



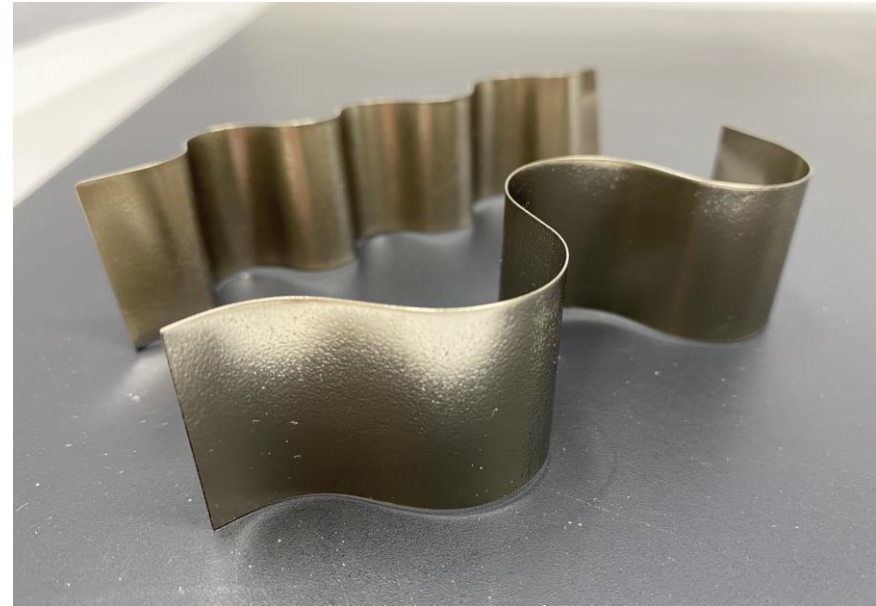
## High Performance Materials: Introducing PEI Resins for Coating Applications

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## Agenda

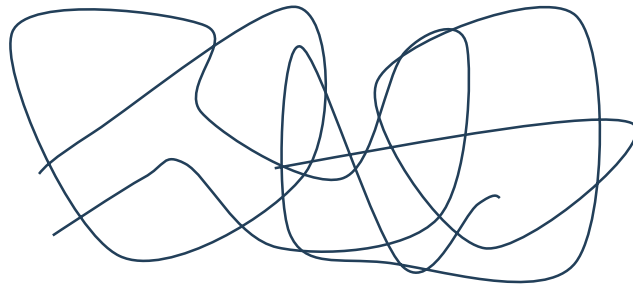
- Thermoplastic vs Thermoset
- Polyetherimide Resin
- PEI coating
- Testing and Results
- Summary



# Polymers

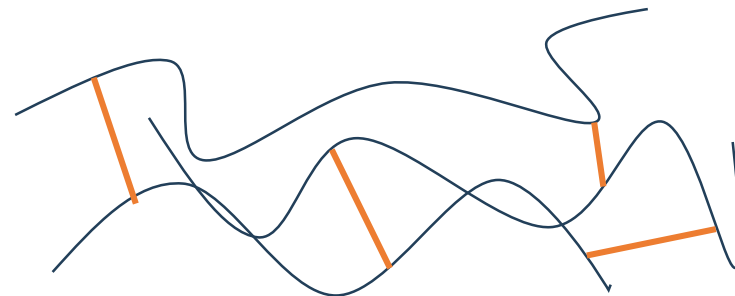
## Thermoplastic

- Soften when heated due to weak intermolecular forces between chains
- Reheat and reshape multiple times

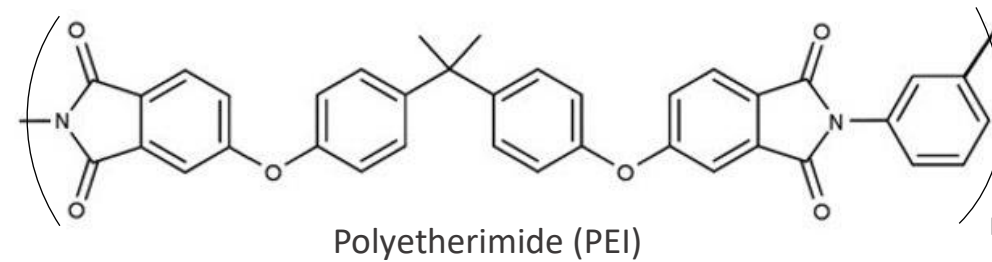


## Thermoset

- Polymer chains crosslink and make strong covalent bonds between polymer chains
- Irreversible



# Polyetherimide Resin



Polyetherimide resin is an amorphous thermoplastic resin, developed for injection molded applications where high mechanical strength, high heat dimensional stability, and chemical resistance are required.



# Polyetherimide Resin

- Polyetherimide with high strength and modulus at high temperatures
- Dimensional stability / tight tolerances
- Long-term high heat stability
- Inherent flame resistance with low smoke evolution & toxicity

## KEY INDUSTRIES



Mass  
Transportation



Electrical &  
Electronics



Automotive /  
Mobility



Healthcare



Food Contact



Harsh  
Environments



# Polyetherimide Resin

PEI Resins may offer (Feature):

- **Healthcare** *USP class VI and ISO10993*
- **Potable water** certificates  
*WRAS, ACS, KTW, W270 and NSF61*
- Gamma, EtO, & Steam **Sterilizable**
- Stable **Electrical** performance (**Dk/Df**)
- Global **Food contact** approvals  
*FDA, EFSA, JHOSPA*
- Long-term **High Heat** capability  
*T<sub>g</sub> 217-227°C, UL746B RTI 170-180°C*
- **Dimensional** stability / Tight tolerances  
*Low/consistent shrinkage, low CTE*



- Inherent **Flame Resistance**, Environmentally Friendly  
*UL V0 down to 0.25mm. FAA compliance*
- **Low smoke** evolution and **toxicity**  
*FAA compliance*
- **Mechanicals** up to high temperatures
- Hydrolytic and **chemical** stability
- Opaque and transparent colors

# Polyetherimide Powder

PROPERTIES	TYPICAL VALUES PEI 1	TYPICAL VALUES PEI 2	UNITS	TEST METHODS
<b>PHYSICAL</b>				
D50 particle size	60	17	μm	SABIC method
D10 particle size	40	11	μm	SABIC method
D90 particle size	94	26	μm	SABIC method
Water Absorption, (23°C, equilibrium)	1.25	1.2	%	ASTM D570
<b>INJECTION MOLDED PROPERTIES</b>				
Specific Gravity	1.27	1.28	-	ASTM D792
Coefficient of Thermal Expansion (-20 to 150°C)	52	51	10 <sup>-6</sup> /°C	ASTM E831
Volume Resistivity	1.0 x 10 <sup>17</sup>	1.1 x 10 <sup>17</sup>	Ω.cm	ASTM D257
Flexural Modulus, 1.3 mm/min, 50 mm span	3200	3100	MPa	ASTM D790
Flexural Stress, yld, 1.3 mm/min, 50 mm span	165	138	MPa	ASTM D790
Heat Deflection Temperature 0.455 MPa, 3.2 mm, unannealed	210	214	°C	ASTM D648

# Polyetherimide Powder

Polyetherimide powders were obtained from commercial grades intended for injection molding applications

- Powder under testing contains 99.9+ wt% PEI resin
- No additional additives or materials incorporated before coating





# Chemical Resistance

- Excellent property retention
- Resistance to environmental stress cracking for:
  - Most automotive & aircraft fluids
  - Fully halogenated hydrocarbons
  - Alcohols
  - Weak aqueous solutions
- Chemistries with partially halogenated hydrocarbons & strong alkaline should be avoided
- **PEI 2 - Chemical Resistance Series**
- The amorphous PEI 2 was developed to further enhance the chemical resistance of PEI with the chemical resistance often associated with crystalline and specialty materials.

➤ For prolonged immersion, parts should be evaluated under actual service conditions.

Chemical Compatibility for PEI 1 and 2 resins

Media	Temp (°C)	Immersion (days)	Strain (%)	PEI 1	PEI 2
				Surface Attack	
Toluene	23	21	0.25	<48	none
Methyl Ethyl Ketone	23	21	0.25	<2	none
Alcohols <sup>1</sup> Methanol	23 °C	21	0.25	none	none
		21	0.5	none	none
	60 °C	21	0.25	none	none
		21	0.5	none	none
Aqueous detergents <sup>2</sup> & cleaners	23 °C	21	0.25	none	none
		21	0.5	none	none
	60 °C	21	0.25	none	none
		21	0.5	none	none
Domestic detergents	23 °C	21	0.25	none	none
		21	0.5	none	none
	60 °C	21	0.25	none	none
		21	0.5	none	none
Bleach (10%)	23 °C	21	0.25	none	none
		21	0.5	none	none
	60 °C	21	0.25	none	none
		21	0.5	none	none

<sup>1</sup> Other examples of alcohols include ethyl, propyl and some glycols

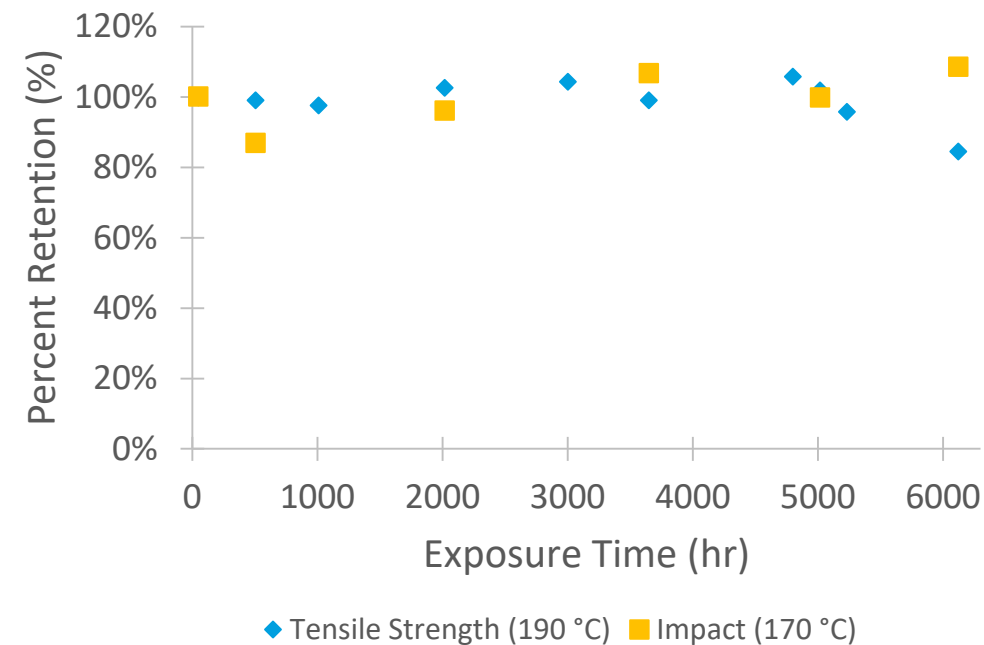
<sup>2</sup> Other examples of aqueous detergents include hypochlorite bleaches & phosphate cleaners

# Thermal Performance

As an amorphous resin, PEI resins has a glass transition temperature of 217°C and no crystalline melting temperature.

PEI resin is rated to a long term electrical and mechanical relative temperature index (RTI, UL 746B) of 170 °C.

Mechanical properties at temperatures higher than RTI will eventually degrade performance. PEI performance, as shown, can remain acceptable for shorter periods of time.



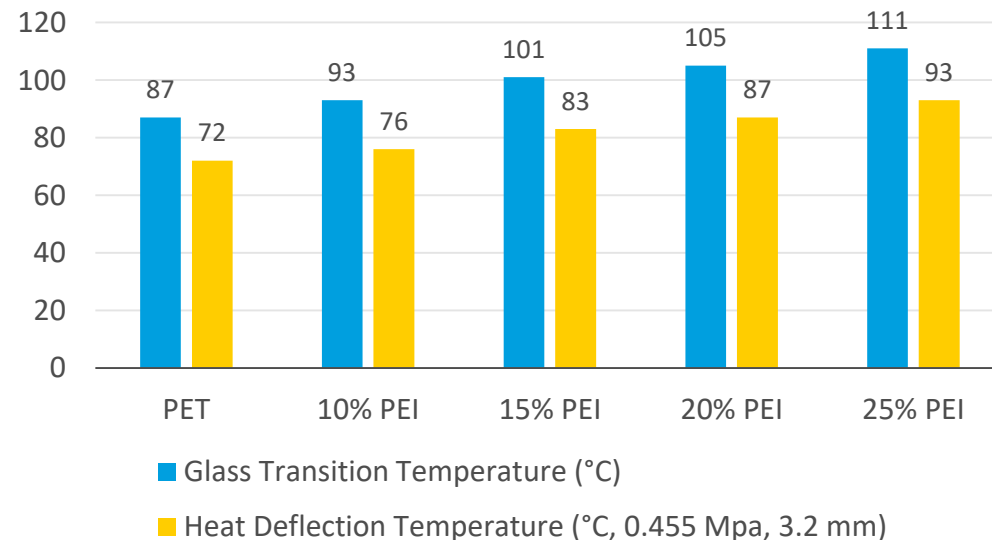
Thermal Properties	Method	Units	PEI	PET	PA11
Vicat Softening Temperature, B/50	ASTM D1525*	°C	215	80	180
Heat Deflection Temperature, 1.82 MPa, 3.2 mm	ASTM D648*	°C	190	75	50
Coefficient of Thermal Expansion, -20 °C to 60 °C	ASTM E831*	× 10 <sup>-6</sup> /°C	52	65	110

# PEI Material Compatibility

Miscible or partially miscible polyester / PEI resin blends can provide a balance of thermal, mechanical, and physical properties

Demonstrated with:

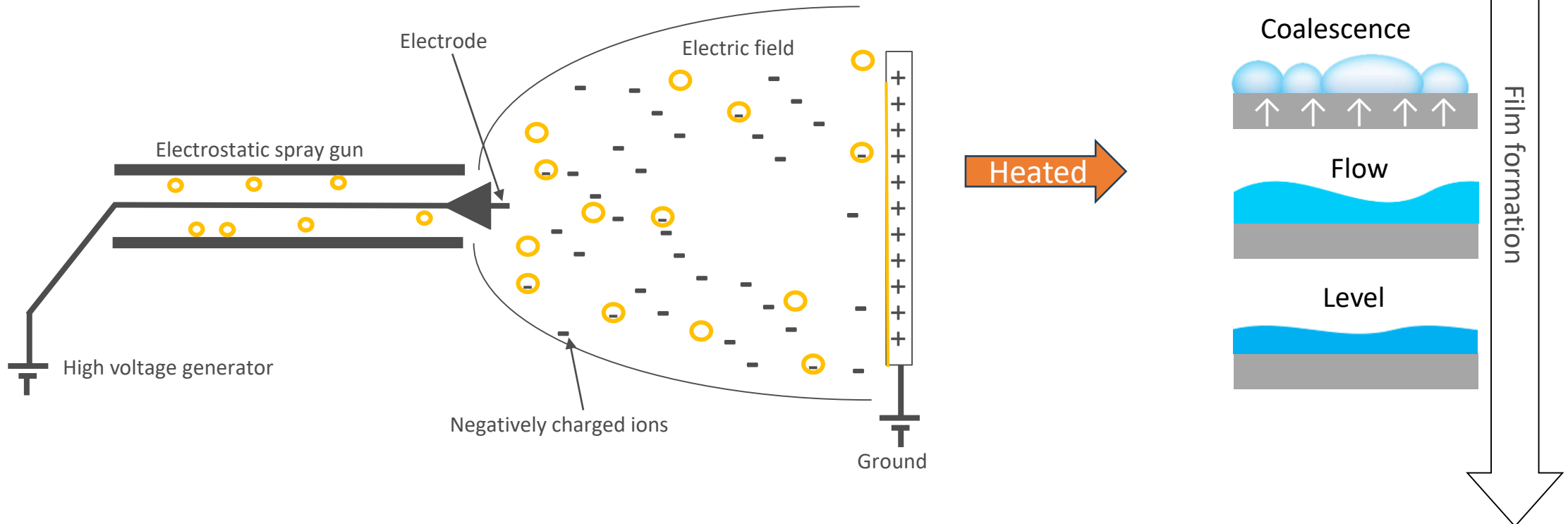
- PET, polyethylene terephthalate
- PBT, polybutylene terephthalate
- Copolyesters with cyclohexane dimethanol (CHDM)



	Polyester (PET)	Polyetherimide (PEI)	PET+PEI Blends versus PET
<b>Property improvements resulting from PEI addition</b>			
Tg (°C)	87	217	Higher
Density	1.4	1.27	Lower
Shrinkage (%)	Up to 3	Up to 0.7	Lower
CTE (ppm / °C)	80	50	Lower
Limiting Oxygen Index (LOI, %O <sub>2</sub> )	21	47	Higher
UL94 Flame Retardancy	HB	V0 @ 0.75 mm	More Flame Retardant
Tensile Strength	60	110	Higher
<b>Trade-offs resulting from PEI addition</b>			
Viscosity	Low	High	Higher
Color	Clear / White	Yellow	Yellow
Cost	Low	High	Higher

# Electrostatic Powder Coating

- Coating particles
- ⊖ Negatively charged coating particles



# PEI Coating Properties on Steel

## Process

Neat resin with no color or additives  
 Electrostatic spray coating  
 Fusion temperature: 360 to 380 °C

## Thickness

60-70 µm layer on cleaned mild steel substrate

## Material

PEI1 and PEI 2 Powder



Crosshatch Adhesion



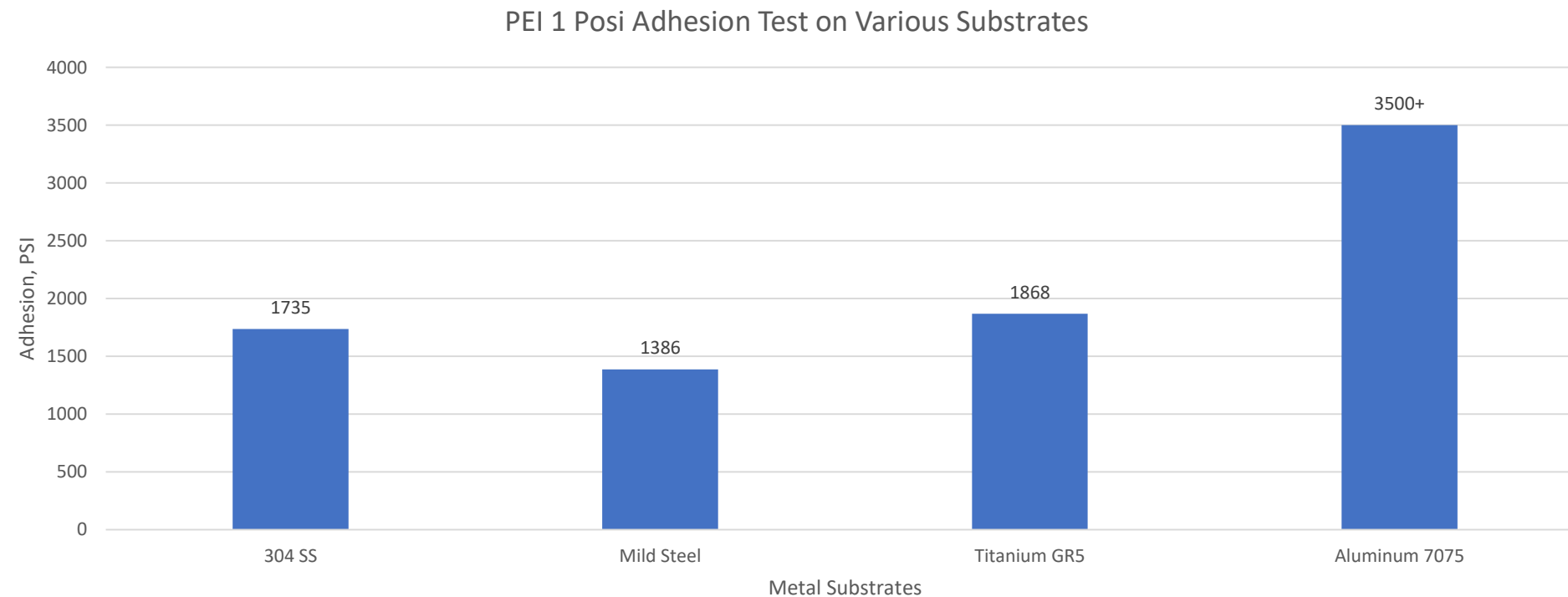
Impact (160lbf) front and backside



Coating	Gloss at 20°/60°/85°	Crosshatch Adhesion	Pencil Hardness	Impact Resistance	Conical Mandrel Bend	MEK Double Rub (100)
Standard	ASTM D2457	ASTM D3359	ASTM D3363	ASTM D2794	ASTM D522	
PEI 1	93/116/97	5B	2H	160lbf	Pass	Pass
PEI 2	113/118/101	5B	2H	160lbf	Pass	Pass



# PEI 1 Coating Adhesion to Various Metal Substrates



# Processing Thermoplastic PEI 1 and PEI 2

- ✓ Direct to metal
- ✓ Can use same electrostatic spray equipment
- ✓ Powder handling is the same as other powder coating powders
- ✓ Film formation with typical heating methods (convection, IR)
- ✓ Adhesion to a variety of metal substrates
- ✓ Added a new set of properties achievable with PEI



# SUMMARY



PEI powder coatings may be applied to variety of metal substrates, provided the substrate can be raised to the necessary coating temperature without causing physical or chemical change to the underlying substrate



No specialized processes are required for the electrostatic spray application of PEI powders



Please ask about other options for modifications to PEI resin in a coating solution: dispersive, reactive, pre-colored resin, or liquid varnish

Thank you

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