A LINCOLN ELECTRIC COMPANY

Turn to the **Pros**

GENERAL THEORY OF OXY-FUEL CUTTING

THEORY OF OXYGEN/FUEL GAS FLAME CUTTING

THE PROCESS

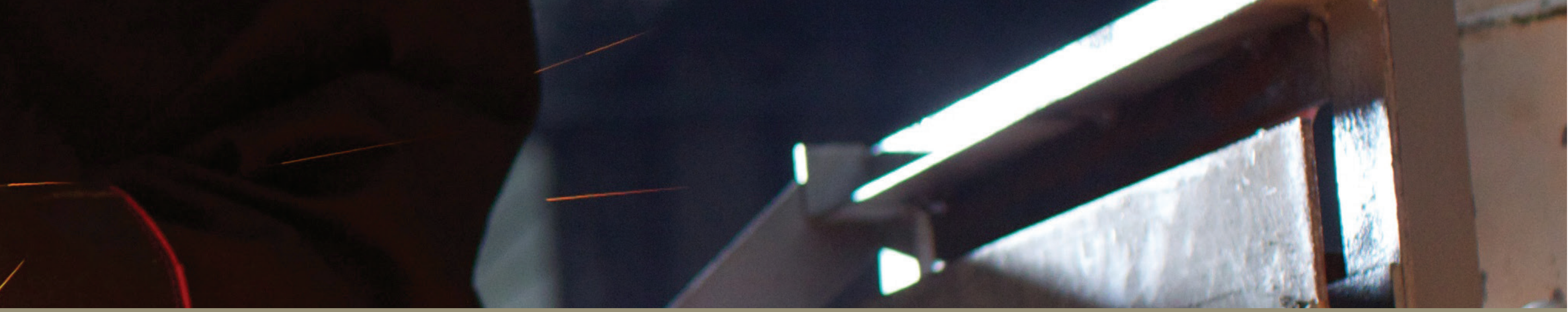
Oxy/fuel flame cutting is a chemical reaction occurring between the steel and cutting oxygen stream. An oxy/fuel cutting torch diverts the oxygen with part of it mixing with the fuel gas to create the preheat flame, which forms the ring of flame around the cutting tip. **This preheat flame will reach a temperature of 4400°F to 6000°F, depending upon the fuel gas used, and the ratio of oxygen to fuel gas. In order to start a chemical reaction, the metal must be raised to the kindling temperature, which in mild carbon steel is approximately 1600°F.** At this point, the metal will reach a bright orange color and sparks will be noticed on the top edge.

When the kindling temperature is reached, the cutting oxygen lever is engaged and the introduction of high purity oxygen (which is generally referred to as the "cutting jet") chemically combines with the iron exothermically. At this temperature, when the oxygen combines iron to form iron oxides, the burning process begins. This is commonly referred to as an **"exothermic reaction"** because it releases heat.

The cutting oxygen jet is always in the center of the tip and instantly starts a rapid oxidation of the steel through the depth of the cut. It is extremely important to understand that a tremendous amount of heat is liberated when the high purity oxygen unites with the steel during the exothermic reaction.

PREHEAT

- **Primary function is to preheat the steel to the ignition temperature, which is approximately 1600°F.**
- **Penetrate and remove any foreign substance on the steel surface, such as rust, scale, dirt and oxide crust, as you progress with the flame cutting.**
- **Maintain the reaction temperature to the new material being constantly presented to the center cutting jet of oxygen.**
- **Maintain a protective envelope around the center cutting jet of oxygen.**
- **Maintain the slag In a fluid condition to run down the kerf, which is the opening created by the cutting process.**



CUTTING OXYGEN

As discussed earlier, it is the cutting oxygen that performs all of the work during the cutting operation. The purity of the cutting oxygen should be 99.5%, or higher. **A 1% decrease in the purity will result in a decrease of cutting speed of approximately 25%, and increase the oxygen consumption at the same time by approximately 25%.** At about 95% oxygen purity, the cutting process will cease and is replaced by a melt and wash action.

The iron oxides formed by the combination of the oxygen stream and preheated metal is the slag which is removed through the kerf. With the chemical reaction comes the evolution of considerable heat, which is an exothermic reaction. Cutting speeds are dependent on two considerations. First, the torch can only travel as fast as it is able to keep the steel under it at ignition temperature. Traveling too fast means "losing the cut". However, on thicker plate, the main speed limitation is not preheat, but the ability to remove all the slag from the kerf. In this instance, too rapid movement results in a "drag" and considerable dross adhering to the underside of the metal.

Theoretically, it takes 4.6 cubic feet of oxygen to oxidize one pound of steel completely to "ferrous oxide" Fe_3O_4. In practical cutting operations, the amount of oxygen used is less because not all of the iron is completely oxidized to ferrous oxide. **This set amount of oxygen is the constant required to flame cut metal no matter what fuel gas is used for the preheat function.** As the iron is oxidized, it starts to flow; some of the material adjacent to the iron oxides is melted and also flows, due only to the intense heat that is liberated in the chemical reaction. The removal of all the metal is based in large part on the velocity and coherency of the center oxygen cutting jet.

Manufacturers publish cutting tip charts, which indicates the tip size and pressures required for given material thickness, and cutting speed expressed in inches per minute (I.P.M.).

Standard cutting tips, with a straight bore cutting oxygen orifice, are used for hand cutting operations. Machine cutting is recommended with high pressure, divergent bore tips. Higher velocities are reached through this style tip while the gas exits at close to, or equal to, atmospheric pressure. The result is a more coherent oxygen stream, and a precise design at the discharge end of the oxygen jet allows expansion and turbulence which takes place in conventional tips. This normally results in an approximate 20% speed increase over conventional or standard designs.

The quality of the cut is determined by these factors; follow manufacturers' recommendations:

- **Tip size for thickness of steel**
- **Preheat flame setting**
- **Cutting oxygen pressure - read as close to torch as possible**
- **Cutting speed**
- **Condition of the tip**

Following these guidelines will produce a high quality flame cut part, which will have these characteristics:

- **Smooth, perpendicular face.**
- **No Pressure or drag lines**
- **Top edge square, not rolled or melted.**
- **Lower edge free of slag.**

There are many flame cutting operations that do not require this high quality, and a slightly lower quality is normally acceptable in the steel fabrication industry where the cut surface is covered by weld, or where the surface is hidden inside of a fabrication or covered with paint. If slightly lower level quality is acceptable, the speeds can normally be increased.

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