

# Advanced Powder Coating Systems for Military Applications

Presenter: Mr. Christopher W. Geib,  
Science Applications International Corporation (SAIC)  
937.431.4332  
christopher.w.geib@saic.com

Contract: W91278-09-D-0037, Task Order 0018  
Issued by: US Army Corps of Engineers, Mobile District,  
Mobile AL



| Report Documentation Page                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                    |                                     |                                                           | Form Approved<br>OMB No. 0704-0188                  |                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|-------------------------------------|-----------------------------------------------------------|-----------------------------------------------------|---------------------------------|
| Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. |                                    |                                     |                                                           |                                                     |                                 |
| 1. REPORT DATE<br><b>MAY 2011</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                    | 2. REPORT TYPE                      |                                                           | 3. DATES COVERED<br><b>00-00-2011 to 00-00-2011</b> |                                 |
| 4. TITLE AND SUBTITLE<br><b>Advanced Powder Coating Systems for Military Applications</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                    |                                     |                                                           | 5a. CONTRACT NUMBER                                 |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                                           | 5b. GRANT NUMBER                                    |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                                           | 5c. PROGRAM ELEMENT NUMBER                          |                                 |
| 6. AUTHOR(S)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                     |                                                           | 5d. PROJECT NUMBER                                  |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                                           | 5e. TASK NUMBER                                     |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                                           | 5f. WORK UNIT NUMBER                                |                                 |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br><b>Science Applications International Corporation (SAIC),4031 Colonel Glenn Highway,Beavercreek,OH,45431</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                    |                                     |                                                           | 8. PERFORMING ORGANIZATION REPORT NUMBER            |                                 |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                    |                                     |                                                           | 10. SPONSOR/MONITOR'S ACRONYM(S)                    |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                                           | 11. SPONSOR/MONITOR'S REPORT NUMBER(S)              |                                 |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT<br><b>Approved for public release; distribution unlimited</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                    |                                     |                                                           |                                                     |                                 |
| 13. SUPPLEMENTARY NOTES<br><b>Presented at the NDIA Environment, Energy Security &amp; Sustainability (E2S2) Symposium &amp; Exhibition held 9-12 May 2011 in New Orleans, LA.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                    |                                     |                                                           |                                                     |                                 |
| 14. ABSTRACT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                     |                                                           |                                                     |                                 |
| 15. SUBJECT TERMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                    |                                     |                                                           |                                                     |                                 |
| 16. SECURITY CLASSIFICATION OF:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     | 17. LIMITATION OF ABSTRACT<br><b>Same as Report (SAR)</b> | 18. NUMBER OF PAGES<br><b>27</b>                    | 19a. NAME OF RESPONSIBLE PERSON |
| a. REPORT<br><b>unclassified</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | b. ABSTRACT<br><b>unclassified</b> | c. THIS PAGE<br><b>unclassified</b> |                                                           |                                                     |                                 |

# 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 ( $> 350^{\circ}\text{F}$ ) 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.

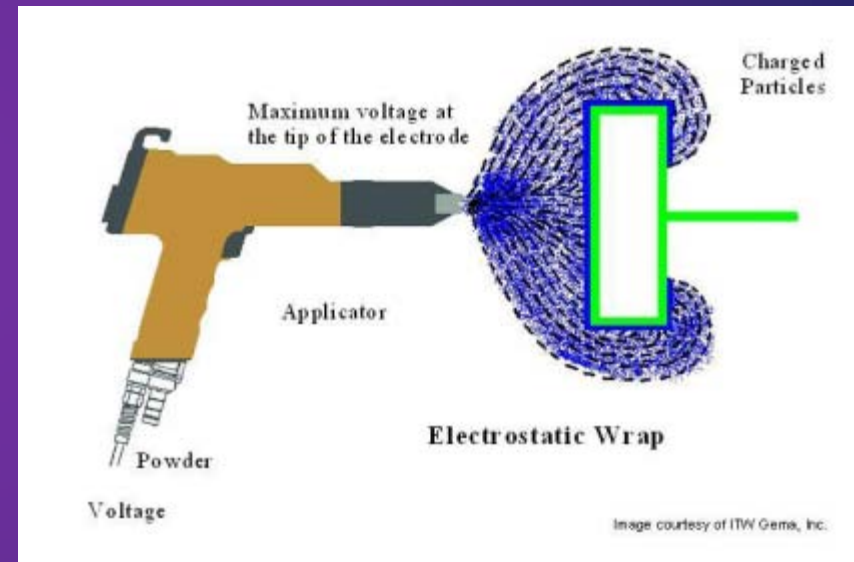
# What is Powder Coating?

- 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

|                       | 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<sup>®</sup> 6 transceiver set





# UVCPC

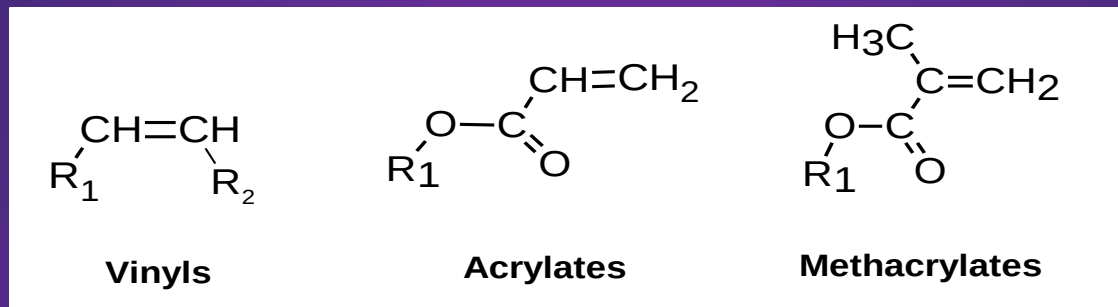
- Ultraviolet Cure Powder Coatings (UVCPC)
- Can be virtually any polymer matrix used for organic coatings
- The common denominator is the presence of a UV light reactive species on/in the polymer matrix



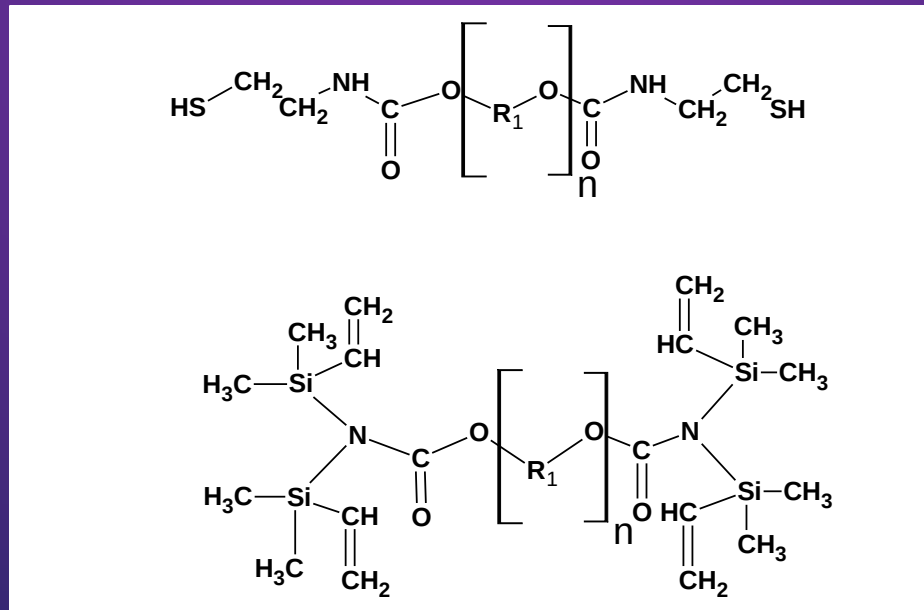


# UVCPC

Most commonly these are vinyl, acrylate or methacrylate groups



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



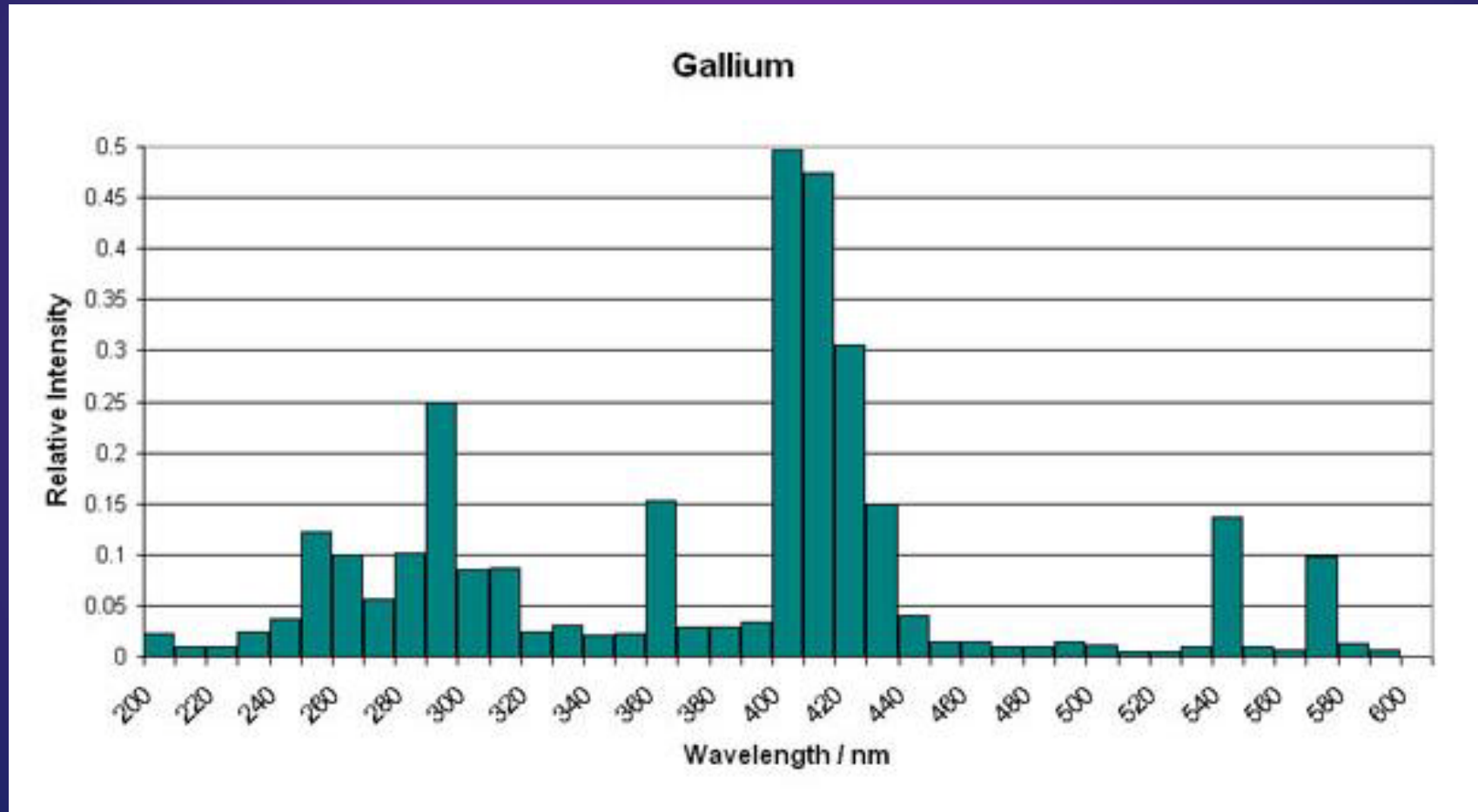
# UVCPC

- 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<sup>®</sup> microwave induced (left)
  - Nordson<sup>®</sup> conventional arc (right)
  - Air Motion Systems<sup>®</sup> 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



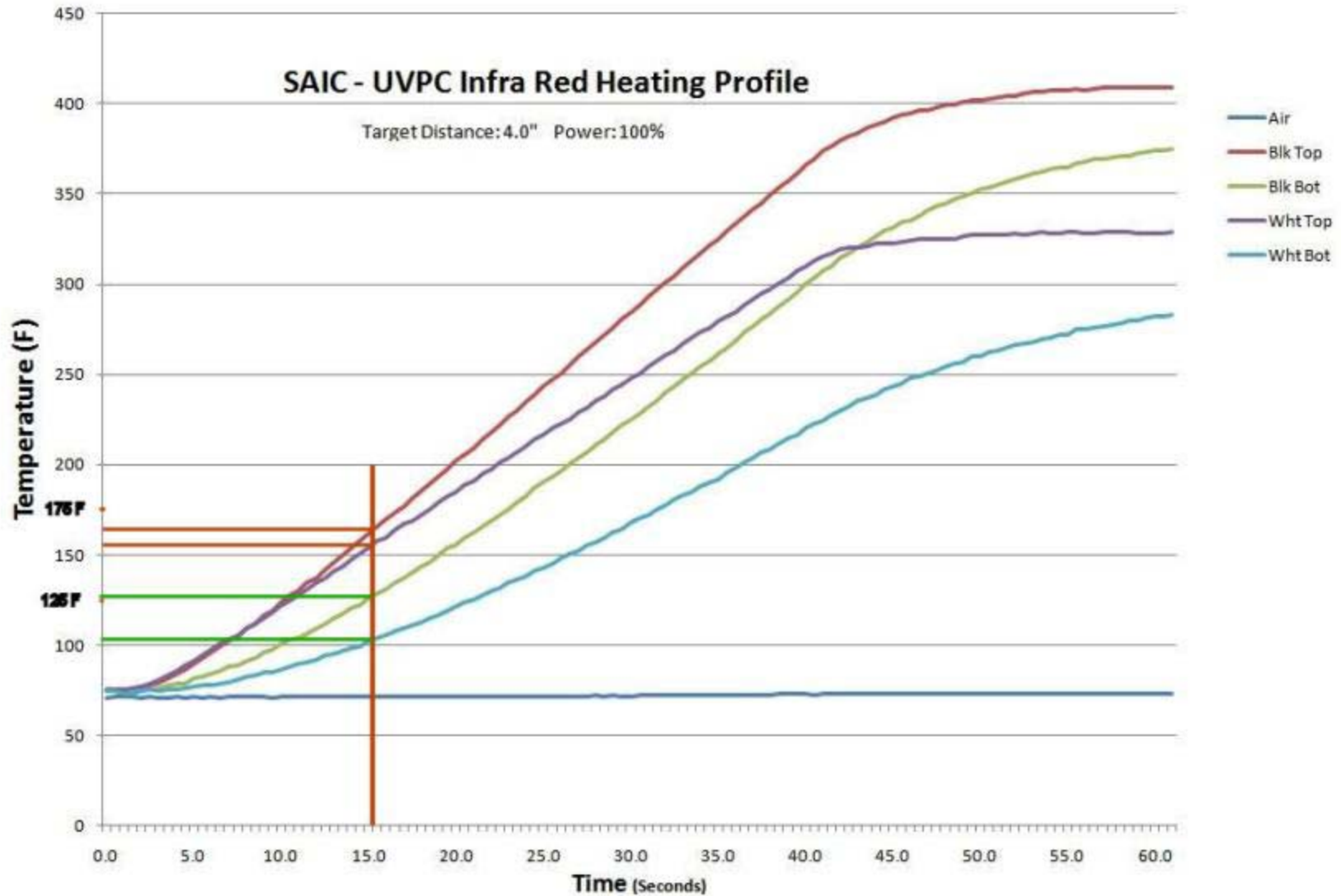
## **Powder Coating**

- 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

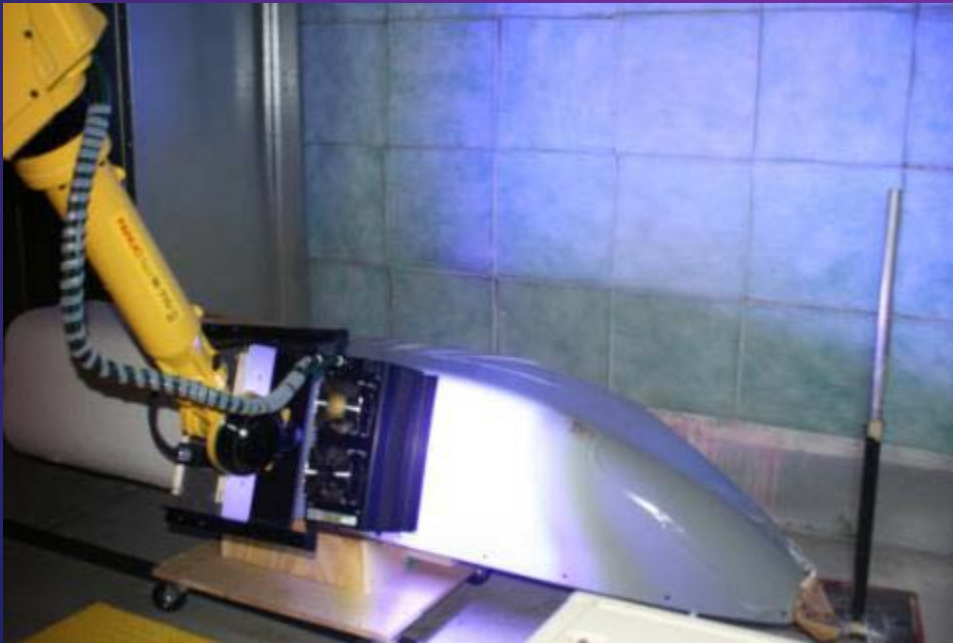
With UVCPC, the substrate does NOT see the temperature the powder sees.





# UVCPC

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



# UVCPC

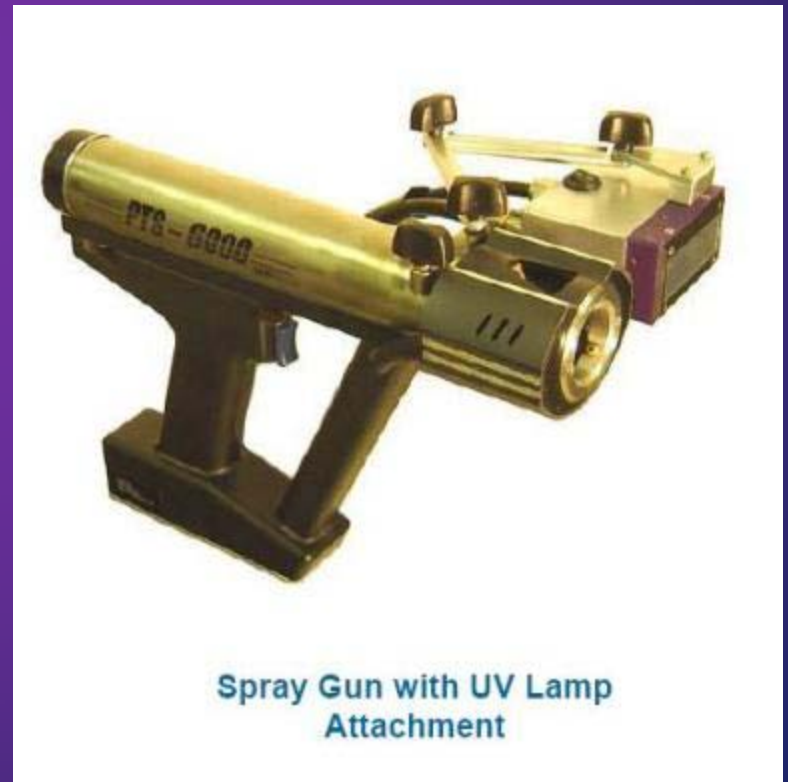
- Plus, UVCPC is not limited to oven size
  - With robotics, just about anything can be powder coated



Image courtesy of Pratt & Whitney

# 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



# 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?

**Mr. Christopher W. Geib**  
**Project Manager**  
**Science Applications International Corp.**  
**4031 Colonel Glenn Highway**  
**Beavercreek, OH 45431**  
**Christopher.W.Geib@saic.com**  
**(937) 431-4332**