## Executive Summary:

## Performance ratings for Gas-Fired Infrared Heaters

In January of 2015, AHRI established a testing and ratings method for gas-fired infrared heaters. This standard was ratified by the AHRI industry group which includes all major manufacturers producing and marketing infrared systems in North America.

In response to this approved standard, Roberts-Gordon has invested in lab materials and equipment to test our systems utilizing the methodology outlined therein, performing over 100 individual tests with calibrated equipment to prove the efficiency levels of our industry leading systems. Each test was performed in strict accordance with CAN/ANSI/AHRI 1330-2015 and with the same diligence that had previously earned Roberts-Gordon's laboratory the certification for Witnessed Manufacturer's Testing based on ISO 17025:2005. Since that time, and as the industry evolves, the group previously mentioned will be attempting to further enhance the standard and possibly align it with an evolving European standard. This will in no way undermine previous tests, as any testing done under the current standard would fall under the auspices of the 2015 version of the CAN/ANSI/AHRI 1330. Testing done under a later version of the standard may supersede existing data, but will also further verify the results and allow for possible standard expansion to incorporate advancements in Infrared technology.

The pages that follow are a summary of the AHRI 1330-2015 Standard scope, terminology and testing methodology, followed by engineering data which supports the sizable reductions in Btu/h output, as much as 25%[1][2], required to properly heat structures with Infrared as compared to competing heating technologies by delivering operable heat where it is required.

For over twenty years, the infrared industry has attempted to put in place a standard whereby an engineer, contractor or owner could verify the efficiency of an individual infrared system and compare it with similar systems. Roberts-Gordon, and a very few others[3], have made the substantial investment of time, equipment and materials to conduct these tests. The following white paper provides context around thermal efficiency and the benefits of infrared systems.

Since AHRI testing and ratings methods are in its infancy, there is still a great deal of confusion regarding radiant efficiency within the industry, resulting in confusion in the market. Because the message is getting misconstrued by some infrared manufacturers, Roberts-Gordon, the innovator and technological leader in the IR industry, was compelled to set the record straight and deliver an unbiased explanation of radiant efficiency, testing and ratings methods, standards, etc. The goal of this white paper is to present the facts, backed by data, to educate the industry and the market so consumers can make informed buying decisions regarding gas-fired, low-intensity infrared equipment.

[1] American Society of Heating, Refrigerating and Air-Conditioning Engineers. 2017. *2017 ASHRAE handbook: Fundamentals*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers

[2] Roberts-Gordon's technological advances allow for further reductions in Btu/h output from those mentioned in the ASHRAE Fundamentals handbook.

[3] Ask your manufacturer if they have invested in the equipment and materials to conduct Infrared testing per AHRI 1330.

**White Paper**

**Performance Rating for Radiant Output of Gas-Fired Infrared Heaters**

**"Radiant Efficiency"**

**CAN/ANSI/AHRI Standard 1330-2015**

January 2015 marked the introduction of a standard that provides a framework for evaluating a gas-fired infrared heater on its efficiency at turning fuel into useable energy. This publication, CAN/ANSI/AHRI 1330-2015, establishes test requirements, definitions, rating requirements, nomenclature, and minimum data requirements needed for manufacturers to publish product ratings. This standard levels the playing field for evaluating the radiant system output of gas-fired infrared products by establishing a universally recognized rating similar to the SEER rating used for packaged HVAC equipment. AHRI 1330 seeks to rectify a long-standing debate that centered upon a prevalent belief in the industry that thermal and combustion efficiencies do not fully describe the utility of a specific radiant system. Ratings are accomplished by implementing a procedure that dictates how a radiant system is to be measured such that the ratio between the fuel input and the radiant output of any gas-fired infrared system can be determined and published reliably across the industry.

**CAN/ANSI/AHRI 1330 Scope:**

The AHRI Standard 1330 has been endorsed by the Air Conditioning, Heating and Refrigeration Institute (AHRI), the American National Standards Institute (ANSI), and the Canadian Standards council. This standard applies to gas-fired high-intensity and low-intensity infrared heaters with input up to 117.5 kW (400,000 Btu/h) per burner for indoor or outdoor installation.

The purpose of the standard is to establish definitions, test requirements, and rating requirements to be used for the guidance of the infrared industry, manufacturers, engineers, contractors, and end users.

It is important to note that conformance to this standard is currently voluntary and conformance cannot be claimed or implied for systems that do not fall within the standard's purpose or scope. Even within the scope of the standard, no minimum rating is delineated as it establishes a rating system and not an efficiency requirement. Contrasting this, and due to the ever-evolving nature of standards and the current industry push toward greater fuel efficiency, it is increasingly more likely that a minimum radiant rating will be set in the future.

**Definitions:**

**ASHRAE:** American Society of Heating, Refrigerating and Air Conditioning Engineers. A globally recognized society with over 50,000 members worldwide that releases standards and guidelines relating to HVAC systems and issues.

**CAN:** The Standards Council of Canada.

**ANSI:** The American National Standards Institute.

**AHRI:** The Air-Conditioning, Heating and Refrigeration Institute.

**Gross Radiant Coefficient:** Heat emitted by the infrared appliance through the appliance's radiation plane divided by the gross heat input of the test gas. This can be interpreted as the useable heat radiated by the system divided by the input to determine a ratio.

**Radiant Efficiency:** A colloquial term that is used to describe the radiant performance of an appliance. This term is created by considering the Gross Radiant Coefficient as a percentage.

**Published Rating**: A statement of assigned values of those performance characteristics, under stated rating conditions, by which a unit may be chosen to fit its application.

**Infrared Factor**: A published rating that is based upon the Gross Radiant Coefficient. The Infrared Factor, or "**IF**", categorizes the radiant coefficient into ratio increments of 0.05 in a range of IF-7 through IF-15. A ratio of 0.35 and below corresponds to the minimum rating, an IF-7. Any coefficient breaching 0.7 is recognized as an IF-15. This factor allows for the quick side by side comparison of multiple appliances and provides a neutral footing for all gas-fired radiant units.

| Gross Radiant Coefficient (Radiant Efficiency) | Infrared Factor (IF) |
|---|---|
| ≤ .35 | 7 |
| > .35 ≤ .40 | 8 |
| > .40 ≤ .45 | 9 |
| > .45 ≤ .50 | 10 |
| > .50 ≤ .55 | 11 |
| > .55 ≤ .60 | 12 |
| > .60 ≤ .65 | 13 |
| > .65 ≤ .7 | 14 |
| > 0.7 | 15 |

Currently, the Infrared Factor chart has a maximum of IF-15, which is equivalent to a gross radiant coefficient of 0.7 or above. As previously mentioned, this is an evolving standard and is subject to change. Although it is not expected to happen in the foreseeable future, the Infrared Factor chart may expand as technology advances. Currently, Roberts-Gordon is the only manufacturer to produce a product with a published Infrared Factor of 15[4].

**Determining the Infrared Factor (Radiant Efficiency):**

The methodology for determining the gross radiant coefficient of a given appliance is defined in CAN/ANSI/AHRI 1330-2015. The information provided below provides a brief summary of the test methods and calculations needed for the determination of the coefficient. For detailed information, please refer to the AHRI 1330-2015 standard.

As mentioned previously, the gross radiant coefficient is defined as the ratio between the useable radiant output and the gross fuel input of the appliance. The heat input is calculated in accordance with the standard using the volumetric flowrate, gross calorific value, temperature, and pressure of the incoming fuel gas, as well as the ambient atmospheric conditions. These must be measured during the radiant coefficient test using calibrated equipment such as a gas meter, thermometer, and barometer. The determined heat input is required to be within ±2% of the appliance's name plate rating during the radiant measurement process.

The methods and calculations used to calculate the heat input stated above are considered standard in the gas industry, but this is not the case with the radiant coefficient. The determination of the coefficient is a multi-step process that, when following the CAN/ANSI/AHRI 1330 to the letter, requires specialized equipment and methodologies. The necessary equipment includes a radiometer, a data acquisition (DAQ) controller, a computer with specialized software, a temperature controlled cooling system, and gas purging equipment. The latter two equipment systems can be safely ignored in this summary due to their support roles, holding the radiometer in thermal equilibrium and keeping it free of any particulate contaminants, respectively.

[4] Rated in accordance with CAN/ANSI/AHRI 1330-2015

The radiometer is a specialized instrument that has been designed to measure incoming radiant energy and turn it into a functional data signal. This is accomplished through a structure inside the device known as an integrating sphere. This sphere collects the radiation through a single entry port, where it then hits a gold-plated disc and is diffused throughout the sphere. This allows an internal pyro-electric detector to sense the energy, but not the directionality, of the incoming radiation, allowing accurate and consistent measurements to be taken. The detector then provides an output signal between 0V and 10V. The DAQ controller receives this signal, collates it, and amplifies it before sending it on to the connected computer. The computer receives this data signal and processes it using specialized software, which sends a single data point to the recording spreadsheet.

The CAN/ANSI/AHRI 1330 describes a methodology through which a large number of these single points can be collected and integrated to provide a full radiant characterization of the appliance. The first step in this method is to define a measurement grid that runs parallel and perpendicular to the longitudinal axis of the appliance. This grid's horizontal plane, known as the measuring plane, is exactly 10 cm below the lowest part of the appliance, which is referred to as the radiation reference plane. Each corner of the grid is known as a node and a measurement is taken at each one. This nodal data is integrated over the total area of the measurement grid and the result is the total radiant energy that has passed through the measurement plane. The total radiant output is then put through several equations that adjust for any effects that the gas layer between the reference plane and the measurement plane, finally giving the total radiant output of the appliance. This output is then divided by the calculated input to derive the coefficient and compared to the table above to determine the appliance's IF rating. The radiant efficiency can be determined concurrently by multiplying the coefficient by 100 to gain a more useable efficiency percentage.

**<u>Influencing Factors</u>**

The radiant output, and therefore the radiant coefficient, can be affected by a number of factors. These factors include the material properties of the heat exchanger[5] and any points of operation, such as the appliance's thermal efficiency, convective losses, and reflector design.

**Thermal Efficiency:**

The thermal efficiency is the traditional way to determine a gas-fired appliance's effectiveness, but it is of secondary concern when considering an infrared heater. The thermal efficiency is a measure that compares the energy lost in the exhaust of a system and the energy input. This term describes how much of the energy input is converted to radiant, convective, and conductive heat and what quantity is ejected through the system exhaust. While it is critically important to maximize thermal efficiency to fully utilize the energy in the fuel, it becomes less so when you consider that the usable heat of the appliance is in the form of radiant heat. Effectively, all of the energy used that is not converted into radiant heat has a minimal impact on the space being heated. The other two operative terms, convection and conduction, should also have very little impact on the space if the appliance is designed correctly. Properly designed low-intensity infrared heaters minimize convection and conduction, and maximize the desired heat transfer mode, Radiation.

It is through this lens that we can observe thermal efficiency's effect on the radiant coefficient. The thermal efficiency is not salient because it wholly characterizes an appliance, but because it partially captures how much of the input has been transferred out of the system before the exhaust. This is to say that an appliance with a thermal efficiency of 75% has lost 25% of its useable energy through the flue. The remaining 75% is divided into the 3 major heat transfer modes detailed above and, in properly designed infrared systems, the radiant heat transfer mode should always dominate the other two modes. In this way, we can gain an understanding of how much of the energy input is available to be converted into radiant heat.

[5] See material emissivity chart on page 5.

**Convective losses:**

Using the definition of thermal efficiency above, it becomes apparent that the total radiant energy output is bounded by the amount of heat that is lost to forms of heat transfer that are not radiation. Heat lost due to conduction can be considered negligible due to the small amount of surface area in direct contact with structural elements of a building. The same cannot be said for heat lost due to convection.

Convection is the process through which a hot object heats the air around it, thus cooling the object itself. This cooling effect is unavoidable when dealing with a temperature differential of over 900°F between the ambient temperature and that of the heat exchanger, but it does reduce the amount of energy that can be radiated from the appliance. This effect can be mitigated through proper heat exchanger material selection and reflector design.

**Heat Exchanger Emissivity:**

The heat exchanger on most low-intensity gas infrared appliances is a metal tube through which the flame is forced or drawn. Arguably, the most important property of this heat exchanger, apart from its length, is a material property know as emissivity. Emissivity is a term that describes a surfaces ability to transfer energy from an object into radiant energy. This term can generally be considered a percentage of the theoretical maximum amount of energy that can be transferred from the surface. In a perfect scenario, with an emissivity of 1, a surface would take 100% of the energy available to it and convert it into infrared radiation. Reciprocally, an emissivity of 0.5 would allow the surface to radiate only 50% of the available energy. The emissivity of several materials commonly used in heat exchangers are listed below.

| MATERIAL | EMISSIVITY[6] [7] [8] [9] [10] [11] |
|---|---|
| Aluminized Steel (Heat Treated) | 0.79 |
| Porcelain Coated Steel | 0.92 to 0.96 |
| Hot Rolled Steel | .80 |
| Cast Iron | 0.35 to 0.7 |
| Schedule 40 Black Steel Pipe | 0.95 |
| Stainless Steel (type 304) | 0.36 to 0.73 |

**Reflector Reflectivity:**

As with the heat exchanger, there is a material property of the reflector that influences the measured radiant output of the heater. Reflectivity is a surface property that describes the amount of thermal radiation that is reflected away from a surface. Ideally speaking, a reflector would redirect 100% of the all incoming energy towards the locations where it is needed most. The most ideal material for this application is aluminum, which reflects 80% to 95% of all the energy that they receive as radiant energy. The reflectivity of several materials commonly used in reflectors are listed below.

[6] Baumeister, Theodore., Eugene A. Avallone, and Theodore Baumeister III. 1978. *Marks' standard handbook for mechanical engineers*. New York: McGraw-Hill.
[7] Stephens, J Hall. 1997. *Kempe's engineers year-book*. Tonbridge, UK: Miller Freeman
[8] Z.J. Lickso, J.J.R. Feddes, J.J. Leonard and D.E. Darby. 1991. Heat transfer from black-steel pipe in a functionally similar barn environment. *Canadian Agricultural Engineering*. 33(2): 341-345
[9] Battelle Memorial Institute, and Webster Wood. 1962. *DMIC report 177: Thermal radiative properties of selected materials*.
[10] Weast, Robert C. 1971. *CRC handbook of chemistry and physics: a ready-reference book of chemical and physical data*. Cleveland, Ohio: Chemical Rubber Co.
[11] Honeywell Inc, and G. G. Gubareff. 1960. *Thermal radiation properties survey: a review of the literature*. Minneapolis: Honeywell Research Center.

| MATERIAL | REFLECTIVITY[6 7 9 10 11 12] |
|---|---|
| Aluminum (Mill Finish) | 0.91 |
| Aluminum (Polished) | 0.91 |
| Stainless Steel (Type 304) | 0.27 to 0.64 |

**Appliance Design:**

Considering the factors above, it becomes critically important that the appliance is designed in such a way to maximize the benefits received and the amount of radiant heat directed to the heated space. The design of the heater must properly utilize the material properties of both the heat exchanger and reflector while still maintaining a high level of thermal efficiency.

The emissivity of the heat exchanger material is one of the easier factors to incorporate into the design. The material itself is selected by balancing the durability, emissivity, ease of installation, and cost for each job or application. These factors must be considered for each installer's specific application.

The design considerations for the reflector are more varied than those of the heat exchanger, but many of them still tie to the physical properties of the material used. The first and most obvious is the selection of the material to construct the reflector. Aluminum is widely used in the industry for this purpose because it is light weight, sufficiently rigid, and delivers a reflectivity of over 0.9. The second major design consideration for the reflector is the physical shape and structure of the reflector. While the reflectivity determines the percentage of energy that gets redirected away from the reflector, it is the profile shape that controls where the energy is directed. Ideally, the radiant energy emitted from the upper circumference of the heat exchanger tube will reflect away from the tube to stop reabsorption and energy loss. A reflector designed to maximize the downward transmission of the radiant energy dramatically improves the infrared efficiency and delivery of heat to occupants and materials below. Poor reflector design can reduce Infrared Efficiency by as much as 40% resulting in greater Btu/h output requirements and higher operating costs.

## Benefits of Low-Intensity Infrared

There are many benefits of low-intensity gas-fired infrared heaters when compared to other appliance types. Due to infrared radiation's ability to directly heat objects and occupants in a space, low-intensity heaters are largely able to avoid the stratification and heat lost due to air changes that affects forced air heaters. This direct heat allows for the floor and other surfaces to act as heat reservoirs that can contribute to heating the space and reducing energy loss. The direct application of heat to the surfaces of a space and other factors discussed both in the following section, as well as factors given by The ASHRAE HVAC Systems and Equipment Handbook, make low-intensity systems a cost-effective way to heat an industrial space when compared to competing technologies.

**Reduced Energy Input Requirements**

As mentioned above, ASHRAE has recognized that infrared heaters are highly effective at directing usable heat into a space. The 2016 ASHRAE Handbook "HVAC Systems and Equipment" states: "Recognizing the reduced fuel requirement for these applications, …. it is desirable for manufacturers of radiant heaters to recommend installation of equipment with a rated output that is 80 to 85%[13] of the heat loss calculated by methods described in Chapters 17 and 18 of the 2013 ASHRAE Handbook – Fundamentals."

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[12] Reflectivity values have been derived using known emissivity values and an assumed transmissivity of 0 for opaque surfaces. Emissivity is assumed to be equal to absorptivity.

[13] With efficiency improvements generated through the High Efficiency Reflector design, Roberts-Gordon recommends installation or equipment with a rated output of 75% to 80% of the calculated heat loss when using High Efficiency Reflectors.

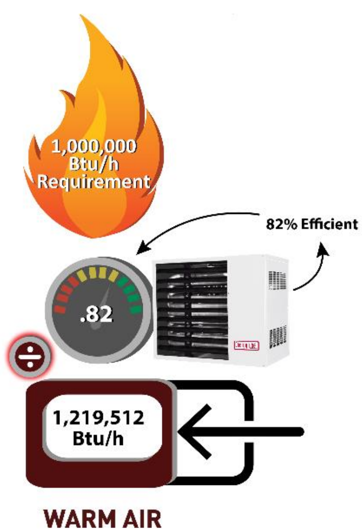
The passage above describes why an infrared system can reduce the number of Btu/h needed to comfortably heat a space and save energy in the future, in contrast to other system types. The standard heat loss equations and methods were developed with a greater emphasis on forced air convection appliances and fails to fully characterize infrared heaters. To rectify this, an ASHRAE study[14] was conducted to determine an adjustment factor for input energy requirements and energy savings garnered from IR applications in contrast to other types of heating systems.

The publication of this study, titled "Engineering Principle Support an Adjustment Factor When Sizing Gas-Fired Low-Intensity Infrared Equipment", demonstrated that "The performance characteristics of low-intensity radiant heating equipment support an overall reduction in the input energy requirement for radiant heating system installation[14]" over competing technologies. Factors driving this determination include: re-radiation and convection from the floor heat reservoir, reduced air stratification, and space comfort that can be maintained with a lower energy input when compared to convective systems. The study concluded from these, and other points, that the Btu/h input required for a space using traditional HVAC system can be reduced by 15% to 20% when considering infrared system installations[14].

**Necessary Total Input for Convective Appliances**

The amount of equipment that must be installed to properly heat a building is determined through calculating the heat loss of the structure. The heat loss is determined via a method described in chapter 17 of the ASHRAE Fundamentals 2017 handbook. This calculation accounts for the size of the building, materials used in its construction, internal air changes per hour, and other considerations. Using this calculated value, the necessary input for the application can be determined by using a convective appliance's thermal efficiency.

The thermal efficiency of a convective heater describes how much of the energy input is turned into heat. For gas-fired, infrared heaters, this value can never be 100% due to inherent energy losses; a space will always need more convective appliances than would be determined by dividing the heat loss by the input rating of the heaters. If it is assumed that a convective appliance has a thermal efficiency of 82% and a building has a calculated heat loss of 1,000,000 Btu/h, then the capacity that would be required to heat the building is the fraction of these two values. Using the heat loss as the numerator and the efficiency as the denominator, the total capacity required to satisfy the total building's heat loss would be 1,219,512 Btu/h. The number is then divided by the proposed heater's inputs to determine the amount of equipment required.




**Required Convective System Input: 1,219,512 Btu/h**

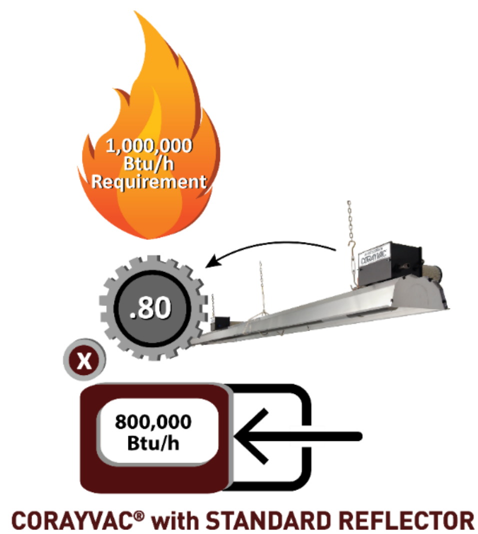
[14] Buckley, N.A. and T.P. Seel. 1987. Engineering principles support and adjustment factor when sizing gas-fired low-intensity infrared equipment. *ASHRAE Transactions* 93(1):1179-1191

**Necessary Total Input for Radiant Appliances**

The calculated heat loss for sizing heating appliances for a low-intensity infrared system begins in the same manner as for convective appliances such as unit heaters, air turnover or make up air systems. Using the method described in the ASHRAE fundamentals handbook referred to above determines, the heat loss for the structure.

Unlike the example above for convective systems, which divides the heat loss by the thermal efficiency of the system, low-intensity infrared system's input capacity is determined by multiplying the calculated heat loss by an adjustment factor of 0.8 to 0.85 as recommended by ASHRAE.[15] [16] In the Buckley and Seel study mentioned previously, it was demonstrated that this adjustment factor, developed through physical principles and numerous field case studies, will properly size the load for infrared equipment.

Following the convective example, we assume that the heat loss has been calculated to be 1,000,000 Btu/h. Ignoring the thermal efficiency as unimportant for heat loss adjustment in radiant applications as shown in the ASHRAE HVAC Systems and Equipment Handbook, the heat loss is multiplied by the adjustment factor of 0.8. The resulting value is the input capacity required to heat the structure with gas-fired low-intensity infrared equipment.

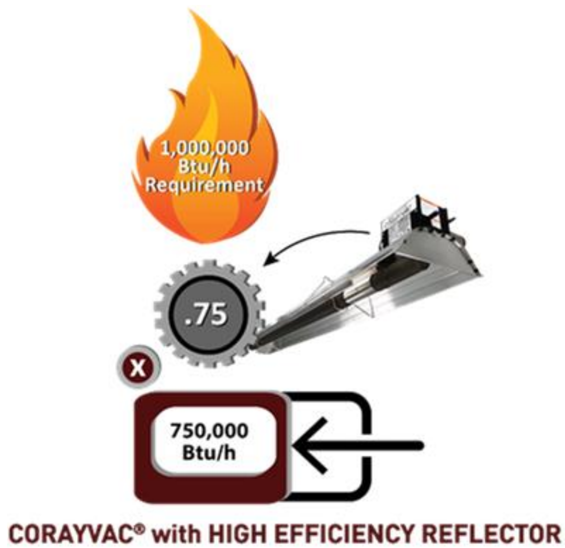



**Required Radiant System Input with Standard Reflector: 800,000 Btu/h**

It is important to note that these calculations published in the ASHRAE Handbook were developed based upon studies performed over 30 years ago, but they are still considered valid for standard low-intensity technology**. New technology has been developed since those studies were completed which allows for a lower adjustment factor**. The ASHRAE adjustment represents a conservative estimate for heat loss adjustment. Roberts-Gordon, for example, has released a new High Efficiency Reflector which reduces the amount of gas-fired low-intensity radiant equipment required for these spaces. Using data collected from the radiometer, Roberts-Gordon has been able to determine that the amount of heat output from an appliance has been significantly increased when the newly designed High Efficiency Reflector is used. With this increased output from the same amount of input, Roberts-Gordon is justified in further reducing the ASHRAE heat loss adjustment factor to 0.75.

[15] With efficiency improvements generated through the High Efficiency Reflector design, Roberts-Gordon recommends installation or equipment with a rated output of 75% to 80% of the calculated heat loss when using High Efficiency Reflectors.

[16] Buckley, N.A. and T.P. Seel. 1987. Engineering principles support and adjustment factor when sizing gas-fired low-intensity infrared equipment. *ASHRAE Transactions* 93(1):1179-1191




**Required Radiant System Input with High Efficiency Reflector: 750,000 Btu/h**

**Lowered Thermostat Setting**

When compared to convective systems, infrared installations also benefit from being able to use a lower thermostat setpoint and provide the same thermal comfort. This is achieved by keeping the operative temperature of the space at the same level while lowering the ambient air temperature. The **Operative Temperature ($T_o$)** is defined in the ANSI/ASHRAE 55 as "a uniform temperature of an imaginary black enclosure and the air within it in which an occupant would exchange the same amount of heat by radiation plus convection as in the actual non-uniform environment." This essentially means that the operative temperature is how warm a space feels versus its actual temperature.

To determine the operative temperature of a space heated by infrared equipment, another value must be determined first. The **Mean Radiant Temperature (MRT)** is a calculated value that, in broad terms, is an average temperature of the floor, walls, ceiling, and surfaces in a space. Due to radiant appliances heating the aforementioned surfaces directly, the average MRT of these surfaces tend to be higher than the **Ambient Air Temperature ($T_a$).** The formula below describes the relationship between $T_o$, MRT, and $T_a$ when the air movement across the occupant is less than 40 feet per minute.

$$T_o = \frac{T_a + MRT}{2}$$

The two following examples show typical values for the convective (unit heaters, air turnover units, or make up air units) and radiant operative temperatures for the same application.

<u>Convective:</u>

$$T_o = \frac{T_a + MRT}{2}$$

**MRT = 65°F**

$T_a$ = 75°F

$$T_o = \frac{75°F + 65°F}{2} = 70°F$$

The convective example above describes the parameters necessary to obtain a perceived comfort temperature of 70° F. Due to the lack of direct heat, the surfaces found in a convectively heated space are lower than the ambient air temperature. This means that given a MRT of 65° F, the ambient air of the space must be 75° F to obtain the 70° F perceived comfort.

Radiant:

$$T_o = \frac{T_a + MRT}{2}$$

**MRT = 75°F**

$T_a$ = 65°F

$$T_o = \frac{65°F + 75°F}{2} = 70°F$$

The Radiant example shows the benefit of infrared technology. By directly heating the surfaces of a structure, the MRT is raised to 75° F. This means that to gain the same operative temperature of 70° F, the ambient air inside can be heated to a much lower 65° F.

The above examples show exactly how radiant heat can reduce fuel costs associated with heating a structure. Because most thermostats measure the ambient temperature of air in a space, the reduction in necessary ambient air temperature due to the high mean radiant temperature means that the thermostat can be set much lower and maintain the same thermal comfort. The US Department of Energy estimates that for every 1° F that the thermostat is lowered, a corresponding 3% reduction in fuel use is realized. This means that, by lowering the thermostat setting by 5° F, up to **15%** can be saved on fuel usage when compared to fuel usage using convective appliances for the same facility.

| | | | **Convective** | **Radiant** |
|---|---|---|---|---|
| **Mean Radiant Temperature** | **MRT** | **[°F]** | **65** | **75** |
| **Ambient Air Temperature** | **$T_a$** | **[°F]** | **75** | **65** |
| **Operative Temperature** | **$T_O$** | **[°F]** | **70** | **70** |

**Operative Temperature and the ROBERTS GORDON® High Efficiency Reflector**

The operative temperature formula, as described previously, helps to explain why the ROBERTS GORDON® High Efficiency Reflector can provide additional fuel savings. The increase in the MRT generated by infrared products is directly tied to the radiant output of the heater, and this improvement can be supplemented through use of High Efficiency Reflectors. Because these reflectors are more efficient at converting fuel input to useable radiant output, surfaces in the space also receive more energy than from a traditional infrared heater. Modeling done for the ROBERTS GORDON® High Efficiency Reflector have shown an increase in surface temperatures when using this technology, versus older, less efficient reflectors, thus raising MRT. The results of this testing are summarized below.

**MRT increase (° F)**

| | Old | New | Increase |
|---|---|---|---|
| Floor | 95.4° | 99.7° | 4.3° |
| End Wall | 93.4° | 97.4° | 4.0° |
| Side Wall | 92.0° | 95.9° | 3.9° |

**Average MRT increase: 4.1°**

This increase of MRT by 4.1° F can be factored into the operative temperature calculation. It can be seen in the example below that the operative temperature of 70° F can be maintained with a lower thermostat setting.

Radiant with High Efficiency Reflector:

MRT = 79°F

$T_a$ = 61°F

$$T_o = \frac{79°F + 61°F}{2} = 70°F$$

Because the appliance is more efficiently converting the fuel's energy into usable radiant heat, the MRT is raised from 75° F to 79° F. Correspondingly, the necessary ambient air temperature to maintain an operative temperature of 70° F is lowered to 61° F. Using the estimate from the US Department of Energy, 3% fuel usage reduction for every 1° F the thermostat setting is lowered, it is possible to save an additional 12% in fuel usage just by using High Efficiency Reflectors. This savings is a direct result of the increased radiant coefficient provided by the High Efficiency Reflectors.

**Final Notes:**

The CAN/ANSI/ASHR 1330 is a standard to characterize gas-fired low-intensity infrared tube heaters. This standard gives guidelines and methodologies for testing how efficiently an infrared appliance system converts fuel energy input to usable radiant output. It has been shown above how this factor relates to the traditional characterizations currently in use in the low-intensity infrared industry. Through this, it is readily apparent that the radiant coefficient is a key concept that affects not only the appliance itself, but the design considerations for applying infrared in installations. Roberts-Gordon has fully embraced this standard and has worked to maximize the radiant coefficient for all offered equipment. The development of the ROBERTS GORDON® High Efficiency Reflector allows systems to be much more efficient, achieving an Infrared Factor (IF) as high as IF-15 for properly designed applications. The end result of this efficiency increase is a fuel and cost savings with no extra work for the installer or end user. The ROBERTS GORDON® High Efficiency Reflector is a smart and fast way to get the most out of radiant heating technology.