

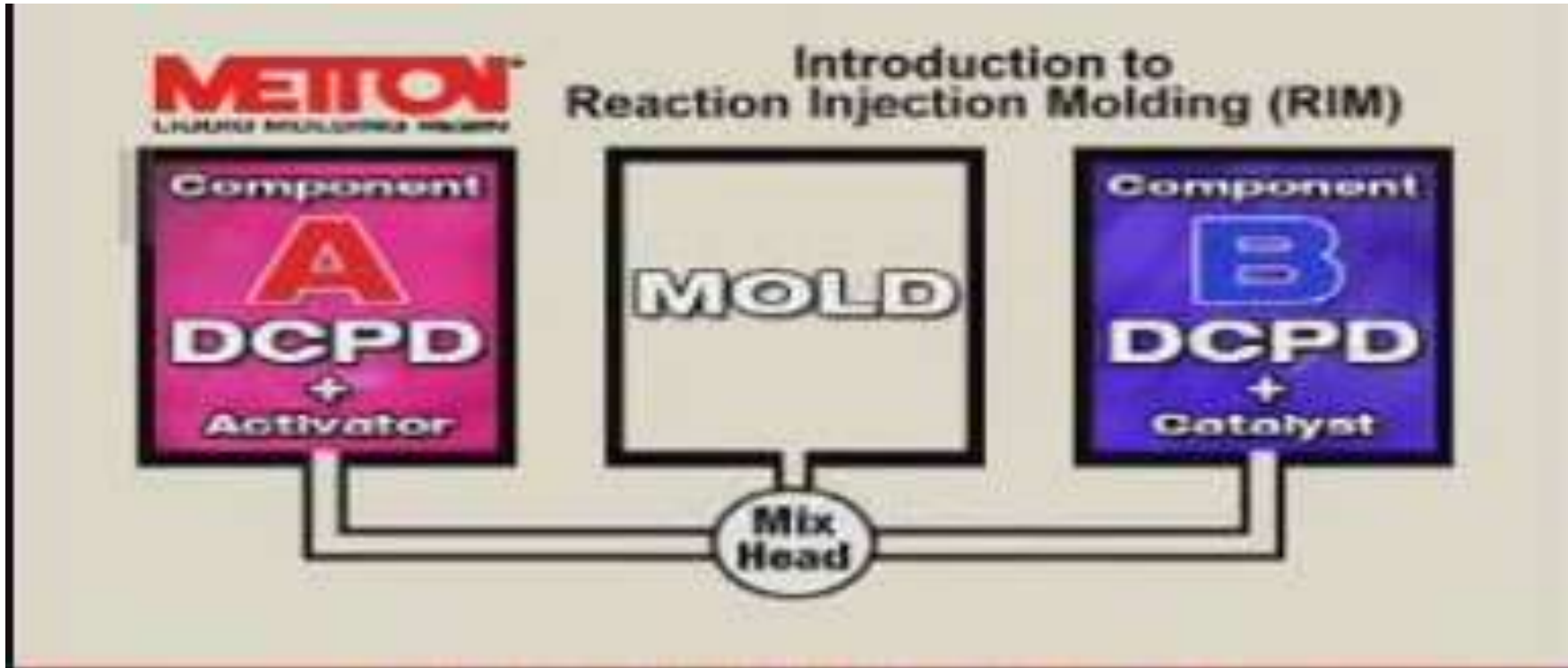
Reaction Injection Moldable Polydicyclopentadiene (pDCPD) for the Heavy Truck Market

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PolyDCPD RIM Molding Evolution:

- Introduction
- Heavy Truck Applications
- Construction/Agriculture Applications
- Industrial Applications

REACTION INJECTION MOLDING



- Viscosity Close to Water @ 300 centipoise
- Inject Parts up to 13 m² or > 100 kg
- Cavity Pressure of 15 to 30 psi (Design Mold to Maximum 50 psi)

LOW PRESSURE PROCESS with LOW VISCOSITY LIQUIDS

TOOLING OPTIONS:



- **Differential Core & Cavity Temperature for Optimum Surface Quality**
 - Core @ 60 C and Cavity @ 80 C
- **Class A Parts: Nickel Shell or Machined Aluminum**
- **Industrial Parts: Cast Aluminum is an Option**
- **Prototypes: Composite Molds, Machined Pattern Material, Plaster, etc.**

LOW PRESSURE MOLDS & MANY PROTOTYPE OPTIONS

MECHANICAL PROPERTY COMPARISON:

PROPERTY U.S. Units (SI Units)	ASTM METHOD	METTON 1539	ABS	FRP	SMC
Density, g/cc (lb/in ³)	D792	1.03 (0.037)	1.05 (0.038)	1.43 (0.0518)	1.84 (0.0667)
Tensile Strength @ yield, Ksi (MPa)	D638	6.8 (46.8)	4.3 (29.6)	10.5 (72.3)	4.7 (32.34)
Tensile Modulus, Ksi (GPa)	D638	275 (1.90)	276 (1.90)	1,170 (8.08)	1,433 (9.90)
Flexural Strength @ 5% strain, Ksi (MPa)	D790	10.1 (70)	7.5 (52)	13.3 (92)	11.9 (82)
Flexural Modulus, Ksi (GPa)	D790	273 (1.88)	276 (1.82)	882 (6.07)	987 (6.79)
Yield Strain, %	D638	4.7	2.0	1.3	0.6 ⁽³⁾
Plate Impact, (ft-lbs) ⁽¹⁾ @ Design Thickness, inches (mm)	-	34.1 .220 (5.6)	6.6 .125 (3.2) ⁽²⁾	15.9 .215 (5.5)	4.6 .110 (2.8)
Notched Izod Impact @ 23° C ft-lb/in., (J/m)	D256	8.7 (460)	-	-	-
@ 0° C		6.0 (317)	-	-	-
@ -20° C		2.5 (132)	-	-	-
@ -40° C		2.0 (106)	-	-	-
DTUL @ 264 psi., °F (°C)	D648	248 (120)	-	-	-

Notes: Mechanical properties are based on most conservative values either long term aged or freshly molded. Competitive materials were cut from production parts.

(1) 2" diameter top; 8,000 inches per minute, 3.5" clamp ring; (2) ABS part was a chassis side fairing versus others which were hoods; (3) Strain to failure.

BALANCED MECHANICAL PROPERTIES with EXCELLENT IMPACT

RIM Molding Process:



- **Standard RIM Injection Unit: Lance or Pump**
- **High Pressure Impingement Mixhead (70-140 bar)**
- **Inject in 5 to 20 Seconds with Part Fully Cured in 60 Seconds**
- **Normally No Mold Release & No Post Cure**
- **Trimming with Hand Tool or Flush Trim Router Bit**
- **Multi-Cavity Molds Do Not Need Balanced Cavities**

LARGE PART MOLDING with 4 to 6 Min. Cycle Time

Bonding:



- **Bonded Reinforcements Optimize Part Stiffness**
- **P-DCPD is a Friendly Substrate for Adhesives**
 - **Typical Adhesives are Urethane, Epoxy & Methacrylate**

Structural Adhesives Create Large Durable Fabrications

Painting:



- **Surface Oxidation is Required After Molding**
 - Chlorinated Detergent Prewash or 24 Hours Natural Oxidation
 - TPO Primers and Part Sanding are also Options
- **P-DCPD is a Friendly Substrate for Paints**
 - Two Component Urethanes are Most Common
 - Paint Bake Temperatures $<100^{\circ}$ C

Paint Adhesion is Excellent & Class A is Achievable

Heavy Truck Applications:



- **First Commercial Applications in 1996**
 - **Hoods, Fenders, Chassis Side Fairings, Roof Fairings, Bumpers, Side Extenders & Sunvisors are In Production**
- **Large Part Capability, No Fiberglass, Design Freedom & Consistent Part Size**
- **Excellent Damage Tolerance, Reduced Warranties & Low Temp Impact**

Large & Durable Class A Parts with Excellent Paint Adhesion

Construction & Agricultural Equipment:



- **First Commercial Applications in 1988**
 - **Hoods, Fenders & Load Floors are In Production**
- **Metal Replacement Requires Design Freedom for Part Reduction & 3-D Styling Options**
- **Excellent Damage Tolerance, No Rust or Dents and Outstanding Surface Finish**

Large Part Design Freedom & Excellent Damage Tolerance

Industrial Applications:



- **Railroad Chocks in 1988 & Automotive Engine Pods in 1990**
- **Design Freedom with Tight Tolerance, Integrated Functionality, Large Parts with THICK-TO-THIN Transitions & Excellent Chemical Resistance**
- **Tough & Durable Performance for High Abuse & Long-Term Performance**

Thickness to 30 cm, Toughness & Durability for Large & Thick Parts

Thank You

Any Questions?