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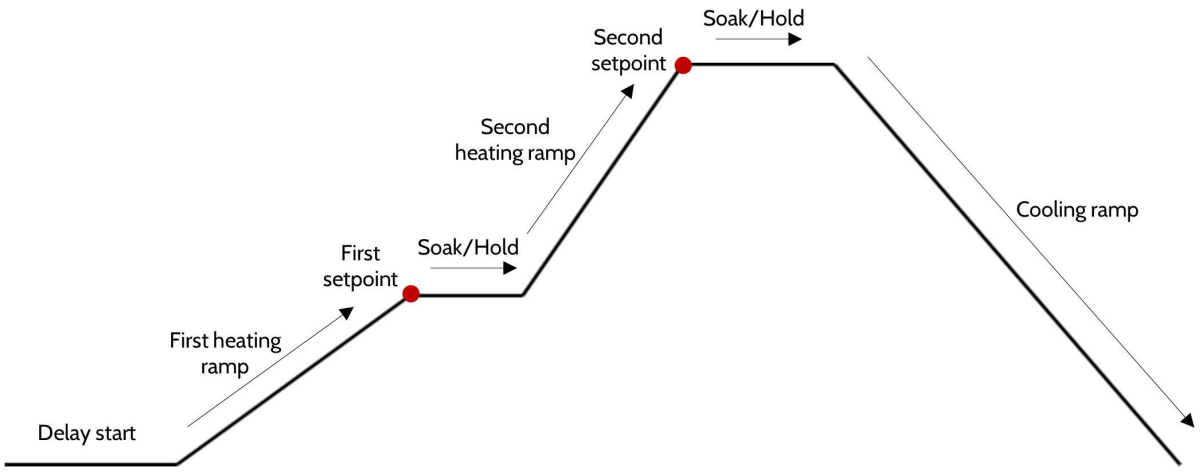
POTCLAYS LIMITED

INFORMATION SHEET

KILN FIRING PROGRAMS
How to program your electric kiln controller

The process of firing must be controlled to ensure the pots are kept safe and that the optimum temperatures and soak times are achieved. This is what your kiln controller does. The controller regulates the speed of heating up and turns the kiln off when the top temperature is reached. In most firings, the heating ramp is slow in the first part of the firing up to a first temperature and faster in the second part, the kiln is left to cool naturally to room temperature. Below is a diagram of a typical firing.



Terminology of Controllers

Electric kiln program controllers use the following definitions:

Segment: Parts of the program, controllers have two, three or more segments.

Each segment has three parts:

- a rate of heating
- a target temperature
- a soak or dwell, holding the temperature

Heating Ramp: The speed at which a kiln heats up defined as degrees per hour.

Target Temperature: The top temperature you wish to achieve in this segment.

Soak or Dwell: Holding the target temperature for a set period of time, expressed in hours and minutes. Soaks allow the temperature in the kiln and pots to even up.

cooling Ramp:	The speed at which the kiln cools down, usually used only for specialist firings and large or vulnerable pieces otherwise the kiln cools naturally.
Delay Start:	A facility to set a program to start firing at a later time.

What a Program Controller Does

Kiln controllers regulate the power input to the kiln, they control the rate of heating by switching the power on and off at longer or shorter intervals depending on the speed of heating required. Controllers show a digital display of the temperature inside the kiln throughout the firing and cooling process, the display also indicates which segment is being operated showing progress through the program. Controllers take their power from the kiln, and are either wired into the kiln or connected to the kiln by a multipin plug. The temperature inside the kiln is measured by a thermocouple, a probe poking into the kiln chamber which produces a millivolt output which is read by the controller. Thermocouples come in different types, "K", "S" or "R", it is very important that the controller is configured to the thermocouple type used or it will misread the temperature. Program controllers are made with a number of safety features:

1. Anti-surge devices: to protect against surges in power that would damage the electronics.
2. Room temperature measurement: if the room temperature exceeds 50°C the firing will be shut down.
3. Over temperature safety: if the kiln chamber temperature exceeds 20°C higher than the temperature set the firing will be shut down.

Controllers are also equipped with diagnostics that will detect problems such as thermocouple failure, failure to heat or cool as specified, power failure, exceeding firing time and more.

Bisque or Biscuit, the first firing.

This is the stage when clay undergoes the chemical change into ceramic. It is important that the first part of the bisque firing is very slow to avoid boiling moisture in the clay which will cause the piece to shatter as the water turns to steam. Even where a pot appears completely dry there will still be moisture in the pores of the clay and also chemically combined with the clay. By gently heating, the moisture is driven

off safely. Firing too fast is the most common cause of damage to pots in firing. On reaching 600°C the moisture will have been driven out and also carbonaceous material present in the clay will, largely have been burnt off and so it is safe to increase the heating speed.

There are two types of biscuit firing:

1. **Low Bisque.** The clay is fired below its maturing range but high enough to give strength to the pot during the glazing process. The pot will be fired higher, to maturity, in the following glaze firing. Maturity means the clay reaches its optimum strength and is within the temperature range specified by the manufacturer. Low bisque firings are used for stoneware and also where a higher temperature earthenware glaze is required, in both cases the clay will reach maturity in the glaze firing.

2. **High bisque.** Here the clay is fired to maturing temperature first. A high bisque enables the ware to be glazed with a lower temperature glaze. High bisque is used for earthenware to ensure that the clay is matured; underfired clay is the most common cause of glazes crazing. This program is suitable for clays maturing, for example, around 1160°C where a glaze around 1020°C is used.

Program for Low Bisque

If your controller has three segments, start with a slow warming up phase as follows to ensure moisture is driven off, this will eliminate the problem of the pot shattering:

First ramp: 80°C per hour to 75°C – soak for one hour.
Second ramp: 100°C per hour to 600°C - no soak,
Third ramp: 200°C per hour to 1000°C - 10 minutes soak - END

If you only have two heating ramps you could make the warming up phase to 70°C a separate program, when finished change the program to start the bisque at 100°C per hour as above.

Program for High Bisque

As above, if your controller has three segments, start with a warming up phase to ensure moisture is driven off, as follows:

First ramp: 70°C per hour to 70°C – soak for one hour.
Second ramp: 100°C per hour to 600°C - no soak,
Third ramp: 200°C per hour to 1140°C* - 10 minutes soak - END

If you only have two heating ramps you could make the warming up phase to 70°C a separate program, when finished change the program to start the bisque at 100°C per hour as above.
*The top temperature must be within the maturing range of the clay as specified by the manufacturer.

Glaze Firing

The first heating ramp in glaze firings should be relatively slow up to 600°C. At 573°C there is a sudden expansion of ceramic because of quartz inversion, this van cause cracking if the work is heated unevenly. After this it is safe to fire faster e.g. 200°C per hour depending on the shape and size of the product. Make the first heating ramp slower for larger, thicker pieces.

Program for low fire earthenware glaze.

First ramp: 100°C per hour to 600°C - soak for 10 minutes.
Second ramp: 200°C per hour to 1060°C* – 10 minutes soak.

Program for stoneware Glaze.

First ramp: 100°C per hour to 600°C - soak for 10 minutes.
Second ramp: 250°C per hour to 1260°C* – 15 minutes soak.

*This is an example, check the maturing temperature range of your glaze.

The actual rate of firing will not follow the program throughout the firing, particularly in the later stages, this is because, as the kiln heats up it begins to lose heat through the kiln walls, slowing down the rate of increase. All kilns slow down as they reach higher temperatures so although the heating ramp set on the controller may be, say 200°C per hour this will be progressively reduced and for example, may even be less than 20°C per hour on reaching 1280°C. To determine the precise level of heatwork achieved by the kiln you will need to use Pyrometric cones. Please see our technical advice leaflet "Heatwork and Pyrometric Cones".

Please note that the top temperatures in our examples depend on the material used – check the maturing temperature range of your clay and glaze with your supplier before firing.

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Further Programming Information

Cooling Ramps

The above program examples cater for the majority of kiln firings but there are instances where additional ramps or a different approach is required for example by including a controlled cooling ramp. This is sometimes useful with large work to ensure that the temperature reduces evenly throughout the piece. A cooling ramp of, say 100°C could be used to control cooling down to 200°C after that it could drop naturally. 200°C is a significant temperature because a sudden contraction of ceramic, the cristobalite inversion which takes place at 226°C.

Makers of Macro-crystal glazes need cooling ramps to allow crystal formation to take place during soaks at specific temperatures. This is also the case with glass slumping and fusing where control over the cooling ramp through the annealing phase is the most important part of the firing. Very little power is required during a cooling ramp as only short bursts of heat are required to slow the cooling process.

Additional Heating Ramps

The normal two heating ramps may need to be augmented to give greater control, a slow warming ramp, also described as candling has already been described but a further stage is sometimes recommended. If clay bodies contain a lot of carbonaceous matter this can cause blistering or craters in the glaze as it is driven off in the glaze firing, to ensure all this matter is burnt away in the biscuit firing a soak of one hour at 940°C is recommended.

A slower heating ramp can be used for the last 100°C of the firing, this could mimic the Orton cone heating rates of 15°C or 60°C enabling a precise measure of heatwork.

Kilns firing off a 13amp supply can be slow reaching to higher stoneware temperatures, consequently are drawing power continuously as the controller demands a faster heating ramp than is possible which can lead to overheating of the plug. If a slower rate of heating is programmed, for example 20°C for the last 50°C or so, this would allow the kiln to switch off for short periods minimising the risk of overheating the plug.