Rules of Thumb

- **Air-Fuel Ratio**: For most systems 2- 3% of oxygen with a 10-50 ppm combustible indicates ideal operating conditions
- **Preheated Combustion Air**: Processes operating above 1600 F are generally good candidates for air preheating

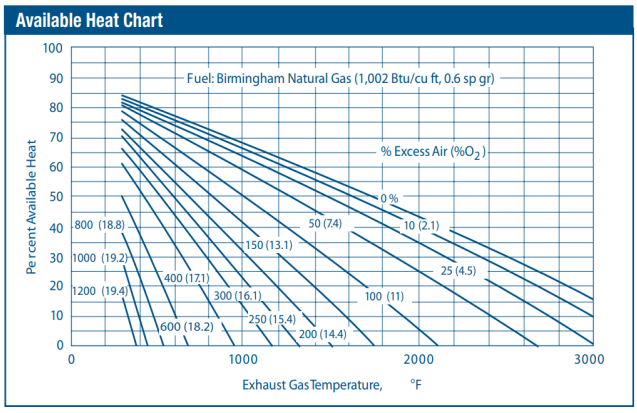
Percent Fuel Savings gained from Preheated Combustion Air

Furnace Exhaust Temperature, ˚F	Preheated Air Temperature, ˚F					
	600	800	1,000	1,200	1,400	1,600
1,000	13	18	–	–	–	–
1,200	14	19	23	–	–	–
1,400	15	20	24	28	–	–
1,600	17	22	26	30	34	–
1,800	18	24	28	33	37	40
2,000	20	26	31	35	39	43
2,200	23	29	34	39	43	47
2,400	26	32	38	43	47	51

Efficiency Reduction caused by soot deposits

Soot Layer Thickness		
1/32 inch	1/16 inch	1/8 inch
2.5%	4.5%	8.5%

Savings obtainable by tuning burner air-gas ratio



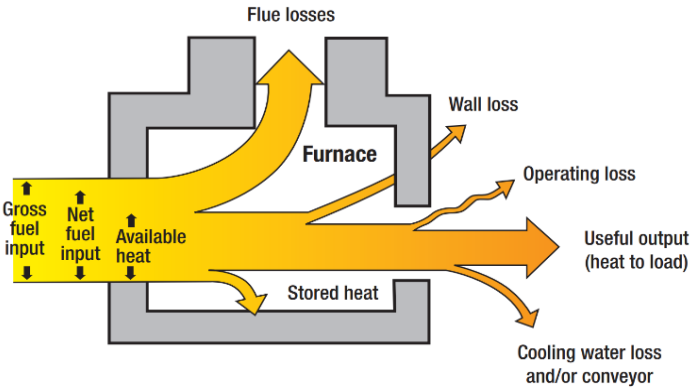
Determine the available heat under present and desired conditions by reading up from the flue gas temperature to the curve representing the excess air or O_2 level; then, read left to the percentage available heat (AH)

$$\%\ \textbf{Fuel Savings} = 100 \times \frac{\%\ \mathbf{AH_{Desired}} - \%\ \mathbf{AH_{Actual}}}{\%\ \mathbf{AH_{Desired}}}$$

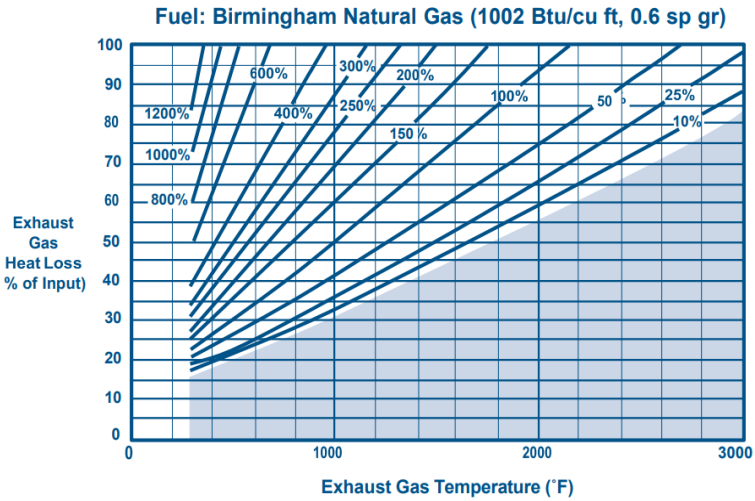
Potential applications of oxygen-enhanced combustion

Industry	Applications
Steel	Reheat, soaking pits, ladles
Aluminum	Melting
Copper	Smelting and melting
Glass	Melting
Pulp and Paper	Lime kilns, black liquor boilers
Petroleum	Process heaters, crackers
Power Production	Coal-fired steam boilers
Chemical	Sulfur

Energy loss diagram in a fuel-based process heating system



Heat lost in exhaust gases @ various exhaust gas temperatures and percentages of excess air



Commonly used waste heat management systems by temperature range

Ultra-High Temperature (>1600°F)	High Temperature (1200°F to 1600°F)	Medium Temperature (600°F to 1200°F)	Low Temperature (250°F to 600°F)	Ultra-Low Temperature (< 250°F)
• Refractory (ceramic) regenerators • Heat recovery boilers • Regenerative burners • Radiation recuperator • Waste heat boilers including steam turbine-generator based power generation • Load or charge preheating	• Convection recuperator (metallic) – mostly tubular • Radiation recuperator • Regenerative burners • Heat recovery boilers • Waste heat boilers including steam turbine-generator based power generation • Load or charge preheating • Metallic heat wheels (regenerative system)	• Convection recuperator (metallic) of many different designs • Finned tube heat exchanger (economizers) • Shell and tube heat exchangers for water and liquid heating • Self-recuperative burners • Waste heat boilers for steam or hot water condensate • Load-charge (convection section) preheating • Metallic heat wheel • Heat pipe exchanger	• Convection recuperator (metallic) of many different designs • Finned tube heat exchanger (economizers) • Shell and tube heat exchangers for water and liquid heating • Heat pumps • Direct contact water heaters • Condensing water heaters or heat exchangers • Metallic heat wheel • Heat pipe exchanger	• Shell and tube type heat exchangers • Plate type heat exchangers • Air heaters for waste heat from liquids • Heat pumps • HVAC applications (i.e., recirculation water heating or glycol-water recirculation) • Direct contact water heaters • Non-metallic heat exchangers