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Low-Gloss, Weatherable, Molded-In-Color PC/PBT Composite for Vehicle Interiors

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Introduction

Ideal Material for Truck Dashboards/Interior Panels

- Dimensionally Stable
- High Stiffness
- Chemically Resistant
- Abrasion Resistant
- Color Matched

Trends...

- Total Systems Cost Out - Eliminate Painting
- Low Gloss Aesthetics

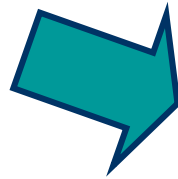


CTQ Flow Down

- Surface finishing
- UV resistance
- Dimensional stability
- Stiff & Strong
- Molded-in color
- Chemical resistance
- Easy to mold

Y

Application
CTQ's



- Gloss
- Flow
- UV-test SAE J1885
- CTLE & shrinkage
- Tensile properties
- Impact resistance
- Abrasion resistance
- Color matches
- ESCR testing

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Target
Properties



- Reinforcement type & loading
- IM type & loading
- UV & heat stabilizers
- Polymer MW
- Polymer blend
- Colorant type & loading

X

Formulation

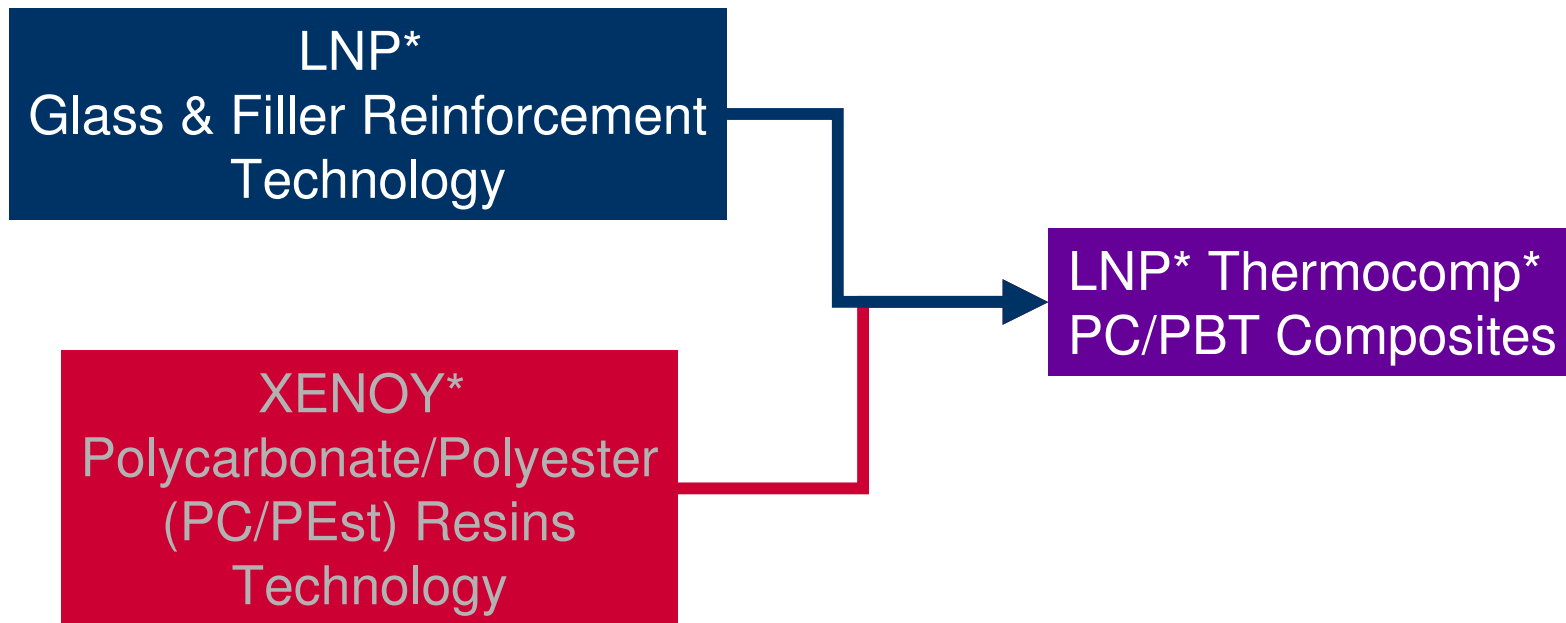
Benchmark Analysis

Properties profile			LG9000 PC/ABS unfilled	FL910 PC-foamed GF	500R PC GF	1760 PC/PBT GF	X5410 PC/PET mineral	CE1821 PC/ABS mineral	9X06433 PC/PBT mixed	NX06434 PC/ABS mixed	
ASTM	MVR 260C/5Kg		17					19*	12	14	12
ASTM	MVR 300C/1.2Kg				7.5						
ASTM	Tensile Yield @50mm/min	MPa	54								
ASTM	Tensile Break @50mm/min	MPa	75								
ASTM	Tensile Yield @5mm/min	MPa		52	66		56	60			
ASTM	Tensile Break @5mm/min	MPa			55	89	45	55	65	65.5	
ASTM	Elong. @Break	%		4.8	15	4.5	38.7	110	4.5	3	
ASTM	Flex modulus	GPa	2.3	3.5	3.4	3.9	2.7	3.1	3.1	3.8	
ASTM	Izod notched impact +23C	J/m	534		106	48	87	500	105	80	
ASTM	Izod notched impact -30C	J/m	320				82	120	55	55	
ASTM	Izod unnotched impact +23C	J/m									
ASTM	Instrum. impact total energy 23C	J	40	46	101	7	54	65			
ASTM	Instrum. impact total energy -30C	J	33								
ASTM	CTE, -40C to 40, flow	1/C	7.2E-05	3.2E-05	3.2E-05	4.5E-05	5.9E-05	6.0E-05	6.0E-05	5.0E-05	
ASTM	CTE, -40C to 40, xflow	1/C	7.2E-05			7.4E-05	7.1E-05	7.0E-05	7.5E-05	7.3E-05	
ASTM	HDT 1.82MPa	C	107		142	115	109	120			
internal test	Mold shrink. flow 3.2mm	%									
internal test	Mold shrink. Xflow 3.2mm	%									
ASTM	Specific gravity	-	1.13	1.12	1.27	1.30	1.27	1.22	1.28	1.20	

*MFR 265C/2.16Kg

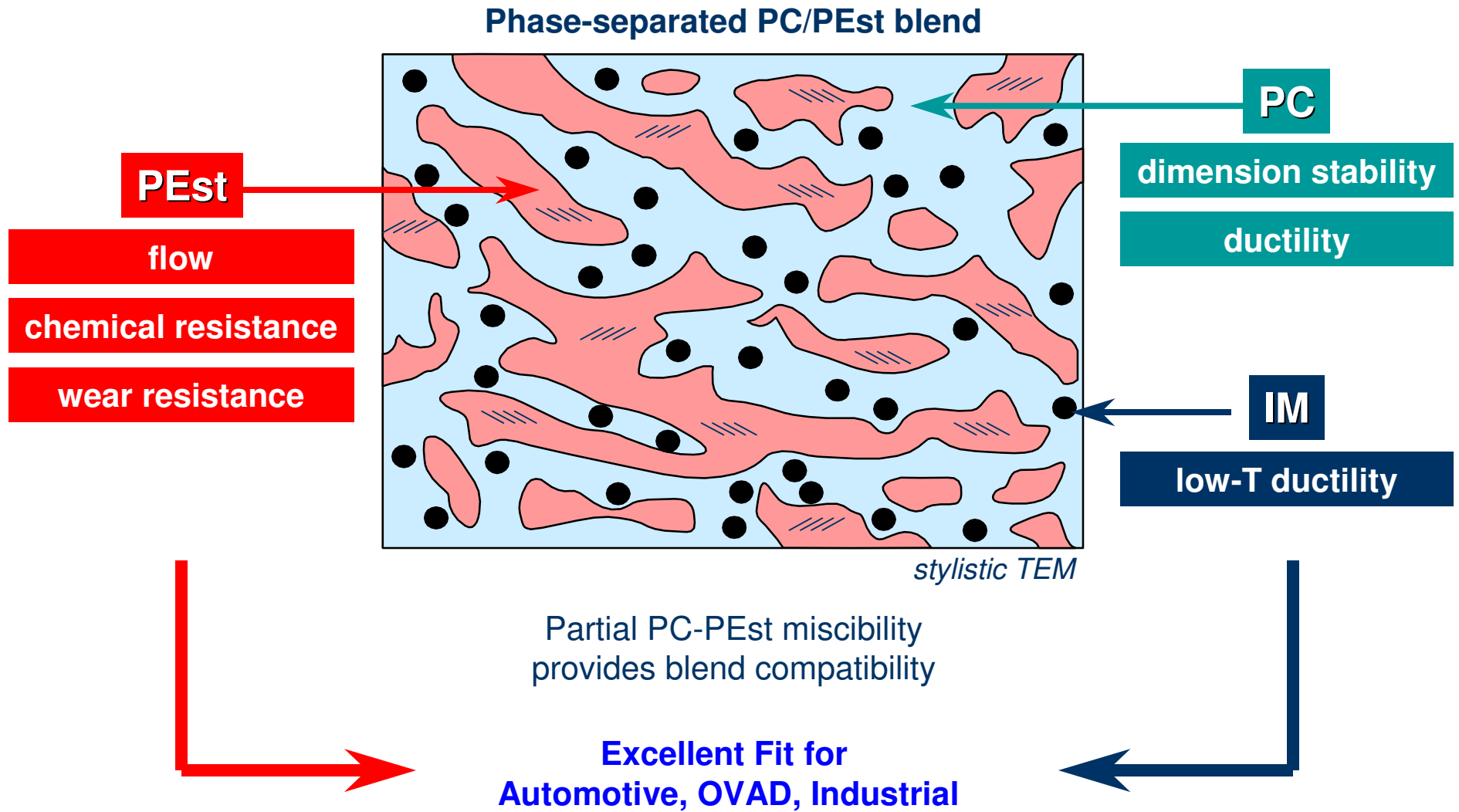
Best Combination of Properties

Matched Capabilities



Best of Both Worlds

PC/PEst Basics



PC/PEst Basics

PC/PEst Compared to...

	TPO	Nylon	ASA Alloys	PC/ABS
Mechanicals/Impact	++	+	+	0
Molded-In Color	+	+	0	0
Heat	+	0	+	+
Weatherability	+	+	--	0
Chem Resistance	+	-	++	++
Hydro Stability	--	-	0	-
Dimensional Stability	0	+	-	-

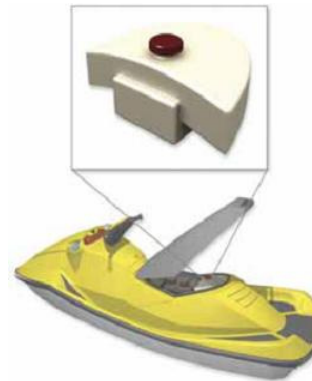
PC/PEst Already Used in...



Body Panels



Energy Absorbers

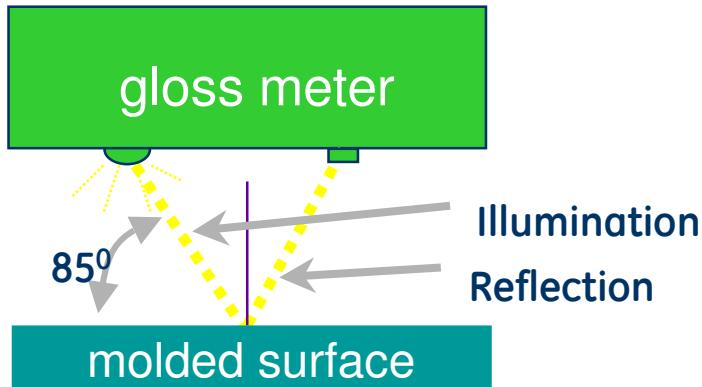


Fuel Tanks

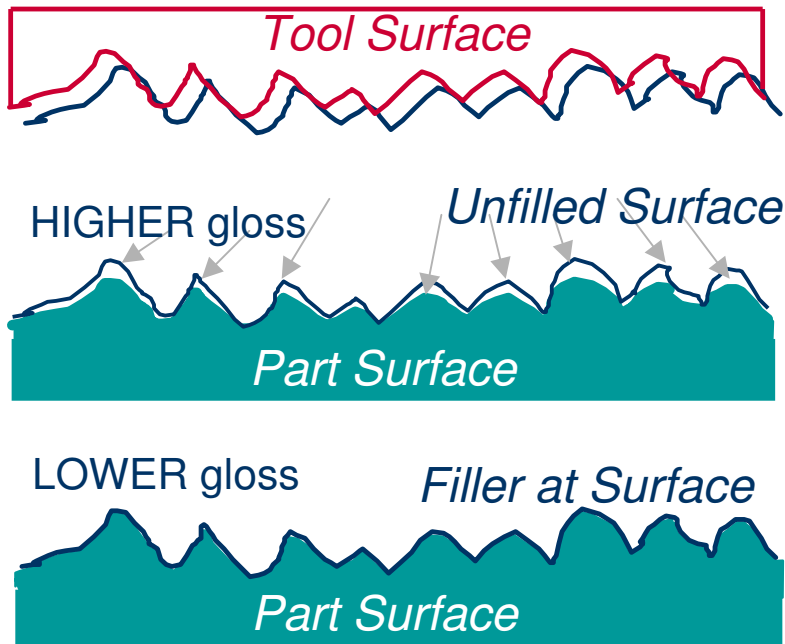


OVAD

Gloss



$$\text{Gloss} = \frac{\text{Reflected intensity}}{\text{Illuminated intensity}} * 100$$



Textured surface

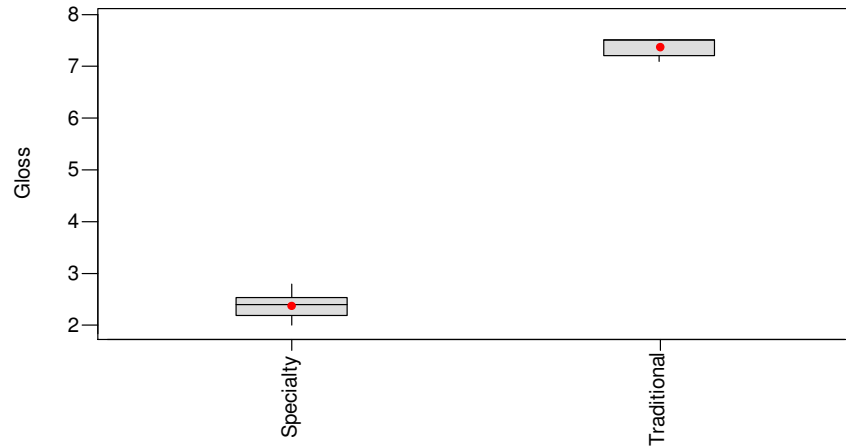
- Replication of mold texture.

Formulation low gloss effects

- Modified polymer matrix ⇔ reduce PC gloss
- Inorganic micro-fillers ⇔ matte surface

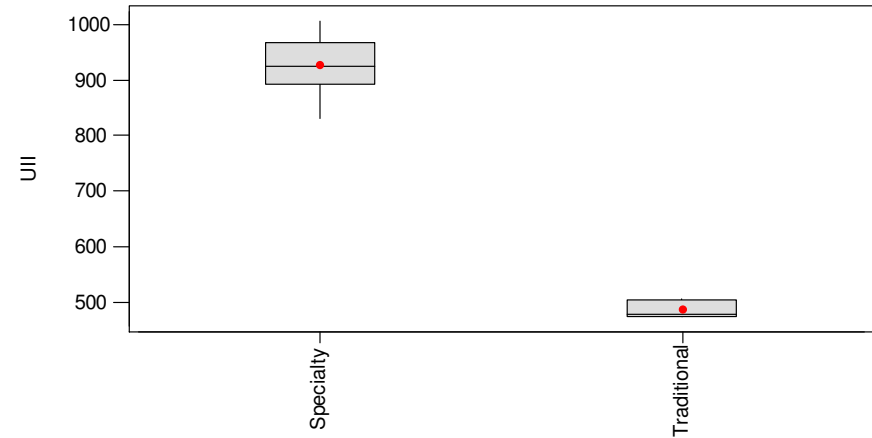
Gloss – Polymer Matrix Modification

Boxplots of Gloss by IM Type



Specialty IM modifies PC matrix
=> lower gloss

Boxplots of UII by IM Type

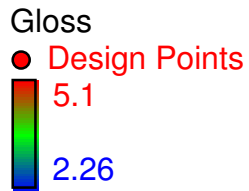


Additional benefit:
better impact

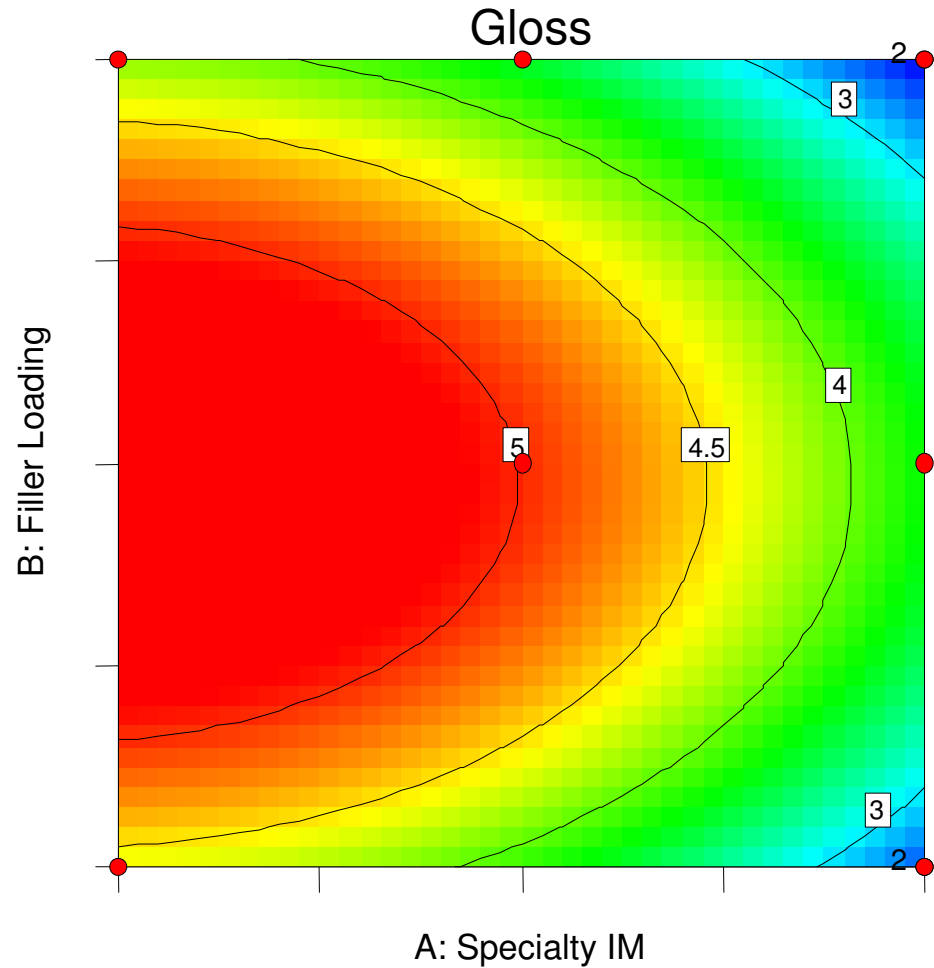
Traditional IM Not Suitable for Low Gloss

Gloss – Filler & Modifier

Design of Experiments on Filler Loading and Polymer Modification

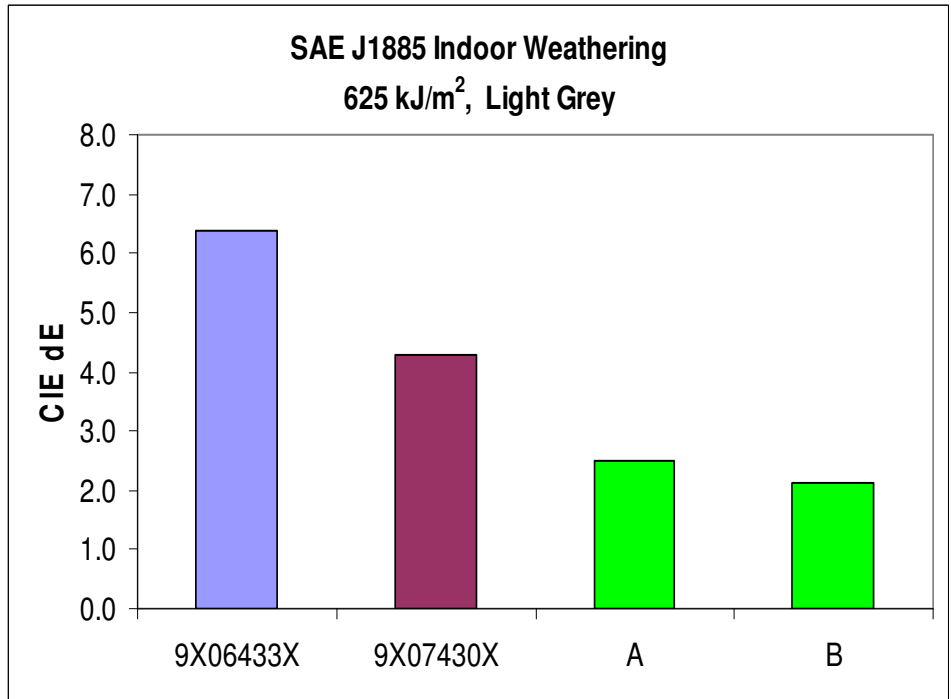
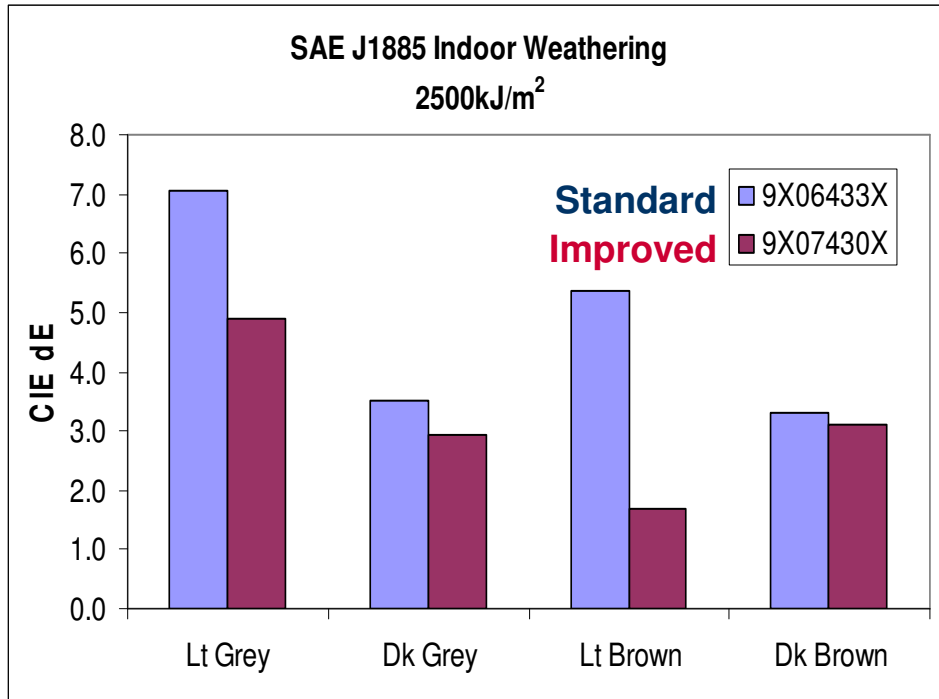


X1 = A: Specialty IM
X2 = B: Filler



Optimal Filler and IM Loading

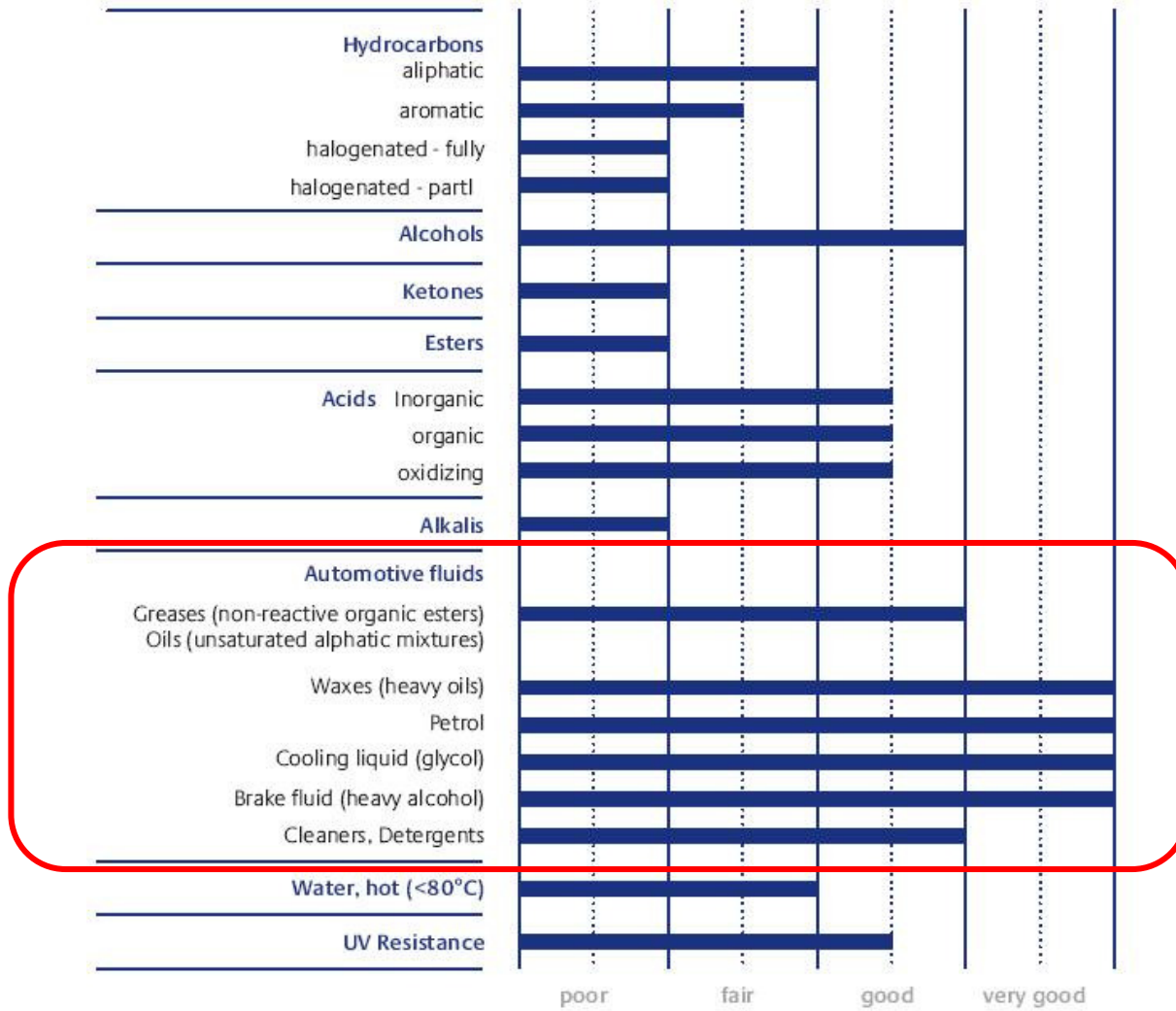
UV Resistance



*Improvements Through
Resin Types/Loadings, UV Absorber, &
Weatherable Colorants*

Good UV Resistance

Chemical Resistance of PC/PBT



Well Suited to Automotive Applications

Resistance to Automotive Fluids

Chemical	Exposure Conditions				Retention of		Discoloration
	Time	Temp	Strain	Method	TS	TE	
Brake Fluid	8 h	70 °C	0%	Wrap	98%	108%	No
Gasoline	8 h	70 °C	0%	Wrap	94%	114%	Slight
Hydraulic Fluid	8 h	70 °C	0%	Wrap	98%	112%	No
ATF	8 h	70 °C	0%	Wrap	97%	111%	No
Engine Oil 5W50	16 h	70 °C	0%	Wrap	100%	109%	No
Diesel	16 h	70 °C	0%	Wrap	100%	109%	No
Aarmor-All Protectant	24 h	70 °C	0%	Wrap	96%	107%	No
Windex Glass Cleaner	8 h	70 °C	0%	Wrap	99%	105%	No
Cooking Oil	24 h	70 °C	0%	Wrap	102%	102%	No
Tomatoe Soup	24 h	70 °C	0%	Wrap	101%	99%	No

Lab Bench Compatibility Rating Basis		
Color Rating	Tensile (% Retention)	Elongation (% Retention)
Not Compatible	< 79%	< 64% or >140%
Marginal	80% - 89%	65% - 79%
Compatible	>90%	80% - 139%

Good Chemical Compatibility

Abrasion & Scuffing

TEST: Resistance to Abrasion
SPECIFICATION: FLTM BN 108-02 (4/96)
CONDITIONS: Subject sample to Taber Abrasion using the following requirements:
 High Wear Areas: 1000 gram load, CS-10 Wheels, and 1000 cycles.
 Low Wear Areas: 500 gram load, CS-10 Wheels, and 100 cycles.
EQUIPMENT: Taber Abraser #1 Model #5130
TEST DATES: 12/03/07
EVALUATION: 8 specimens were tested.

High Wear Areas:

Sample Identification	Performance Rating	Evaluation
Grey #1	3	Exhibited noticeable wear, however not through to the substrate.
Grey #2	3	
Tan #1	3	
Tan #2	3	

Low Areas:

Sample Identification	Performance Rating	Evaluation
Grey #1	4	Exhibited very slight wear, however not through to the substrate.
Grey #2	4	
Tan #1	4	
Tan #2	4	

Ratings:
 5 = No change
 4 = Barely noticeable
 3 = Slight but obvious
 2 = Appreciable
 1 = Significant

TEST: Resistance to Scuffing
SPECIFICATION: FLTM BN 108-04 (4/91)
CONDITIONS: Subject sample to Taber Abrasion using the following requirements:
 High Wear Areas: 0.9 kg load, Scuff Head A, and 1000 cycles.
 Low Wear Areas: 0.9 kg load, Scuff Head A, and 250 cycles.
EQUIPMENT: Taber Abraser #1 Model #5130
TEST DATE: 12/03/07
EVALUATION: 8 samples were tested.

High Wear Areas:

Sample Identification	Performance Rating	Evaluation
Grey #1	3	Exhibited no cracks in the finish transverse to the direction of motion and no wear-through to the substrate.
Grey #2	3	
Tan #1	3	
Tan #2	3	

Low Areas:

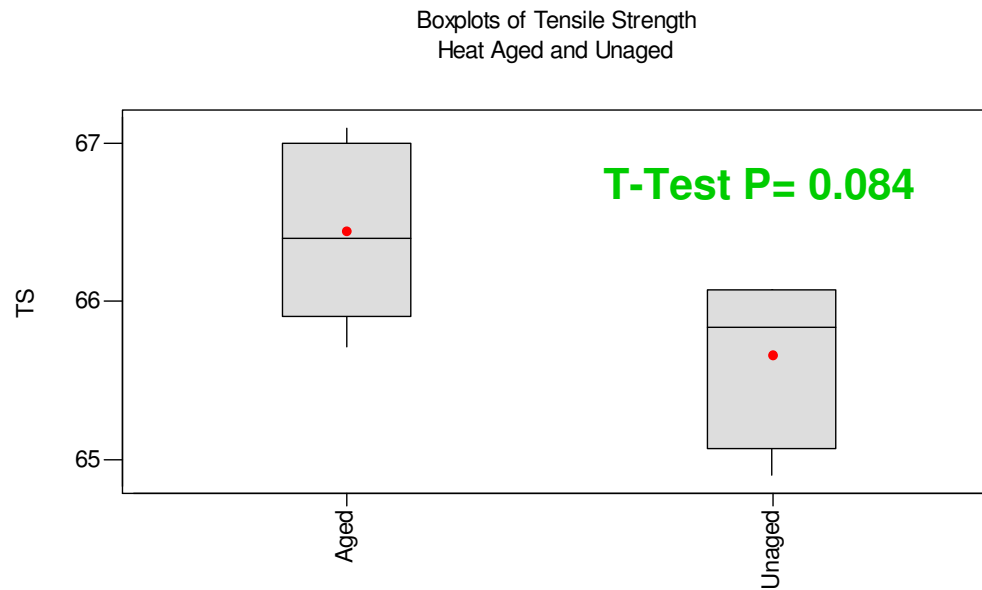
Sample Identification	Performance Rating	Evaluation
Grey #1	4	Exhibited no cracks in the finish transverse to the direction of motion and no wear-through to the substrate.
Grey #2	4	
Tan #1	4	
Tan #2	4	

Testing performed by
 Michigan Testing Institute

Ratings of 3 or Better Achieved

Long Term Heat Aging (LTHA) Exposure

Standard: WSS-M15P4-E section 3.5.1
Test Conditions: 7days at 80C +/-2C
Mechanical evaluation: Tensile strength retention
Conclusion: -No significant properties change measured
-No wrinkling, distortion, blistering warping, blushing, hazing, milking, staining or any other surface modification observed
-No color shift measured



No Significant Effects

Short Term Cold/Heat/Humid Cycle Exposure

Standard:

WSS-M15P4-E section 3.5.2

Test Conditions:

Cycle Aging

Mechanical evaluation:

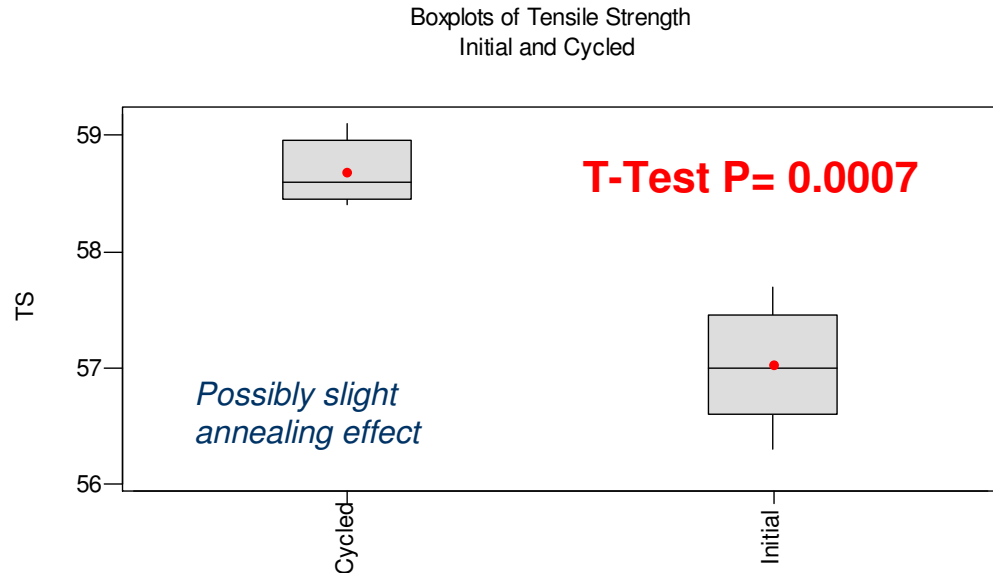
Tensile strength retention

Conclusion:

- Slight increase in TS observed
- No wrinkling, distortion, blistering warping, blushing, hazing, milking, staining or any other surface modification observed
- No color shift measured

Cycling Protocol

Duration [h]	Temp [°C]	%RH
5	-40	-
0.5	23	50
5	85	-
0.5	23	50
2	50	95
0.5	23	50
5	-40	-
0.5	23	50
5	85	-



No Practical Effects

Typical Properties

LNP Thermocomp* 9X07430

TYPICAL PROPERTIES	UNIT	STANDARD	TYPICAL DATA
MECHANICAL			
Tensile Modulus, 50mm/min, 23°C	MPa (ksi)	ASTM D 638	3300 (479)
Tensile Stress, yield, 5mm/min, 23°C	MPa (ksi)	ASTM D 638	57 (8.3)
Tensile Stress, break, 5mm/min, 23°C	MPa (ksi)	ASTM D 638	51 (7.4)
Tensile Elongation, break, 5mm/min, 23°C	%	ASTM D 638	4.8
Flex Modulus, 1.3mm/min, 23°C	MPa (ksi)	ASTM D790	3140 (455)
Flex Stress, yield, 1.3mm/min, 23°C	MPa (ksi)	ASTM D790	99 (14.4)
IMPACT			
Izod Impact, unnotched, 23°C	J/m (ft-lb/in)	ASTM D 4812	715 (13.4)
Izod Impact, notched, 23°C	J/m (ft-lb/in)	ASTM D 256	80 (1.5)
Instrumented Impact, Total Energy, 23°C	J (ft-lb)	ASTM D3763	14 (10)
THERMAL			
CTE, -30°C to 30°C, flow	ppm/°C (ppm/°F)	ASTM E 831	57 (32)
CTE, -30°C to 30°C, xflow	ppm/°C (ppm/°F)	ASTM E 831	83 (46)
HDT, 1.82 MPa, 3.2mm, unannealed	°C (°F)	ASTM D 648	102 (216)
PHYSICAL			
Density	g/cc	ASTM D 792	1.31
Mold Shrinkage, flow, 24 hr	%	ASTM D 955	0.50
Mold Shrinkage, xflow, 24 hr	%	ASTM D 955	0.58
Moisture Absorption, 50% RH, 24 hr	%	ASTM D 570	0.11
Melt Volume Rate, 260°C, 5kg	cc/10 min	ASTM D 1238	10

Summary

- Leveraged inherent benefits of PC/PEst...
 - Chem resistance
 - Mechanicals
 - Stability

- Optimized fillers, modifiers and colorants for...
 - Colorability
 - Low gloss
 - UV resistance
 - Stiffness & CLTE
 - Abrasion resistance

- Ideally suited for paint elimination in...
 - Truck interiors
 - Ag equipment

- Other automotive applications possible?

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