazes dry. It will take several seconds for the glaze to lose its sheen after application. If the glazes starts to dry faster, this is a sign that problems may be ahead. AMACO® Gum Solution is a combination of binders and bactericide designed to add more organic binder into the system to replace what has been lost and bactericide to prevent future rotting. Gum solution may be added in the quantity needed to bring the glazes drying properties back to its original condition. It is impossible to recommend an amount to add to a glaze because it depends on how “bad” the drying properties of the glaze have gotten. Adding too much gum solution can cause the glaze to dry so slowly that it becomes an issue. Always add this material in small amounts until you get the glaze where you need it to be. After using it a few times you will develop a good feel for how much to add. Remember that when adding gum solution or water to a glaze, you are reducing the amount of solids you are applying to your artwork so you may want to add a little extra glaze thickness to your piece.

The issue of poor glaze adhesion can happen to any type of glaze. The thicker the application of glaze or underglaze, the more likely it is for glazes to pop off. Glazes with high percentages of clay (which leads to high shrinkage of the glaze when drying) will tend to be more prone to this issue. Poor adhesion is often the case with underglaze decorations that pop off the piece as they tend to have higher amounts of clay. Many people will think that something has changed with a glaze when in fact it has simply been depleted of its organic binder. Replenishing the binder will make older glazes usable again with good results.

Glaze Crawls

Glaze crawls may be caused by many things but are usually seen as areas where the glaze has peeled back from the clay body during firing, creating a clump of glaze. Due to the surface tension of the glaze, it will



not move back over the bare spot. This is a very difficult defect to repair. You can attempt to grind the piled up glaze down to a level surface with the rest of the glaze, fill the hole with glaze and refire to temperature again. The defective area is usually visible even through the repair. The more important concern is to determine why the glaze crawled. There are many chemical reasons that cause glaze crawls if you formulate your own glazes. Over grinding glazes may also cause crawls. In commercially prepared glazes there are a few main causes:

1. Poor adhesion of the glaze to the clay body. See the section above for possible solutions.
2. Poorly cleaned bisque ware. Glazing over dusty bisque can easily cause glaze crawls. The dusty area will cause areas where glaze adhesion will be poor and cause crawls. All bisque and for that matter greenware should be totally free from loose dust.
3. Do not handle greenware or bisque with any kind of grease, oil, or hand lotion on your hands. The net result of getting these materials on your pieces will again be poor glaze adhesion to the clay body. Save hand lotions for after clean-up of the area at the end of the day.
4. Keeping a tidy work area and using good habits when handling greenware, bisque, your glazes and equipment will all help prevent crawls.

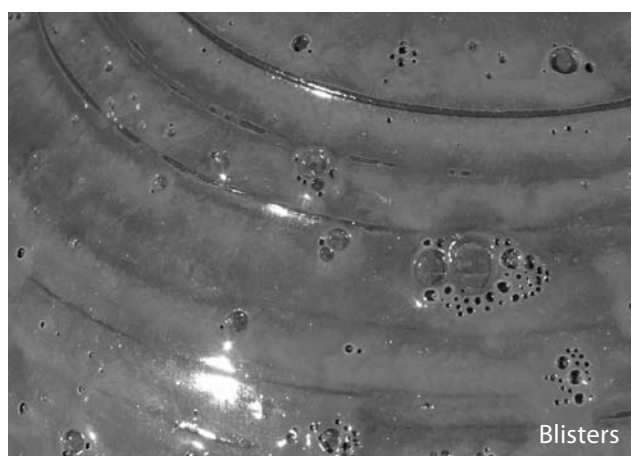
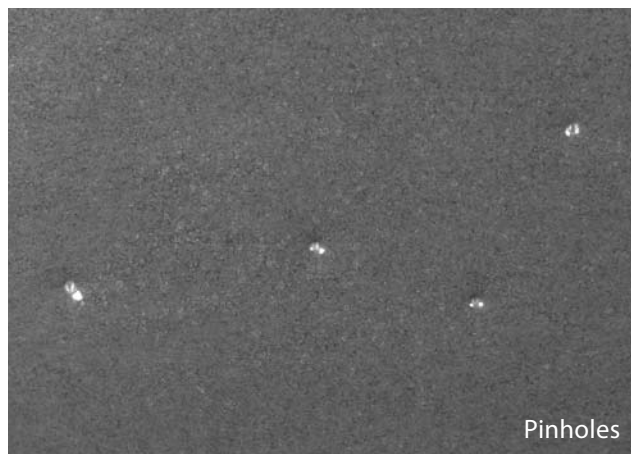
Over-fired Ware

Pyrometric cones can also be important in determining if a load has been over-fired. Pieces that have been over-fired are usually lost. Applying a thin coat of glaze and re-firing can be attempted, but this usually doesn't fix the problem. Determining WHY the kiln over-fired is important so that the problem doesn't occur in the next firing.

1. Make sure the kiln was programmed correctly and that the correct cone value was selected.
2. Check the thermocouple to make sure it isn't old and corroded. This can cause the temperature reading of the controller to be different than the actual temperature in the kiln.
3. Check that the thermocouple is protruding into the kiln chamber at least 2 inches, otherwise the temperature can be inaccurate.

4. Check for broken elements. A broken or weak element near the thermocouple may cause that area to read colder than the rest of the kiln load. See Troubleshooting Guide, p. 36 for additional solutions.

Under-fired Ware (Bubbles in Fired Glaze, Pinholes, Blisters)



It is ALWAYS a good idea to have a set of pyrometric cones in every kiln firing. They cost only a few pennies each and can be critical in determining if a kiln load is under-fired. Under-fired ware can be caused by kiln issues like weak elements or non-functional elements. A kiln load that is over filled may cause areas of the kiln to be under-fired.

Usually simply re-firing the pieces to the correct temperature can correct the problem. Some potters like to apply a thin coat of glaze to the piece before re-firing simply to make the glaze a little more reactive and to help it melt easier.

The causes of these issues can be many but the most likely cause is off-gassing of material in the clay body that cause air bubbles to either pop on the surface of the glaze or become trapped inside the glaze when it solidifies. The key is to have the gases escape from the body before the glaze melts enough to seal off the escape route of the gases. This is not always an easy thing to do because the actual cause will depend on the system

the potter is using. Sometimes firing the load faster can solve the problem, sometimes a slower firing will work, and sometimes simply putting a thinner layer of glaze on will work.

1. Off-gassing of carbonates and sulfates in stoneware bodies can be problematic if they are given off after the glaze has sealed the body over. Looking at different clay bodies may be a solution where these materials are not present. Changing glazes to ones that melt later may also solve the problem.

2. Many times the bubbles will actually form in the glaze and float to the top surface of the molten glaze, the bubbles pop and the glaze surface smoothes itself out. If the glaze is applied too heavy, this extra glaze thickness may cause all the bubbles to not be liberated.

3. Sometimes the issue will only happen with certain clay bodies that tend to be much more reactive. Examples of this might be red clay bodies or bodies with speckles that tend to react with glaze due to the iron or manganese and cause bubbles to form. Severe bubbles may look like large blisters. Switching to a clay body without these elements may totally eliminate the problem.

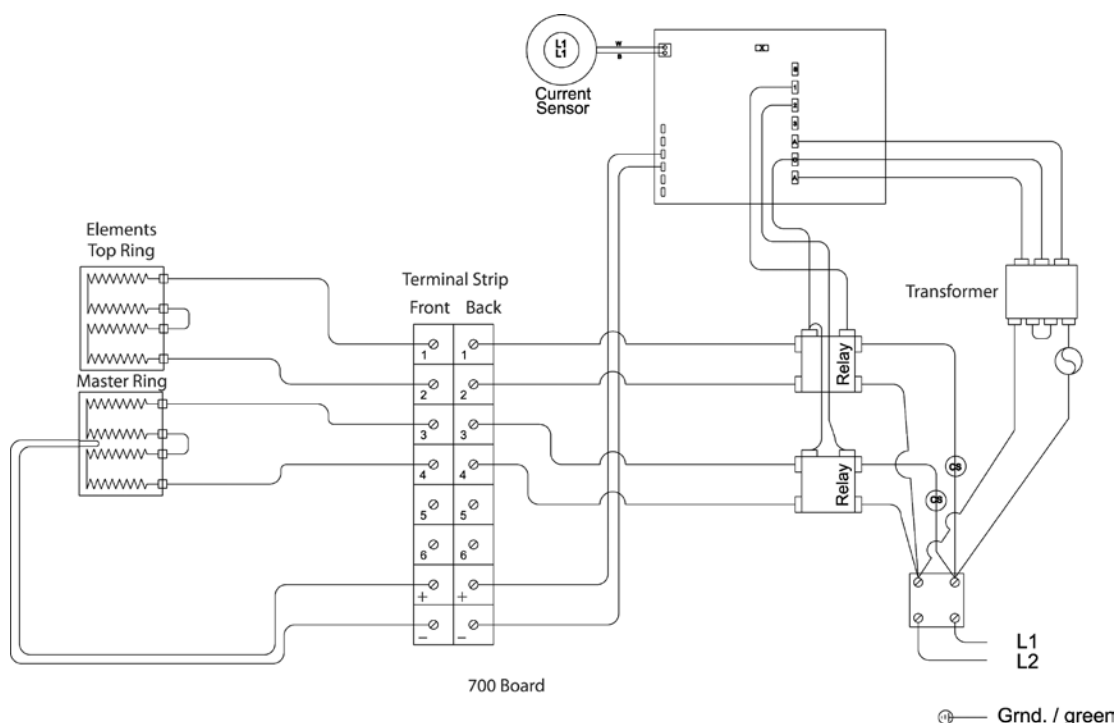
4. If the glaze surface looks like most of the bubbles have popped and many have smoothed over, the solution may be a little more heat, a slower approach rate to the peak temperature or a small hold at peak.

5. If the glaze surface looks like most of the bubbles are still in the glaze and only a few have popped, it might work to fire at a slightly lower temperature, approach the peak temperature at a faster rate or eliminate any hold at peak.

6. Sometimes certain glazes and clay bodies will simply not work together. It is always important to run trials on new clays or glazes. Remember that glazing a cup where almost the entire surface of the clay is covered with glaze is very different than glazing a tile which only has glaze on one surface. Gases will always attempt to find the easiest path to get out of the clay. The easiest areas for gases to escape are where the piece is not glazed.

Glaze Flowing Off the Piece

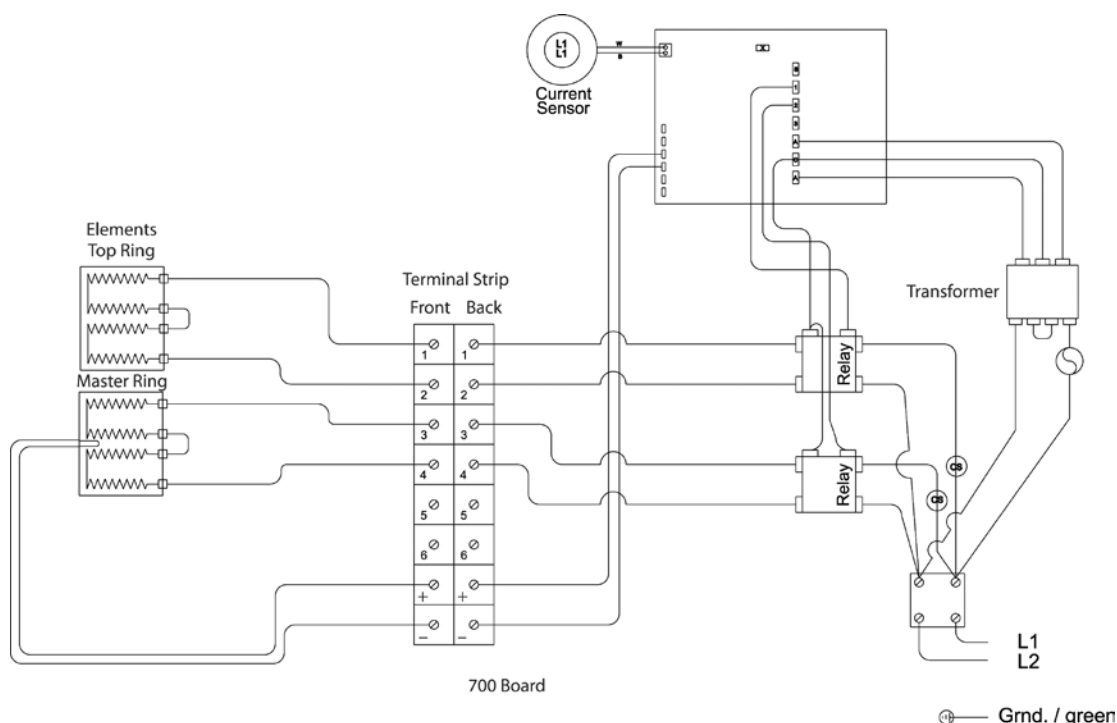
All glazes are made to work the same at peak temperature. Some glazes are formulated to flow a lot during firing to produce certain effects and some are formulated to move very little for a different aesthetic and not all glazes can be applied the same. Understanding how much your glaze will flow (move down a vertical surface) is important in determining how to glaze the piece. Running test tiles that have a vertical face is critical to understanding how the glaze will flow in the kiln. A stiff glaze may be glazed with an even applied thickness all the way down to just above the foot or all the way to the bottom if the piece is to be stilted. A very fluid glaze presents some issues that must be trialed. Glaze may need to be applied thinner near the bottom of the piece to compensate for the movement of the glaze towards the foot. In extreme cases glaze may have to not be applied near the bottom of the piece at all. If glaze flows off the piece it may cause the piece to stick to the kiln shelf which may ruin the piece and the kiln furniture. Always use liberal coats of kiln wash when working with very fluid glazes just in case.



Stock No.	Description	QTY per kiln
All Models		
24288X	Brick for lid with band/no hardware	1
24261N	Lid support brace, bracket, and arm	1
24289A	Brick, grooved for peephole	4
24290B	Brick, grooved straight	24
24291C	Brick, grooved terminal	3
24244H	Insulator tubes	8
24252S	Supply cord connector	1
24253T	Power supply cord	1
24293E	Kiln stand 8-sided	1
24256X	Heat shield supply cord	1
24295G	Bottom slab w/ band	1
24258B	Sash lock	2
24294F	Stainless steel body band	2
24285T	Hinge, complete	1
24265T	Lid handle	1
Select Fire™ Models		
28815L	Thermocouple	1
24319J	Relay	2
24250P	Control panel	1

Stock No.	Description	QTY per kiln
24278K	Transformer	1
24320M	Harness wire set	1
24332C	Current sensor kit	1
28071F	Connectors/terminal lugs	8
24325T	Terminal block, single phase	1
22134W	Fuse holder	1
24296H	Terminal strip	1
Manual Style/Sitter Timer Models		
24292D	Brick, grooved for tube assembly	1
24245J	Switch box with shield	2
28068C	Infinite control switch	4
24246K	Switch box, upper	1
28782C	Kiln-Sitter®/limit timer model LT-3K	1
24304S	Tube assembly only	1
24249N	Pilot light assembly	1
24274F	Master switch box	1
28071F	Connectors NPW/terminal Lugs	8
24275G	Master switch box shield	1
24266V	Switch box shield, lower	1

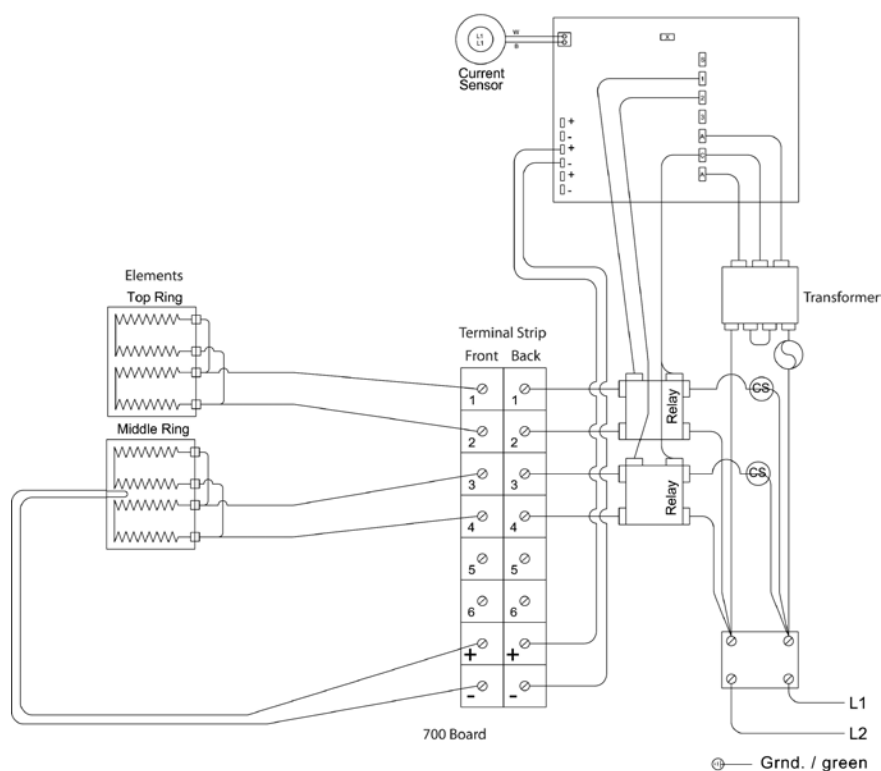
Wiring Diagram/Parts List EX-324/EX-324SF Single Phase



Stock No.	Description	QTY per kiln
All Models		
24297J	Brick for lid with band/no hardware	1
24261N	Lid support brace, bracket, and arm	1
24298K	Brick, grooved for peephole	4
24299L	Brick, grooved straight	24
24300M	Brick, grooved terminal	3
24244H	Insulator tubes	8
24252S	Supply cord connector	1
24253T	Power supply cord	1
24293E	Kiln stand, 8-sided	1
24256X	Heat shield supply cord	1
24302P	Bottom slab with band	1
24258B	Sash Lock	2
24294F	Stainless steel body band	2
24285T	Hinge, complete	1
24265T	Lid handle	1
Select Fire™ Models		
28815L	Thermocouple	1
24319J	Relay	2
24250P	Control panel	1

Stock No.	Description	QTY per kiln
24278K	Transformer	1
24320M	Harness wire set	1
24332C	Current sensor kit	1
28071F	Connectors/terminal lugs	8
24324S	Terminal block, three phase	1
22134W	Fuse holder	1
24296H	Terminal strip	1
Manual Style/Sitter Timer Models		
24282D	Brick, grooved for tube assembly	1
24245J	Switch box with shield	2
28068C	Infinite control switch	4
24246K	Switch box, upper	1
28782C	Kiln-Sitter®/limit timer model LT-3K	1
24305T	Tube assembly only	1
24249N	Pilot light assembly	1
24274F	Master switch box	1
28071F	Connectors NPW/terminal lugs	8
24275G	Master switch box shield	1
24266V	Switch box shield, lower	1

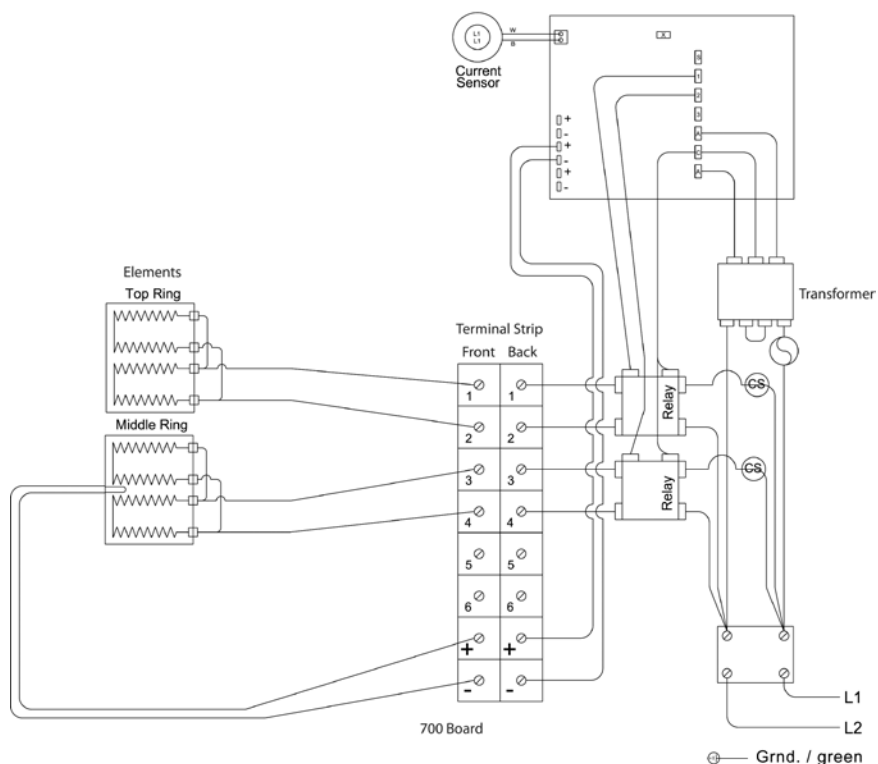
Wiring Diagram/Parts List EX-247/EX-247SF Single Phase



Stock No.	Description	QTY per kiln
All Models		
24236T	Brick for lid with band/no hardware	1
24262P	Lid support brace, bracket, and arm	1
24240D	Brick, grooved for peephole	4
24242F	Brick, grooved straight	32
24243G	Brick, grooved terminal	3
24244H	Insulator tubes	8
24252S	Supply cord connector	1
24253T	Power supply cord	1
24254V	Kiln stand 10-sided	1
24256X	Heat shield supply cord	1
24295G	Bottom slab with band	1
24258B	Sash lock	2
24259C	Stainless steel body band	2
24286V	Hinge, complete	1
24265T	Lid handle	1
Select Fire™ Models		
28815L	Thermocouple	1
24319J	Relay	2
24250P	Control panel	1

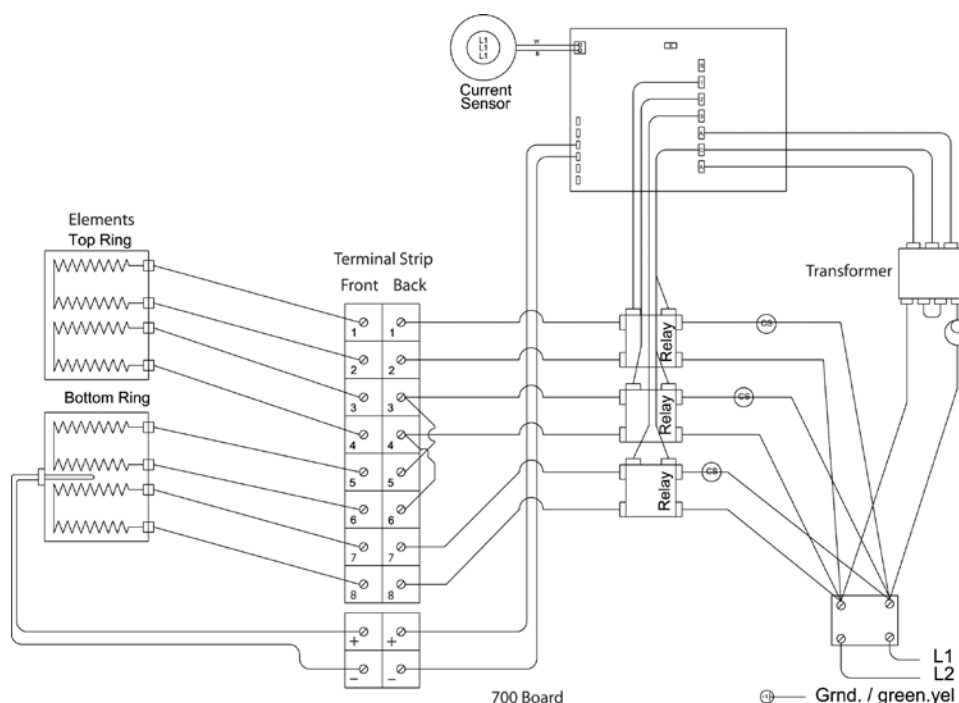
Stock No.	Description	QTY per kiln
24278K	Transformer	1
24321N	Harness wire set	1
24332C	Current sensor kit	1
28071F	Connectors/terminal lugs	8
24325T	Terminal block, single phase	1
22134W	Fuse holder	1
24296H	Terminal strip	1
Manual Style/Sitter Timer Models		
24251R	Brick, grooved for tube assembly	1
24245J	Switch box with shield	2
28068C	Infinite control switch	4
24246K	Switch box, upper	1
28782C	Kiln-Sitter®/limit timer model LT-3K	1
24304S	Tube assembly only	1
24249N	Pilot light assembly	1
24274F	Master switch box	1
28071F	Connectors NPW/terminal lugs	8
24275G	Master switch box shield	1
24266V	Switch box shield, lower	1

Wiring Diagram/Parts List EX-344/EX-344SF Single Phase



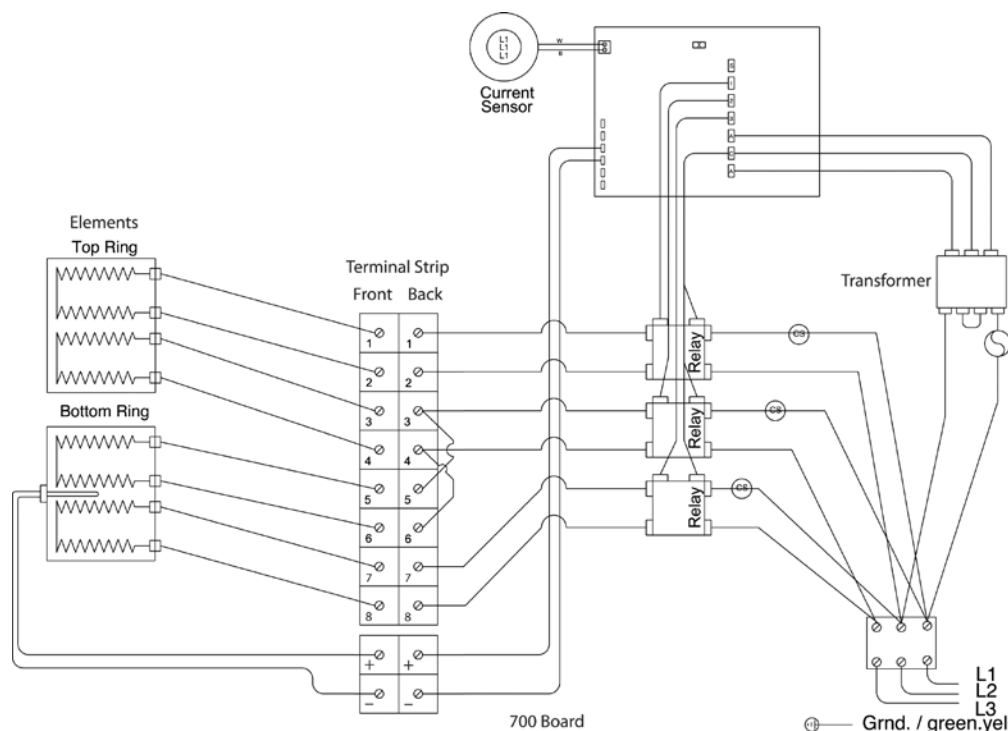
Stock No.	Description	QTY per kiln
All Models		
24267W	Brick for lid with band/no hardware	1
24262P	Lid support brace, bracket, and arm	1
24268X	Brick, grooved for peephole	4
24269A	Brick, grooved straight	32
24270B	Brick, grooved terminal	3
24244H	Insulator tubes	8
24252S	Supply cord connector	1
24253T	Power supply cord	1
24254V	Kiln stand, 10-sided	1
24256X	Heat shield supply cord	1
24272D	Bottom slab with band	1
24258B	Sash lock	2
24259C	Stainless steel body band	2
24286V	Hinge, complete	1
24265T	Lid handle	1
Select Fire™ Models		
28815L	Thermocouple	1
24319J	Relay	2
24250P	Control panel	1

Stock No.	Description	QTY per kiln
24278K	Transformer	1
24321N	Harness wire set	1
24332C	Current sensor kit	1
28071F	Connectors/terminal lugs	8
24325T	Terminal block, single phase	1
22134W	Fuse holder	1
24296H	Terminal strip	1
Manual Style/Sitter Timer Models		
24271C	Brick, grooved for tube assembly	1
24245J	Switch box with shield	2
28068C	Infinite control switch	4
24246K	Switch box, upper	1
28782C	Kiln-Sitter®/limit timer model LT-3K	1
24305T	Tube assembly only	1
24249N	Pilot light assembly	1
24274F	Master switch box	1
28071F	Connectors NPW/terminal lugs	8
24275G	Master switch box shield	1
24266V	Switch box shield, lower	1

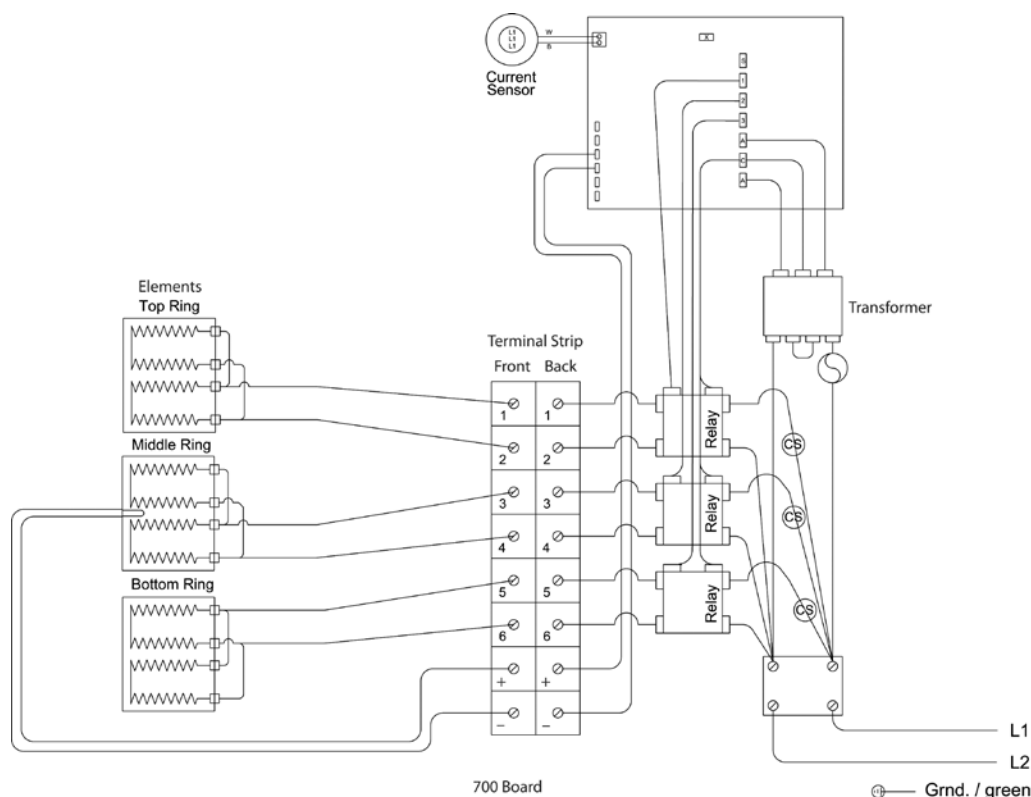


Stock No.	Description	QTY per kiln
24277J	Brick for lid with band/no hardware	1
24263R	Lid support brace, bracket, and arm	1
24279L	Brick, grooved for peephole	4
24280M	Brick, grooved straight	40
24281N	Brick, grooved terminal	3
24244H	Insulator tubes	8
24252S	Supply cord connector	1
24253T	Power supply cord	1
24282P	Kiln stand, 12-sided	1
24256X	Heat shield supply cord	1
24306V	Bottom slab with band	1
24258B	Sash lock	2
24235R	Stainless steel body band	2

Stock No.	Description	QTY per kiln
24287W	Hinge, complete	1
24265T	Lid handle	1
28815L	Thermocouple	1
24319J	Relay	2
24250P	Control Panel	1
24278K	Transformer	1
24322P	Harness wire set	1
24332C	Current sensor kit	1
28071F	Connectors/terminal lugs	8
24325T	Terminal block, single phase	1
24324S	Terminal block, three phase	1
22134W	Fuse holder	1
24296H	Terminal strip	1



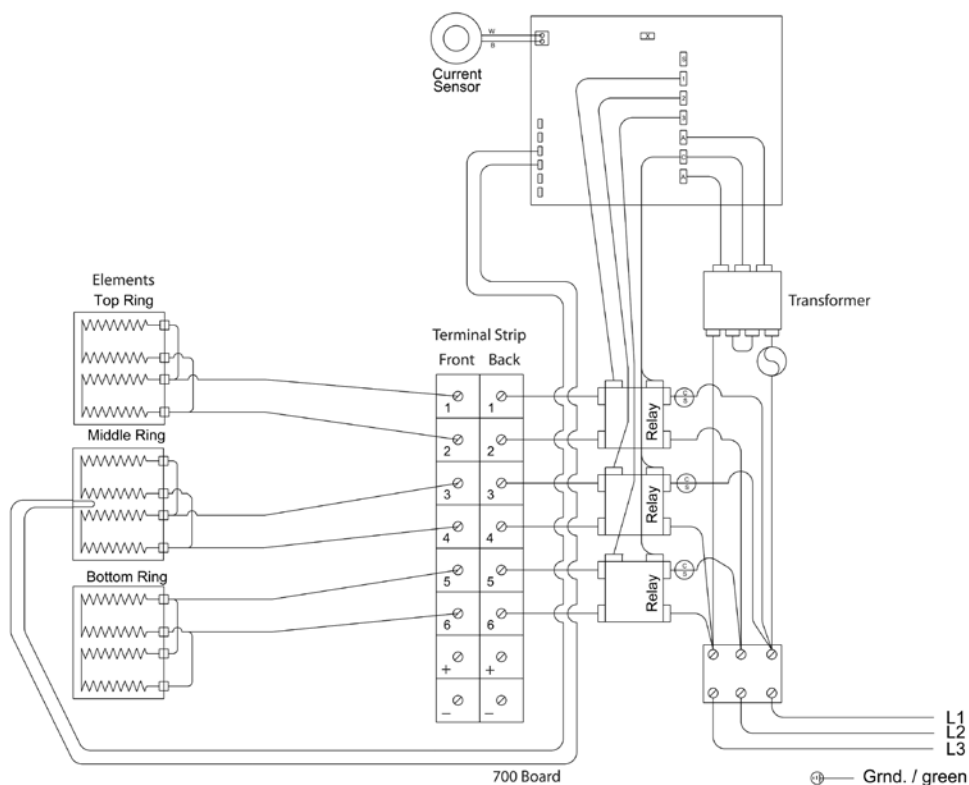
Stock No.	Description	QTY per kiln
24287W	Hinge, complete	1
24265T	Lid handle	1
28815L	Thermocouple	1
24319J	Relay	2
24250P	Control panel	1
24278K	Transformer	1
24322P	Harness wire set	1
24332C	Current sensor kit	1
28071F	Connectors/terminal lugs	8
24325T	Terminal block, single phase	1
24324S	Terminal block, three phase	1
22134W	Fuse holder	1
24296H	Terminal strip	1



Stock No.	Description	QTY per kiln
All Models		
24236T	Brick for lid with band/no hardware	1
24262P	Lid support brace, bracket, and arm	1
24240D	Brick, grooved for peephole	6
24242F	Brick, grooved straight	48
24243G	Brick, grooved terminal	5
24244H	Insulator tubes	12
24252S	Supply cord connector	1
24253T	Power supply cord	1
24254D	Kiln stand, 10-sided	1
24256X	Heat shield supply cord	1
24257A	Bottom slab with band	1
24258B	Sash lock	2
24259C	Stainless steel body band	3
24286V	Hinge, complete	1
24265T	Lid handle	1
Select Fire™ Models		
28815L	Thermocouple	1
24319J	Relay	3
24250P	Control panel	1

Stock No.	Description	QTY per kiln
24278K	Transformer	1
24322P	Harness wire set	1
24332C	Current sensor kit	1
28071F	Connectors/terminal lugs	12
24325T	Terminal block, single phase	1
22134W	Fuse holder	1
24296H	Terminal strip	1
Manual Style/Sitter Timer Models		
24251R	Brick, grooved for tube assembly	1
24245J	Switch box with shield	2
28068C	Infinite control switch	6
24246K	Switch box, upper	1
28782C	Kiln-Sitter®/limit timer model LT-3K	1
24304S	Tube assembly only	1
24249N	Pilot light assembly	1
24274F	Master switch box	1
28071F	Connectors NPW/terminal lugs	12
24275G	Master switch box shield	1
24266V	Switch box shield, lower	1

Wiring Diagram/Parts List EX-270/EX-270SF Three Phase

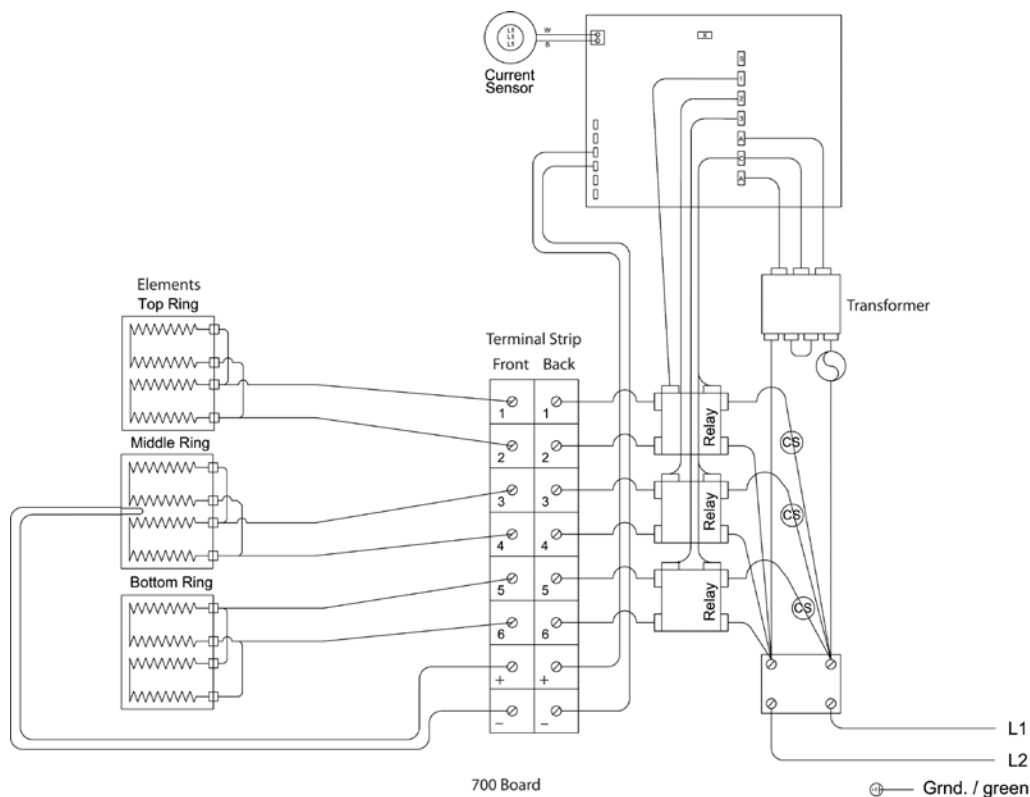


Stock No.	Description	QTY per kiln
All Models		
24236T	Brick for lid with band/no hardware	1
24262P	Lid support brace, bracket, and arm	1
24240D	Brick, grooved for peephole	6
24242F	Brick, grooved straight	48
24243G	Brick, grooved terminal	5
24244H	Insulator tubes	12
24252S	Supply cord connector	1
24253T	Power supply cord	1
24254D	Kiln stand, 10-sided	1
24256X	Heat shield supply cord	1
24257A	Bottom slab with band	1
24258B	Sash lock	2
24259C	Stainless steel body band	3
24286V	Hinge, complete	1
24265T	Lid handle	1
Select Fire™ Models		
28815L	Thermocouple	1
24319J	Relay	3
24250P	Control panel	1

Stock No.	Description	QTY per kiln
24278K	Transformer	1
24322P	Harness wire set	1
24332C	Current sensor kit	1
28071F	Connectors/terminal lugs	12
24324S	Terminal block, three phase	1
22134W	Fuse holder	1
24296H	Terminal strip	1
Manual Style/Sitter Timer Models		
24251R	Brick, grooved for tube assembly	1
24245J	Switch box with shield	2
28068C	Infinite control switch	6
24246K	Switch box, upper	1
28782C	Kiln-Sitter®/limit timer model LT-3K	1
24304S	Tube assembly only	1
24249N	Pilot light assembly	1
24274F	Master switch box	1
28071F	Connectors NPW/terminal Lugs	12
24275G	Master switch box shield	1
24266V	Switch box shield, lower	1

Wiring Diagram/Parts List

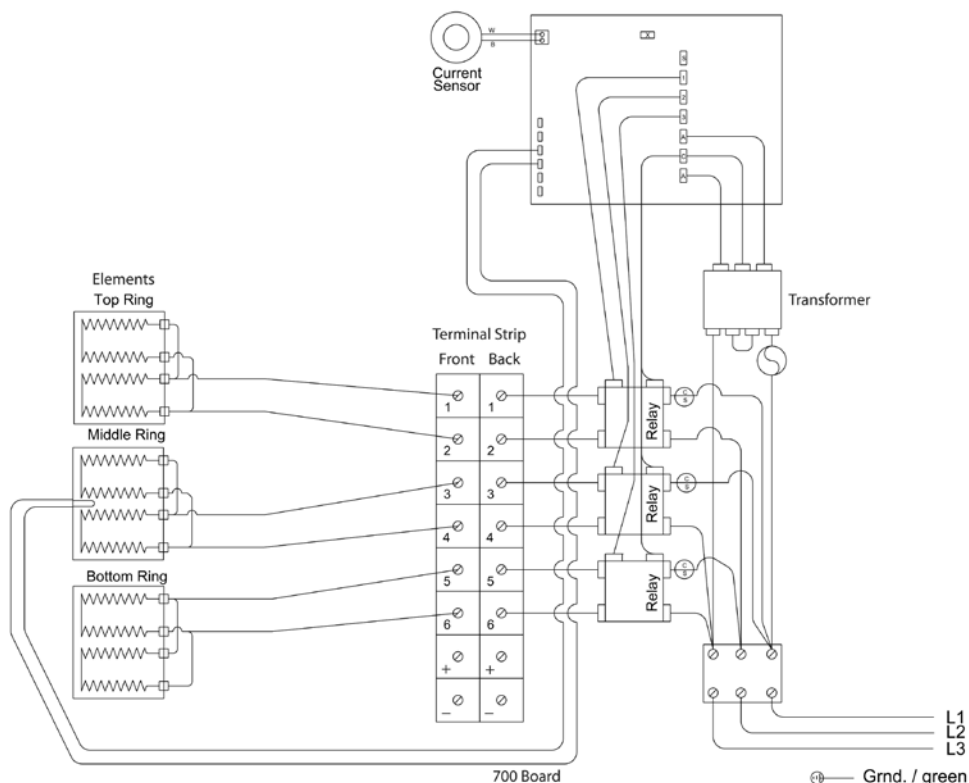
EX-365/EX-365SF Single Phase



Stock No.	Description	QTY per kiln
All Models		
24267W	Brick for lid with band/no hardware	1
24262P	Lid support brace, bracket, and arm	1
24268X	Brick, grooved for peephole	6
24269A	Brick, grooved straight	48
24270B	Brick, grooved terminal	5
24244H	Insulator tubes	12
24252S	Supply cord connector	1
24253T	Power supply cord	1
24254V	Kiln stand, 10-sided	1
24256X	Heat shield supply cord	1
24272D	Bottom slab with band	1
24258B	Sash lock	2
24259C	Stainless steel body band	3
24286V	Hinge, complete	1
24265T	Lid handle	1
Select Fire™ Models		
28815L	Thermocouple	1
24319J	Relay	3
24250P	Control panel	1

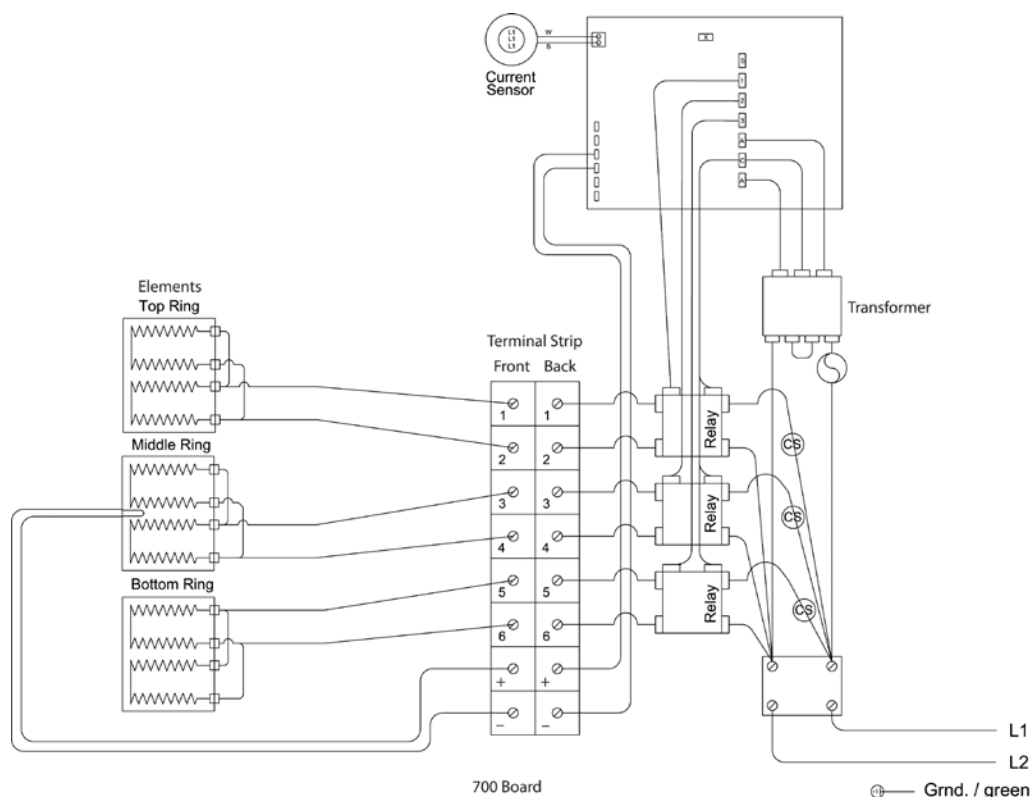
Stock No.	Description	QTY per kiln
24278K	Transformer	1
24322P	Harness wire set	1
24332C	Current sensor kit	1
28071F	Connectors/terminal lugs	12
24325T	Terminal block, single phase	1
22134W	Fuse holder	1
24296H	Terminal strip	1
Manual Style/Sitter Timer Models		
24271C	Brick, grooved for tube assembly	1
24245J	Switch box with shield	2
28068C	Infinite control switch	6
24246K	Switch box, upper	1
28782C	Kiln-Sitter®/limit timer model LT-3K	1
24305T	Tube assembly only	1
24249N	Pilot light assembly	1
24274F	Master switch box	1
28071F	Connectors NPW/terminal lugs	12
24275G	Master switch box shield	1
24266V	Switch box shield, lower	1

Wiring Diagram/Parts List EX-365/EX-365SF Three Phase



Stock No.	Description	QTY per kiln
All Models		
24267W	Brick for lid with band/no hardware	1
24262P	Lid support brace, bracket, and arm	1
24268X	Brick, grooved for peephole	6
24269A	Brick, grooved straight	48
24270B	Brick, grooved terminal	5
24244H	Insulator tubes	12
24252S	Supply cord connector	1
24253T	Power supply cord	1
24254V	Kiln stand, 10-sided	1
24256X	Heat shield supply cord	1
24272D	Bottom slab with band	1
24258B	Sash lock	2
24259C	Stainless steel body band	3
24286V	Hinge, complete	1
24265T	Lid Handle	1
Select Fire™ Models		
28815L	Thermocouple	1
24319J	Relay	3
24250P	Control panel	1

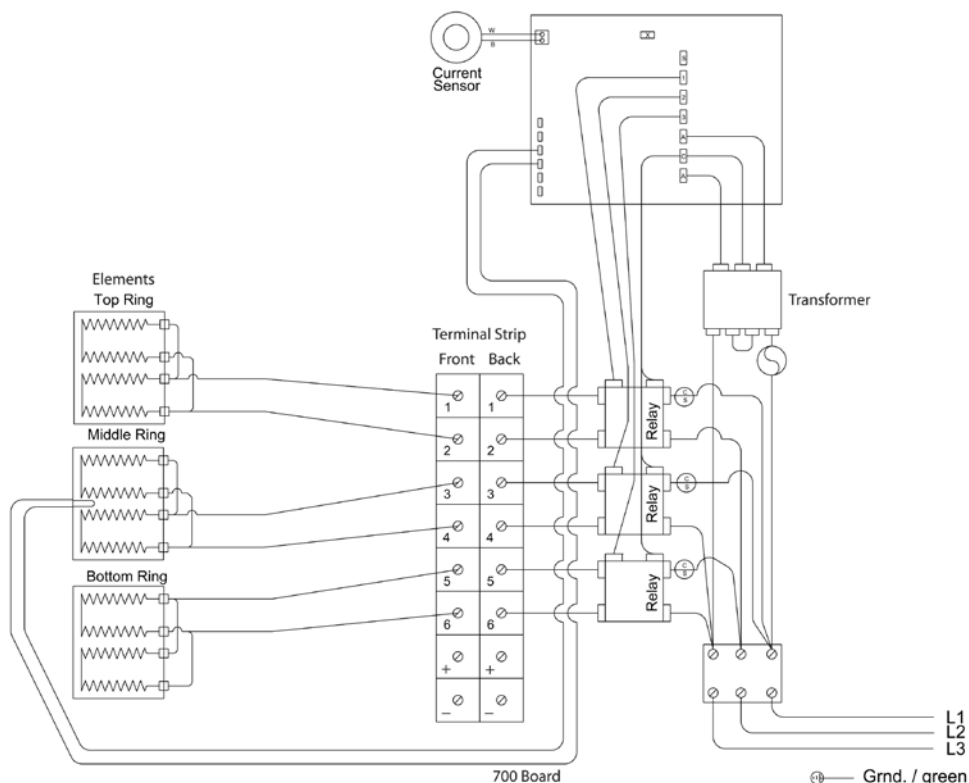
Stock No.	Description	QTY per kiln
24278K	Transformer	1
24322P	Harness wire set	1
24332C	Current sensor kit	1
28071F	Connectors/terminal lugs	12
24324S	Terminal block, three phase	1
22134W	Fuse holder	1
24296H	Terminal strip	1
Manual Style/Sitter Timer Models		
24271C	Brick, grooved for tube assembly	1
24245J	Switch box with shield	2
28068C	Infinite control switch	6
24246K	Switch box, upper	1
28782C	Kiln-Sitter®/limit timer model LT-3K	1
24305T	Tube assembly only	1
24249N	Pilot light assembly	1
24274F	Master switch box	1
28071F	Connectors NPW/terminal lugs	12
24275G	Master switch box shield	1
24266V	Switch box shield, lower	1



Stock No.	Description	QTY per kiln
All Models		
24277J	Brick for lid with band/no hardware	1
24263R	Lid support brace, bracket, and arm	1
24279L	Brick, grooved for peephole	6
24280M	Brick, grooved straight	60
24281N	Brick, grooved terminal	5
24244H	Insulator tubes	12
24252S	Supply cord connector	1
24253T	Power supply cord	1
24282P	Kiln stand, 12-sided	1
24256X	Heat shield supply cord	1
24306V	Bottom slab with band	1
24258B	Sash lock	2
24235R	Stainless steel body band	3
24287W	Hinge, complete	1
24265T	Lid handle	1
Select Fire™ Models		
28815L	Thermocouple	1
24319J	Relay	3
24250P	Control panel	1

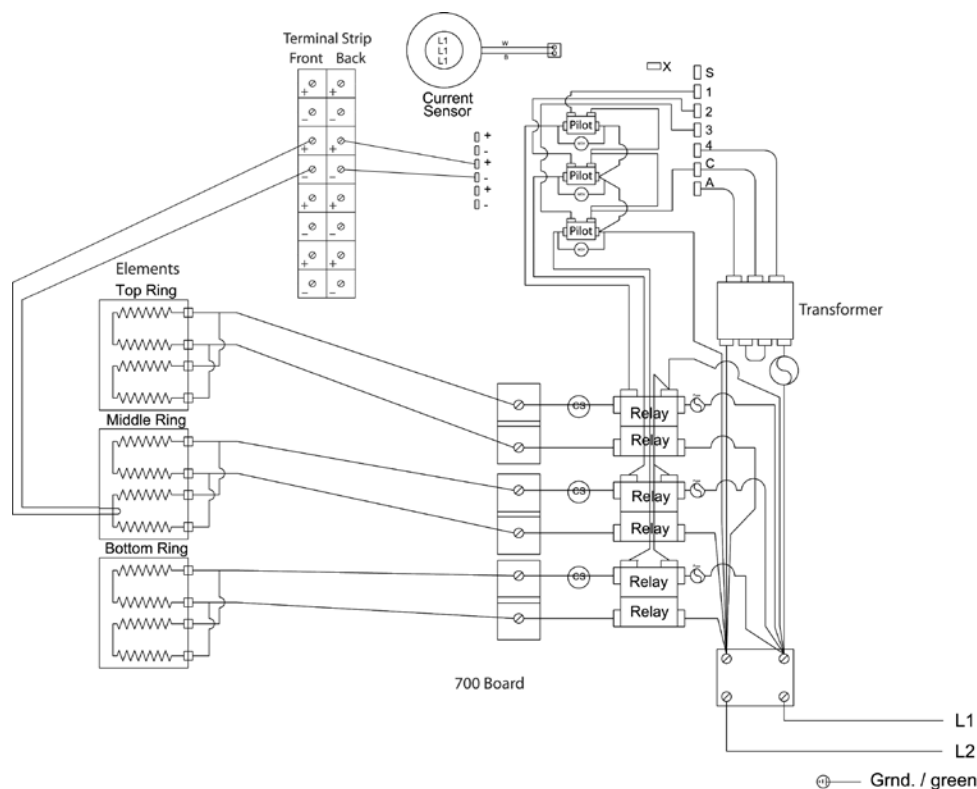
Stock No.	Description	QTY per kiln
24278K	Transformer	1
24322P	Harness wire set	1
24332C	Current sensor kit	1
28071F	Connectors/terminal lugs	12
24325T	Terminal block, single phase	1
22134W	Fuse holder	1
24296H	Terminal strip	1
Manual Style/Sitter Timer Models		
24307W	Brick, grooved for tube assembly	1
24245J	Switch box with shield	2
28068C	Infinite control switch	6
24246K	Switch box, upper	1
28782C	Kiln-Sitter®/limit timer model LT-3K	1
24305T	Tube assembly only	1
24249N	Pilot light assembly	1
24274F	Master switch box	1
28071F	Connectors NPW/terminal lugs	12
24275G	Master switch box shield	1
24266V	Switch box shield, lower	1

Wiring Diagram/Parts List EX-399/EX-399SF Three Phase



Stock No.	Description	QTY per kiln
All Models		
24277J	Brick for lid with band/no hardware	1
24263R	Lid support brace, bracket, and arm	1
24279L	Brick, grooved for peephole	6
24280M	Brick, grooved straight	60
24281N	Brick, grooved terminal	5
24244H	Insulator tubes	12
24252S	Supply cord connector	1
24253T	Power supply cord	1
24282P	Kiln stand, 12-sided	1
24256X	Heat shield supply cord	1
24306V	Bottom slab with band	1
24258B	Sash lock	2
24235R	Stainless steel body band	3
24287W	Hinge, complete	1
24265T	Lid handle	1
Select Fire™ Models		
28815L	Thermocouple	1
24319J	Relay	3
24250P	Control panel	1

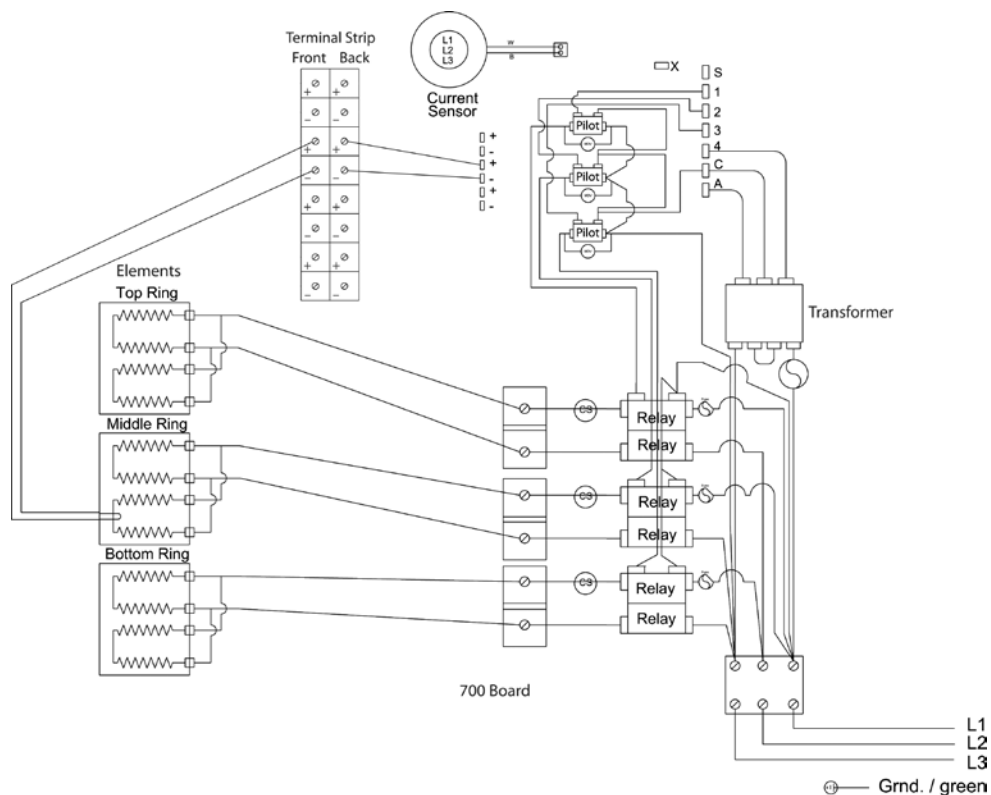
Stock No.	Description	QTY per kiln
24278K	Transformer	1
24322P	Harness wire set	1
24332C	Current sensor kit	1
28071F	Connectors/terminal lugs	12
24324S	Terminal block, three phase	1
22134W	Fuse holder	1
24296H	Terminal strip	1
Manual Style/Sitter Timer Models		
24307W	Brick, grooved for tube assembly	1
24245J	Switch box with shield	2
28068C	Infinite control switch	6
24246K	Switch box upper	1
28782C	Kiln-Sitter®/limit timer model LT-3K	1
24305T	Tube assembly only	1
24249N	Pilot light assembly	1
24274F	Master switch box	1
28071F	Connectors NPW/terminal lugs	12
24275G	Master switch box shield	1
24266V	Switch box shield, lower	1



Stock No.	Description	QTY per kiln
24277J	Brick for lid with band/no hardware	1
24263R	Lid support brace, bracket and arm	1
24279L	Brick, grooved for peephole	6
24280M	Brick, grooved straight	60
24281N	Brick, grooved terminal	5
24244H	Insulator tubes	12
24252S	Supply cord connector	1
24253T	Power supply cord	1
24282P	Kiln stand, 12-sided	1
24256X	Heat shield supply cord	1
24306V	Bottom slab with band	1
24258B	Sash lock	2
24235R	Stainless steel body band	3

Stock No.	Description	QTY per kiln
24287W	Hinge, complete	1
24265T	Lid handle	1
28815L	Thermocouple	1
Special order	Relay	3
24250P	Control panel	1
24278K	Transformer	1
24326V	Harness wire set	1
24332C	Current sensor kit	1
28071F	Connectors/terminal lugs	12
24325T	Terminal block, single phase	1
24324S	Terminal block, three phase	1
22134W	Fuse holder	1
24296H	Terminal strip	1

Wiring Diagram/Parts List EX-1099SF Three Phase



Stock No.	Description	QTY per kiln
24277J	Brick for lid with band/no hardware	1
24263R	Lid support brace, bracket, and arm	1
24279L	Brick, grooved for peephole	6
24280M	Brick, grooved straight	60
24281N	Brick, grooved terminal	5
24244H	Insulator tubes	12
24252S	Supply cord connector	1
24253T	Power supply cord	1
24282P	Kiln stand, 12-sided	1
24256X	Heat shield supply cord	1
24306V	Bottom slab with band	1
24258B	Sash lock	2
24235R	Stainless steel body band	3

Stock No.	Description	QTY per kiln
24287W	Hinge, complete	1
24265T	Lid handle	1
28815L	Thermocouple	1
Special order	Relay	3
24250P	Control panel	1
24278K	Transformer	1
24326V	Harness wire set	1
24332C	Current sensor kit	1
28071F	Connectors/terminal lugs	12
24325T	Terminal block, single phase	1
24324S	Terminal block, three phase	1
22134W	Fuse holder	1
24296H	Terminal strip	1





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