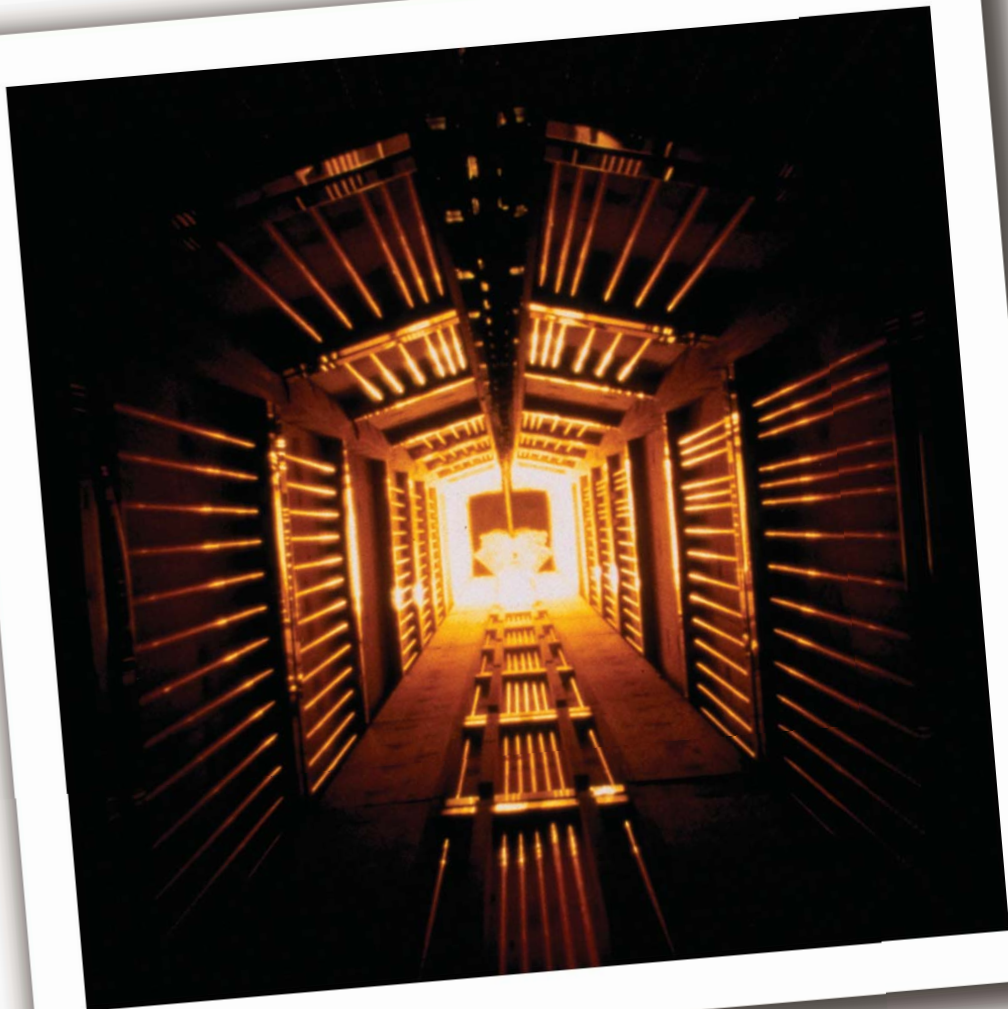


# Infrared Process Heating Handbook for Industrial Applications

First Edition



A Publication of the Infrared Equipment Division (IRED)  
Industrial Heating Equipment Association (IHEA)

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# Infrared Process Heating Handbook

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## Introduction

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The membership of the Infrared Equipment Division (IRED) of the Industrial Heating and Equipment Association (IHEA) is proud to present this first edition handbook as a quick introduction to the many applications of infrared heating in industrial processes today. Infrared (IR) process heating was first developed in the 1930s for curing the paint on automobile bodies. Since then, IR heating has been successfully applied to hundreds of different process heating applications, such as curing metal finishes and protective coatings; fusing thermo set and thermoplastic powder coatings; forming molded plastics; bonding adhesives and metals; drying papers, inks, and fabrics; and processing foods.

When you understand the infrared basics, you can comfortably discuss improvements in your process heating systems with the infrared equipment manufacturers and the utility companies that help promote their applications. This teamwork approach to process improvement will ensure a well designed application of infrared heating. The “Infrared Applications” section of this handbook has been designed so that you can look for processes similar to your needs.

A list of IRED members can be found on the IHEA website along with additional information about IHEA and IRED: [www.IHEA.org](http://www.IHEA.org). We invite your questions and inquiries. Thanks for taking time to review our handbook. We hope you will find it informative and useful as you explore the world of infrared heating.

## Disclaimer

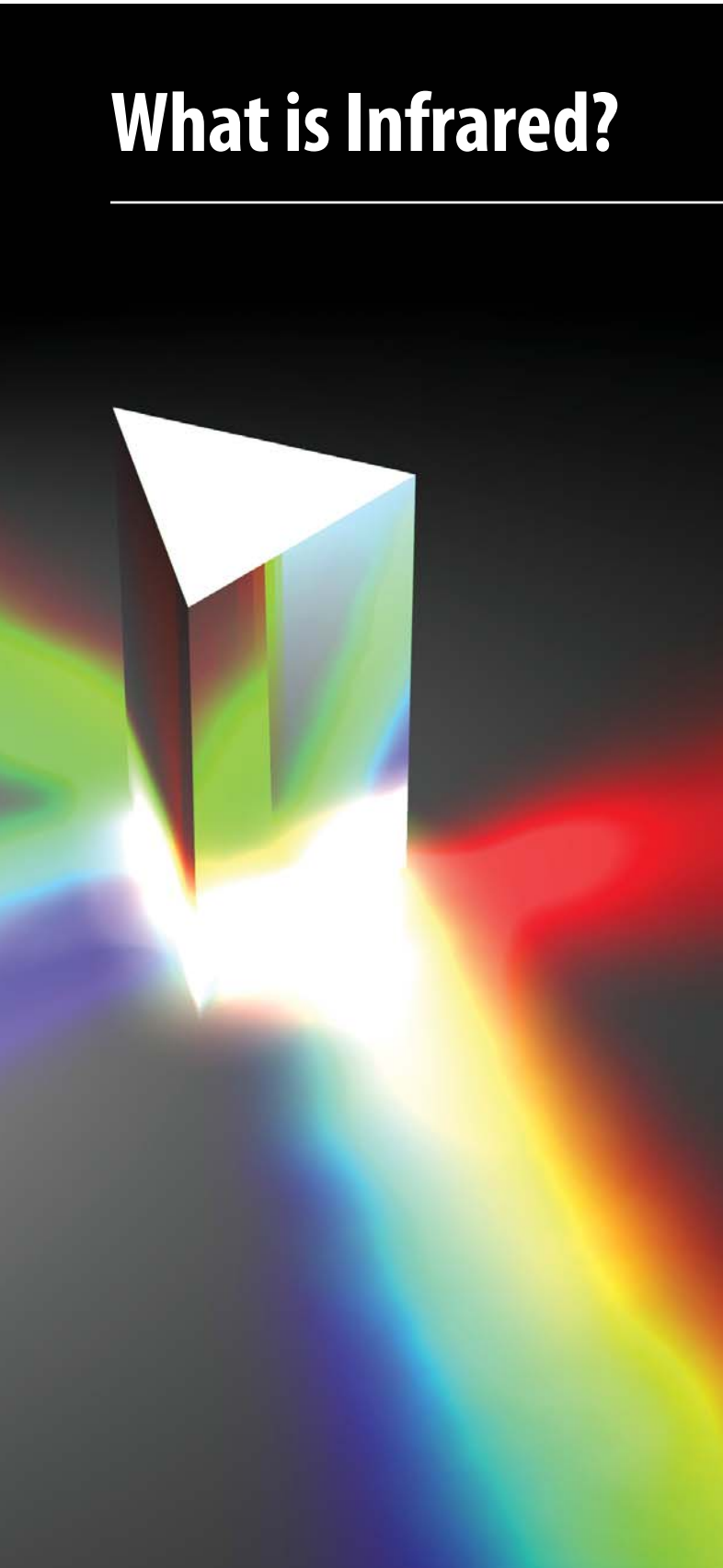
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# What is Infrared?

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## WHAT IS INFRARED?

Comparing infrared with other methods of heat transfer can help you understand the infrared heating method. All heat is transferred by one of three methods:

- Conduction heating is the transfer of heat by physical contact between a heat source and the object to be heated.
- Convection heating is the transfer of heat using heated air as the transfer medium between the heat source and the object to be heated
- Radiation heating is the transfer of heat using invisible electromagnetic waves of energy from a heat source to the object to be heated.

Infrared is one of several ways to accomplish radiation heating along with ultraviolet, microwave, radio frequency, and induction. This handbook is only concerned with infrared heating and therefore we will use the terms radiant and infrared interchangeably.

One of the first forms of heat transfer each of us encounter is radiant. The sun beam that warms us is radiant heat. Radiant energy is not absorbed by air and does not actually become heat until an object absorbs it. While radiant energy does generally show up as heat, this is because it vibrates and rotates the atoms in the absorbing object, which results in a rise in the temperature of that object. However, radiant energy may also show up as a chemical change in the absorbing object (polymerization) or evaporation of water or solvents (drying).

## HOW IS INFRARED ENERGY PRODUCED?

Every object with a temperature above absolute zero emits infrared energy. This is because there exists in every object a measured amount of heat, so each object has the ability to radiate heat from itself. The object that radiates heat is called the emitting source (see figures on page 11), and the object to which it radiates heat, having a lesser amount of heat content, is called the target.

There are several physical laws that explain the properties of infrared radiation. The Stefan-Boltzman law of radiation states that as the temperature of a heat source is increased, the radiant output increases to the fourth power of its temperature. The conduction and convection components increase only in direct proportion with the temperature change. In other words, as the temperature of a heat source is increased, a much greater percentage of the total energy output is converted into radiant energy.

For the purpose of this handbook, we will address only those sources of infrared heat used in industrial heating applications. This generally means looking at emitting source temperatures in a range from 500 degrees Fahrenheit to 4,200 degrees Fahrenheit. (These temperatures are not to be confused with oven set point temperatures or

any other temperature requirements related to your product or process). As the emitting source temperature moves from 500 degrees to 4,200 degrees, the radiant output increases with a corresponding increase in peak wavelength. At each temperature point, there is a unique set of wavelength characteristics and peak wavelengths. An additional set of physical laws helps us to understand this relationship. By applying Planck's Law and Wien's Law, it is possible to calculate both the distribution of wavelength (spectral distribution) and the peak wavelengths of a given emitter, operating at a given temperature.

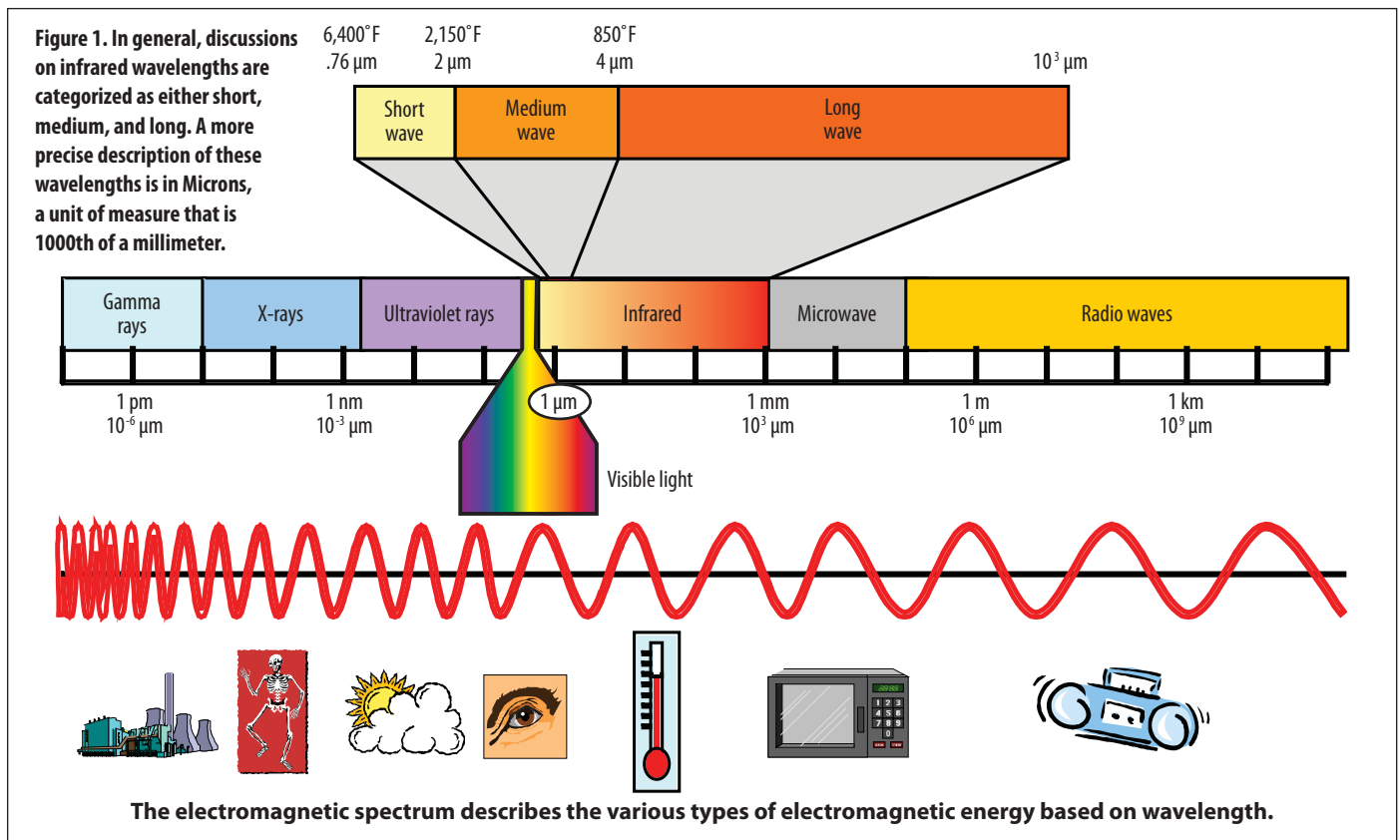
The Stefan-Boltzman law relates the total amount of radiation emitted by an object to its temperature:

$$E = \sigma T^4$$

E = total amount of radiation emitted by an object per square meter

$\sigma$  is the Stefan-Boltzman constant =  $5.67 \times 10^{-8}$  Watts  $m^{-2}$   $K^{-4}$

T is the temperature of the object in  $K^\circ$





# What is Infrared?

## CHARACTERISTICS OF INFRARED ENERGY

Infrared heating is the transfer of thermal energy in the form of electromagnetic waves. It is related to visible light and other forms of electromagnetic energy shown in the electromagnetic spectrum (Figure 1, page 7). The infrared portion of this spectrum has been expanded to show that we can further divide infrared into long wave, medium wave and short wave.

By describing an infrared emitter as long wave, medium wave, or short wave, one can quickly determine the approximate temperature range an emitter is operating, as well as an approximate wavelength range measured in microns. Since the temperature of a source determines the wavelength characteristics of that source, the peak wavelength of a given emitter can be controlled only by changing the temperature of the emitter. All emitters can be adjusted for wavelength simply by adjusting their temperatures. However, not all emitters are designed to attain the complete spectrum of long, medium, and short wavelength.

There are some heat processing applications that are rather forgiving and will work with long, medium, or short wavelength infrared. On the other hand there are applications where it's important to choose an emitter so that its wavelength distribution and peak wavelength match the absorption, reflection and transmission characteristics of the coating or substrate. In these processes, choosing the right wavelength can make a tremendous difference in the overall efficiency and speed of the process, and may even determine whether or not the process works.

### Spectral Characteristics of Infrared

There are many factors that determine whether a substrate or coating has the ability to heat up when infrared energy is applied. First, understand that infrared energy

is absorbed, reflected or transmitted. For an object to be heated by infrared, some portion of the infrared energy from the emitting source must be absorbed. Once the energy is absorbed, the heat generated at the surface travels into the material by conduction.

The factors that describe the behavior of infrared are referred to as Spectral Characteristics. They explain to what degree infrared is reflected or absorbed in different materials. For all heating applications, matching the infrared output with the absorption spectrum will produce a heating process that is effective as well as energy efficient.

Approximate Emissivity of Metals			
Materials	Nominal	Polished	Oxidized
Aluminum		0.05	0.15
Brass		0.09	0.60
Cast Iron		0.21	0.70
Copper		0.02	0.60
Galvanized		0.02	0.60
Glass	0.94		
Stainless Steel		0.17	0.85
Steel		0.11	0.75
Rubber	0.86-0.95		
Wood	0.95		

The relationship between reflectivity and absorption is called **emissivity**. An emissivity scale with a numeric value from 0 to 1 has already been developed for all materials. A perfect absorber of infrared will have an emissivity value of 1 and is called a black body absorber. On the other end of the scale, a perfect reflector of infrared will have an emissivity value of 0. Although emissivity can vary with thickness, temperature, and wavelength, emis-

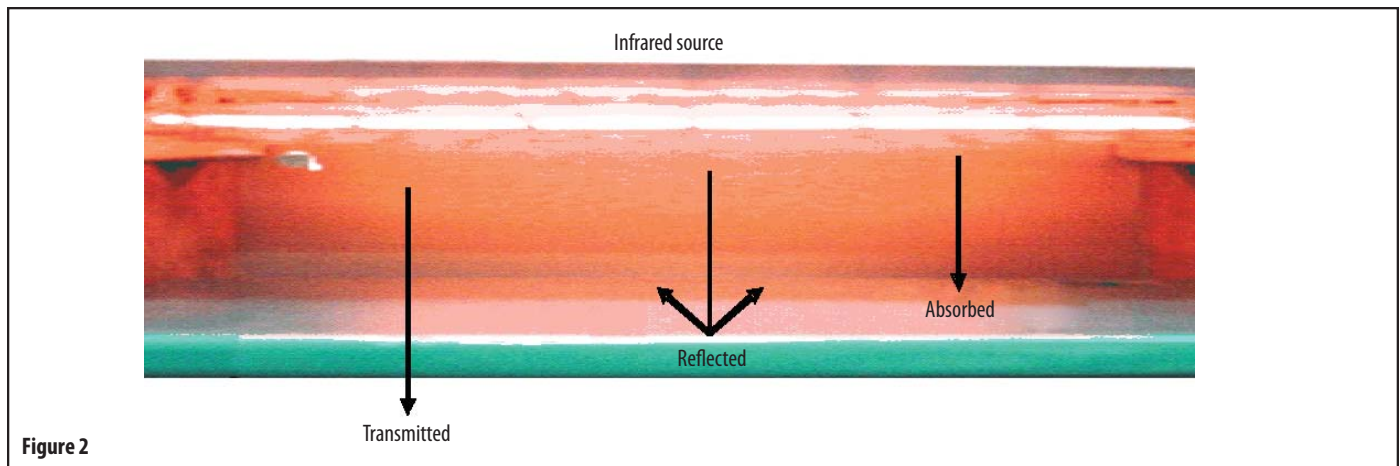


Figure 2

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sivity is generally approximated with a constant value. You can find this value for many common materials in emissivity tables found in many engineering handbooks. A short list of emissivity values for some of the more common materials used in industrial processes is provided in the table on page 8.

Another consideration for infrared applications is color sensitivity, which describes the role color has in determining the absorption and reflectivity of infrared. This can be a concern with highly reflective colors such as silver or chrome, and must be considered with some white and yellow colors since they tend to discolor if overheated. Color

sensitivity is more pronounced with higher emitter temperatures. For this reason, shortwave emitters are the most color sensitive and long wavelength emitters are the least color sensitive. In many industrial processes, the color sensitivity with medium and long wavelength emitters produces such a small change in temperature that it is negligible.

Variations in absorption can even be different for the same color depending on whether the finish is gloss, satin, or flat. When applying infrared heat, give consideration to color as well as surface characteristics of the material. For best results, a range of heater temperatures should be tested to obtain the best absorption characteristics on suspect colors.

# Equipment Sources of Infrared

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## **EQUIPMENT SOURCES OF INFRARED**

Industrial infrared processing equipment is either fueled by electricity, natural gas or propane. Regardless of which fuel source is utilized, the terms used to describe infrared heating remain the same. In every case, the sole factor that determines whether an emitter emits long, medium, or short wave is the **temperature of the emitter itself**. If the operating temperature of an electrically heated emitter is the same as that of a gas fired emitter, then both emitters will emit the same wavelengths of infrared energy.

Radiant output should not be confused with Btu output. The Btu output of an emitter is based on the amount of energy consumed to produce the temperature of the emitter. For example, a 100,000 Btu rated infrared emitter operating at 1,400 degrees Fahrenheit will contain more energy than a 37,000 Btu rated emitter operating at 1,400 degrees Fahrenheit. However, both emitters will have the same wavelength because the source temperature is the same.

**It is crucial to remember that the radiant output of an emitter depends on its temperature, not on its composition.**

### **Electric**

For electrically heated emitters, the hot surface is metal, usually tungsten, nickel-chromium or iron-chromium-aluminum that generates heat due to the resistance the material has to the flow of electricity applied. The metal may be in a variety of shapes, such as thin filaments, ribbons, rods, bars, or screens.

Electric infrared emitters can produce source temperature ranging from hundreds of degrees Fahrenheit to 4,200 degrees Fahrenheit. For that reason, they have the ability to generate wavelengths in all three categories: short wave, medium wave, and long wave. The following voltages are common for electric emitters: 240v, 277v, 480v, and 600v.

**Electrically heated emitter sources: samples**



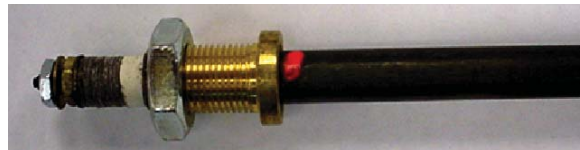
Robbon, surface mounted - resistance alloy



Tungsten in a quartz envelope



Embedded - resistance alloy



Metal sheath rod, nickel chrome spiral wire inside, protective metal sheathing outside.

**Figure 3**

**Natural Gas and Propane**

There are four major types of gas fueled infrared emitters:

- metal fiber matrix
- ceramic fiber matrix
- ceramic tile
- catalytic

Except for the catalytic type, heat is generated when pre-mixed gas and air are released through the porous material and burned at the surface. The burning gases heat the porous materials, which then emit infrared energy to the product. The surface temperature of the porous material, depending on the design of the emitter, operates in a range from 1,200 degrees Fahrenheit to as high as 2,000 degrees Fahrenheit. This temperature range puts these emitters in the medium wave category of infrared.

heater. When the gas and oxygen meet in the presence of the heated catalyst, an oxidation-reduction reaction occurs, generating heat. Once the catalytic reaction begins, it is self-sustaining and the electric preheat element is de-energized. The surface temperature of these emitters operates in a range from 450 degrees Fahrenheit to as high as 900 degrees Fahrenheit. This temperature range puts these emitters in the medium and long wave category of infrared. Since the maximum surface temperature is below the auto-ignition temperature of the fuel, there is no flame.

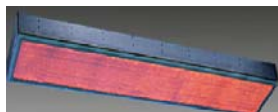
**Gas fuel emitters**



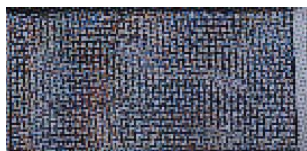
Metal fiber matrix



Ceramic tile



Ceramic fiber matrix

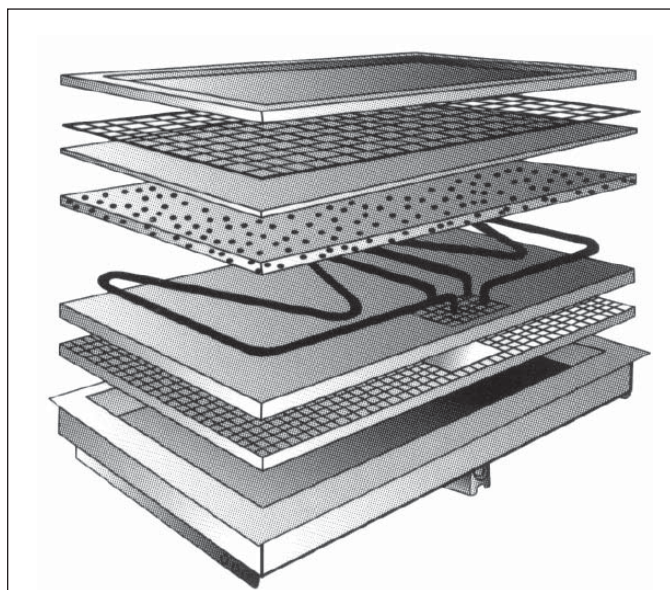


Catalytic

**Figure 4**

**Gas Catalytic**

With gas catalytic infrared emitters, unmixed fuel enters the back of the airtight heater pan and is dispersed through a catalyst pad which is preheated by a low wattage electric element. Oxygen from the surrounding air diffuses through the catalyst pad from the front of the



- Preheat catalyst by means of electric element
- Fuel enters emitter
- Fuel reacts with heated catalyst and atmospheric oxygen to produce heat energy
- Reaction becomes established
- Disconnect preheat elements
- Thermocouple or thermoswitch used to verify safe operation

**Figure 5**

**Catalytic emitters**

### HOW DOES INFRARED COMPARE TO CONVECTION?

Convection heating, particularly gas fired convection, is the most common type of oven in the United States for industrial process heating. In these ovens, natural gas (methane), or liquefied petroleum gas (a mixture of butane and propane) is burned to provide heat. Most gas convection ovens are direct-fired ovens, meaning the hot combustion gases come into direct contact with the product. In indirect fired ovens, combustion takes place in a special chamber and heat exchangers are used to heat the air, which then comes into contact with the product.

In most applications, infrared heating offers numerous advantages over convection heating including:

- Higher rate of heat transfer
- Higher efficiency
- Floor space savings
- Lower maintenance
- Faster response
- Greater control accuracy
- Ability to control temperature by zoning
- Lower capital expense and install cost

Infrared heating is more efficient than convection because a higher percentage of the input energy goes into the product rather than being lost to the surrounding air and lost up the flue. In addition, infrared ovens do not require long pre-production heat-up periods like convection ovens do. During these periods, a significant amount of energy is consumed without any product being produced.

The higher rate of heat transfer is evident in the following heat transfer equations:

	$Q = hA(T_p - T_a)$	$Q = \text{watts}$
Convection		$h = \text{coefficient of convection heat transfer}$
		$A = \text{area}$
		$T_p = \text{temperature of the product}$
Infrared	$Q = \sigma A(T_p^4 - T_e^4)$	$T_a = \text{temperature of the air}$
		$T_e = \text{temperature of the emitter}$
		$\sigma = \text{Stefan-Boltzman constant}$

Convection heat transfer is a function of the temperature difference to the first power whereas infrared heat transfer is proportional to the temperature difference to the fourth power. Because convection ovens have a lower heat transfer rate, the products

must be in the oven longer. The longer dwell time means more heat gets conducted into the part. When drying or curing coatings on the surface, the heat that gets conducted inside is wasted heat. Infrared's high heat transfer rate raises the surface to the required temperature more quickly. This allows for shorter dwell times with less heat conducted into the part. This is another reason why infrared is more efficient than convection.

When drying paint with a convection oven, it is sometimes necessary to slow down the process to avoid blistering the coating. Since convection heating can only dry the coating from the outside in, rapid drying sometimes forms a dry skin at the surface of the paint. As the inside of the paint dries, the evaporating solvent blisters up through the dried skin eventually popping and leaving a crater with a pin hole.

With infrared heating, some of the energy heats the surface of the paint, and some energy is transmitted through the coating which helps to drive solvents out of the inside of the paint before the formation of a dry skin at the surface.

The shorter dwell times with infrared heating can translate to a much smaller oven, which can save valuable floor space, capital cost, and installation cost.

### INFRARED PROCESS CONTROL

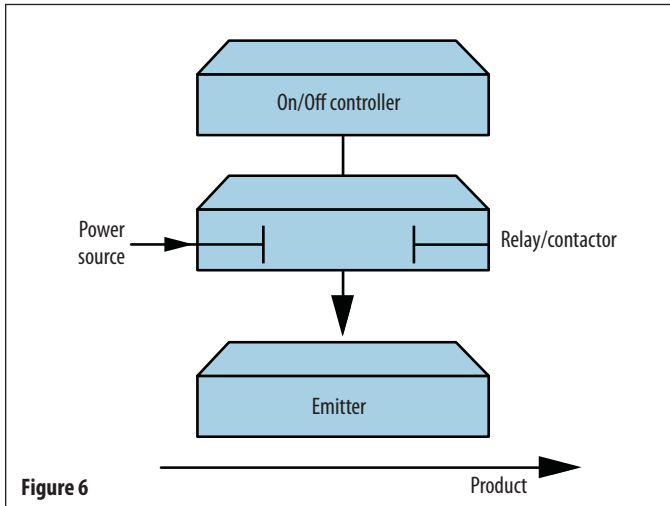
Controlling the heating process is one of the main advantages of using infrared. Whether you are using long, medium, or short-wave infrared, gas or electric energy sources; utilizing infrared's controllability to fine tune your process adds efficiency, higher production rates and better quality control.

#### Controlling Electric Infrared

There are two basic methods used to control the emitter output, On/Off Control and Variable Control.

#### On/Off Controllers

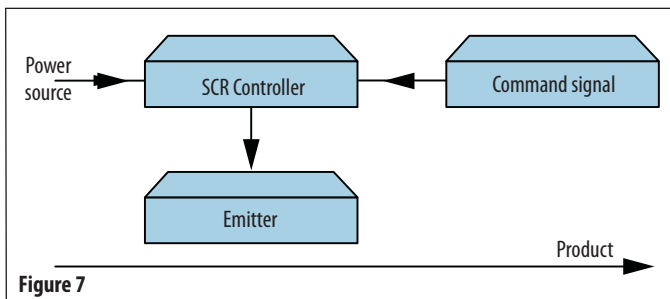
The basic concept of On/Off Control is to turn power on and off to the emitter rapidly. The net effect will give an average emitter power output less than full output. By varying the percentage of time the power is on, the emitter can be adjusted from zero to full power. This method is typically used with long and medium wave emitters. Most long and medium wave emitters/elements have higher mass, which causes them to react more slowly to produce an even output. The use of On/Off Control is the least expensive and simplest method to control emitter output.



### Variable Controllers (SCR Controllers)

Variable Controllers are electronic devices that vary the voltage being supplied to the emitter. The device actually blocks the current for a certain amount of time; this amount of time is adjusted by varying the command signal to the silicon controlled rectifier (SCR). This method allows for infinite emitter output from zero to full power. Also, this device can be connected to temperature controllers, tachometers or pyrometers to provide "Closed-Loop Control," which can automatically adjust emitter output to maintain set point temperatures. A temperature controller provides set point options. It can either be set to manual mode, where a fixed temperature set point is maintained until physically changed, or set to a Proportional Integral Derivative (PID) mode for automatic temperature modulation.

This method is typically used for medium and short wave applications. Variable Controllers are more expensive, but offer many advantages for high volume production lines requiring optimum controlling of product temperature profile.

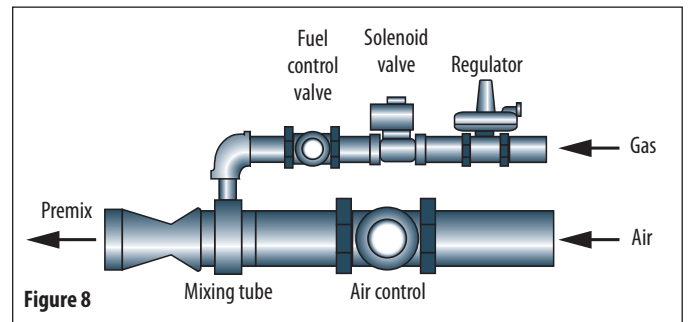


### Controlling Gas Infrared

To assure optimum time and/or temperature control of a specific process, there is a complete range of control options – from simple on/off switches to advanced Programmable Logic Controller (PLC) systems. As with electric infrared systems,

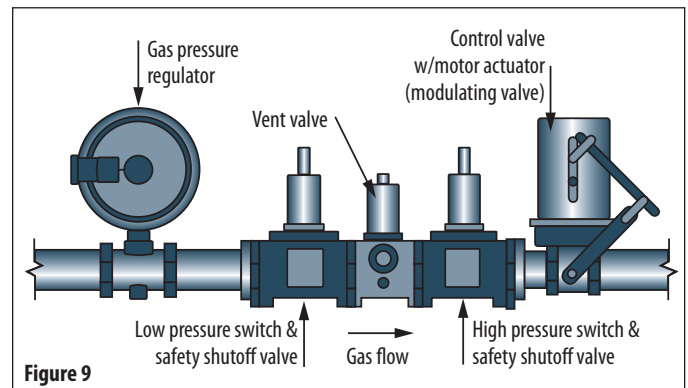
gas IR systems may also employ a temperature controller that provides set point options. It can either be set to manual mode, where a fixed temperature set point is maintained until physically changed – or set to a Proportional Integral Derivative (PID) mode for automatic temperature modulation.

As mentioned previously, the metal fiber matrix, ceramic fiber matrix, and ceramic tile types of emitters burn fuel gas that is premixed with air. Figure 8, below illustrates a common premix-piping layout.



The air and fuel control valves are typically "butterfly valves". The emitter temperature is adjusted by modulating one or both of these valves. Typically, electric positioning motors are used to drive the valve linkage open or closed. All gas-fueled emitters require a specific minimum amount of fuel in order to sustain the combustion or oxidation-reduction reaction. The minimum output level is referred to as "low fire". The valve linkages are set to provide the proper amount of fuel over the range from low fire to high fire.

Catalytic emitters do not need an air/gas mixer since the oxygen they need is provided by ambient air diffusing into the surface of the heater. There is typically a modulating gas valve on a pre-assembled gas train that responds to the temperature controller set point (see Figure 9). This modulating valve will provide a total range of gas adjustment from low fire to high fire, resulting in substantial heater intensity variances to meet optimum process temperature.

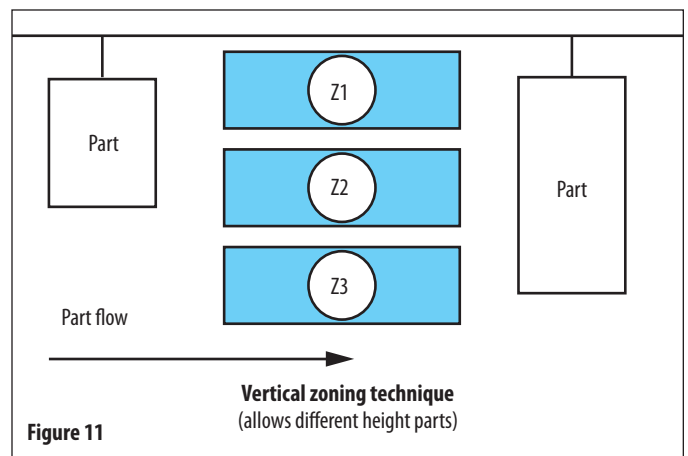
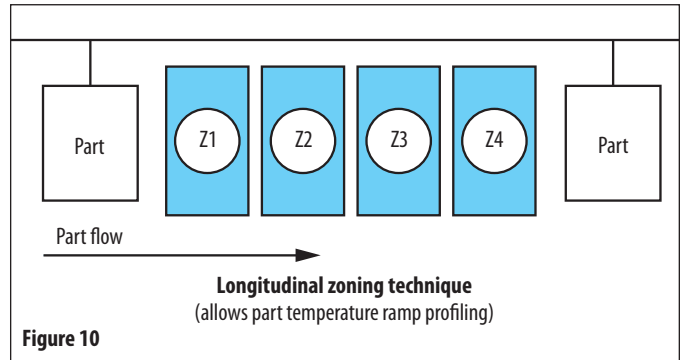


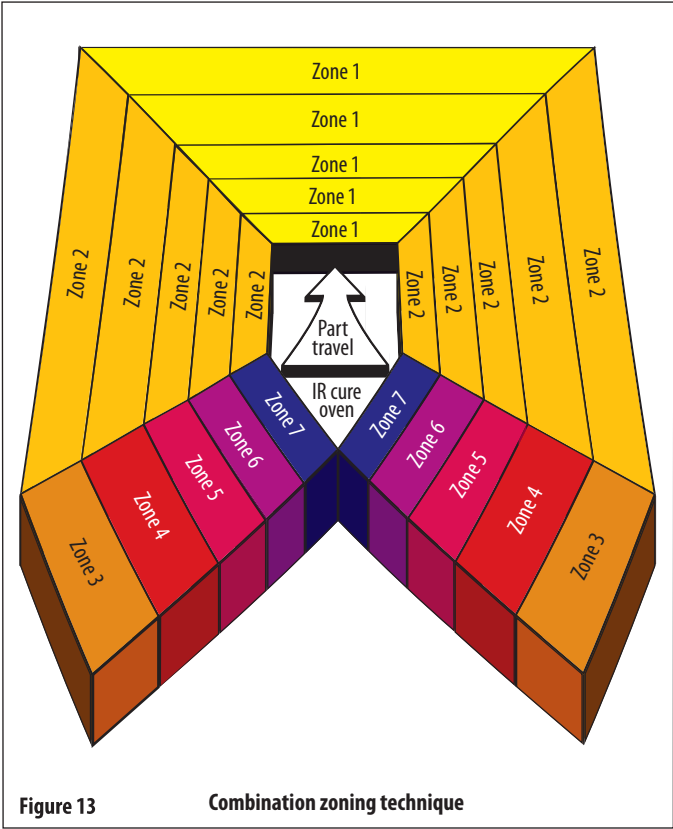
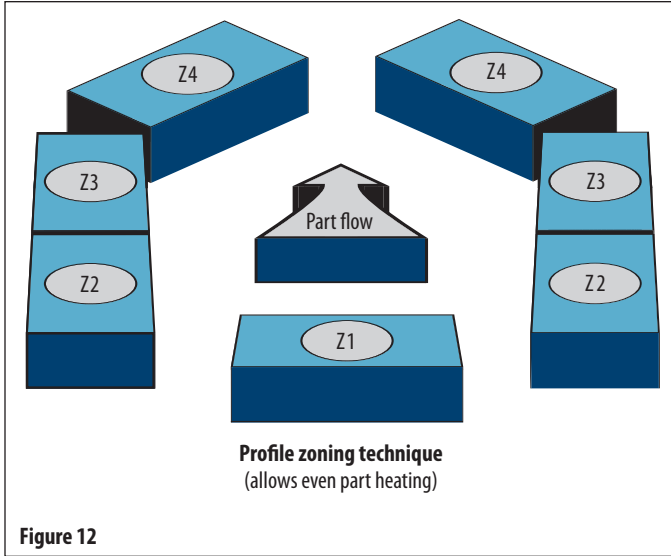
A further review and understanding of the many different types of gas controls available for industrial process control can be found in IHEA's Combustion Technology Manual, Fifth Edition, 1994, published by the Combustion Division of IHEA.

### Zone Temperature Control

In addition to process speed and floor space requirements, another advantage of infrared over convection heating is the ability to zone heat. A good example of how zoning can improve the effectiveness of a process is to look at water dry-off. In some drying applications, when the product first enters the dryer, it can withstand high temperatures because of the amount of water in it. As the product moves through the oven or dryer and contains less moisture, it may be necessary to reduce the temperature in subsequent zones to allow further drying without overheating and damaging the product.

In other applications, if a coating needs to be cured, sometimes a quick blast of high temperature is all that is needed to initiate the cross-linking process. In other cases, multiple zones of different heat intensity can be the best approach. The sample zoning configurations which follow (Figures 10, 11, 12 & 13) show the flexibility of an infrared oven.







# Infrared Process Heating Applications

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## **Infrared Process Heating Applications**

Since the 1930s, infrared heating has come a long way from its first application of curing paint on automobiles. Today's industrial processes are being fine-tuned with infrared heating leading the way. This section will conclude our handbook by presenting examples of applications for some of the many industrial segments that infrared currently serves. Because it would be impossible to include all the applications for infrared within each particular segment, we have chosen to select some of the most common industrial segments.

If you see an application described in this section that fits your need or is close to addressing your process requirements, we recommend that you contact an IRED member as the next step to evaluating the specifics of your application. We also suggest that you contact your utility supplier. Most utilities have energy experts available to assist you with virtually any energy related needs. A few utilities even have technology centers in partnership with the IRED membership. These centers are great places to see firsthand the benefits of infrared heating, as well as provide limited testing of your application. Final testing, engineering, and price quoting will be provided by the infrared equipment manufacturer.

We hope this handbook has been effective in presenting the benefits of infrared technologies. If you have any questions or inquiries, please refer to our IRED membership list on the IHEA website: [www.IHEA.org](http://www.IHEA.org). Thank you for considering infrared technologies for your next process improvement project.

<b>PRODUCT</b>	Appliance manufacturer
<b>MATERIAL</b>	Appliance parts requiring silk screened inks
<b>PROBLEM</b>	About a decade ago, an appliance manufacturer evaluated an electric infrared (IR) system to use when curing silk screen inks and for pre-heating parts prior to applying the decals. The quality – compared to the gas infrared, that at that time was the industry standard – just didn't stand up.

**Background**

The IRED member knew that the technology had improved over the past 10 years – and had the facts to back up their belief. Late 1998, when the facility was contemplating ways to reduce floor space and increase production on its silk screening process, engineers didn't seriously consider the electric infrared option - - until, that is, the IRED member showed them that a lot has changed over the last decade.

**The Solution**

With company officials receptive, a coating consultant from Electric Power Research Institute (EPRI) Center for Material Fabrication (CMF) was brought in for technical support. Several options were evaluated before deciding that an electric IR oven was the best device for preheating and curing the parts. Among the advantages are energy savings, quick cycle times, more precise controls, and safer and cleaner workplace environment.

**The Results**

After two months, with the new infrared process being used to cure silk screen inks and for pre-heating parts prior to applying decals on range control panels, he said the results are even better than expected. "In fact, we are so happy that we're looking at installing another electric infrared oven at our facility." Initial studies indicate that the new electric process will reduce the annual energy bill for the drying process by 40%. Just as important, it improves two other core business issues – it provides workers with a safer and cleaner workplace environment and is faster and more responsive to line conditions -- thus making the overall manufacturing process more efficient. And it's small -- a quality that matters at a plant in which space is at a premium.



“This installation clearly shows that infrared can save money, and in the long run that helps everyone”.

Application Provided Courtesy of TVA

**PRODUCT** Case Goods

**MATERIAL** Steel

**PROBLEM**

- Parts were hung from an overhead conveyor system and conveyed through the powder booth to the hot air oven.
- As the parts conveyed through the oven, the power and free conveyor would stack the parts for 30 minutes before they exited the oven.
- Parts of similar colors had to be run in batches to eliminate contamination.
- Increase in demand could not be met with the existing labor force.

### Background

Conveyor Type..... Overhead  
Line Speed..... 45' per minute  
Hot Air Oven Size..... 20' Wide x 100' Long  
Hot Air Oven Time..... 30 minutes

### Solution Process

- Increase production output
- Process different colors without delays or contamination
- Reduce time in hot air oven
- Maintain high quality finish
- No increase in labor cost
- The IRED member proposed a process to utilize the power and free conveyor along with a high intensity electric infrared booster oven.
- A 12' section of opposing heaters in the existing oven vestibule was installed.
- The parts were conveyed in, as before, at 45 FPM. However, now the parts stopped for 12.4 seconds in the infrared booster section then continued on at 45 FPM.
- The total exposure time in front of the infrared was 28.4 seconds and the product temperature was raised to 250°F.

### The booster section yielded the following results:

- The powder was melted and flowed in the section

of the oven without a lot of air flow.

- Low air flow eliminated powder from becoming airborne in the oven and contaminating other parts of different colors.
- A 250°F rise in the product temperature reduced the hot air oven time from 30 minutes to 15 minutes.

### Benefits and Paybacks

#### Increased Production

- Production rate was doubled (without an increase in manpower or oven size).
- Fewer delays, because colors no longer had to be run in batches.

#### Space Savings

- No added floor space since the infrared booster was able to be installed inside the existing hot air oven. (A gas oven with comparable capacity would be as big as the existing hot air oven, 20' wide x 100' long.)

#### Goals Were Met

- All 6 goals set for this project were realized.
- The customer has invested minimal time, money, and man power to achieve these goals.
- They are putting out high quality product in a more efficient method with no additional manpower required.



Application Provided Courtesy of ITW BGK

**PRODUCT** Eighty cylinder models used for scuba tanks, medical oxygen tanks, tanks for exotic gases, carbon dioxide tanks for soda and beer industry

**MATERIAL** Aluminum High Pressure Gas Cylinders

**PROBLEM** The company was outsourcing the coating operation.

#### **Background**

The products require more than 30 standard and customer requested powder colors. Production levels are 800,000 cylinders a year.

#### **Solution Process**

Three catalytic I.R. ovens. Dry-off, Pre-heat, and Cure oven systems.

#### **Benefits/Payback**

Doubled the line speed and throughput. Cure all products in house.

Improved process control.



Application Provided Courtesy  
of Catalytic Industrial Systems

<b>PRODUCT</b>	This company manufactures and powder coats and/or e-coats suspension coil springs and trunk lid torsion bars for the global automotive markets.
<b>MATERIAL</b>	Truck springs
<b>PROBLEM</b>	Conventional thinking dictated a requirement for two separate ovens that would take up valuable floor space. "Adding new curing ovens would negatively impact other parts of the production process, and consume the much needed production space", according to their Plant Manager.

### Background

The company has (4) production and coating lines. Their markets demanded that they expand beyond traditional electrocoat painting, and begin powder coating. They needed to add powder coating to at least one line that was originally designed for E-coating only.

### Solution Process

Through the efforts and teamwork of the IR manufacturer and TVA, the local utility, a rather unique solution was determined. It had already been determined that electric infrared would be employed to speed up the powder coating process, increase production, and bring the unit cost down. But trying to squeeze ovens in the lines was not the answer, again due to space considerations.

A novel approach to put an IR booster oven inside the convection oven was then considered and implemented. Locating IR components inside the oven is possible with specially designed refractory board and medium-wave quartz tube IR emitters, which are essentially impervious to the high temperature atmosphere inside the convection oven. In addition, the refractory board reaches high enough temperatures that the board essentially becomes a secondary emitter and is basically self-cleaning.

### Benefits and Paybacks

The IR equipment design addressed all anticipated floor space problems, and enabled this company to increase line speed and therefore increase production. Now they can quickly gel the powder just before the parts hit the high

turbulent area of the convection oven. They now also employ IR in their E-coating line for dewatering.

Lastly, the addition of the IR booster system changed the cure cycle substantially, since the direct heat was much quicker than convection, and the radiant heat was now being re-captured. The company can turn down the convection oven set points, and further save on energy consumption.



Application Provided Courtesy of Fostoria Industries

<b>PRODUCT</b>	Wide range of boat engines finished in a black epoxy paint
<b>MATERIAL</b>	Inboard and stern-drive marine propulsion products
<b>PROBLEM</b>	Company's goal was to reduce cycle times in order to better respond to the needs of their customers.

#### **Background**

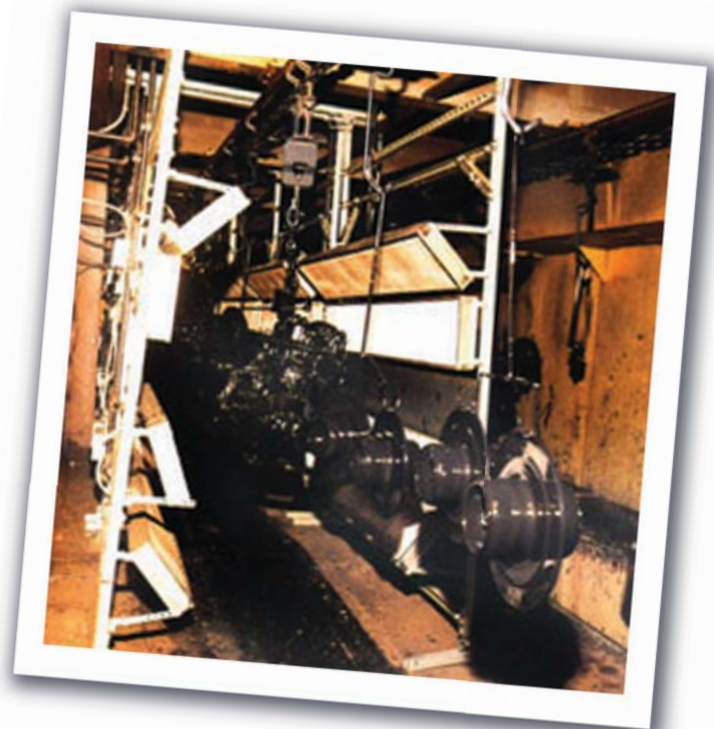
Formally two convection ovens, each of them 80 ft long, were used for paint curing. The process required each engine to make five conveyor trips through the ovens.

#### **Solution Process**

A new 40 foot long catalytic I.R. oven in place of an 80 foot long convection oven, reducing the cycle time by more than half, overall oven foot prints and conveyor length.

#### **Benefits/Payback**

Cut paint cycle time from 4 hours to 2 house. Reduced paint cure time from 50 minutes to 16 minutes. Replaced an 80 foot long convection oven with a 40 foot long I.R. oven, eliminating 240 feet of conveyor. Also creates a higher gloss on the finished product.



Application Provided Courtesy of Catalytic Industrial Systems

<b>PRODUCT</b>	<b>Engine Blocks</b>
<b>MATERIAL</b>	<b>Steel</b>
<b>PROBLEM</b>	<ul style="list-style-type: none"><li>• Process time is too long and does not allow them to meet production.</li><li>• The entire engine block reached 475°, so a significant cool time was required.</li></ul>

### Background

Conveyor Type..... Overhead  
Line Speed..... 5' per minute  
Hanger Load..... 600 pounds (max)  
Cure Time ..... 75 Minutes

- Gas convection curing with a 380' oven.
- After 75 minutes in a 475° oven the engine blocks took a significant amount of time to cool before packaging and shipping.

### Solution Process

- 19' short-wave infrared oven (only 5% of previous oven length)
- 23 zones of control – allows for adjustments for various part sizes
- Instant oven response time – allows the power setting to be reduced to idle during line stops and in between parts

### Benefits and Paybacks

- Coating cured in 1/10 the time.
- Infrared oven used only 5% of the floor space of the gas convection oven (infrared oven took up 258 ft<sup>2</sup> versus 7,200 ft<sup>2</sup> for the gas oven)
- Increased production by 46%
- 73% cost per part reduction



Application Provided Courtesy of ITW BGK

<b>PRODUCT</b>	Miscellaneous Weldments
<b>MATERIAL</b>	Steel
<b>PROBLEM</b>	<ul style="list-style-type: none"> <li>• The two-pass requirement resulted in a bottleneck at the paint line and loss of overall production and an increase in manpower costs.</li> <li>• Then the product mix began to include more 2-coat process parts.</li> </ul>

**Background**

Conveyor Type.....	Overhead
Line Speed.....	8' per minute
Hanger Spacing.....	4' (varied)
Hanger Load.....	100 pounds (max)
Production Load .....	12,000 pounds/hour (max)
Partial Cure Time.....	90 seconds

- The 2-coat powder primer/topcoat system added significant corrosion resistance and durability to their high-end sweepers.
- The problem was the 2-coat process needed to be added to an existing 1-coat layout. The customer approached the problem in stages.
- First, a powder primer booth was added to the line.
- Parts needed to pass from the primer booth through the convection oven all the way back to the topcoat booth and back through the convection oven.

**Solution Process**

- The decision to add an intermediate oven between primer and topcoats was obvious.
- The updated process begins when parts are manually loaded onto hangers supported from the overhead conveyor.
- The hangers then travel through a pretreatment system, a dry-off oven and open-air cooling before entering the primer powder booth.
- Once primed, parts enter the infrared cure oven to partially cure the coating.
- Parts then immediately enter a cooling chamber and on through the topcoat powder booth.
- After the topcoat the conveyor serpentine through a long convection oven for final full cure, through

another cooling chamber and back to the load/unload area.

**Benefits and Paybacks**

- By adding the electric infrared, partial cure oven, the customer was able to transform an existing single pass, 1-coat powder finishing line into a single pass 2-coat system without conveyor modifications.
- As a result, the customer is able provide their customers with a premium corrosion resistant, powder-coated product with minimal conversion costs.
- The customer also realized significant energy savings, operating and maintenance costs.
- Most importantly they eliminated the requirement for a second shift.



Application Provided Courtesy of ITW BGK



<b>PRODUCT</b>	Components of wood office furniture including conference tables, desks, credenzas, cabinets and wardrobes.
<b>MATERIAL</b>	Wood office furniture
<b>PROBLEM</b>	Floor space requirements too large with convection ovens and boxed surface temperature higher than desired, resulting in extended cool down times with convection.

### Background

Company changing to a propriety water-based coating and component parts finished prior to assembly.

### Solution Process

Five catalytic I.R. ovens in place of convection and in line to sure each of the coats of finish required at a line speed of 20 FPM.

### Benefits/Payback

The catalytic I.R. ovens reduced the floor space requirements from 1,000 ft. total to 130 ft total, due to the cure time being reduced from 10 minutes to 1.3 minutes. Also the new ovens significantly reduced fuel and air movement costs, plus greatly reduced conveyor requirements.



Application Provided Courtesy of Catalytic Industrial Systems

**PRODUCT** Manufacturer of wood veneer products

**MATERIAL** Wood veneer

**PROBLEM** Moisture content in a small percentage of veneer exiting the primary drying oven was not under the acceptable limits to be graded for use in downstream processing.

### Background

The customer needed to quickly drive off the extra moisture content that caused the veneer to be graded unacceptable for processing downstream from the initial operations. Previously, dielectric re-dryers had been employed, but the customer experienced several reliability and maintenance issues associated with that type of equipment.

### The Solution

Testing at the IRED member's technical applications center, that included a simulated production oven, revealed that infrared could quickly drive off the extra moisture content in the veneer, to allow for a positive grading and subsequent return of the veneer to the production line for final processing. A new drying line incorporating short wave IR was installed independent of the primary drying line, and was dedicated to handle only the non-graded veneer.

### The Results

This and a similar application at another facility have been operating for more than 4000 hours with no reported problems in the IR system's ability to remove the necessary moisture from the veneer. Maintenance and reliability issues that plagued the previous system were not problems with the new IR system, once minor start-up issues were addressed. Having this separate IR line to handle the small percentage of veneer with the additional moisture levels, has served the customer very well.

Application provided courtesy of Alabama Power Co. TAC West and Fostoria Industries.



**PRODUCT** The rubber seals are used on doors, trunks, and hatch back/lift gates to provide an airtight and watertight seal. The manufacturer applies a water based "low friction" coating to help reduce annoying rubbing noises and squeaks; and to prevent ice from accumulating that can cause the doors to freeze.

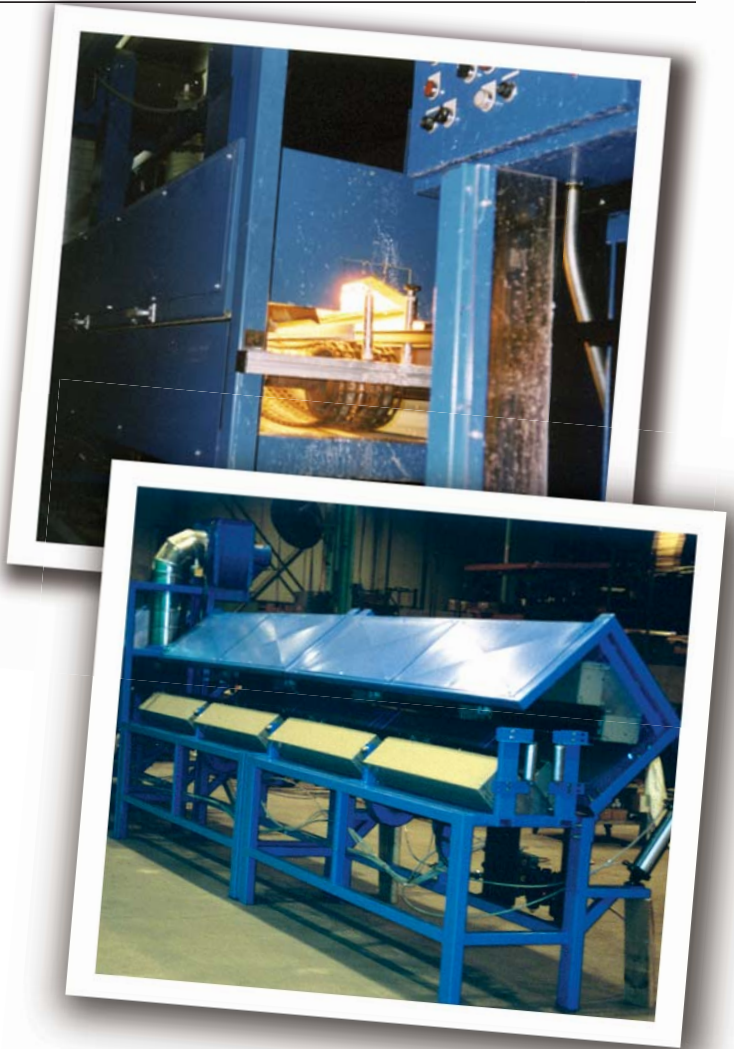
**MATERIAL** Extruded rubber seals for the automotive industry.

**PROBLEM** The manufacturers provide many sizes and types of seals, that require various heat and power densities, and various line speeds (normal ranges are 30 to 80 feet per minute), to adequately cure the coatings. They need a curing system that brings instant on-off heating capabilities, cures the coating in as little as 30 seconds, is capable of completely surrounding the product, or be flexible enough to cure just one coated side, if that is all that is required.

### Background

Lab testing performed at an IRED member's test lab, enabled the customer to experiment with various configurations, watt densities, various IR heat sources and varying line speeds. The most flexible system proved to be short wave electric infrared, using T-3 quartz lamps. They require little heat-up, respond to process changes extremely fast and can be de-energized instantly if needed. Cure times in as little as 30 seconds were also achieved. The oven configuration, which basically employs IR on all four sides of the seal, allows the product to be completely surrounded by heat, or if need be, allows the IR to be focused on only the side or sides of the seal that have been coated, if the entire seal is not coated.

A "clam shell" oven design with pneumatic cylinders was also employed to allow the system to open-close around the product, and allow for ease of maintenance.



Lastly, the systems were designed with multiple heat zones utilizing SCR power controllers. The output of each zone is infinitely variable from 0 to 100%, allowing the manufacturer to match the heat output to the requirements of the curing process.

### Benefits and Payback:

- Faster line speeds
- Less maintenance with electric IR
- Less product defects or damage. The product will not overheat if the line stops, since the T-3 lamps are virtually instantaneous.
- Dependable results through precise control, and the ability to focus the heat at the exact areas to be cured
- Lower operating costs by heating just the areas that require a cure, and through the other benefits as outlined above.

Application Provided Courtesy of Fostoria Industries.

**PRODUCT** 20-ton and 23-ton hydraulic excavators. Booms and arm weldments for 27, 33 and 45 ton excavators.

**MATERIAL** Construction machinery

**PROBLEM** A convection oven would take twice the floor space of an I.R. oven and the cost would be too much for convection, due to the need for more building structure.

#### **Background**

Primer black, yellow and orange paints are electrostatic air – sprayed on excavator parts. They are applied as two component urethane liquids.

#### **Solution Process**

Catalytic I.R. oven to reduce oven size, conveyor length, and cure time. Eliminated parking space for air drying assemblies and eliminated any building additions.

#### **Benefits/Payback**

Cure time from six to eight hours down to just 15 minutes.  
Cut required oven size by half



Application Provided Courtesy of Catalytic Industrial Systems

<b>PRODUCT</b>	Aluminum Cookware
<b>MATERIAL</b>	Non-Stick Coating
<b>PROBLEM</b>	<ul style="list-style-type: none"><li>• The convection oven is operating at maximum capacity</li><li>• Taking too long to cure parts</li><li>• Significant heat introduced into workers environment</li></ul>

### Background

Conveyor Type..... Chain-on-Edge  
Line Speed..... 9 FPM  
Cure Time ..... 15 Minutes  
Oven Size ..... 60' Long x 10' Wide  
Oven Temperature ..... 600°F  
Oven Type..... Convection

Company used a 600°F convection oven to cure the non-stick coating onto the exterior portions of the cookware.

### Solution Process

- To increase production without sacrificing quality of product
- Replaced convection oven with short-wave infrared oven
- Infrared oven reduced cure time to 1 minute and 20 seconds

### Benefits and Paybacks

- Reduced heat into the workers environment
- Increased production within the first hour by 84 pieces
- More consistent appearance (gloss, color, etc)
- Reduced floor space from the 600 sq ft convection oven to a 48 sq ft infrared oven



Application Provided Courtesy of ITW BGK

**PRODUCT** Oil and air filters for OEM customers and after market sales for automotive, truck and tractor use.

**MATERIAL** An international filter manufacturer.

**PROBLEM** The customer had outdated and inefficient ovens used to heat-set folded paper filter media. The treated paper would be fed through a pleating machine onto a conveyor belt and through a "knuckle setting" oven. To keep up with production demands, the customer required an oven and conveyor system that could handle various widths and heights of pleated material. This required adjustable side guides and a height adjustable hold down device. Zoned heaters were also a requirement for energy conservation and a final requirement was fast responding heaters to eliminate the possibility of fires on line stops.

### Background

The company has multiple production lines for all facets of filter production, many of which needed updated equipment to improve product quality or increase production or both.

All of the above criteria had to be accomplished within a fixed amount of line space while delivering faster line speeds.

### Solution

Process: Through the design efforts of the IR manufacturer and utilizing their unique stamped metallic element heater design, a conveyORIZED oven was built which would produce a width range of 1 inch to 15 inches and a height range of ½ inch to 2 inches. The fast response, high efficiency, long life heaters were designed to heat in 2 inch wide zones, from the center out.

A lighter weight conveyor belt was used to transport the pleated material and because of that and overall oven design, the connected load is half of what was required for their existing oven.

### Benefits & Paybacks

The IR oven design performed better than anticipated and delivered a more consistent product at faster line speeds. Because of the unique fast response heater design, down



time due to fires has been eliminated. The design integrity of the width adjustment and hold down devices, plus extremely long heater life have also eliminated down time.

The customer estimated a nine-month payback for the oven.

Because of the success of the first knuckle set oven, the customer has ordered and installed multiple ovens, some with widths to 36 inches and heights to 4 inches, for their four operating locations.

Application Provided Courtesy of  
Process Thermal Dynamics



**Advanced Energy**

[www.advancedenergy.org](http://www.advancedenergy.org)

**Catalytic Industrial Systems**

[www.catalyticovens.com](http://www.catalyticovens.com)

**Despatch Industries, L.P.**

[www.despatch.com](http://www.despatch.com)

**Duke Energy**

[www.dukeenergy.com](http://www.dukeenergy.com)

**Electrotechnology Applications Center - Northhampton Community College**

[www.etctr.com](http://www.etctr.com)

**Fostoria Industries, Inc.**

[www.fostoriaindustries.com](http://www.fostoriaindustries.com)

**Gas Technology Institute**

[www.gastechnology.org](http://www.gastechnology.org)

**ITW/BGK Finishing Systems**

[www.itwbgk.com](http://www.itwbgk.com)

**George Koch Sons, LLC**

[www.kochllc.com](http://www.kochllc.com)

**Process Thermal Dynamics, Inc.**

[www.pro-therm.com](http://www.pro-therm.com)

**Red-Ray Manufacturing Co., Inc.**

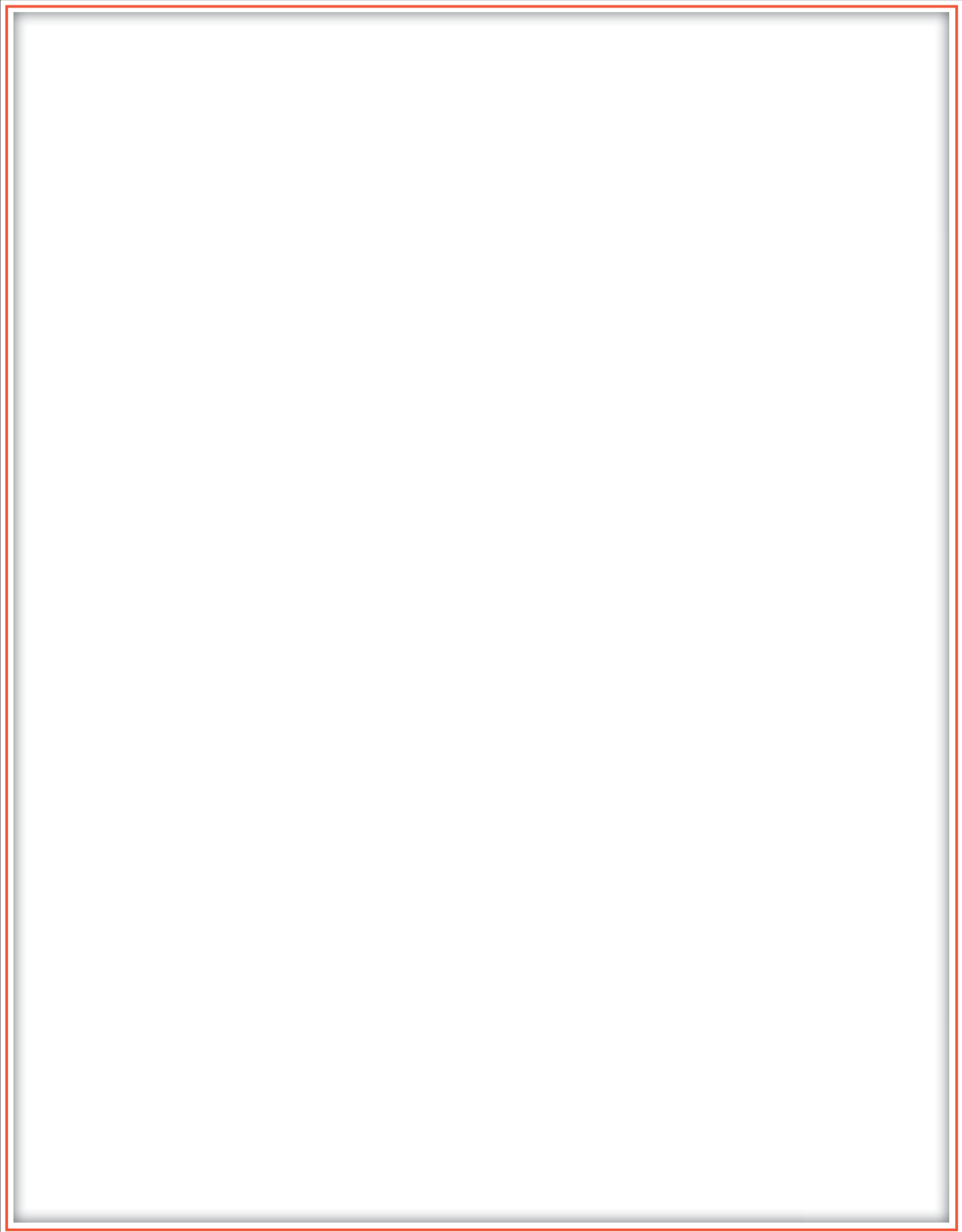
[www.red-ray.com](http://www.red-ray.com)

**TVA**

[www.tva.gov](http://www.tva.gov)

**Wisconsin Oven Corporation**

[www.wisinfrared.com](http://www.wisinfrared.com)



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