Gas Fired Low Intensity Infrared Heaters

Operating Principles of Two-Stage and Modulating Systems

This white paper presents the operational characteristics of two-stage and modulating infrared heaters. Data presented represents an in-depth analysis of industry practices and on-site testing at our approved laboratory.

A Detroit Radiant Products Company **White Paper**

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Introduction

Traditional sizing of a building's heating system has typically been based on the maximum or worst-case heat loss analysis. However, the calculated maximum heat load is normally encountered for only 1-2% of the annual heating hours.

In an era of extreme concern for energy consumption, more efficient technologies have been developed. One proven technology entails adjusting heat output to perform to the changing demands of the environment. Significant energy savings and improved equipment longevity can be achieved by varying the flow of gas or both gas and air to the appliance.

Infrared tube heaters gradually decrease in temperature over the length of the heater. A well-designed tube heater can minimize the total output differential.

A two-stage heater's valve adjusts only the gas flow to the burner allowing for operation in a high and a low fire mode. During high fire operation, the gas and air mixture remains equivalent to that achieved while in single-stage operation. During low fire operation, gas flow through the burner is reduced while airflow remains a constant. This results in reduced fuel consumption and costs. In addition, an elongated flame is maintained, resulting in continued comfort levels during both firing stages.

In contrast, a modulating heater varies the amount of both air and gas flow to the burner to achieve this varied heat output. Unfortunately, reducing airflow to the combustion process of an infrared heater compromises the heat output pattern and also slows responsiveness. This results in inferior heat distribution and ultimately sacrifices comfort levels in the space.

Applicable Definitions

Two-Stage Operation: The ability of an infrared heater to operate at two predetermined rates; typically 65% (low fire) and 100% (high fire) of the maximum firing rate.

Modulation: The ability of an infrared heater to operate and adjust output according to demand. Adjustments occur between an upper and a lower limit; typically 65% (minimum) and 100% (maximum) of the maximum firing rate.

Radiant Efficiency: The radiant heat energy emitted by an appliance divided by the total energy available. A crucial factor in determining the effective performance of an infrared heater.

While commonly used as a measure of the efficiency of heating appliances, thermal efficiency can be misleading when applied to an infrared heater. A common method to achieve high thermal efficiencies is to allow an infrared heater to cool below the condensing point, thereby emitting very little radiant heat.

Thermal Efficiency: The total useful heat energy captured by an appliance divided by the heating value of the fuel supplied. A measurement of three factors which combine to quantify the total energy available to the appliance.

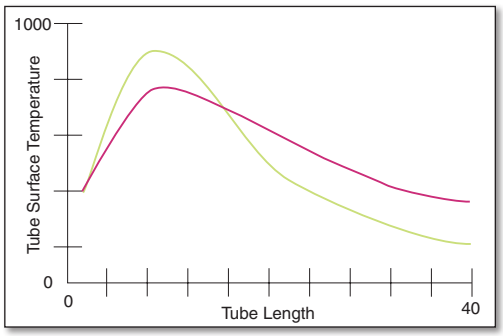
Radiant Flux Density: A measurement of energy leaving a source, divided by a unit of time multiplied by an area of coverage. This is often interpreted as intensity, radiant output or coverage. Example: BTU/h per sq. ft.

Performance Comparison

Operating Principles of Two-Stage and Modulating Systems

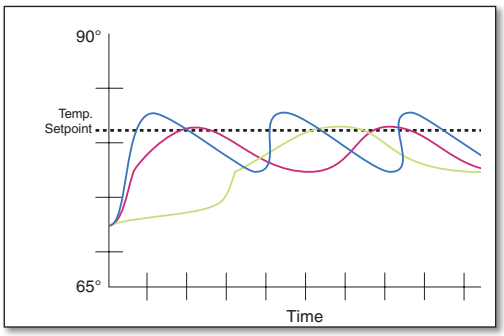
Typical response time of a low intensity infrared heater is 180 seconds. However, when modulating, the response time will inevitably lag as a result of the core design principle that prioritizes thermal efficiency.

Temperature Curve Graph



This graph depicts the temperature differential of the radiant tube exchangers over the length of the heater while operating at reduced output.

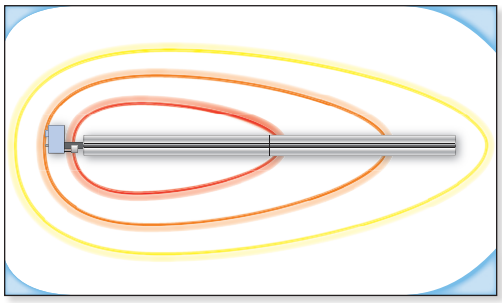
Response and Cycle Graph



Here we see the response time of a two-stage, single-stage, and modulating heater starting from the same initial conditions.

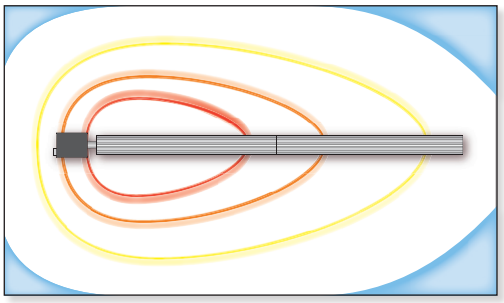
When fan speed is slowed in the combustion process, the burner flame is shortened. A shorter flame negatively impacts heater performance and comfort levels.

Two-Stage Flux Density Pattern



A two-stage heater operating at low fire has a greater coverage and comfort area when compared to a modulating heater because of a longer flame.

Modulating Flux Density Pattern



A modulating heater operating at reduced output results in a diminished comfort zone because of a shortened flame and uneven heat pattern.

Product Comparison Chart

TOPIC	TWO-STAGE	MODULATION
Burner Flame Length	Longer flame utilizing more air.	Shorter flame utilizing less air.
Controls	Simple with a variety of options.	Complicated and costly.*
Emissions	Lower CO_2 and NO_X.	Higher emissions.
Efficiencies	Targets higher radiant efficiencies.	Targets higher thermal efficiencies.
Heat Distribution	More even with higher exhaust temperatures.	Less even with cooler exhaust temperatures.
Heat Recovery	Fast recovery.	Slow ramp-up period.
Product Life	Even flame enhances longevity.	Hot spots reduce longevity.
Tube Temperatures	Higher downstream tube temperatures.	Hotter first tube section produces uneven output.

* Some models in the market require a specific controller in order to enable the operation of modulation.

Frequently Asked Questions (FAQ's)

Q: ***Why is modulation a technology not well suited for infrared heaters?***

A: Modulation was developed primarily to improve comfort levels in the space by reducing on/off cycles and optimizing thermal efficiencies. However, several key factors negate the usefulness of this technology when applied to a low intensity infrared heater. They include:

1. The reduced flame length caused by slowing air speed decreases comfort levels. This differential in the heat flux pattern is prominent because of the lack of an intermediary object in the transfer of thermal energy.

2. The maximum advantages of modulation occur when there is a greater turndown in energy input over a traditional two-stage unit. For example, some boilers and residential modulating furnaces can modulate significantly (70% turndown) below their maximum input. However, when modulation is applied to an infrared heater, input reduction is limited by a fixed exchanger length in order to avoid condensation.

3. Ramp up and response time is reduced in infrared heaters utilizing modulation technology. Rather than focusing on heat recovery, modulation systems chase a false moving target of obtaining optimal thermal efficiencies, ultimately sacrificing heat recovery and response time.

Q: ***Is two-stage more energy efficient than modulation?***

A: Two heaters with identical high- and low-limit firing rates will demonstrate similar energy saving benefits regardless of whether they utilize two-stage or modulation technology. Both heaters will prove beneficial over single-stage unitary heaters.

Q: ***Is it true that a two-stage heater has a lower thermal efficiency rating than its modulating counterpart?***

A: Yes, a small percentage (1%-2%) of thermal efficiency is intentionally sacrificed in order to improve comfort levels, reduce harmful emissions and enhance radiant flux density patterns.

Q: ***Is there a financial benefit to using two-stage versus modulation?***

A: The initial investment is typically lower with two-stage; therefore, the energy saving payback benefit is realized in a much shorter time period. In addition, the controls required for modulation are more complex and costly, potentially negating the payback benefit of variable output operation. The bottom line: two-stage heaters offer a reduced capital investment, shorter payback period and control simplicity.

Summary

Tests show that both types of heaters operate within a similar minimum and maximum firing range. The added costs and complexities required to modulate a heater within that range, in conjunction with adverse performance characteristics (due to the reduction of air output), call into question the logic of a modulating infrared heater. Re-Verber-Ray® two-stage heaters are proven energy saving appliances with proven product and application related features.