Infrared Radiant Heaters

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Most commercial buildings use either a furnace or boiler to meet space heating needs. However, many use unit heaters for space heating, as do many industrial buildings.[1]

Unit heaters are self-contained heating units that burn natural gas or oil, or use electric-resistance to heat spaces in buildings. Often, they are hung from the ceiling of a space, but can also be installed on floors or walls. Because many people find unit heaters aesthetically undesirable, unit heaters tend to be used in spaces with less sensitivity to aesthetics, such as garages, or in buildings with high ceilings, such as big-box retail stores.

Unit heaters transfer heat to spaces via forced convection. They consist of a heat source, a heat exchanger, and a fan. In natural gas- or oil-fired unit heaters, combustion occurs in a combustion chamber and the hot combustion gases flow through the inside of a metal heat exchanger and exhaust to the outdoors through a vent. In electric-resistance heaters, the resistance heating surfaces are the heat exchanger. In both fuel-fired and electric units, a fan (e.g., propeller or blower) blows air over the hot outer surface of the heat exchanger and through louvers or a discharge cowl to direct and distribute the heated air throughout the conditioned space.[2,3]

Radiant infrared heaters are an alternative to unit heaters that transfer heat to spaces via a mix of radiant and natural convection heat transfer (the latter often is primarily a loss because most of that heat ends up near the ceiling). They can use either gas, oil, or electricity to produce heat.

Gas- and oil-fired radiant infrared heaters have a burner assembly that uses a blower to blow (or, an upstream vacuum pump to induce) air into the assembly, mixes the fuel with the air, and ignites the fuel. The flame propagates downstream of the burner assembly into a long radiant heating tube that achieves high surface temperatures and radiates heat to the area below (ranging from approximately 400°F to 900°F (200°C to 500°C) over the length of the heating tube).[2] In addition, units have reflectors above and to the sides of the heating tube to suppress natural convection heat transfer and to redirect a large portion of the radiated heat downward, increasing the effective delivery efficiency of the heater to the occupied zone (i.e., floor level) in the building.[2,3]

Radiant infrared heaters mounted near the ceiling with the radiant output directed toward the floor can maintain comfort conditions for occupants with less fuel consumption than warm-air space heating equipment, particularly in industrial and commercial spaces having comparatively high ceilings (e.g., in excess of 16 ft [5m]). In essence, radiant infrared heaters directly radiate heat to the occupants and also warm the floor and other surfaces near the floor, which re-radiate heat to the occupants and warm the air near the floor. In contrast, warm air heating equipment, such as unit heaters, tends to heat spaces unevenly and much of the warm air output buoyantly rises to the ceiling in spaces with high ceilings. This, in turn, increases heat loss through the roof while providing less heat to the occupants. In sum, radiant infrared heaters do not transfer heat to the overall space more efficiently than unit heaters, but usually direct that heat more effectively to the occupants.

Energy Savings Potential

Few analyses compare the energy performance of radiant infrared heaters to unit heaters. Nonetheless, test data support the assertion that radiant infrared heaters can maintain heating temperature setpoints in the occupied zone of spaces with higher ceilings while consuming less energy than unit heaters. Specifically, one set of tests compared unit heater and radiant infrared heater performance in a 20 ft (6 m) high test building. The tests found that, after adjusting for the outdoor temperatures over the test periods, the radiant infrared heaters consumed about half the energy to heat the same space as the unit heaters.

A major factor in the increased energy consumption with unit heaters was that the unit heaters developed vertical temperature gradients more than twice as great as the radiant infrared heaters. Consequently, roof insulation levels have a significant impact on the relative performance of the two equipment types. Preliminary analyses indicate that higher insulation levels would reduce the difference between unit heater and radiant infrared heater energy consumption by about one-third, in which case the radiant infrared heater would consume approximately 33% less energy than unit heaters.[2] (Note: Arthur D. Little Inc. estimated "conservative" savings of around 20%).[4]

To extrapolate the energy savings to a national basis, however, requires knowing what percentage of unit heater installations are in spaces with high ceilings; unfortunately, this is not known. Assuming that half of the unit heaters deployed in commercial buildings and all those used in industrial buildings have sufficient ceiling heights to realize 33% to 50% savings, radiant infrared heaters could decrease energy consumption in spaces currently heated by unit heaters by about 0.17 to 0.25 quads.[1,5]

Market Factors

Several factors have inhibited the market penetration of radiant infrared heaters. Earlier studies show that radiant infrared heaters cost appreciably more than unit heaters, i.e., about a 50% installed cost premium.[4] Radiant infrared heaters also have high surface temperatures, which limits their use in several ways. Hot surfaces can ignite combustible gases, dusts, or vapors in potentially dangerous (i.e., flammable or explosive) concentrations and should not be used in spaces where these conditions may occur. Similarly, high temperatures can also decompose some chemical compounds to form hazardous or toxic materials, so radiant heaters must be avoided or used with special exhaust systems in these situations. Finally, installations must maintain sufficient clearance between radiant heaters, people and combustible materials to avoid overheating-induced stress and fires, respectively.[3]

Limited feedback in comparative testing described earlier from comfort juries also suggests that the unit heaters provided greater comfort than the radiant infrared heaters. Specifically, relative to the radiant heaters, the participants found that the unit heaters heated the body more evenly, i.e., the radiant heaters tended to overheat people's heads and torsos while operating while supplying insufficient heat to the lower body when off. Lastly, although radiant infrared heaters might be expected to provide similar comfort levels with a lower temperature setpoint due to the radiant heating contribution, the comfort juries selected similar temperature settings for both heaters.[2]

On the other hand, radiant infrared heaters have several positive attributes compared to unit heaters. In environments exposed to large quantities of outdoor air, such as open truck loading bays or garages, the radiant infrared heater does a better job of heating people in the exposed areas. Essentially, the radiant heater element and the surfaces heated by the radiant heater continue to heat objects in the room even after the thermal energy in the air has dissipated.[2,6] In addition, although the aforementioned comfort juries found unit heaters to be more comfortable overall, they preferred the quiet, passive heat transfer of infrared radiant heaters to the noise generated by the fans of operational unit heaters. They also found that, in the building where the test occurred, the unit heaters yielded localized "hot spots" that could be uncomfortable.[2]

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