Advanced Powder Coating Systems for Military Applications

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Overview

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• 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 an 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

<table>
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<th>Compatible Substrates</th>
<th>Traditional Primers &amp; Topcoats</th>
<th>Waterborne Primers &amp; Topcoats</th>
<th>Traditional Powder Coatings</th>
<th>Low-Temperature Cure Powder Coatings</th>
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<td><strong>Advantages</strong></td>
<td>Steel, Aluminum, Magnesium, Composites</td>
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<td>Solvent flash-off leaves a uniform coating free of blemishes</td>
<td>VOC and HAP content are significantly reduced relative to traditional primers and topcoats</td>
<td>Single application coating; No VOC or HAP; fast cure, 15 minutes</td>
<td>Single application coating; No VOC’s or HAP’s; fast low temp cure ~30min@250F; enhanced corrosion inhibitors; improved transfer efficiency; primer application eliminated</td>
<td>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</td>
<td>Single application coating; No VOC’s or HAP’s; Line of sight cure; use of Hg containing UV lamps</td>
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<td><strong>Disadvantages</strong></td>
<td>Environmental burden of high VOC and HAP production and release; hexavalent chromium; free isocyanates; up to 72 hrs “dry to fly” time</td>
<td>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</td>
<td>High temp cure &gt;350F; Al and Mg substrates compromised; Can’t be applied at field level due to high curing temperature requirement</td>
<td>Currently, only proposed for depot production environments; part sizes limited by oven size; 250F temperature still too high for some components</td>
<td></td>
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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
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
UV CPC

- UV CPC are cured extremely fast by ultraviolet light.
UV light can come from several sources:

- Fusion® microwave induced (left)
- Nordson® conventional arc (right)
- Air Motion Systems® LED (bottom)
Advantages of UV Powder Coatings:

Combined advantages of UV-Curing and Powder Coating:

**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
UV-CPC

- Finally, UV-CPC 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.
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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