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TechData Sheet

Naval Facilities Engineering Service Center
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Infrared Radiant Heating

Retrofitting convective forced air heating systems with infrared (IR) systems can save as much as 50 percent of the total heating bill. Infrared heating is more efficient for two reasons: it can be directed to heat only occupied space; and it does not heat the air in a space, it only heats people and objects. Infrared heating works best where convective heaters are not practical. Large open bay buildings, such as hangars, workshops, and warehouses, with large volumes of air to be heated and plenty of unoccupied space are good candidates for retrofit.

This TechData Sheet will help activity personnel understand infrared radiant heating, and identify opportunities for energy-conserving retrofit projects.

Technical Background

Infrared heat is a radiated form of invisible electromagnetic energy (like light) that directly warms people and objects, without heating the air in between. Infrared heat travels in a straight line, at the speed of light. Air, the medium for convective heat, is a poor absorber of infrared heat, thus infrared heat can be transmitted a long distance with minimum loss of energy to air. Infrared heaters can be aimed, reflected, and focused on a desired area. When infrared energy shines on people or objects, the energy is converted into heat. The heated personnel and objects then become heat sources that transfer heat into the air. Thus, radiant heat works from the bottom up, warming people, floors, and machines first. Radiant energy striking a concrete floor is converted into heat, which is absorbed by the floor. The floor then becomes a heat storage reservoir, retaining heat in the lower working areas of the building. This makes the working level extremely comfortable and heat is not wasted at the ceiling level, as would be the case with a forced air system.

In open areas radiant heat can be directed onto occupied areas. Convective heat warms the entire volume of air in a room starting at the top and continuing until the thermocline reaches the bottom of the room where the people work regardless of which portions of the room are occupied. This accounts for a significant waste of energy.

Distribution patterns for IR heaters vary depending on heater capacity, type, and reflector shape. Determining these design patterns is integral to the design of IR heater systems, which is fairly complicated and best left to the installer. Most dealers provide a site specific design as part of the cost. Over the years, experience has led to many design conventions that are difficult to derive analytically. Chapter 15 of ASHRAE's 1992 Systems and Equipment Handbook outlines a procedure for radiant heater design.

Heater Types

The three main characteristics that separate IR heaters are:

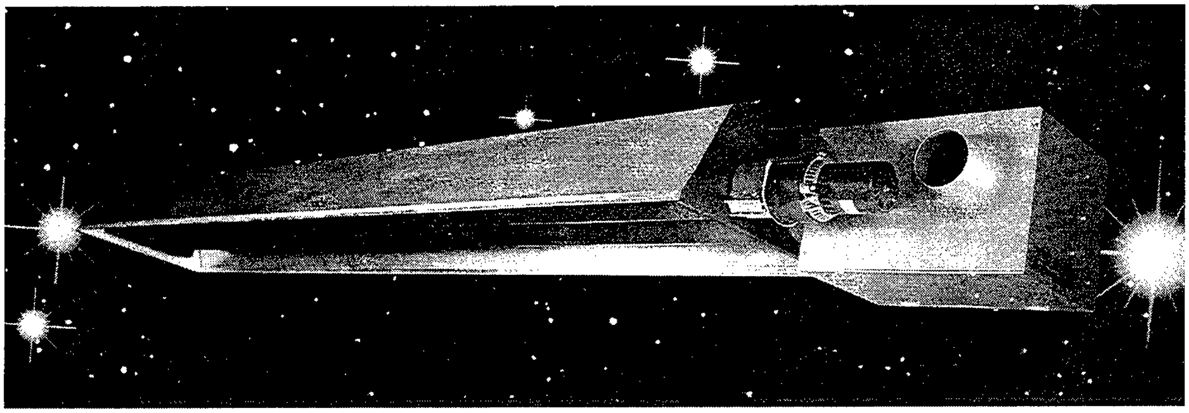
- Fuel source
- Emitter type
- Ventilation

IR heaters can use electricity, natural gas, propane, or fuel oil to produce heat. This TechData Sheet focuses on gas-fired units since they are the most likely candidates for an energy saving retrofit.

The two most common types of emitters are tubes and refractory materials. Tube IR heaters blow hot combustion gas through a straight or U-shaped tube, which then emits IR heat. These units can be vented to the outside and can take their combustion air from either indoors or outdoors. Tube heaters operate at up to 1,200°F and can produce 60,000 Btu/hr per 20-foot section. The average combustion efficiency is 86 percent. Figure 1 shows a tube heater.

Refractory material emitters can be made of stainless steel, metallic screens, or porous ceramic. Ceramic, high-intensity, or refractory heaters normally operate between 1,600 to 1,800°F (see Figure 2). A 12- by 1-foot heater of this type can provide 100,000 Btu/hr. The average combustion efficiency is 90 percent.

High-intensity heaters are usually configured to vent to the space so adequate ventilation must be provided (about 4 cfm per 1,000 Btu/hr). In the past, when high-intensity heaters were installed in spaces without adequate ventilation there was a



(Courtesy of Perfection-Schwank, Inc.)

Figure 1. Straight tube infrared heater.

noticeable decrease in air quality. For this reason tube heaters have become more popular for indoor applications. The rectangular heaters are often more economical than the tube heaters but really have limited application due to the venting problem. When choosing between the two types of heaters, carefully consider the ventilation of the space and ask the manufacturer or dealer about adapting the rectangular units for external ventilation.

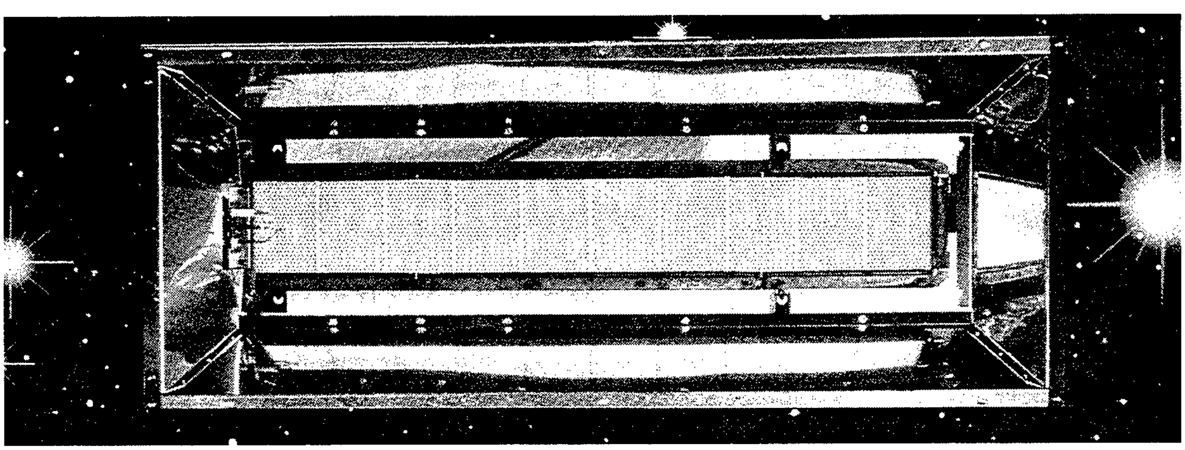
Applications

The first characteristic to look for when considering IR heaters is the ceiling height of the space to be heated. Most heaters have a minimum distance from people and combustible materials. Generally, the surface of the heater needs to be at least 8 feet from anything that could be damaged by the intense heat. Fortunately IR heat can be directed with reflectors. In short, any space with a ceiling height of 12 feet or more may be a candidate.

High bay shops are probably the most frequently retrofitted buildings. They have adequate ceiling height, are expensive to heat with convection heaters, and are usually full of equipment and concrete floors, which make good secondary emitters when heated by IR heat.

Small, semi-enclosed areas, such as patios and carports, are also good sites for IR heaters. Convective heat is ineffective and costly in areas where the number of air changes in a space is high. IR heat cost does not increase with the number of air changes. However, IR heaters may not perform as well in drafty or windy conditions. Despite the decreased performance, it is still cheaper to put up windscreens and use IR heat than to heat with convective units in some cases.

IR heat can be used either as a supplemental heat source or to handle the total heating load. Often IR heaters are used on the perimeters of buildings or near doorways as spot solutions to "cold spot" problems. Keep in mind that sometimes IR cannot be effectively used to heat a building by itself. It is common practice to use both IR and convective heat together. In these cases, the convective source will keep air temperatures at 40 or 50°F while the IR sources will provide occupant comfort only. Buildings that are suitable for only IR heat have the highest potential for savings.



(Courtesy of Perfection-Schwank, Inc.)

Figure 2. Typical ceramic emitter infrared heater.

As a final note on applications, it should be mentioned that U-tube configuration heaters are more common than straight tube heaters. The U-shaped configuration tends to even out heat distribution better and is less likely to cause hot or cold spots in the space.

Sizing and Costs

As mentioned earlier, analytic sizing is a difficult process and is usually not done. More often, manufacturers and dealers rely on rules of thumb derived from experience to decide on appropriate heater size. A summary of those conventions is offered here to give facilities mangers an idea of what equipment will be required. A dealer cost estimate is required for all project submissions.

A common first run sizing method for tube heaters is relatively simple. If the building is 200 feet or less wide, two rows of tubes will be required. The length of each tube is the length of the building divided by two. For example, a building 50 feet by 100 feet would need two tubes, each 50 feet long. Two-hundred feet is the maximum building width that two tubes can accommodate. For a building 200 to 400 feet wide, three tubes would be required, and so on.

Tube heater prices vary but one can expect to pay $900 for the first 10 feet of tube, which contains the burner. Each additional 10-foot section is about $130, these sections will be the emitter only. Prices also vary depending on rated input in Btu/hr. Total capacity required is often estimated by taking 80 to 85 percent of the total building heat loss in Btu/hr. This works for either tube or high-intensity heaters.

A common size panel for rectangular ceramic heaters is 2 feet by 1.5 feet and costs about $400 for a 30,000 Btu/hr unit and about $550 for a 100,000 Btu/hr unit. Some manufacturers calculate coverage area by multiplying the mounting height by two. For example, a unit mounted at 10 feet will cover a 20- by 20-foot area. That is the area the heater will cover. The capacity of the heater will then have to be determined by the desired interior temperature, space conditions, and exterior temperature.

To estimate the labor costs, consider that for either tube or refractory heaters the labor for installation is usually three to four times the material cost.

Table 1 gives a summary of heaters and their characteristics.

In general, sizing is a function of mounting height, heater dimension, heater capacity, and interior and exterior temperatures. An experienced designer can adjust dimensions and sizes of heaters by raising or lowering the rated capacity of the units. To get an idea of what equipment is necessary to heat a building, use the following procedure:

1. Calculate the building's heat load.

2. The total rated capacity of IR heat should be 80 to 85 percent of the building's heat load.

3. Determine which type of heater is most appropriate based on the space characteristics.

4. Use the area coverage conventions mentioned above to determine the number of refractory heaters or the length of tube required.

5. Use the total IR capacity required and the number of heaters or length of tube to determine the capacity (Btu/hr) of each unit or tube.

Economics

The cost of the current heating system is the largest factor affecting the cost effectiveness of converting to IR heat. The two biggest factors affecting convective heat in high bay industrial buildings are heating degree days and building volume. Although the U-values of the walls and the roof are important, changes in volume or weather usually have a more profound effect on the heating cost.

The payback for converting to IR heat from convective heat in a 200- by 500-foot building with a 40-foot ceiling is almost 2 years. This is based on the following assumptions:

Table 1
Heater Characteristics

Heater Type	Ventilation	Surface Temperature (°F)	Combustion Efficiency (%)	Capacity (Btu/hr)[1]	Cost ($)
Tube	Interior or exterior	1,200	86	60,000[2]	975
High Intensity	Interior[3]	1,600	90	60,000[4]	470

[1]Rated input.
[2]For a 20-foot section.
[3]Can be vented to exterior but is not usually configured as such from the manufacturer.
[4]For a 2- by 1.5-foot unit.

- \$4.0/MBtu fuel cost

- 70% existing system efficiency (including line loss of a central system)

- A roof U-value of 0.12 Btu/hr x °F x ft^2

- A wall U-value of 0.05 Btu/hr x °F x ft^2

- 4,000 annual heating degree days

By adjusting these values it becomes clear what has the most effect on payback (see Table 2). Note that the percent change is highest when the building volume changes, followed by a change in the number of degrees days. Wall U-values and boiler efficiencies had a much smaller effect on the payback. The point here is that building volume and weather will most often determine the ideal building retrofit.

These calculations were made using a specific building as a model. Its characteristics are unique and this table is not intended to be a source for payback calculations. However, the data does support the idea of building volume and degree days being the most significant factors in cost effectiveness.

To calculate the payback for any building use the following procedure:

1. Calculate the building's annual heating load using ASHRAE methods. Include all losses and internal gains, and multiply this by the fuel cost to obtain the annual heating cost.

2. Contact a few manufacturers or dealers for a cost estimate and an estimated annual fuel cost for IR heaters.

3. Divide the estimated installation cost by the difference between the current cost of heating and the dealer's estimate.

If you have any questions regarding infrared heating, contact either ***Stephen Cannon at (805) 982-1453, DSN 551-1453, or scannon@ nfesc.navy.mil*** or ***Michael Rocha at (805) 982-3597, DSN 551-3597, or mrocha@nfesc. navy.mil.***

Table 2
Factors Affecting Simple Payback

Degree Days	Building Volume	U-Value Roof	U-Value Wall	Boiler Efficiency	Payback	Change* (%)
4,000	4,000,000	0.12	0.05	0.7	1.8	N/A
2,000	4,000,000	0.12	0.05	0.7	6.32	251
4,000	2,250,000	0.12	0.05	0.7	7.75	330
4,000	4,000,000	0.06	0.025	0.7	1.91	6.1
4,000	4,000,000	0.12	0.05	0.8	2.23	23.8

*All % change values are based on the case in the first row.

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