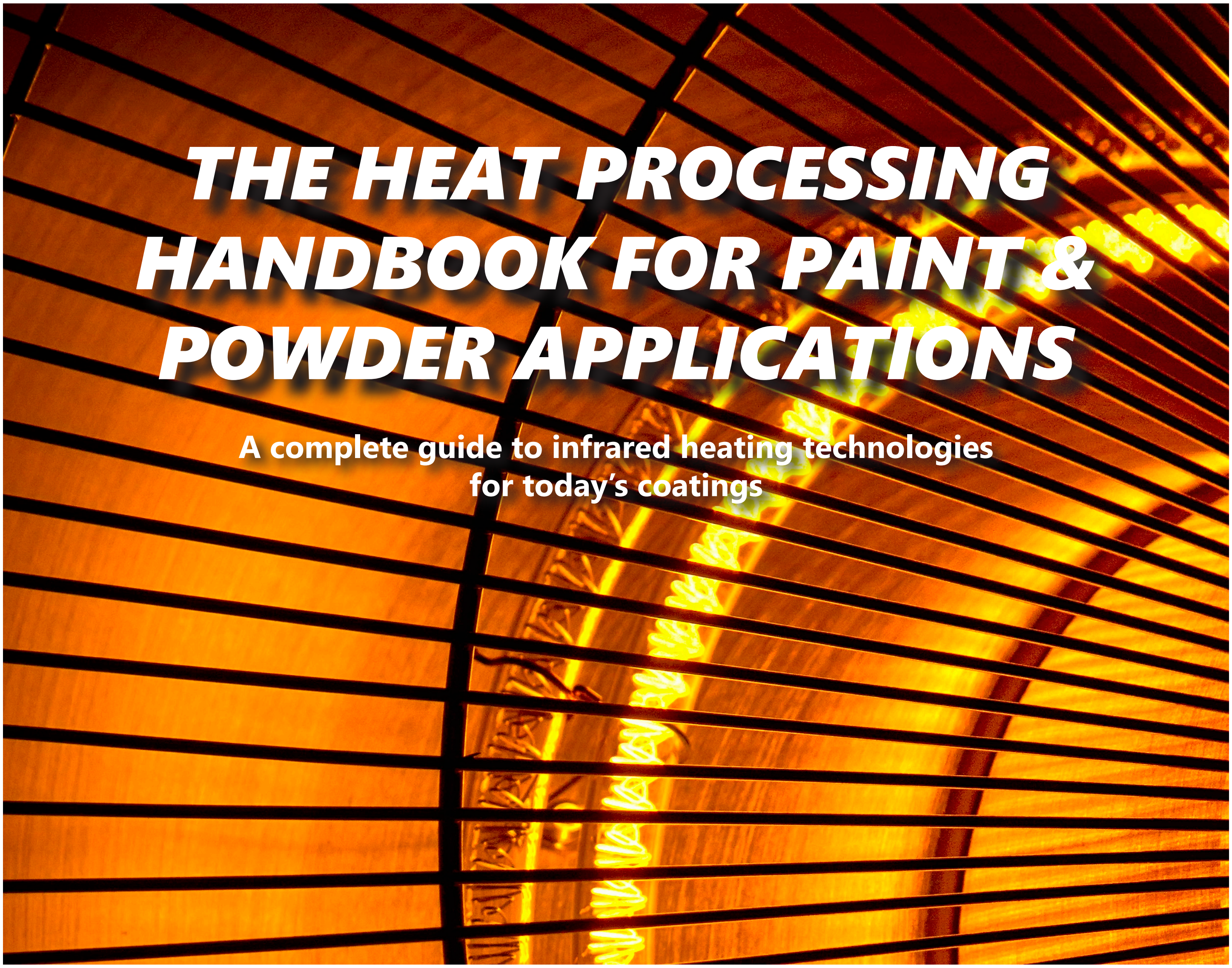
THE HEAT PROCESSING HANDBOOK FOR PAINT & POWDER APPLICATIONS

A complete guide to infrared heating technologies for today's coatings



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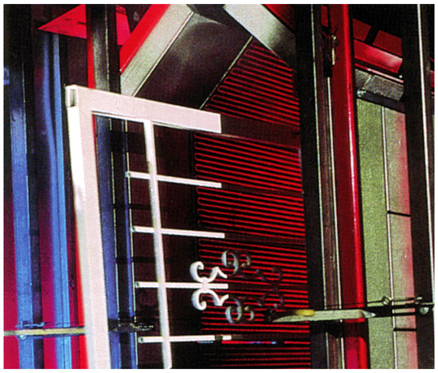

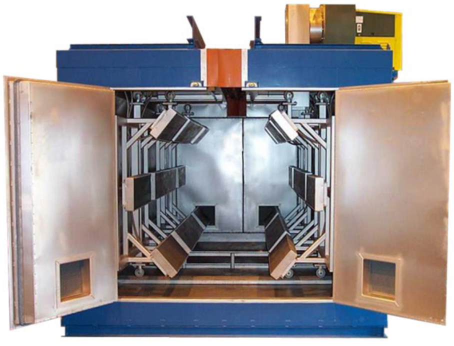

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THE HEAT PROCESSING HANDBOOK FOR PAINT & POWDER APPLICATIONS

First Edition

INTRODUCTION

This manual is the result of the many questions on Heat Processing which plague coaters in the Paint and Powder Industry. The handbook explains why it is important to review the available heating options. With EPA regulations in effect, coaters are most commonly changing from solvent based coatings to either high solids, 100% solids, water based or powder coatings in order to reduce the VOC emissions. Today, 80% of the coatings used are still liquid (either solvent or water based). Clearly the trend is toward water based and powder coatings. For this reason, the handbook will primarily review these types of coatings.

The regulations have •driven the market to re-evaluate the best means of curing the coating. In many cases, the appropriate heating technology is not a convection oven alone. In some cases, the answer is a combination oven with IR heating added as a booster oven to the beginning of the convection oven, as in a powder coating application. Sometimes, the IR booster oven is added to the end of a convection oven, as is the case for some water based coatings. For other applications, the best choice may not require the existing convection oven at all.

Infrared heating has the following advantages:

- **Reduces floor space**
- **Lowers energy consumption**
- **Increases line speed**
- **Reduce~ maintenance significantly**

If you have already switched to a new coating, the problem has, most likely, already reared it's ugly head. Reduced line speed, improper cure, powder blow off, powder discoloration, dramatically increased energy costs (due to higher curing temperatures and longer dwell time), or any number of other problems may arise. The end result is reduced product quality and/or cost increases.

Additionally, this handbook will review the basics of -heating and the many heating technologies available in today's market. Basic heat application for both convection and infrared will be reviewed along with heater advantages and disadvantages. Separate from the handbook, we have provided several case studies that review the many advantages of infrared heating.

This information will give you the required basic knowledge to ad as an educated buyer when reviewing the many heat processing options with your oven supplier or turnkey house.

Why should I learn about the many heat processing technologies available in today's market?

It's a simple matter of money! By lowering the cost of production, you can stay competitive in today's world market. That's why you need to review the options! New coatings require a fresh look at new technologies. That fresh look can mean the difference between red or black - in your financial report.

The cost of floor space continues to escalate. The cost of expansion is even greater. Energy costs continue to rise. Maintenance, downtime, and production costs are under pressure to be kept at a minimum as budgets are trimmed and the workforce is continually downsized. Management is always pushing for more production without more expenditure. The quality "gurus" are demanding better finishes in order to compete globally. All of these items, along with the change in coatings, require a fresh look at the many heat processing options available today.

THE BASICS OF HEAT

There are three means of transferring heat:

CONDUCTION

Transfer of heat by either contact between the heat source and the object to be heated or within the object from one point to another. An example would be a coffee pot on a warming plate.

CONVECTION

Transfer of heat, from the heat source to the object being heated, via a medium. That medium is commonly air. An example would be the convection oven used in your paint or powder application.

RADIATION

Transfer of heat via electromagnetic radiation between the heat source, which is at the higher temperature, and the object to be heated. Radiation is broken down into many subsets separated by different wavelengths. For example:

- **ULTRAVIOLET**
- **INFRARED**
- **MICROWAVE**
- **RADIO FREQUENCY**
- **INDUCTION**

CONDUCTION

While conduction heating has its place in the world of heating, it is not used, generally speaking, in paint and powder applications. Conduction is the means of heat transfer once the coating or outer part layer has been heated. The transfer of heat through most substrate materials is via conduction. Because conduction heating methods are not applied for paint or powder applications, we will not spend time reviewing it further.

CONVECTION

Convection heating has been the standard in paint applications for many years now. The system is very easy to design. It is a simple matter of determining how much heat is required to bring a part's mass up to temperature and then maintaining the required dwell time to cure the powder or paint. Another big advantage of convection ovens is that they are typically present in existing applications. The problem is in applying the convection oven, that was originally designed for solvent based paints, for water based paints and powders. Water based coatings usually require more time to flash-off than solvent based coating. That means that the existing oven has to either be slowed down (which no coater wants to do) or an infrared booster is added to the existing convection oven.

Typical Industrial Convection Oven.

When applying infrared heaters to water based coatings, it is important to dry the coating in the first stage. The infrared booster oven, for this application, is sometimes placed at the beginning of the existing convection oven and is sometimes placed at the end of the oven. This depends on the coating and the substrate. It is possible to dry the coating too quickly resulting in blistering. Adding an infrared oven to an existing convection oven for water based coatings can assure that the line speed is not reduced. In some cases, the infrared booster oven can increase the production rate. This assumes that the complete finishing system line speed can increase. The spray booth, for example, may already be operating at the peak production rate.

In a new installation, a combination infrared/ convection oven can be used for the drying stage of the process and an infrared oven only is used for the second stage to cure the coating. This approach assures both proper and fast drying in the first stage of the oven along with the speed of infrared to cure the coating in the second stage. If the part has a complex geometry, then a combination oven may be used for the complete drying and curing cycle. Adding infrared to convection heating will allow for a much smaller overall oven.

A powder coating application requires a little different approach. One problem with a convection oven can be powder blow-off. One way to increase heat transfer in a convection oven is to increase the airflow or the resulting air velocity that flows across the part. Though this approach works well for solvent or water based coatings, it is very undesirable for powder coatings. Another problem is spotting. This is the discoloration of powders in direct fired convection ovens. The products of combustion are resident in the oven air and can contaminate the powder coating. The products of combustion along with byproducts of the curing process can also generate surface cratering. There is no concern, as with water based coatings, with blistering. Therefore, the goal with powder coating applications is to first raise the temperature of the coating to the curing temperature and gel the powder with an infrared booster oven. Then, the part can enter immediately into the convection oven for the cure cycle. Because infrared heating has a much higher heat transfer rate, the overall time is dramatically reduced as compared to using the convection oven by itself. If it is a new installation, a combination oven (infrared and convection) will require far less floor space than a convection oven by itself.

Parts with many hidden nooks and crannies are typically better served using an infrared oven in conjunction with a convection oven. Many times, parts that would seem to not work very well with infrared, can work very well. An example would be an aluminum wheel rim that has many hidden areas. One would think that this is not a good application for infrared. But the opposite is true. Because aluminum is very conductive, the infrared heat will quickly transfer through the rim to cure the complete coating. One point that is often forgotten is that the heat transfer through a part in a convection oven is via conduction. The same is true with IR heating as it relates to transferring energy to out of sight areas of a part. For this reason, testing is the only way to assure that infrared will work properly. In fact, wheel rims can be completely gelled and cured with a complete infrared oven. Another approach, that is applied with infrared ovens, is to rotate the part. This will assure good coverage of the piece with infrared energy. Parts with simple geometries are almost always better served with an infrared oven only.

Other disadvantages of convection ovens:

- **Consumes considerable floor space**
- **Takes a long time to heat up and cool down**
- **Difficult to zone**
- **Requires careful air balancing for acceptable results**

RADIATION

Microwave is one type of radiation. To help you better understand how radiation works, think of your microwave oven at home. The oven uses microwave energy to heat food. However, when you open the door, it does not feel hot like your standard convection oven. How can this be? It works because waves of energy excite the molecules in the food and heat is generated. Typically, the container used to hold that food is manufactured of plastic. You will note, that after the food is heated, the plastic container is still close to room temperature. This is because microwave energy passes right through plastic or is transmitted but is absorbed by the food.

Therefore, the food gets hot and the container does not. Of course, there are those times that we have all burned our fingers when removing a container from the microwave. This is because the heat is passed from the food to the container by conduction.

The toaster is another appliance that uses radiation as the means of heat transfer. In this case the means is infrared heating. The heating element is a nickelchromium (ni-chrome) wire that primarily heats up your toast, bagel, or English muffin by infrared energy. There is also a slight convective heating component, as with all infrared heaters. It is that convective element along with re-radiation from your breakfast food that supplies the heat that you feel when you place your hand over the opening in the top of the toaster.

Radiant energy is either Reflected, Absorbed, or Transmitted (meaning to pass through) when it reaches an object. The goal is to have the energy absorbed for heating, drying, and curing applications.

Why are we going through this lengthy exercise on heating food? Because it helps you to understand how infrared radiation works. The sun works in the same way to provide heat to the earth, namely radiation that is primarily at the infrared wavelength.

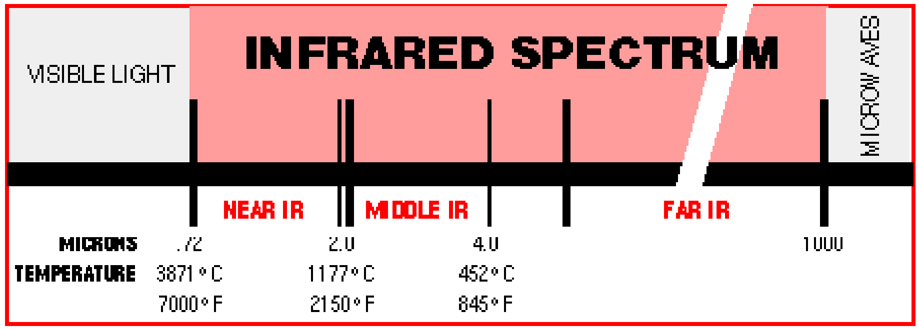


Figure 1

INFRARED

Note the electromagnetic spectrum in Figure 1: As you can see from the figure, the infrared spectrum is again subdivided into three separate categories: The wavelength is inversely proportional to the emitter temperature. By this we mean, as the emitter temperature goes up, the wavelength goes down.

Keep in mind that Chart 1, on the following page, is the wavelength range for the infrared spectrum, not necessarily the usable range of industrial process heating. A short wave element (T3 lamp) has a maximum temperature of approximately 4000°F which equates to roughly 1.17 microns. Most medium wave elements have a maximum temperature of approximately 1800 -2000°F which equates to 2.3 - 2.12 microns. Many elements, considered in the industry to be long wavelength, actually fall into the medium wavelength when operating at higher temperatures and fall into the long wavelength region when operating at temperatures lower than 845°F. The useable infrared range is typically considered to go from 1.17 - 10 microns. In reality, the range is from 1.17 - 5. 4 microns (4000°F - 500°F) for industrial process heating. Operating an infrared heater below 500°F is not very common.

Wavelength	Micron range	Temperature -F	Temperature -C
short (near)	0 .72 -2	7000 - 2150	3871 -1177
medium (middle)	2- 4	2150 - 845	1177 - 452
long (far)	4 -1000	845 -<32*	452 -<0*

CHART 1

* Long wavelength infrared temperatures go well beyond the freezing point of water. Ibis energy has no value for our applications.

Following is a simple formula used to calculate °F when the wavelength is known.

$$°F = \frac{9}{5}\left(\frac{2898}{\text{wavelength (microns)}} - 273\right) + 32$$

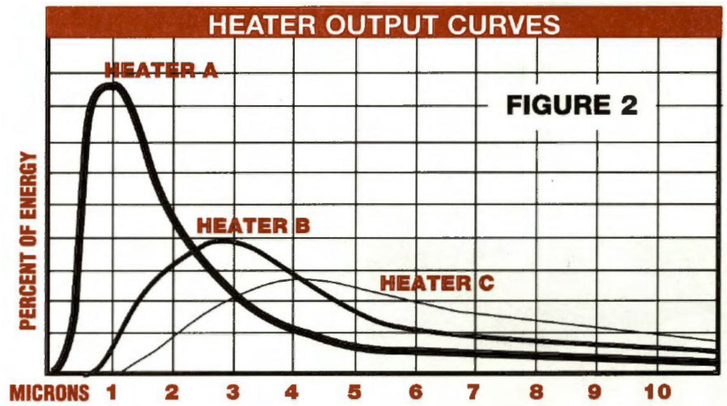
Through testing, heater output curves can be generated. Heaters do no.t output all of their energy at one wavelength, but rather over a range of wavelengths. There is commonly a peak output for infrared heaters. If a vertical line were drawn through the peak, you would find that 25% of the energy is at a shorter wavelength than the peak and 75% of the energy is at a longer wavelength than the peak. The following discussion compares three heaters, all having the same power output, with completely different output curves.

AN EXAMPLE:

All heaters are not created equal. Figure 2 displays a comparison between three heaters, each covering a 10" x 10" area at 1000 watts per element.

- **HEATER A** (short wave) is one (1) 1000 watt short wave lamp (T3) operating at 4000°F.
- **HEATER B** (medium wave) is two(2) 500 watt medium wave quartz tubes operating at 1800°F.
- **HEATER C** (long wave) is a ceramic face heater with ten(10) 100 watt coils operating at 800°F

Infrared operates under the same principles as microwave radiation, just at different wavelengths of energy. Infrared energy is commonly used to cook food, to heat plastics, to remove moisture, and to dry and/or cure the finish on painted products. As a powder coating is cured, it goes-through a chemical reaction known as polymerization -



Each heater will have a completely different output as displayed in Figure 2.

the formation of plastic. A cross-linking occurs between the short molecules (monomers) creating a long chain of molecules (polymers or plastics). The cured coating is a polymer with great strength due to the cross-linking of molecules. There are many additives that go into the perfect powder, such as reinforcements, fillers, resins, and curing agents. But, the coating is primarily comprised of plastic. Common plastics used for powders are polyethylene and polystyrene.

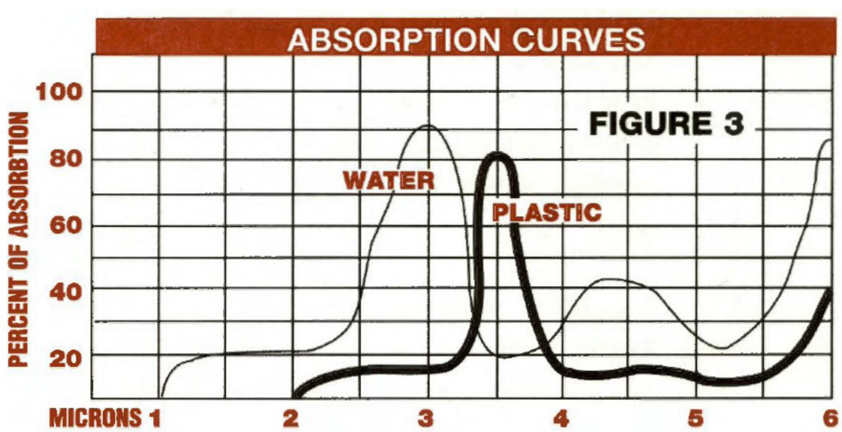
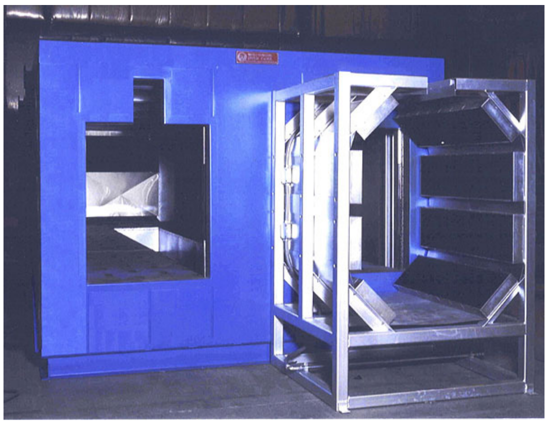


Figure 3 displays a typical absorption curve for water and plastic.

Just as heaters have output curves associated with the individual heater, materials have absorption curves for that specific material. Ibe peaks on the absorption curve are the wavelengths where the infrared energy is best absorbed.

As you can see by the curve, plastic absorbs medium wave infrared energy more quickly than other wavelengths of radiation. That is because the peak absorption for plastic is commonly found at 3.5 microns (1030 °F). This falls right smack into the medium wave infrared heating range.

The goal, with infrared, is to put as much energy into the product without damaging the finished product. This is best accomplished by outputting the peak amount of energy at the peak absorption of the product. Wavelength, heater radiant efficiency, and overall system efficiency all determine how quickly the powder coating can be cured or the water based coating can be dried and cured. It also determines how much energy is required.



Note that there is also a peak for plastics ranging between 6 - 10 microns. If the emitter were set to operate in this range, then very little energy would be transferred from the heater (6 microns relates to a temperature below 500°F). Generally speaking, as the temperature of the emitter goes down, the amount of energy transmitted to the product goes down as well.

The same is true for removing moisture. The peak absorption for water is 3.0 microns. There is also another peak at 6 microns. The goal for water removal would therefore be to output as much energy as possible at 3.0 microns or 1280°F. Each material has its own specific absorption curve that helps to determine which wavelength of energy will most quickly heat up the material.
It should be noted that shorter and longer wavelengths, within the absorption range, can also be used for these applications. Shorter wavelengths can sometimes shorten the time to cure and longer wavelengths will commonly lengthen the time to cure. This is due to the amount of energy that falls into the absorption range of the product or coating. Short wave elements may deliver more total energy and, therefore, the coating may come up to temperature and cure in less time than medium or long wave. It depends on how much of that energy is absorbed by the coating or part.

Though there are absorption curves for some materials used in the marketplace, most materials do not have this information easily accessible. You will not find real output curves for heaters on the market either. Even if both pieces of information were available, there is no easy formula available to translate that information into useable criteria for the heating system. There are also other factors that come into play when heating with infrared, as well, such as the emissivity of the product and color sensitivity.

EMISSMTY describes the relationship between reflectivity and absorption. A perfect absorber (black body) has an emissivity of 1.0. The perfect reflector has an emissivity of 0. All products fall somewhere in between this range.

COLOR SENSITMTY occurs more often with short wavelength emitters. White coatings will have a tendency to absorb less than black coatings and will therefore take longer to cure. The point is that curing times can be quite different when using short wave emitters on different color materials. Medium and longwave heaters are not color sensitive.

THE IMPORTANCE OF TESTING

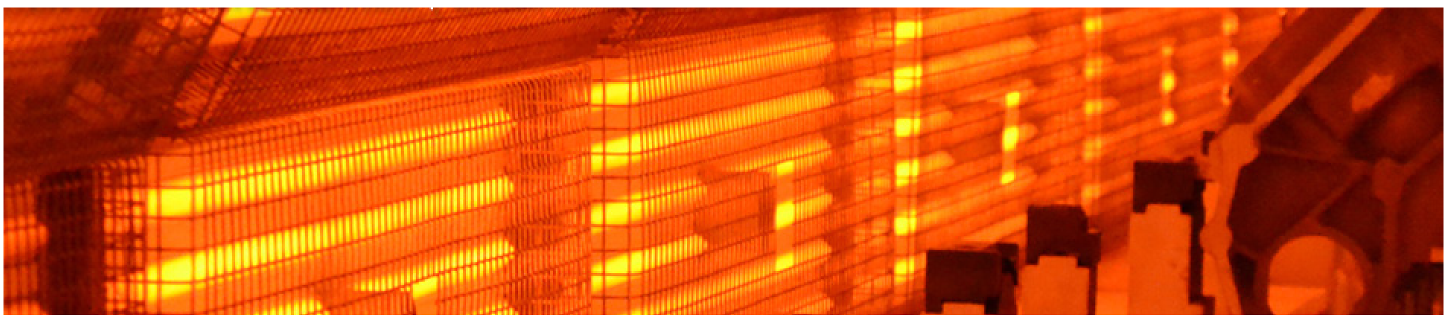
It is advisable to do testing with the material or process and determine what watt density, heater type, and/or temperature will best accomplish the goal. Testing is provided by the oven manufacturer to assure the best results for the finished product. The infrared oven manufacturer usually has a good idea of which technology would work best for a given application. But until the testing is complete, it is just a good guess. When general heating calculations are used, the most common result is an oversized system due to lack of application experience. When there is a lack of knowledge, the usual approach is to add a big engineering safety factor to assure that the system will work. (This assumes that your engineering staff is conservative. A risk taking engineering staff can create a disaster.) Though this approach will work, it results in a much higher capital expenditure and a requirement for more floor space, which translates into higher costs.

There are many factors that go into the final decision, such as available floor space, maintenance requirements, heater durability, response time, initial oven cost, energy consumption cost, conveyor speed (now and in the future) , part size variation and aggravation cost. All of these items have to be considered in order to pick the right solution.

As you can see, there are many other factors that go into selection of the proper emitter type. Following is a review of the more common emitter types available in today's market and some comparisons between those emitters. As can be seen by the charts, many of the long wave emitters fall into the medium wave category as well. These elements can operate at temperatures that fall into both wavelength groups.

GAS INFRARED HEATERS

SHORT WAVELENGTH	MEDIUM WAVELENGTH	LONG WAVELENGTH
There are no gas infrared heaters that fall into the short wavelength	Ceramic Tile Type Porous Matrix Type Radiant Tube	Radiant Tube Catalytic



GAS INFRARED HEATERS

DETAILS	CERAMIC TILE RADIANT BURNER	POROUS MATRIX TYPE	RADIANT TUBE	CATALYTIC
Radiant Efficiency*	40 - 60% 45% is common	35 - 45%	30 – 40%	50-70%
Source Temperature Range (°F)	1200 – 1900	1200 – 1900	400 – 1200	500 – 800
Input Power Density (watts/sq in)	Up to 200 wsi †	Up to 150 wsi †	20 wsi	12 wsi
Warm-up Time				
Temperature Uniformity	Average	Average	Below Average	Below Average to Poor
Surface Material	Ceramic tile plate	Porous Ceramic or or Metallic Screens	Metal Tube	Wire mesh covering blanket impregnated with platinum catalyst

*An important note: Radiant efficiency relates to the percentage of total power that is infrared energy. 1be remaining percentage of energy is primarily convective beat. Ibis statement is also true for the electric elements. Gas heaters also lose 8% to the production of water vapor. Even though gas catalytic heaters have the highest radiant efficiency of gas infrared, they also have the lowest power output.

Therefore, the amount of energy that the product actually absorbs is the lowest with gas catalytic. Radiant efficiency is only part of the equation required to determine how much energy is actually absorbed by the product and therefore determines the resulting time to heat, cure, or dry the product. Power output, wavelength, and radiant efficiency all determine the productivity results and the operating cost of the system.

† It is not common to run gas infrared heaters at 150 -200 wsi for paint and powder applications. The intensity would be too high, resulting in damage to the coating.
Gas, as an energy source, works very well within the convection oven, but it is far more common to use electric infrared. Electric infrared has many advantages over gas infrared. Some of the advantages of electric infrared are listed below:

Electric infrared is infinitely controllable. Gas infrared has very little turndown capability. It is close to on/off operation. The best way to control the heat being directed to the part, with gas infrared, is to move the heaters closer or further from the part. Moving the heaters further away may control the part temperature, but it also reduces the system efficiency and therefore increases the cost of operation.

All infrared heaters have a convective heat component. With electric infra~ed, that convective component can be used in the heating process. Gas infrared requires an exhaust to remove those products of combustion. Therefore, the exhaust gases are not used for heating and the system efficiency, with gas infrared, is therefore much lower.

Electric infrared has no products of combustion. Gas infrared, with the exception of gas catalytic, will generate products of combustion - which can create discoloration and surface imperfections.

It is often stated that gas costs less than electric. For that reason, it makes sense to use gas, right? Wrong! The fact is that gas infrared heaters are less than half the radiant efficiency of electric infrared heaters. So, even though electric rates are commonly twice that of gas rates, the overall efficiency of electric infrared heaters is higher.

Besides, the cost of energy for drying and/or curing the coating is often less than 1 % of the product selling price. It is more useful to reduce expenses that account for a higher percentage of the total product cost.

SHORT WAVELENGTH	MEDIUM WAVELENGTH	LONG WAVELENGTH
T3 Lamps G30 Bulbs Halogen Lamps	Quartz Tube Panel Type Ceramic Elements Metal Sheathed Tubular (Calrod™) Coiled Metal Sheathed w/ Parabolic Reflector Ceramic Generator w/ Parabolic Reflector Metal Ribbon or Sinuated Wire	Quartz Tube Panel Type Ceramic Elements Metal Sheathed Tubular (Calrod™) Coiled Metal Sheathed w/ Parabolic Reflector Ceramic Generator w/ Parabolic Reflector Metal Ribbon or Sinuated Wire

ELECTRIC INFRARED HEATERS

DETAILS	T3 LAMPS	METAL RIBBON OR SINUATED WIRE	QUARTZ TUBES	FUSED QUARTZ PANEL HEATERS	QUARTZ
Radiant Efficiency	75% - 85%	80% - 85%	70% - 80%	80% - 85%	70% - 80%
Typical Life Expectancy	5000 Hours	10000 Hours	10000 Hours	25000 Hours	25000 Hours
Source Temperature Range (°F)	up to 4000	up to 1900	up to 1800	up to 1800	up to 1700
Input Power Density (watts/sq in)	Up to 200 wsi †	Up to 55 wsi	Up to 60 wsi	Up to 60 wsi	Up to 25 wsi
Warm-up Time in seconds	1 - 2	30 - 60	10 - 40	300 (5 minutes)	300 (5 minutes)
Temperature Uniformity	Very Good	Very Good	Very Good	Excellent	Excellent
Surface Material	Vacuum Sealed Quartz Lamp	None (Bare Element)	Quartz tube	Quartz tube	Glass, Ceramic, Metal or Quartz Composite
Picture of the Heater	photo needed	photo needed	photo needed	photo needed	photo needed

† 30-60 wsi is more common for paint and powder applications.

ELECTRIC INFRARED HEATERS

DETAILS	CERAMIC ELEMENTS	METAL SHEATHED TUBULAR (CALROD™)	COILED METAL SHEATHED WITH PARABOLIC REFLECTOR	CERAMIC GENERATOR WITH PARABOLIC REFLECTOR
Radiant Efficiency	70% - 80%	60% - 65%	70%	70%
Typical Life Expectancy	10000 - 15000 Hours	10000 - 15000 Hours	10000 - 15000 Hours	10000 - 15000 Hours
Source Temperature Range (°F)	up to 1400	up to 1400	up to 1500	up to 1100
Input Power Density (watts/sq in)	Up to 30 wsi †	Up to 20 wsi	Up to 20 wsi	Up to 7 wsi
Warm-up Time in seconds	300 (5 minutes)	300 (5 minutes)	300 (5 minutes)	300 (5 minutes)
Temperature Uniformity	Good	Good	Very Good	Very Good
Surface Material	Ceramic	Metal	Metal	Ceramic
Picture of the Heater	photo needed	photo needed	photo needed	photo needed

The following chart breaks down a few of the advantages and disadvantages between the heaters/wavelengths:

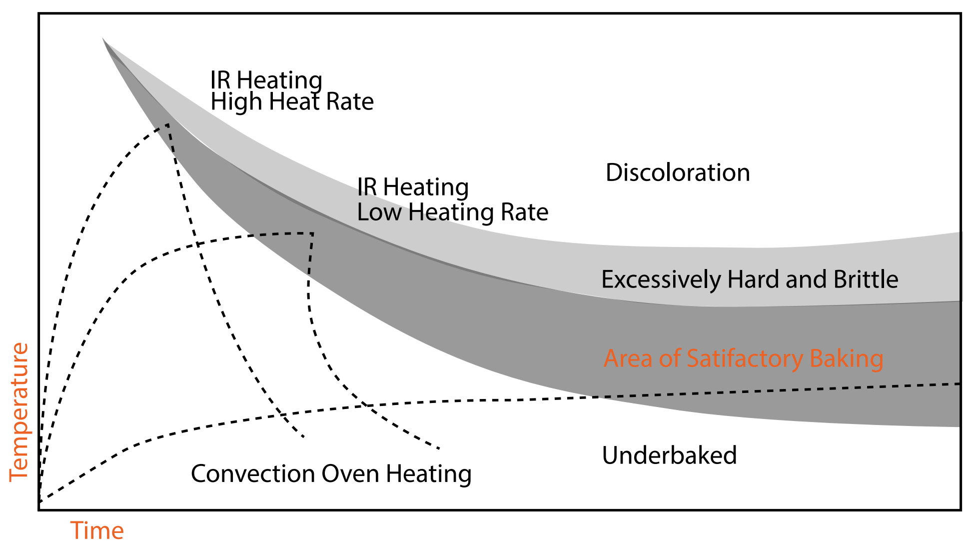
ADVANTAGES

SHORT WAVELENGTH	MEDIUM WAVELENGTH QUARTZ TUBE	MEDIUM WAVELENGTH PANEL HEATERS	LONG WAVELENGTH
Immediate response High watt densities Very fast cure cycles	Moderate life (10,000 Hrs) Reasonably priced control systems Cure time is 1/2 to 1/3 of convection time	Highly durable Modestly priced control system Long element life typically 25,000 Hrs Cure time is 1/2 to 1/3 of convection time	Very good element life Smoother On/Off Cycle Hybrid oven design due to larger amount of convection heat Cure time is 1/2 of convection time

DISADVANTAGES

SHORT WAVELENGTH	MEDIUM WAVELENGTH QUARTZ TUBE	MEDIUM WAVELENGTH PANEL HEATERS	LONG WAVELENGTH
Shorter life (5,000 Hrs) Quartz lamps are fragile High cost control system High maintenance cost	Quartz tubes can be fragile	Slower reaction time	Slowest reaction time Longest oven length Low temperature applications only

APPLICATION OF INFRARED HEATERS



Now that you have an understanding of infrared heaters, let's talk about how to apply them. How do you choose which heater to use? How do you choose the watt density that is required? First, let's take a look at why you may choose infrared heaters over a convection oven by reviewing

Typical drying and hardening curve compliments of CMF (Center for Material Fabrication).

As you can see from the Typical Drying and Hardening Curve, the infrared heating rate is much faster than a convection oven.

- **A short wave oven commonly requires 25% of the time required for a convection oven.**
- **A medium wave oven commonly requires 33% to 50% of the time required for a convection oven.**
- **A long wave oven commonly requires 50% to 60% of the time required for a convection oven.**

HEATER SELECTION

Now that we know a little bit more about the selection process, we have to determine which of the available heaters will be the best choice. There are many factors to consider at this time: size, heater response, heater efficiency, and heater pricing.

Size is a consideration based on the product(s) that are being heated. The heater should always be slightly oversized due to edge heat loss. If a product is an 18″ by 18″ flat piece of sheet metal, then two (2) 12″ high panel heaters would be stacked to form a 24″ heated wall on each side of the product. Assuming that both sides are being coated. The oven length is determined by how long it takes to heat the product to the required temperature. This can be determined by heating the product in a stationary position and noting the time. Knowing this fact and the speed of the conveyor, the length of the heaters can be determined. If it is determined that 20′ of heated length is required, then the heaters would be broken down into units of reasonable length.

Zoning is another consideration. Let's look at an application where that same 18″ x 18″ sheet metal piece is running through the oven. But, in addition, there are batches of parts that are 40″ high and 36″ long. In this case the oven has to sized for the larger part. We would most likely use four (4) 12″ high heaters stacked on top of each other to create a wall of heaters that are 4′ high. In this case we would probably want to break up the line into a minimum of two (2) zones down the length of the oven. A 24″ high center zone and a zone that encompasses a 12″ top heater and a 12″ bottom heater row. These top and bottom heaters may be angled inward 30 degrees. When the 18″ x 18″ part passes through the oven, the center zone will be operating and the top and bottom heaters will be run at a lower temperature or turned off. When the larger part passes through the oven, both zones would operate. Taking this approach allows for a very efficient oven design.

The next step would be to increase the quantity of zones for better process control. One example would be to add a zone in the beginning of the oven. If the coating process is powder based, then it is common to operate the first section of the oven at an elevated temperature. This will bring the coating up to temperature more quickly. Once the coating is up to temperature, the remaining zones will operate at a lower setting to cure out the powder. If the coating process is water based, then it is common to put that extra zone at the end of the oven. Water based paints can blister if too much heat is used up front. It is important to dry first, by removing the moisture. Once this is completed, the coating can be exposed to a higher temperature zone to cure it.

Every heating system has advantages and disadvantages. The key to purchasing the correct oven for your application is to:

- **Understand the strengths and weaknesses of the system**
- **Define the product(s) that are being coated and the coating itself**
- **Know the space constraints**
- **Recognize money constraints**
- **Determine process speed requirements**
- **Realize maintenance limitations**
- **Research expected heater life**
- **Know the company constraints**

Which heater would you select for this particular application? Any of the available heaters would complete the job. If the space available for the oven is very small, then short wave quartz lamps are the most likely choice. In most cases, short wave elements will require the shortest oven length. But, the capital cost will be high. The system is energy efficient, due to the ability to quickly cycle the lamps on/off when there is no part or a smaller part in the oven. This means that some of that up front cost will be recouped over time. Quartz lamps do have a fairly short life (5000 hrs). So, if you have a small maintenance staff that is already overworked, quartz lamps may not be the best choice.

Many times, customers will use medium wave quartz tubes in lieu of short wave quartz lamps. The cost for a complete medium wave quartz tube system is much lower than for a short wave system. The curing time and oven length are slightly longer for quartz tubes. The life expectancy of the quartz tube is twice as long at 10,000 hrs. The control system is considerably lower in cost. Quartz tubes come up to temperature fairly quickly, 30 seconds on average, so the tubes can be turned off when not in use.

The biggest problem with quartz tubes or lamps is their fragility. These elements not only have an inherent shorter life than do other types of infrared heaters, but they also have a much higher casualty rate due to breakage. Ceramic heaters are not commonly used in the paint and powder industry, though they can be. Ceramic heaters are efficient, are reasonably priced, and have a fairly long life. But the element size is very small, namely 2.5” x 10”. Ceramic heaters require a lot of installation time and wiring cost due to the small element size. It is more common to see this element type used in other process heating applications, such as thermoforming.

Metal sheathed heaters (Calrod™) have been used for well over 30 years in paint and powder applications. The main advantage to calrods is the element durability, purchase price, and reasonable life expectancy. The main drawback is the efficiency of these elements. The up front efficiency is between 60 - 65%. But, these elements are very dependent on an external reflector. That reflector will get dirty fairly quickly, cutting the radiant efficiency down by 50%. This leaves a heating system that is only 30% efficient. Unless you want to spend a lot of time maintaining the reflectors, the heater efficiency is lower than is acceptable. **Keep in mind that these numbers refer to the heater efficiency,not the system efficiency. The system efficiency will always be lower due to losses in the oven.** For these reasons, it is not common to see metal sheathed heaters in paint and powder applications in today’s market.

Coiled metal sheathed heaters and Ceramic generators, both with a parabolic reflectors, are very commonly used in the paint and powder industry. These elements have all the advantages of metal sheathed heaters along with a higher radiant efficiency and a reflector that is better designed to deliver infrared energy to the coating. They are also better designed for maintenance of the reflector. Zoning is very easy due to size (one element per square foot) and construction of the element. These elements are limited in watt density and do depend on external reflectors. Therefore, they may not be the best choice for all applications.
Panel heaters have experienced the most growth in paint and powder applications. Panel heaters are extremely durable with an average rated life expectancy of 25,000 hours. An oven with panel heaters is very cost effective up front. The energy consumption of panel heaters is very low due to the insulated panel construction. The radiant efficiency is very high, namely 80%. Unlike most infrared heaters, the panel heater construction has no external reflector. The ceramic board, which holds the heating elements, acts as the reflector. The ceramic board is really a re-radiator. The ceramic board is protected by the face construction and does not change reflectivity over time. Therefore, the heater maintains the same radiant efficiency over time. Because the heaters have mass, the heater output is very consistent, even with reasonably priced control systems. Mercury relays or solid state relays are commonly used to control the heater along with temperature controllers. These control systems can be very reasonably priced. This helps to keep the cost of the entire oven lower in comparison to other emitter types. One disadvantage of an oven with panel heaters could be the required floor space. The length can be 1.5-2 times longer than a short wave oven or 1.25 - 1.5 as long as a quartz tube oven. This is due to a lower maximum watt density with most of the panel heater designs. Keep in mind that the panel heater oven length is still 1/3 to 1/2 that of a convection oven. It therefore requires 50 - 70% less floor space than a convection oven. This is not true of the fused quartz panel heaters

which can have a maximum watt density of 60 wsi. Shorter oven designs can be achieved with this type of panel heater along with the high life expectancy often found with panel heaters. The heaters also have a high mass, which was earlier stated as an advantage. This can also be a disadvantage with some products. That mass holds the heat very well. So, if the line stops, quartz lamps and quartz tubes will lose their heat very rapidly. Panel heaters will take longer to reduce the emitting temperature. This can sometimes be a problem for the part being coated. In most cases this is not an issue, but it is something to be aware of.

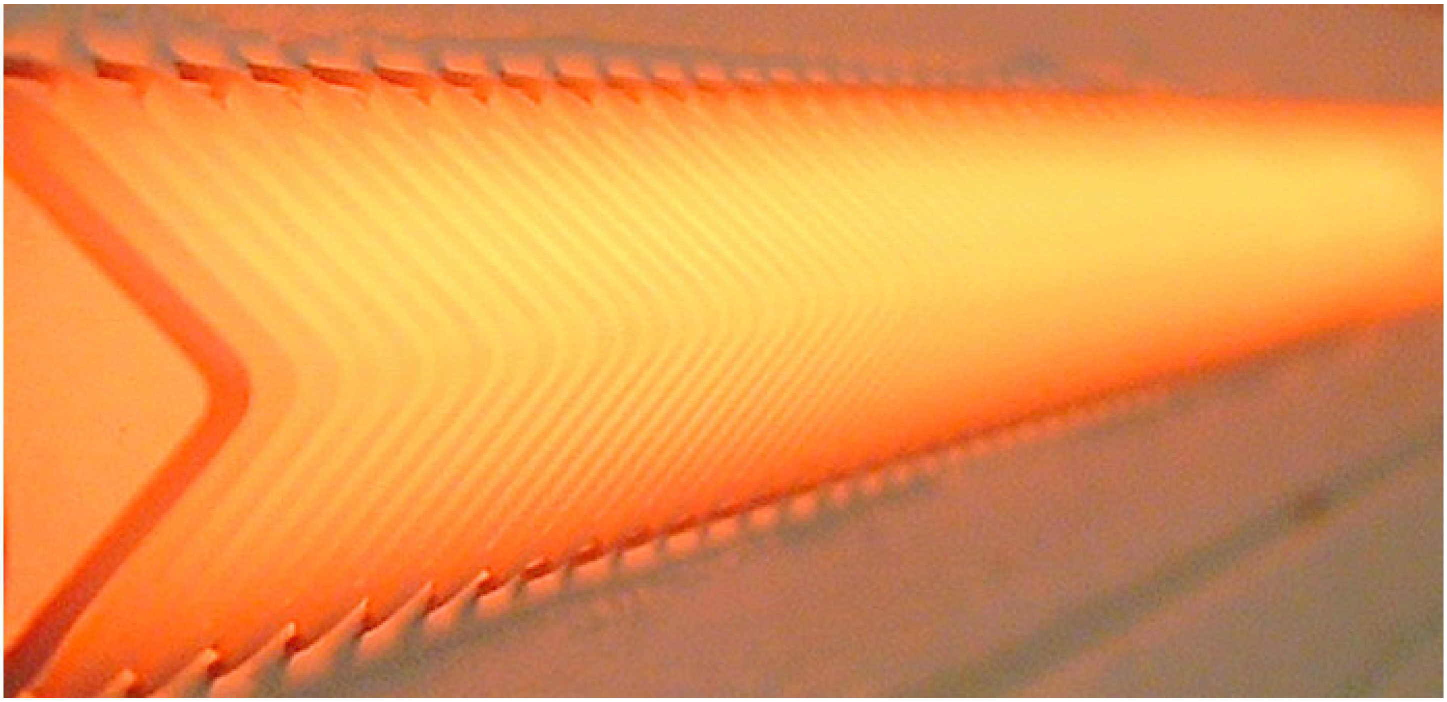
Overall, panel heaters seem to have the fastest growing acceptance in the paint and powder industry. They seem to fill most of the desirable requirements of an infrared system with the fewest amount of trade offs.

CLOSING REMARKS

Please remember that all heating technologies have their place in the market. That is why there are so many types of infrared heaters available today. Some are better at certain applications than are others, as discussed in the Heater Selection section.

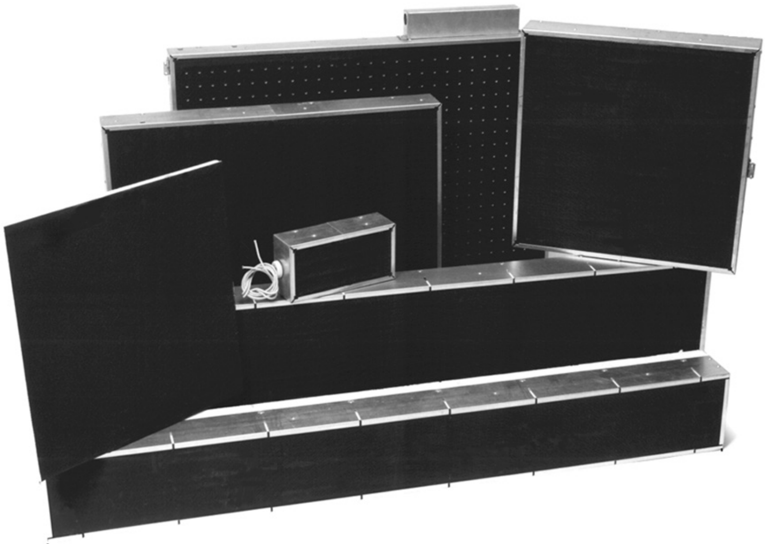
As the customer, determine which technology is best for your application today and in the future. That decision is driven by many parameters, such as initial cost, operating cost, available space, parts to be coated, the coating type, process speed, maintenance costs, aggravation and acceptable downtime of the system. Only after reviewing all of these items can an educated decision be made. It often helps to speak with as many industry people as possible. This will allow you to hear the good and the bad points about each system. Attending paint and powder shows and conferences, subscribing to industry magazines and trade journals, joining industry organizations, and communicating with friends in the industry are all ways to determine the best heating technology for your particular company. It seems like more work than would be required in selecting a convection oven, and it most likely is more work. But in this case, the end result does justify the means. The payoff is a better quality finish. Not to mention an efficient operation that puts more money in the company coffer. If the company is more prosperous, then so are its employees.

You couldn't ask for a better Win-Win condition. Good luck!



SOLAR PRODUCTS PANEL HEATERS

Solar Products designs and manufactures electric medium wave infrared heaters for process heating applications, including the paint and powder industry. Our product line consists of the F-Series, FBASeries, G-Series, T-Series and Q-Series.

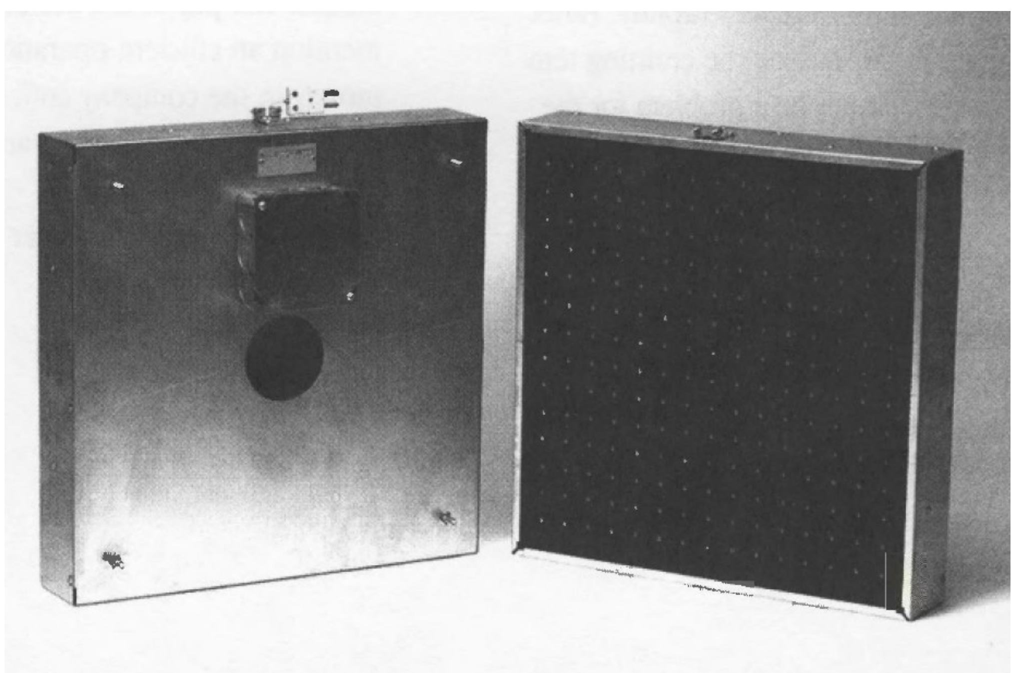


F-SERIES

The F-Series heater is a quartz composite face panel heater. It is our best selling heater due to its flexibility, durability, efficiency, and price. Dimensionally, the heater can be as wide as 30” and as long as 78”. The heater is very flexible in sizing and watt density options. It has a maximum watt density of 25 wsi. Durability is defined by a typical life expectancy of 25,000 hours. The heater has a high radiant efficiency of 80%. Because the heater design does not depend on an external reflector, the heater maintains that efficiency over time.

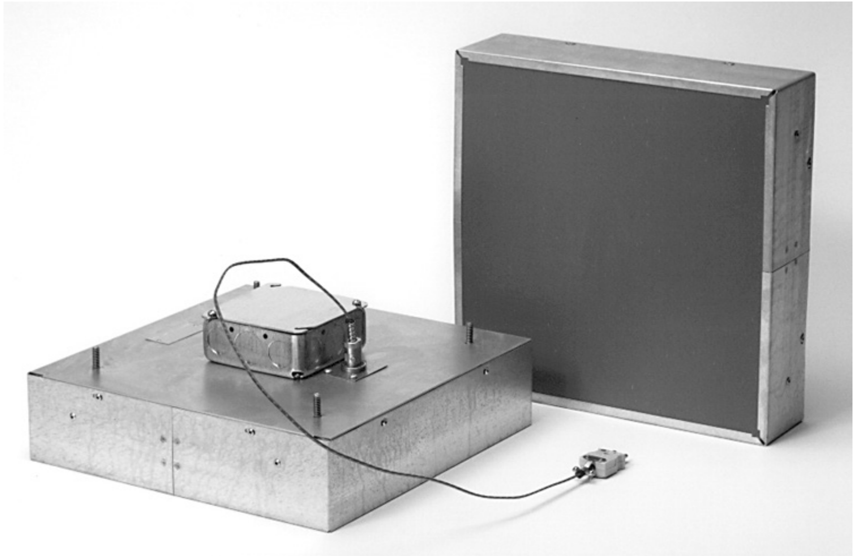
FBA-SERIES

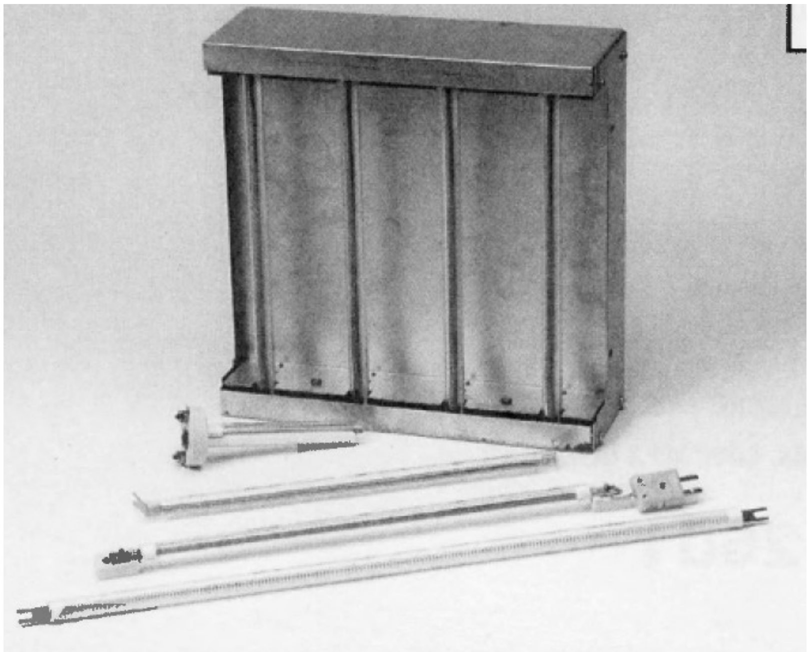
The FBA heater is a unique heater designed to offer a combination of infrared and convection heating. This heater can be used for water based applications. The infrared excites the water molecules while the gentle air movement removes the moisture from the coating.



G-SERIES

The G-Series heaters are similar to the F-Series in construction with a high temperature glass face. These heaters are traditionally used when a protective covering is required over the heater face. These heaters also come in standard and custom sizes.



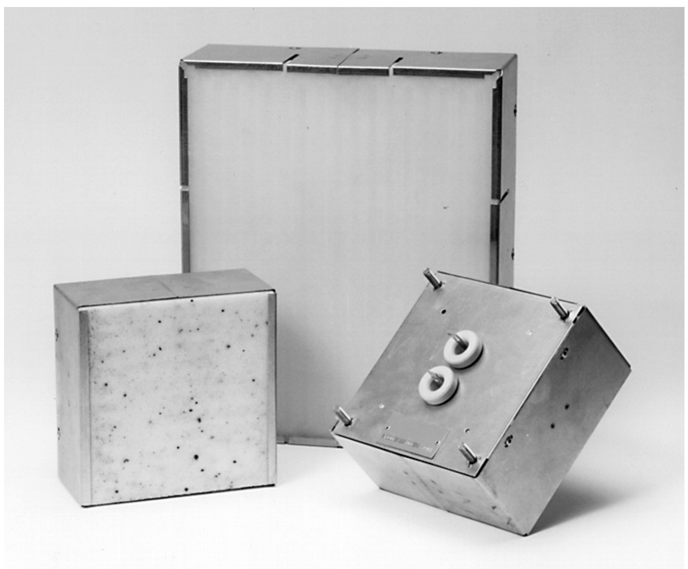


T-SERIES

The T-Series is a quartz tube heater that has a nique internal reflector which will not degrade with time as will an external reflector. Tube lengths can exceed 70″ with watt densities up to 60 watts/lineal inch.

Q-SERIES

The Q-Series is a panel heater with a fused opaque quartz face. All of the advantages of a panel heater along with a high amount of available power. A great combination for a booster oven that can quickly raise the coating temperature up to the curing temperature. This heater has a maximum watt density of 60 wsi. The maximum size of this heater is 12″ x 12″.



In 1956, Richard Eck, the founder, had a few ideas about making a better infrared heater. Today, over 60 years later, that philosophy continues to radiate throughout Solar Products. Many ideas and several patents later, Solar Products has become the largest supplier of medium wave infrared panel heaters in the U.S. market. Our annual sales exceed 6.5 million dollars. The company has a 40,000 sq. ft. manufacturing facility located in Pompton Lakes, NJ.

SOLAR PRODUCTS INC.
THE INFRARED HEATER COMPANY

QUESTIONS?

If you have any questions or comments about this handbook, we would enjoy hearing your viewpoints. Give us a call us at: **(973) 248-9370**

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