Principles of Gas-Fired Infrared Heating

by Bob Genisol

HEATING IMPACT REPORT

CHARLOTTE, NC — In planning for or renovating an industrial or commercial building, making the right decision in a heating system could make the difference of hundreds of thousands of dollars during the lifespan of the building.

Many structures are heated with electricity, steam or forced-air heating systems. Others are heated with gas-fired infrared systems.

It has been proven that the installation of infrared heating systems can save the building owner up to 50% of the heating costs over a one-year period when compared to forced-air heat. Many successful infrared heating system applications include warehouses, auto sales and service agencies, farm buildings, greenhouses, truck garages and terminals, airplane hangars, fire stations, gymnasiums, tennis courts, and loading docks, to name just a few.

In addition, employee welfare can be improved because heat is more evenly distributed from the floor up. In a manufacturing environment, this can result in increased productivity.

What Is Infrared?

Infrared is a form of radiation that closely resembles and behaves as light energy. Both infrared and light energy are carried from a source to an object by wave motion. The major difference between them is source temperature and the fact that the human eye cannot see low-temperature infrared energy.

Infrared follows the principle of electromagnetics. It forms a small portion of the electromagnetic spectrum, located between visible light and the top end of the radar and microwave portion of the electronic spectrum.

Because infrared is similar to light energy, it follows the same laws of optics. It radiates in all directions from a point source, travels in a straight line at the speed of light (186,000 miles/second), and can be polarized, focused, or reflected the same as light.

Upon striking an object, infrared energy causes the molecular particles on the surface to react. This generates heat, which is then transferred through the object being heated by conduction. The object becomes a radiant emitter, but at a much lower temperature and intensity.

Types of infrared

Depending on wavelength, the infrared section of the electromagnetic spectrum can be classified in three distinct areas: near, middle and far infrared. Temperature range and wavelength of the three types are detailed in Table 1.

Type	Temperature range (F°)	Wavelength range (microns)
Near infrared	6,000 — 3,000°	0.8 — 1.5
Middle infrared	3,000 — 500°	1.5 — 5.5
Far infrared	500 — (460°)	5.5 — 50+

Table 1

Figure 1 shows the electromagnetic spectrum and the location of infrared radiation within the spectrum. Every object at temperatures above absolute zero will give off infrared energy. The temperature, emitter area, and emissivity will determine the amount given off.

It has been determined that an object heated to 1,700°F generates infrared energy in the 0.75 to 20 micron range and peaks at 2.41 microns. Infrared energy with wavelengths of less than 0.8 microns is actually visible light. Heating an object to a higher temperature generates more infrared energy and in the process, also generates a greater percentage of visible light, which contributes little toward comfort heating.

Heating principles

Infrared directly heats people, floors, walls, and other surfaces without heating the air first. Upon striking an object or a floor slab, the infrared energy is converted to heat.The floor slab then becomes a giant low-temperature radiant emitter.

Machinery and equipment at the floor level are warmed by direct radiation as well as conduction though contact with the floor slab. The temperature differential is the driving force and determines the rate of radiant energy transfer. In many installations, the floor slab temperature will be five to ten degrees higher than the ambient air temperature.

Convection heat transfer from the warm floor slab and machinery to the cool air

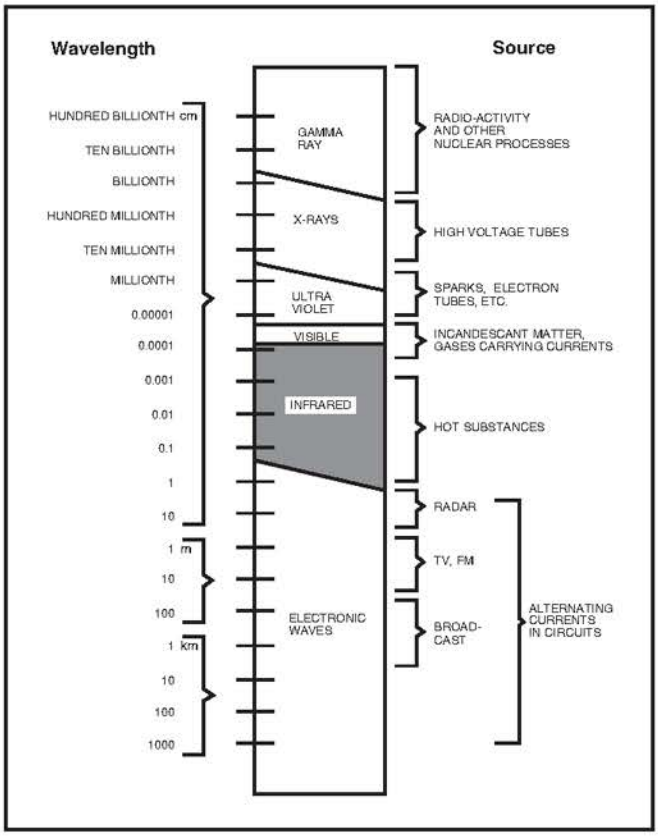

FIGURE 1 – Electromagnetic spectrum.

lying at floor level also plays an important role in the heating process. The cool air sweeping across the floor picks up the convected warm air and rises within the building structure. Warm air is displaced by cooler air in a continuous cycle, gradually raising air temperature in the building to a comfortable level.

Radiant output concept

The radiant ouput of a gas infrared heater is given in the following equation:

$R = SEA (T^4 - T^4_a)$

Where:

R = radiant output
S = Stefan-Boltzmann constant
E = emissivity of radiating surface
A = surface area
T = emitter surface temperature in °R
T_a = ambient temperature °R

The major variables affecting the heater's radiant output include the emissivity of the radiating surface and the emitter surface temperature. Materials with emissivities of close to 0.99 are highly desirable.

The temperature of the emitter surface also plays an important role in radiant heating. The temperature is expressed in °Rankine and raised to its fourth power. Any increase in surface temperature greatly in-creases the radiant output of the gas-fired radiant heater.

Infrared heater types

Gas-fired infrared heaters are classified according to emitter material and emitter surface temperatures.

There are basically three types of gas-fired infrared heaters: ceramic heaters, tube heaters, and broad-area and floor model infrared heaters made with perforated steel emitters (see Figure 2).

Designed to operate in the 1,650° to 1,800° range, ceramic heaters have a porous ceramic emitter surface. Combustion takes place on the ceramic surface, with the pro-ducts of combustion released into the building. Polished aluminum reflectors focus infrared rays onto the floor. Shallow reflectors spread the infrared rays to a broader area and deeper parabolic reflectors concentrate rays in a narrow area.

The second type of gas-fired infrared heaters, tube heaters, use steel tubing where the hot gases are either pulled or pushed through the tube. The tubing is either calorized or painted to increase the emissivity of the tube material.

Tube heaters currently available operate at average emitter temperatures from as low as 450° to as high as 1,000° and in-clude both vented and unvented versions. Designs vary from ready-mount unitized systems requiring little field assembly time to continuous systems requiring substantial field assembly time.

A third type of infrared heater includes the broad area and floor models. These heaters have perforated stainless steel emitters for durability and increased life. Broad area heaters radiate low intensity heat in a 360° pattern for wide coverage. The perforated stainless steel emitter is conical in shape, with emitter surface temperatures ranging from 1,350° to 1,450°F.

The floor model infrared heaters also have perforated stainless steel emitters which are formed into a vertical, rather than conical, cylinder. These units are designed primarily for spot heating and/or warming stations.

Infrared versus forced air systems

The major difference between gas-fired infrared heating systems and forced air systems is the method used to create a comfortable heating environment.

Gas-fired infrared units heat the floor slab and machinery before heating the air. This results in a more comfortable heating environment because people working in the comfort zone are blanketed by direct radiation from above, secondary radiation from below, and warm air rising from the floor.

In a forced air system, the hot air rises to the ceiling and stratifies, generally working its way down to the thermostat level. The floor slab usually never becomes warm enough to be comfortable.

In fact, in many instances, buildings heated with forced hot air have a high temperature differential between the floor and ceiling. The ceiling area of a high bay building can be easily 30° to 40° warmer than the floor area.

In the same type of building heated with an infrared system, the temperature is much more uniform. It is not uncommon to find a high-bay building heated with infrared where the ceiling is at a slightly lower temperature than the floor slab.

In essence, a forced air system heats from the top down making the floor area the last and most difficult to heat. In comparison, an infrared system heats from the floor up, satisfying the comfort zone first. Due to the differences in these operating principles, infrared systems normally save 30% to 50% over forced air heating systems, depending on the installation and application.

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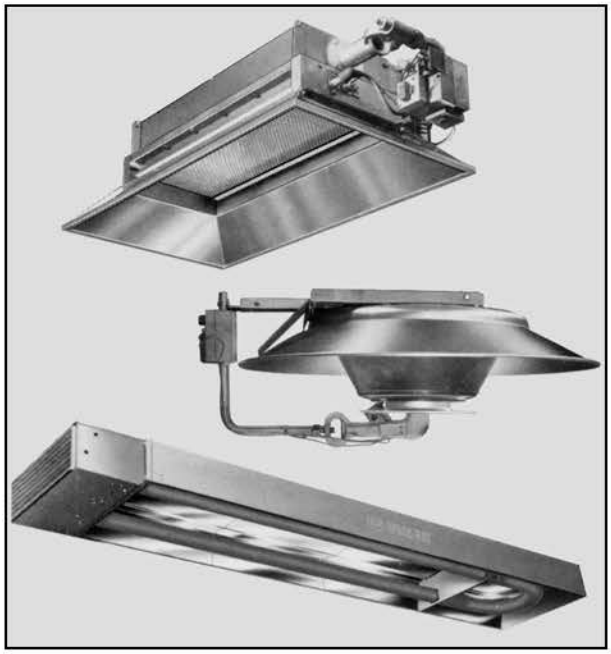

FIGURE 2 – Typical infrared heaters.