Mechanical Association Railcar Technical Services

Technology Advancement In Coating Curing On Railcars

CCI Thermal Technologies INC.

Infrared

Processing

Innovative

Efficiency

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Presentation Overview

Infrared

How does it function

Infrared curing of coatings

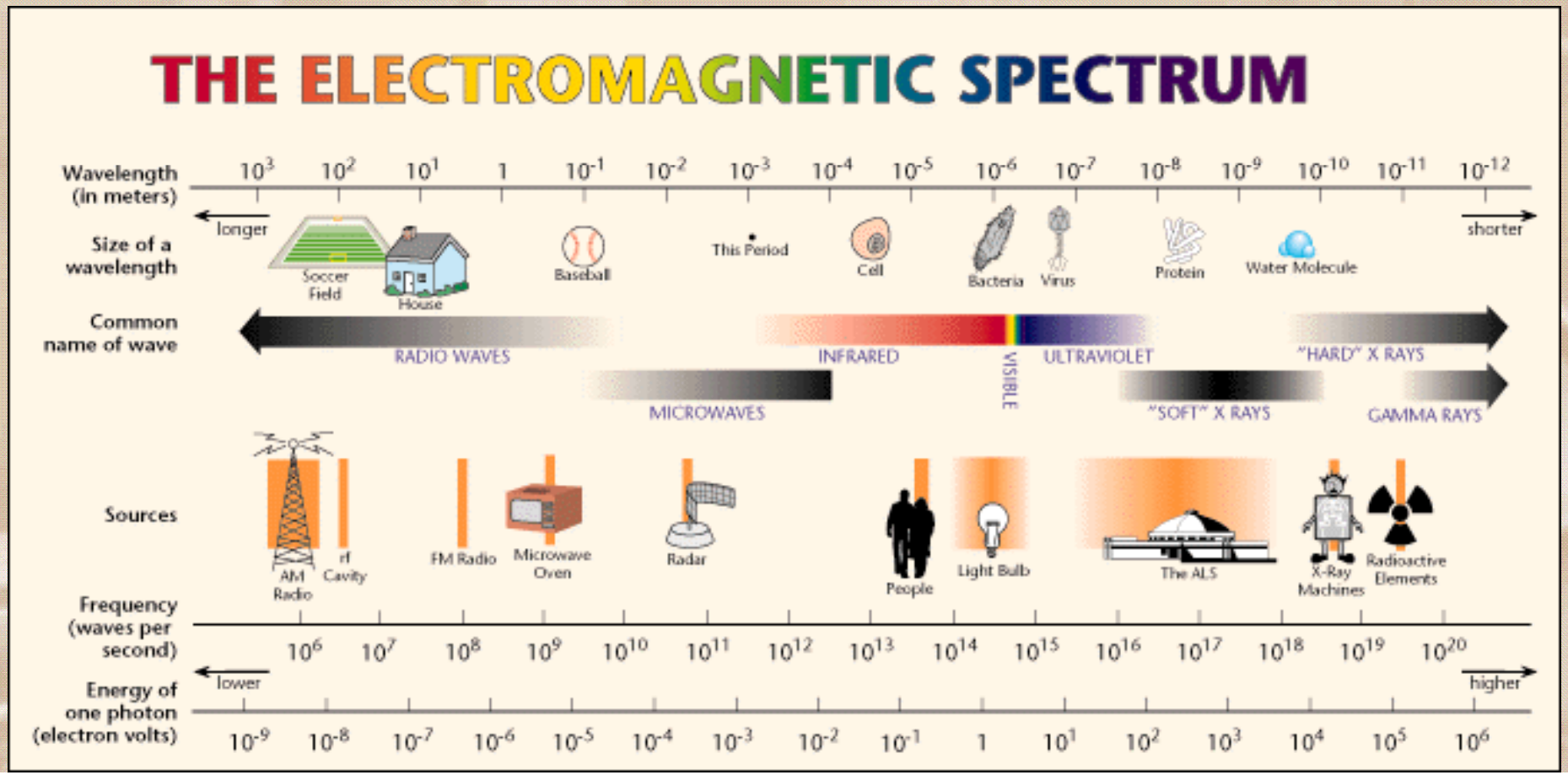
What is the difference between Infrared and Convection

Some Sample Processes

Specific Example Process

Infrared is a form of Electromagnetic Energy

- pulses or waves that can be measured both electrically and magnetically
- pulses travel at speed of light
- wavelength determined by surface temperature of emitting surface



Infrared

Generally categorized into three wavelengths

- **Short wavelength emitters:**
  - Electric tungsten/halogen/tube (2200° F to 4298° F)
- **Medium wavelength emitters:**
  - Electric quartz (1,300° F to 2200° F)
- **Long wavelength emitters:**
  - Catalytic gas emitters (500° F to 1,050° F)
  - Electric ceramic/coiled sheathed resistance element (570 ° F to 1,300 ° F)

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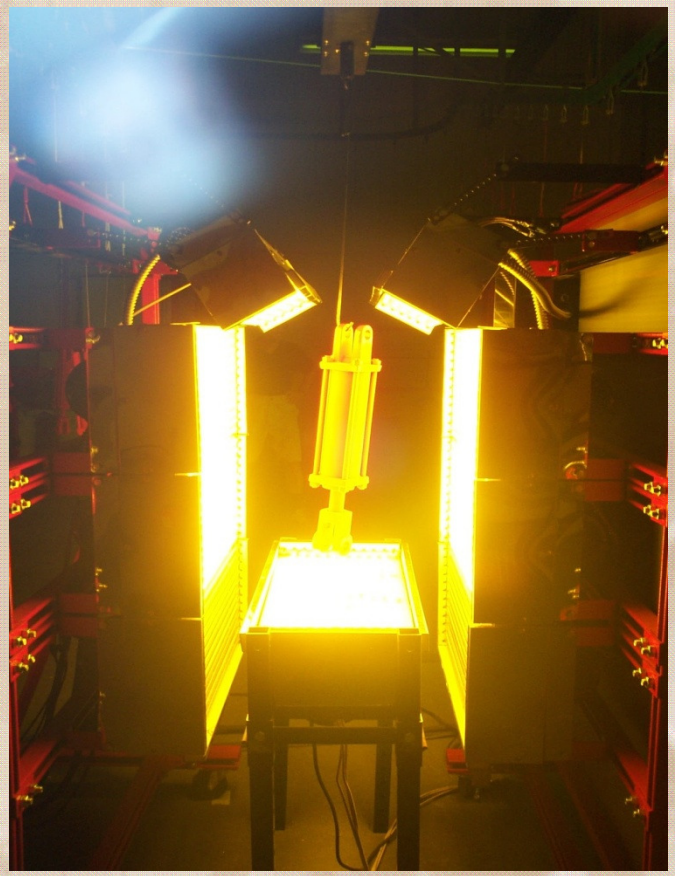
Infrared Curing of Coatings



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How it works

Direct transmission of radiant energy from the emitter to the part surface

- –energy is absorbed into the resin component of the coating
- –some of the energy emitted will be reflected off of the part surface
- –some is transmitted or conducted into the substrate

Energy is transferred into the coating film at a rate greatly in excess of that possible with a convection process. With certain short wavelength technologies the transfer rate can exceed the substrate's ability to behave as a heat sink and conduct the energy out the back of the coating

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Direct transfer of energy creates an immediate reaction in the coating quickly elevating the coating temperature

–Solvents are evaporated before the coating has opportunity to skin over

No Flash-Off requirement on metal substrates

–Cross-linking at the molecular level begins quickly as the coating rapidly enters the catalyst operational temperature range

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Direct transfer of energy creates an immediate reaction in the coating quickly elevating the coating temperature

- Coating can be run at the upper end of the catalyst operational temperature which allows for dramatically increased rate of cross-linking shortening the overall process time

- Short process time, the coating receives the energy at a rate that greatly exceeds the rate possible with convection impingement

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Differences between Convection and Infrared

Convection Curing

-transfer method is impingement

Efficiency of energy transfer depends on boundary layer reduction (velocity and turbulence of air stream on part surface)

-transfer medium is typically air

Not a dense material by nature so has poor thermal conductivity characteristics and will only carry so much energy per unit of mass

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Convection Curing

-Muti-step energy transfer

Energy from gas or electricity to burner/heat exchanger - to air - to entire mass of part - and eventually to coating

-Involves significant exhaust and air movement equipment

Typical exhaust for gas oven is 10% to 15% of oven volume per minute

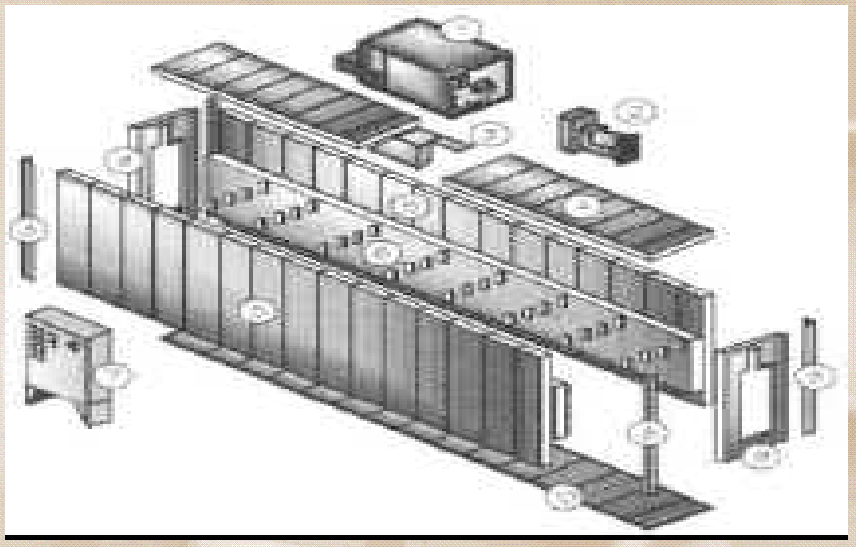
Typically need blowers for:

containment

recirculation

exhaust

burner package



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Convection Curing Strengths

- The principle is easily understood
- Coatings Manufacturers cite “air baking” recommendations
- Perceived to be low cost capital equipment
- Relatively easy to configure multi-pass configurations

Convection Curing Issues

- Air stream impingement is inefficient
  - longer process times
  - increased energy usage
  - possible contaminant deposition
  - associated blower/filter operating costs
  - onsite assembly costs

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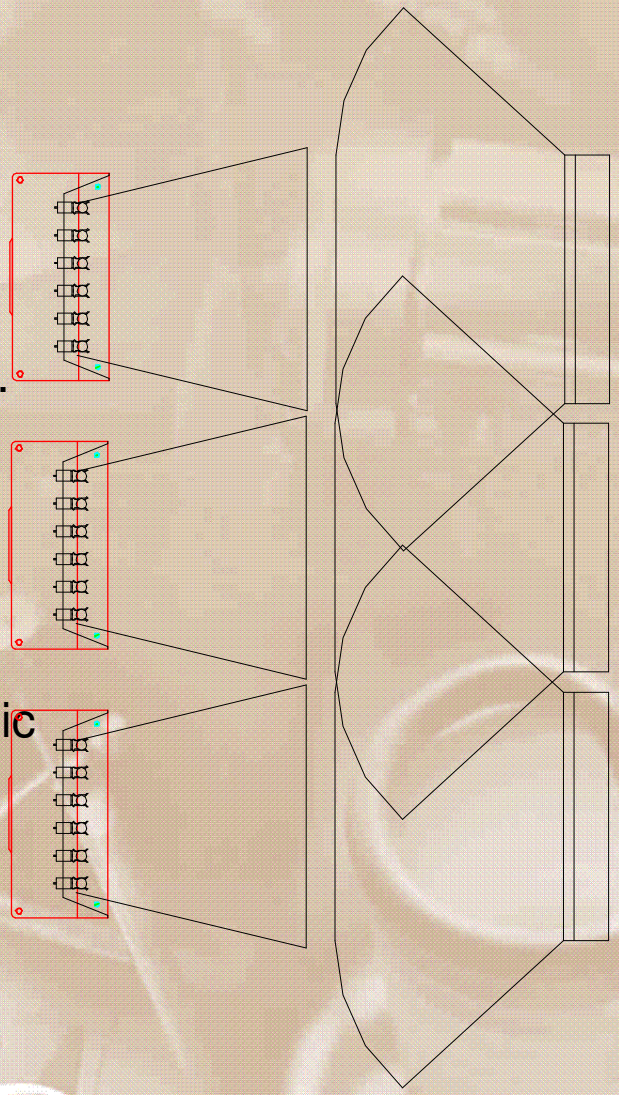
Infrared Curing

transfer method is radiant electromagnetic pulses

-Does not require an additional transfer medium to carry the energy to the object (i.e. air is transparent to IR and is not heated by the electromagnetic pulses)

transfer medium is direct molecular vibration of coating resin molecules absorbing the electromagnetic pulses



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Sensitivities of Infrared Processing

Patterning

- –Even distribution of energy transfer
- –Range to Object
- –Intensity of energy transfer (Technology Type and Infrared Density)

Turn down during line stoppages

- –Rapid output adjustment
- –Recirculated air-streams

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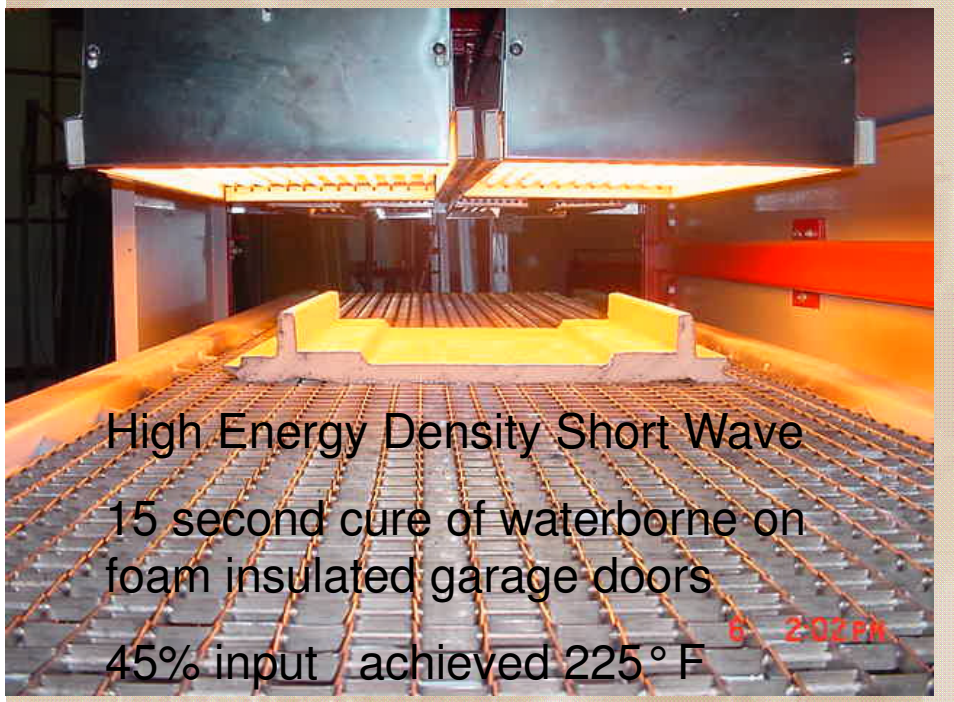
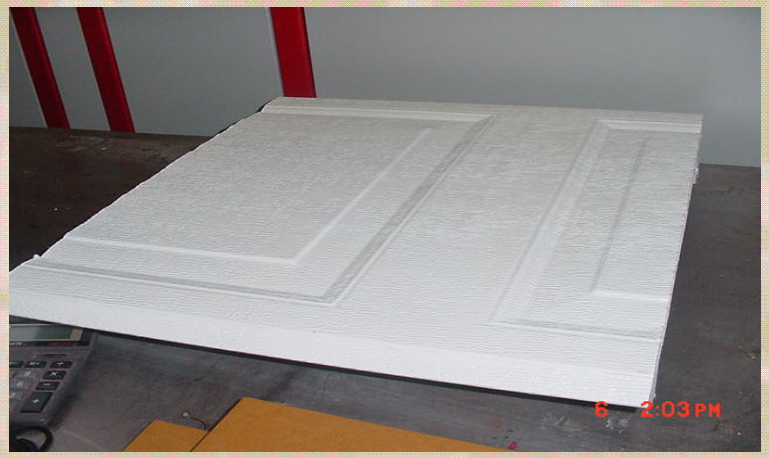


High Energy Density Short Wave

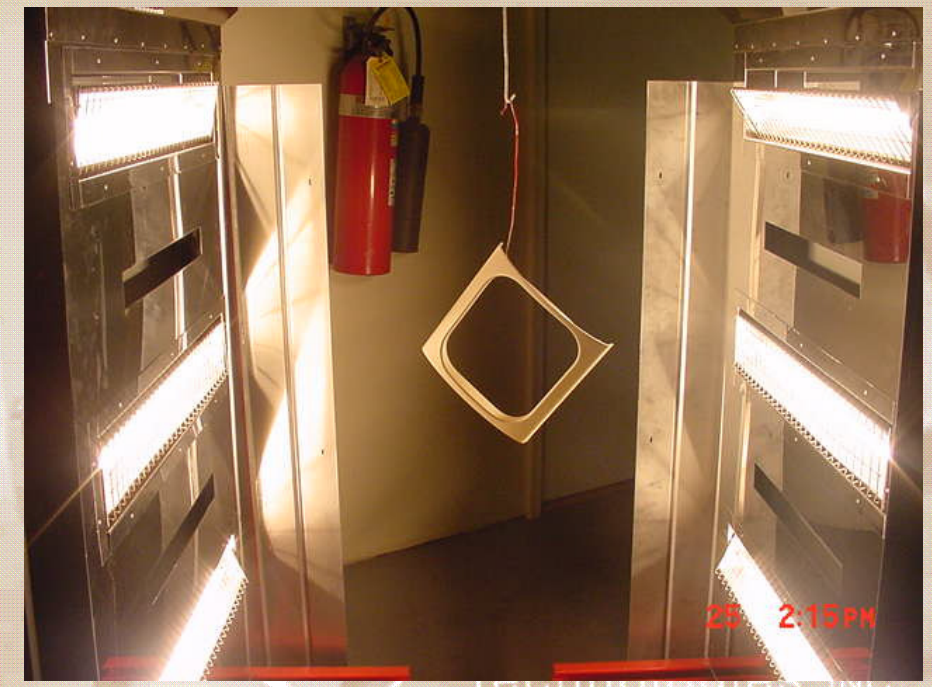
15 second cure of waterborne on foam insulated garage doors

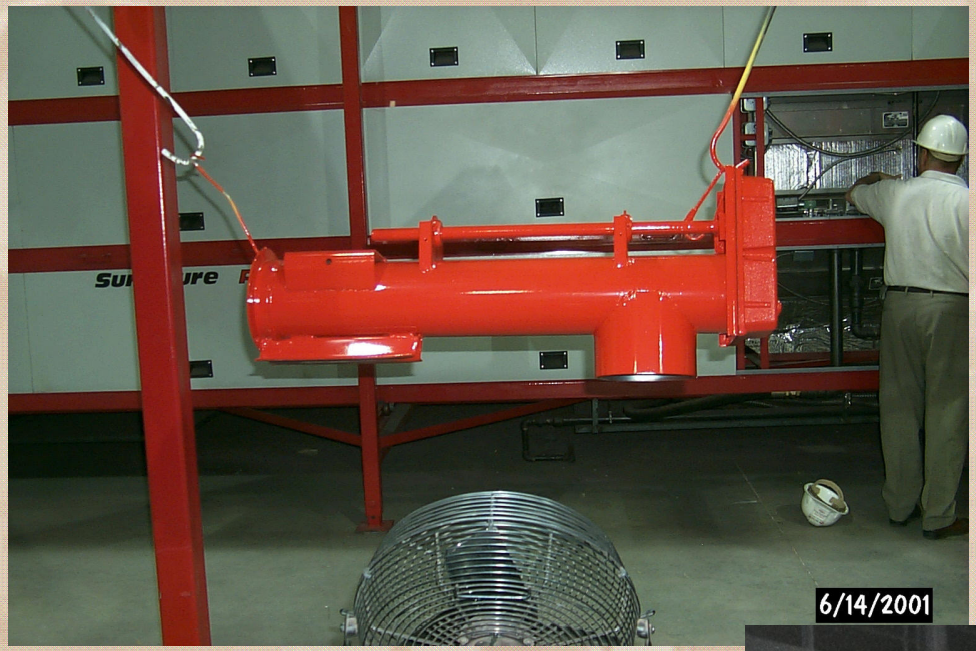
45% input achieved 225° F



Low Energy Density Short Wave

3 minute exposure cures waterborne on automotive plastic trim parts (170° - 180° F)





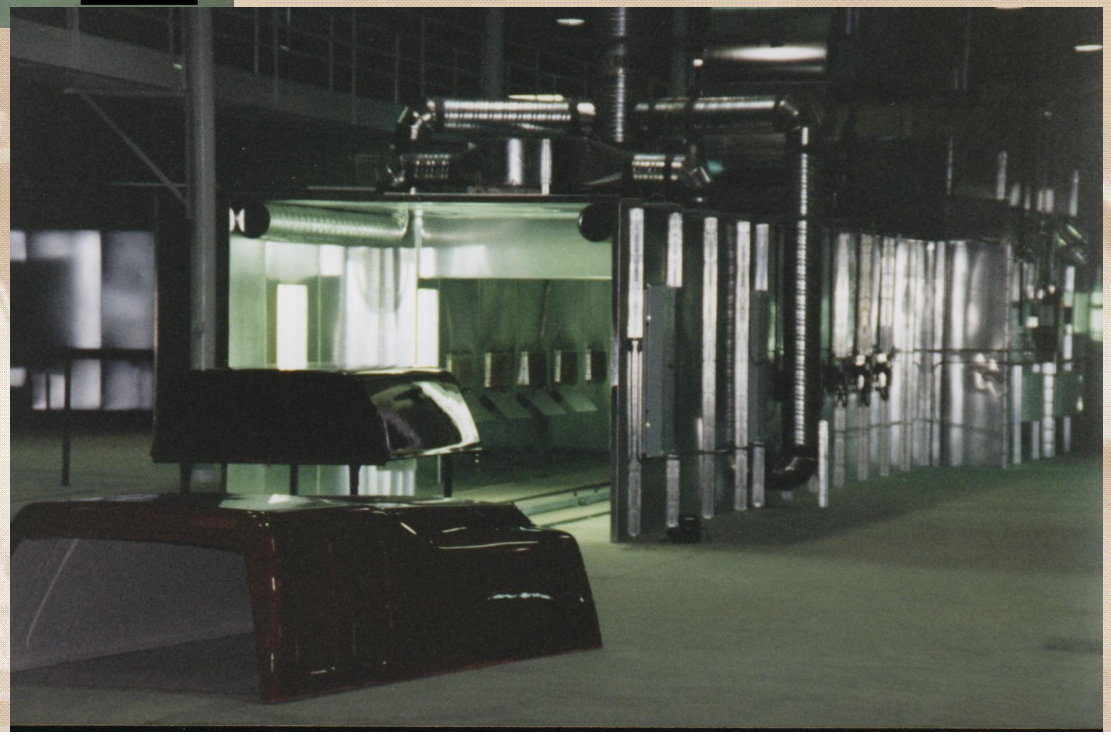
Wet Coat on Auger Assemblies

Thermal limit 184° F

Urethane cure to handle 2 ½ minutes

Technology is Long Wavelength

Energy Density 900 Btuh/ft³



Wet Coat on Fiberglass

Thermal limit 158° F

Base/Clear 2K cure in 12 minutes

Technology is Long Wavelength

Energy Density 249 Btuh/ft³

Low Energy Density Wet Coat Curing on Tank Cars

Technology is Long Wavelength

Energy Density 146 Btuh/ft^3

Epoxies and Urethanes

Cure time 60 minutes

System Details
Two curing chambers ~ 2,900,000 Btuh max capacity each
Cure cycle 60 minutes with terminal temperature of ~ 145°F
Input setting ~ 48% = 1,400,000 Btu per tank car cure cycle

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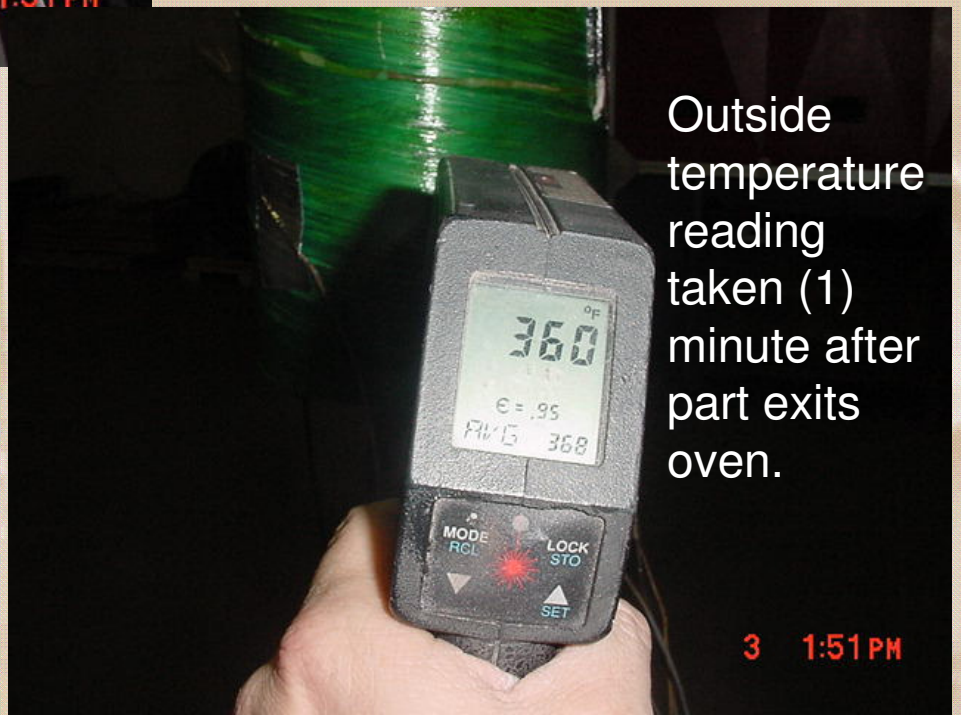
Inside temperature reading taken (1) minute after part exits oven.

Composite Curing

8 minute process on 5/8 " winding

Energy Density 1600 Btuh/ft^3

Technology is Long Wavelength



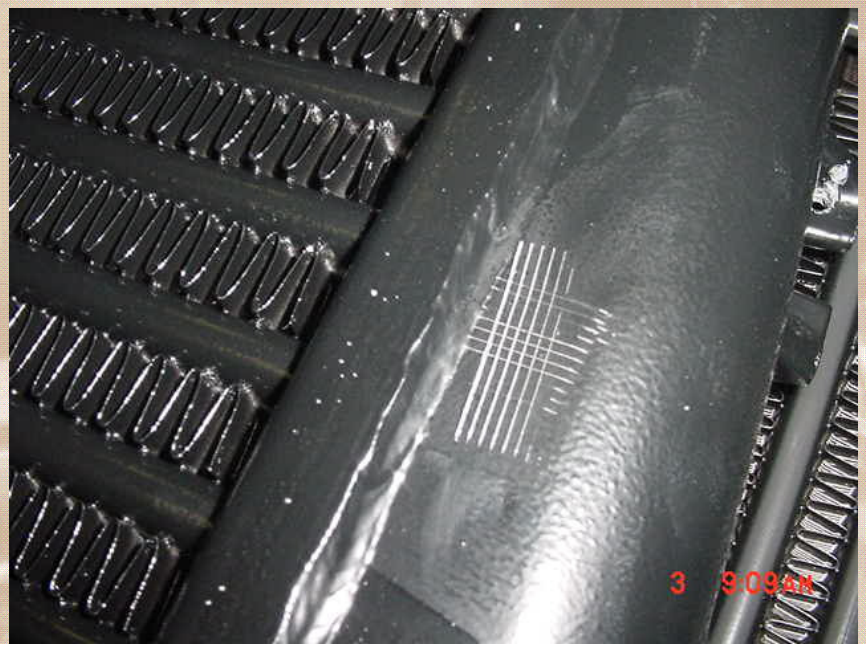
Outside temperature reading taken (1) minute after part exits oven.

Powder Cure on Simple Geometry

2 minute full cure

Catalytic Gas IR at 80% input

Energy Density 2600 Btuh/ft^3



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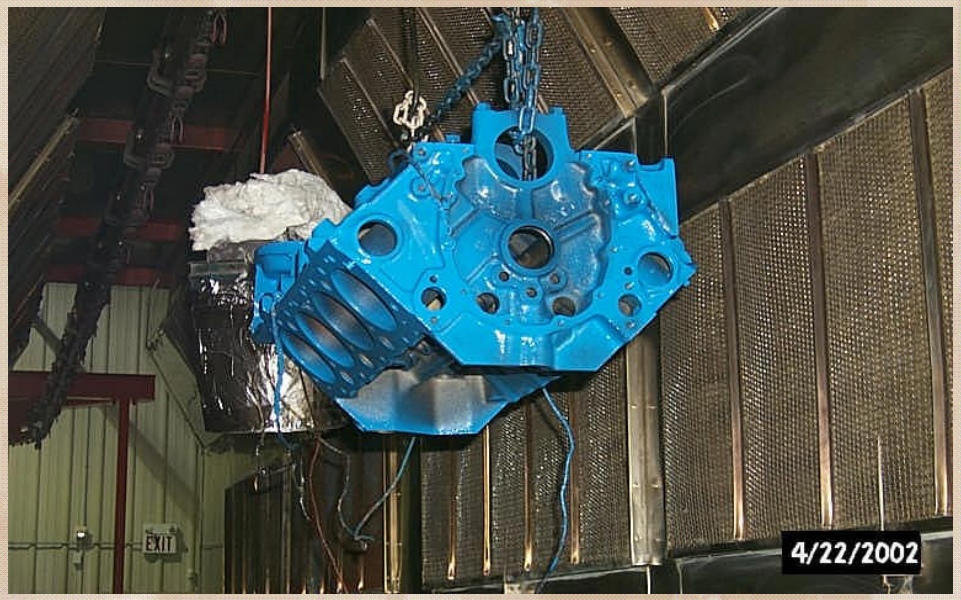
Powder Cure on Complex Geometry

2 ½ minute Gel

12 minute full cure

Catalytic Gas IR at 100% input

Energy Density 1800 Btuh/ft^3



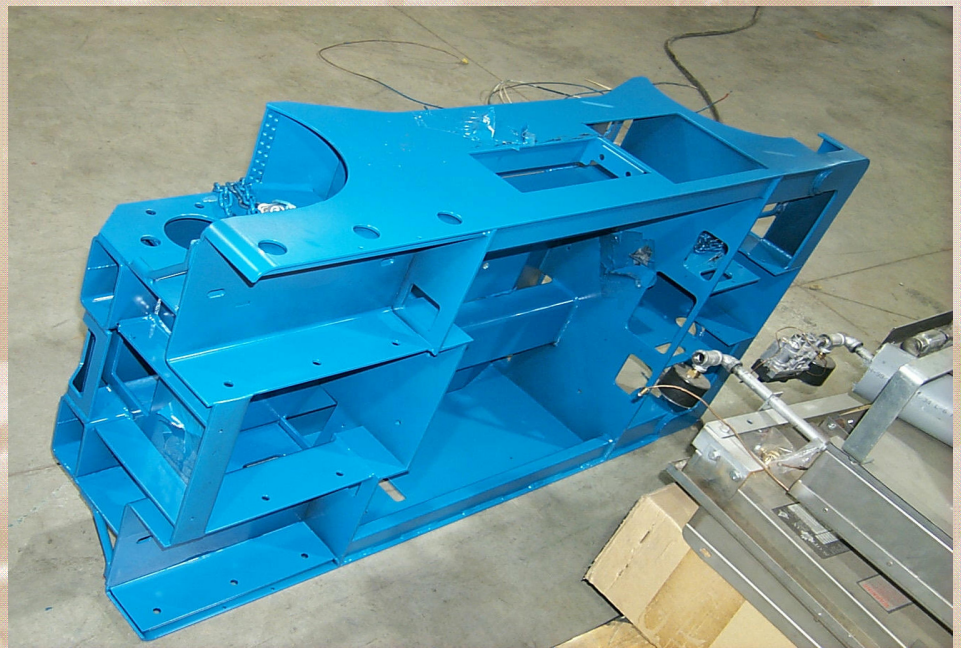
Powder on Engine Block

Long wavelength

Gel 8 minutes

Cure 13 minutes

Energy Density 2100 Btuh/ft^3



Powder Cure on Frame Assembly

12 minute cure

Energy Density 1800 Btuh/ft^3

Technology is Long Wavelength

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Benefits of Infrared Processing

Short Process Time

Energy Efficiency

Inherently Clean

Environmentally Friendly

Additional Significant Benefits of Infrared Processing of Railcars

No flash-off station required for new plant designs

- curing chamber can flash directly to spray booth exit door set

Catalytic Gas Infrared emitters can be sourced with Class One, Division One, Group D hazardous environment certification by F.M., CSA, ATEX/CE

- **can be legally installed directly in spray booths** (for repair/refinish facilities)

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Comparison of Convection Process versus Infrared Process

Part opening	4’ w x 11’h	
Line Speed	6 fpm	
Parts	cylindrical steel assemblies (typically 10 gauge steel cylinders up to 24” diameter racked three units high, includes some 5/8” attachment brackets and reinforcements)	
	Mass being processed (for convection purposes) is 800 pounds per minute	
Hours of Processing	6.5 hr per shift	
Hours of Standby	1.5 hr per shift	
Number of Shifts per Day	1	
Utility Costs	Gas	$ 11.84 per 1,000,000 Btu
	Electrical	$ 0.052 per kW

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	Catalytic Gas Infrared Oven	Convection Oven
Heated Length	45’ = 7 ½ minutes	228’ = 38 minutes
Btuh (max) Input	3,456,000 Btuh	5,800,000 Btuh
Number of Zones	4	1
Average zone Input	83%	90%
Exhaust	4,000 cfm (2 x 2hp)	1,600 cfm (1 x 2hp)
Recirculation	5,000 cfm (1 x 5hp)	60,000 cfm (2 x 20hp)
Burner blower	N/A	(1 x 1hp)
Air Knives	N/A	(2 x 5hp)
Total blower horse power	9 hp	53 hp

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	Catalytic Gas Infrared Oven	Convection Oven
Cost/Month start-up	$ 219.91	$ 769.36
Cost/Month process	$ 5,333.97	$ 11,019.92
Cost/Month standby	$ 192.22	no standby
Monthly Total Cost	**$ 5,747.10**	**$ 11,789.28**

Efficiency visible from our example:

Infrared oven uses 49% of the energy that the convection oven requires

Infrared oven occupies 20% of the floor space required by the convection oven

Infrared oven moves 8% of the air that the convection oven circulates

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Testing Proves Processes

Our Greensburg facility has the world's definitive Infrared test centre.