INFRARED TECHNOLOGY

INTRODUCTION

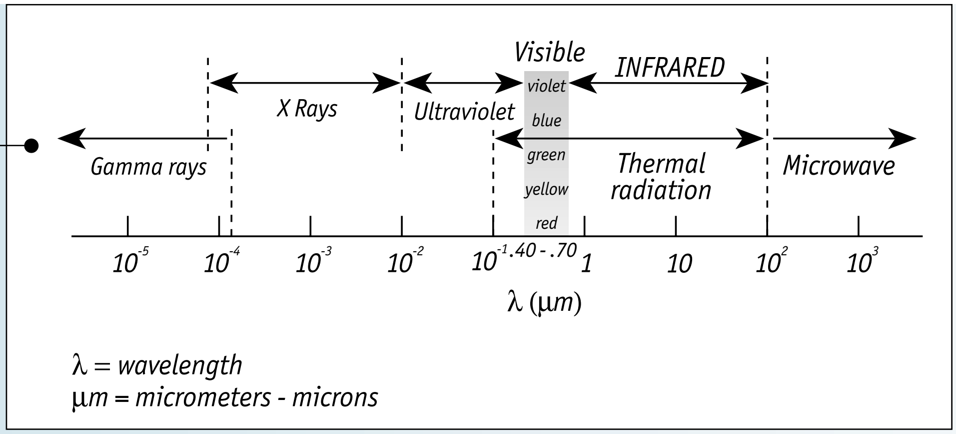
Ciscan has been an industry leader in the research and development of infrared products since 1964. Our patented CATA-DYNE™ technology has proven ideal for many industrial applications including explosion-proof heating, high temperature paint drying, powder coat curing, adhesive activation, pipeline heating, ground thawing, and many other industrial processes.

In recent years, interest in infrared technology for industrial applications has increased tremendously because of the distinct advantages it provides. Even with the complex principles surrounding it, the opportunities for utilizing infrared technology for new and unique applications are numerous.

BASICS OF INFRARED ENERGY

Infrared energy is a form of electro-magnetic energy with the following properties:

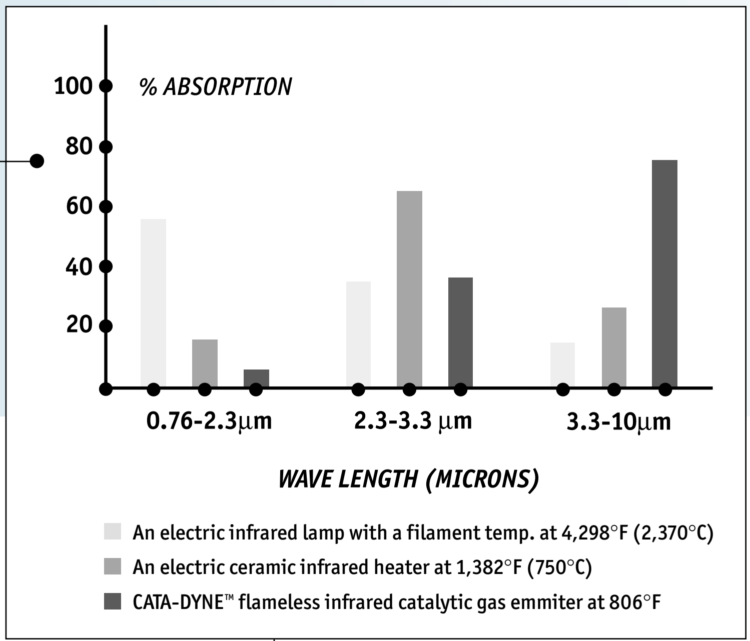
- ***Waves travel in straight lines at 3.0 x 10 ^{8} meters (186,000 miles) per second***
- ***It is either transmitted, absorbed or reflected by matter***
- ***It can be focused or dispersed by lenses or prisms***



Directed at a specific object, infrared rays will flood the area around it with radiant energy the same way a light bulb floods the area around it with light. In fact, infrared energy has many of the same properties as light, except it has longer wavelengths.

ELECTROMAGNETIC SPECTRUM

All bodies with temperatures above absolute zero emit and absorb electromagnetic waves. The Electromagnetic Spectrum consists of gamma rays, x-rays, ultraviolet, visible light, infrared, microwaves, and radio waves. The difference between these types of radiation is their wavelength or frequency. As you move along the Electromagnetic Spectrum, wavelength increases and frequency decreases from gamma rays to radio waves.



Infrared radiation is located between the "visible" and "microwave" sections of the spectrum. This means that infrared waves have wavelengths that are longer than "visible" but shorter than "microwaves".

The radiant energy (or wavelength) of an infrared element depends on its temperature: the higher the temperature, the shorter the peak wavelength. All infrared heaters/emitters fall into one of three categories on the IR portion of the spectrum. This is determined by the maximum wavelength generated by the emitter:

- ***Short Wave - 0.76 - 2.3 μm*** — ***Poor absorption on most materials***
- ***Medium Wave - 2.3 - 3.3 μm*** — ***Fair absorption on most materials***
- ***Long Wave - 3.3 - 10 μm*** — ***Excellent absorption on most materials***

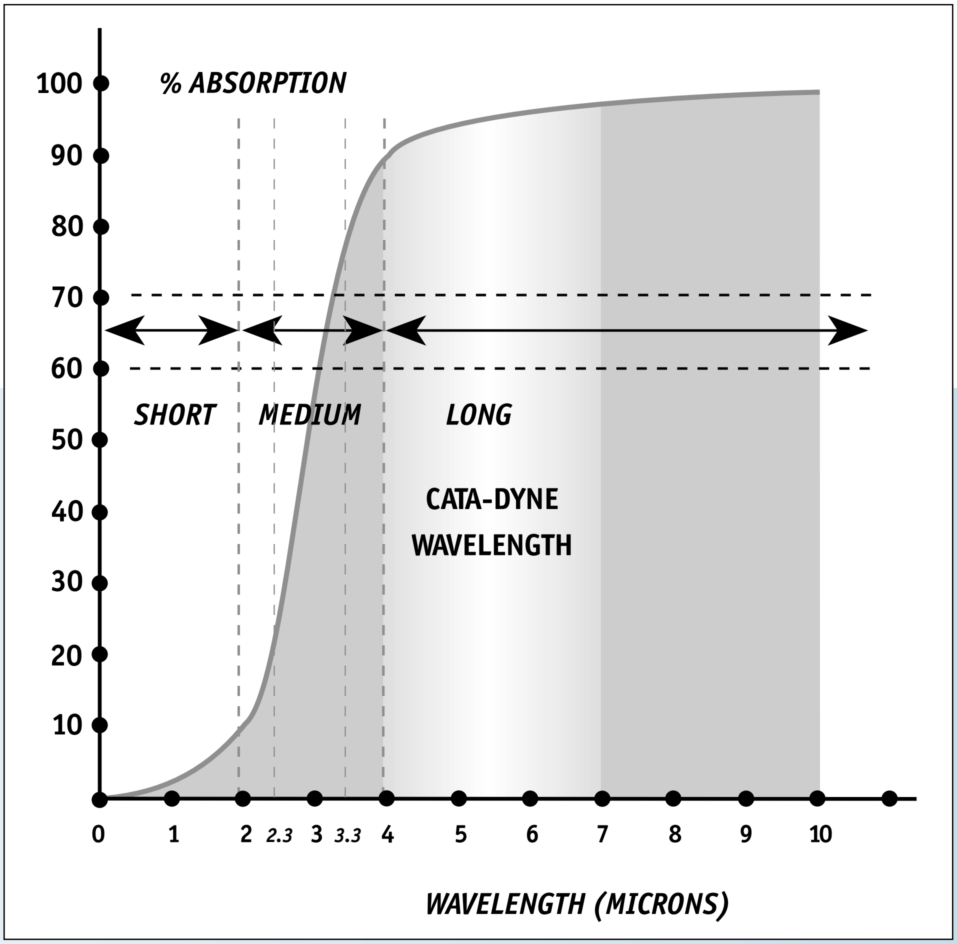
Each type has distinct characteristics as well as specific amounts of energy. For example, the shortest infrared waves are closest to visible light. Longer infrared waves are furthest away and are more readily absorbed by most materials.

INFRARED ABSORPTION

The wavelengths of radiant energy absorbed is an inherent property of every substance. Each substance has an infrared absorption spectrum that is characteristic to it alone. These have been determined for many substances and can be found in an atlas of infrared absorption spectra.

Depending on the substance in question, certain wavelengths will be absorbed, some to a considerable extent, others less, and some very little or not at all. The ratio of radiant energy absorbed to the amount of energy striking an object is called its emissivity. An object that absorbs all of the radiant energy striking it has an emissivity of "one" and is called a blackbody. A perfectly reflective object reflects all the energy striking it (like a mirror) and has an emissivity of "zero". All other substrates have an emissivity somewhere between one and zero.

The amount of radiant energy converted to heat after it is absorbed by a substance is generally accepted to be dependent upon the wavelength. When infrared rays are absorbed by an object, changes take place within the object's molecules.



Normally, these molecules oscillate within a certain frequency and amplitude, but when infrared rays are absorbed, the molecule's oscillating state changes. It rises to a higher energy level before returning to normal, and it is while it is in the "returning" stage that it releases energy in the form of heat. It is this heat that dries and cures coatings in industrial applications.

This type of heat transfer is called radiation, and it transmits energy to the receiver without heating the air. (Similar to the way a microwave oven cooks your meal without heating the air around it).

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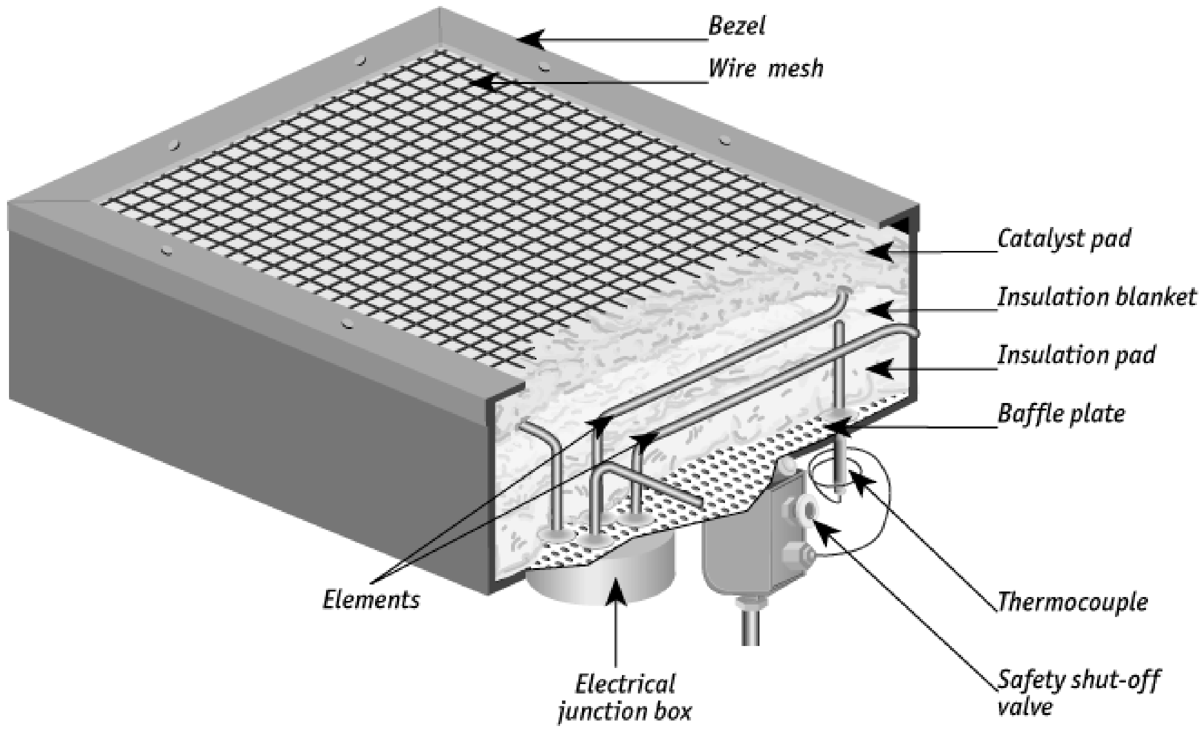
INFRARED EMITTERS

There are many different kinds of infrared emitters on the market today, and they differ in energy source categories and radiation wavelengths. Each type has its own properties, and can offer specific advantages or disadvantages, depending on its application. Therefore, selecting the most suitable emitter for your particular application is of primary importance.

For example, most organic materials, including waterborne, solvent and powder coatings, absorb maximum infrared energy above 3 microns. CATA-DYNE infrared emitters produce maximum wavelengths between 4-7 microns, and have proven ideal for many curing applications. Testing has shown that long wavelength emitters are usually more effective for curing coatings than short or medium wavelength emitters because shorter wavelengths tend to penetrate the coating to heat the substrate directly, thereby reducing efficiency and damaging pre-treated surfaces by overheating them.



CATA-DYNE™ OPERATING PRINCIPLES

The heart of the CATA-DYNE heater is its unique patented catalyst beds. These beds are constructed of ceramic fibers and contain chemicals which form the basis of the exothermic catalytic reaction. The first action to occur is the preheating of the catalyst bed by an integrally incorporated low watt density electrical element.

The temperature of the catalyst bed is raised to an activity temperature of 250° F (120° C). Once this temperature is achieved, fuel enters the back of the CATA-DYNE emitter and is dispersed through the catalyst pad. At the same time, oxygen from the air is diffusing through the front of the emitter. Once the fuel and oxygen converge in the pad, a catalytic reaction takes place resulting in flameless combustion and the creation of infrared energy. Once oxidation begins, the catalytic reaction will continue until either the fuel supply or the oxygen is eliminated.

The unique feature of the CATA-DYNE catalyst bed is the secondary group of chemicals which gives the CATA-DYNE its explosion-proof characteristics. Our technology governs the rate of reaction of the oxidation process in the primary catalyst and ensures that the catalyst does not become an ignition point — even when the heater is operating in a potentially explosive atmosphere.

GAS INFRARED ADVANTAGES

Catalytic gas infrared ovens convert approximately 90% of their energy to heat. Generally, these systems cure powder and paint much faster and more efficiently than convection ovens because infrared waves are directly absorbed by the coating. This results in curing times of up to 80% faster than convection ovens.

Infrared ovens have smaller floor space requirements when compared to convection oven systems. In addition, infrared systems do not require the high air flows commonly found in convection ovens, resulting in minimal dust contamination. Compared to convection systems, catalytic gas infrared emitters offer a number of advantages:

- ***Ovens are smaller, therefore require less floor space***
- ***Faster curing times***
- ***Better quality finish***
- ***Higher energy efficiency***
- ***More suitable for multiple zones***
- ***Products heat up faster and cool down quicker***
- ***Faster line speeds***

RECIRCULATED AIR ENHANCEMENT

At Ciscan, many of our CATA-DYNE infrared oven systems are designed with a recirculating air system to enhance the infrared heat. This is an effective and cost-efficient alternative for curing products that have complex part shapes and/or hard to reach internal surfaces.

CURING PAINT
AND POWDER COATINGS

Infrared energy has proven to be an ideal solution for curing many powder and paint coatings because these coatings readily absorb this type of radiation. As a result of the absorption, powder/paint molecules vibrate more vigorously, generating frictional heat internally. It is this reaction that effectively heats and cures the coating.

In basic terms, infrared curing is the process of converting the applied powder or paint to a dry film. Powder is cured by a chemical reaction called crosslinking - a three dimensional polymerization. This process adds additional strength and protection to the powder coating. Wet coatings are cured by solvent evaporation, chemical reaction, or crosslinking in the case of two component materials.

To explain this process, infrared energy is directly transferred from the emitter to the coating. It travels in straight lines (similar to light rays) and is absorbed by the coating film. Excess infrared energy is transferred to the substrate and diffused to other areas through conductivity.

The major difference between infrared and convection ovens is that infrared ovens efficiently transfer energy directly to the coating, whereas in convection ovens the substrate behaves as a heat sink; a convection oven must heat up the substrate mass first and then transfer the energy from the substrate to the coating.

IR energy provides a faster, smoother cure. Because infrared energy affects the coating, long wave infrared transfer eliminates premature skinning-over of the coating surface — a problem often associated with convection ovens. Since air is not a good infrared absorber, energy is not wasted heating the exhaust air.