



Suggested Actions

Taking the following actions can reduce air leakage in a furnace:

1. Repair the air leakage area by replacing or repairing insulation or seals.
2. Close furnace doors properly to maintain a tight seal and avoid opening.
3. Install a pressure control system that maintains balanced, slightly positive (in hundredths of an inch) pressure, at the point of major air leakage.
4. Install a damper in the stack that can be adjusted manually if an automated furnace pressure control cannot be used or justified.
5. Install or use a “draft gage” to monitor furnace pressure at the level of air leakage if it cannot be sealed properly, and adjust the manual damper to maintain balanced, slightly positive (in hundredths of an inch) pressure, at the point of major air leakage.

Note: Actions 3-5 work only in forced and balanced draft furnaces.

Resources

See also *Improving Process Heating System Performance: A Sourcebook for Industry*. Washington, D.C.: U.S. Department of Energy and Industrial Heating Equipment Association, 2004.

U.S. Department of Energy—

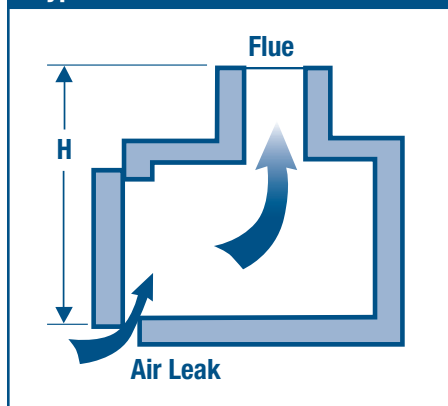
For additional information on process heating system efficiency, to obtain DOE’s publications and Process Heating Assessment and Survey Tool (PHAST) software, or to learn more about training, visit the BestPractices Web site at www.eere.energy.gov/industry/bestpractices.

Reduce Air Infiltration in Furnaces

Fuel-fired furnaces discharge combustion products through a stack or a chimney. Hot furnace gases are less dense and more buoyant than ambient air, so they rise, creating a differential pressure between the top and the bottom of the furnace. This differential, known as *thermal head*, is the source of a natural draft or negative pressure in furnaces and boilers.

A well-designed furnace (or boiler) is built to avoid air leakage into the furnace or leakage of flue gases from the furnace to the ambient. However, with time, most furnaces develop cracks or openings around doors, joints, and hearth seals. These openings (leaks) usually appear small compared with the overall dimensions of the furnace, so they are often ignored. The negative pressure created by the natural draft (or use of an induced-draft fan) in a furnace draws cold air through the openings (leaks) and into the furnace. The cold air becomes heated to the furnace exhaust gas temperature and then exits through the flue system, wasting valuable fuel. It might also cause excessive oxidation of metals or other materials in the furnaces.

Figure 1. Air leakage and gas flow in a typical fuel-fired furnace



The heat loss due to cold air leakage resulting from the natural draft can be estimated if you know four major parameters:

- The furnace or flue gas temperature
- The vertical distance H between the opening (leak) and the point where the exhaust gases leave the furnace and its flue system (if the leak is along a vertical surface, H will be an average value)
- The area of the leak, in square inches
- The amount of operating time the furnace spends at negative pressure.

Secondary parameters that affect the amount of air leakage include these:

- The furnace firing rate
- The flue gas velocity through the stack or the stack cross-section area
- The burner operating conditions (e.g., excess air, combustion air temperature, and so on).

For furnaces or boilers using an induced-draft (ID) fan, the furnace negative pressure depends on the fan performance and frictional losses between the fan inlet and the point of air leakage. In most cases, it would be necessary to measure or estimate negative pressure at the opening.



The amount of air leakage, the heat lost in flue gases, and their effects on increased furnace or boiler fuel consumption can be calculated by using the equations and graphs given in *Industrial Furnaces* (see W. Trinks et al., below). Note that the actual heat input required to compensate for the heat loss in flue gases due to air leakage would be greater than the heat contained in the air leakage because of the effect of available heat in the furnace. For a high-temperature furnace that is not maintained properly, the fuel consumption increase due to air leakage can be as high as 10% of the fuel input.

Example

An industrial forging furnace with an 8-foot (8-ft) stack operates at 2,300°F for 6,000 hours per year (hr/yr) on natural gas costing \$8.00/MMBtu. The door of the furnace has an unnecessary 36-square-inch (36-in.²) opening at the bottom that allows air to infiltrate. The table below shows the annual cost of the fuel that would be wasted because of the leak.

Cost of Air Infiltration in a Furnace	
Stack height (ft)	8
Stack diameter (ft)	3
Opening size, area (in. ²)	36
Gross input (MMBtu/hr)	20
Combustion air temperature (°F)	70
Oxygen in flue gases (%)	2
Temperature of flue gases (°F)	2,300
Fuel cost (\$/MMBtu)	8
Operating hr/yr	6,000
Air infiltration (ft ³ /hr)	15,300
Annual cost of wasted fuel (\$)	100,875

Furnace Pressure Controllers

Furnace pressures fluctuate with the burner firing rate and tend to be lowest at the lowest firing rates. To compensate for this constantly changing condition, a furnace pressure control system is used. It consists of a stack damper automatically controlled to maintain a neutral or slightly positive pressure in the combustion chamber. As burner firing rates decrease, the damper throttles the flow out of the stack to hold the pressure constant. Many different types of pressure controllers are available for use with furnaces and boilers. See the tip sheet titled *Furnace Pressure Controllers* for more information.

References

- Fan Engineering*. Robert Jorgensen, ed. New York: Buffalo Forge Company. 1961.
- Gas Engineers Handbook*. George C. Segeler, ed. New York: The Industrial Press. 1968.
- W. Trinks et al. *Industrial Furnaces, Sixth Edition*. New York: John Wiley & Sons, Inc. 2003.

BestPractices is part of the Industrial Technologies Program Industries of the Future strategy, which helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together emerging technologies and best energy-management practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

BestPractices emphasizes plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small- and medium-size manufacturers.

FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

EERE Information Center
1-877-EERE-INF
(1-877-337-3463)
www.eere.energy.gov

Industrial Technologies Program
Energy Efficiency
and Renewable Energy
U.S. Department of Energy
Washington, DC 20585-0121
www.eere.energy.gov/industry

A STRONG ENERGY PORTFOLIO FOR A STRONG AMERICA

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.