



Together, We See Further

Light-weighting Vehicles With New Glazing Concepts

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Vitro Automotive Glass

Pittsburgh Glass Works, LLC.

10/29/2019

Light-weighting Vehicles With New Glazing Concepts

Vitro History & Agenda

Our History

1929

The first flat glass factory opens in Nuevo León.



1960

Vitro started its Automotive Glass operations



2015

Vitro divests its food and Beverage Glass Containers Business and strengthens its financial position.



2016

Vitro acquires PPG's Flat Glass business and PGW OE Automotive Glass



Light-weighting Vehicle Agenda



- **Glazing Weight Saving Potential & Benefits**
 - Weight savings per car-set (12.3 Kg / 22%)
- **New Weight Saving Glazing Concepts**
 - Asymmetrical windshield constructions
 - Thinner laminated sidelite constructions
 - Asymmetrical sunroof constructions
- **Sidelites with improved acoustic performance and weight savings**
 - Tri-layer laminate

Light-weighting Vehicles With New Glazing Concepts

Glazing Weight Savings Potential & Benefits

Weight Savings from Light Weight Glazing



Car Set Weight Saving Potential = **12.3 Kg (22%)**

Windshield Weight Savings = 3.1 Kg (20%)

Standard: 2.1 / 2.1 mm = 15.2 Kg
Light Weight: 2.1 / 1.2 mm = 12.1Kg
Average Size: 1.34 M²

Sunroof Weight Savings = 0.8 Kg (12%)

Standard: 4.1 mm Tempered = 6.4 Kg
Light Weight: 2.1 / 1.2 mm = 5.6 Kg
Average Size: 0.62 M²



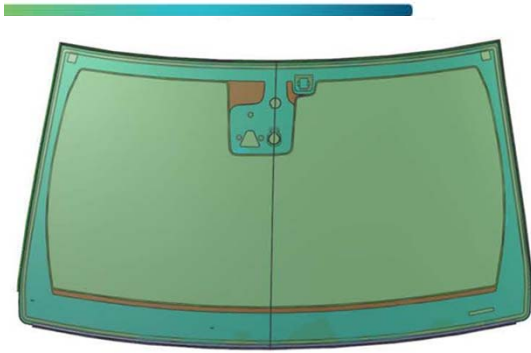
Backlite Weight Savings = 1.1 Kg (12%)

Standard: 4.1 mm Tempered = 9.3 Kg
Light Weight: 2.1 / 1.2 mm = 8.2 Kg
Average Size 0.9M²

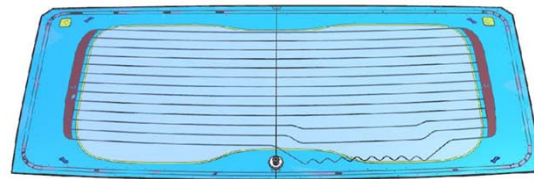
Sidelites Weight Savings = 7.3 Kg (31%)

2 Front / 2 Rear Doors:
Standard: 2.1 / 2.1 mm = 23.5 Kg
Light Weight: 1.4 / 1.4 mm = 16.2 Kg
Average Size 0.52 M²/each

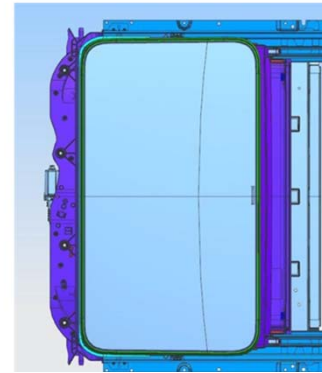
Benefits From Lightweight Laminated Glazing



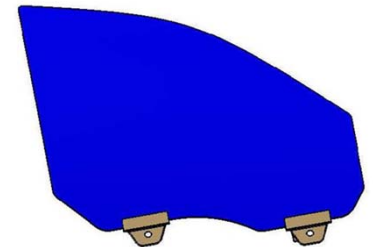
Windshield



Backlite



Single Sunroof



Sidelites

Benefits:

- Improved Fuel Economy
- Lower Emissions
- Faster Acceleration

Plus

- Lower Center of Gravity
- Lower Energy for Defrost

Plus

- Improved HUD image

Windshields and Backlites

Windshields

Light-weighting Vehicles With New Glazing Concepts

Benefits from Asymmetrical Windshield Construction

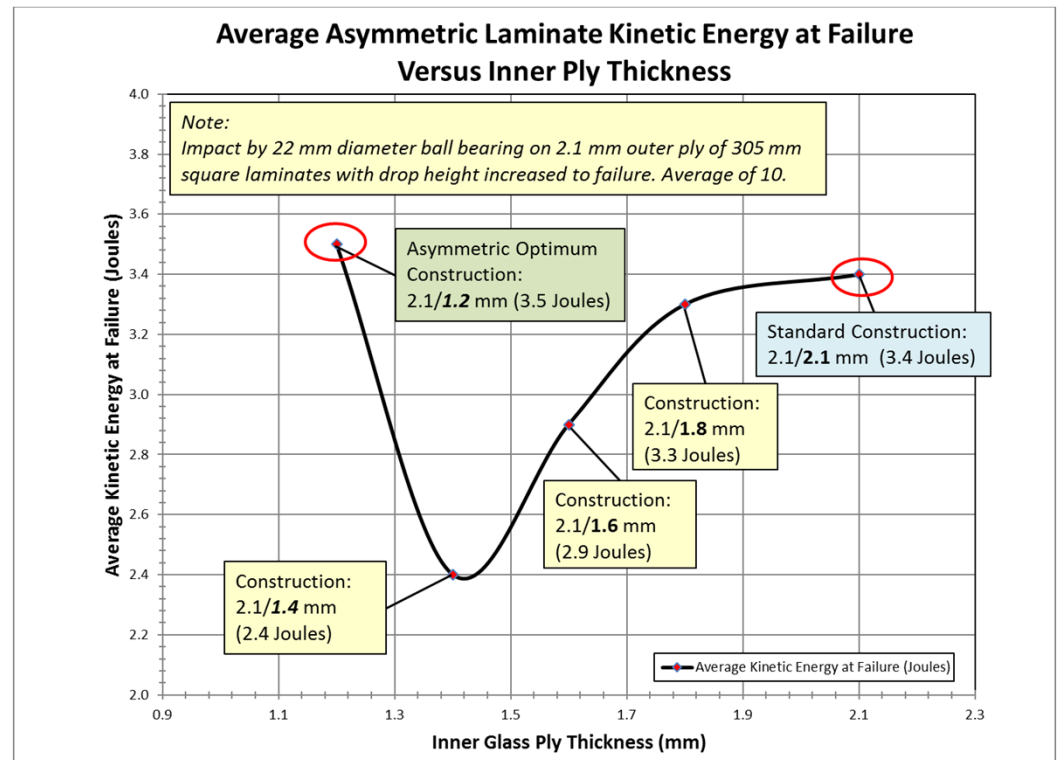
From SAE Paper 2017-01-1306
“Practical Design Considerations for
Lightweight Windshield Applications”

Stone Impact Performance of Asymmetrical 2.1/1.2 mm Windshield Matches Symmetrical 2.1/2.1 mm Construction

- Asymmetrical windshield stone impact performance was reported in SAE Paper 2017-01-1306. This paper won the SAE Colwell Merit Award.
- This SAE paper addresses the “Impact Strength of Windshields”
- Two basic questions are answered

What is the impact strength of standard windshields?

How do lightweight constructions compare to standard constructions?



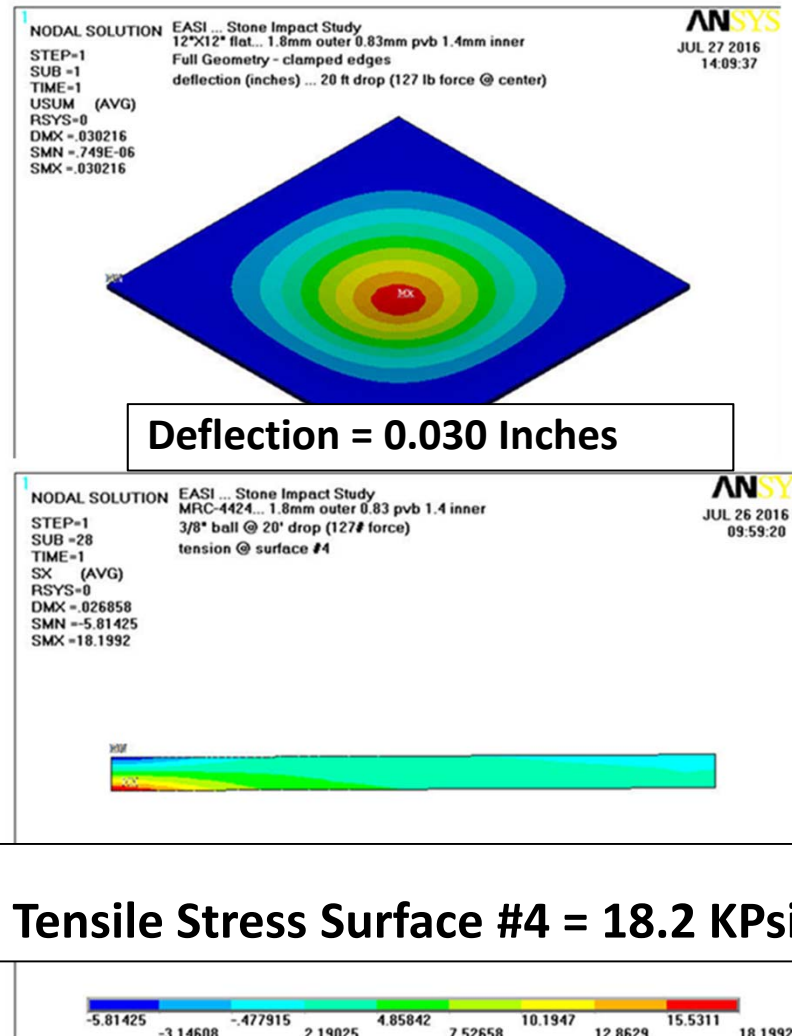
Windshield Stone Impact Simulation Capability Development



Lightweight windshield performance simulation capability was developed using ANSYS and validated.

- Impact testing of 305 by 305 mm laminated constructions with strain gages was used to validate the ANSYS finite element simulations for a range of constructions.
- Impact testing was done using a ball drop tower for gravity impacting of the samples with a 22 mm diameter ball bearing.
- Strain gage data from each impact was collected at 1 million samples per channel per second in order to capture the peak value.
- The measured maximum strain was used to validate the ANSYS model.

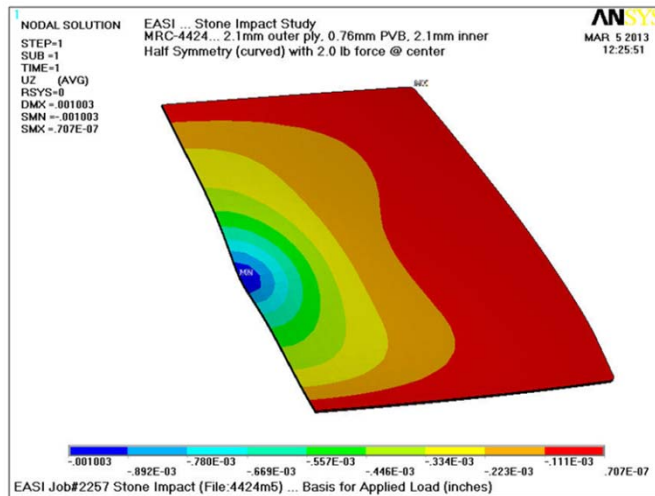
Lightweight Windshield Performance Prediction using ANSYS Simulations



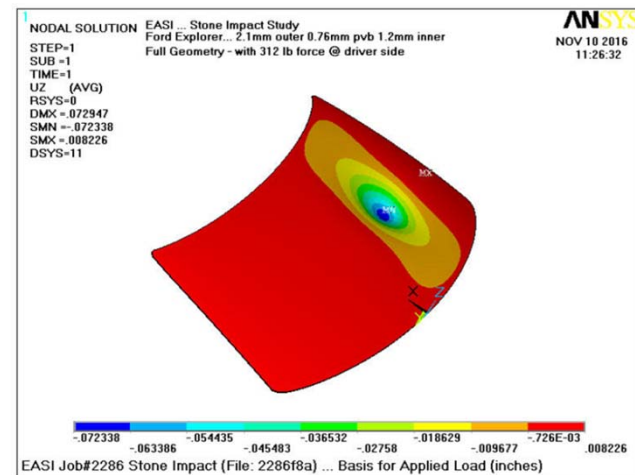
Validated Simulation Methodology Expanded to Full Size Windshields



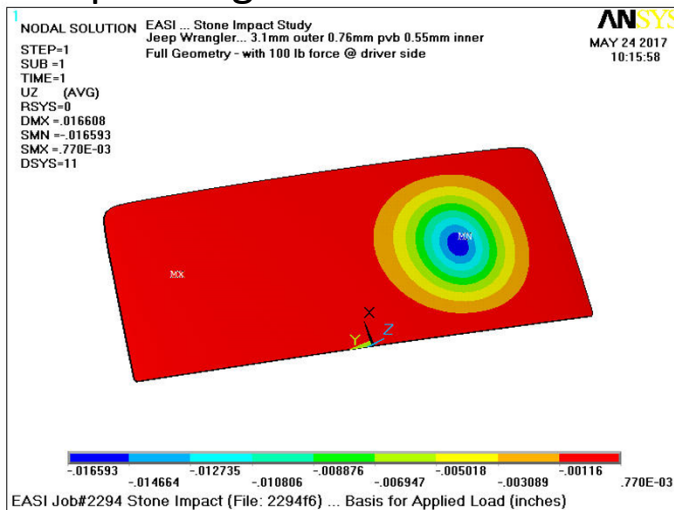
Mercedes C Class Windshield



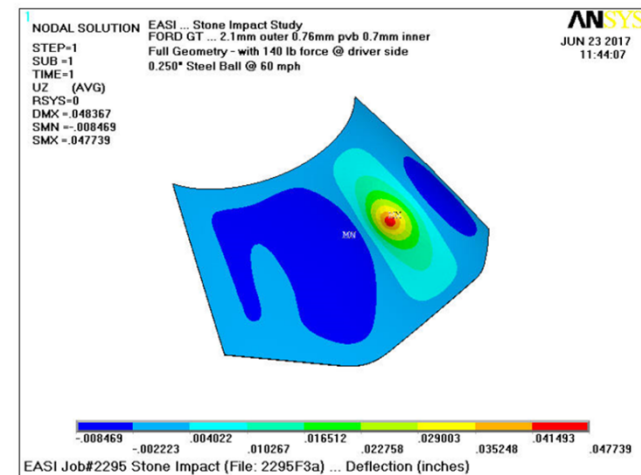
Ford Explorer Windshield



Jeep Wrangler Windshield



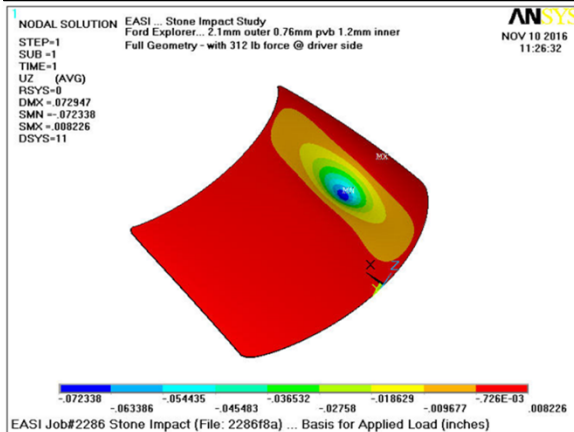
Ford GT Windshield



Lightweight Asymmetric Windshields Provide Superior Stone Impact Performance



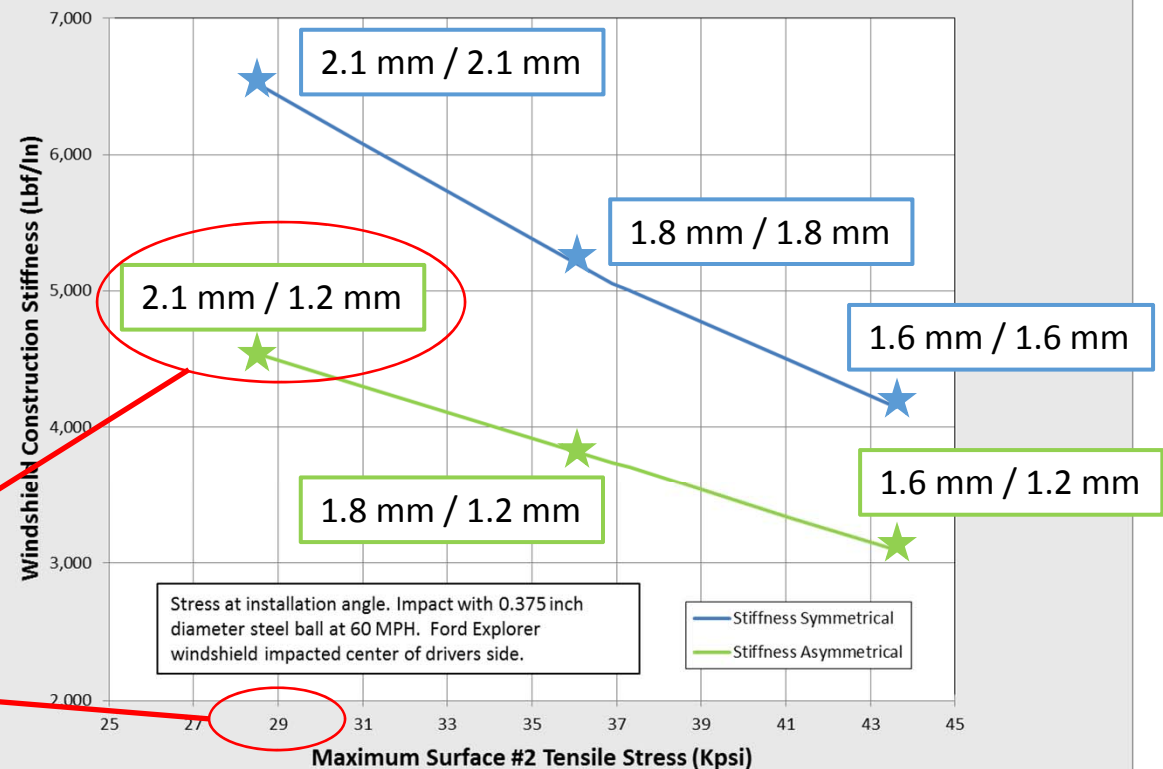
2.1/1.2 Asymmetrical Model Output



Optimum Asymmetrical Lightweight Construction

- ✓ - Lowest stress level
- ✓ - 20% weight savings versus baseline 2.1/2.1 mm.

Simulated Maximum Glass Stress Levels Stone Impact of Ford Explorer Windshield

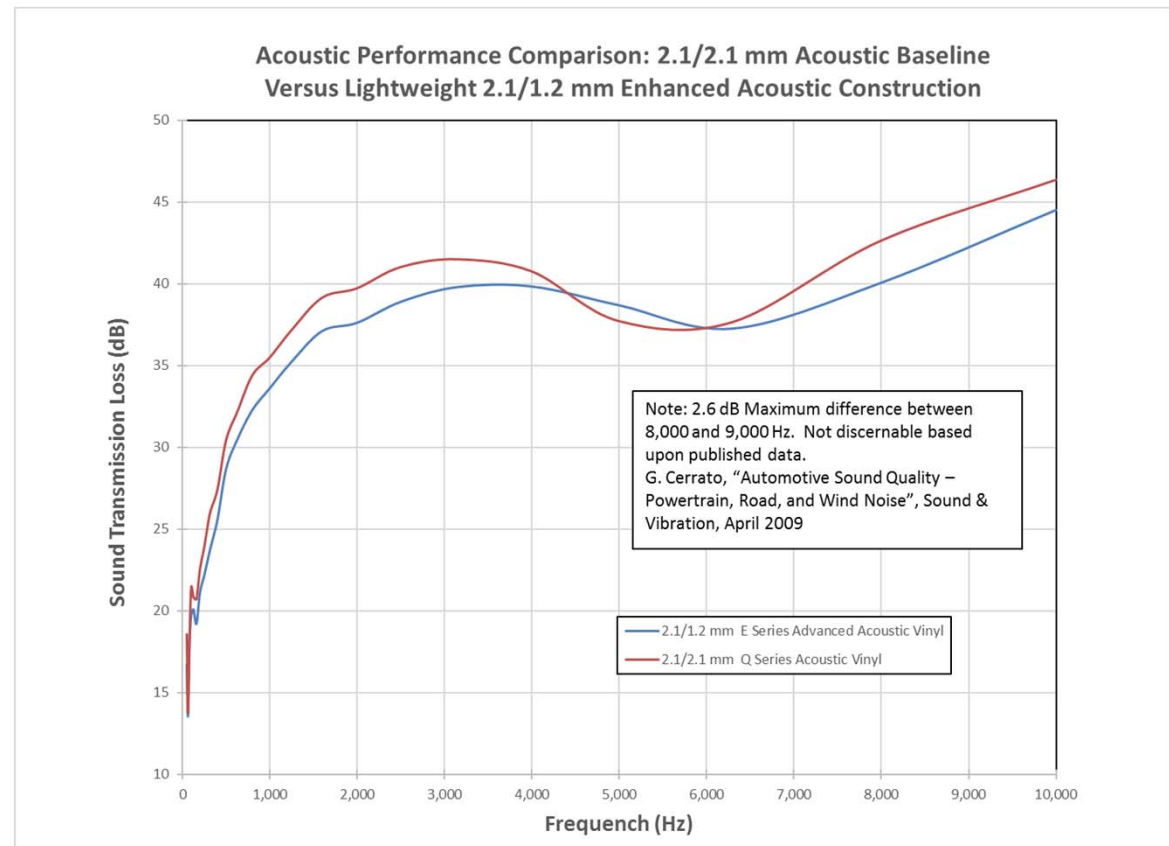


Lightweight Windshield Acoustic Performance Compared to Standard Construction



Lightweight
Glazing Acoustic
Performance
Comparable to
Baseline 2.1/2.1
mm Construction

Recent ASTM E90-09
acoustic test results for
lightweight construction
laminated with new
Eastman E Series
enhanced acoustic vinyl



*Twenty percent weight savings with
lightweight windshield construction.*

Lightweight Windshield Transmittance & Solar Performance Can Meet Production Targets



Solar Performance & Light Transmittance Options for Lightweight Windshields with 1.2 mm clear inner ply:

- Specialized dark composition glass for 2.1 mm outer ply
- Standard composition 2.1 mm outer ply with IR absorbing vinyl
- SUNGATE reflective coated 2.1 mm clear outer ply with IR absorbing vinyl

Total Solar Transmittance (Tts) and Visible Light (Lta) Values for Lightweight Windshield Constructions			
Windshield Construction Description	Construction Detail	Lta	Tts
Standard Production Baseline	2.1 SG C5	74.3	57.8
	2.1 SG C5		
	Clear Vinyl		
Lightweight 2.1/1.2 mm Dark SG Composition	2.1 SG C2.3 Vetro	72.2	56.3
	1.2 mm clear		
	Clear Acoustic Vinyl		
Lightweight 2.1/1.2 mm Standard SG Composition + IR Absorbing Vinyl	2.1 SG C3.9	78.2	60.5
	1.2 Clear		
	IR Absorbing Vinyl		
Lightweight SUNGATE Coated 2.1/1.2mm & IR Absorbing Vinyl	SPO5 2.1 Clear	79.7	52.9
	1.2 mm Clear		
	Clear Vinyl		
	IR Absorbing Vinyl		

Light-weighting Vehicles With New Glazing Concepts

Light Weight Laminated Sidelite Construction

From SAE Paper 2018-01-0465
“Practical Design Considerations for
Lightweight Side Window Applications”

Significant Weight Saving Potential From Thin Laminated Sidelite Construction



Sidelites Weight Savings = 7.3 Kg (31%)

2 Front / 2 Rear Doors:

Standard: 2.1 / 2.1 mm = 23.5 Kg

Light Weight: 1.4 / 1.4 mm = 16.2 Kg

Average Size 0.52 M²/each

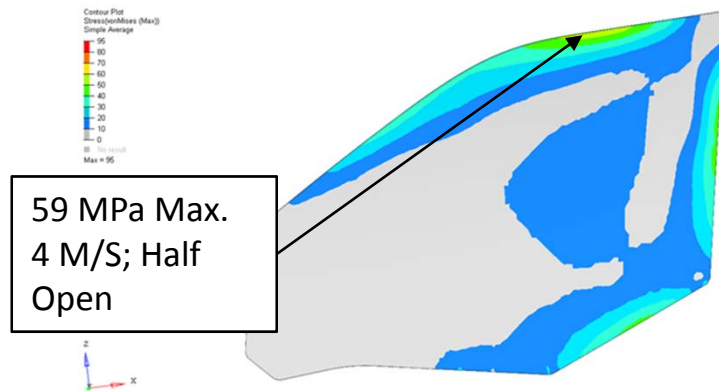
Development Path to Thin Laminated Sidelite Construction:

- ✓ Door Slam Simulation to Determine Maximum Glass Stress Level
- ✓ Probability of Failure Calculation at Maximum Glass Stress Level Loading
- ✓ Probability of Failure Less Than 100 PPM: Fabricate Samples & Test

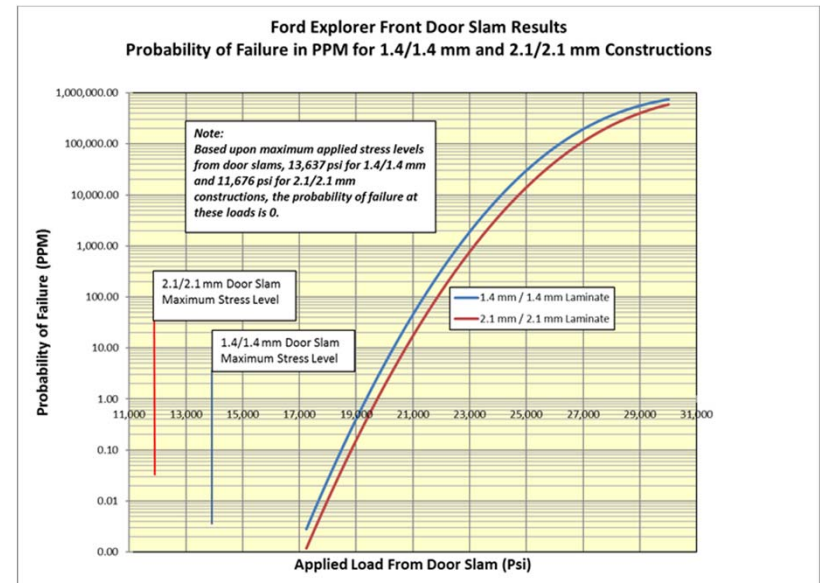
Development Steps: 1.4/1.4 mm Lightweight Sidelite



Door Slam Simulation Results 1.4/1.4 mm Lightweight Sidelite



Probability of Failure Result Zero for Lightweight Construction



1.4/1.4 mm Lightweight Sidelite

Ford Explorer Door Slam Test Set-up

- 1.4/1.4 mm Lightweight Sidelite
- Passed Ford 4 M/S Door Slam Test
(Strain Gages, Velocity Meter, Data Acquisition)

Light-weighting Vehicles With New Glazing Concepts

Asymmetric Sunroof Constructions

Sunroof Weight Saving Potential From Asymmetrical Laminated Construction



Sunroof Weight Savings = 0.8 Kg (12%)

Standard: 4.1 mm Tempered = 6.4 Kg

Light Weight: 2.1 / 1.2 mm = 5.6 Kg

Average Size: 0.62 M²

Weight Savings Concept: Replace Either 4.1 mm Tempered or 2.1/2.1 mm Laminate with Asymmetrical 2.1/1.2 mm Laminate

Benefits:

- Tempered to laminate significantly improves acoustic performance
- Laminate construction provides occupant rejection protection
- Asymmetrical laminate lowers center of gravity
- Impact strength equal for both asymmetrical and symmetrical constructions

Stone Impact Test Results	Average Kinetic Energy at Failure (Joules)	
	22 mm Diameter Steel Ball (45 Gram)	ECE R43 Steel Dart (199 Gram)
Laminate Construction		
2.1 Float /PVB/1.2 mm Float Glass Laminate	3.48	2.20
2.1 Float /PVB/2.1 mm Float Glass Laminate	3.44	2.17

Note: Gravity impact of 503 x 503 mm samples.

Light-weighting Vehicles With New Glazing Concepts

Tri-layer Laminated Sidelites with
Improved Acoustic Performance

From SAE Paper 2019-01-0395
“Novel Laminates for Improved Acoustic
Performance”

Tri-layer Laminate Sidelite Constructions



**Ford Explorer Sidelite
Size 0.55 Square Meters**

2.1 mm
0.76 ACPVB
2.1 mm

Baseline 6.18 Kg

1.2 mm
0.76 ACPVB
1.2 mm
0.76 ACPVB
1.2 mm

Weight 6.06 Kg (-1.9%)

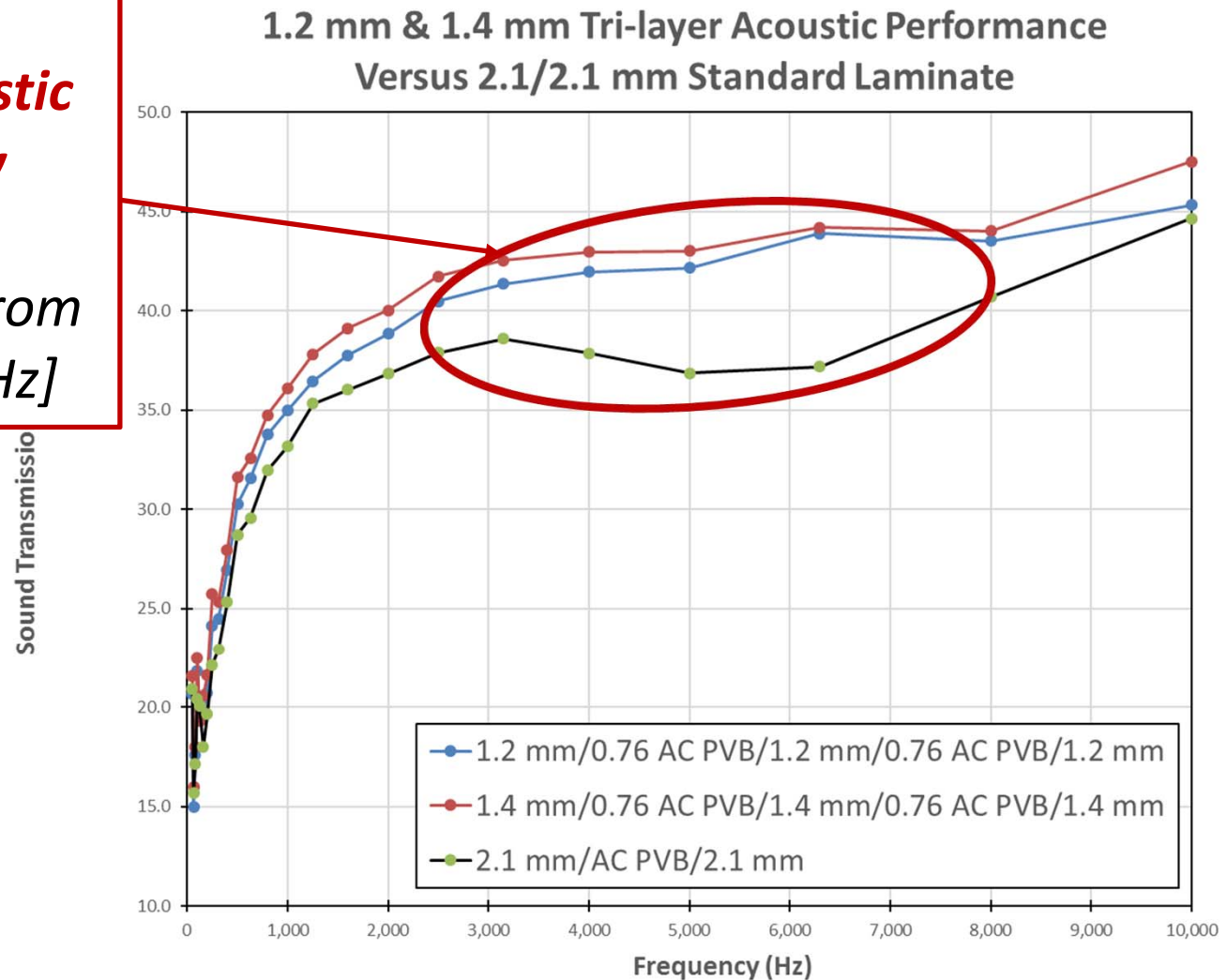
1.4 mm
0.76 ACPVB
1.4 mm
0.76 ACPVB
1.4 mm

Weight 6.62 Kg (+7.2%)

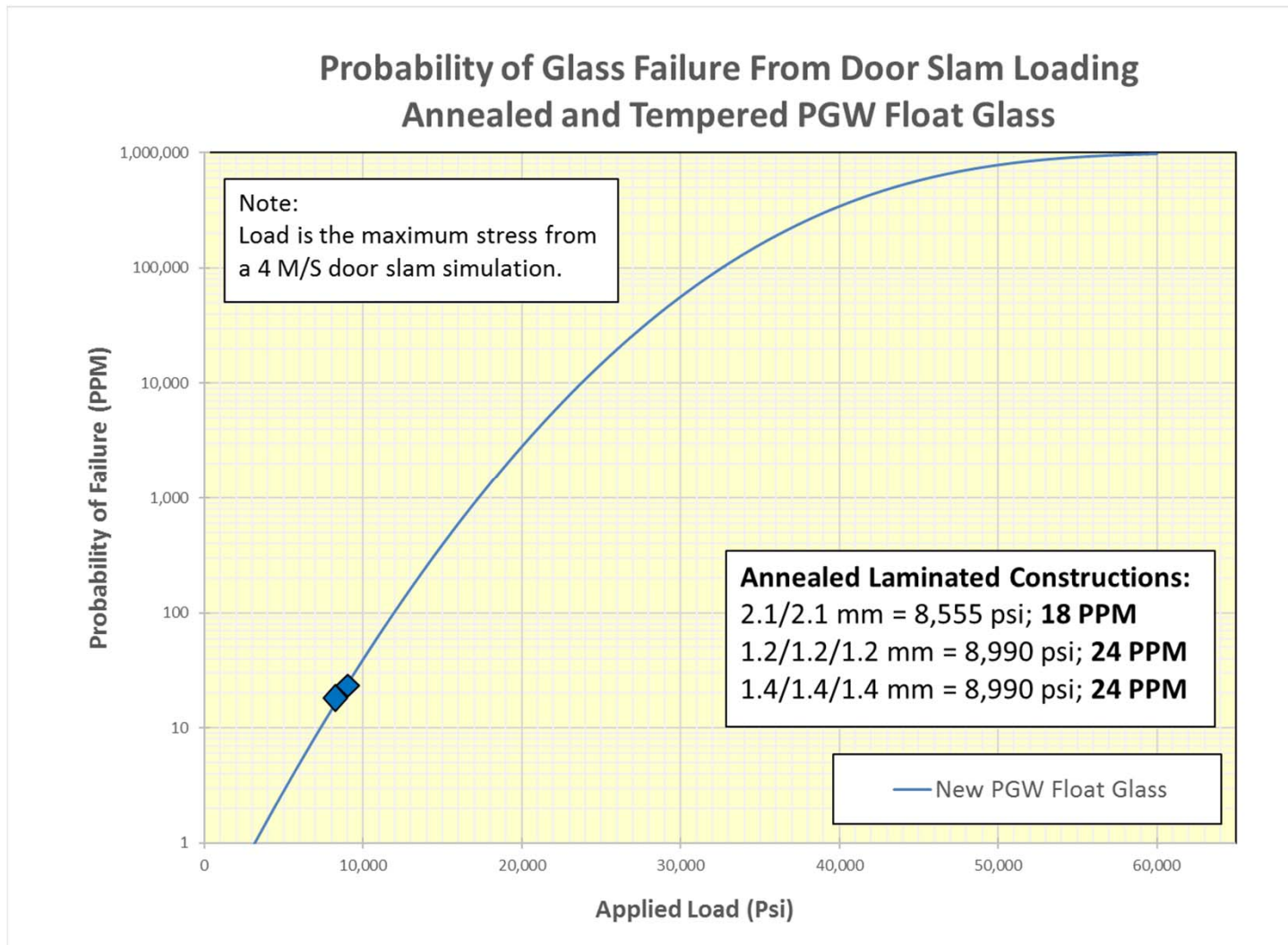
Tri-laminates Provide Superior Acoustic Performance



**Significantly
Improved Acoustic
Performance by
Tri-laminates**
[4 dB average from
2,500 to 8,000 Hz]



Excellent Door Slam Performance for Tri-laminates & Standard Laminates: Less Than 25 PPM



Benefits From Tri-layer Laminate Sidelite Construction



Benefits from Tri-layer Laminates

- ✓ Both tri-layer laminates have significantly improved acoustic performance compared to a standard 2.1/2.1 mm laminated sidelite
- ✓ The 1.2 mm tri-laminate construction saves 1.9% weight compared to a standard 2.1/2.1 mm laminated sidelite
- ✓ The 1.4 mm tri-laminate construction provides the highest acoustic performance with a weight penalty of 7.2%
- ✓ Probability of failure from door slam is the same for both the tri-laminates and the standard construction

Questions?

