Status of the UV Cure Powder Coating Demonstration Project
**Title:** Status of the UV Cure Powder Coating Demonstration Project

**Performing Organization:** Air Force Research Laboratory/RXSSO, Wright-Patterson AFB, OH, 45433

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Outline

- Project Team
- UV Cure Technology
- UV Curable Powder Overview
- UV Cure Powder Coating
  Demonstration/Validation
Project Team

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UV Cure Technology
UV Cure Technology

- Requires a source of UV light
UV Cure Technology

Example lamp output power 10 kW

Typical medium pressure mercury discharge lamp power distribution.
UV-Cure Technology

- We use a Gallium doped lamp:
UV Cure Technology

- **Chemistry of UV-cure coatings**
  - 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
  - Commonly vinyl, acrylate or methacrylate groups

![Chemical structures of vinyl, acrylates, and methacrylates](chart.png)
UV Cure Technology

- UV Cure formulations require:
  - Light reactive polymer resins
  - Additives such as pigments and flow agents
  - Photoinitiators
UV Cure Technology

- UV-cure powder coatings
  - Typically, the most common UV curable powders are:
    - Polyurethanes
    - Polyesters
    - Epoxies
    - Hybrids and mixtures of the above
  - For the UVCPC project, we use a special composition of light activated polyurethanes and polyesters
UV Curable Powder Overview
UV-Curable Powder Overview

- Previous ways of thinking about powder
  - Coating cure temperatures – typically above 220°C
  - Prohibitive for use on tempered metals (Al, Mg, Ti)
  - Prohibitive to use on composites
  - Powder coatings were designed as barrier protection
UV-Curable Powder Overview

- Modern powder coatings can be formulated to have:
  - Lower melt & flow temperatures (< 110°C)
  - UV or EB cure functionality can be added
  - Various advanced non-chrome corrosion inhibitors
Advantages of UV-cure powder coating:

- Elimination of volatile organics (VOC)
- Elimination of hazardous air pollutants (HAP)
- Reduction/elimination of hazardous waste
- Transfer efficiencies as high as 95% (w/reclaim)
- Decrease in thermal exposure.
- Large bulky parts that cannot fit into existing ovens can be coated and cured.
- UV-cure powder requires less energy because the energy is focused to a specific part only as long as needed.
UV Curable Powder Overview

- Powder is applied using electrostatic powder gun
- Applied powder is cured with IR and UV lights mounted on robotic curing system
The UV cure powder process:
UV Curable Powder Overview

- Crosslinking occurs during UV irradiation:

Unsaturated resin + photoinitiator → Photoinitiator breaks down to form free radicals → Resin crosslinks
UV Cure Powder Coating Demonstration/Validation
UVCPC Dem/Val

Timeline

- Project based on Commercial Off The Shelf (COTS) UV cured powder coatings
- Project started in 2008
- Initially had two powder vendors
- One dropped because of constant merger issues
- Initial validation testing completed in 2010
  - Results questionable due to adhesion issues
  - A number of tests rerun as a result
- Adhesion study completed in 2010
  - Found one of the reasons for poor adhesion
UVCPC Dem/Val

Timeline (Cont.)

Adhesion study completed in 2010 (Cont.)

- Low copper alloys (6000, 3000 series) not a problem
- High copper alloys scavenge free radicals at surface
- Determined that certain surface treatments are effective:
  - Anodized
  - Alodine 1600
  - Zinc Phosphate
  - Epoxy wash primers

Building 2801 modification completed end 2010

Robot installation occurred in 2011
UVCPC Dem/Val

- **Timeline (Cont.)**
  - First light and testing in early 2012
    - Discovery that kinetics also play major role in adhesion
  - First parts coated with UVCPC
    - Ammo can
    - Aircraft jack hydraulic reservoirs
    - USAF aircraft wheels
# UVCPC Dem/Val

- Validation Testing Results (Summary) of COTS UVCPC

## UVCPC Validation Test Matrix

<table>
<thead>
<tr>
<th>Corrosion Tests</th>
<th>500</th>
<th>1000</th>
<th>1250</th>
<th>1500</th>
<th>1750</th>
<th>2000</th>
<th>2250</th>
<th>2500</th>
<th>2750</th>
<th>3000</th>
<th>3250</th>
<th>3500</th>
<th>3750</th>
<th>4000</th>
<th>4250</th>
<th>4500</th>
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<tbody>
<tr>
<td>B117 - 4130 steel (ZnPhos)</td>
<td></td>
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<tr>
<td>B117 - Aluminum (Alodine 1600)</td>
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<tr>
<td>Filiform Corrosion</td>
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<tr>
<td>SO₂ Corrosion - steel (500 hr)</td>
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<tr>
<td>SO₂ Corrosion - aluminum (500 hr)</td>
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</tr>
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</table>

**General Tests**

<table>
<thead>
<tr>
<th>Impact Flexibility</th>
<th>Pass/ Fail</th>
<th>Pass/ Fail</th>
<th>Initial</th>
<th>Redo</th>
</tr>
</thead>
<tbody>
<tr>
<td>-60°F flexibility</td>
<td></td>
<td></td>
<td>Not run</td>
<td></td>
</tr>
<tr>
<td>Wet tape adhesion</td>
<td></td>
<td></td>
<td>Not run</td>
<td></td>
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<tr>
<td>Dry tape adhesion</td>
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<td></td>
</tr>
<tr>
<td>Pencil hardness</td>
<td></td>
<td></td>
<td>Not run</td>
<td></td>
</tr>
<tr>
<td>Initial Appearance</td>
<td></td>
<td></td>
<td>Not run</td>
<td></td>
</tr>
<tr>
<td>Initial Color</td>
<td></td>
<td></td>
<td>Not run</td>
<td></td>
</tr>
<tr>
<td>Initial Gloss</td>
<td></td>
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<td>Not run</td>
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<tr>
<td>Weatherability</td>
<td></td>
<td></td>
<td>Not run</td>
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<tr>
<td>Color</td>
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<tr>
<td>Gloss</td>
<td></td>
<td></td>
<td>Not run</td>
<td></td>
</tr>
<tr>
<td>Cleanability</td>
<td></td>
<td>Not rerun</td>
<td>Not run</td>
<td></td>
</tr>
<tr>
<td>Heat Resistance</td>
<td></td>
<td></td>
<td>Not run</td>
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<tr>
<td>Fluid Resistance</td>
<td></td>
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<td>Not run</td>
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<tr>
<td>Strippability</td>
<td></td>
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<td>Not run</td>
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<tr>
<td>Erosion</td>
<td></td>
<td></td>
<td>Not run</td>
<td></td>
</tr>
</tbody>
</table>

**Outdoors beach exposure (months)**

<table>
<thead>
<tr>
<th>Aluminum - color</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum - gloss</td>
<td></td>
<td></td>
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<tr>
<td>Aluminum - corrosion</td>
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<tr>
<td>Steel - color</td>
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<tr>
<td>Steel - gloss</td>
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<tr>
<td>Steel - corrosion</td>
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</tr>
</tbody>
</table>

Note: Passed 40in-lb; Failed 40in-lb reverse
Note: Cracked at bend
Note: >F to H
Note: Initial gloss was a failure before weatherability. Will use beach exposure for weatherability gloss change.
Note: Initial gloss passed outdoors; Failed after outdoor exposure
Note: ΔE ~ 1.84

UVCPC Dem/Val

- General test results
  - Color (FED-STD-595C)
    - FED-STD-595C 17925 Reference Chip
      - L*: 96.06
      - a*: -1.95
      - b*: 3.10
      - ΔL*: Δa*: Δb*: ΔE*: 0
    - PCRG High Gloss White
      - L*: 95.82
      - a*: -1.96
      - b*: 2.66
      - ΔL*: -0.24
      - Δa*: -0.01
      - Δb*: -0.45
      - ΔE*: 0.5
    - FED-STD-595C 26173 Reference Chip
      - L*: 55.05
      - a*: -1.24
      - b*: -3.66
      - ΔL*: Δa*: Δb*: ΔE*: 0
    - PCRG Semigloss Initial
      - L*: 55.13
      - a*: -1.24
      - b*: -3.98
      - ΔL*: 0.08
      - Δa*: 0.00
      - Δb*: 0.32
      - ΔE*: 0.2

- Gloss (FED-STD-595C)
  - Sample ID
    - 20° | 60° | 85°
    - PCRG High Gloss White
      - 55.1 | 84.4 | 95.6
    - PCRG Semi Gloss Initial
      - 8.8 | 45.8 | 78.1

UVCPC Dem/Val

- **General test results**
  - **Pencil Hardness (ASTM D3363)**
    - Marginal, falls between F and H pencil
  - **Impact Flexibility (MIL-PRF-85285D)**
    - Passed 40 in-lb forward, Failed 40 in-lb reverse
UVCPC Dem/Val

- General test results
  - Low temperature (-60°F) flexibility initial (MIL-PRF-85285D)
UVCPC Dem/Val

- General test results
  - Low temperature (-60°F) flexibility rerun
UVCPC Dem/Val

- General test results
  - Dry/Wet tape adhesion (ASTM D3359, FED-STD-141D)
    - Initial results were failures due to adhesion issue
  - Dry adhesion was rerun on various pretreatments
    - Because adhesion seemed to change with time, a month of testing run
    - Summary of the dry tape adhesion results is shown on next slide
## General test results

<table>
<thead>
<tr>
<th></th>
<th>Film Thickness</th>
<th>Cross Hatch Adhesion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alodine 12005</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45 sec</td>
<td>1.3 - 1.4</td>
<td>4B</td>
</tr>
<tr>
<td>90 sec</td>
<td>1.5 - 1.8</td>
<td>3B</td>
</tr>
<tr>
<td>3 min</td>
<td>1.7 - 2.2</td>
<td>2B</td>
</tr>
<tr>
<td><strong>Alodine 1600</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 min</td>
<td>1.7 2.1</td>
<td>5B</td>
</tr>
<tr>
<td>3 min</td>
<td>1.5 - 1.7</td>
<td>5B</td>
</tr>
<tr>
<td>5 min</td>
<td>1.4 - 1.7</td>
<td>5B</td>
</tr>
<tr>
<td>20 sec</td>
<td>1.6 - 2.0</td>
<td>5B</td>
</tr>
<tr>
<td><strong>Alodine 5200</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 min</td>
<td>1.3 - 1.5</td>
<td>5B</td>
</tr>
<tr>
<td>2 min</td>
<td>1.5 - 1.8</td>
<td>5B</td>
</tr>
<tr>
<td>4 min</td>
<td>1.5 - 2.0</td>
<td>4B</td>
</tr>
<tr>
<td><strong>Alodine 5900</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 min</td>
<td>1.3 - 1.4</td>
<td>4B</td>
</tr>
<tr>
<td>10 min</td>
<td>1.2 - 1.5</td>
<td>4B</td>
</tr>
<tr>
<td><strong>Alodine 8800</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy</td>
<td>1.6 -1.7</td>
<td>5B</td>
</tr>
<tr>
<td>Light</td>
<td>1.5 - 1.7</td>
<td>5B</td>
</tr>
<tr>
<td>Control</td>
<td>1.5 - 1.9</td>
<td>0B</td>
</tr>
<tr>
<td><strong>Carpenter B/700</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>S-W Wash Primer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2024-T3</td>
<td>Dry</td>
<td>5B + no change</td>
</tr>
<tr>
<td>2024-T3</td>
<td>Wet</td>
<td>5B + no change</td>
</tr>
<tr>
<td>4130 steel</td>
<td>Dry</td>
<td>5B + no change</td>
</tr>
<tr>
<td>4130 steel</td>
<td>Wet</td>
<td>5B + no change</td>
</tr>
</tbody>
</table>

UVCPC Dem/Val

- General test results
  - Wet tape adhesion
General test results

- Fluid resistance (MIL-PRF-85285D)
- Initial fluid resistance test halted as soon as adhesion issue discovered
- Follow on fluid resistance test rerun passed
UVCPC Dem/Val

General test results

- Weatherometer (MIL-PRF-85285D, ASTM G155)
  - 500 hour test
  - $\Delta E^* = 0.97$ (Pass)
  - Gloss loss $\approx 63.7$ units (Fail)

- Heat Resistance (MIL-PRF-85285D)
  - $\Delta E^* = 1.84$ (Marginal)

- Cleanability (MIL-PRF-85285D)
  - Efficiency = 67% (Marginal)

- Strippability (MIL-PRF-85285D)
  - 100% removed in < 4 hours (Pass)
UVCPC Dem/Val

- Corrosion resistance tests
  - Neutral salt fog (MIL-PRF-23377J, ASTM B117)
    - UVCPC over Zn Phosphate 4130 steel, 2000 hrs (Pass)
    - UVCPC over Alodine 1600, 2024-T3 Al, 4430 hrs (Pass)
UVCPC Dem/Val

- Corrosion resistance tests
  - SO$_2$ corrosion resistance (ASTM G85, Annex 4)
    - UVCPC over Aluminum (Pass)
    - UVCPC over cold rolled steel (Fail)
UVCPC Dem/Val

- Corrosion resistance tests
  - Filiform corrosion resistance (MIL-PRF-23377J, ASTM D2803)
    - 1000 hour test (Pass)
UVCPC Dem/Val

- **Erosion/Abrasion tests**
  - Falling sand erosion testing (ASTM D968)
  - Within $1\sigma$ of the legacy coating

### Falling Sand Evaluation (UVCPC)

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Liters (V)</th>
<th>Mean thickness (t)</th>
<th>A Factor A=V/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>144</td>
<td>2.32</td>
<td>62.1</td>
</tr>
<tr>
<td>3</td>
<td>162</td>
<td>2.8</td>
<td>57.9</td>
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<tr>
<td>4</td>
<td>144</td>
<td>2.53</td>
<td>56.9</td>
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<td>5</td>
<td>133</td>
<td>2.53</td>
<td>52.6</td>
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<tr>
<td>6</td>
<td>144</td>
<td>2.58</td>
<td>55.8</td>
</tr>
<tr>
<td>8</td>
<td>143</td>
<td>2.49</td>
<td>57.4</td>
</tr>
</tbody>
</table>

Mean 57.0

Std Dev 3.09
UVCPC Dem/Val

- Long term outdoor exposure (ASTM D1014)
  - Three parameters evaluated
    - Color drift
    - Gloss drift
    - Overall corrosion
  - Semi-gloss gray UVCPC used
  - Results:
    - Color drift maximum $\Delta E^* = 0.82$ (Pass)
    - Gloss drift 36.6 gloss units (Fail)
    - Corrosion overall:
      - Aluminum still passing after 18 months (~12900 hours exposure)
      - Cold rolled steel failed after 7 months (~5000 hours exposure)
UVCPC Dem/Val

- Long term outdoor exposure
- Color drift

<table>
<thead>
<tr>
<th>Coating</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>ΔL*</th>
<th>Δa*</th>
<th>Δb*</th>
<th>ΔE*</th>
</tr>
</thead>
<tbody>
<tr>
<td>FED-STD-595C 26173 Reference Chip</td>
<td>55.05</td>
<td>-1.24</td>
<td>-3.66</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCRG Semigloss Initial</td>
<td>55.13</td>
<td>-1.24</td>
<td>-3.98</td>
<td>0.08</td>
<td>0.00</td>
<td>0.32</td>
<td>0.2</td>
</tr>
<tr>
<td>PCRG 7-month color</td>
<td>55.40</td>
<td>-1.18</td>
<td>-4.16</td>
<td>0.35</td>
<td>-0.06</td>
<td>0.50</td>
<td>0.32</td>
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<td>PCRG 12-month color</td>
<td>55.77</td>
<td>-1.16</td>
<td>-4.11</td>
<td>0.72</td>
<td>-0.08</td>
<td>0.45</td>
<td>0.75</td>
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<tr>
<td>PCRG 18-month color</td>
<td>55.82</td>
<td>-1.21</td>
<td>-4.17</td>
<td>0.76</td>
<td>-0.07</td>
<td>0.31</td>
<td>0.82</td>
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</tbody>
</table>
UVCPC Dem/Val

- Long term outdoor exposure
- Gloss drift

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>20°</th>
<th>60°</th>
<th>85°</th>
</tr>
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<tbody>
<tr>
<td>PCRG Semi Gloss Initial</td>
<td>8.8</td>
<td>45.8</td>
<td>78.1</td>
</tr>
<tr>
<td>PCRG 7-month semigloss</td>
<td>3.0</td>
<td>25.7</td>
<td>66.9</td>
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<tr>
<td>PCRG 12-month semigloss</td>
<td>2.2</td>
<td>21.9</td>
<td>60.2</td>
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<tr>
<td>PCRG 18-month semigloss</td>
<td>0.9</td>
<td>9.2</td>
<td>41.6</td>
</tr>
</tbody>
</table>

UVCPC Dem/Val

- Long term outdoor exposure
  - Aluminum after 18 months (~12,900 hours)
UVCPC Dem/Val

- Long term outdoor exposure
- Steel after 7 & 18 months
UVCPC Dem/Val

- Actual components coated
  - Ammunition can
UVCPC Dem/Val

- Actual components coated
- Aircraft jack hydraulic reservoirs
UVCPC Dem/Val

- Actual components coated
  - F-16 main wheel (before)
UVCPD Dem/Val

- Actual components coated
  - F-16 main wheel (after)
UVCPC Dem/Val

- Actual components coated
  - F-15 nose wheel (before)
UVCPC Dem/Val

- Actual components coated
  - F-15 nose wheel (after)
UVCPC Dem/Val

- Actual components coated
  - Coast Guard MC-130 landing gear door
Summary

- Overall, the COTS UVCPC did well
  - Better overall test results than previous Low Temp powder
- Positives
  - Excellent B117 corrosion resistance over aluminum
  - Good corrosion resistance over zinc phosphated steel
  - Excellent Filiform corrosion resistance
  - Good room temperature flexibility
  - Erosion resistance on par with legacy 2K coatings
Summary

- Overall, the COTS UVCPC did well (cont.)
- Could use some improvements going forward
  - Coating
    - Lower melt/flow temperature
    - Improve -60°F flexibility
    - Increase hardness to 2H or greater pencil
    - Improve impact flexibility
    - Better heat resistance
    - Improve weatherability (gloss)
    - Reformulate for direct-to-metal
Summary

- Overall, the COTS UVCPC did well (cont.)
  - Could use some improvements going forward
    - Robotics
      - Better profiling
        - Use profiling radiometers
        - Better thermal profiling
      - Better control during operations (thermal, UV)
        - IR and UV feedback to robot
    - Powder Coating
      - Incorporate non-contact uncured powder thickness gauge
Questions?
UVCPC Back up slides
UVCPC Adhesion

- Adhesion of UVCPC over 2000 series aluminum
  - Adhesion results could not be duplicated between CTIO and PCRG
    - Key differences between locations was power of UV lamps
    - Formulation developed under a 300 Watt/in lamp
    - Originally thought it was photoinitiator based
    - “Flash” effect considered
  - Determined to test on the robotic curing system at NASWI
    - Nordson lamp is power adjustable unlike the CTIO/PCRG lamps
    - Robot can duplicate conveyor speeds (5 fpm vs. 9 fpm)
    - Robot can execute multiple passes in programming
    - Felt that the system could duplicate either lab
    - However, the results were completely unexpected
    - Realized the lamp at NASWI is a non-focused lamp
  - NASWI results led to the belief that both chemistry and kinetics play a role in the cure and adhesion on metallic substrates
UVCPC Adhesion

- Adhesion of UVCPC over 2000 series aluminum
  - The robotic curing system was able to cure with 5B adhesion
    - 5086, 6061, 3003 aluminum, and 4130 steel
    - None of the test panels had been prepared
      - Wiped free of dust
      - No pretreatment
      - No scuffing of surface (except steel which was bead blasted)
    - On 2000 series untreated, unprepared aluminum, 3B to 4B adhesion was possible
  - Kinetics plays a role as well as free radical scavengers
    - Free radical concentration at an instant in time
    - Focused lamps vs. unfocused lamps

UV CPC Adhesion

- Adhesion of UV CPC over 2000 series aluminum
  - Focused vs. unfocused reflectors

![Elliptical Diagram](image1)

- Used by CTIO and PCRG

![Parabolic Diagram](image2)

- Used by NASWI

UVCPC Adhesion

- Adhesion of UVCPC over 2000 series aluminum
  - Focused vs. unfocused reflectors
  - Dose at each location (typical)

<table>
<thead>
<tr>
<th></th>
<th>WPAFB lamp (focused) J/cm² 2-pass, 9 fpm</th>
<th>PCRG lamp (focused) J/cm² 2-pass, 5 fpm</th>
<th>NASWI lamp (unfocused) J/cm² 1-pass, ~4 fpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>UVA</td>
<td>2.54</td>
<td>2.22</td>
<td>1.53</td>
</tr>
<tr>
<td>UVB</td>
<td>1.83</td>
<td>1.39</td>
<td>1.62</td>
</tr>
<tr>
<td>UVC</td>
<td>0.13</td>
<td>0.17</td>
<td>0.22</td>
</tr>
<tr>
<td>UVV</td>
<td>12.7</td>
<td>10.41</td>
<td>12.23</td>
</tr>
</tbody>
</table>
UVCCPC Adhesion

- Adhesion of UVCCPC over 2000 series aluminum
  - Focused puts almost full dose in a 1” path
  - Unfocused puts similar dose down across ~4” path
    - Between 0.6 (WPAFB) and 1 (PCRG) second for full dose in focused
    - About 5 seconds (NASWI) for full dose in unfocused
UVCCPC Adhesion

- Adhesion of UVCCPC over 2000 series aluminum
- Kinetics of the cross linking reaction in UVCCPC
- Time based equations

\[ \nu_i = 2k_d f[I] \]

\[ \nu_p = k_p [M][M \cdot] \]

\[ \nu_t = 2k_t [M \cdot]^2 \]
UVCPC Adhesion

- Adhesion of UVCPC over 2000 series aluminum
  - Concentration of free radicals directly related to dose received
  - For a given “instant” in time:
    - WPAFB instantaneous free radical conc. is 3.4 times PCRG lamp
    - WPAFB instantaneous free radical conc. is 5.4 times NASWI lamp
    - Results in a relative increase of 11.6, or 29 time increase in \( v_t \) between WPAFB, PCRG, and NASWI lamps

\[
\begin{align*}
  v_p &= k_p [M][M \cdot] \\
  v_t &= 2k_t [M \cdot]^2
\end{align*}
\]

- If \( v_t \) is \( \geq v_p \), then:
  - Premature termination
  - Excessive shrinkage
  - Low cross link density
  - No or poor adhesion

UVCPC Adhesion

Summary of Adhesion Issue:

- Copper or other free radical scavengers have an effect
  - Scavenger “effect” can be overcome with:
    - Certain chromate conversion coatings
    - Anodizing
    - Epoxy based wash primer
    - Adjustment “tweak” in formulation

- Kinetics based on free radical concentration at an instant in time
  - Overcome termination rate by spreading the dose
  - A little longer cure is a “better” cure (5 seconds vs. 1 second)

- These factors have now been demonstrated by actual test
UVCPC Demonstration

- General test results
  - Strippability
UV-CPC Demonstration

- Falling sand testing

UV-CPC over 2024 Anodized

Legacy over 2024 Anodized

**UVCPC Demonstration**

- Actual components coated
  - Coast Guard MC-130 landing gear door
  - Entrained moisture created huge bubble during IR phase
UV CPC Demonstration

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UV CPC Demonstration

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UVCCPC Demonstration

- Better Robotic Profiling
  - Use of small radiometers
  - Extended use of thermal profiling
UV CPC Demonstration

- Better Powder Coating
  - Use of non-contact uncured powder thickness gauge
UV CPC Demonstration

- Estimated Cost of Improvements
  - Hardware - $6K
  - Robotics modifications - $12K
  - Coatings reformulation and revalidation - $120K