

# ceramics

M O N T H L Y

Topic: Ceramic Kilns

From the December 2019 issue

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## Techno File: Kiln Atmosphere

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**Oxidation, reduction, or neutral? Here's a brief review of kiln atmosphere, how it can be determined each firing, and why it's important.**

### Defining the Terms

**Clamming:** Sealing kiln openings after firing, usually with a thin mix of sand, clay, and water, to make the kiln airtight during cooling.

**Neutral Atmosphere:** When air and fuel in the kiln are in perfect balance, with just enough oxygen to burn the fuel, but no more.

**Oxidation Atmosphere:** When there is more oxygen in the kiln than needed to completely burn the fuel.

**Reduction Atmosphere:** When there is not enough oxygen in the kiln for complete combustion of the fuel present.

**Positive Pressure:** Pressure inside the kiln is higher than the air pressure outside, causing kiln gases to exit the kiln through any leaks or openings.

**Negative Pressure:** Pressure inside the kiln is lower than air pressure outside, causing air to enter the kiln through any leaks or openings.

### Science

Fuel-fired kilns permit large swings in kiln atmosphere. Historically, potters saw that reduction produced different results, and that the degree of reduction also mattered. Oxygen hadn't been discovered by scientists but its effects were known and controlled centuries ago. Early potters obviously learned from experience rather than scientific understanding. That experience most likely came from the continuous cycles of reducing, neutral, and oxidizing atmospheres that stoking a wood kiln produces.

### Atmosphere in a Wood Kiln

Wood firing typically produces oxidation early on as the kiln temperature is raised carefully. Once heavy stoking (adding a large quantity of wood to the fire box) begins, the kiln is thrown into a period of reduction, followed by a brief neutral atmosphere, and then oxidation again in between stokings. When wood is first stoked into a hot kiln's firebox, the surface of the wood and combustible gases coming out of the wood burn. If the wood is in slender pieces or the stoking is heavy, all the oxygen in the firebox is consumed. This deficiency of oxygen is what we call reduction. As the volatile portion of the wood is burned off, combustion slows to a closer balance with the entering oxygen. At some point the fuel and oxygen balance exactly, producing an atmosphere we call neutral. If the fire is allowed to burn down to slow the rate of temperature rise, there is more oxygen than the fuel requires for combustion in the firebox and we say the kiln is in oxidation. Heavy stoking starts the cycle again.

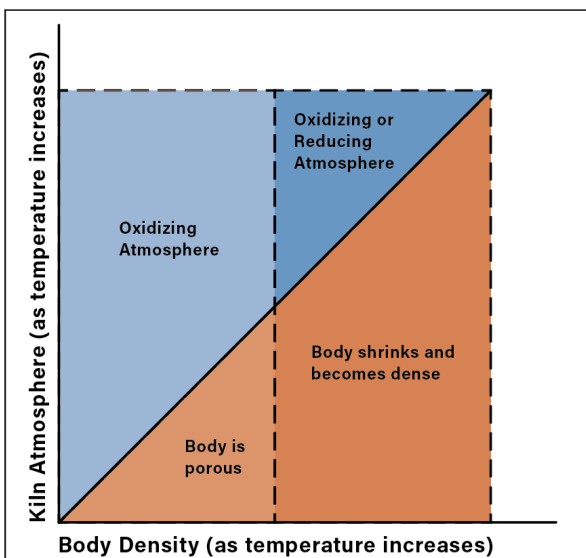
Wood firers know that heavy smoke from the flue is evidence a kiln is in reduction. Either adding fuel or dampering (closing) the air inlets produces that smoke. No smoke at all with wood burning indicates oxidation or a neutral atmosphere.

## Atmosphere in a Gas Kiln

Gas-fired kilns should never have visible smoke coming from the flue. While they often have the benefit of an oxygen analyzer, it is possible to determine, in general, gas kiln atmosphere by careful observation. Here it is necessary to add a note of caution. Opening the peep hole of any kiln during a firing can be dangerous. If the atmosphere inside the kiln is at a higher pressure than the air just outside the opened peep, gases hot enough to cause severe burns can flow out and those gases may be invisible! Always use proper personal protective equipment (PPE) and stand safely to the side when opening a peep hole.

Look for flame coming out of the peep. Flame there means the hot kiln gases are igniting when they hit the air outside the kiln, a sign the kiln is in reduction. No flame at the peep raises questions. Either the kiln is under positive pressure and in oxidation, in which case invisible hot gases are blowing out, or the kiln is under negative pressure and air is being drawn in through the open peep.

To determine the pressure, sweep a piece of paper past the peep hole. The paper will ignite quickly if hot, oxidizing kiln gas is coming out the peep under positive pressure. If the paper doesn't light, the kiln is under negative pressure; however, that doesn't reveal the kiln atmosphere. Carefully inserting a fine sliver of wood into the peep hole while wearing protective clothing (including fire-resistant gloves) will provide information on the atmosphere. If the wood bursts into flame, the kiln atmosphere is oxidizing. If the wood only chars while inside the kiln but bursts into flame as it's withdrawn from the peep hole, the atmosphere is reducing.



All clay bodies need a clean, oxidizing firing up to a certain point, while the body remains porous (actual cone and temperature range varies based on clay body composition). This ensures organic materials can burn off. Beyond that temperature, the atmosphere can be altered/controlled to suit the glazes in use.

These simple tests are nothing like the precision of an oxygen analyzer. However, with experience, one can gain from them helpful clues about a firing atmosphere.

Adding fuel to a kiln at the end of a firing and then clamping the ports, peeps, and doors permits reduction while the kiln cools. Keep in mind, reduction cooling just affects the glaze surface. Full reduction effects in glazes can only be obtained before the glaze melts and glosses over. Once the glaze is glassy, the kiln atmosphere affects only its surface. The temperature range for reduction depends on the glazes being used and the clay body maturation temperature. Clay bodies should be oxidized as long as they are porous (about cone 04 for stonewares), and then the glaze can be safely reduced. Glaze must be reduced before it melts.

### Note on Electric Kilns

While electric kiln firings are generally oxidizing, even an electric firing has some small amount of fuel from the burnoff of organics in clay, sulfur in pyrite, and glaze additives like gums. If the kiln seal is tight, those combustibles can consume all the oxygen in the kiln and create a reducing atmosphere.

Modern kiln vents draw air into electric kilns to burn off combustibles and produce a cleaner firing, which improves element life and can yield brighter glazes. Deliberate reduction in an electric kiln is possible, but it reduces element life. If done continuously, it can produce poisonous carbon monoxide gas, so a well-ventilated kiln space is essential.

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