Coatings and Process Development for Reduced Energy Automotive OEM Manufacturing

DE-EE0005777

PPG, Dürr Systems USA & North Dakota State University

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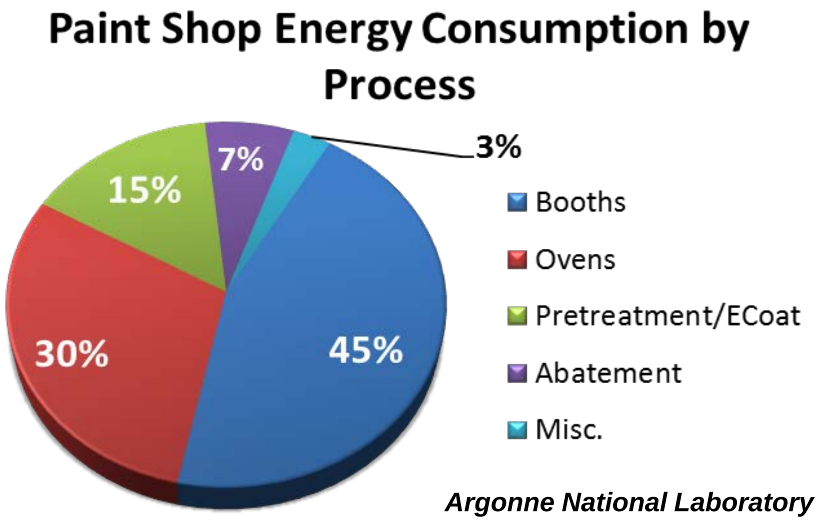
Washington, D.C.
June 13-14, 2017

Project Objective

- Develop coatings, processes and facility design to reduce energy consumption in automotive OEM paint shops

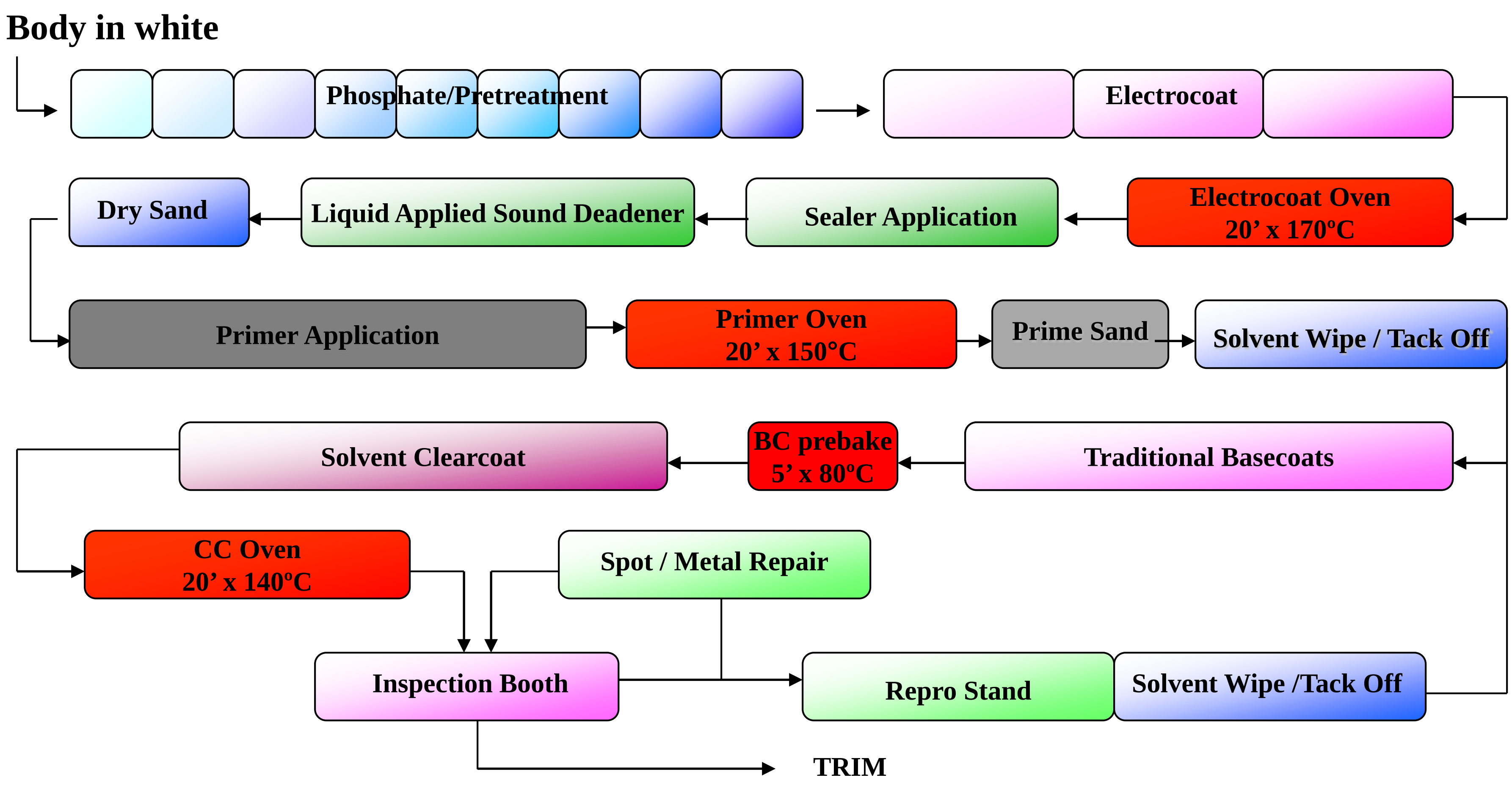
70% of the automotive assembly plant energy is consumed in the paint shop



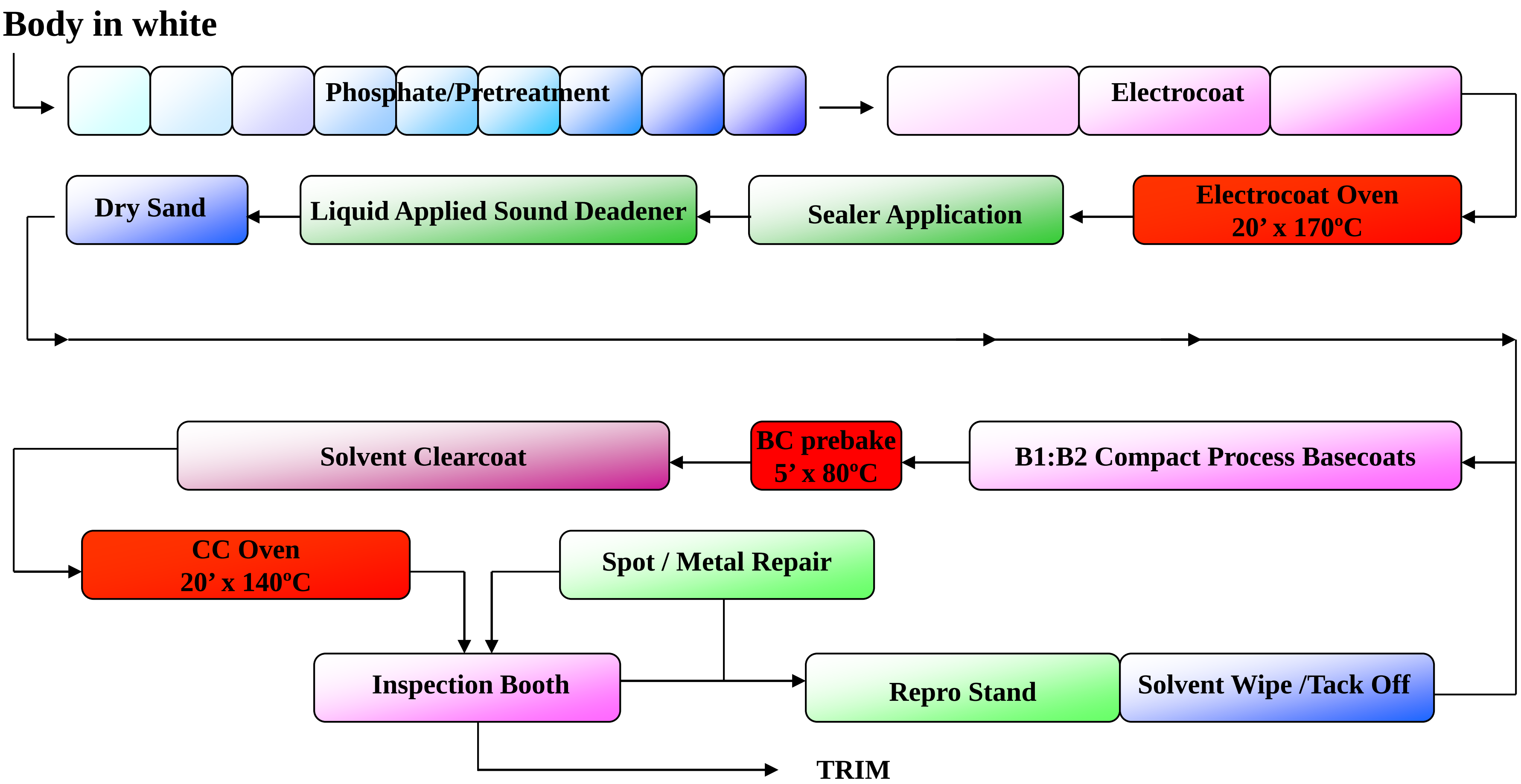
Argonne National Laboratory

- Technical Barriers
  - Maintaining coating properties at lower temperature cure
  - Low temperature cross-link chemistries not commercial
  - Adoption of waterborne technologies and VOC restrictions
  - Process optimization compatibility with “Brownfield” conversion

Technical Innovation – Conventional Process



Technical Innovation – PPG B1:B2® Compact Process



Energy Savings – 30%

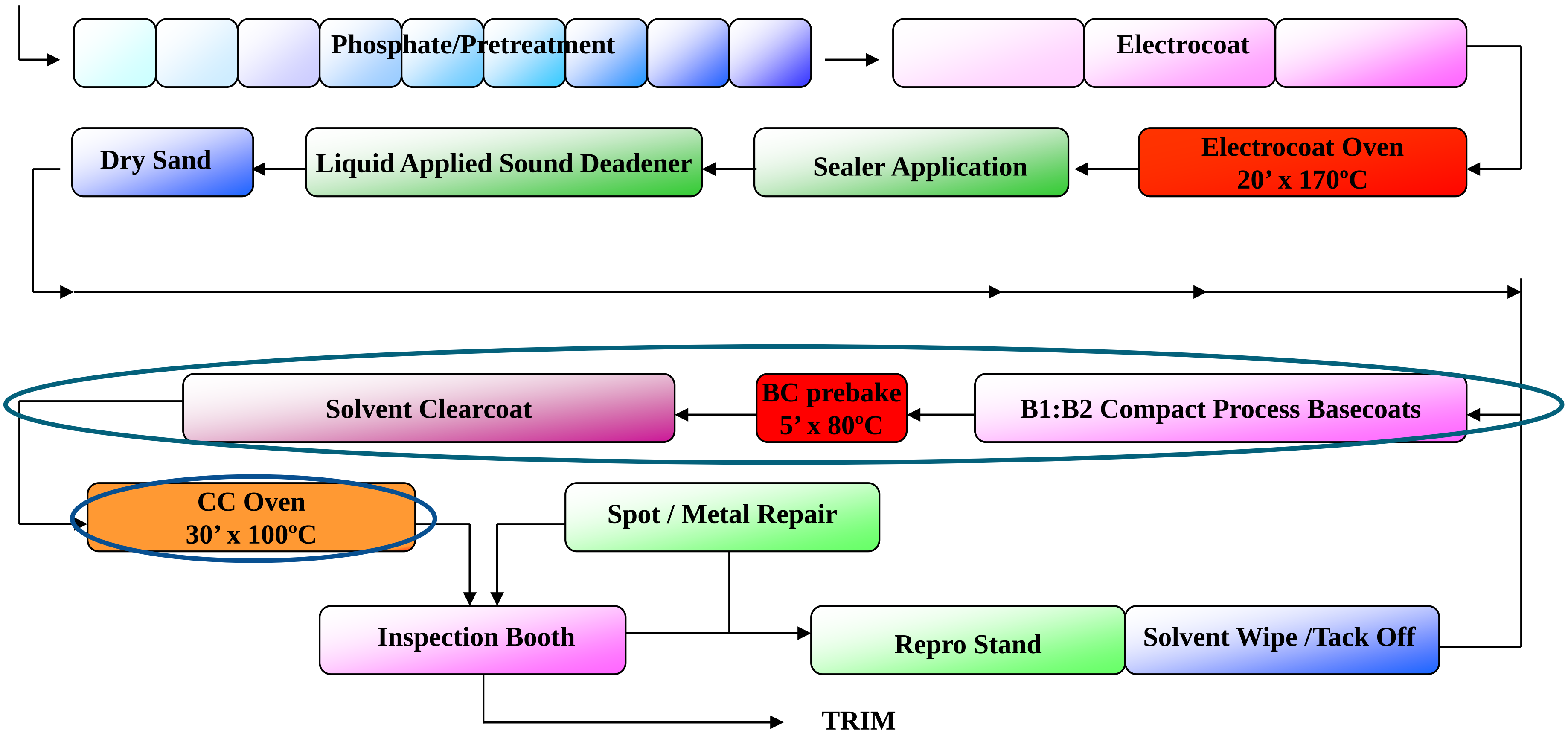
CO_2 Reduction – 43%

VOC Reduction – 7%

Cycle Time Reduction – 15 minutes

Technical Innovation – Reduced Energy Process

Body in white



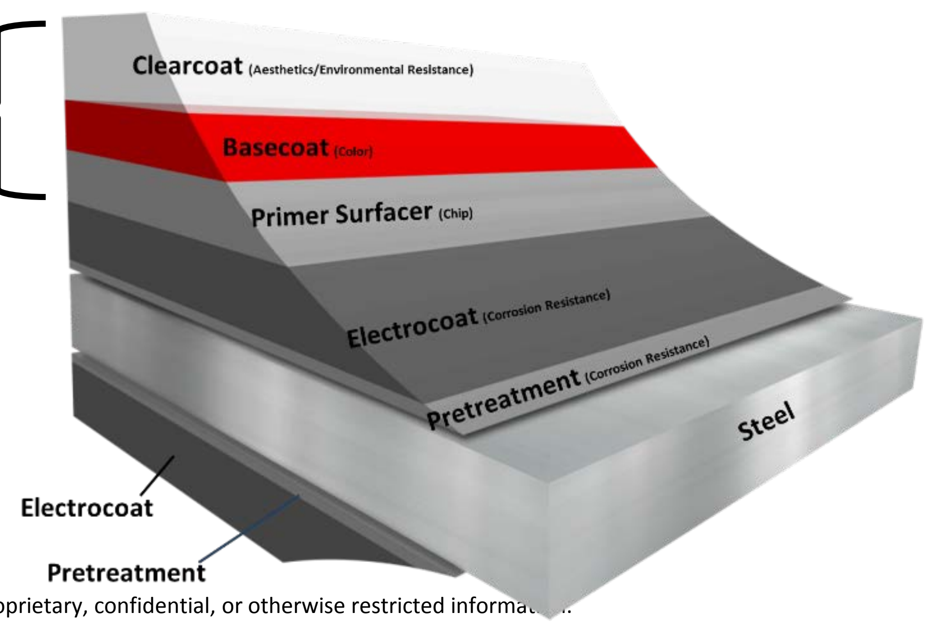
- Lower Oven Temperature
- Reduction in Waste Heat
- Faster Time Between Layer Applications
- Lowers Fresh Air Demand in Oven
- Reduced Temperature/Humidity Control Requirements
- Enable Lightweighting– Temperature Sensitive Substrates

Technical Approach – Low Temperature Cure

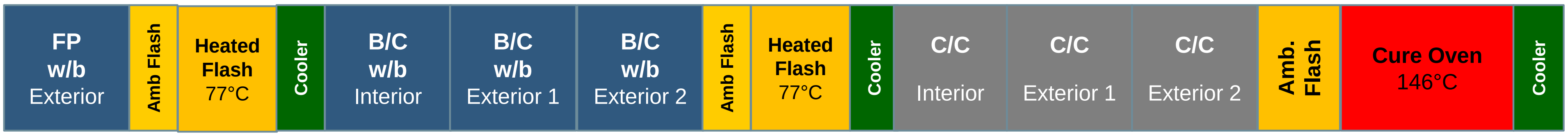
Low Temperature Cure Coating

- Development of new low temperature cure polymers and formulas
  - Oven temperature reduction 140°C → ≤100°C
  - Dehydration redesign for smaller footprint, lower energy
- Target layers include; Primer, Basecoat and Clearcoat
- North Dakota State University: High-throughput material analysis
- Dürr Systems Inc.: Application system modeling, design, and fabrication

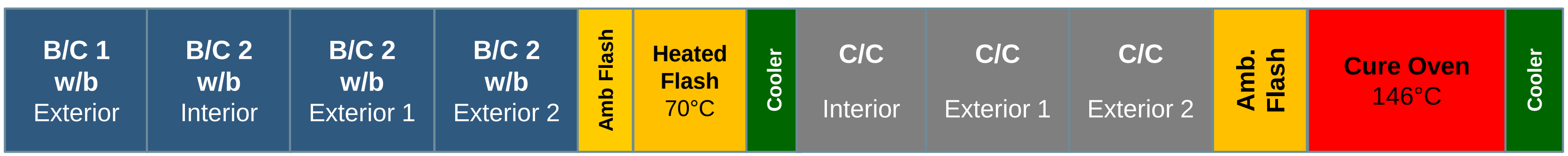
Target Layers



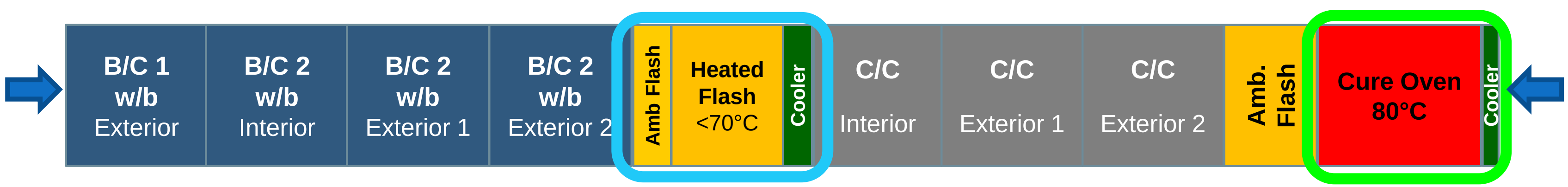
Technical Approach – Coating System Engineering



Baseline 2 - FP-BC-CC Compact Painting Process



Baseline 1 - B1-B2-CC Painting Process



PPG Monobooth Approach

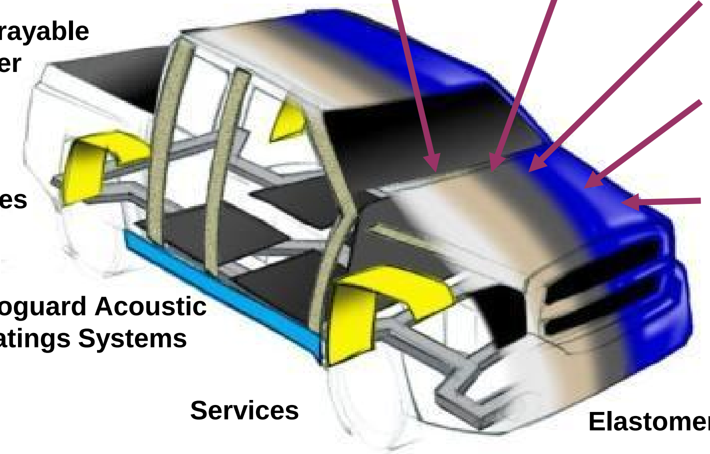
Compacts the process further

Transition (beyond DOE assistance)

- Automotive Industry

PPG Innovations

❖ Cationic Electrodeposition
❖ Powder Clearcoat
❖ B1:B2 Process



- Enable application temperature sensitive substrates and lightweighting

- Staged commercialization to manage risk
  - Low temperature application on existing lines
  - Monobooth conversion in target plant
  - Implementation dependent on automotive facility capital depreciation plans

Measure of Success

- Development of low temperature cure topcoat systems that meet stringent automotive performance properties
- Lab scale prototype validation of a consolidated topcoat booth design and associated energy saving
- OEM briefings are on-going
- Identification of an OEM partner planned for continued development and commercialization

- Project proposal identified 18 TBtu/year savings based on 2012 US vehicle projection
  - Project on track to meet these goals based on BP1 achievements
  - Dürr Systems quantified energy savings of material and process improvements relative to current baseline

Project Management & Budget

BP1
- 15 Mo
- Jan 15 – Mar 16

Develop low temperature cure polymers and formulas

BP2
- 17 Mo
- Apr 16 – Aug 17

Engineering and manufacture of lab scale oven design

BP3
- 10 Mo
- Sep 17-Jun 18

Lab scale validation of materials and process

Title	Milestone	Description	Completed/ Planned
Synthesis	M1.1.1 ✓	Physical data on polymer samples	Mar 2015
Initial Formulation	M1.2.1 ✓	Solid color basecoat/clearcoat application	Jun 2015
Monobooth Coatings	M1.3.1 ✓	Metallic color basecoat/clearcoat applications	Aug 2015
Monobooth Process	M1.3.2 ✓	Process variables defined	Sep 2015
Combinatorial catalysts	M2.1 ✓	Catalyst investigations through combinatorial techniques	Feb 2016
Design Principles	M3.3.1 ✓	Coating system design strategies communicated to equipment supplier	Feb 2016
Chemistry Selection	M4.1 ✓	Coating chemistry down-selection	Mar 2016
Combinatorial coatings	M6.1 ✓	Coating investigations through combinatorial techniques	Aug 2016
Equipment Design	M7.4.1 ✓	Oven/booth equipment requirements defined	Dec 2016
Equipment Fabrication	M7.5.1	Fabrication of lab scale equipment	Q2 2017
Equipment Installation	M9.1	Equipment installation at PPG labs	Q3 2017
Lab Scale simulations	M10.1	Demonstration using newly fabricated monobooth concept	Q4 2017
System Optimization	M11.1	Coating systems demonstrated using optimized equipment and materials	Q2 2018
Final reporting	M12.1	Final Reporting for entire project	Q3 2018

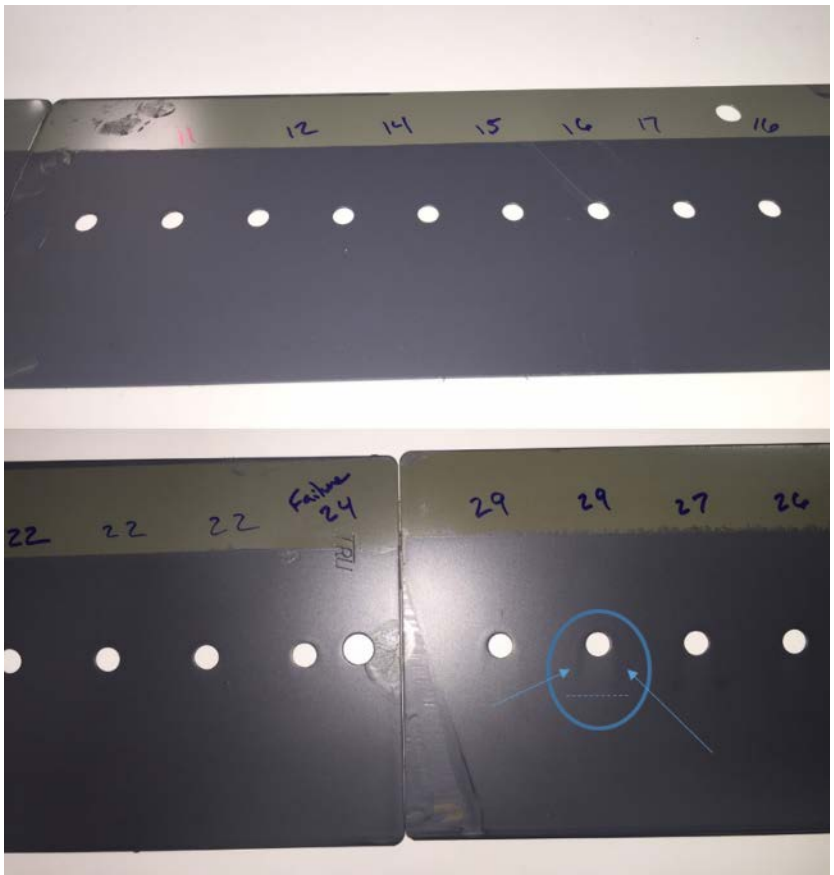
Total Project Budget	
DOE Investment	$2,972,349
Cost Share	$1,273,722
Project Total	$4,246,071

Results and Accomplishments

Initial State	Current State
• Unproven resin system • Unsuitable viscosity changes • Rheology shortcomings • Performance gaps • Lab sprayouts	• Proven advanced resin system • OEM-grade formulation • Class I appearance and performance • Demonstrated on pilot scale application equipment

Results and Accomplishments - Applications

- Paint scaled up for robotic spray application
- Optimized for sag and appearance
- Wedge panels used to quantify sag



Results and Accomplishments - Dürr

- Oven design features
  - Fits 1′ x 1′ panels to auto door skins (24" x 34")
  - Top and size nozzle panels
  - Max Temperature: 300°F
  - Water content: 2 – 20 g/kg

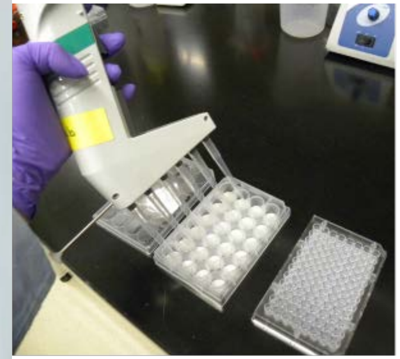
Probe	Name
#1	Ambient
#2	Hood
#3	Roof Metal
#4	Fender
#5	Driver Door
#6	Lower Windshield
#7	Upper Windshield
#8	Lower A-Pillar
#9	Upper A-Pillar
#10	Middle B-Pillar
#11	Lower B-Pillar
#12	Front Rocker
#13	Rear Rocker
#14	Lower C-Pillar
#15	Upper C-Pillar
#16	Rear Roof Rail

- Adjustable variables
  - Airflow
  - Air velocity
  - Fresh air percentage
  - Supply air temperature
  - Supply air humidity level

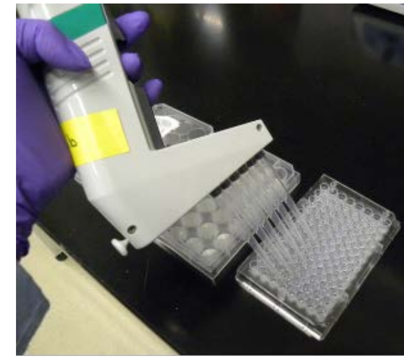
- **Enables flash and cure development in customer relevant environment**
- **Accommodates future coating generations**

Results and Accomplishments - NDSU

- High throughput dye extraction technique
- Indirect measure of crosslink density
- Applied to waterborne latex for first time
- Variables: latex structure, crosslinker type and level, cure temperature



Deposition of toluene over coatings



Transfer of extract to 96 well plate

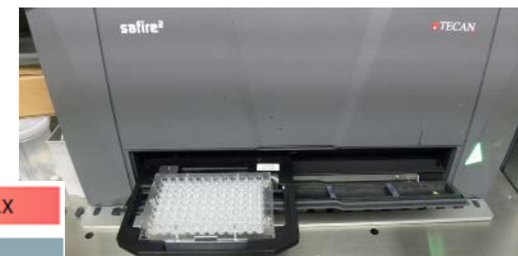


Plate reader for measuring fluorescence

MIN — MAX

Crosslinker B, mole/keto eq.								
0.50	325	297	299	296	300	305	315	324
0.38	347	323	323	320	323	318	329	344
0.25	363	342	339	327	332	330	331	352
0.13	417	388	386	377	378	366	370	382
0	442	412	404	394	393	379	373	389
Crosslinker A, % solids/resin solids	0	2	4	6	8	12	18	24

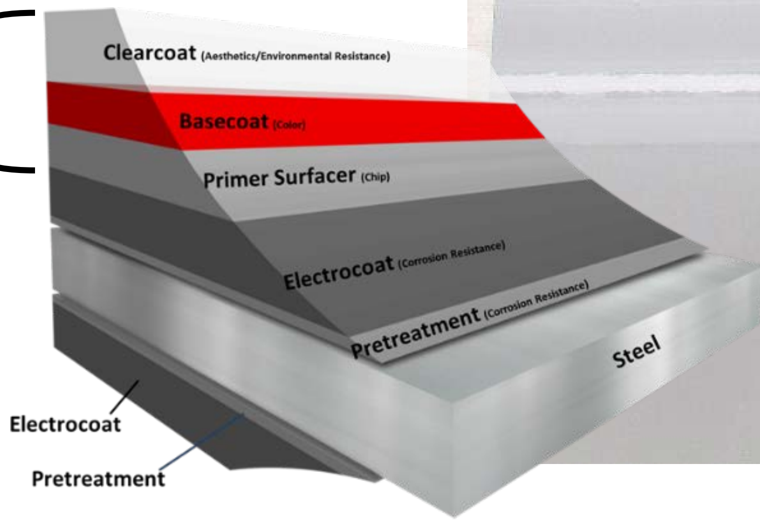
Crosslinker B, mole/keto eq.								
0.50	304	281	276	265	257	245	251	272
0.38	333	305	305	294	286	274	269	286
0.25	355	331	323	310	307	294	284	306
0.13	405	380	377	364	352	332	327	333
0	417	396	393	381	367	349	332	344
Crosslinker A, % solids/resin solids	0	2	4	6	8	12	18	24

80 °C — CURING TEMPERATURE — 120 °C

Results and Accomplishments - Monocoat

- Low temperature cure for monocoats
- Opportunity for lightweighting in commercial vehicles – composites and other temperature sensitive substrates

Combined layers



Questions?

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