

Using Orton  
Pyrometric Cones

Cone Numbers 022-14



Pyrometric cones have been used to monitor ceramic firings for more than 100 years. They are useful in determining when a firing is complete, if the kiln provided enough heat, if there was a temperature difference in the kiln or if a problem occurred during the firing.

Cones are made from carefully controlled compositions. They bend in a repeatable manner (over a relatively small temperature range - usually less than 40° F). The final bending position is an indication of how much heat was absorbed.

Behavior of Pyrometric Cones

Pyrometric cones deform due to the formation of glass and the pull of gravity as they are heated to their designed operating temperature. This is known as pyro plastic deformation. Careful control over the shape and composition allows Orton to provide a standardized product that reliably performs to known heating conditions. Cones bend and deform in an arc as they start to develop glass within. This behavior is gradual at first, and hastens as the cone reaches its maximum operating temperature. The time interval from when a cone begins to deform until the tip of the cone reaches the shelf is typically 15-25 minutes. The interpretation of the location of the tip of the cone along the bending arc can be done in a couple of ways. One method of interpretation is to correlate the position of the tip to the numbers on a clock face. Initially, the cone is in the 1 o'clock position and continues to deform until the tip is in contact with a shelf, the 6 o'clock position. A more precise method of interpretation is to use the Orton measuring template. The template measures the angle of deformation along a protracted scale numbered from 0 to 90°. The endpoint temperature for a cone is considered to be when the tip is measured with a 90° bend, or in the 5 o'clock position.

The difference in temperature between cones in the 90° (or 5 o'clock) position to one where the tip is touching the shelf is typically only a few degrees and is considered insignificant.

Temperatures shown on the Orton charts were determined using precisely controlled kilns in an air atmosphere. Cones do not measure temperature alone. They measure heatwork, the combined effect of time and temperature. The role that heating rates have on the endpoint temperature is observed to be that the temperature required to cause a cone to bend will be higher for faster heating rates and lower for slower rates. Heating rates that simulate fast, medium, or slow firings were tabulated.

Temperatures shown for small cones were determined using a heating rate of 300C/hr (540F/hr) in a gas fired kiln. Small cones will come close to duplicating the results of self-supporting cones if mounted upright, properly simulating the position of a self-supporting cone. Typically, small cones will deform 7-10 degrees C earlier than a self-supporting cone, so the temperature values for a self-supporting cone can be used to determine an equivalent small cone temperature by subtracting 7-10 degrees C (or 12-18 degrees F). Placing a small cone or bar cone into a kiln shutoff device (Kiln sitter), will not always produce the desired temperature stated on the cone chart. To produce a properly fired result, the next cone higher in sequence is placed into the shutoff device and the result is confirmed by a cone placed inside the kiln on a kiln shelf.

Reducing atmospheres can affect the bending behavior of cones, especially the red colored cones manufactured between numbers 010-3. If these cones are used in the absence of oxygen, the red iron oxide used in the formulation can reduce and change the appearance so the cone will appear matte, green, or bloated. Orton recommends using the Iron free series for all reduction firings between cones 010 – 3.

For more information on pyrometric cones, contact Orton or visit us at [www.ortonceramic.com](http://www.ortonceramic.com)



The Edward Orton Jr. Ceramic Foundation  
P.O. Box 2760 • Westerville, OH 43086-2760  
(614) 895-2663 • (614) 895-5610 fax  
[info@ortonceramic.com](mailto:info@ortonceramic.com) • [www.ortonceramic.com](http://www.ortonceramic.com)

These tables provide a guide for the selection of cones. The actual bending temperature depends on firing conditions. Once the appropriate cones are selected, excellent, reproducible results can be expected.

Temperature Equivalents for Orton Pyrometric Cones (°F)

| Heating Rate* | Self Supporting Cones |          |          |                 |          |          | Large Cones   |          |                 |          | Small    |
|---------------|-----------------------|----------|----------|-----------------|----------|----------|---------------|----------|-----------------|----------|----------|
|               | Regular – SSB         |          |          | Iron Free – SSK |          |          | Regular – LRB |          | Iron Free – IFB |          | Regular  |
|               | 27°F/hr               | 108°F/hr | 270°F/hr | 27°F/hr         | 108°F/hr | 270°F/hr | 108°F/hr      | 270°F/hr | 108°F/hr        | 270°F/hr | 540°F/hr |
| Firing Speed  | Slow                  | Medium   | Fast     | Slow            | Medium   | Fast     | Medium        | Fast     | Medium          | Fast     | Fast**   |
| Cone #        |                       |          |          |                 |          |          |               |          |                 |          |          |
| 022           |                       | 1087     | 1094     |                 |          |          |               |          |                 |          | 1166     |
| 021           |                       | 1112     | 1143     |                 |          |          |               |          |                 |          | 1189     |
| 020           |                       | 1159     | 1180     |                 |          |          |               |          |                 |          | 1231     |
| 019           | 1213                  | 1252     | 1283     |                 |          |          | 1249          | 1279     |                 |          | 1333     |
| 018           | 1267                  | 1319     | 1353     |                 |          |          | 1314          | 1350     |                 |          | 1386     |
| 017           | 1301                  | 1360     | 1405     |                 |          |          | 1357          | 1402     |                 |          | 1443     |
| 016           | 1368                  | 1422     | 1465     |                 |          |          | 1416          | 1461     |                 |          | 1517     |
| 015           | 1382                  | 1456     | 1504     |                 |          |          | 1450          | 1501     |                 |          | 1549     |
| 014           | 1395                  | 1485     | 1540     |                 |          |          | 1485          | 1537     |                 |          | 1598     |
| 013           | 1485                  | 1539     | 1582     |                 |          |          | 1539          | 1578     |                 |          | 1616     |
| 012           | 1549                  | 1582     | 1620     |                 |          |          | 1576          | 1616     |                 |          | 1652     |
| 011           | 1575                  | 1607     | 1641     |                 |          |          | 1603          | 1638     |                 |          | 1679     |
| 010           | 1636                  | 1657     | 1679     | 1600            | 1627     | 1639     | 1648          | 1675     | 1623            | 1636     | 1686     |
| 09            | 1665                  | 1688     | 1706     | 1650            | 1686     | 1702     | 1683          | 1702     | 1683            | 1699     | 1751     |
| 08            | 1692                  | 1728     | 1753     | 1695            | 1735     | 1755     | 1728          | 1749     | 1733            | 1751     | 1801     |
| 07            | 1764                  | 1789     | 1809     | 1747            | 1780     | 1800     | 1783          | 1805     | 1778            | 1796     | 1846     |
| 06            | 1798                  | 1828     | 1855     | 1776            | 1816     | 1828     | 1823          | 1852     | 1816            | 1825     | 1873     |
| 05½           | 1839                  | 1859     | 1877     | 1814            | 1854     | 1870     | 1854          | 1873     | 1852            | 1868     | 1909     |
| 05            | 1870                  | 1888     | 1911     | 1855            | 1899     | 1915     | 1886          | 1915     | 1890            | 1911     | 1944     |
| 04            | 1915                  | 1945     | 1971     | 1909            | 1942     | 1956     | 1940          | 1958     | 1940            | 1953     | 2008     |
| 03            | 1960                  | 1987     | 2019     | 1951            | 1990     | 1999     | 1987          | 2014     | 1989            | 1996     | 2068     |
| 02            | 1972                  | 2016     | 2052     | 1983            | 2021     | 2039     | 2014          | 2048     | 2016            | 2035     | 2098     |
| 01            | 1999                  | 2046     | 2080     | 2014            | 2053     | 2073     | 2043          | 2079     | 2052            | 2070     | 2152     |
| 1             | 2028                  | 2079     | 2109     | 2046            | 2082     | 2098     | 2077          | 2109     | 2079            | 2095     | 2163     |
| 2             | 2034                  | 2088     | 2127     |                 |          |          | 2088          | 2124     |                 |          | 2174     |
| 3             | 2039                  | 2106     | 2138     | 2066            | 2109     | 2124     | 2106          | 2134     | 2104            | 2120     | 2185     |
| 4             | 2086                  | 2124     | 2161     |                 |          |          | 2120          | 2158     |                 |          | 2208     |
| 5             | 2118                  | 2167     | 2205     |                 |          |          | 2163          | 2201     |                 |          | 2230     |
| 5½            | 2133                  | 2197     | 2237     |                 |          |          |               |          |                 |          |          |
| 6             | 2165                  | 2232     | 2269     |                 |          |          | 2228          | 2266     |                 |          | 2291     |
| 7             | 2194                  | 2262     | 2295     |                 |          |          | 2259          | 2291     |                 |          | 2307     |
| 8             | 2212                  | 2280     | 2320     |                 |          |          | 2277          | 2316     |                 |          | 2372     |
| 9             | 2235                  | 2300     | 2336     |                 |          |          | 2295          | 2332     |                 |          | 2403     |
| 10            | 2284                  | 2345     | 2381     |                 |          |          | 2340          | 2377     |                 |          | 2426     |
| 11            | 2322                  | 2361     | 2399     |                 |          |          | 2359          | 2394     |                 |          | 2437     |
| 12            | 2345                  | 2383     | 2419     |                 |          |          | 2379          | 2415     |                 |          | 2471     |
| 13            | 2389                  | 2428     | 2458     |                 |          |          | 2410†         | 2455†    |                 |          |          |
| 14            | 2464                  | 2489     | 2523     |                 |          |          | 2530†         | 2491†    |                 |          |          |

|  |                                |
|--|--------------------------------|
|  | Cones made with red iron oxide |
|  | Cones made without iron oxide  |

\* Heating Rate during the last 180°F / 100°C of Firing

\*\* Fired in a gas kiln

Temperatures shown are for specific mounted height above base. For Self Supporting - 1¾"; for Large - 2"; for Small - 15/16". For Large Cones mounted at 1¾" height, use Self Supporting temperatures. † These Large Cones have different compositions and different temperature equivalents.

Temperature Equivalents for Orton Pyrometric Cones (°C)

| Heating Rate* | Self Supporting Cones |         |          |                 |         |          | Large Cones   |          |                 |          | Small    |
|---------------|-----------------------|---------|----------|-----------------|---------|----------|---------------|----------|-----------------|----------|----------|
|               | Regular – SSB         |         |          | Iron Free – SSK |         |          | Regular – LRB |          | Iron Free – IFB |          | Regular  |
|               | 15°C/hr               | 60°C/hr | 150°C/hr | 15°C/hr         | 60°C/hr | 150°C/hr | 60°C/hr       | 150°C/hr | 60°C/hr         | 150°C/hr | 300°C/hr |
| Firing Speed  | Slow                  | Medium  | Fast     | Slow            | Medium  | Fast     | Medium        | Fast     | Medium          | Fast     | Fast**   |
| Cone #        |                       |         |          |                 |         |          |               |          |                 |          |          |
| 022           |                       | 586     | 590      |                 |         |          |               |          |                 |          | 630      |
| 021           |                       | 600     | 617      |                 |         |          |               |          |                 |          | 643      |
| 020           |                       | 626     | 638      |                 |         |          |               |          |                 |          | 666      |
| 019           | 656                   | 678     | 695      |                 |         |          | 676           | 693      |                 |          | 723      |
| 018           | 686                   | 715     | 734      |                 |         |          | 712           | 732      |                 |          | 752      |
| 017           | 705                   | 738     | 763      |                 |         |          | 736           | 761      |                 |          | 784      |
| 016           | 742                   | 772     | 796      |                 |         |          | 769           | 794      |                 |          | 825      |
| 015           | 750                   | 791     | 818      |                 |         |          | 788           | 816      |                 |          | 843      |
| 014           | 757                   | 807     | 838      |                 |         |          | 807           | 836      |                 |          | 870      |
| 013           | 807                   | 837     | 861      |                 |         |          | 837           | 859      |                 |          | 880      |
| 012           | 843                   | 861     | 882      |                 |         |          | 858           | 880      |                 |          | 900      |
| 011           | 857                   | 875     | 894      |                 |         |          | 873           | 892      |                 |          | 915      |
| 010           | 891                   | 903     | 915      | 871             | 886     | 893      | 898           | 913      | 884             | 891      | 919      |
| 09            | 907                   | 920     | 930      | 899             | 919     | 928      | 917           | 928      | 917             | 926      | 955      |
| 08            | 922                   | 942     | 956      | 924             | 946     | 957      | 942           | 954      | 945             | 955      | 983      |
| 07            | 962                   | 976     | 987      | 953             | 971     | 982      | 973           | 985      | 970             | 980      | 1008     |
| 06            | 981                   | 998     | 1013     | 969             | 991     | 998      | 995           | 1011     | 991             | 996      | 1023     |
| 05½           | 1004                  | 1015    | 1025     | 990             | 1012    | 1021     | 1012          | 1023     | 1011            | 1020     | 1043     |
| 05            | 1021                  | 1031    | 1044     | 1013            | 1037    | 1046     | 1030          | 1046     | 1032            | 1044     | 1062     |
| 04            | 1046                  | 1063    | 1077     | 1043            | 1061    | 1069     | 1060          | 1070     | 1060            | 1067     | 1098     |
| 03            | 1071                  | 1086    | 1104     | 1066            | 1088    | 1093     | 1086          | 1101     | 1087            | 1091     | 1131     |
| 02            | 1078                  | 1102    | 1122     | 1084            | 1105    | 1115     | 1101          | 1120     | 1102            | 1113     | 1148     |
| 01            | 1093                  | 1119    | 1138     | 1101            | 1123    | 1134     | 1117          | 1137     | 1122            | 1132     | 1178     |
| 1             | 1109                  | 1137    | 1154     | 1119            | 1139    | 1148     | 1136          | 1154     | 1137            | 1146     | 1184     |
| 2             | 1112                  | 1142    | 1164     |                 |         |          | 1142          | 1162     |                 |          | 1190     |
| 3             | 1115                  | 1152    | 1170     | 1130            | 1154    | 1162     | 1152          | 1168     | 1151            | 1160     | 1196     |
| 4             | 1141                  | 1162    | 1183     |                 |         |          | 1160          | 1181     |                 |          | 1209     |
| 5             | 1159                  | 1186    | 1207     |                 |         |          | 1184          | 1205     |                 |          | 1221     |
| 5½            | 1167                  | 1203    | 1225     |                 |         |          |               |          |                 |          |          |
| 6             | 1185                  | 1222    | 1243     |                 |         |          | 1220          | 1241     |                 |          | 1255     |
| 7             | 1201                  | 1239    | 1257     |                 |         |          | 1237          | 1255     |                 |          | 1264     |
| 8             | 1211                  | 1249    | 1271     |                 |         |          | 1247          | 1269     |                 |          | 1300     |
| 9             | 1224                  | 1260    | 1280     |                 |         |          | 1257          | 1278     |                 |          | 1317     |
| 10            | 1251                  | 1285    | 1305     |                 |         |          | 1282          | 1303     |                 |          | 1330     |
| 11            | 1272                  | 1294    | 1315     |                 |         |          | 1293          | 1312     |                 |          | 1336     |
| 12            | 1285                  | 1306    | 1326     |                 |         |          | 1304          | 1324     |                 |          | 1355     |
| 13            | 1310                  | 1331    | 1348     |                 |         |          | 1321†         | 1346†    |                 |          |          |
| 14            | 1351                  | 1365    | 1384     |                 |         |          | 1388†         | 1366†    |                 |          |          |