



APPENDIX 2

Cone Chart and Heat Work

Cone deformation

Each cone has a number which corresponds to a heating rate/temperature combination producing a cone deformation. At the beginning of the firing the cone is standing at an $8\frac{1}{2}$ angle. A perfectly fired cone will be bent to a $90\frac{1}{2}$ angle. More than a $90\frac{1}{2}$ angle is overfired, less than $90\frac{1}{2}$ is underfired.

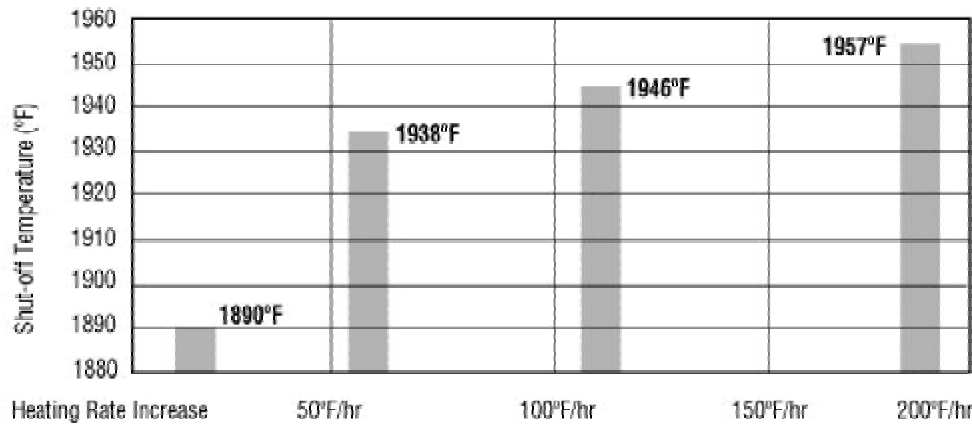
How a cone works.

- The maturing temperature or bending point of a cone is determined by different chemical compounds which are formulated to relate to heat work in clays and glazes.
- Time and temperature are key factors in the way a cone operates. Here are some points to consider:

1. Firing clay takes varying amounts of time to be "done". Thick walled pieces take more time to cure to the center than thin walled-cast pieces. For example, if you bake a cake for 15 minutes at $750^{\circ}\text{F}/400^{\circ}\text{C}$ it will be different from a cake baked 45 minutes at $350^{\circ}\text{F}/177^{\circ}\text{C}$.
2. Cones continue to drop after the firing is complete. A cone held at a temperature for a long time will continue to bend even if the programmed temperature is lower than the cone number. For example, if the end firing temperature is slightly short of maturity and put on hold for a long time, the cone will eventually bend to full maturity.
3. Cone deformation depends on heating rate and the final temperature. The chart on the next page helps define this principle. It illustrates the different temperatures a cone will bend depending on the heating rate per hour. For example, heating at $18^{\circ}/\text{hr}$, the cone will deform at 1890° ; heating at $108^{\circ}/\text{hr}$, the cone will deform at 1944° , at $175^{\circ}/\text{hr}$, the cone will deform at 1954° .



Cone 04, 90° drop, Relationship of heating rate and shut-off temperature.



How the KilnMaster can emulate cones.

As you have just seen, a cone drops according to a complex set of factors. The KilnMaster has been designed to take these factors into account when it shuts off the kiln. Most important to the KilnMaster is the heating rate if a cone correlation is to be accurate. Here's how the KilnMaster does it.

Cone Fire mode

- By selecting Slow, Medium or Fast, the controller goes into a set routine for finishing the firing to insure a good cone correlation.
- The controller has a preset final heating rate that allows the KilnMaster to adjust the final temperature value up or down from the 108⁰/hour standard heating rate that is used on Orton's Cone chart.
- If the kiln cannot produce the rate, the KilnMaster still measures the actual rate and adjusts the final temperature accordingly.

Orton Pyrometric Cones Self-Supporting Regular

Cone Number	Final Temperature at 108° E/hr
10	2345° F
9	2300
8	2273
7	2228
6	2199
5	2165
4	2142
3	2109
2	2091
1	2080
01	2046
02	2017
03	1990
04	1944
05	1891
05 1/2	1855
06	1819
07	1787
08	1737
09	1683
010	1632
011	1607
012	1575
013	1542
014	1488
015	1452
016	1411
017	1353
018	1314
019	1243
020	1159
021	1112
022	1087

Final temperature for cone maturity depends on rate of temperature increase during final 300 to 400° of firing. Courtesy Edward Orton Jr. Ceramic Foundation.

Ramp/Hold mode

In Cone Fire mode, the KilnMaster does all the calculating and thinking that goes into emulating a cone. In Ramp/Hold, you the operator must participate to get accurate cone firing results.

- If you are trying to fire to a cone temperature in this mode, you must use a rate/temperature combination in the last hour of firing that the kiln can reasonably accomplish and that is predictable. Yes, you can program 200⁰ or 300⁰/hr, but a heating rate of 108⁰/hour is about the maximum final heating rate you can achieve with an electric kiln when high firing.
- If you program a target heating rate that the kiln can't achieve, overfiring will probably result. That final Ramp/•Hold segment will run until the desired temperature is reached. However, the slower actual rate will cause more heat work to be done than you desired.
- We recommend using Cone Fire mode to emulate a cone because the controller will automatically compensate for the firing rate of your kiln. When you need to achieve a temperature between cones, we recommend making the last hour of the firing your final segment and using a rate less than 108⁰/hour. Use the 108⁰F data from the Orton Cone Chart shown here instead of any other charts you may be using.