Energy Tips – Process Heating

Process Heating Tip Sheet #7 • January 2006

Industrial Technologies Program

Suggested Actions

The following actions can prevent or reduce radiations losses:

- Eliminate the furnace opening or keep the furnace door open the shortest possible time.
- For a continuous furnace in which opening size cannot be reduced, you can use flexible materials such as ceramic strips, chains, or ceramic textiles as "curtains." These generally reduce heat loss by half and help reduce infiltration of air into the furnace and leakage of hot furnace gases into the atmosphere. Tunnel-like extensions on the end of the furnace can also reduce the effective opening; shallow inclines in extension tunnels can direct radiation into furnace insulation or incoming cold work. These methods still allow the load to enter the furnace.
- Repair or plug fixed openings. If that is not possible, use a radiation shield such as an alloy sheet or ceramic board. Use proper refractory or insulation to plug holes. For openings such as a sight glass, use a damper or slide valve to block radiation when using the sight glass.

Resources

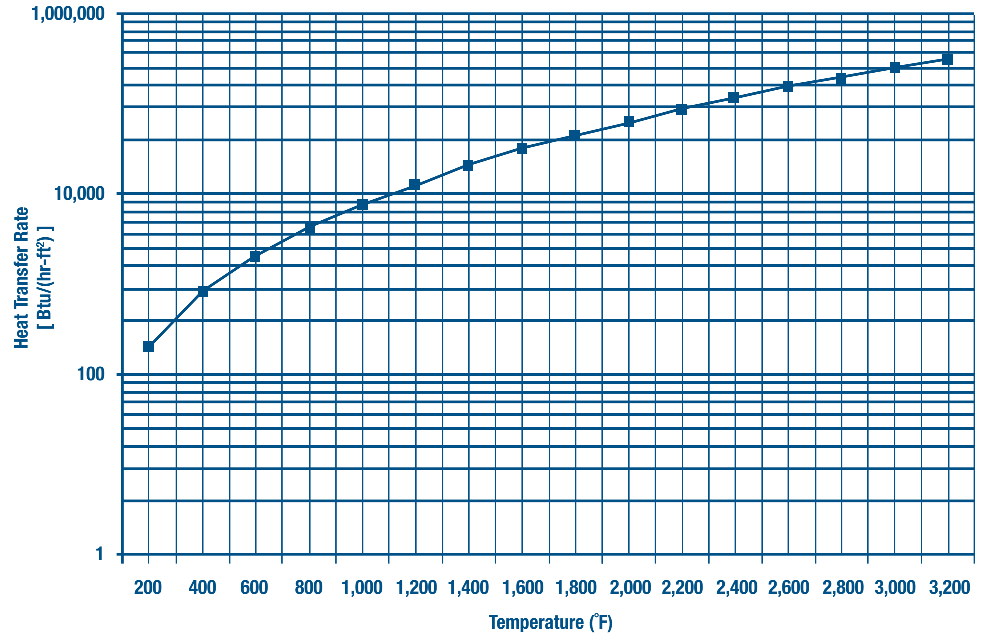
See also Robert Siegel and John Howell, *Thermal Radiation Heat Transfer*, New York: McGraw-Hill, 1972; and W. Trinks et al., *Industrial Furnaces*, Sixth Edition, New York: John Wiley & Sons, Inc., 2003.

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 Radiation Losses from Heating Equipment

Heating equipment, such as furnaces and ovens, can experience significant radiation losses when operating at temperatures above 1,000°F. Hot surfaces radiate energy to colder surfaces in their line of sight, and the rate of heat transfer increases with the fourth power of the surface's absolute temperature. Figure 1 shows radiation heat flux from a heat source at a given temperature to 60°F ambient.

Figure 1. Radiation heat transfer rates[1]

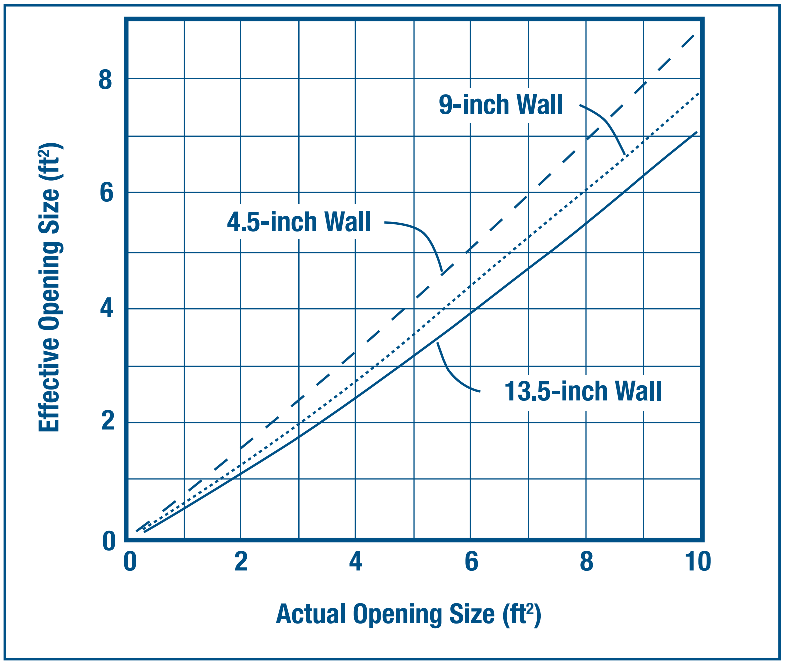


The biggest radiant energy loss in furnace operations is caused by doors remaining open longer than necessary, or doors left partially open to accommodate a load that is too large for the furnace. Furnace openings not only waste energy through radiation losses, they also allow ambient air to enter the furnace or hot furnace gases to escape if the furnace pressure is not controlled (see the tip sheets titled *Reduce Air Infiltration in Furnaces*; *Furnace Pressure Controllers*).

Radiation losses are a function of three factors:

- The temperature of the internal furnace surfaces facing the opening.
- The effective area of the opening that the radiation passes through. This is the true opening size corrected for both the thickness of the wall surrounding it and for its height/width ratio. The thicker the wall and the higher the opening's aspect ratio (longer dimension divided by shorter dimension), the smaller its effective area. Figure 2 can be used in calculating effective area for openings in a furnace wall. These graphs give results that are within 5% of the results of using detailed view-factor calculations.
- The length of time the opening permits radiation to escape.

Figure 2. Calculation of effective area for openings in a furnace[2]



Technically, the temperature of the colder (receiving) surface also plays a part. However, this surface is usually the area surrounding the furnace, which can range from 20°F for an outdoor furnace up to 120°F for a hot factory building, and it has little effect on radiation losses.

Estimating Radiation Heat Losses

Radiation losses can be estimated by using a simple formula:

$Q_{radiation}$ (Btu/hr) = (black body radiation at the source temperature – radiation at the ambient temperature) x effective area of the opening x fraction of the time an opening (e.g., the furnace door) is open

In most cases, the furnace temperature can be used as a radiation source temperature for estimating radiation losses. Figure 1 can be used to estimate radiation heat flux based on furnace temperature. As mentioned earlier, ambient temperature has very little effect on the losses and can be ignored. The effective area of the opening can be estimated by using Figure 2 along with the dimensions of the opening and the furnace wall thickness. For a fixed opening, the fraction open time would be 1.0. However, for doors opened for loading or unloading, this should be calculated as the time the door is open divided by the cycle time for loading-unloading. In some cases, the door might not be fully closed, and a small gap is constantly maintained. In this case, the fraction open time would again be 1.0.

[1] Calculations by Arvind Thekdi, E3M, Inc.

[2] Calculations by Richard Bennett, Janus Technology Group.

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