Gas-Fired Infrared Heaters

Understanding AHRI Standard 1330 and Radiant Efficiency

This White Paper presents an overview of radiant efficiency as it pertains to gas-fired infrared heaters, as well as an overview of the AHRI 1330 Standard and its application in the marketplace. 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

Rising energy costs coupled with a concern for the environment has driven a demand to increase efficiencies of heating appliances. Determining which appliance is the most efficient to install presents a greater challenge as technologies evolve, and determining how best to measure these efficiencies has been a subject of debate for several decades.

Heating with infrared technology is an excellent method to reduce energy costs. However, the fact that infrared technology is fundamentally different than traditional means of heating requires special attention when evaluating an infrared appliance for its efficiency, particularly where radiant efficiency is concerned.

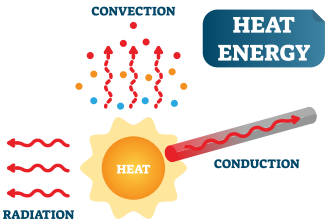
Heat Transfer

Heat Transfer: Thermal energy that is transferred from one area to another by three modes of heat transfer: Conduction, Convection, and Radiation. This is due to a differential in temperatures.

Conduction: The transfer of energy between objects in contact.

Convection: The transfer of energy between air and the object in contact.

Radiation: The transfer of radiant energy directly from the source to the object - air is not directly heated.



What is Radiant Efficiency?

Radiant efficiency is a measure of how much thermal energy is converted into radiant heat energy. This form of thermal transfer is fundamentally different from conduction or convection as it does not require an intermediary heat transfer device. This greatly reduces the amount of heat lost during the transmission process because it sends the heat directly to the intended load. This is one reason why heating with radiant energy is more effective and efficient than traditional forced air systems.

The Infrared Industry has worked to develop an accurate metric for measuring radiant efficiency for over 30 years. This task has proven quite challenging as the concepts and formulas are steeped in principles and laws of physics and calculus. Efforts to obtain reliable measurement metrics as well as a way to provide accurate and meaningful data to consumers has been an Industry priority.

Understanding Efficiencies

Efficiency: A mathematical ratio of two values used to determine a performance rating of a system. Simply put, what energy you get out ÷ what you put in.

Combustion Efficiency: A measure of how completely an appliance converts fuel into heat energy.

Thermal Efficiency: A measure of the total heat energy captured by an appliance which is available for useful output.

Radiant Efficiency: A measure of all radiant energy leaving the heater.

What is CAN/ANSI/AHRI 1330?

Industry leaders in North America and Europe have developed standards and regulations to help guide manufacturers as to the proper radiant efficiency test methods. For North America, the recognized standard is CAN/ANSI/AHRI 1330, commonly referred to simply as “1330.”

1330 is an **optional** performance standard published by the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) and written by Industry experts. It is based on similar testing standards and regulations developed in Europe and provides direction on test equipment specifications and proper methods of testing. By specifying the proper equipment and test methods to be used, reliable and repeatable data can be obtained and provided to consumers.

Performance Objectives

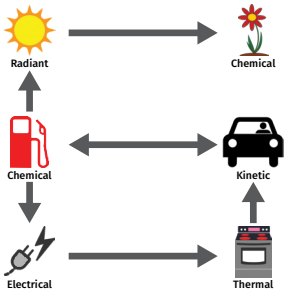
A primary objective of I330 is to develop a rating system by which the radiant efficiency of comparative infrared heaters can be measured against one another (think of SEER ratings for air conditioning units). By providing a single, comparable number, one aspect of choosing the best option for a particular install becomes much simpler.

It is important to use caution, however, when choosing a unit for a particular application that the decision is made based upon a multitude of factors including efficiencies (radiant and thermal), clearances to combustibles, desired comfort level, and heat pattern. For example, a 40 ft. long, 75 MBH tube heater will typically have a higher radiant efficiency than a 20 ft. long, 75 MBH tube heater. However, the shorter heater is often a better choice for a spot heating application, such as a patio, as there is the same amount of heat in a more compact area.

Laws of Thermodynamics

The science of thermodynamics involves the study of heat transfer and its resulting changes. The first of the Four Laws of Thermodynamics, known as the "Law of Conservation of Energy," states that energy cannot be created or destroyed, only transferred. This transference can be in the form of another type of energy (kinetic, potential, etc.) or in the form of work.

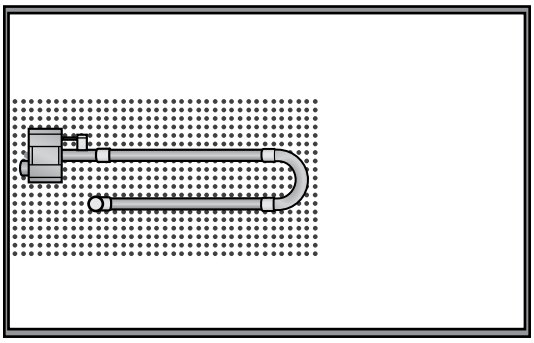
Energy Transformation Examples



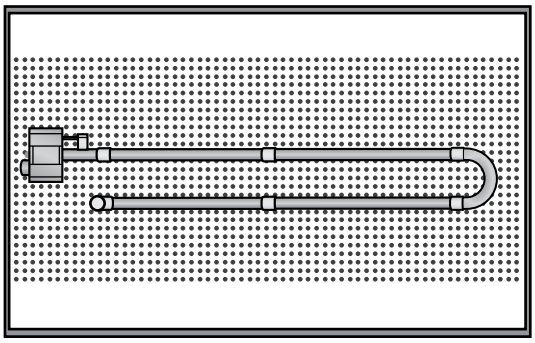
Testing Methodology

Information collected from the many data points during radiant efficiency testing is compiled into summation-based calculations. The size of the testing grid is determined by the heat output of the unit being tested. A 20 ft. long, 75 MBH tube heater may have around 600 data points tested whereas a 40 ft. long, 75 MBH unit may have 1,000 data points from which to gather information.

Sample Test Layout - 20 ft., 75 MBH U-Tube

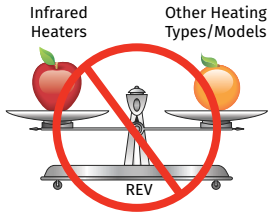


Sample Test Layout - 40 ft., 75 MBH U-Tube



Remember: Apples to Apples

The reporting metrics laid out in 1330 are for comparing one infrared heater to another (apples to apples). REV is not designed to be used to compare infrared heaters to any other heating type.



Performance Metrics

Rationale

Just as SEER ratings are used to market air conditioners, REV was developed to market infrared heaters. The actual Gross Radiant Coefficient numbers do not appear favorable as a percentage, so REV is more desirable to present.

Radiant efficiency test methods and standards are still growing and evolving, and so are the performance metrics. Europe was the first to begin putting radiant efficiency testing requirements into their standards and regulations, and early versions of 1330 were influenced by similar European testing. The first published version of 1330 specified reporting an Infrared Factor (IF). Possible IFs ranged from 7 to 15, with each number corresponding to a Gross Radiant Coefficient percentage range. **Gross Radiant Coefficient (GRC)** is measured during radiant efficiency testing and is defined as the heat emitted by the appliance divided by the gross heat input of the gas, written as a percentage.

Due to errors in the original test methods and equipment, data produced during testing was not always accurate or reliable, and one small discrepancy could change the reported IF by several numbers. Without a meaningful reporting metric, the testing and related claims become worthless.

REV and Heater Components

An REV **only** applies to a whole heater (or heater branch in a multiburner system). A specific heater part or accessory, such as a reflector, **cannot** be assigned an REV or IF.

As the test methods and equipment were refined, 1330 was revised to remove IF and replace it with Radiant Emission Value (REV). While REV is also based on the GRC, it is more precise than the IF with a wider reporting range. The reporting requirements of the standard were updated as well for specific data to be reported alongside a REV.

Infrared Factor (IF) - 1330-2015

Typical Range	7-15
Reporting Requirements	Model Number
	Heat Input, kW
	Length of Exchanger Tube
	Infrared Factor
	Min. Mounting Angle if not tested in a horizontal position (deg.)

Radiant Emission Value (REV) - 1330-2018

Typical Range	80-120
Reporting Requirements (These are the basic requirements for most heaters. Multiburner systems have additional requirements.)	Model Number
	Heat Input, kW
	Length of Exchanger Tube
	Radiant Emission Value
	Min. Mounting Angle if not tested in a horizontal position (deg.)

IF	GRC Range
7	≤ 35%
8	36-40%
9	41-45%
10	46-50%
11	51-55%
12	56-60%
13	61-65%
14	66-70%
15	> 70%

REV	GRC Equivalent
80.3	30%
84.9	35%
89.3	40%
93.3	45%
97.1	50%
100.6	55%
103.9	60%
106.9	65%
109.8	70%

Seasonal Efficiency

In Europe, the Seasonal Efficiency of an appliance is often reported. The **Seasonal Space Heating Energy Efficiency** is the annually weighted combined thermal and radiant efficiency. Included in the calculation is a correction factor allowing for an increase in efficiency for staged and modulating appliances.

Regulatory and Compliance

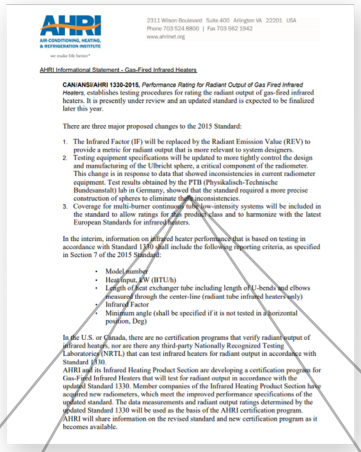
In North America, manufacturers will typically certify their products to one or more performance standards. For example, infrared tube heaters are certified to ANSI Z83.20/CSA 2.34. When certifying to performance standards, manufacturers must undergo regular agency compliance inspections of both the product and manufacturing facilities.

As of 2019, there is not a certification program that allows manufacturers to certify **to** the 1330 Standard. Nor is there a third party verifying data that is released by manufacturers. **Compliance to the standard is completely voluntary**, and until a certification program is created, manufacturer data published is not agency verified.

Public Positions

AHRI 1330-2018 was created to address known laboratory and data reporting errors, which occur both from testing to previous versions of standards and from using previous versions of the radiometer (a critical testing component). These errors have been outlined in informational statements from AHRI and ELVHIS.

AHRI Statement (Jan. 2019)



AHRI Informational Statement – Gas-Fired Infrared Heaters

CAN/ANSI/AHRI 1330-2018, *Performance Rating for Radiant Output of Gas Fired Infrared Heaters*, establishes testing procedures for rating the radiant output of gas-fired infrared heaters. It is presently under review and an updated standard is expected to be finalized later this year.

There are three major proposed changes to the 2015 Standard:

1. The Infrared Factor (IF) will be replaced by the Radiant Emission Value (REV) to provide a metric for radiant output that is more relevant to system designers.
2. Testing equipment specifications will be updated to more tightly control the design and manufacturing of the Ulbricht sphere, a critical component of the radiometer. This change is in response to data that showed inconsistencies in current radiometer equipment. Test results obtained by the PTB (Physikalisch-Technische Bundesanstalt) lab in Germany, showed that the standard required a more precise construction of spheres to eliminate these inconsistencies.
3. Coverage for multi-burner continuous tube low-intensity systems will be included in the standard to allow ratings for this product class and to harmonize with the latest European Standards for infrared heaters.

In the interim, information on infrared heater performance that is based on testing in accordance with Standard 1330 shall include the following reporting criteria, as specified in Section 7 of the 2015 Standard:

- Model number
- Heat input, kW (BTU/h)
- Length of heat exchanger tube including length of U-bends and elbows measured through the center-line (radiant tube infrared heaters only)
- Infrared Factor
- Minimum angle (shall be specified if it is not tested in a horizontal position, Deg)

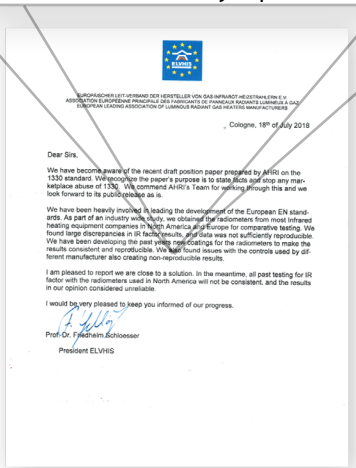
In the U.S. or Canada, there are no certification programs that verify radiant output of infrared heaters, nor are there any third-party Nationally Recognized Testing Laboratories (NRTL) that can test infrared heaters for radiant output in accordance with Standard 1330.

AHRI set its Infrared Heating Product Section are developing a certification program for Gas-Fired Infrared Heaters that will test for radiant output in accordance with the updated Standard 1330. Member companies of the Infrared Heating Product Section have acquired new radiometers, which meet the improved performance specifications of the updated standard. The data measurements and radiant output ratings determined by the updated Standard 1330 will be used as the basis of the AHRI certification program. AHRI will share information on the revised standard and new certification program as it becomes available.

"Testing equipment specifications will be updated.... This change is in response to data that showed inconsistencies in current radiometer equipment."

"We obtained radiometers from most infrared heating equipment companies in North America and Europe... [and] found large discrepancies in IR factor results, and data was not sufficiently reproducible."

ELVHIS Statement (July 2018)



EUROPÄISCHER LEIT-VERBAND DER HERSTELLER VON GAS-INFRAROT-HELLSTRAHLERN E.V.
ASSOCIATION EUROPÉENNE PRINCIPALE DES FABRICANTS DE PANNEAUX RADIANTS LUMINEUX À GAZ
EUROPEAN LEADING ASSOCIATION OF LUMINOUS RADIANT GAS HEATERS MANUFACTURERS

Cologne, 18th of July 2018

Dear Sirs,

We have become aware of the recent draft position paper prepared by AHRI on the 1330 standard. We recognize the paper's purpose is to state facts and stop any marketplace abuse of 1330. We commend AHRI's Team for working through this and we look forward to its public release as is.

We have been heavily involved in leading the development of the European EN standards. As part of an industry work study, we obtained the radiometers from most infrared heating equipment companies in North America and Europe for comparative testing. We found large discrepancies in IR factor results, and data was not sufficiently reproducible. We have been developing the past years new coatings for the radiometers to make the results consistent and reproducible. We also found issues with the controls used by different manufacturer also creating non-reproducible results.

I am pleased to report we are close to a solution. In the meantime, all past testing for IR factor with the radiometers used in North America will not be consistent, and the results in our opinion considered unreliable.

I would be very pleased to keep you informed of our progress.

Prof. Dr. Friedhelm Schloesser
President ELVHIS

Certification Program: Vision for the Future

To combat the inconsistencies of the Ulbricht sphere (a piece of equipment critical to testing integrity), PTB, a testing laboratory in Germany, agreed to manufacture a single batch of spheres. By manufacturing all the spheres in a single, small batch, PTB could ensure that each sphere was created equally. While the new spheres are consistent, discrepancies between different rigs and laboratories may still exist, which is why AHRI is working to establish a certification program to allow certifying agencies to certify specific products **to** 1330.

ANSI Standards

ANSI Z83.19/CSA 2.35: Gas-fired high intensity infrared heaters performance standard.

ANSI Z83.20/CSA 2.34: Gas-fired tubular and low intensity infrared heaters performance standard.

ANSI Z83.26/CSA 2.37: Gas-fired outdoor infrared patio heaters performance standard.

Certifying Agencies

Canadian Standards Association: Uses the CSA mark.

Intertek: Uses the ETL mark.

Underwriters Laboratory: Uses the UL mark.

Various Notified Bodies in Europe: Use the CE mark.

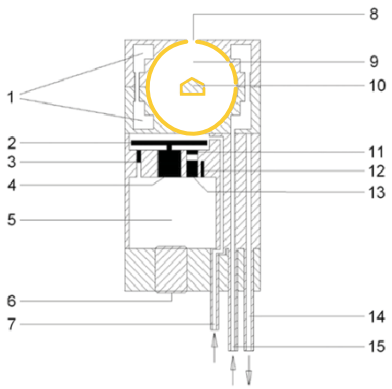
Remember!

Neither an IF or REV can apply to a heater component. Each individual heater model must be tested for radiant efficiency. If only an IF or REV is provided, don't be afraid to ask for the rest of the **required reporting data which includes:**

- Full Model Number
- Heat Input in kW
- Length of Exchanger Tube
- REV
- Minimum Mounting Angle if not tested in a horizontal position (deg.)

The Science Behind it All

So how is the radiant efficiency of an infrared heater actually tested? To begin, there are three main components a testing laboratory should have: a test rig, an Ulbricht sphere contained within a radiometer head, and a calibration oven. There are also other components that perform functions such as monitoring temperatures and humidity, flowing nitrogen, and collecting data.



Key

1 - Water cooling recess
2/3 - Chopper wheel & sensor
4 - Chopper motor
5 - Electrical connection chamber
6- Electrical socket
7- Inlet nitrogen purge
8 - Radiometer inlet opening
9 - Ulbricht sphere
10 - Gold plated radiation shader
11 - Radiation transmission window (Si) of sensor

Before testing can commence, the radiometer head containing the Ulbricht sphere (commonly referred to as the radiometer) is calibrated in a special calibration oven. The calibration process can be time consuming, and is typically performed approximately once every six months or when switching to testing of a different heater type (e.g.: high intensity to tube heaters).

After the radiometer is properly calibrated, it is placed inside of a protective box on the test rig. Rigs can be manually or automatically controlled. The radiometer is moved underneath the heater in a grid pattern (typically 10 cm x 10 cm) as a minimum of 100 data points are collected by the radiometer. Heat output is received from the heater, and the radiometer produces a voltage reading. The grid pattern testing is performed on the entire heater, and the data output is compiled and processed using a series of mathematical equations. One such equation (shown below) from the Stefan-Boltzmann Law shows how radiant output can increase exponentially with relatively small temperature changes.

$$w = A\epsilon\sigma T^4, \text{ where}$$

w = Total radiant output
A = Area
ϵ = Emissive Value
σ = Stefan-Boltzmann constant
T = Absolute temperature

Other equations are performed to calculate the GRC, REV, etc. The data is saved and stored so that it can be referenced in the future.

Did You Know?

In order to help ensure data accuracy and repeatability between labs, around 20 Ulbricht spheres were manufactured in one batch by a single manufacturer specifically for radiant efficiency testing. It is important that published data is obtained from a rig utilizing one of the new spheres.

The Calibration Oven

The calibration oven in which the Ulbricht sphere is calibrated is based on the physics concept of blackbodies. A **blackbody** is an object or surface that absorbs all light energy that touches it rather than reflecting it. Placing the sphere in the oven and calibrating it several times at different temperatures helps to ensure the radiometer can properly interpret a heater's radiant output.

Net vs. Gross

European calculations tend to use **net** factors whereas North American calculations tend to use **gross** factors. This means that the same heater would seem to have a lower radiant efficiency percentage (reported as GRC) when using the North American standard vs. the European standards (reported as Radiation Value). Understanding this difference is important when approaching a global marketplace.

Frequently Asked Questions (FAQs)

Q: ***Does AHRI Standard 1330 impact other certifications?***

A: No. Product testing for certification purposes will continue to measure thermal efficiency only as per the ANSI standards.

Q: ***How did the industry determine that the old test rigs and radiometers were producing flawed data?***

A: Manufacturers performed "round robin" testing with the original test rigs and radiometers by sending the same heater to be tested on each of the separate rigs. What they found was a large deviation in test results between the rigs. Upon further testing by Physikalisch-Technische Bundesanstalt (PTB), the technical authority in Germany for metrology, the original radiometers were found to have been built inconsistently, leading to flawed results. Both ELVHIS and AHRI have published letters stating that tests performed on the original radiometers and rigs are subject to errors and should not be used for publishing radiant efficiency data.

Q: ***Is there a minimum required radiant efficiency?***

A: Currently, 1330 and other ANSI standards in North America do not specify a minimum radiant efficiency. It is possible that minimums will be added to standards and/or state, local, or provincial laws in the future.

Q: ***How do I find out the radiant efficiency of a manufacturer's products?***

A: Manufacturers may post radiant efficiency data in brochures, installation manuals, rating labels, specification sheets, websites, etc. It is important to remember that there is additional information that must be reported with an REV (refer to page 4) for each heater. Since there is not currently a certification program containing a public database of reported values, it is best to contact a manufacturer directly for this information. No means for addressing the 2018 sphere conformity have yet been provided, but this is a key data metric to consider.

Q: ***Are there any studies demonstrating the efficiency of infrared heaters?***

A: YES! In fact, multiple studies have tracked the fuel savings of infrared heaters when compared to traditional heating methods. ASHRAE Awarded Technical Paper Number 4643 states the average fuel savings measured with infrared heating is 23%. According to the *ASHRAE Handbook - Fundamentals*, a New York State report noted that, in some instances, up to 50% has been realized. It is even recommended that when heating with infrared, a reduction of 15-20% of required MBH is permissible.

Common Myths

Myth #1:
Compliance to 1330 is mandatory.

Fact #1:
Compliance is **voluntary**.

Myth #2:
An IF or REV can apply to a whole family or series of heaters.

Fact #2:
Each individual heater model must be tested as the overall heater size, BTU, and configuration, which will affect radiant output.

Myth #3:
A high IF or REV is equal to a superior heater.

Fact #3:
Radiant efficiency alone does not account for all the factors that contribute to the energy savings of an infrared heater. A heater's appropriateness for a particular application, heat loss of the space, desired comfort levels, etc. all contribute to choosing the heater that will be best suited for each situation. For example, if a heater is chosen simply because it has a high REV but has to run much more often than a shorter, hotter heater due to the desired comfort levels, the energy-saving benefits of the higher efficiency unit are lost.

Myth #4:
IF or REV can be used to compare infrared heaters to other heating types.

Fact #4:
Remember: make sure you are comparing apples to apples. REV is not to be used to compare infrared heaters, of equal size and value, to any other heating type.

Glossary

AHRI: Air Conditioning, Heating, and Refrigeration Institute. A leading Authority in the development of Standard 1330. Visit www.ahrinet.org for more information.

Gross Radiant Coefficient (GRC): Heat emitted by the appliance through the radiation reference plane divided by the gross heat input of the test gases. Effectively, GRC is a percentage value of the radiant output emission of an appliance.

Infrared Factor (IF): A performance rating value predicated upon the GRC of a heater. Defined in Standard 1330-2015 for use in North America, this table simply cross references the GRC to a factored score of 7-15.

Radiant Emission Value (REV): A performance rating value predicated upon the GRC of a heater. Defined in Standard 1330-2018 to replace IF, an REV is calculated by inputting the GRC into a specific formula.

Seasonal Efficiency (SE): In the context of radiant heaters, this term is used by European manufacturers to describe total heat energy output, but with the inclusion of stated radiant energy performance values.

Basic Model Group (BMG): A selection of specific model heating equipment, produced by manufacturers, for round-robin testing in accordance with testing protocol defined in Standard 1330-2015.

Ulbricht Sphere: Also called a radiometer, the Ulbricht sphere is located inside the radiometer head attached to a testing rig. It measures incoming irradiance and outputs it as a voltage signal that can be used to determine the radiant energy emitted by an appliance.

American National Standards Institute (ANSI): A private, non-profit organization that helps to develop and publish voluntary U.S. standards and corresponding assessment programs.

European Leading Association of Radiant Gas Heater Manufacturers (ELVHIS): A non-profit organization of European Industry leaders created to represent the interests of its members to authorities including the European Commission and the European Parliament.

Summary

Radiant efficiency testing was created for the purpose of accurately measuring one of the four efficiency types and using the data collected to compare one infrared heater to another. At its core, it is a marketing tool aimed at providing another way for consumers to choose a product that best suits their particular needs. However, radiant efficiency is only one piece of the puzzle and is not all-encompassing. In order to have a truly efficient heating system, the selection of the appropriate heaters must be done by considering the myriad of design factors beyond just radiant efficiency, and by applying those factors correctly.

Ultimately, the Industry's goal for radiant efficiency is to push the bar of infrared heater quality - to make heaters that are even *more* efficient than those already manufactured today. While radiant efficiency testing is not perfect, the road ahead is promising as new technologies are continually developed and introduced, and it is only a matter of time before the next generation of infrared heaters emerges.

Look to the leaders in infrared for trusted and factual communication on AHRI 1330. Use caution on products claiming to be 1330 certified or with blanket IR factors or the like.

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