

# Firing Tips

## UNDERSTANDING HEAT TRANSFER

### How Heat is Transferred

Heat moves through the kiln from hotter to cooler zones by:

1. convection
2. conduction
3. radiation

### Convection

Convection is the first step in the heating process in the kiln. Air is heated as it passes across the warming kiln elements. As the hot air rises and cool air falls, air currents are created which circulate hot air to cooler places in kiln. This heat is transferred to the ware, shelves, etc.

The kiln will not be uniform in temperature at this early stage of firing unless the hot air is pushed through the kiln by mechanical means. Low cone firings such as 022 and 021 depend more heavily on convection for heat transfer.

The most common type of convection we are familiar with is wind chill. The cool air passes across the face and pulls heat from our warmer body, which lowers our skin temperature.

### Conduction

When heat moves through a solid, it is conducted. An example would be heat moving through the handle of a saucepan. This is a slow way to heat, but the handle will eventually get hot.

In a kiln, conduction moves heat from the inside to the outside of the kiln and from the outside to the inside of the ware. Conduction is the main way we get uniform heating in the kiln. This is a slow process and if we fire too fast, the inside of our ware will receive too little heat and not fire properly.

### Radiation

At the beginning of the firing, the elements are the hottest part of the kiln. The heat from the elements radiates out - like the sun warming us on a cool day. Eventually the firebrick and the ware will also get hot and will radiate heat as well.

As the temperature increases, more and more of the heat is transferred by radiation from the heating elements. For uniform heating, is important that all surfaces of the ware be exposed to heating elements, even partially.

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## Typical Heating Problems

### Temperature Uniformity

At low temperatures, heat moves primarily by convection. This is not a very efficient method. The hot gases and some radiation heat the surface of the ware, where it is conducted into the ware. Sufficient time is needed to move heat to and into the ware.

Unless we move the heat through the kiln by mechanical means, the hot air will naturally rise to near the top of the kiln and the cool air will fall to near the bottom. We may see up to a 2 cone difference from top to bottom in the kiln at low cone values.

Soaking or holding the kiln at temperature can help equalize heat, but truly uniform conditions will not naturally occur until higher temperatures, where radiation is more effective.

### Evenly Heating Ware

Heat moves through ware from the outside to the inside. It is important to try to uniformly heat all the surfaces of the ware. Loading of the kiln can help even heating. Also, fire slower to allow heat time to penetrate inside the ware.

If the top of a piece is heated, but the bottom is touching a cool shelf, the ware may crack or warp as one surface of a piece is heated more rapidly than the other. This is why it is important to use plate and tile setters for large flat objects which may warp.

Nesting bisque will prevent the inside pieces of ware from heating at all, and

will restrict heat moving into the inside pieces, or the inside of the bottom piece. This is why it is better to invert or box bisque items.

It is also important to make sure that larger pieces of ware don't block smaller ones from the heat source and that ware is kept at least 1" away from the hot elements.

Ware placed too close to the elements may distort or colors may burn off or shift because they have received too much localized heat.

If ware is not placed so it can evenly receive the heat, some surfaces may end up cooler than others and the piece may crack, warp or bloat.

### Want to learn more?

Read more about heat transfer in the Orton Firing Line and Technical Tips publications. Each issue is packed full of articles to help you learn more about firing. Members of the Orton Firing Institute receive these publications at no charge. Single copies are available to non-members at a per issue rate. Orton's 80 minute video, *Key Principles of Successful Firing*, is also an excellent resource on firing.

For information on Orton products, see your Orton dealer or distributor. For information on the Firing Institute or publications, contact

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