New Transparent OSU-Compliant Polycarbonate Copolymers

LEXAN* FST

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Transparent OSU-Compliant Polycarbonate Copolymers

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Special Thanks To

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Plastics in Aircraft Applications

Highly regulated market

FST Tests Required by FAA & OEMs

Ignitability, Melting/Dripping

60-sec vertical Bunsen burner

6” burn length

15-s specimen extinguishing time

3-s drip extinguishing time

Heat release

Ohio State Univ calorimeter

65 kW • min/m^2 total (during first 2 min)

65 kW/m^2 peak rate (during first 5 min)

Smoke release

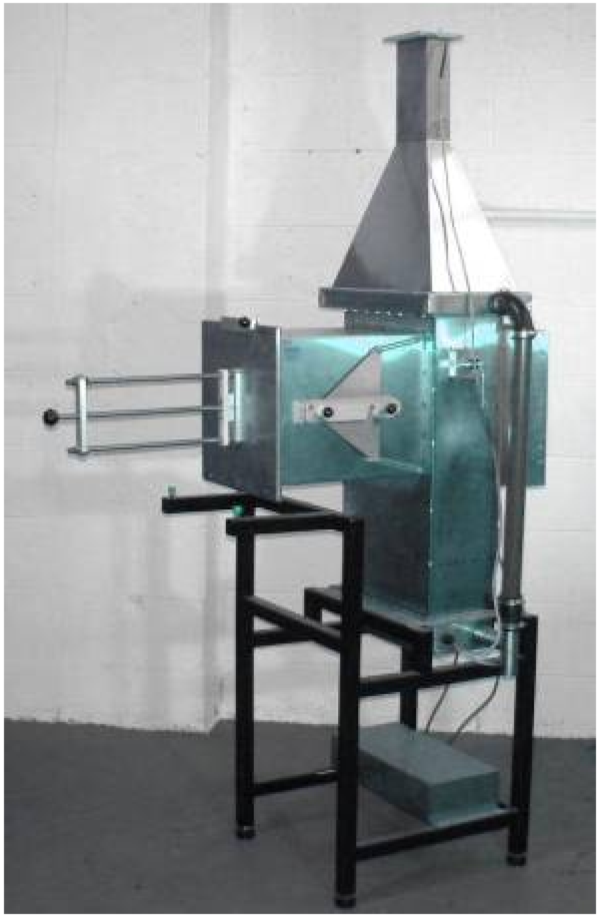
National Bureau of Standards smoke chamber

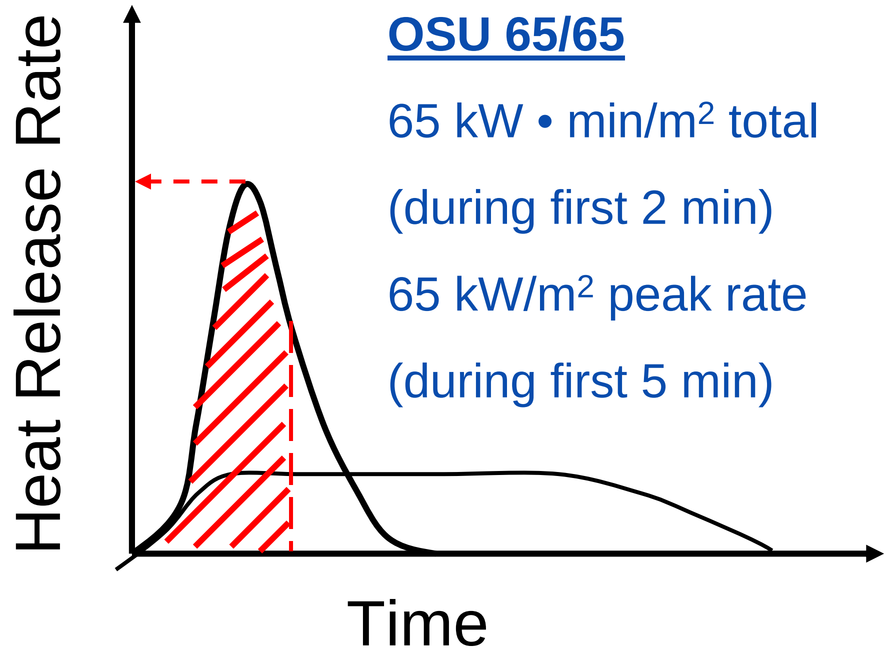
specific optical density < 200 (during 4-min test)

Toxicity (OEM): CO, HCN, HF, HCl, SO2, NOX

OSU 65/65 most challenging requirement

OSU Test



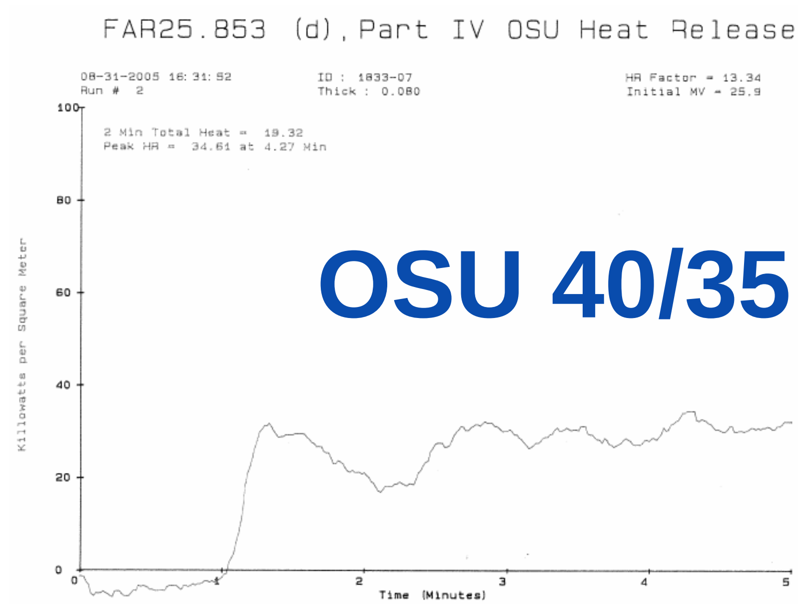


Existing commercial materials all opaque:
Polyetherimide, polysulfone

Need for transparent OSU compliant polymer

New Transparent Polycarbonate Copolymers

t = 0.08"
for aircraft dust
cover application



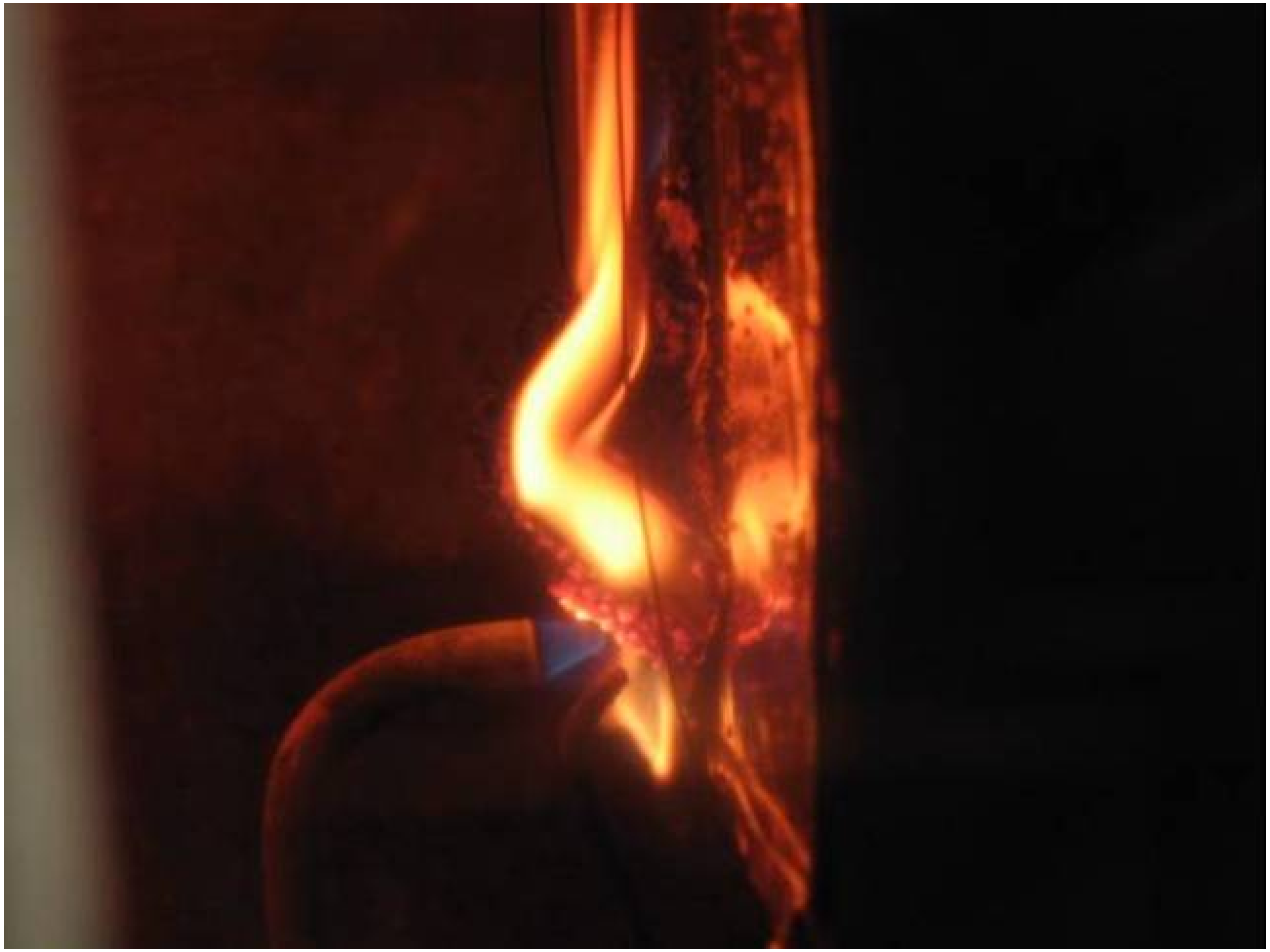
Heat release capacity & char forming
controlled at molecular level

OSU Performance: Flame & Heat Applied

t=0

Heat & Flame Applied

OSU Performance: Start of burning & char



t=30 sec

Key factors:

- **Low fuel value**
- **Formation of char**
- **Rheology**

Sample starts to char with low heat release

OSU Performance: Full Burning

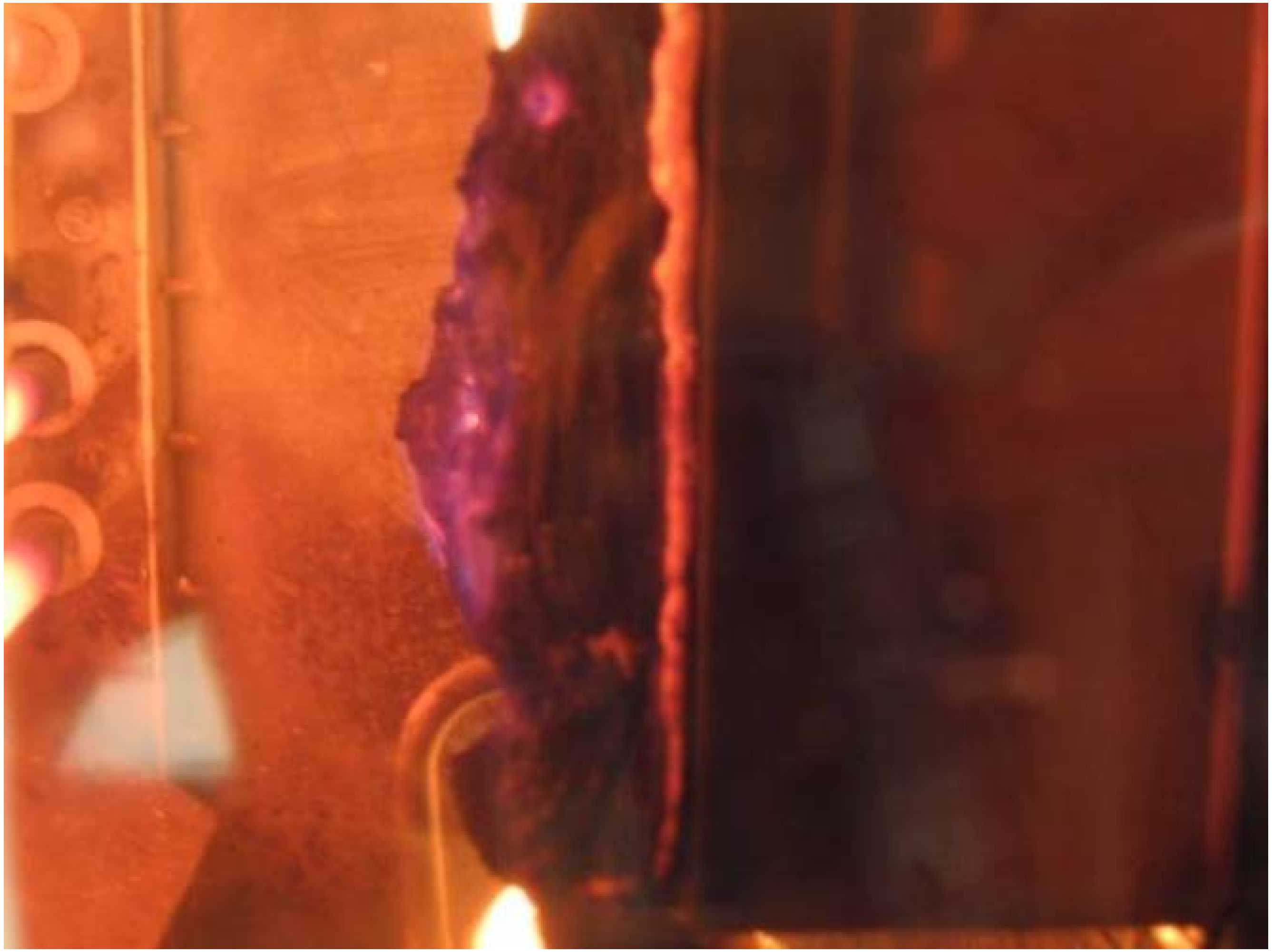
t=2 min

Key factors:

- **Char layer forming**
- **Char layer needs good integrity**
- **Low sagging & running**
- **No exposure of fresh fuel**

Polymer composition and structure key to char layer integrity

OSU Performance: Burning stops



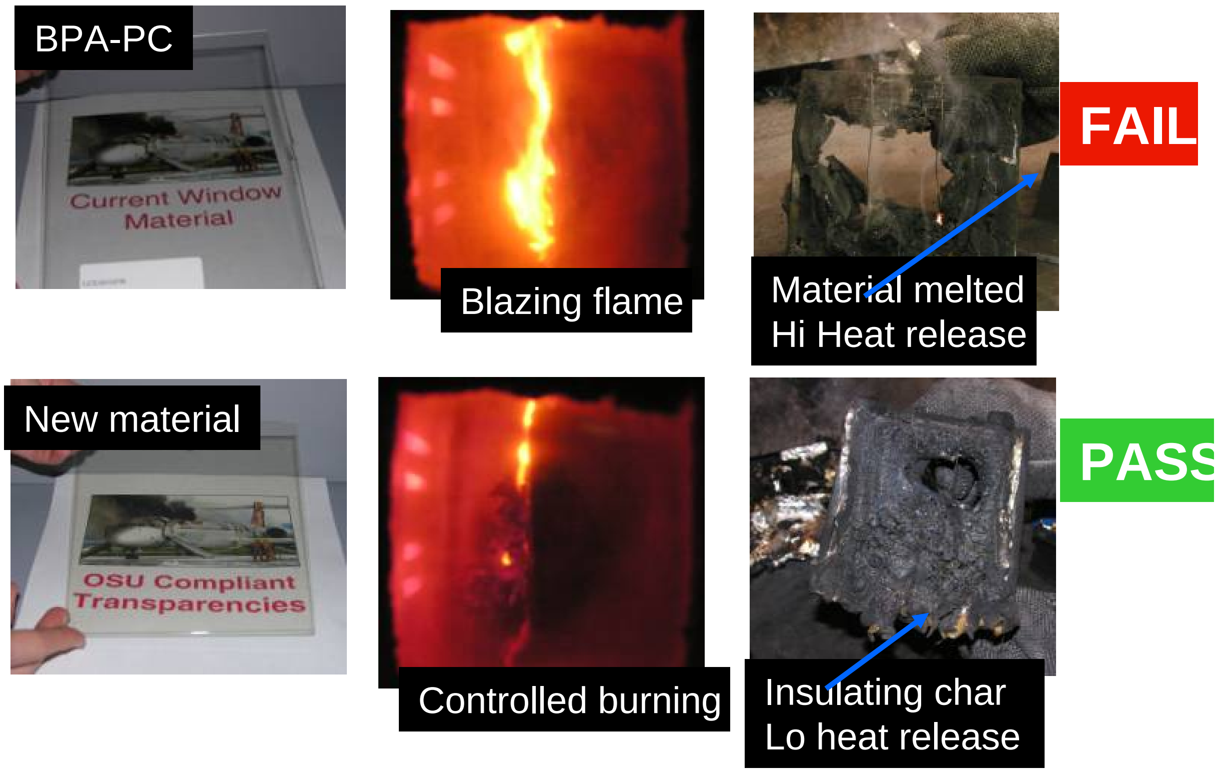
t=5 min

Char layer slows burn rate & holds sample in place

First halogen-free transparent materials to meet OSU

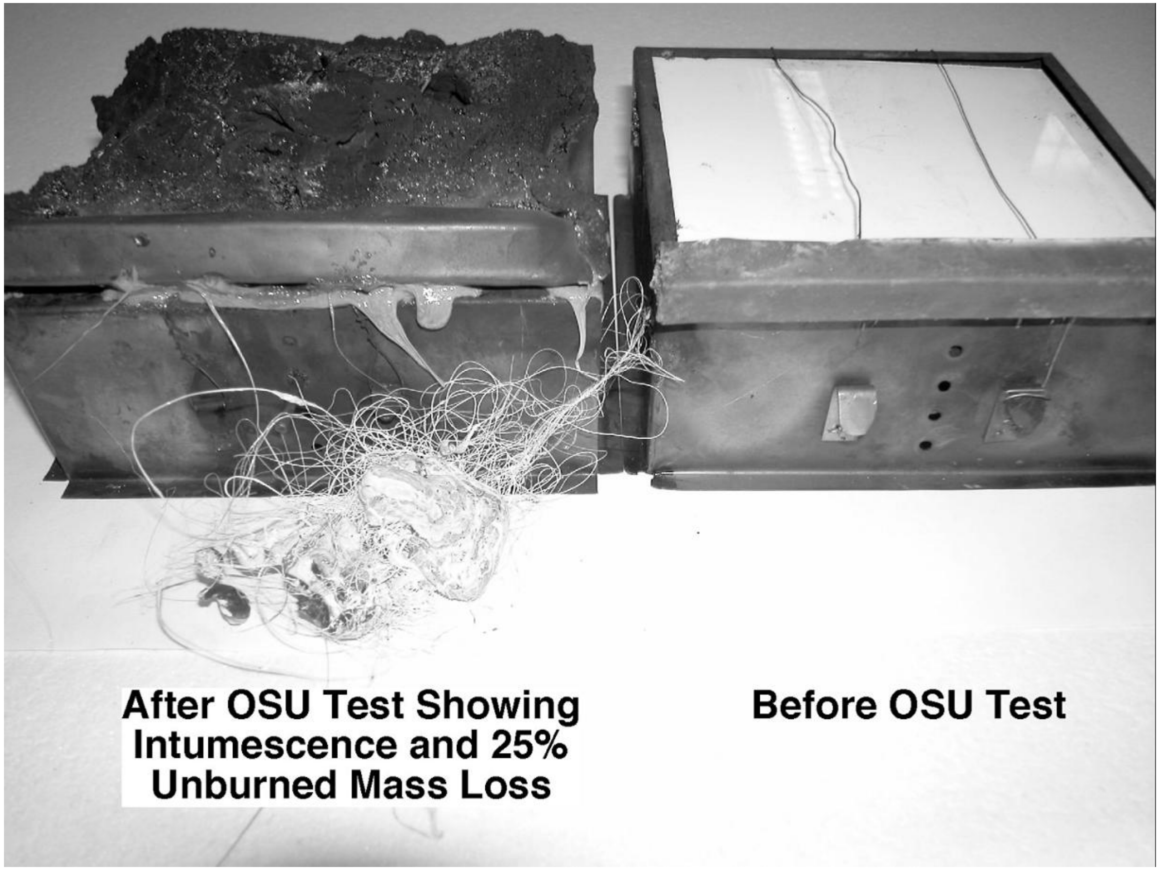
FR Performance of New Copolymers

Time = 0 | **At t =2 min** | **After t= 5min**



Validated at Boeing labs

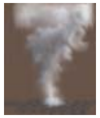
FR Performance of New Copolymers



Thickness (mm)	Peak HRR (kW/m2)	2-min HR (kW-min/m2)	NBS Smoke Density (4Dm)
CLEAR/TRANSPARENT			
1.5	37	25	6
1.5	39	29	6

ource: Non-halogen Fire Resistant Plastics for Aircraft Interiors, Rich Lyon, FAA, Oct 2007

Smoke, Vertical Burn, Toxicity



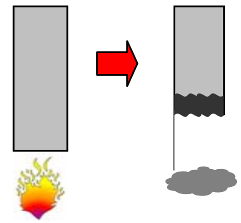
Smoke Density (3 sample avg.)

Smoke Generation	Max	New Mat.
(Ds) @ 4 min	200	23.15

Toxicity

Component	Max (ppm)	New Mat.
HF	200	1
HCL	500	0
HCN	150	1
H2S	-	0
Nox	100	1
HBr	-	0
PO4	-	0
SO2	100	0

60 Second Vertical Burn (3 sample avg.)

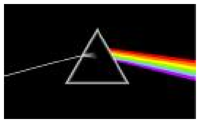


PC Mat Sys 1

Vertical Burn	Max	New Mat.
Extinguishing Time	15 sec	2.3
Burned Length	6 inches	0.6
Drip Extinguishing Time	3 sec	no drips

Exceeding FAA requirements

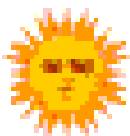
Beyond Fire, Smoke, Toxicity Performance



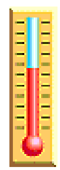
Optical
Total Transmission
Haze
Color/Yellowness

Mechanical
Tensile
Flex
Impact

Physical
Density
Specific Gravity
Molecular Weight



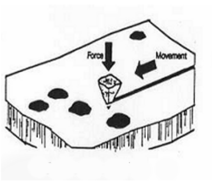
Aging
UV Resistance
Temp/Humidity Cycling



Thermal
Glass Transition
CTE
HDT

Processing
MFI
Capillary Rheology
Dynamic Rheology

Solvent Sensitivity
Discoloration
Crazing



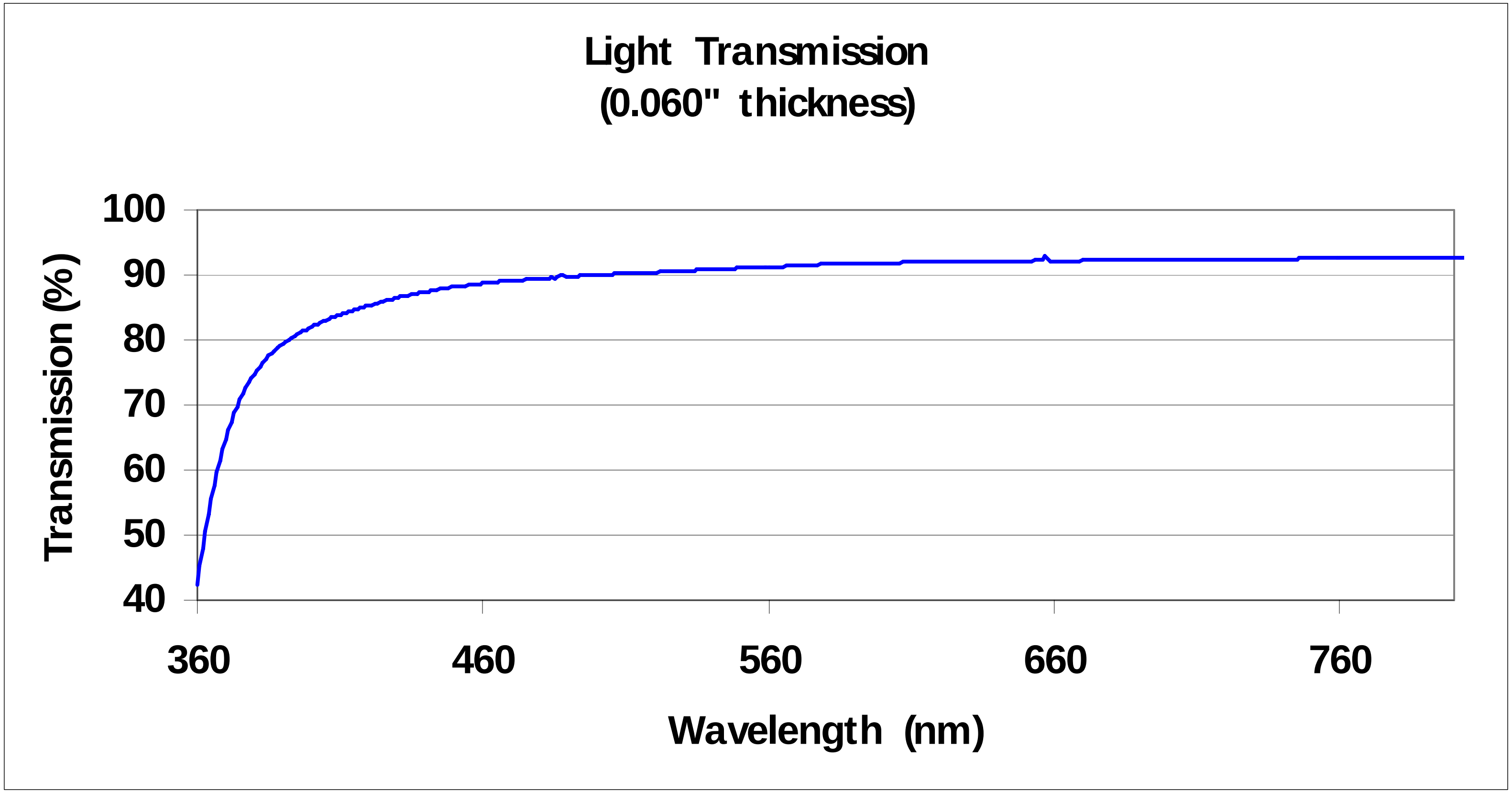
Abrasion Resistance

New copolymers extensively tested across mechanical, chemical, optical and rheological properties

Injection molding, sheet and film extrusion Thermal forming, profile extrusion…

Extruded sheet of new copolymer (GE Plastics)

Visible Spectrum



Light transmission close to BPA-PC

Color Space

Low color & high transmission expand color space

Gardner Impact & Reverse Scratch

Production- quality coated sheets with varying levels of UV protection evaluated

Boeing Specification = No scratch 80 in-lbs min/
Scratched reverse impact 26 in-lbs min

New material = no scratch 172-210 in-lbs/
Scratch reverse Impact 144-170 in-lbs

MRAC = no scratch 174 in-lbs/
Scratch reverse impact 170 in-lbs

Strong performance, well above minimum requirements

Physical Properties

PROPERTY	Units	Method	PC	Transparent OSU Resin
MECHANICAL				
Tensile Stress at Yield, 50 mm/min	MPa	ASTM D 638	62	74.2
Tensile Stress at Break, 50 mm/min	MPa	ASTM D 638	66	72.8
Tensile Elongation at Yield, 50 mm/min	%	ASTM D 638	7	6.9
Tensile Elongation at Break, 50 mm/min	%	ASTM D 638	110	99
Tensile Modulus, 50 mm/min	MPa	ASTM D 638	2,351	2,510
Flexural Modulus 1.27 mm/min	MPa	ASTM D 790	2,344	2,480
Flexural Stress@Yield, 1.27mm/min	MPa	ASTM D 790	93	116
IMPACT				
Notch Izod Impact, 23°C	J/m	ASTM D 256	801	719
THERMAL				
HDT, 0.455MPa	°C	ASTM D 648	138	131
HDT, 1.82MPa	°C	ASTM D 648	127	120
Tg	°C	DSC	150	140
PHYSICAL				
Melt Flow Rate, 300°C/1.2 kgf	g/10 min	ASTM D 1238	10.5	6

Polycarbonate-like physical properties

Chemical Resistance

Production- quality coated sheets with varying levels of UV protection evaluated

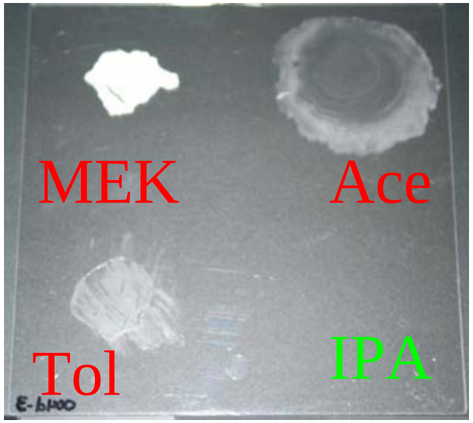
✓ Solvent Sensitivity (per BMS8-246):

All pass

✓No visible response to acetone, toluene, and IPA

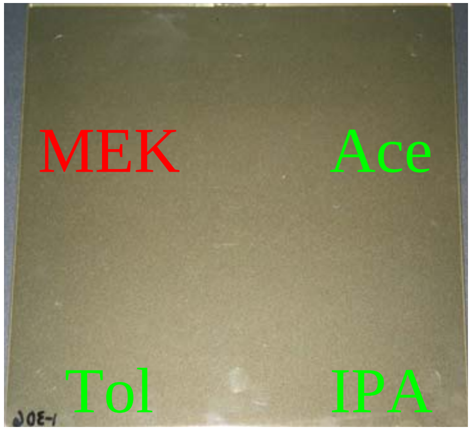
Chemical resistance better than BPA-PC

Uncoated
PC Base for MRAC sheet



Pass: IPA

Uncoated
LEXAN* FST



Pass: Ace, Tol, IPA

Hardcoat Adhesion

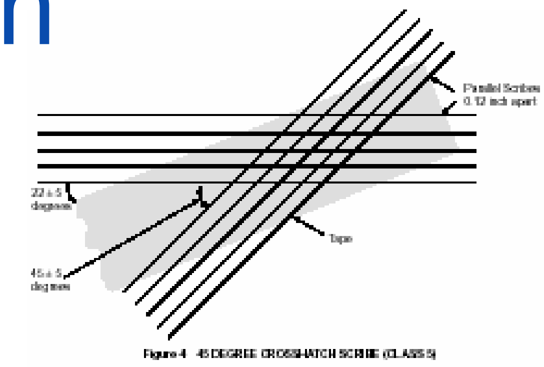
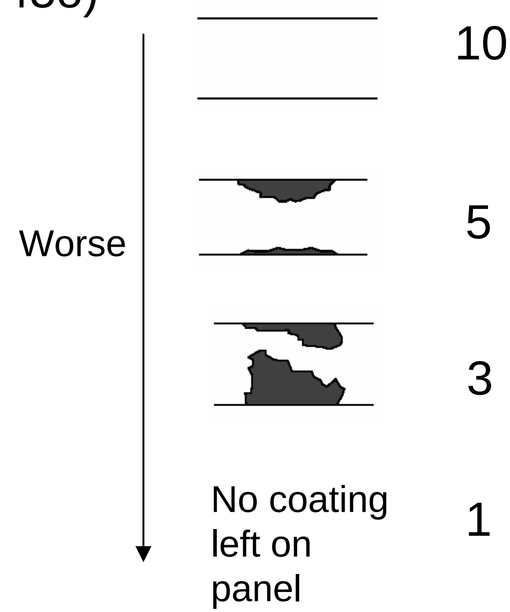


Figure 4 45 DEGREE CROSSHATCH SCRIBE (CLASS 5)

- ✓ Adhesion- Wet & Dry:

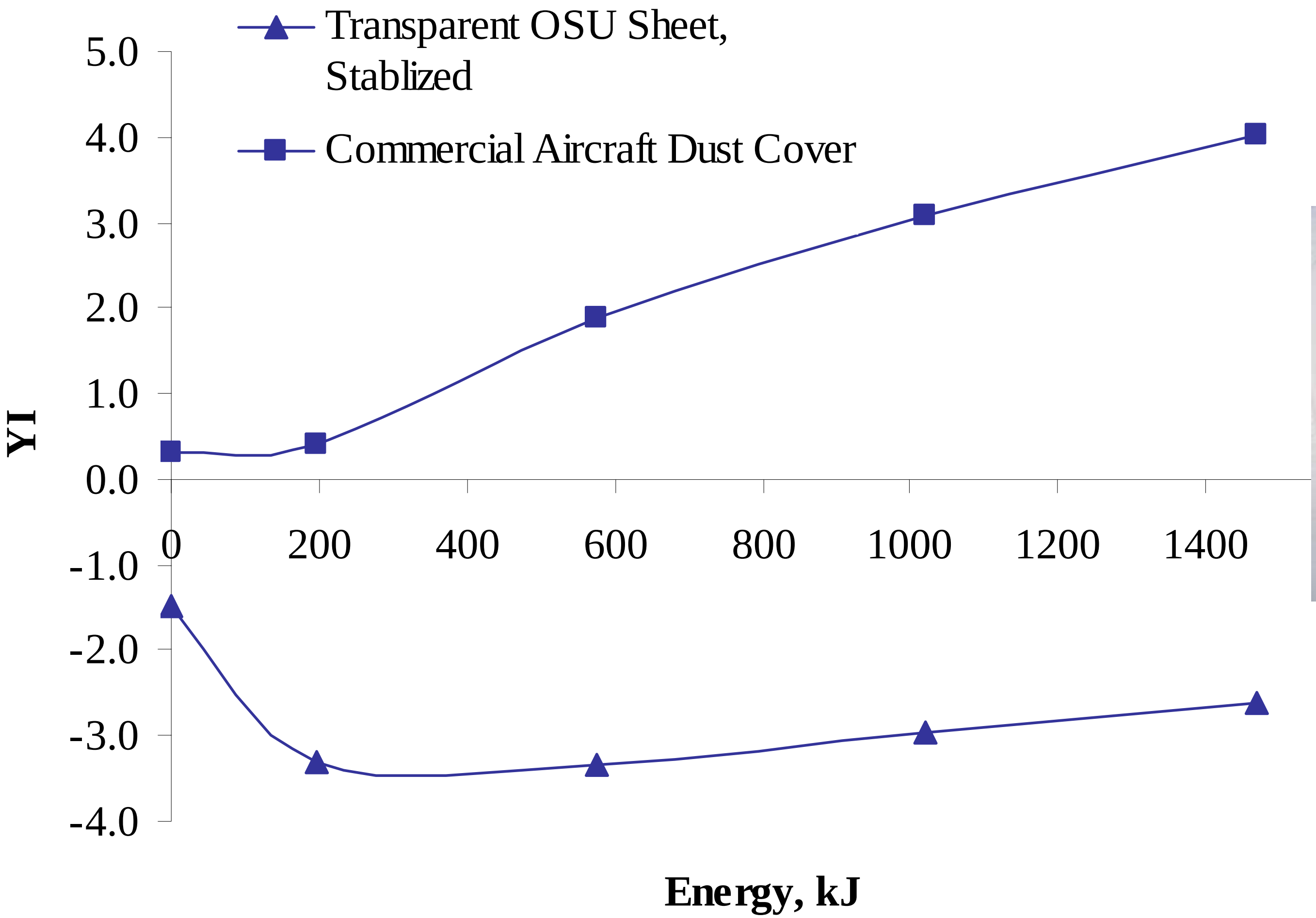
All perform excellently
(10s on scale of 0-10)

Numerical Ratings are per Boeing BSS7225 w Class 5 Cross-hatches (6 x 3 mm at 45o)



Ground-Air-Ground Cycling: **All pass**

Weathering



Color change during Xenon Arc weathering of transparent OSU formulations

Weathering resistance good compared to current product

Hard Coating

- Good adhesion with standard BPA-PC hard coat
- Improved scratch resistance
- Same fire performance
- Good light transmission
- Works with commercial coating for BPA-PC

“Drop in” for existing process

Special Thanks To

Goodness Gracious
Great Balls of Fire !!!

Gary “Hell Fire” Davis

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