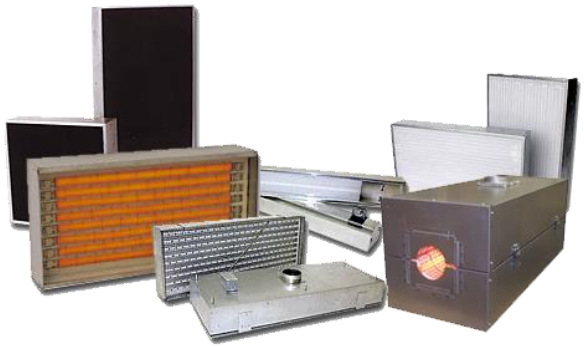
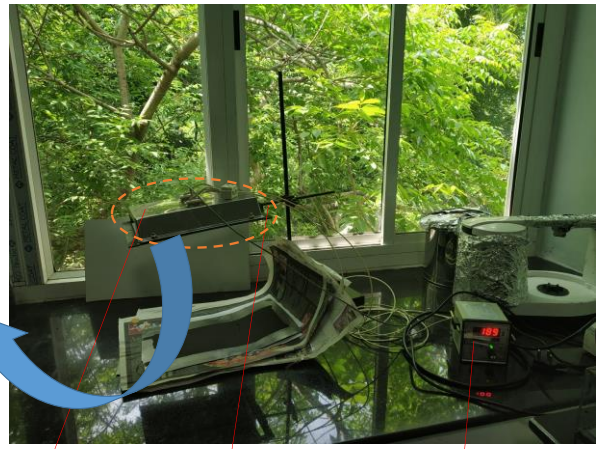
Instrumental Technique: IR wave/heater



IR heater



Md Rabiul Islam
15-12-2018

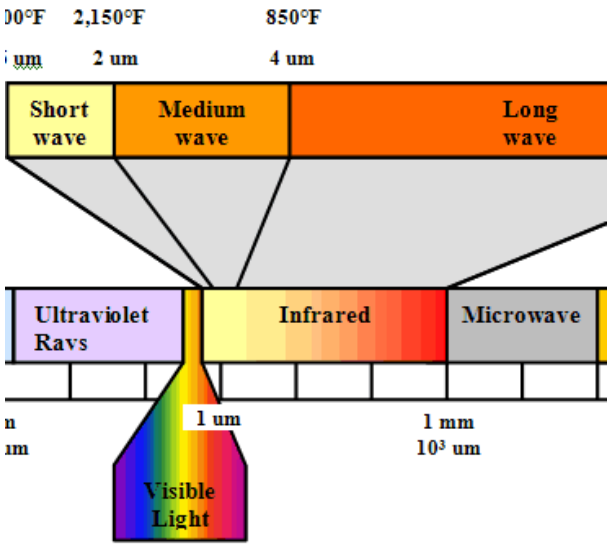
What is infrared technology?

What Exactly is Infrared Heat?

Infrared radiation is electromagnetic radiation which is generated in a hot **source**(quartz lamp, quartz tube, or metal rod) by vibration and rotation of molecules.

The electromagnetic spectra within infrared wavelengths can be divided into three parts: long waves (4 um–1 mm), medium waves (2–4 um) and short waves (0.7–2 um). The short waves appear when temperatures are above 1000 ºC; the long waves appear below 400ºC and medium waves between these temperatures.

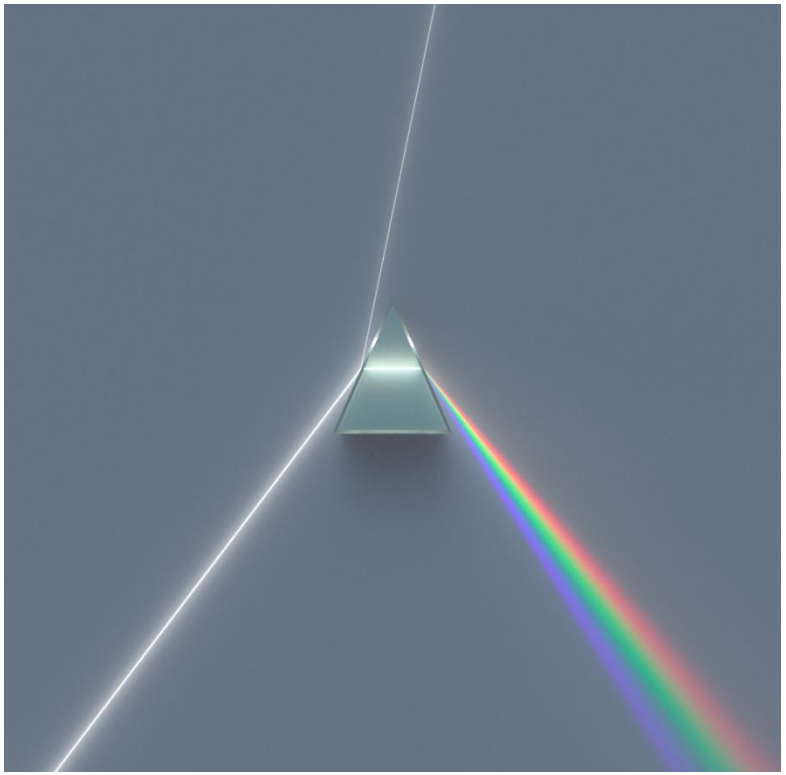
The useful range of wavelengths for infrared heating applications fall within the range of **0.7 um to 1 mm** on the electromagnetic spectrum and are termed short-wave, medium-wave or long-wave. **The medium to long range wavelengths are most advantageous to industrial applications since almost all materials to be heated or dried provide maximum absorption in the 2-4 um region**. Energy from an infrared heat source that also emits light (short-wave) will typically emit 80% of its energy around the 1mm wavelength, where as the ceramic infrared heater emits 80% of its energy around the 3 mm wavelength..



History

Discovered by William Herschel, a German born British musician and self-taught astronomer in 1800.

- He split sunlight using prism into a spectrum of visible light.
- He placed a thermometer just outside of the red end of color spectrum and there was a large temperature increase.
- He noticed that the temperature was high even if there was no light. This meant invisible rays were also emitted.



http://upload.wikimedia.org/wikipedia/commons/0/0b/Dispersive_Prism_Illustration_by_Spigget.jpg

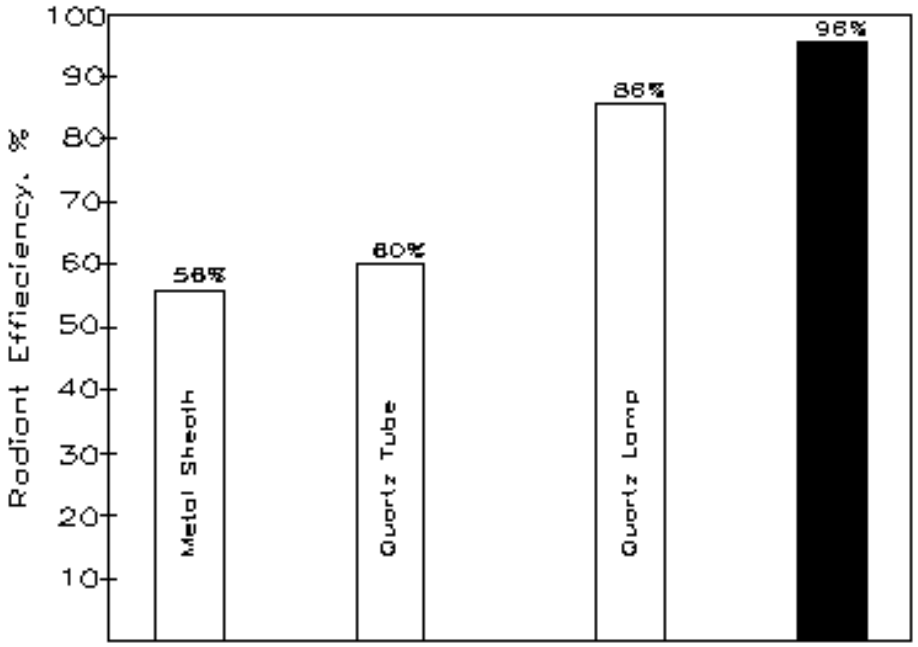
Types of Electric Infrared Heaters

Some of the types of industrial electric infrared heaters are ceramic elements, quartz tubes and lamps, quartz emitters, flat faced quartz, glass and metal panel heaters, metal sheathed tubular (calrods,) and open coil wire elements.

Comparing Infrared Heaters

Radiant Efficiency of Various Heating Elements

Ceramic Heaters are the highest at 96% efficient in converting electricity into infrared heat.
When comparing all the different types of heaters on efficiency, life expectancy, zoning ability and other factors, ceramic elements and quartz tubes are the preferred heaters, especially for complex sheet-fed thermoforming applications. Metal sheathed tubulars have a low initial cost but rate low in all areas except durability.



Applications of Infrared Waves

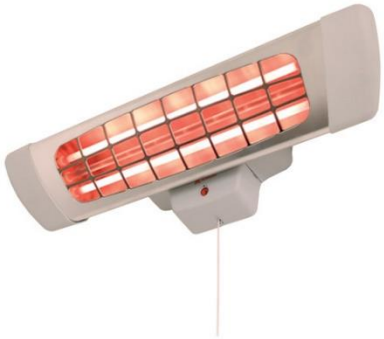
Astronomy: Infrared Telescopes

•Telescopes reveal information about the universe which the visible light technology cannot detect.

•Objects like the center of our galaxy, which we can't see in visible light because dust clouds are in the way can be "seen" by looking at the infrared light given off.

•Infrared Telescopes are typically placed in high and dry areas like the mountains of Hawaii.

http://s.ngeo.com/wpf/media-live/photos/000/116/cache/infrared-space-photography-comparison_11621_600x450.jpg



http://image.made-in-china.com/2f0j00vBMaORjhnicG/Infrared-Lamp-PAR38-for-Piglet.jpg

Heat

•The higher the temperature, the more rays. If the temperature is very high there will be rays of visible and infrared light.

•The biggest source of radiation heat is the sun. Its infrared radiation heats the earth's atmosphere.

•There are infrared heaters that are used to treat muscle injuries. The heat stimulates blood flow, speeding up the heating process.

Applications of Infrared Waves

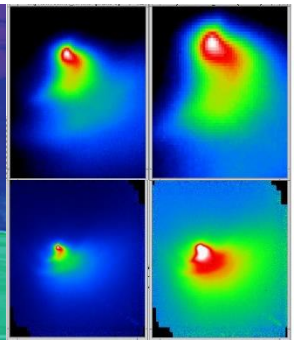
Photography: Thermography

•Thermography is used to determine the relative temperature of objects by detecting amounts of radiation it produces.

•Thermograms use light sensitive crystals to generate electrical information which converts into an image.

•Theromography is also a form of night vision.

http://www.goinfrared.com/images/gallery/F185_ir.jpg



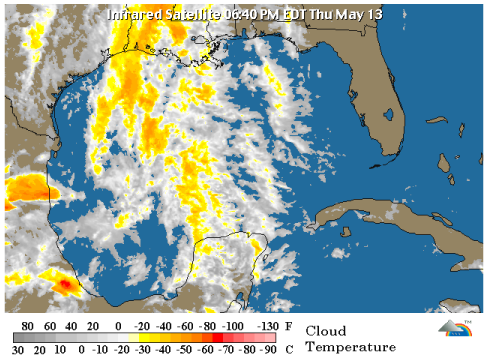
http://www2.jpl.nasa.gov/comet/gif/palomar1.jpg

Warfare: Heat Seeking Missiles

•Missiles are sent out to follow their targets based on their infrared radiation.

Meteorology: Weather Satellites

•Infrared technology is used to determine water temperature, map cloud patterns, and make weather predictions.



http://www.wunderground.com/data/640x480/2xg1_ir_anim.gif

Advantages of Infrared Heating

1) HEATS PEOPLE WITHOUT HEATING AIR Infrared travels through space and is absorbed by people and objects in its path. Infrared is not absorbed by the air. With convection heating the air itself is warmed and circulated ... however, warm air always rises to the highest point of a building. With Infrared heating, the warmth is directed and concentrated at the floor and people level where it is really needed.

2) ZONE CONTROL FLEXIBILITY Infrared heating is not dependent upon air movement like convection heat. Infrared energy is absorbed solely at the area it is directed. Therefore it is possible to divide any area into separate smaller zones and maintain a different comfort level in each zone. For example, Zone A, with a high concentration of people, could be maintained at a 70 degree comfort level while at the same time Zone B. a storage area, could be kept at 55 degrees or even turned off completely.

3) **REDUCED OPERATING COSTS** The previous statements are advantages in themselves; but combined they account for an energy/fuel savings of up to 50 percent. Actual savings will vary from building to building depending on factors such as insulation, ceiling height and type of construction.

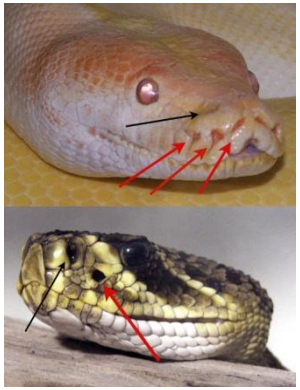
4) **INSTANT HEAT** Electric infrared produces virtually instant heat. There is no need to wait for heat buildup. Turn the heaters on just prior to heating requirements.
5**) NEGLIGIBLE MAINTENANCE** Electric infrared is strictly a resistance type heat. There are no moving parts or motors to wear out; no air filters or lubrication required. Periodic cleaning of the reflectors and heat source replacement is all that will be required.
6) **CLEAN Electric infrared**, like other forms of electric heating, is the cleanest method of heating. There are no by-products of combustion as with fossil fuel burning units. Electric infrared adds nothing to the air nor takes anything from it.
7) **SAFE**
•No open flame
•No moving parts to malfunction
•No fuel lines to leak
•No toxic by-products of combustion
8) EFFICIENT All Electric Heaters convert energy to heat at 100% efficiency.

Visibility

Animals

•Snakes in the pit viper family, like rattlesnakes, have sensory "pits" to seek prey.
•Snakes with two sensory pits have depth perception in the infrared.
•Flickering tongues of snakes are equipped with infrared heat sensors that help with finding warm bodies of their prey.

http://www.enjoyspace.com/uploads/editorial_cases/juin2009/herschel/infrared-spitzer.jpg

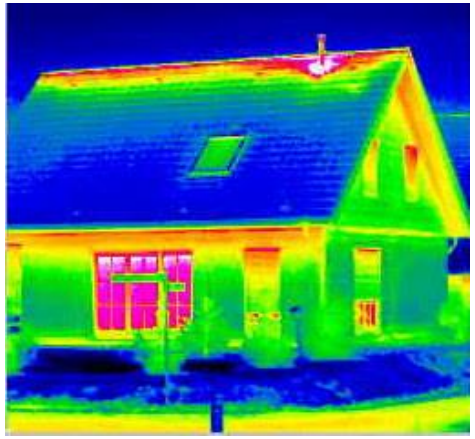


Red arrows point to the pits

http://upload.wikimedia.org/wikipedia/commons/thumb/4/47/The_Pit_Organs_of_Two_Different_Snakes.jpg/220px-The_Pit_Organs_of_Two_Different_Snakes.jpg

Technology

•Infrared can be seen through special cameras and film that detect the difference in temperature and assign different colors to them.



http://www.cognizance.org.in/main/pages/techexpo/Infrared.jpg

Humans

•Infrared is an invisible form of energy.
•Humans cannot see infrared light with the naked eye, but can feel it as heat.

Infrared Spectroscopy

• The study of how materials respond to exposure to infrared light.
  •Different materials absorb infrared differently. So molecular property we can see using IR source e.g. FT-IR

Other application:

IR heaters can satisfy a variety of heating requirements, including:

•Extremely high temperatures, limited largely by the maximum temperature of the emitter

•Fast response time, on the order of 1–2 seconds

•Temperature gradients, especially on material webs with high heat input

•Focused heated area relative to conductive and convective heating methods

•Non-contact, thereby not disturbing the product as conductive or convective heating methods do.

Thus, IR heaters are applied for many purposes including:

•Heating systems

•Curing of coatings

•Plastic shrinking

•Plastic heating prior to forming

•Plastic welding

•Glass & metal heat treating

•Cooking

•Warming suckling animals or captive animals in zoos or veterinary clinics

Precaution for using IR heater:

1) Wiring

Do not use copper wire or ring terminals when wiring radiant heaters. Backside temperatures can reach 500°F or higher in enclosed ovens. Use nickel or nickel clad wire of the proper size and derated for the ambient temperatures. Heaters should be properly grounded.

2) Vibration

Continuous vibration will break down the electrical insulation in most heater constructions. Consult Watlow. If the heaters are indexed back and forth, they must not slam to a stop when they reach the end of their travel. Dampers or shock absorbers should be used to bring the heaters to a gentle stop.

Maintenance

Infrared heaters are durable and can be easily maintained and cleaned. Since these heaters are used seasonally and often in industrial or commercial spaces that might produce dust and debris, regular maintenance by an experienced service professional is essential to the equipment's safe use and reliability. Like all gas burning products, infrared heaters have installation, operation and service procedures that must be followed to help ensure safety and reliable performance.

Is infrared dangerous?

It is nothing more than heat. On the other hand, you certainly would not want to place your hand on a hot stove, in which case IR radiation would be **dangerous.**

Thank You

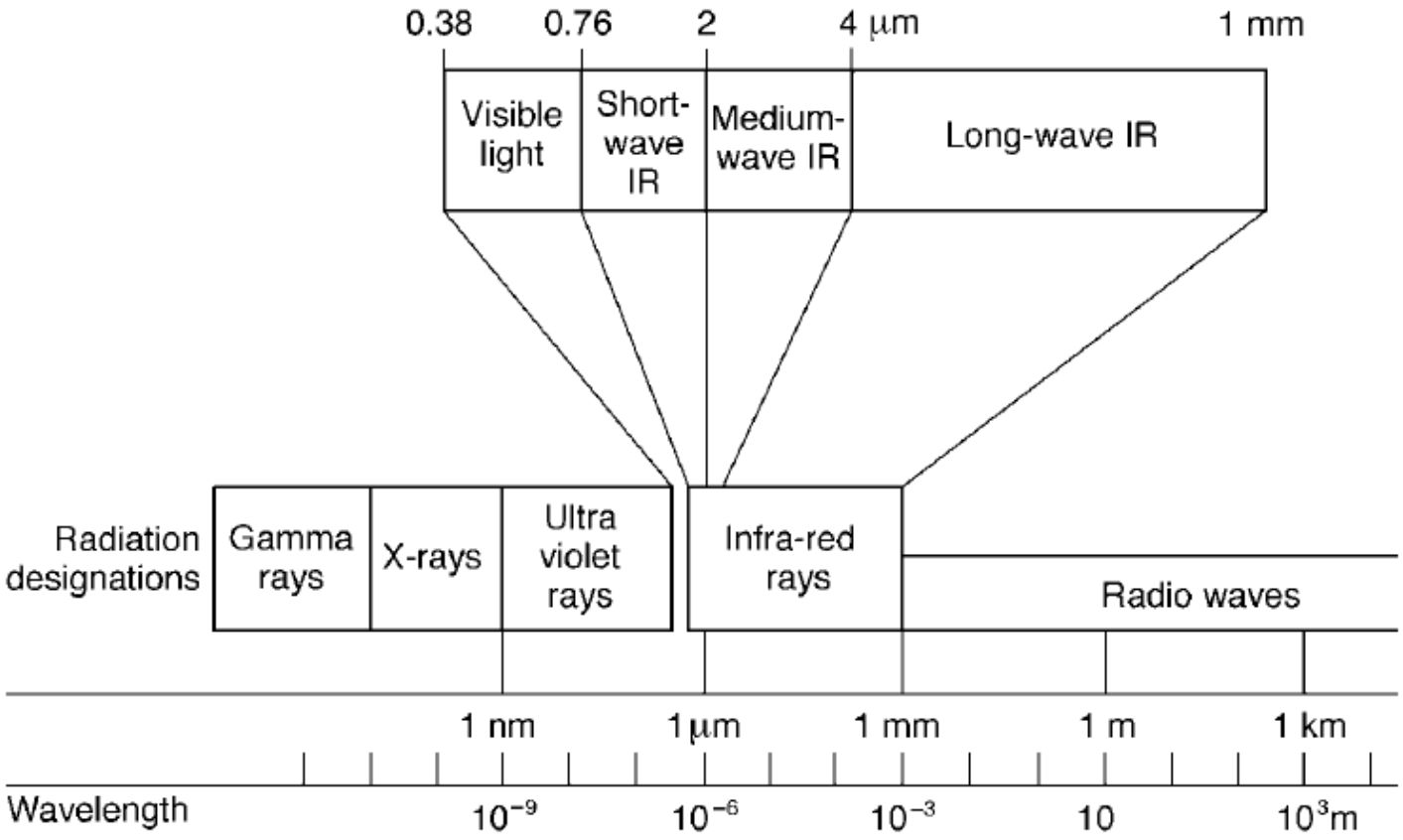


Fig. 11.1 The electromagnetic spectrum (from Anon. 1974).

IR sources[edit]

FTIR spectrometers are mostly used for measurements in the mid and near IR regions. For the mid-IR region, 2−25 μm (5000–400 cm^{-1}), the most common source is a silicon carbide element heated to about 1200 K. The output is similar to a blackbody. Shorter wavelengths of the near-IR, 1−2.5 μm (10000–4000 cm^{-1}), require a higher temperature source, typically a tungsten-halogen lamp. The long wavelength output of these is limited to about 5 μm (2000 cm^{-1}) by the absorption of the quartz envelope. For the far-IR, especially at wavelengths beyond 50 μm (200 cm^{-1}) a mercury discharge lamp gives higher output than a thermal source.[8]

One classification of infrared heaters is by the wavelength bands of infrared emission.

- Short wave or near infrared for the range from 780 nm to 1400 nm, these emitters are also named bright because still some visible light is emitted;
- Medium infrared for the range between 1400 nm and 3000 nm;
- Far infrared or dark emitters for everything above 3000 nm.

Infrared heaters are commonly used in infrared modules (or emitter banks) combining several heaters to achieve larger heated areas.
Infrared heaters are usually classified by the wavelength they emit:
Near infrared (NIR) or short-wave infrared heaters operate at high filament temperatures above 1800 °C and when arranged in a field reach high power densities of some hundreds of kW/m^2. Their peak wavelength is well below the absorption spectrum for water, making them unsuitable for many drying applications. They are well suited for heating of silica where a deep penetration is needed.
Medium-wave and carbon (CIR) infrared heaters operate at filament temperatures of around 1000 °C. They reach maximum power densities of up to 60 kW/m^2 (medium-wave) and 150 kW/m^2 (CIR).
Far infrared emitters (FIR) are typically used in the so-called low-temperature far infrared saunas. These constitute only the higher and more expensive range of the market of infrared sauna. Instead of using carbon, quartz or high watt ceramic emitters, which emit near and medium infrared radiation, heat and light, far infrared emitters use low watt ceramic plates that remain cold, while still emitting far infrared radiation.
The relationship between temperature and peak wavelength is expressed by Wien's displacement law.

Metal wire element[edit]

Metal wire heating elements first appeared in the 1920s. These elements consist of wire made from chromel. Chromel is made from nickel and chrome and it is also known as nichrome. This wire was then coiled into a spiral and wrapped around a ceramic body. When heated to high temperatures it forms a protective layer of chromium-oxide which protects the wire from burning and corrosion, this also causes the element to glow.[5]

Heat lamps[edit]

A heat lamp is an incandescent light bulb that is used for the principal purpose of creating heat. The spectrum of black body radiation emitted by the lamp is shifted to produce more infrared light. Many heat lamps include a red filter to minimize the amount of visible light emitted. Heat lamps often include an internal reflector.

Heat lamps are commonly used in shower and bathrooms to warm bathers and in food-preparation areas of restaurants to keep food warm before serving. They are also commonly used for animal husbandry. Lights used for poultry are often called brooding lamps. Aside from young birds, other types of animals which can benefit from heat lamps include reptiles, amphibians, insects, arachnids, and the young of some mammals.

The sockets used for heat lamps are usually ceramic because plastic sockets can melt or burn when exposed to the large amount of waste heat produced by the lamps, especially when operated in the "base up" position. The shroud or hood of the lamp is generally metal. There may be a wire guard over the front of the shroud, to prevent touching the hot surface of the bulb.

Ordinary household white incandescent bulbs can also be used as heat lamps, but red and blue bulbs are sold for use in brood lamps and reptile lamps. 250-watt heat lamps are commonly packaged in the "R40" (5" reflector lamp) form factor with an intermediate screw base.

Heat lamps can be used as a medical treatment to provide dry heat when other treatments are ineffective or impractical.[6]

Ceramic infrared heat systems[edit]

Ceramic infrared heating elements are used in a diverse range of industrial processes where long wave infrared radiation is required. Their useful wavelength range is 2–10 μm. They are often used in the area of animal/pet healthcare too. The ceramic infrared heaters (emitters) are manufactured with three basic emitter faces: trough (concave), flat, and bulb or Edison screw element for normal installation via an E27 ceramic lamp holder.

Far-infrared[edit]

This heating technology is used in some expensive infrared saunas. It is also found in space heaters. These heaters use low watt density ceramic emitters (usually fairly big panels) which emit long wave infrared radiation. Because the heating elements are at a relatively low temperature, far-infrared heaters do not give emissions and smell from dust, dirt, formaldehyde, toxic fumes from paint-coating, etc. This has made this type of space heating very popular among people with severe allergies and multiple chemical sensitivity in Europe. Because far infrared technology does not heat the air of the room directly, it is important to maximize the exposure of available surfaces which then re-emit the warmth to provide an even all round ambient warmth.

Quartz heat lamps[edit]

Clear quartz element

Halogen lamps are incandescent lamps filled with highly pressurized inert gas. This gas is combined with a small amount of halogen gas (bromine or iodine) which causes tungsten atoms to regenerate by lessening the evaporation of the filament. This leads to a much longer life of halogen lamps than other incandescent lamps. Due to the high pressure and temperature halogen lamps produce, they are relatively small and made out of quartz glass because it has a higher melting point than standard glass. Common uses for halogen lamps are table top heaters.[7][8]

Quartz infrared heating elements emit medium wave infrared energy and are particularly effective in systems where rapid heater response is required. Tubular infrared lamps in quartz bulbs produce infrared radiation in wavelengths of 1.5–8 µm. The enclosed filament operates at around 2500 K, producing more shorter-wavelength radiation than open wire-coil sources. Developed in the 1950s at General Electric, these lamps produce about 100 W/in (4 W/mm) and can be combined to radiate 500 watts per square foot (5400 W/m^2). To achieve even higher power densities, halogen lamps were used. Quartz infrared lamps are used in highly polished reflectors to direct radiation in a uniform and concentrated pattern.

Quartz heat lamps are used in food processing, chemical processing, paint drying, and thawing of frozen materials. They can also be used for comfort heating in cold areas, in incubators, and in other applications for heating, drying, and baking. During development of space re-entry vehicles, banks of quartz infrared lamps were used to test heat shield materials at power densities as high as 28 kilowatts/square foot (300 kW/m^2).[9]

Most common designs consist of either a satin milky-white quartz glass tube or clear quartz with an electrically resistant element, usually a tungsten wire, or a thin coil of iron-chromium-aluminum alloy. The atmospheric air is removed and filled with inert gases such as nitrogen and argon then sealed. In quartz halogen lamps, a small amount of halogen gas is added to prolong the heater's operational life.

Much of the infrared and visible energy released is caused by the direct heating of the quartz material, 97% of the near infrared is absorbed by the silica quartz glass tube causing the temperature of the tube wall to increase, this causes the silicon-oxygen bond to radiate far infrared rays.[*citation needed*] Quartz glass heating elements were originally designed for lighting applications, but when a lamp is at full power less than 5% of the emitted energy is in the visible spectrum

Quartz tungsten[edit]

Quartz heater

Quartz tungsten infrared heaters emit medium wave energy reaching operating temperatures of up to 1500 °C (medium wave) and 2600 °C(short wave). They reach operating temperature within seconds. Peak wavelength emissions of approximately 1.6 μm (medium wave infrared) and 1 μm (short wave infrared).

Carbon heater[edit]

Carbon Fiber Heater

Carbon heaters use a carbon fiber heating element capable of producing long, medium and short wave far infrared heat. They need to be accurately specified for the spaces to be heated.[11]

Gas-fired[edit]

There are two basic types of infrared radiant heaters.

•Luminous or high intensity

•Radiant tube heaters

Radiant tube gas-fired heaters used for industrial and commercial building space heating burn natural gas or propane to heat a steel emitter tube. Gas passing through a control valve flows through a cup burner or a venturi. The combustion product gases heat the emitter tube. As the tube heats, radiant energy from the tube strikes floors and other objects in the area, warming them. This form of heating maintains warmth even when a large volume of cold air is suddenly introduced, such as in maintenance garages. They cannot however, combat a cold draught.

The efficiency of an infrared heater is a rating of the total energy consumed by the heater compared to the amount of infrared energy generated. While there will always be some amount of convective heat generated through the process, any introduction of air motion across the heater will reduce its infrared conversion efficiency. With new untarnished reflectors, radiant tubes have a downward radiant efficiency of about 60%. (The other 40% comprises unrecoverable upwards radiant and convective losses, and flue losses.)

Health effects[edit]

In addition to the dangers of touching the hot bulb or element, high-intensity short-wave infrared radiation may cause indirect thermal burns when the skin is exposed for too long or the heater is positioned too close to the subject. Individuals exposed to large amounts of infrared radiation (like glass blowers and arc welders) over an extended period of time may develop depigmentation of the iris and opacity of the aqueous humor, so exposure should be moderated.[12]

Types of Infrared Heaters

Low-Intensity Tube Heaters

Sometimes referred to as positive/negative pressure heaters, tube heaters, radiant tube heaters, or tube brooders.

➤ Hot exhaust gases travel through the inside of the tube resulting in tube surface temperatures up to 1100°F, which is considered low-intensity.

➤ Generally these heaters are vented and have the capability to use fresh air for combustion.

➤ Low intensity tube heaters are a popular choice for total building heat.

Patio Heaters

Sometimes referred to as suspended, radiant, mushroom style, free-standing, or floor-mounted patio heaters.

➤ Ceramic or stainless steel radiant emitters.

➤ Designed to heat a concentrated outdoor area.

➤ Permanent or portable products that may be deck mounted or suspended.

High-Intensity Ceramic Heaters

Sometimes referred to as luminous heaters, radiant ceramic heaters, or plaque heaters.

➤ Combustion takes place on a ceramic tile surface with surface temperatures of approximately 1800°F. Higher temperatures produced by this equipment means they must have a higher clearance to combustibles.

➤ Direct-fired operation releases products of combustion into a properly ventilated heated space.

➤ Often used in high air change applications.

➤ Affords great flexibility for total building heating, area heating, or spot heating applications.

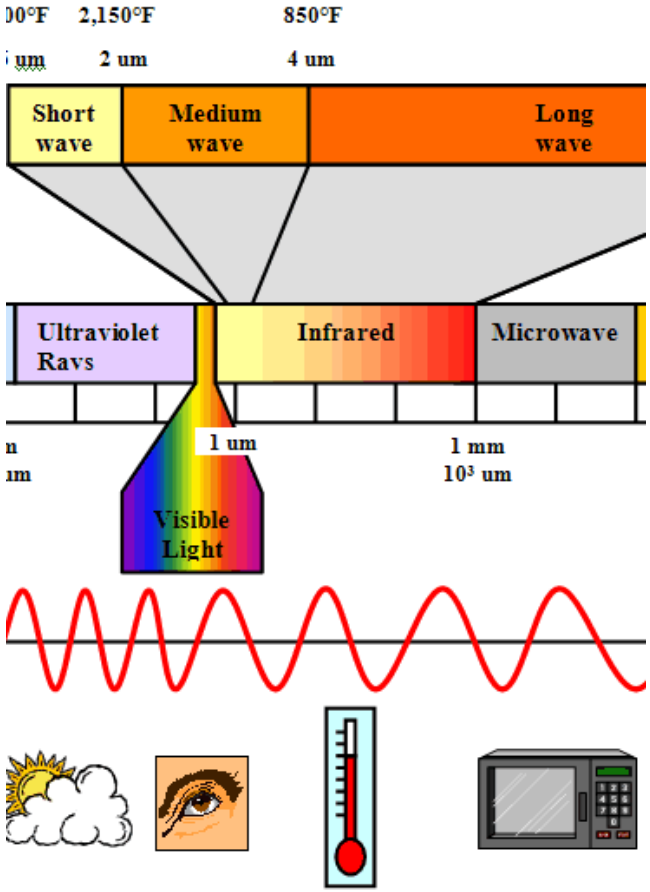
Construction Heaters

Sometimes referred to as spot heaters, portable construction heaters and tank top heaters.Heat turns a ceramicor stainless steel emitter red hot.

➤ Used in spot heat applications and/or as warm up stations.

➤ While commonly used in outdoor applications, units may also be used in industrial applications or temporarily used inside buildings under construction or repair. At no time shall construction heaters be used in residential applications.

Characteristics of Infrared Waves



http://www.astrobio.net/blog/wp-content/uploads/2009/11/114284main_em_spectrum5002-450x285.jpg

- Infrared waves lie between microwaves and visible waves.

- Wavelength: 7.5×10^{-7} to 0.001 Meters

Shorter Wavelengths

- "Near infrared" light is not hot at all.
- Waves are about the size of microscopic cells.

Longer Wavelengths

- Waves are able pass through clouds of dust, water vapor.
- Waves are thermal.
- Waves are about the size of a pin head.

- Frequency: 8×10^{10} to 4×10^{14} Hertz

The following chart is designed to help with the process of heater selection when asking these specific questions:

	Ceramic Emitters	Metal Tubulars	Quartz Tubes	Quartz Lamps
How quickly must the heater reach maximum temperature? Response time:	Slow	Slow	Fast	Instantly
How does the lifespan of the heater relate to cost of a replacement, and this cost relate to the cost of the end product? Lifespan:	Excellent	Excellent	Good	Good
Does the application require a durable heater? Durability:	Good	Excellent	Poor	Poor
How does the efficiency of the heater relate to the cost, and this cost relate to the end product? Infrared efficiency:	96%	56%	61%	85%
Would the application benefit from zone control? Controllability with an integral thermocouple:	Yes	No	No	No
What is the maximum temperature required to heat the material? Maximum operating temperature:	1292 °F (700 °C)	1400 °F (760 °C)	1600 °F (871 °C)	2500 °F (1371 °C)
Compare the cost of the heater with the budget of the application. Cost:	Medium	Low	Medium	High
Installation and replacement time must be considered as part of the "cost" of operation. Installation:	Moderate	Easy	Moderate	Difficult
What wavelength does the material require? Wavelength:	Medium	Medium	Short	Short
Which heater will work most effectively with the emissivity level of the material? Emissivity of material:	High	High	Low	Low