Periodic checking and resetting of air-fuel ratios for burners is one of the simplest ways to get maximum efficiency out of fuel-fired process heating equipment such as furnaces, ovens, heaters, and boilers. Most high temperature direct-fired furnaces, radiant tubes, and boilers operate with about 10% to 20% excess combustion air at high fire to prevent the formation of dangerous carbon monoxide and soot deposits on heat transfer surfaces and inside radiant tubes. For the fuels most commonly used by U.S. industry, including natural gas, propane, and fuel oils, approximately one cubic foot of air is required to release about 100 British thermal units (Btu) in complete combustion. Exact amount of air required for complete combustion of commonly used fuels can be obtained from the information given in one of the references. Process heating efficiency is reduced considerably if the combustion air supply is significantly higher or lower than the theoretically required air.

Air-gas ratios can be determined by flow metering of air and fuel or flue gas analysis. Sometimes, a combination of the two works best. Use the Available Heat Chart below to estimate the savings obtainable by tuning burner air-gas ratios. The excess air curves are labeled with corresponding oxygen percentages in flue gases.

To figure potential savings, you need to know:
- The temperature of the products of combustion as they leave the furnace
- The percentage of excess air or oxygen in flue gases, at which the furnace now operates
- The percentage of excess air or oxygen in flue gases, at which the furnace could operate.

On the chart, determine the available heat under present and desired conditions by reading up from the flue gas temperature to the curve representing the excess air or O₂ level; then, read left to the percentage available heat (AH). Calculate the potential fuel savings:

\[
\text{% Fuel Savings} = 100 \times \left( \frac{\text{%AH Desired} - \text{%AH Actual}}{\text{%AH Desired}} \right)
\]
Example
A furnace operates at 2,400°F flue gas temperature. The optimum ratio is 10% excess air (2.1% O₂ in flue gases), but tests show an actual ratio of 25% excess air (4.5% O₂ in flue gases). The chart shows an actual available heat of 22% compared to an ideal of 29%.

Fuel Savings = 100 X \frac{(29 - 22)}{29} = 24%

Note: The graph on the front page is for combustion air at ambient temperature (about 60°F) using natural gas with specific gas composition. The exact numbers may vary slightly if the natural gas composition is different from the one used for this graph. The available heat will also be different if the combustion air temperature is different. Use the Process Heating Assessment and Survey Tool (PHAST) or other methods to estimate fuel savings if your operating conditions are significantly different from the conditions stated above.

Suggested Actions
To get the most efficient performance out of fuel-fired furnaces, ovens, and boilers:
1. Determine the best level of excess air for operating your equipment.
2. Set your combustion ratio controls for that amount of excess air.
3. Check and adjust ratio settings regularly.