

Ultraviolet Curable Powder Coatings With Robotic Curing for Aerospace Applications



Report Documentation Page

Form Approved
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 MAY 2012	2. REPORT TYPE	3. DATES COVERED 00-00-2012 to 00-00-2012	
4. TITLE AND SUBTITLE Ultraviolet Curable Powder Coatings With Robotic Curing for Aerospace Applications		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) Air Force Research Laboratory/RXSSO, Wright-Patterson AFB, OH, 45433		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 Approved for public release; distribution unlimited			
13. SUPPLEMENTARY NOTES Presented at the NDIA Environment, Energy Security & Sustainability (E2S2) Symposium & Exhibition held 21-24 May 2012 in New Orleans, LA.			
14. ABSTRACT			
15. SUBJECT TERMS			
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified	
			18. NUMBER OF PAGES 34
			19a. NAME OF RESPONSIBLE PERSON

Outline

- Project Team
- UV-Cure Technology
- UV-Curable Powder Overview
- Current Status of ESTCP Project WP-0801

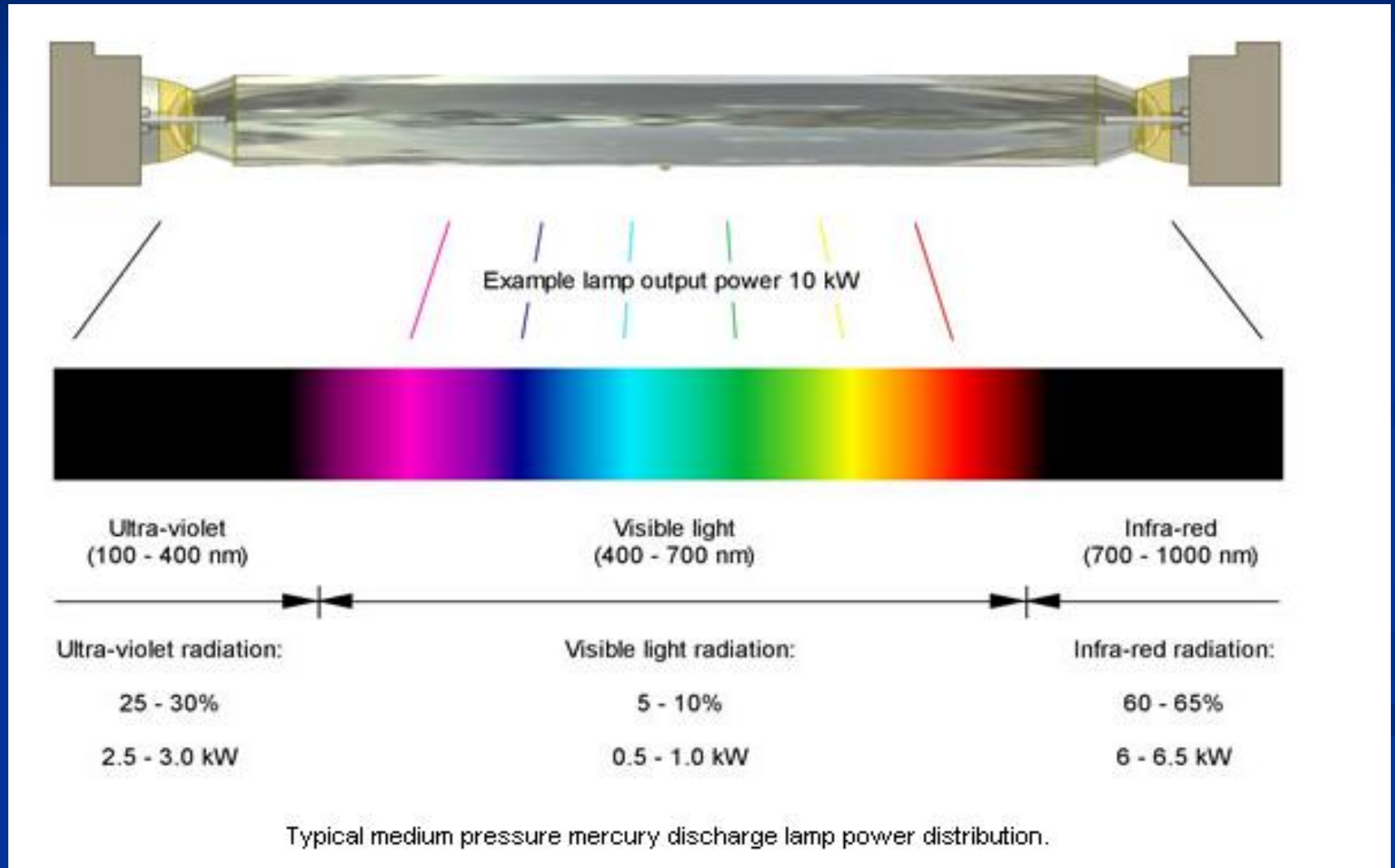


Project Team

- Mr. William Hoogsteden, Principal Investigator
Air Force Research Laboratory/RXSSO
Wright-Patterson AFB, OH 45433
William.Hoogsteden@wpafb.af.mil
(937) 656-4223
- Mr. Christopher W. Geib, Co-Principal Investigator
Science Applications International Corp.
4031 Colonel Glenn Highway
Beavercreek, OH 45431
Christopher.W.Geib@saic.com
(937) 431-4332

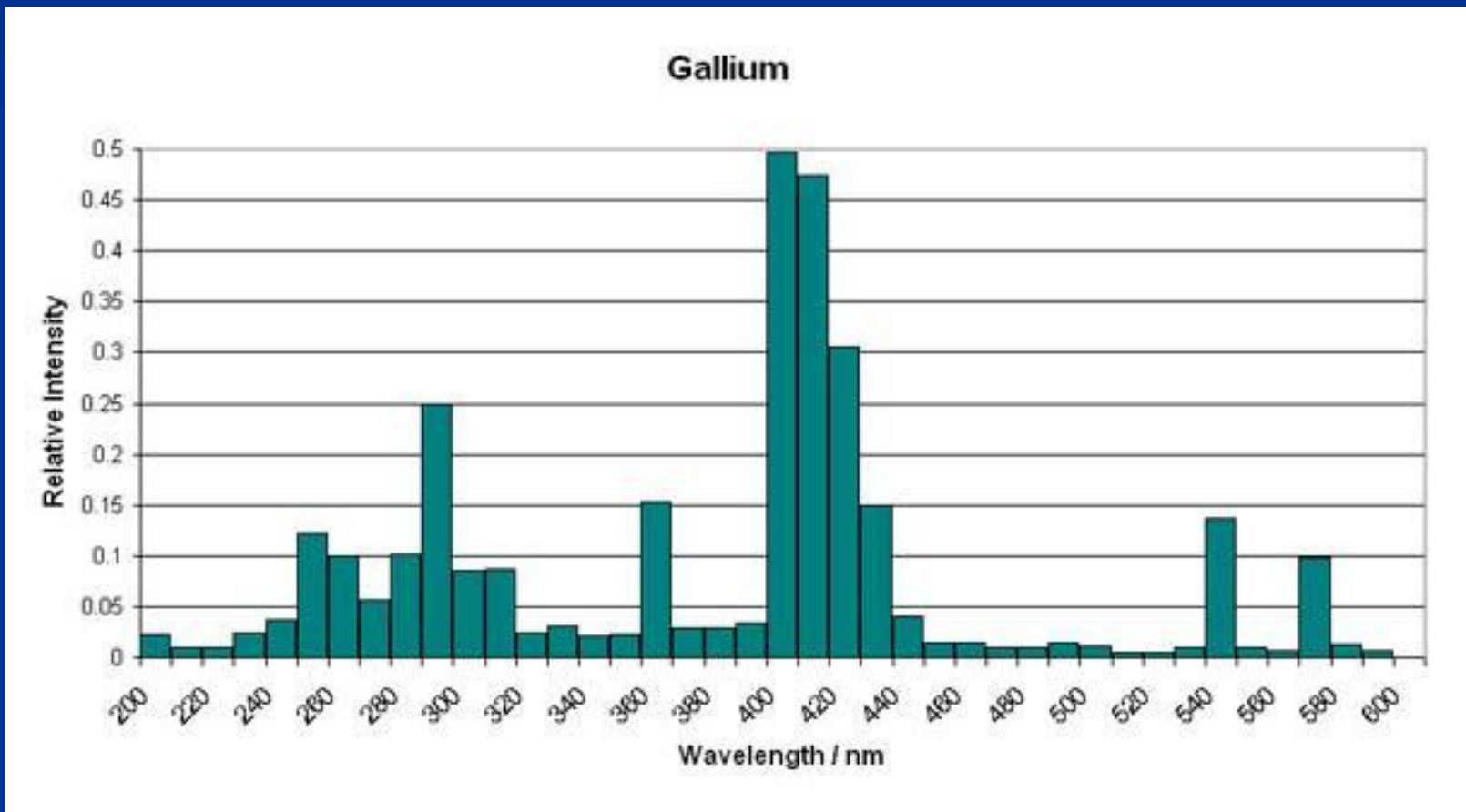
UV Cure Technology

UV Cure Technology



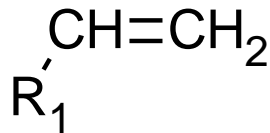
UV-Cure Technology

■ Typical Ultraviolet Lamp Spectra:

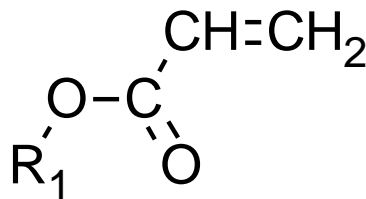


UV Cure Technology

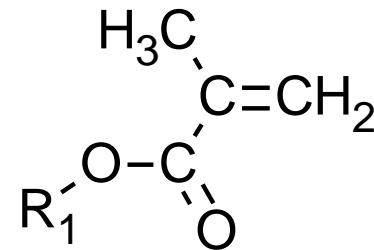
- Chemistry of UV-cure coatings
 - Can be virtually any polymer matrix used for organic coatings
 - The common denominator is the presence of a UV light reactive species on/in the polymer matrix
 - Commonly vinyl, acrylate or methacrylate groups



Vinyl



Acrylates



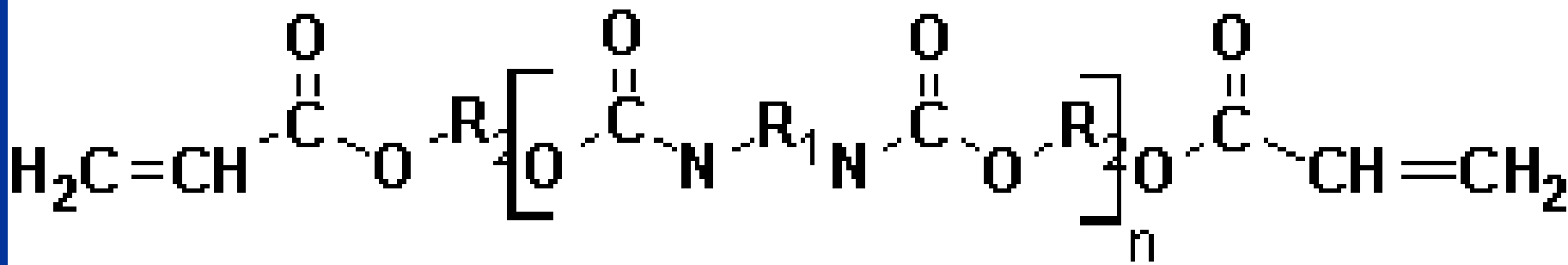
Methacrylates

UV Cure Technology

- Chemistry of UV-cure 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

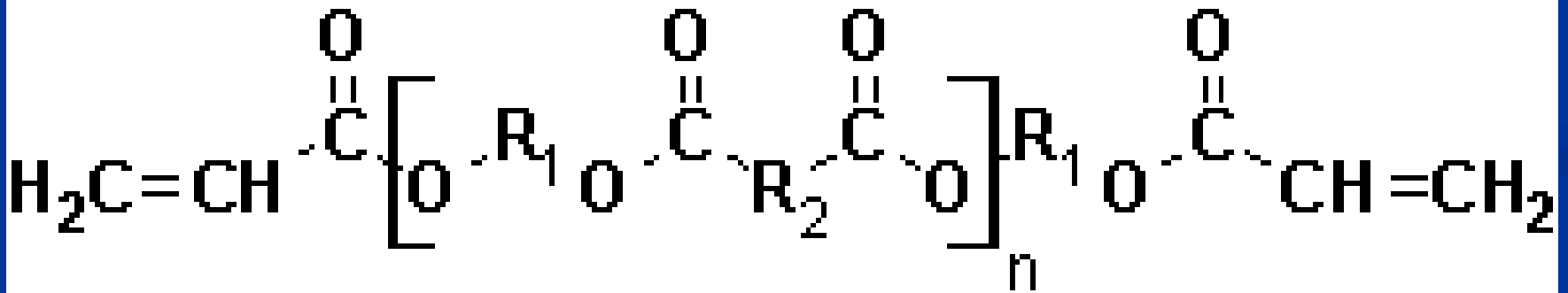
UV Cure Technology

- Polyurethane diacrylate (typical) MW ~2000 - 4000



UV Cure Technology

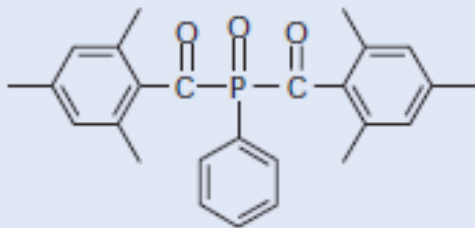
- Polyester diacrylates (typical) MW ~2000 - 4000



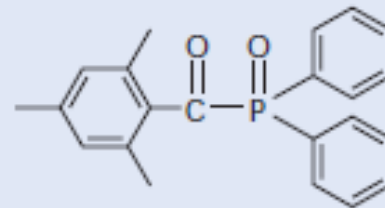
UV Cure Technology

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

IRGACURE 819 and IRGACURE 819 DW



DAROCUR TPO



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

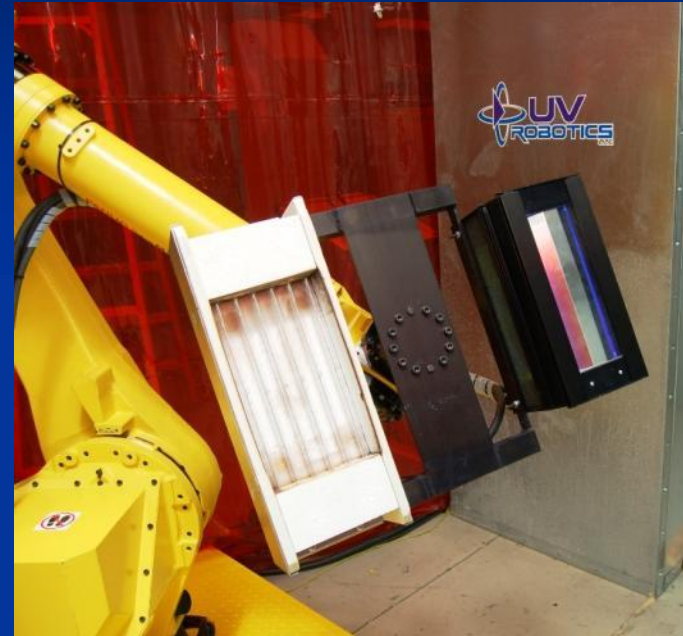
- Modern powder coatings can be formulated to have:
 - Lower melt & flow temperatures ($< 110^{\circ}\text{C}$)
 - UV or EB cure functionality can be added
 - Various advanced non-chrome corrosion inhibitors



UV-Curable Powder Overview

- 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.

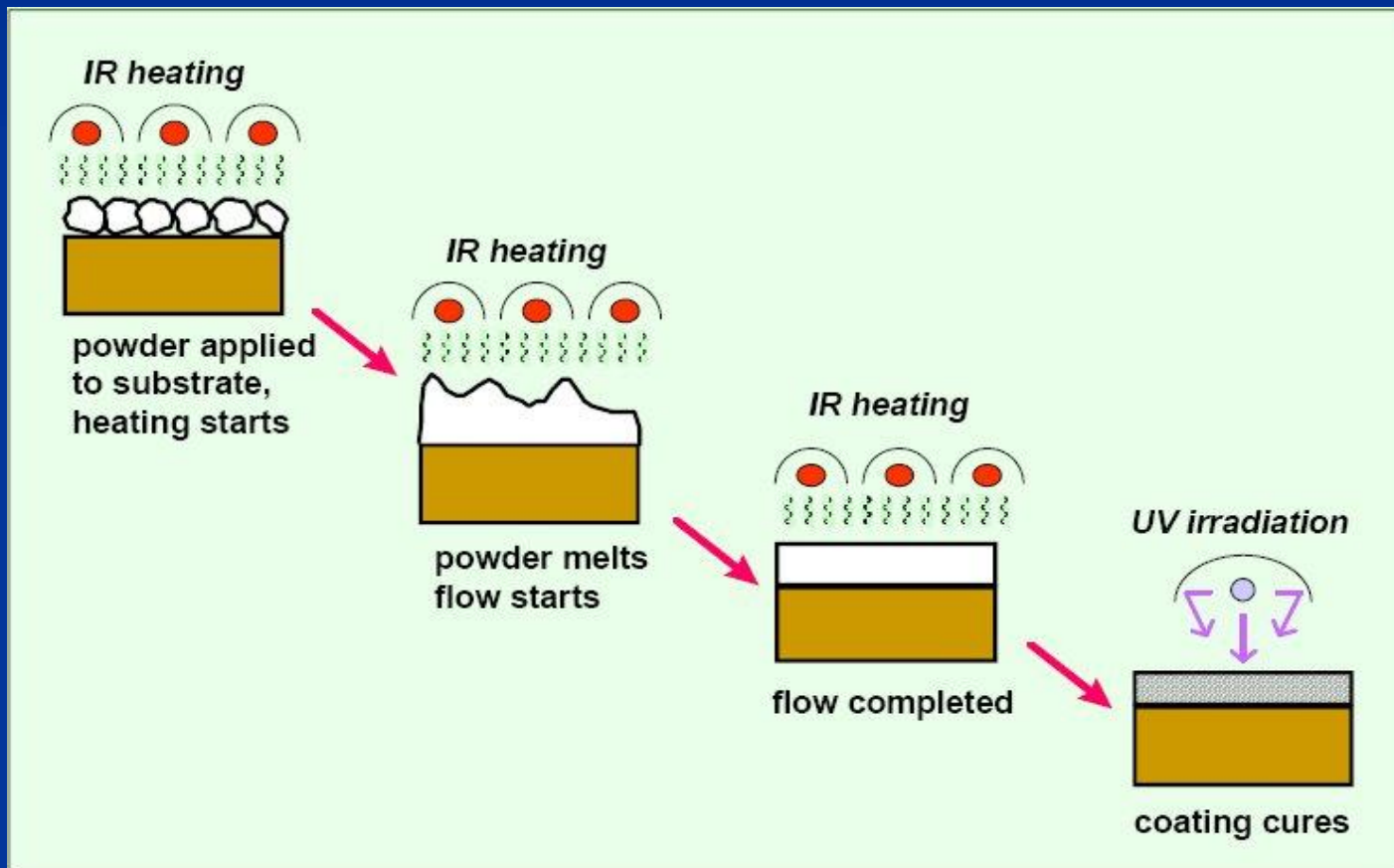
UV Curable Powder Overview



- Powder is applied using electrostatic powder gun
- Applied powder is cured with IR and UV lights mounted on robotic curing system

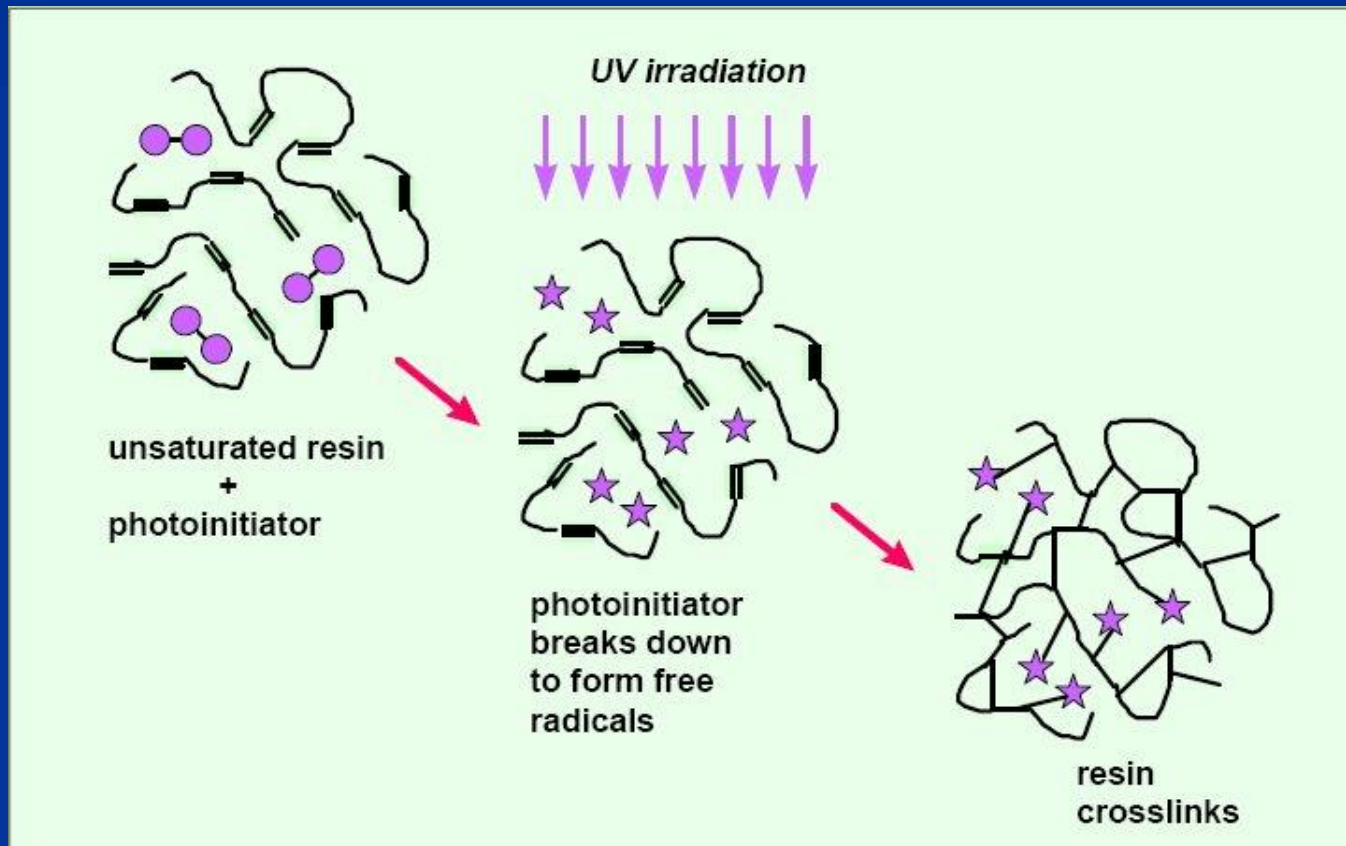
UV Curable Powder Overview

- The UV cure powder process:



UV Curable Powder Overview

- Crosslinking occurs during UV irradiation:



ESTCP Project WP-0801

ESTCP Project WP-0801

- The Problem:
 - DoD spends millions of dollars annually on solvent-based coatings
 - Hexavalent chrome primer use still very widespread
 - Contains or requires volatile solvent use
 - Significant hazardous waste costs
 - Hazardous materials pose risks to human health and environment
 - Process times measured in hours to days
 - Transfer rates are less than 60%

ESTCP Project WP-0801

- The WP-0801 Objectives are:
 - Demonstrate a VOC/HAP-free, Ultraviolet cure powder coating (UVCPC) on DoD hardware
 - Demonstrate state-of-the-art robotics for curing



ESTCP Project WP-0801



- Requirements of a UVCPC for military use:
 - Must perform at least as well as MIL-PRF-23377 primer
 - Must also perform as well as MIL-PRF-85285 topcoat
 - Can be prepared in gloss, semi-gloss, and flat finishes



ESTCP Project WP-0801

- Robotic Curing System:
 - Robot carries the Infrared and Hg vapor UV lamps



ESTCP Project WP-0801

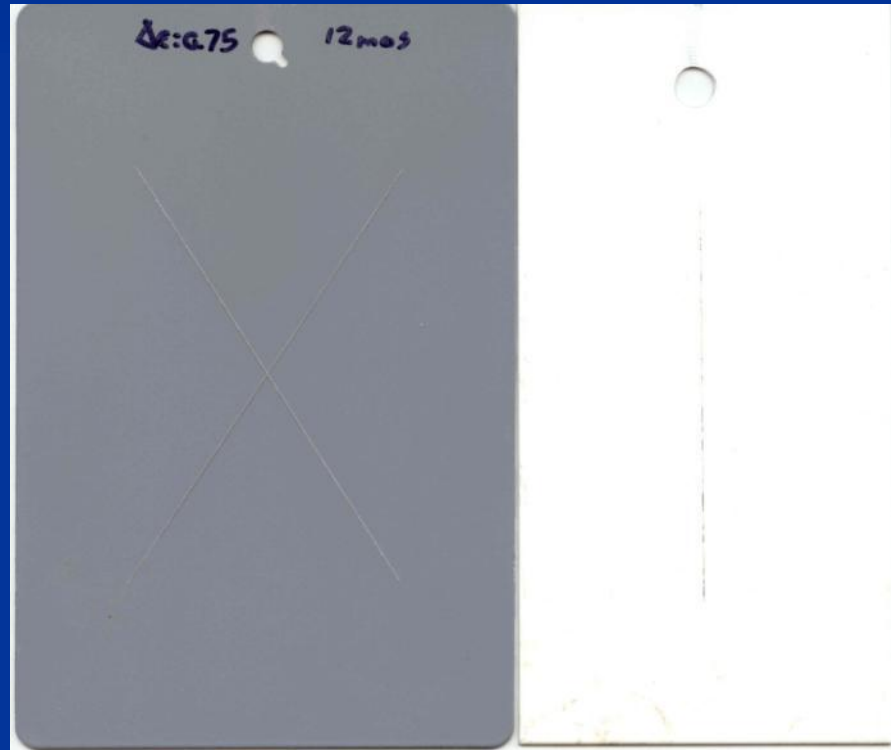
- UV Cure Powder:
 - Currently utilizing one vendor
 - Three colors, two gloss whites, one semi-gloss gray
 - Current powder melts and flows at 115°C
 - Has undergone a number of tests to validate performance
 - The current powder has no Chromium, Molybdenum, Vanadium, Barium, or any rare earth inhibitors
 - In fact, it has no corrosion inhibitors

ESTCP Project WP-0801

- UV Cure Powder Performance Summary:
 - Greater than 4400 hours scribed B117 salt spray
 - 18 months on beach with shiny scribes
 - Better than the control in 1000 hour filiform
 - UVCPC is 38% more durable in falling sand testing
 - Easily passed fluid immersion testing
 - Strippability demonstrated

ESTCP Project WP-0801

- Salt Spray Panels
 - 12 months on beach
 - 4400 plus hours B117



12-month beach

4400 hour B117

ESTCP Project WP-0801

- **Filiform corrosion resistance results**
 - Testing performed by NAVAIR, Patuxent River
 - Panels removed after 1000 hours without failure

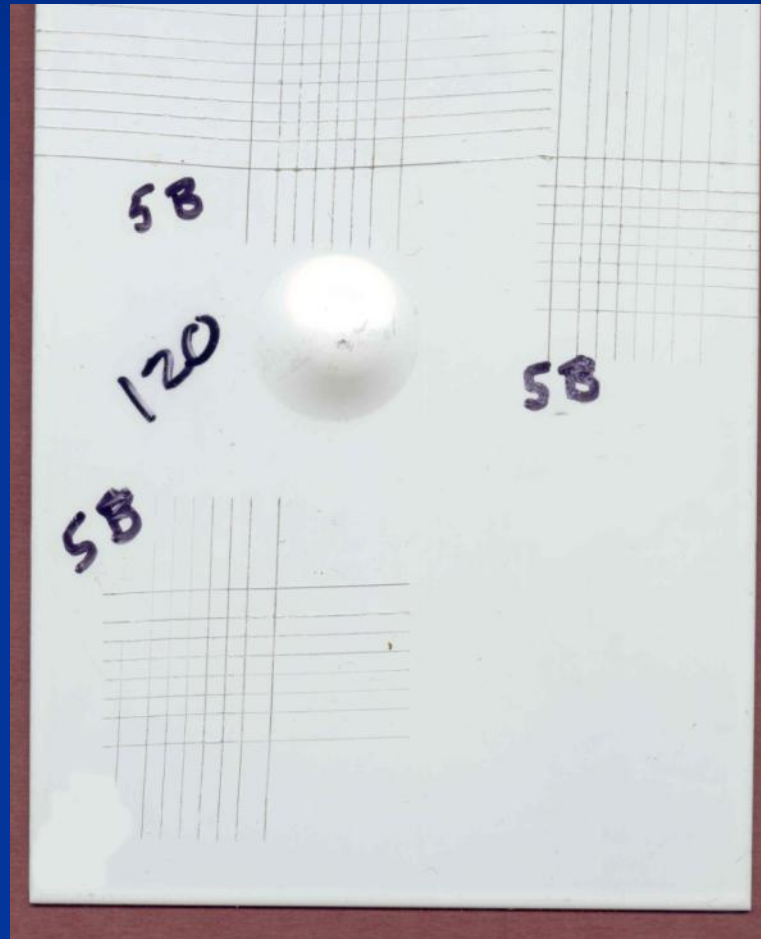


UVCPC

Control

ESTCP Project WP-0801

- Reverse Impact Flexibility
 - >120 in-lb



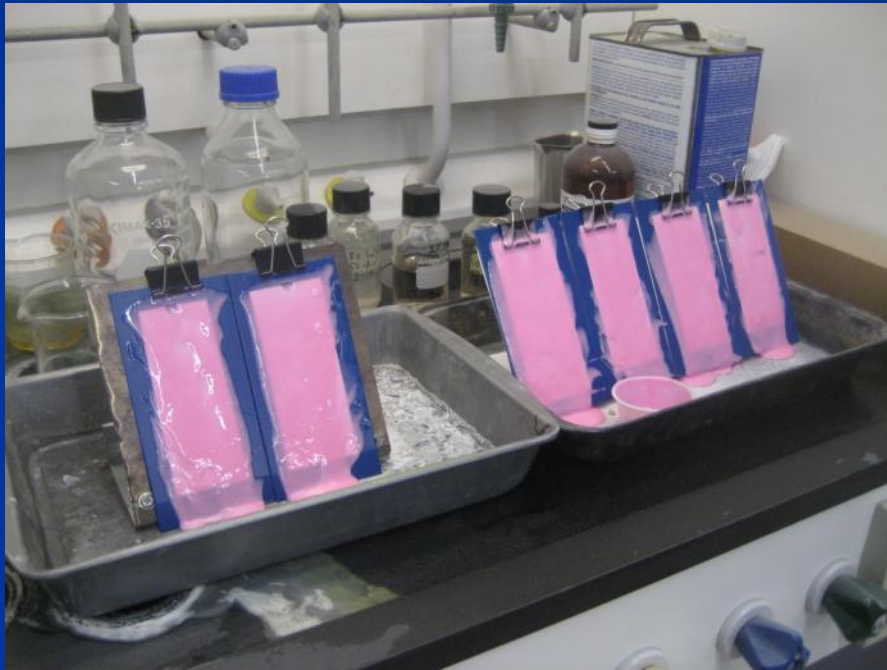
ESTCP Project WP-0801

- Fluid Immersion Resistance



ESTCP Project WP-0801

■ Strippability Tests



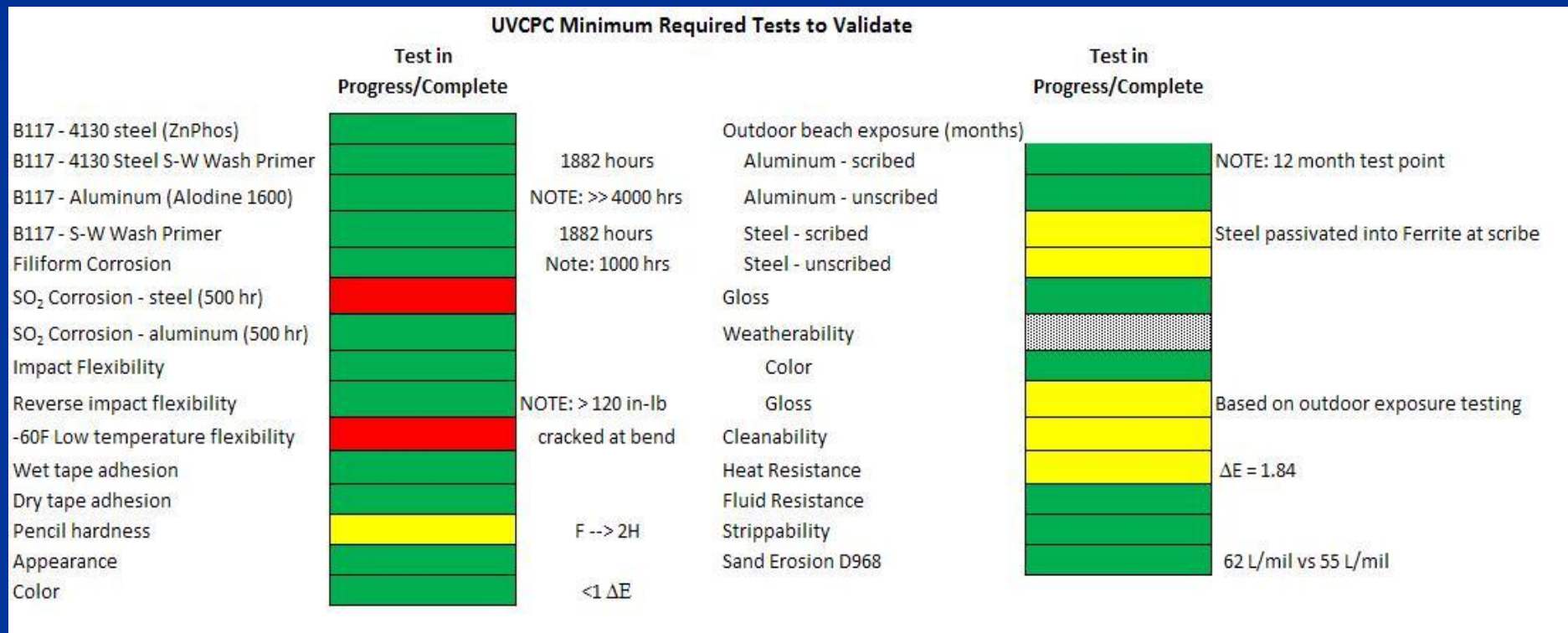
Initial stripper applied



UVCPC after 4 hours

ESTCP Project WP-0801

■ Summary of Validation Testing



ESTCP Project WP-0801

■ Planned demonstration weapon systems:



EA-6B wheels, landing gear



HH-65 helicopter



P-3 wheels, landing gear, radomes



Mk-48 ADCAP torpedo



HC-130 main landing gear doors



Ammunition and storage cases

ESTCP Project WP-0801

■ Studies:

- UVCPC aircraft wheels for PEWG
- Successfully demonstrated capability to electrostatically powder coat otherwise non-conductive materials.



Questions?