

## Upgrade Boilers with Energy-Efficient Burners

### Background

The purpose of the burner is to mix molecules of fuel with molecules of air. A boiler will run only as well as the burner performs. A poorly designed boiler with an efficient burner may perform better than a well-designed boiler with a poor burner. Burners are designed to maximize combustion efficiency while minimizing the release of emissions.

A power burner mechanically mixes fuel and combustion air and injects the mixture into the combustion chamber. All power burners essentially provide complete combustion while maintaining flame stabilization over a range of firing rates. Different burners, however, require different amounts of excess air and have different turndown ratios. The turndown ratio is the maximum inlet fuel or firing rate divided by the minimum firing rate.

An efficient natural gas burner requires only 2% to 3% excess oxygen, or 10% to 15% excess air in the flue gas, to burn fuel without forming excessive carbon monoxide. Most gas burners exhibit turndown ratios of 10:1 or 12:1 with little or no loss in combustion efficiency. Some burners offer turndowns of 20:1 on oil and up to 35:1 on gas. A higher turndown ratio reduces burner starts, provides better load control, saves wear and tear on the burner, reduces refractory wear, reduces purge-air requirements, and provides fuel savings.

### Efficient Burner Technologies

An efficient burner provides the proper air-to-fuel mixture throughout the full range of firing rates, without constant adjustment. Many burners with complex linkage designs do not hold their air-to-fuel settings over time. Often, they are adjusted to provide high levels of excess air to compensate for inconsistencies in the burner performance.

An alternative to complex linkage designs, modern burners are increasingly using servomotors with parallel positioning to independently control the quantities of fuel and air delivered to the burner head. Controls without linkage allow for easy tune-ups and minor adjustments, while eliminating hysteresis, or lack of retraceability, and provide accurate point-to-point control. These controls provide consistent performance and repeatability as the burner adjusts to different firing rates.

Alternatives to electronic controls are burners with a single drive or jackshaft. Avoid purchasing standard burners that make use of linkages to provide single-point or proportional control. Linkage joints wear and rod-set screws can loosen, allowing slippage, the provision of suboptimal air-to-fuel ratios, and efficiency declines.

### Applications

Consider purchasing a new energy-efficient burner if your existing burner is cycling on and off rapidly. Rotary-cup oil burners that have been converted to use natural gas are often inefficient. Determining the potential energy saved by replacing your existing burner with an energy-efficient burner requires several steps. First, complete recommended burner-maintenance requirements and tune your boiler. Conduct combustion-efficiency tests at full- and part-load firing rates. Then, compare the measured efficiency values with the performance of the new burner. Most manufacturers will provide guaranteed excess levels of oxygen, carbon monoxide, and nitrous oxide.

### Suggested Actions

- Perform burner maintenance and tune your boiler.
- Conduct combustion-efficiency tests at full- and part-load conditions.
- If excess oxygen exceeds 3%, or combustion efficiency values are low, consider modernizing the fuel/air control system to include solid-state sensors and controls without linkage. Also consider installing improved process controls, an oxygen trim system, or a new energy-efficient burner.
- A new energy-efficient burner should also be considered if repair costs become excessive, reliability becomes an issue, energy savings are guaranteed, and/or utility energy conservation rebates are available.
- Install a smaller burner on a boiler that is oversized relative to its steam load.

## Example

Even a small improvement in burner efficiency can provide significant savings. Consider a 50,000 pound-per-hour process boiler with a combustion efficiency of 79% (E1). The boiler annually consumes 500,000 million Btu (MMBtu) of natural gas. At a price of \$8.00/MMBtu, the annual fuel cost is \$4 million. What are the savings from an energy-efficient burner that improves combustion efficiency by 1%, 2%, or 3%?

$$\text{Cost Savings} = \text{Fuel Consumption} \times \text{Fuel Price} \times (1 - E^1/E^2)$$

Energy Savings Due to Installation of an Energy-Efficient Burner

Burner Combustion Efficiency Improvement, %	Annual Energy Savings, MMBtu/yr	Annual Dollar Savings, \$
1	6,250	50,000
2	12,345	98,760
3	18,290	146,320

If the installed cost is \$75,000 for a new burner that provides an efficiency improvement of 2%, the simple payback on investment is:

$$\text{Simple Payback} = \$75,000 / \$98,760/\text{year} = 0.76 \text{ year}$$

## Maintenance Requirements

Conduct burner maintenance at regular intervals. Wear on the firing head, diffuser, or igniter can result in air leakage or failure of the boiler to start. One burner distributor recommends maintenance four times per year, with the change of seasons. A change in weather results in a change in combustion.

## Fan Selection

Fan selection is also important. Backward-curved fans provide more reliable air control than forward-curved fans. Radial-damper designs tend to provide more repeatable air control at lower firing rates than blade-type damper assemblies.

Steam Tip Information is adapted from material supplied by PBBS Equipment Corp. and Blesi-Evans Company and reviewed by the AMO Steam Technical Subcommittee. For additional information, refer to Steam Tip Sheet #4, *Improve Your Boiler's Combustion Efficiency*.

## Resources

U.S. Department of Energy—DOE's software, the *Steam System Assessment Tool* and *Steam System Scoping Tool*, can help you evaluate and identify steam system improvements. In addition, refer to *Improving Steam System Performance: A Sourcebook for Industry* for more information on steam system efficiency opportunities.

Visit the Advanced Manufacturing Office website at [manufacturing.energy.gov](http://manufacturing.energy.gov) to access these and many other industrial efficiency resources and information on training.



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 Energy Efficiency and Renewable Energy  
 U.S. Department of Energy  
 Washington, DC 20585-0121  
[manufacturing.energy.gov](http://manufacturing.energy.gov)

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