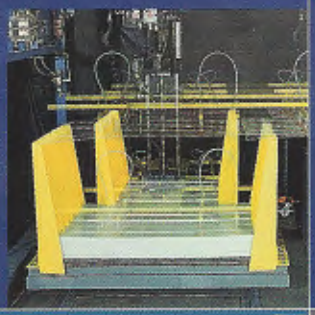
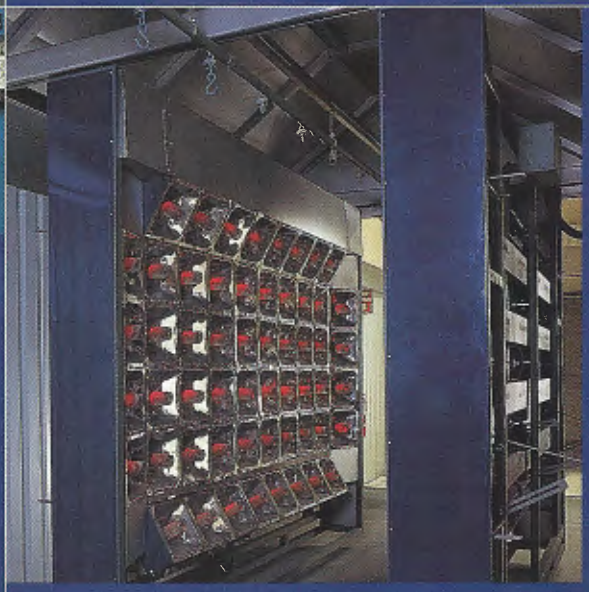


Blasdel Enterprises, Inc.



BLASDEL

CUSTOM HEAT AND MOTION TECHNOLOGIES

A TRADITION OF QUALITY AND TECHNOLOGY

Blasdel Enterprises, Inc.

Blasdel Enterprises, Inc. was formed in 1982 as an expansion of the WB Panel Company founded in 1974 by Bill and Jackie Blasdel. Located in a 40,000 sq. ft. facility, Blasdel Enterprises has since added infrared ovens, conveyors, high velocity air convection ovens, pick and place robots, and other specialty equipment. Since the company specializes in custom designed equipment, new products are continually developed. Blasdel Enterprises, Inc. is a family business focusing on customer service and satisfaction.

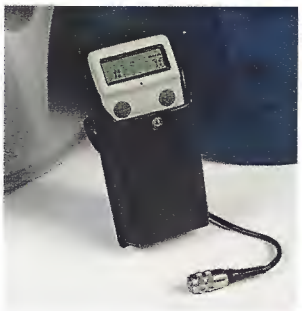
EXPERIENCE WORKING FOR YOU

With customers in a variety of markets including automotive, construction, furniture, and appliances utilizing diverse substrates such as plastic, metal, wood, and glass, Blasdel Enterprises has the experience to design equipment for your application.

PUT THE APPLICATION TO THE TEST

In order to guarantee the right equipment for your needs, Blasdel Enterprises tests the application in a full-scale production lab facility. Cure times and temperatures can be altered for best results. Various control levels can be employed. Several types of infrared emitters can be used. Material handling options can be explored. All of this can be seen and tried firsthand before the system is designed based on theory or someone else's parts. Customers are invited and encouraged to participate in this critical design process.

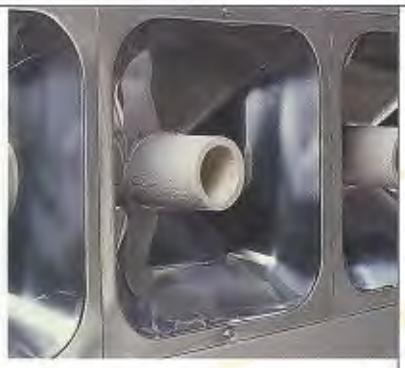
Hand held sensors are crucial in the quality control process, providing data at our fingertips with reference to temperature, thickness and other critical factors.



SERVICE FOR LIFE

Blasdel Enterprises offers service contracts renewable on an annual basis to keep your equipment operating at peak performance. Inquire about the right program for your new purchase.

SELECT THE RIGHT EQUIPMENT FOR THE JOB



Ceramic Emitter

COR Emitter

Quartz Tube Emitters

Blasdel Enterprises is continually discovering new applications for infrared technology and determining which emitters are best suited for the situation. Even when the wavelength is the same, the physical material design of the emitter can affect the way in which heat is delivered to the product.

BEI specializes in applications requiring medium wave technology. Primary emitters are ceramic emitters, COR emitters and ceramic panel heaters. Quartz tube heaters are used when heating narrow or selected areas of a product.

CERAMIC EMITTER

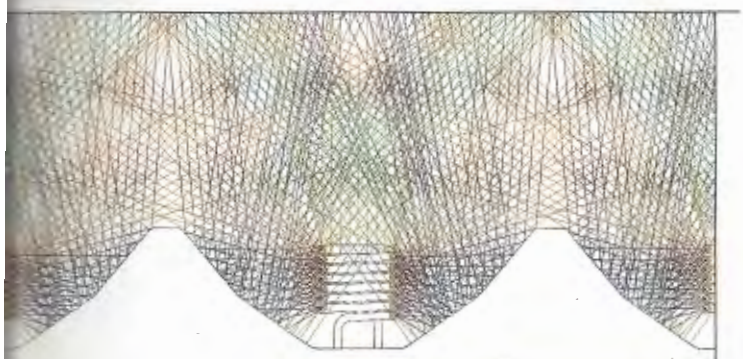
Ceramic emitters are ideal for wood, plastic, and other low temperature substrates. The durable nichrome wire wound around a ceramic core is embedded in a ceramic material and fired in a kiln. These elements, controlled by a Blasdel control panel, can maintain a very even temperature. Full temperature can be attained within five minutes from start-up.

COR EMITTERS

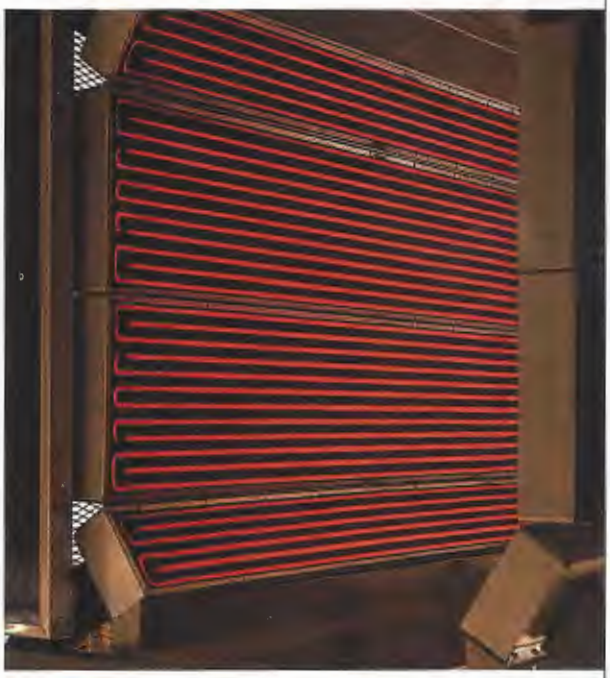
COR emitters are best suited to powder coating, baked liquid coatings, moisture dry-off, softening plastics, compression molding or vacuum forming, degreasing, and paint on plastics, where higher temperatures are required or where cleanliness is critical. Fast start-up, within three minutes, is possible with the COR emitter. Properly controlled, the desired temperature can be accurately maintained.

QUARTZ TUBE EMITTERS

When a fast response is required, medium wave quartz tube emitters are an excellent choice. Generally quartz tube emitters are controlled with SCR or SSR devices such that they are always on to avoid thermal shock to the element but the voltage is modified to change the output of heat. Watt densities can be up to 60 watts/lineal inch. A variety of connectors are available according to the application and environment in which they will be used. Quartz tube emitters have an internal reflector as well as a secondary external reflector. The secondary reflector can focus the infrared heat to a very narrow area while the remainder of the product is virtually unaffected. Average life expectancy of a quartz tube emitter is about 10,000 hours.



Heat distribution of Blasdel Reflectors
— DIRECT HEAT
— CONVECTIVE HEAT
— RADIATED HEAT



Ceramic Panel Heater

REFLECTORS

Blasdel reflectors are the key to heating three dimensional objects, producing uniform heat patterns, and promoting maximum energy efficiency. The square design with complex angles results in a square pattern of heat distribution with the emitter 8″ to 12″ away from the product. This eliminates hot and cold spots commonly found in round or trough shaped reflectors.

The emitter is located in front of the reflector so there is no need for insulating material in the back of the housing. We use solid aluminum reflectors that have been buffed to a high polished finish. Polished aluminum is significantly more reflective than stainless steel which results in a more efficient oven. Disposable aluminum reflectors are also available for simple maintenance or in specialized applications.

CERAMIC PANEL HEATERS

The ceramic panel heater may be constructed with extremely high watt density. The resistance wire is embedded in a quartz plate and then covered with a quartz cloth. Control is achieved by monitoring the internal temperature of the heater with a thermocouple. The ceramic panel heater also requires very little maintenance, as it has no reflector to clean. Panel heaters deliver heat to the product much differently than the standard Blasdel emitter. The lack of a reflector to direct the heat means that this heater has more true direct radiant heat and a high level of convection occurring to transfer the energy. The convection component is very useful in working with reflective products or coatings. It easily overcomes one of the common challenges in utilizing infrared technology.

This heater is ideal for applications involving massive or reflective products and in compressing the footprint of the system. The high watt density can shorten the oven for a given application since it takes the same amount of BTU or KW delivered to the part to complete the process.

CONVEYORS

Blasdel Enterprises, Inc. manufactures a variety of conveyors for use with our ovens or as stand alone units. By purchasing the conveyor with the oven, you are guaranteed that proper consideration has been given to the temperature requirements of the conveyor. Other manufacturers may try to cut costs by decreasing the ratings on the belt resulting in downtime and higher maintenance costs.

Choose from stainless steel wire mesh belts, square mesh flat wire belts, or a variety of woven or rubber compound belts including butyl, Teflon, etc. in a slider bed, roller bed, (powered or gravity) or slat conveyor design.

High velocity air convection ovens with butyl belt slider bed conveyors

HIGH VELOCITY AIR CONVECTION OVENS

High velocity air ovens recirculate air at high velocities to remove solvents and water from coatings and accelerate the cure. In some instances, the part may be processed in an IR oven for final bake. Blasdel Enterprises, Inc. has designed this oven to be a closed loop recirculation system with minimal losses. A small percentage of air is exhausted to remove accumulated solvents or moisture. It is important to keep the humidity level at a minimum. There is no need for air knives or air curtains due to the balanced system. Temperature ranges from ambient to 500˚F are available. Insulated side walls are required above 150˚F. A PID temperature control system is used for very even heat, end-to-end and top-to-bottom.

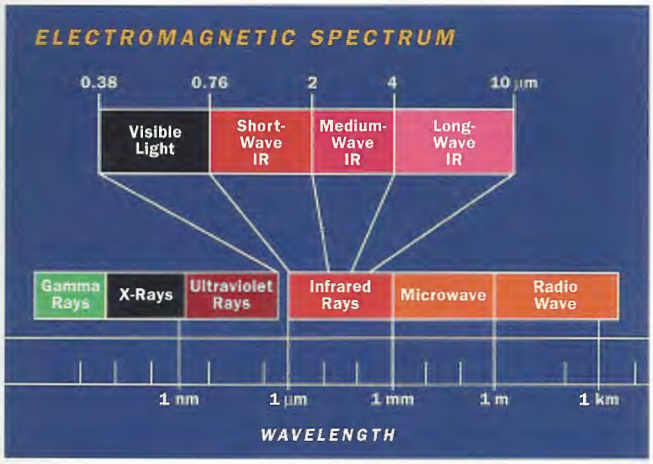
Stainless steel mesh conveyor

FORCED COOLING TUNNELS

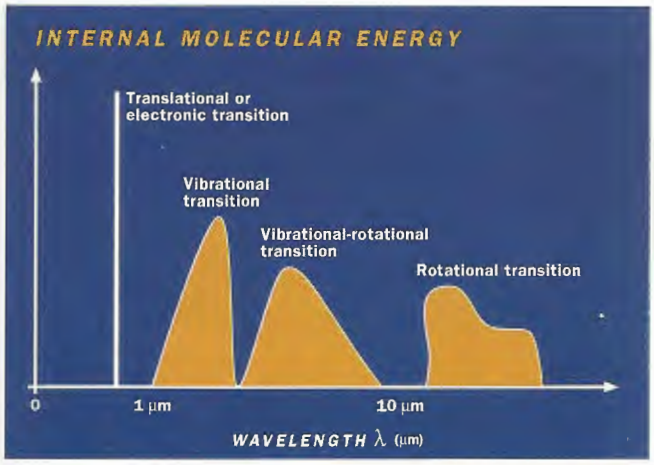
Cooling tunnels may be fabricated as above but with no heating capacity. In the cooling tunnels, two blowers force ambient or outside air in while drawing the heated air from the parts out the opposite end. Simply passing air over a part results in significantly faster cooling. If additional speed in cooling is desired, air conditioning may be added.

Finishing cell with chain or edge conveyor

HARNESSING THE POWER OF INFRARED ENERGY



Infrared (IR) energy or radiant energy consists of electromagnetic waves or photons. All materials continuously emit or absorb electromagnetic waves. Therefore, all materials emit or absorb infrared. Infrared is a form of light that is invisible to human eyes but detectable by the feeling of heat on the skin. Infrared occurs at wavelengths just below red light on the electromagnetic spectrum.



Compare this information to the Electromagnetic Spectrum chart (above) and align the wavelengths.

THEORETICAL PRINCIPLES

Infrared energy is within the electromagnetic spectrum between .76 and 1000 µm. Infrared is divided into three ranges: short, medium and long wave infrared. The wavelength of short infrared ranges from .76 to 2 µm. Medium infrared is from 2 to 4 µm. Long infrared for process heating uses from 4 to 10 µm. As the wavelength decreases, the temperature of the radiant source increases. Some emitters crossover into more than one category of radiance. For example, an emitter that is considered to be medium wave infrared operating at a lower temperature can fall into the long wave region.

INTERNAL MOLECULAR ENERGY

All substances absorb and emit radiative energy. Their atoms or molecules carry a certain amount of energy, consisting of kinetic energy and internal molecular energy. The internal molecular energy consists of levels of electronic or translational, vibrational and rotational energy states. Also, higher molecular energy levels are associated with higher temperatures. When molecules collide, photons are absorbed only if they are at the same energy states, or frequency and phase. Therefore, when the molecules are absorbed, they vibrate more and increase the frequency. As the energy increases, the temperature rises.

It is seen that shorter wavelengths are at higher frequency and energy level. Therefore it takes a higher level of energy to be absorbed by atoms at translational level than at rotational levels.

Therefore, all substances are affected by all of these energy states at levels dependent upon the molecular composition of the substance.

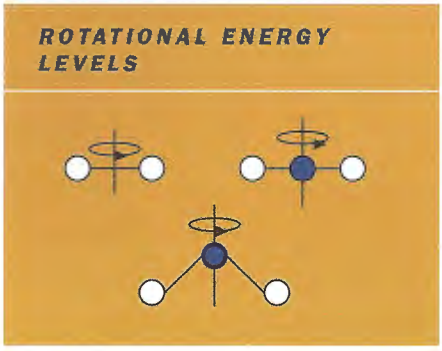
Translational transitions occur in the ultraviolet (UV) range of the spectrum.

Vibrational and rotational transitions occur in the spectrum from short infrared to long infrared.

This is why testing is very important.

INFRARED AND MOLECULAR INTERNAL ENERGY

A molecule increases its energy only when it absorbs a passing photon that has the same frequency and phase. This is how curing and drying occur in infrared heating processes.



MOLECULAR ROTATION

Changes in rotational energy levels take the least amount of energy. Rotational lines are found in the long infrared region (>20 μm). In liquids or solids, these lines broaden into a continuum due to molecular collisions and other interactions.

MOLECULAR VIBRATION

Atoms in a molecule are subject to a number of different vibrations. Vibrations fall into the two main categories of stretching and bending. Vibrational energy levels are found in the medium infrared region (between 1.5 μm and 20 μm). Water and glass absorb energy above 2 μm.

Stretching

Stretching consists of vibration along the central axis, which changes the distance between the atoms.

Bending

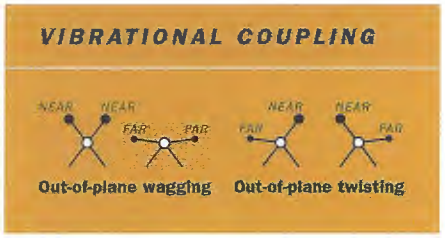
Bending consists of a change in the angle between two bonds.

VIBRATIONAL-ROTATIONAL BONDS

Changes in vibrational energy may be accompanied by rotational transitions. These are called vibration-rotation bonds. Therefore, the infrared regions that affect these molecules are from the medium infrared to the long infrared regions.

VIBRATIONAL COUPLING

When a single central atom joins vibrating bonds, vibrational coupling can occur. Coupling between a stretching vibration and a bending vibration occurs if the stretching bond is one side of an angle varied by bending vibration. Vibrational coupling energy changes occur in the short infrared region (between 10^{-2} μm and 1.5 μm).



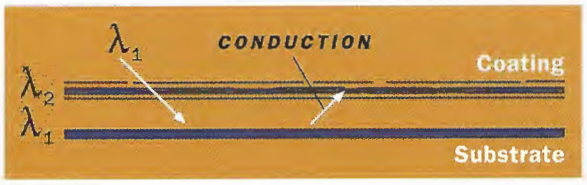
THEORY OF INFRARED ABSORPTION

IR radiation does not have energy to generate electronic transitions as seen with ultraviolet (UV). Absorption of IR only affects substances with small energy differences, or in the vibrational and rotational energy states. For a molecule to absorb IR, the vibrations or rotations within a molecule must cause a net change in the dipole moment of the molecule. If the frequency and phase of the energy radiated corresponds with the vibrational or rotational frequency of the molecule, the energy will be absorbed. The amplitude of the molecular vibration increases causing the substance to increase in temperature.

ABSORPTION

Materials absorb at different wavelengths (λ).

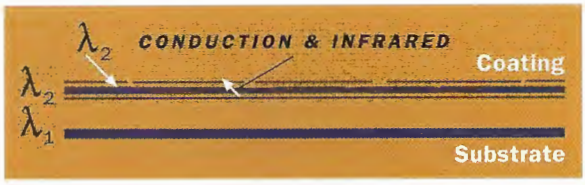
In the figure below, λ_1 represents the wavelength of the emitter and a substrate of a particular material with absorption characteristics whose molecular bonds are affected at a maximum level by the wavelength represented by λ_1.



λ_2 represents a different wavelength. The coating's molecular bonds are affected by λ_2.

λ_1 passes through the coating and adds energy (heats up) to the molecular bonds of the substrate. The coating is cured by conduction, effectively from the inside to the outside or from the bottom up.

In the figure below, λ_2 represents the wavelength of the emitter and a coating of a particular material with absorption characteristics whose molecular bonds are affected at a maximum level by the wavelength



represented by λ_2. λ_1 represents a different wavelength. The substrate's molecular bonds are affected by λ_1. λ_2 heats the surface of the coating and adds energy (heats up) to the molecular bonds of the coating with infrared. The coating is cured by direct infrared and conduction.

CONVECTIVE AND CONDUCTIVE PROPERTIES OF INFRARED

While an infrared emitter is heating an object, certain molecules in the air surrounding the object are also absorbing the infrared energy. This causes convection. Also, as the object is heated, it is losing heat due to losses from the object being hotter than the air. This heat transfer is increasing the temperature of the air causing convection. Also, there is conduction on the surface of the part. Because this process contains convection, conduction, and infrared, the entire object has the opportunity to be heated over its entire surface. Thus, line of sight problem is overcome. Each wavelength of infrared energy has a convective to radiant energy ratio. Short wavelength infrared has the lowest and long wavelength has the highest ratio.

INFRARED-RELATED DEFINITIONS

Planck's law/Planck's distribution:
(blackbody emissive power distribution)

1. The emitted radiation varies continuously with wavelength.
2. At any wavelength the magnitude of the emitted radiation increases with increasing temperature.
3. The spectral region in which the radiation is concentrated depends on temperature, with comparatively more radiation appearing at shorter wavelengths as the temperature increases.
4. A significant fraction of the radiation emitted by the sun, which may be approximated as a blackbody at 5800°K (9980°F), is in the visible region of the spectrum. In contrast for T≤800°K (980°F), emission is predominately in the infrared region of the spectrum and is not visible to the eye.

View factor:
Also: configuration factor, angle factor, shape factor, diffuse view factor.

The fraction of radiation leaving a surface area in all directions that is intercepted by another surface area.

Wein's displacement law:

For a blackbody, the product of the wavelength corresponding to the maximum radiancy and the thermodynamic temperature is a constant, Wein's displacement law constant. As a result, as the temperature rises, the maximum of the radiant energy shifts toward the shorter wavelength (higher frequency and energy) end of the spectrum.

Flux:

Amount of energy (watts) per square inch of emitter. Watts density.

Stefan-Boltzman Law:

Calculates the maximum flux, which may be emitted from a surface at the absolute temperature of the surface. Thermal radiation flux is proportional to the fourth power of the temperature.

$$q \propto T^4$$

For convection, the heat flux is directly proportional to the temperature.

$$q \propto T$$

Emissivity:

Property that indicates how efficiently the surface emits compared to an ideal radiator (blackbody). Radiative efficiency.

Blackbody:

Perfect absorber. Emissivity = 1

Q&A ABOUT INFRARED

IS ELECTRIC IR MORE EXPENSIVE TO OPERATE THAN GAS IR OR CONVECTION?

Due to the power and thermal efficiencies of the equipment, electric IR can be very competitive. In fact, electric may appear to be 4 times higher per KW or BTU and still have competitive operating costs.

WHEN COMPARING GAS CONVECTION AND ELECTRIC IR, WHICH IS THE MOST COST EFFECTIVE CAPITAL INVESTMENT?

Electric IR is the most cost effective capital investment. The typical electric IR oven is 10% to 20% less than a comparable gas convection oven.

WHAT IS THE PAYBACK PERIOD FOR AN IR OVEN?

Typically the payback period is one year.

HOW SHOULD I EVALUATE THE "REAL" COST OF AN INFRARED OVEN?

In order to get a "real" picture of the impact of an infrared oven, one must evaluate the purchase based on what it costs to produce each part. Capital equipment price, energy costs, down time, maintenance, labor, overhead, floorspace, and so on must be figured for each technology being considered and then divide that total by how many parts can be produced in a given time frame. The results can be astounding!

ARE ELECTRIC INFRARED OVENS SAFE?

Yes. There is no chance of fuel explosions. There is no production of CO, SOx or NOx on site. While short wave ovens are extremely hot, medium and long wave length ovens are as safe as your electric space heater at home. Most of the heat is contained within the oven so workers are more comfortable working near the oven.

WHAT INFORMATION WILL I NEED TO PROVIDE TO DETERMINE IF MY PROCESS IS A GOOD CANDIDATE FOR INFRARED?

Your Blasdel representative will need to know: part configurations, mass, type of substrate, temperature required, and the type of process. The available voltage, production rates, line speed and intended location for the oven will also be required. Upon receipt of this information and testing materials, our engineering team will compile a report and quotation for evaluation.

WHAT WAS THE FIRST INDUSTRIAL APPLICATION OF ELECTRIC IR HEATING?

In the 1930's Ford Motor Company pioneered the use of electric IR for curing automobile paint. Over the past 70 years tremendous advances have been made in emitters, application technology and controls. Computer controlled closed loop systems are commonplace for superior quality control.

CAN I PUT IR SECTIONS INSIDE OF MY CONVECTION OVEN FOR A BOOSTER SECTION?

Generally this is not recommended. They should be placed outside of the oven in the vestibule area. Blasdel IR sections need to be accessed from behind for element replacement. Good ambient air flow is important for maintaining an appropriate ambient air temperature for electrical components. Each case should be examined separately.

AS A JOB SHOP, I NEVER KNOW WHAT PARTS I WILL BE COATING. IS INFRARED FLEXIBLE?

Blasdel's adjustable infrared ovens are the most flexible you can buy. They have precise zoning controls that allow the user to turn rows off when not needed or have multiple temperature settings throughout the oven. The sides of the oven move in and out for varying widths of parts or racks. It is also possible to change the angle on the horizontal rows of this type of oven.

IF I JOB SHOP PAINT PARTS AND THE NEXT PART I BID IS TOTALLY DIFFERENT THAN WHAT THE OVEN WAS DESIGNED FOR, CAN THE OVEN BE USED?

This is one of the advantages of electric infrared ovens. If an Adjustable Width IR oven isn't flexible enough, the oven can easily be taken apart and reconfigured or added to so that the design is always right for the part. If the production requirements are increased, another length of oven can be positioned right next to the original oven.

IS IT TRUE THAT I CAN ONLY BAKE FLAT PARTS IN AN INFRARED OVEN?

Absolutely not. Especially in the case of a Blasdel infrared oven, complex shapes can be evenly cured due to the reflector design and containment of convection heat. Much of the heat transfer in a convection oven is due to conduction of heat through the part. The same principle applies to infrared.

CAN I ONLY USE IR AS A PREHEAT OR BOOSTER FOR CURING POWDER COATING?

Infrared may be used as a booster prior to a convection oven or for a full cure on many parts. Process testing can determine how much time would be required for a full cure compared to the convection specifications listed on the powder technical specifications.

ARE POWDER COATING QUALITY STANDARDS ON ADHESION, IMPACT RESISTANCE, CURE LEVEL, COLOR STABILITY AND HARDNESS CHANGED IF I CURE THEM WITH AN ELECTRIC IR OVEN VERSUS THE GAS CONVECTION OVEN I AM USING NOW?

The use of electric infrared ovens often improves quality. Impact resistance and hardness are often improved with no adverse effects on adhesion. Cure is achieved in much less time. Colors are likely to be more stable in the electric IR oven since the SOx and NOx found in a gas oven are not present in the electric oven to build up and yellow the powder. Gas infrared ovens are usually not recommended for powder coating because of lower operational temperatures.

HOW IS THE WAVELENGTH OF AN INFRARED EMITTER ADJUSTED TO BE MOST EFFICIENT FOR A PARTICULAR MATERIAL?

The wavelength is adjusted by controlling the emitter temperature. This is accomplished in electric infrared by controlling the voltage supplied to the emitter or by controlling the amount of time the emitter is on. Electric IR ovens have the highest degree of controllability compared to gas convection or gas IR ovens. As the temperature is increased, the wavelength is shortened, therefore every emitter has a wide range of wavelengths that it can produce.

WHEN COMPARING ELECTRIC IR AND GAS IR HEAT EMITTERS, WHICH OPERATE OVER A WIDER RANGE OF WAVELENGTHS AND TEMPERATURES?

Electric IR operates over a wider range of temperatures and wavelengths. Due to the construction of a gas emitter and the physics of burning gas, gas IR can only attain temperatures in the medium and long wave ranges. Electric IR emitters can produce short, medium or long wavelengths. It is important to use the correct emitter for the job to be cost competitive in buying the capital equipment.

WHAT IS THE AVERAGE LIFE OF AN ELEMENT?

Both the ceramic and COR generators are noted for exceptionally long service life. On average, one can expect about 10,000 hours, however much longer is not uncommon. Ceramic panel heaters with a higher thermal mass can achieve 20,000 hours under proper conditions. Quartz tubes and bulbs have a service life of approximately 5,000 hours. Proper temperature controls must be used to achieve good performance with any style of emitter. To operate with only an on/off switch is inefficient and causes tremendous thermal shock which dramatically reduces the element life.

HOW MUCH MAINTENANCE IS REQUIRED FOR A BLASDEL INFRARED OVEN? WHEN IS IT REQUIRED?

Maintenance for an infrared oven is no more involved than the care of a convection oven. Because it is simple, it is also easily overlooked. BEI recommends adding oven maintenance to the normal plant preventative maintenance plan with at least a complete annual checkup.

Control panel and oven terminal block connections should be tightened. Exhausts should be cleaned and checked for broken fan blades or other hazards. Make sure safety devices are present and working correctly.

Ceramic panel emitters require minimal maintenance since there are no reflectors to clean. They need to be checked for operation. Simply run at a setting high enough to see the internal coils glowing red. Non-operational areas will be black.

Very little maintenance is required for ceramic generators or COR generators as well. As above, check for operation by turning the oven on at a moderately high setting. Reflectors will need to be rebuffed, cleaned or dusted. Depending on the level of accumulated dirt and dust in your plant environment, the frequency may be more than annually. Accumulated dirt absorbs the IR heat and reduces radiant efficiency.

Quality problems that are attributed to the cure oven may be disguised in a convection oven due to daily fluctuations in performance whereas they would be easily identified and corrected in an infrared oven by following the simple maintenance checklist.

WHAT IS THE NORMAL DELIVERY FOR AN INFRARED OVEN?

Generally, the delivery is quoted as 6 to 8 weeks for "standard" ovens. Extremely large ovens are usually 8 to 10 weeks. Blasdel Enterprises works closely with their customers to coordinate shipping dates with customer's installation crews. We are also able to expedite orders for customers that need an oven in as little as a few weeks.

TYPICAL USES FOR BLASDEL OVENS AND CONVEYORS

PRODUCT	APPLICATION: POWDER COATING	LIQUID COATING	WOOD FINISHING	PLASTIC FINISHING	METAL FINISHING	MOISTURE DRY-OFF	THERMOFORMING	SHRINK WRAPPING
High Watt Density Ceramic Panel	●	●			●	●	●	●
Medium Watt Density COR Emitters	●	●		●	●	●	●	●
Medium to Low Watt Density Ceramic Emitters		●	●	●				
Quartz Tube Emitters	●	●		●	●		●	●
High Velocity Air Oven		●	●	●	●	●		
High Velocity Air Cooling Chamber (not heated)	●	●	●	●	●			
Electric Convection Oven		●	●	●	●	●		
Conveyors	●	●	●	●	●	●	●	●

Metals
- Degreasing
- Drying foundry molds and sand cores
- Moisture dryoff
- Expansion parts fitting

Electrical
- Drying motors
- Drying electrical varnishes
- Soldering

Foundries
- Preheating molds

Plastics
- Softening plastics for pressure and vacuum forming
- Drying and curing sheets
- Heat sealing
- Prosthetics
- Compression molding

Adhesives
- Drying

Packaging
- Heat shrink

Wood
- Curing catalyzed materials
- Drying fillers, lacquers, toners, varnishes, sealers
- Drying printed finishes
- Setting adhesives

Textiles
- Setting flock
- Silk screening

Paper and Printing
- Drying inks
- Silk screening

Glass
- Silk screening
- Drying mirrors
- Preheating plate glass

Rubber
- Curing
- Curing latex
- Heating rubber adhesives

Space Heaters

BLASDEL

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CUSTOM HEAT AND MOTION TECHNOLOGIES

IREA Infrared Equipment Association

FOR MORE INFORMATION, CALL 800-661-3213 OR FIND US ON THE WEB AT www.blasdel.net.