Advanced Powder Coating Systems for Military Applications

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Overview

- Background
- What is Powder Coating?
- Benefits of Powder Coating
- Disadvantages to Powder Coat
- Wet vs. Dry
- LTCPC
- Advanced LTCPC
- UVCPC
- Conclusions

Background

- DoD spends billions of dollars annually on protective organic coatings
  - Hexavalent chrome primer use still widespread
  - Contains or requires volatile solvent use
  - Significant hazardous waste costs (Recordkeeping, permitting, etc)
  - Hazardous materials pose risks to both human health and the environment
  - Process times are measured in hours to days
  - Partially used paint is costly and adds to the overall waste burden

Background

- Temperature-sensitive aluminum, magnesium and composites are used throughout DoD for high durability & low weight
- These materials cannot withstand the high (> 350°F) temperatures of traditional powder coatings
- Newer coatings types are needed to reduce the environmental and ESOH burden
- Advances in powder coatings offer solutions to these issues

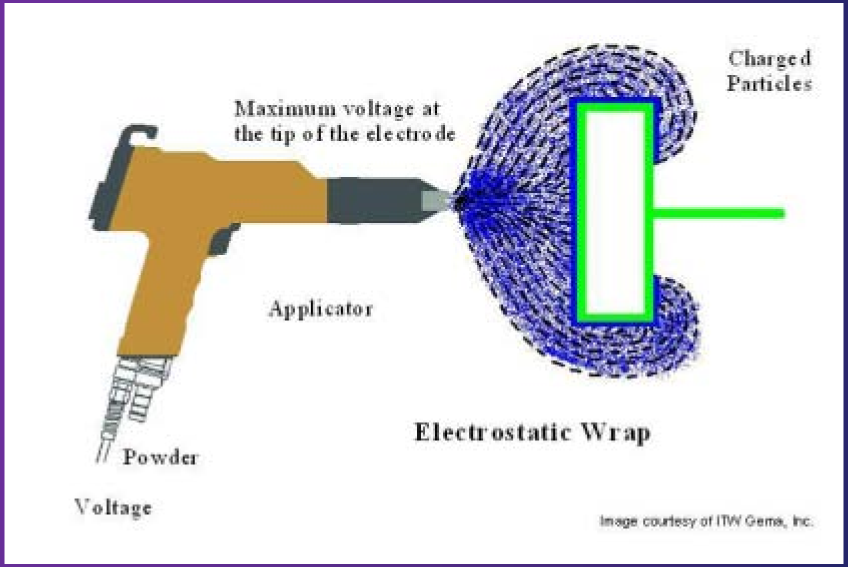
What is Powder Coating?

A coating material applied in a solid state which either melts during the application process, or while at elevated temperature in an oven.

Contrast this to legacy wet coating materials which are borne in solvent/aqueous solutions that must evaporate in conjunction with curing.

What is Powder Coating?

- Application Process
  - Most powder is applied using a electrostatic gun featuring a high-voltage electrode at the front end. The electrode imparts a charge to the powder particles and those particles are attracted to the electrically grounded part. Other gun types exist, however, the electrostatic gun is the most used.
- Curing
  - Once applied, powder must be heated to melting. Curing then takes place by heat, light, or both



Benefits of Powder Coat

- Elimination of Volatile Organic Compounds (VOC)
- Elimination of Hazardous Air Pollutants (HAP)
- Reduction/Elimination of ESOH Concerns
  - Elimination of hexavalent chromium
  - Elimination of free epoxide and isocyanate reactives
- Reduction of Hazardous Waste
  - Powder coating generally classified as non-hazardous
- Process Efficiency
  - Single component, solvent free material, no pot life limitations
  - Quick cure times
  - Quick equipment prep and clean-up
  - Transfer efficiencies as high as 95% versus 50 – 60%

Disadvantages of Powder Coating

- Previous ways of thinking about powder:
  - Processing temperatures too high
  - Powder coating is only a barrier coating with no corrosion protection if compromised
  - No way to perform field repair
  - Component size limited to largest oven size available
  - Gloss under 10 @ 60° incidence was virtually impossible
  - Faraday Cage limitations

Today, these are no longer limitations

Wet vs. Dry

	Traditional Primers & Topcoats	Waterborne Primers & Topcoats	Traditional Powder Coatings	Low-Temperature Cure Powder Coatings	Ultraviolet Cure Powder Coatings
Compatible Substrates	Steel, Aluminum, Magnesium, Composites	Steel, Aluminum, Magnesium, Composites	Steel	Steel, Aluminum, Magnesium	Steel, Aluminum, Magnesium, Composites
Advantages	Solvent flash-off leaves a uniform coating free of blemishes	VOC and HAP content are significantly reduced relative to traditional primers and topcoats	Single application coating; No VOC or HAP; fast cure, 15 minutes	Single application coating; No VOC's or HAP's; fast low temp cure ~30min@250F; enhanced corrosion inhibitors; improved transfer efficiency; primer application eliminated	Single application coating; No VOC's or HAP's; Melt and flow in under 20 seconds with IR, cure in 4 seconds with UV; Not limited to size of oven; enhanced corrosion resistance; can be applied almost anywhere
Disadvantages	Environmental burden of high VOC and HAP production and release; hexavalent chromium; free isocyanates; up to 72 hrs "dry to fly" time	Longer cure times than traditional primers and topcoats; still has VOC and HAP; hexavalent chromium; up to 72 hrs "dry to fly" time; solvents still used to clean system	High temp cure >350F; Al and Mg substrates compromised; Can't be applied at field level due to high curing temperature requirement	Currently, only proposed for depot production environments; part sizes limited by oven size; 250F temperature still too high for some components	Line of sight cure; use of Hg containing UV lamps

LTCPC

- Early Low Temperature Cure Powder Coating (LTCPC)
  - Outcome of SERDP (PP-1268) and ESTCP (WP-0614) projects
  - Resin based on a "superdurable" polyester backbone
  - Used TGIC to cure at 250 – 280°F for 30 minutes
  - Contains corrosion inhibitors
  - Difficult to get an in-specification semi-gloss, no flat available
  - In service mostly with US Navy on GSE
  - Unlikely to pass CARC testing if submitted

Advanced LTCPC

- Advanced Low Temperature Cure Powder Coatings
- One example currently being marketed:
  - Resin system based on interpenetrating networks
  - Current version can cure below 300°F in 15 minutes
  - Contains corrosion inhibitors as required for the application
  - Uses tight particle size range lightfast inorganic pigments
  - Available in gloss, semi-gloss, and camouflage flat colors
- Performance exceeds MIL-PRF-85285 & MIL-PRF-23377
  - Essentially impervious to chemicals like Skydrol LD-4
  - Forward impact flexibility greater than 160 in-lb
  - B117 corrosion resistance > 3000 hours on scribed Al substrate
  - Mandrel bend elongation > 31%
  - Dry tape adhesion 5B
  - High likelihood of passing CARC chemical agent testing

Advanced LTCPC

- Examples of Advanced LTCPC in FED-STD-595C Black 37038, Green 34088, Gray 36173, and Sand 33303

Advanced LTCPC

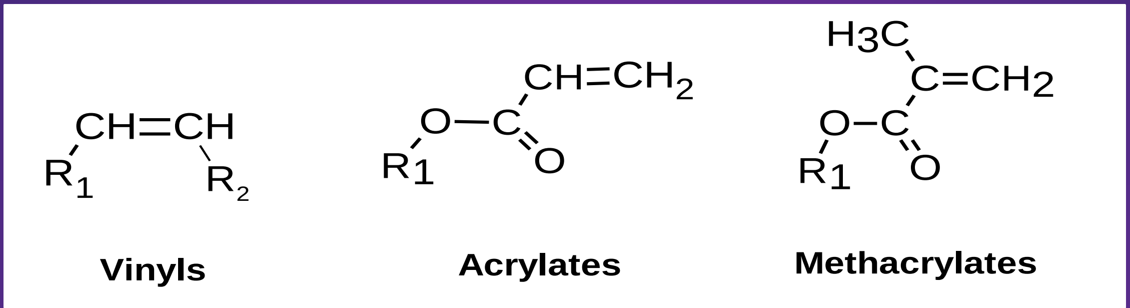
- Advanced LTCPC is currently being applied to the L-3 Communications Rover® 6 transceiver set

UVCPC

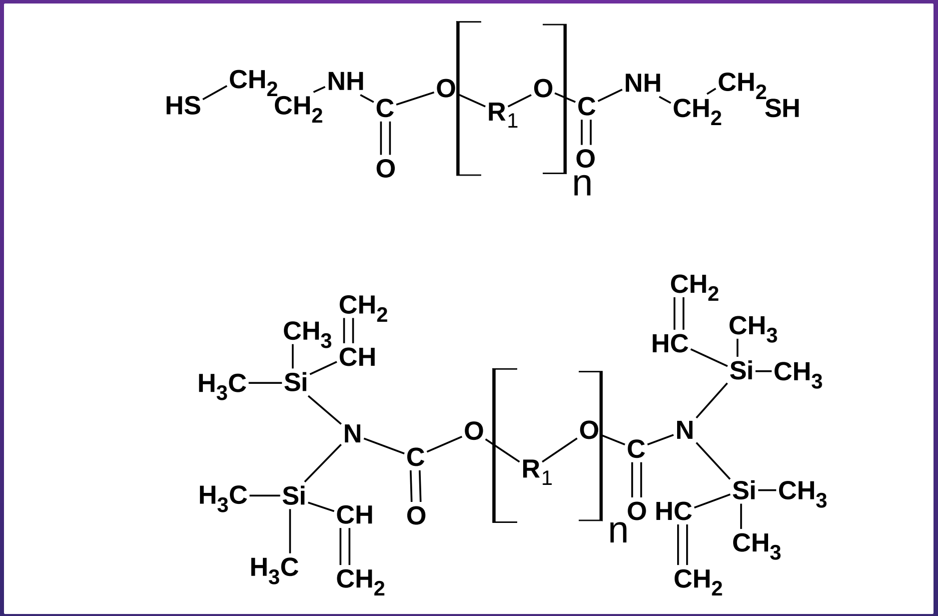
- Ultraviolet Cure Powder Coatings (UVCPC)
- Can be virtually any polymer matrix used for organic coatings
- The common denominator is the presence of a UV light reactive species on/in the polymer matrix

UVCPC

Most commonly these are vinyl, acrylate or methacrylate groups



But other novel types are being introduced based on thiol-ene chemistries

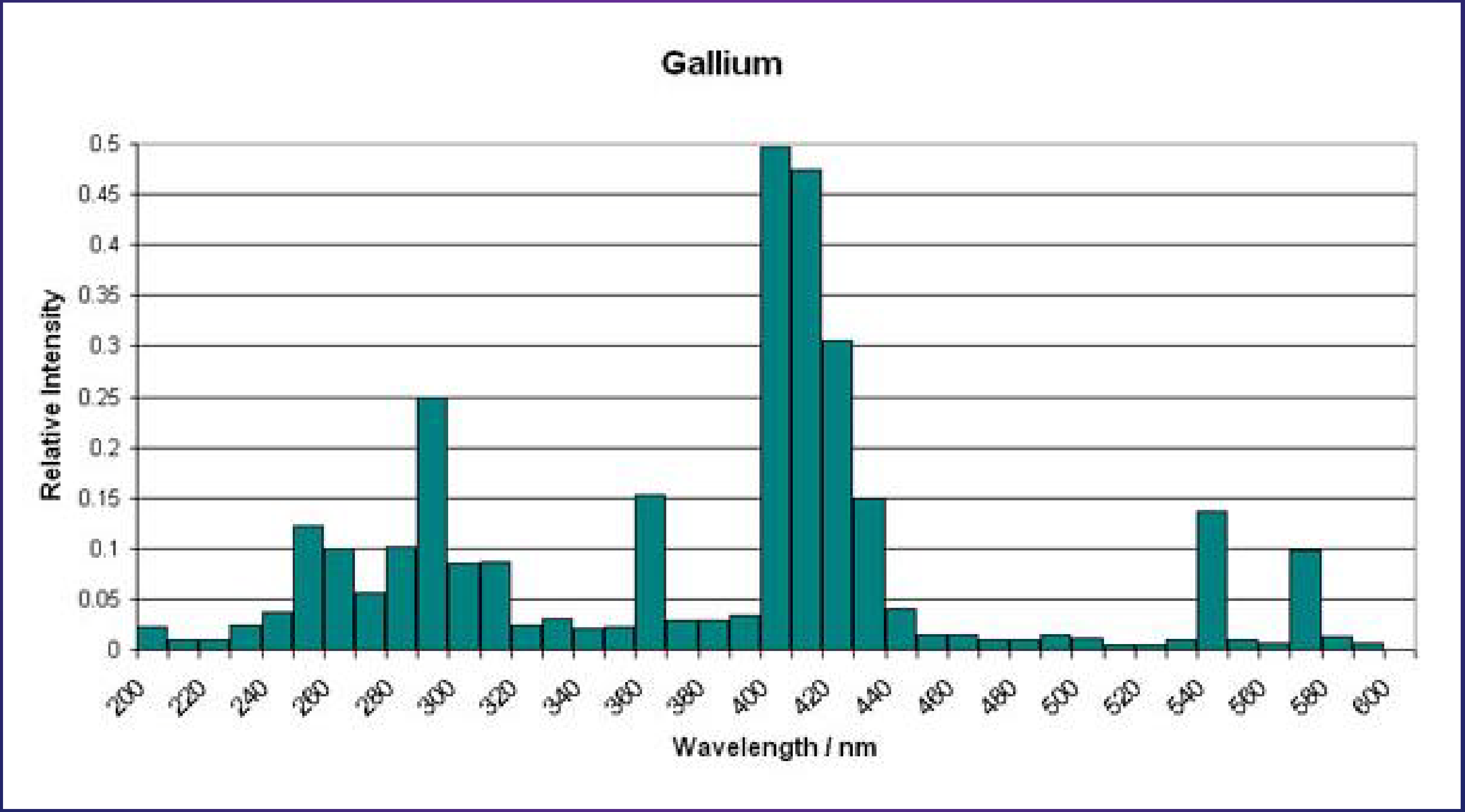


UVCPC

- UVCPC after being applied, needs to be melted before curing
- This can be done with a shortwave IR system or oven

UVCPC

- UVCPC are cured extremely fast by ultraviolet light



Typical UV spectra (gallium doped lamp)

UVCPC

- UV light can come from several sources:
  - Fusion ® microwave induced (left)
  - Nordson ® conventional arc (right)
  - Air Motion Systems ® LED (bottom)

UVCPC

- Advantages of UV Powder Coatings:

= Combined advantages of ……

UV-Curing

- very fast
- low energy demand
- ok on heat sensitive substrates
- low floor space requirements

+

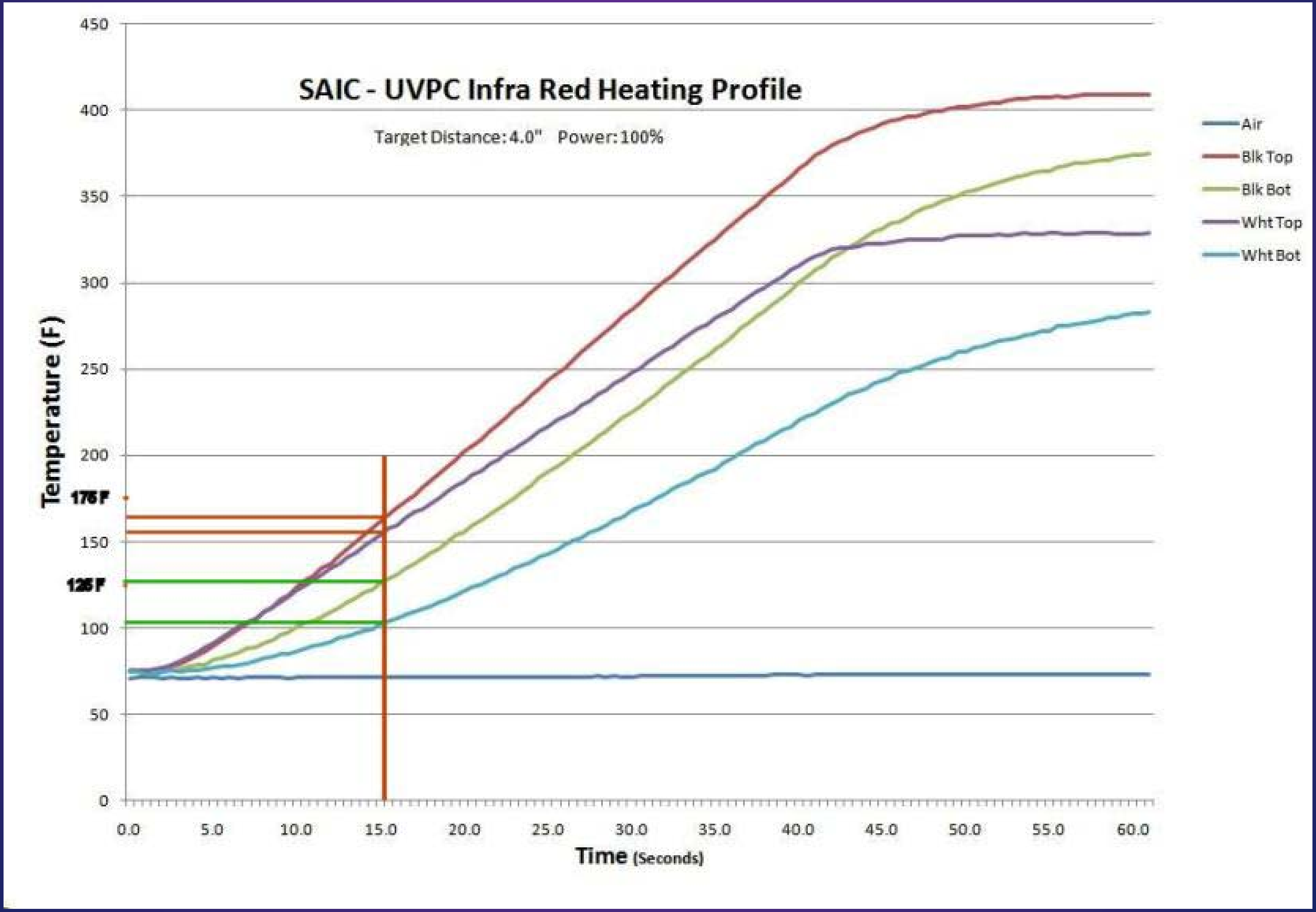
Powder Coating

- dry handling
- recyclable overspray
- easily automated
- almost no emissions
- thick coatings in one pass
- textured surfaces possible

UVCPC

- Ultraviolet Cured Powder Coatings
  - Resin systems based on various polymer types
    - Interpenetrating polymer networks
    - Thiol-ene polyurethane/polyester hybrids
  - Can contain various advanced corrosion inhibitors
  - Uses tight particle size range lightfast inorganic pigments
  - Available in gloss, semi-gloss, and camouflage flat colors
  - Outstanding performance in one version currently in production:
    - Essentially impervious to chemicals like Skydrol LD-4
    - Forward impact flexibility greater than 160 in-lb
    - B117 corrosion resistance > 2000+ hours on Al substrate
    - Mandrel bend elongation > 31%
    - Dry tape adhesion 5B
    - High likelihood of passing CARC testing
  - Current versions can melt and flow under IR light in < 15 sec.
  - Substrates do not see the same temperature as the powder

With UVCPC, the substrate does NOT see the temperature the powder sees.



UVCPC

- In addition, UVCPC can be applied and cured on composite materials

UVCPC

- Plus, UVCPC is not limited to oven size
  - With robotics, just about anything can be powder coated

UVCPC

- Finally, UVCPC does have the potential of being used on the flightline for field repair

- This shows an example of a prototype powder application gun that delivers the powder in molten state and has integral UV light curing

Spray Gun with UV Lamp Attachment

Conclusions

- The thinking about powder coatings has changed
- Advanced thermal and ultraviolet light curable powders are available today
- Powders reduce/eliminate VOCs, HAPs and hazardous waste
- Powders offer faster turnaround times, less costly than wet coatings
- These coatings can be drop in replacements for 2K coatings exceeding MIL-PRF-23377 and MIL-PRF-85285 performance
- Some of the newer powders can likely pass CARC requirements
- Powders can be formulated for flightline application
- With robotic application and curing systems, size is no longer an object

GOT POWDER?

QUESTIONS?

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