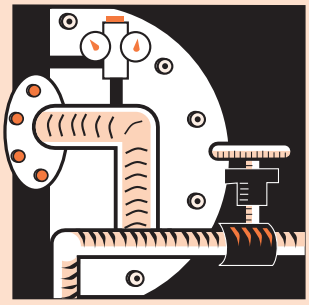

Flue Gas Analyzers

The percentage of oxygen in the flue gas can be measured by inexpensive gas absorbing test kits. More expensive ($500-$1,000) hand-held, computer-based analyzers display percent oxygen, stack gas temperature, and boiler efficiency. They are a recommended investment for any boiler system with annual fuel costs exceeding $50,000.

Oxygen Trim Systems

When fuel composition is highly variable (such as refinery gas, hog fuel, or multi-fuel boilers) or where steam flows are highly variable, an on-line oxygen analyzer should be considered. The oxygen "trim" system provides feedback to the burner controls to automatically minimize excess combustion air and optimize the air-to-fuel ratio.

Adapted from an Energy TIPS fact sheet that was originally published by the Industrial Energy Extension Service of Georgia Tech. For additional information on steam system efficiency measures, contact the Information Clearinghouse at (800) 862-2086.

Improve Your Boiler's Combustion Efficiency

Combustion Efficiency

Operating your boiler with an optimum amount of excess air will minimize heat loss up the stack and improve combustion efficiency. Combustion efficiency is a measure of how effectively the heat content of a fuel is transferred into usable heat. The stack temperature and flue gas oxygen (or carbon dioxide) concentrations are primary indicators of combustion efficiency.

Given complete mixing, a precise or stoichiometric amount of air is required to completely react with a given quantity of fuel. In practice, combustion conditions are never ideal, and additional or "excess" air must be supplied to completely burn the fuel.

The correct amount of excess air is determined from analyzing flue gas oxygen or carbon dioxide concentrations. Inadequate excess air results in unburned combustibles (fuel, soot, smoke, and carbon monoxide) while too much results in heat lost due to the increased flue gas flow—thus lowering the overall boiler fuel-to-steam efficiency. The table relates stack readings to boiler performance.

Combustion Efficiency for Natural Gas

Excess %		Combustion Efficiency				
		Flue gas temperature less combustion air temp, °F				
Air	Oxygen	200	300	400	500	600
9.5	2.0	85.4	83.1	80.8	78.4	76.0
15.0	3.0	85.2	82.8	80.4	77.9	75.4
28.1	5.0	84.7	82.1	79.5	76.7	74.0
44.9	7.0	84.1	81.2	78.2	75.2	72.1
81.6	10.0	82.8	79.3	75.6	71.9	68.2

Assumes complete combustion with no water vapor in the combustion air.

On well-designed natural gas-fired systems, an excess air level of 10% is attainable. An often stated rule of thumb is that boiler efficiency can be increased by 1% for each 15% reduction in excess air or 40°F reduction in stack gas temperature.

Example

A boiler operates for 8,000 hours per year and consumes 500,000 MBtu of natural gas while producing 45,000 lb/hr of 150 psig steam. Stack gas measurements indicate an excess air level of 44.9% with a flue gas less combustion air temperature of 400°F. From the table, the boiler combustion efficiency is 78.2% (E1). Tuning the boiler reduces the excess air to 9.5% with a flue gas less combustion air temperature of 300°F. The boiler combustion efficiency increases to 83.1% (E2). Assuming a steam value of $4.50/MBtu, the annual cost savings are:

Cost Savings = Fuel Consumption x (1 - E1/E2) x steam cost
= 29,482 MBtu/yr x $4.50/MBtu = $132,671 annually

Suggested Actions

Boilers often operate at excess air levels higher than the optimum. Periodically monitor flue gas composition and tune your boilers to maintain excess air at optimum levels.

About DOE's Office of Industrial Technologies

The Office of Industrial Technologies (OIT), through partnerships with industry, government, and non-governmental organizations, develops and delivers advanced energy efficiency, renewable energy, and pollution prevention technologies for industrial applications. OIT is part of the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

OIT encourages industry-wide efforts to boost resource productivity through a strategy called Industries of the Future (IOF). IOF focuses on the following nine energy and resource intensive industries:

Agriculture	Chemicals	Glass	Mining	Steel
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To help industries begin to save energy, reduce costs, and cut pollution right away, IOF technical assistance programs offer a comprehensive portfolio of emerging technology, practices, tools, information, and resources in a variety of application areas, for example, motor systems, steam systems, compressed air systems, and combined heat and power systems. Likewise, IOF has Industrial Assessment Centers (IAC) throughout the U.S. that offer energy, waste, and productivity assessments to small and medium-sized manufacturers. Users can take advantage of the abundant resources, such as software, fact sheets, training materials, etc. available from the IOF technical assistance programs.

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- ☐ Optimizing Your Motor-Driven System
- ☐ Frequently Asked Questions on: The Impacts of the Energy Policy Act of 1992 on Industrial End Users of Electric Motor-Driven Systems
- ☐ Energy Management for Motor Driven Systems
- ☐ Improving Pumping System Performance: A Sourcebook for Industry

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- ☐ Pumping System Assessment Tool

Training –

- ☐ MotorMaster+ 3.0 Software
- ☐ Adjustable Speed Drive Application
- ☐ Pumping System Optimization
- ☐ Pumping System Assessment Tool

Access the Web site at ***www.motor.doe.gov***.

Steam Systems — helps industry enhance productivity, increase profits, and reduce emissions through better steam system management.

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- ☐ Plant Services Article - *The Steam Challenge*
- ☐ Energy Manager Article - *Steaming Ahead*
- ☐ Oak Ridge National Laboratory's Insulation Guidelines
- ☐ 1998 IETC Steam Session Papers

Case Studies –

- ☐ Georgia Pacific Achieves 6-Month Payback
- ☐ Bethlehem Steel Showcase Demonstration

Software –

- ☐ 3EPlus Software for Determining Optimal Insulation Thickness

Access the Web site at ***www.oit.doe.gov/steam***.

Compressed Air Systems — dedicated to improving the efficiency and performance of industrial compressed air systems.

Documents –

- ☐ Improving Compressed Air System Performance: A Sourcebook for Industry

Training –

- ☐ Fundamentals of Compressed Air Systems (For schedule and location, call (800) 862-2086)

Access the Web site at ***www.knowpressure.org***.

Industrial Assessment Centers — enable small and medium-sized manufacturers to have comprehensive industrial assessments performed at no cost to the manufacturer.

Documents –

- ☐ IAC Database

Access the Web site at ***www.oit.doe.gov/iac***.

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For more information on Motor, Steam, Compressed Air Systems, and IACs, call the Information Clearinghouse at (800) 862-2086. For overall OIT and IOF information, contact the OIT Resource Room at (202) 586-2090 or access the Web site at *www.oit.doe.gov*.