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Electric Radiant Heating Ceiling System in a Commercial Project

70% estimated cost savings over other electric systems??

It's not as crazy as it sounds based on a real-life project.

This is not a scientific/engineering study or white paper. There was a problem to solve and the best solution for cost and comfort was to install ThermaRay electric radiant AS heaters. What follows is some in-depth, back of the napkin calculations. However, the efficiency numbers should give pause to anyone contemplating using standard electric convection solutions.

Project

The original Heating system was a Gas Boiler with 4' steam radiators running continuously along (2) Walls at floor level in a floor to ceiling tiled lunchroom. The cost to fix or replace the failed boiler system and steam radiators was too expensive.

There were (15) radiator segments along the full length of the 45' east and south walls.

The initial request was to install electric baseboard heaters in place of the steam radiators (built into the tiled walls). The engineer estimated 15Kw of connected load and the following NET Hydro Charge calculations with baseboard heating.

1. Assume 250w /FT for a standard 4' baseboard heater = 1000 watts @240v.
2. Assume 15 x 4' Baseboard Heaters @ 1000w resulting in 15kW connected load (approx. 51.2 BTU/hr.) at 240v.
3. Assume 12 hours /Day MIN Load … (12 x 15,000) … 180,000 kWh (approx. 0.64 GJ /Day)
4. Assume $0.11 /kWh (Hydro NET charge for a Commercial Billing Account).
5. NET Hydro Charge: (180kWh x 0.11) … $19.80 /Day … $594.00/month assuming full Load for 12 hours /Day and 240v circuit voltage.

NOTES:

- In this case the power circuit is 208v with a 2P Breaker in a single phase (1PH) 208Y/120v panel resulting in derated heat capacity for each heater.
- Available capacity at the (1PH) 208v Panel was limited to 2 Circuits @ 15-20A (208v) and MAX 8,320w (assuming 2 single phase 208v circuits used)
- The energy and NET cost above are a quick calculation based on realistic Load assumptions in a commercial /industrial building lunchroom.
- We could assume smaller 900w baseboard heaters but there is likely considerable heat loss through the walls (Est. R-10 below grade) and single pane windows above grade.

A practical solution with Outside Air Temperature (OAT) of 8°C (46°F)

The engineer used 5-7 w/SF target watt-density and wide area coverage using 2x4' AS Panels (750w @240v) for maximum radiant uniformity, in (2) Rows of (3) with circuit capacity and space for (2) more panels at the south windows if needed.

As noted on the thermostat, actual room temperature of 20°C (68°F) does not reach the setpoint of 21°C (70°F) with 8°C (46°F) outside air temperature, primarily due to derated heater capacity at 208v, as below.

Heating capacity is effectively (6 x 750 x 0.75) … 3,375w @208v … (25% derating factor).
Approximate watt density: 3,375 / 1,440 SF (room area) … 2.3 w/SF @ 8°C (46°F) outside air temperature.

Impressive for a lunchroom with limited insulation and single pane windows.

Using Calculations Above for Estimate of Cost Savings

3,375 w @ 12 hrs. /day … 40,500 w-h (40.5 kWh x 0.11 $/kWh) = $4.46 /Day
Or …
$133.65 /Month NET Hydro cost vs $594.00 x 0.75 … $445.50 /month using baseboards.

70% savings of $3,742.20 /year!!!

In this case, the engineer estimated the customer is saving approximately **70%** over an electric baseboard heating installation using the following calculation:

Ratio of NET Charges / Day, with Derated Heat Output @208v:
[$4.46 /($19.80/0.75)] = 0.30 x 100 … % Reduced consumption using the AS Panel Heaters.

Or … 30% of electric baseboard heating cost considering:

- Outside Air Temperature @8°C (46°F)
- Wall Thermostat Room Temperature @19-20°C (66-68°F) within 1-2°C of setpoint @21°C (70°F).

Initial Project Observations

24" x 48" 750W 240V Heater Installation

1. (3) Heaters each on (2) 208v circuits so power is derated to 75%.
2. Room Size is approximately 1450 square feet. Watt density is very low @approximately 2.3 w/ft² with power derated on 208v circuits.
3. Room is comfortable.
4. Outside Air Temp @ 8°C (46°F) during measurements.
5. Wall temperatures are uniformly 17-18°C (63-64°F).
6. Ambient temperature readings on both thermostats are approximately 20°C (68°F). We expect to reach the setpoint with full rated power @240v.

Radiant ceiling heaters after running for (2) weeks … **No complaints**. There is circuit capacity to add a minimum of (2) more heaters if needed for cooler weather next year (2023).

These are impressive results for a room of this size (45x32'), approximately 1450 SF.

This installation has spawned interest since the old boiler heating system included (15) 4' steam radiators along the bottom of (2) walls. The failed boiler cannot be replaced cost effectively.

Summary

The equivalent in baseboard heating would be an impossible (15) x 1000w (15kW) and the boiler cannot be fixed thus limiting the usual options. The use of electric radiant ceiling panels is the best option as it solves the heating problem, provides comfortable heat and energy savings.

The Question then - Why aren't more heating system designers and engineers using electric radiant ceiling panels?

- Basic Heat Loss calculations use a Linear Delta T (Temp) relationship between the Hot

source and a Cold surface.

- Heat transfer is typically considered proportional to:

  Insulation (1/R-Factor) x (Area) x Delta T $\mathbf{(T_H - T_C)}$

- Primarily for Heat Loss by conduction or transfer through insulated wall surfaces

BUT … For Radiant Heating … (Ref: Stefan-Boltzmann (S-B) Radiant Theory)

- Radiant Heat Transfer (gain/loss) is proportional to:

  Surface Area x Emissivity & S-B constants x **(Delta-T at the 4th Power of Absolute Temperatures)**

- With Delta T as $\mathbf{(T_H^4 - T_C^4)}$ … a significant Heat Transfer (Loss/Gain) difference is neglected by mechanical and HVAC heating system designers and installers.
- In effect, there is a misunderstanding of the impact of Radiant Heat Transfer (from/to) a body, in the world of space heating.