kuraray

trosifol™
world of interlayers

Trosifol® - World of Interlayers

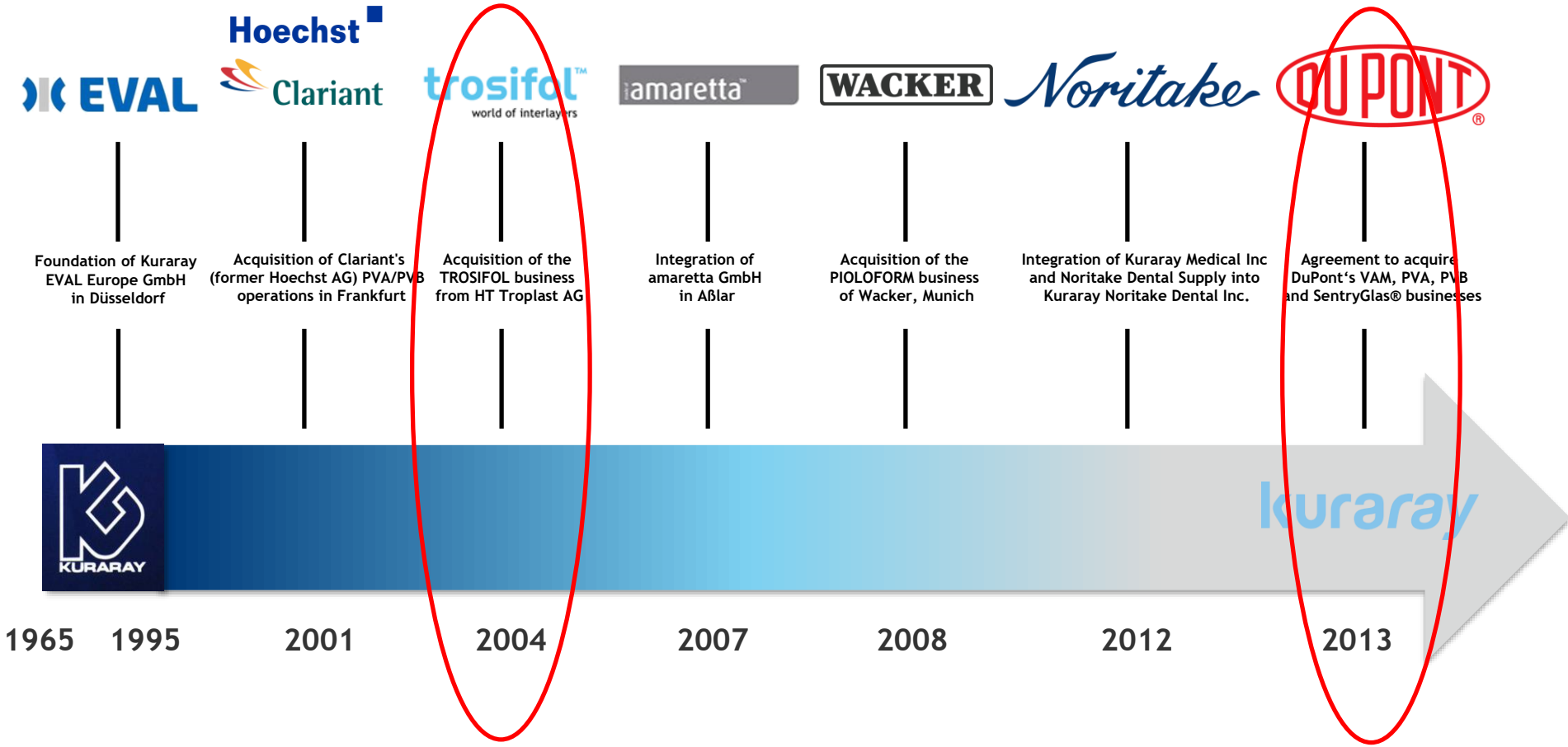
Which interlayer for which application?

Björn Sanden – Market development Mgr

Agenda:

- Trosifol – World of Interlayers –
- Laminated glass
- Interlayers
- Which interlayer for which application?
  - Performance
    - Safety
    - Structural
    - Acoustic
    - Security and Disaster mitigation
    - UV control
    - Decorative
  - Quality
    - Clarity
    - Edge integrity

Trosifol: Part of the Kuraray family



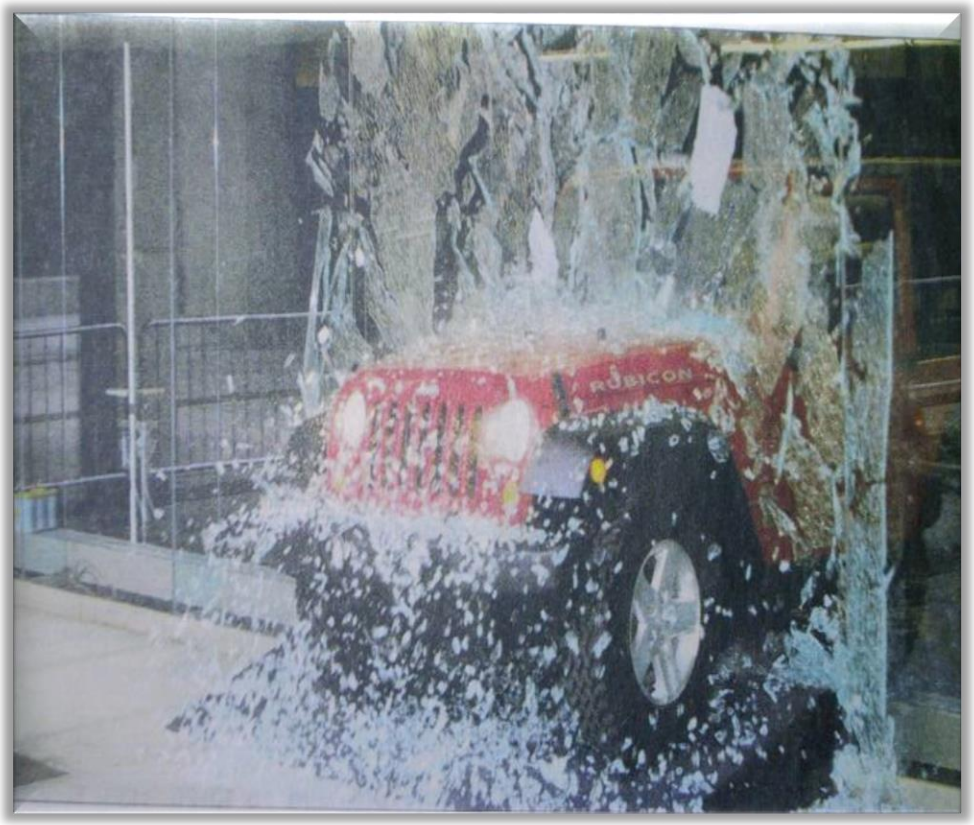
Glass is a fantastic material…

Louis Vuitton, Paris

Marina Bay Sands, Singapore

Shanghai Tower

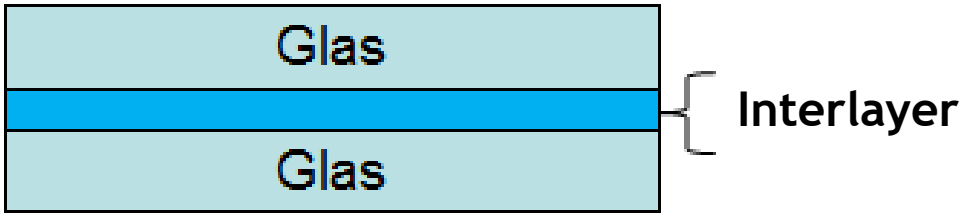
…but sometimes it breaks.

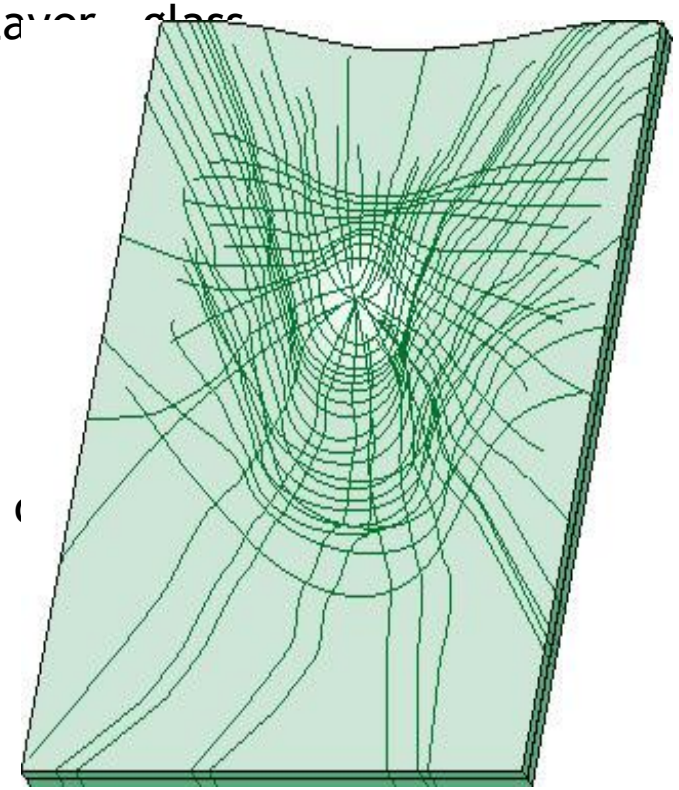


Wikipedia, building in Texas after a

Laminated glass and interlayer - basics

- A laminated glass is a sandwich of glass – Interla[illegible] glass





- A laminated SAFETY Glass meets the following c

  - To The interlayer ensures that in case of glass breakage the spalls stick to the interlayer..

  - The laminated glass is classified according to a safety standard

From automotive to architectural requirements:

80 years ago; automotive windscreens : PVB:

.Single ball drop test requirement ➔ 0.76mm PVB

- Durability meets requirements of automobile lifetime.
- Crash protection: lowest possible head-injury risk, protection against being thrown out of the car ⇒ requires soft and flexible film!

40 years ago: Architectural applications:

- Compound effect, spall adhesion
- Extended range of Safety and security performance
- No 'high speed head injury risk ⇒ allows application of interlayer with increased stiffness
- High requirements on dimensional stability of glass laminate, safe post-breakage behavior especially for overhead glazing
- Continuously Increasing glass size for higher transparency and aesthetics.
- Value added requirements in acoustic, decoration and UV performance.
- Standard PVB followed by Enhanced interlayers

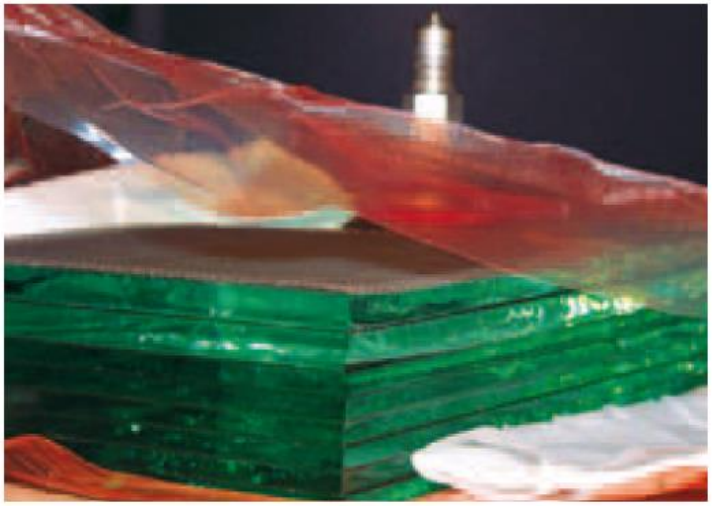
Laminated safety glass - demonstration

Lamination Process

Roller line

- ✓ Automatization
- ✓ High Throughput
- ✓ High Productivity/L

Vacuum bag & ring line



- ✓ Complex glass make-up
  - ✓ Curved
  - ✓ Multi-lam
  - ✓ Anti-Spall
- ✓ Heat-treated glass
- ✓ Autoclave free process

Interlayer families

- PVB's
- Ionoplasts

Special applications:

- PET/ PVB by layers
- EVA
- PC/PU
- CIP's

Which interlayer for which application?

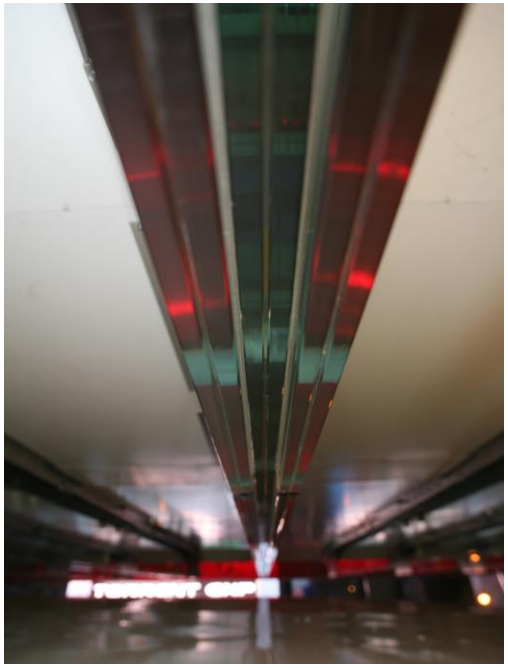
Performance: Safety

Safety Glass with PVB

- PVB = Polyvinyl Butyral, :
- Industrial Standard (since ~ 1930's)

- Today Standard PVB covers around 70% of laminated glass demand

- **Modified PVB for enhanced Performance**
  - **Acoustic performance**
  - **UV filtration**
  - **Decoration**
  - **Structural interlayers: Stiff PVB**



Standard PVB (plasticizer ~30pph)

- Application:
  - 4-sided supported glass
  - 1-3 side & minimally supported glass
    - Lower post breakage performance
- Primary Benefit:
  - Enhance glass safety and security through fragment retention and penetration resistance
    - EN12600, ASTM Z93…
- Other benefits:
  - Acoustic performance
  - UV Protection
  - Blast performance where need for a a compliant interlayer is required
- Limitation:
  - Strength
    - Increased weight vs monolithic
    - Size limitation
  - Post breakage performance
    - Tempered glass

Which interlayer for which application?

Performance: Structural

Structural interlayers

Application:

- 1-3 side supported glass + minimally supported
  - High post-breakage performance
  - Low glass thickness
- Structural balsutrades
- Skylites , floor and canopies

Primary Benefit:

- Glass thickness/weight reduction
- Glass size increase

Other benefits:

- Enhance glass safety and security through fragment retention and penetr resistance
  - EN12600, ASTM Z93…
- UV Control
- Blast performance where need for a stiff interlayer is required

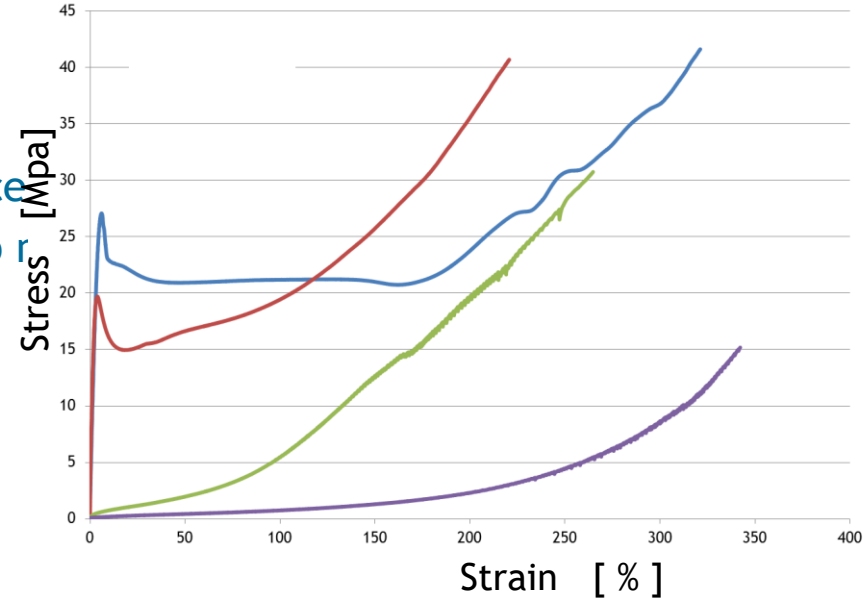
Limitation:

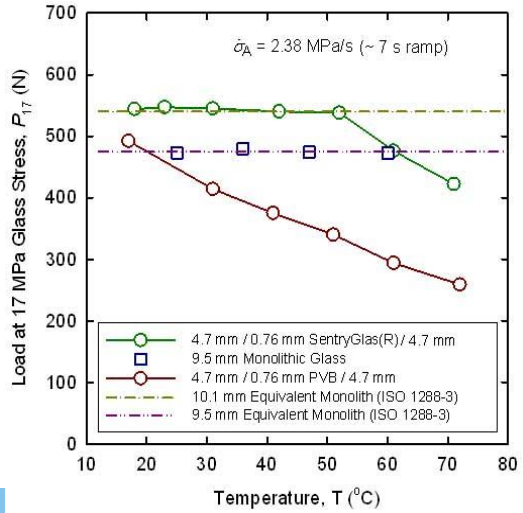
- Acoustic performance

Structural Interlayers

2 Products:

- Ionoplast
  - High temperature mechanical performance
  - Edge aging performance and resistance to r
- Stiff PVB
  - Optimum performance < 30 deg C
  - Shorter load duration





kuraray

trosifol™
world of interlayers

Interlayer performance comparison

Properties	Standard PVB	Other Stiff PVB	Trosifol® PVB	SentryGlas® Ionoplast
Post Breakage Performance at room temperature (21°C/70°F)				
Post Breakage Performance at elevated temperature (50°C/122°F)				
Structural Properties/Coupling effect at room temperature (21°C/70°F)				
Structural Properties/Coupling effect at elevated temperature (50°C/122°F)				
Clarity	 *			
Sealant compatability/Edge stability				
Product offering	Rolls up to Jumbo 321 cm/126 in	Rolls up to Jumbo 321 cm/126 in	Rolls up to Jumbo 321 cm/126 in	Sheet up to 250 cm/98 in and rolls up to 270 cm/106 in
Calipers	15,30, 60 and 90 mils 0.38, 0.76, 1.52 and 2.28 mm	30 mil/0.76 mm	30 mil/0.76 mm	30, 35, 60, 90, 100, 105 mil 0.76, 0.89, 1.52, 2.28, 2.53 and 3.04 mm
Chemistry	Plasticized PVB	Lower Plasticized PVB	Lower Plasticized PVB	Ionoplast chemistry/ No plasticizer

* Not valid for Trosifol® UltraClear film

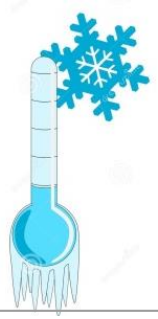
Comparison Shear Modulus G_{PVB} / SGP / ES f(t,T)

Relaxation modulus G [N/mm²]	Product type	Load duration 3 sec	30 sec	1 min	5 min	30 min	1 hour	1 day	5 days	3 weeks	1 month	1 year
10°C	Trosifol® PVB	-	-	-	-	-	-	-	-	-	-	-
Temperature	Trosifol® Extra Stiff	699	603	573	502	420	388	234	157	95	80	19
	SentryGlas®	236	228	225	220	217	206	190	178	172	171	161
20°C	Trosifol® PVB	8	-	1.6	-	-	0.8	0.5	-	-	0.4	0.3
Temperature	Trosifol® Extra Stiff	342	230	196	122	55	37	5.3	2.8	2.0	1.9	1.6
	Other Stiff PVB	325	-	-	-	-	96	2[illegible]	-	-	3.0	1.0
	SentryGlas®	211	206	195	188	175	169	146	130	115	112	96.5
30°C	Trosifol® PVB	1	-	0.8	-	-	0.4	0.3	-	-	0.1	0.1
Temperature	Trosifol® Extra Stiff	58	14	9.2	4.0	2.3	2	1.6	1.6	1.5	1.5	1.5
	Other Stiff PVB	97	-	-	-	-	2.4	0.8	-	-	0.5	0.4
	SentryGlas®	141	119	110	82.8	66.1	60	49.7	24.7	12.9	11.6	6.8
40°C	Trosifol® PVB	0.6	-	0.5	-	-	0.2	0.2	-	-	0.1	0.1
Temperature	Trosifol® Extra Stiff	3.4	1.9	1.8	1.6	1.6	1.6	1.5	1.5	-	1.5	-
	Other Stiff PVB	6	-	-	-	-	0.6	0.4	-	-	0.2	-
	SentryGlas®	63	36.6	30.7	19.4	11.4	9.3	4.5	3.6	3.4	3.3	3.1
50°C	Trosifol® PVB	0.4	-	0.3	-	-	0.1	0.1	-	-	0.1	0.1
Temperature	Trosifol® Extra Stiff	1.7	1.6	1.6	1.5	1.5	-	-	-	-	-	-
	Other Stiff PVB	1	-	-	-	-	0.4	0.2	-	-	-	-
	SentryGlas®	26.4	13.5	11.3	7.3	4.9	4.2	2.8	2.4	2.2	2.2	2.1
60°C	Trosifol® PVB	-	-	-	-	-	-	-	-	-	-	-
Temperature	Trosifol® Extra Stiff	1.6	1.5	1.5	-	-	-	-	-	-	-	-
	SentryGlas®	8.2	4.3	3.7	2.6	1.9	1.7	1.3	1.2	1.2	1.1	1.0
70°C	Trosifol® PVB	-	-	-	-	-	-	-	-	-	-	-
Temperature	Trosifol® Extra Stiff	-	-	-	-	-	-	-	-	-	-	-
	SentryGlas®	2.9	2.1	1.9	1.4	1.0	0.8	0.6	0.6	0.5	0.5	0.5
80°C	Trosifol® PVB	-	-	-	-	-	-	-	-	-	-	-
Temperature	Trosifol® Extra Stiff	-	-	-	-	-	-	-	-	-	-	-
	SentryGlas®	1.3	1.0	0.8	0.6	0.4	0.3	0.3	0.2	0.2	0.2	0.2

* Measurements for Trosifol® PVB and Trosifol® Extra Stiff performed by the Fraunhofer-Institute, Darmstadt, Germany

Conditions where Ionoplast and Stiff PVB have equivalent performance

Sub Zero Temp. Sc
(-20° C)



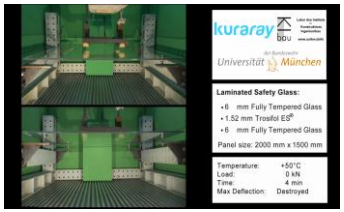
1.52 mm PVB

Room Temp. Sce
(21° C)

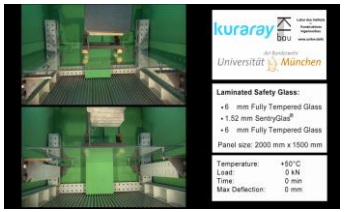
1.52 mm PVB

1.52 Stiff PVB

Elevated Temp. Sc
(50° C)



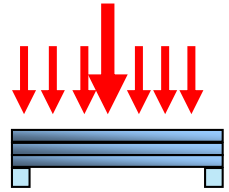
1.52 mm Stiff PVB



1.52 mm Ionomer

Eurocode Classes A1 A1 A3
Residential applications

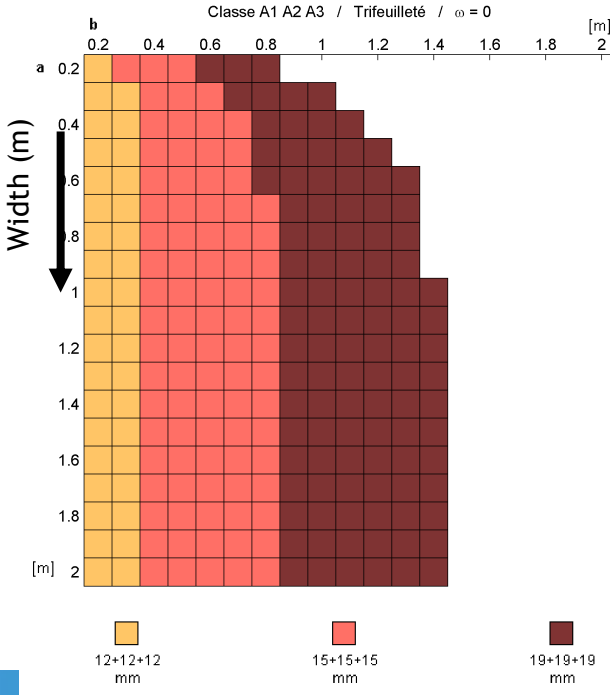
Uniform load: 2.0 - 4.0kN/m2
Point load: 2.0 kN
Temperature: < 50 ˚C



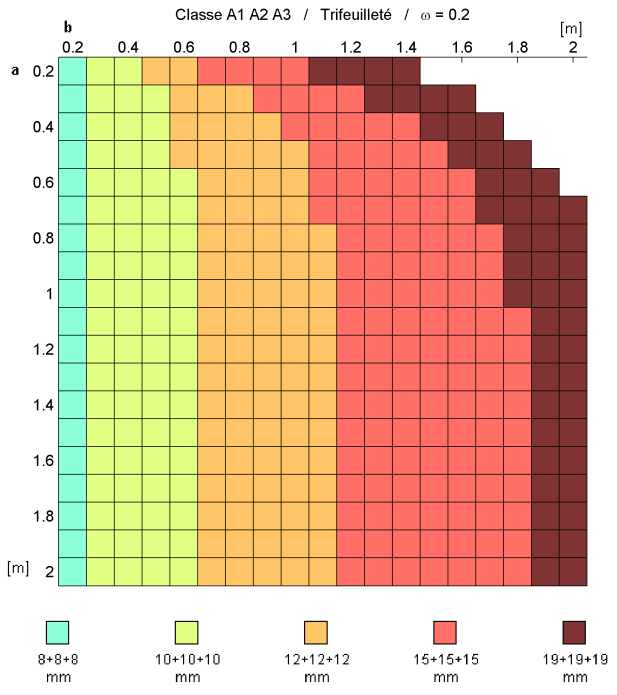
2- sided support
Triple laminate

PVB long load duration
ω= 0

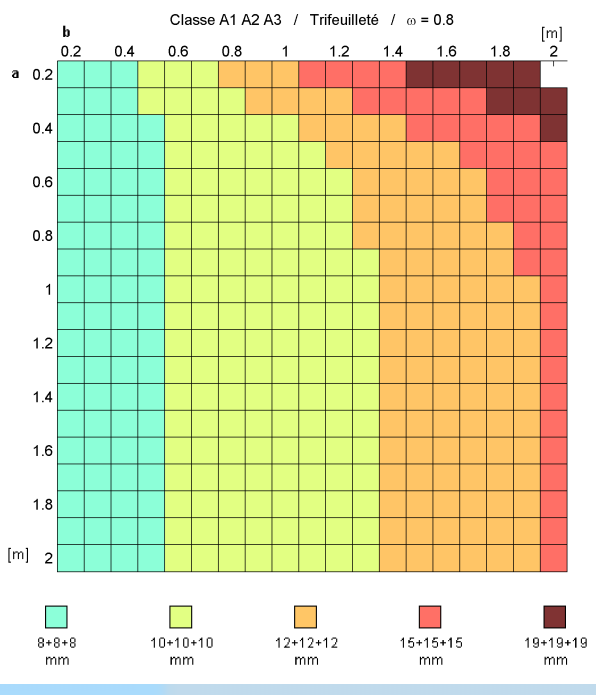
Length (m)



PVB short load duration
ω= 0.2(room temp.)

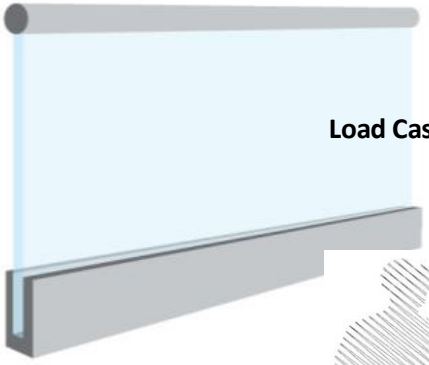


Structural interlayers
ω= 0.7



Load Case Cost control through glass thickness reduction:

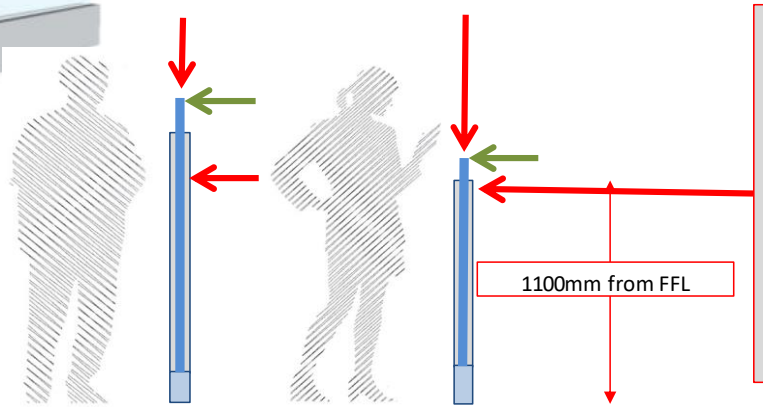
Cantilevered Balustrade with Handrail- 3kN Line load



Load Case

Type A: Cantilevered Balustrade- With a handrail
Size: 1500mm (W) x 1100mm (H)

Support Conditions:
Glass uniformly bonded into rigid channel in accordance with BS6180-2011.



3000N/m run uniform line load applied 100mm from FFL, with associated loads applied to the infill.

1500N/m²uniform load applied to the infill only.

1500N point load applied to the most onerous point anywhere on the barrier structure. The recommended size of the impactor is 25mm x 25mm.

Maximum allowable deflection: 20mm

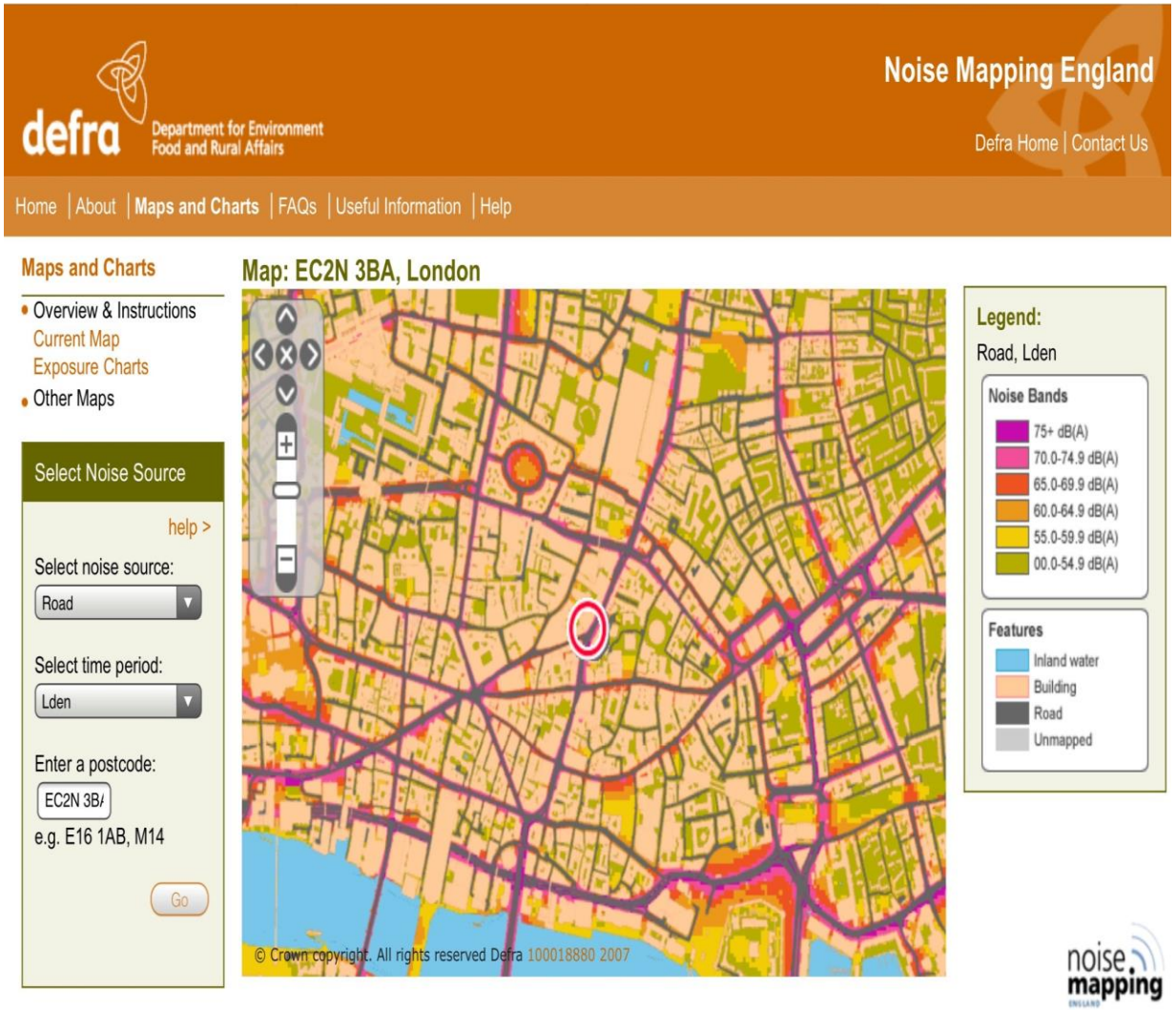
Note these loads are not concurrent.

Comparison Data

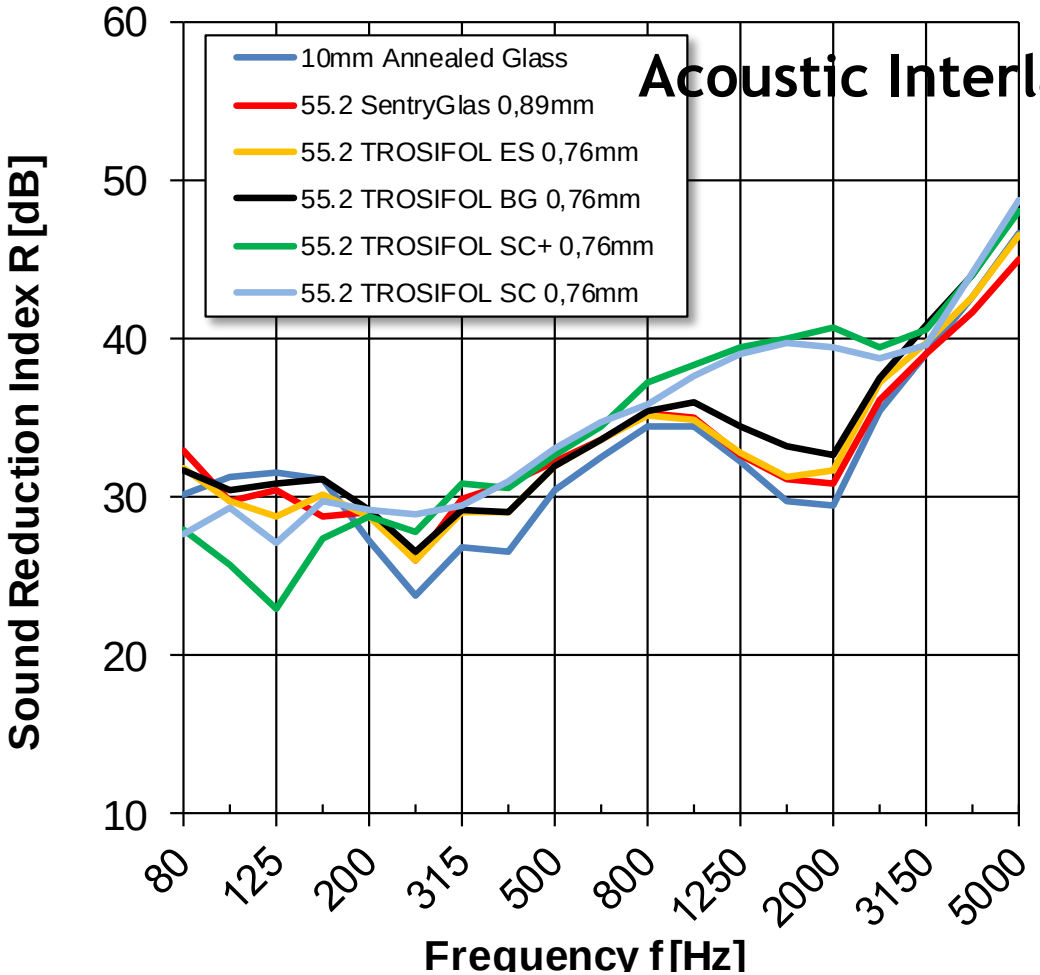
Interlayer Type	Glass Specification-mm	Comparison of glass thickness as a %	Peak Deflection-mm	Peak Stress-N/mm²	Weight of glass	Cost Comparison %
PVB	15 temp/1.52mm PVB/temp HST	125	13.73	33.44	130Kg	125%
Ionoplast	12 temp/0.89mm SGIonoplatP/12 temp	100	13.38	32.87	105 Kg	100%
Monolithic	25mm	105	12.4	31.25	103 Kg	137%

Which interlayer for which application?

Performance: Acoustic


defra
Department for Environment Food and Rural Affairs
Noise Mapping England
Defra Home | Contact Us
Home | About | Maps and Charts | FAQs | Useful Information | Help
Maps and Charts
Overview & Instructions
Current Map
Exposure Charts
Other Maps
Select Noise Source
help >
Select noise source:
Road
Select time period:
Lden
Enter a postcode:
EC2N 3B
e.g. E16 1AB, M14
Go
Map: EC2N 3BA, London
© Crown copyright. All rights reserved Defra 100018880 2007
Legend:
Road, Lden
Noise Bands
75+ dB(A)
70.0-74.9 dB(A)
65.0-69.9 dB(A)
60.0-64.9 dB(A)
55.0-59.9 dB(A)
00.0-54.9 dB(A)
Features
Inland water
Building
Road
Unmapped
noise mapping
© Crown copyright | Terms & conditions | Privacy | Help | Feedback
Department for Environment, Food and Rural Affairs

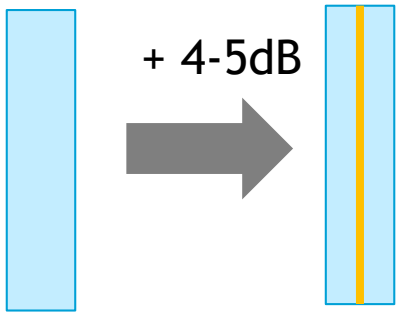
Acoustic Interlayers



Interlayer	Rw (C,Ctr) [dB]
Annealed glass 10mm	33 (-1/-2)
SentryGlas 0,89mm	35 (-2/-3)
TROSIFOL ES 0,76mm	35 (-1/-3)
TROSIFOL BG 0,76mm	35 (0/-2)
TROSIFOL SC+ 0,76mm	38 (-1/-3)
TROSIFOL SC 0,76mm	38 (0/-2)

Thumb rule

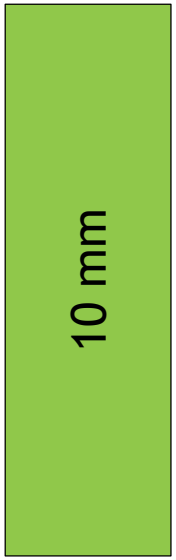
Monolithic ⇒ Laminate with acoustic PVB: +4 dB



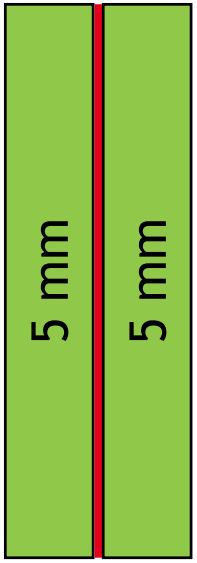
How can I achieve noise insulation with monolithic glass, reduce weight of the construction and save costs?

Laminated glass
0,76 mm

Monolithic glass



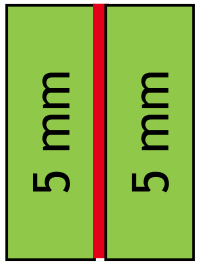
R_w = 33 dB



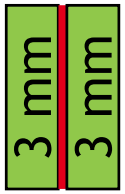
R_w = 35 dB

StandardPVB

Acoustic laminated glass
0,76 mm

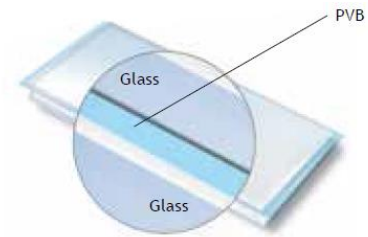
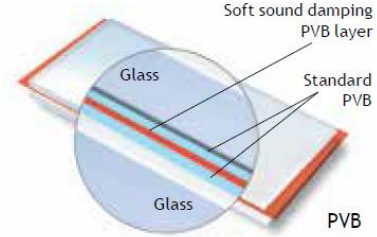
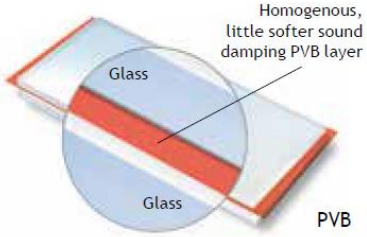


R_w = 38 dB



R_w = 36 dB

Acoustic PVB

	Standard PVB	Acoustic Multilayer	Acoustic Monolayer
			
Acoustic performance	some	Excellent	Excellent
Optic	Great Good	Risk for Orange peel	Great Good
Films' Combination	Yes, standard and color	Yes, standard and color	No
P2A	0.76mm	0.76mm	1.52mm
Yellowness Index	Low for UltraClear	Low	Low

The acoustic vs.weight performance optimization Paradox

- Less and Thinner glass panes
- Stiffer interlayers

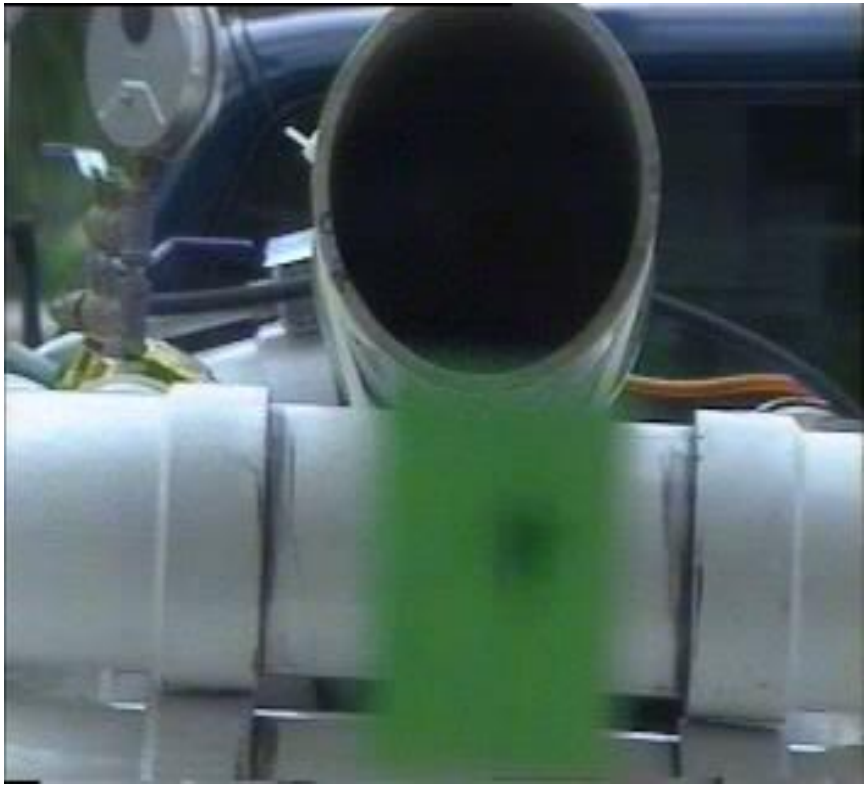
Paradox

- More and Thicker glass
- Softer interlayers

- Improved performance of laminated glass components?
- Improved window systems?

Performance: Security & Disaster Mitigation

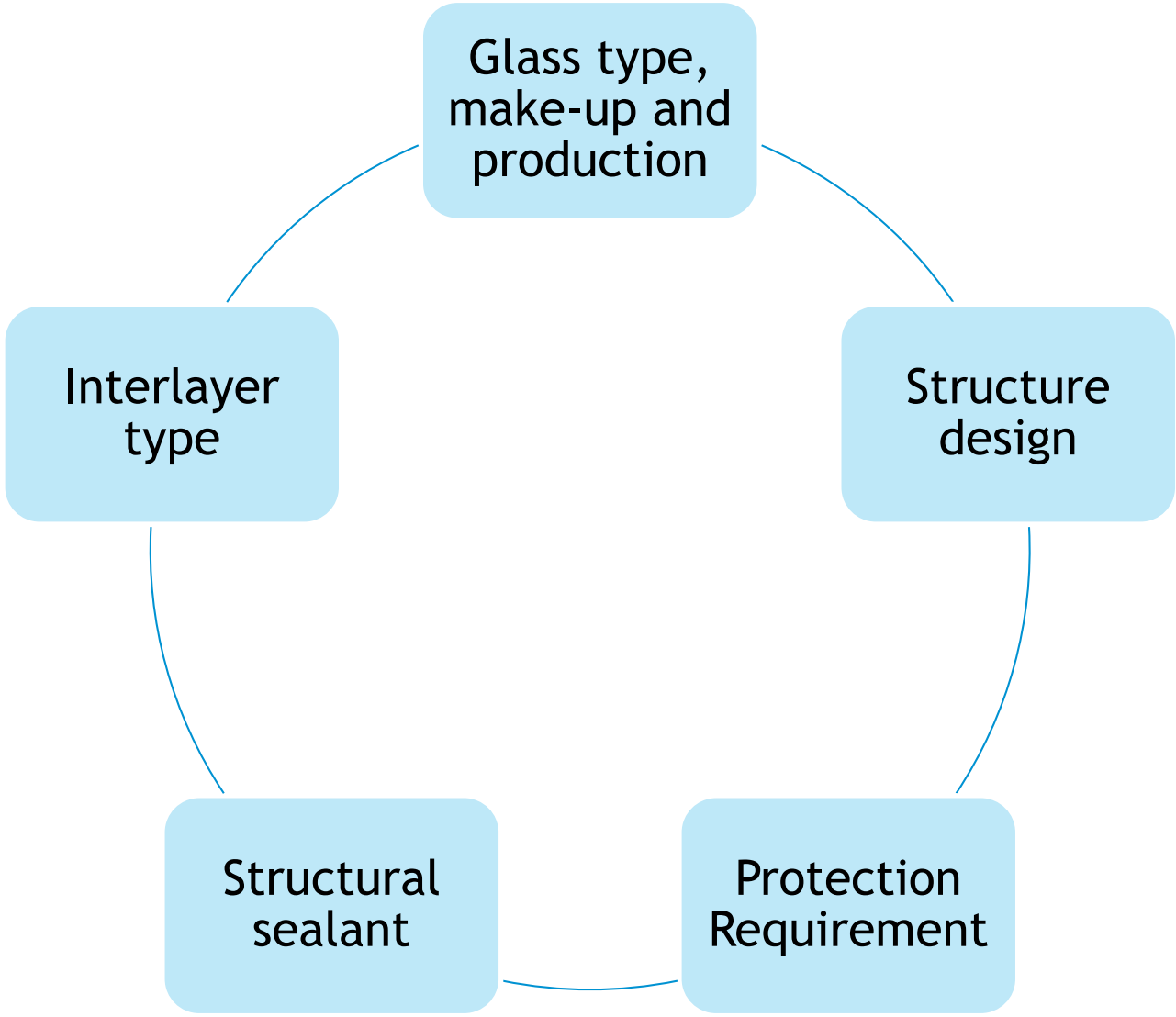

Job# T231-0701-10
HTL LLC
525 32nd St.
Lubbock, Texas 79404



Security and disaster mitigation

Interlayers

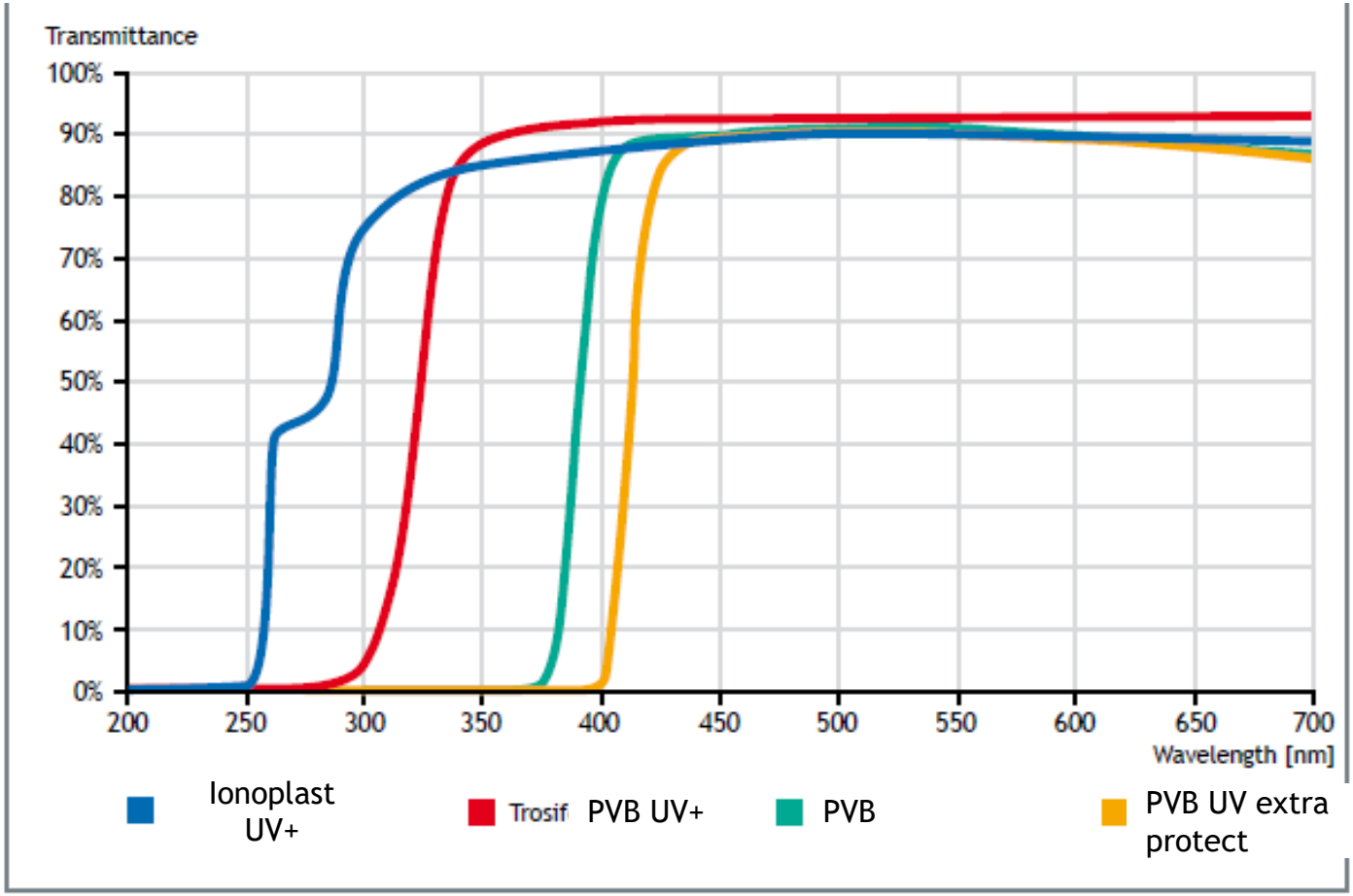
- Standard PVB
- **E**xtra **S**tiff PVB's
- Ionoplast
- PC/PU



Which interlayer for which application?

Performance: UV control

UV transmittance vs wave length



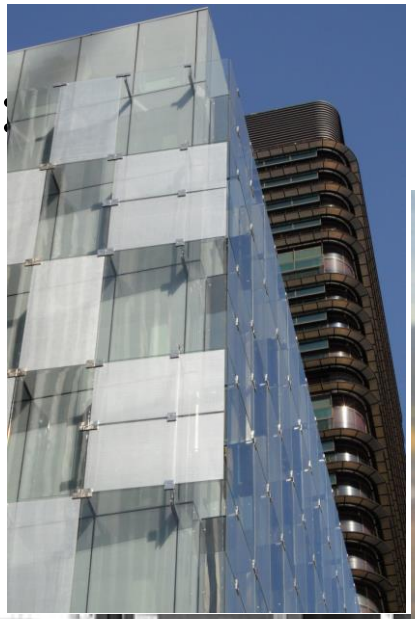
kuraray

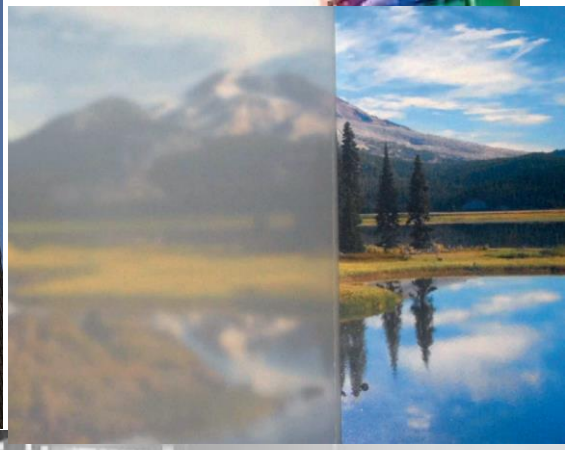
trosifol™
world of interlayers

Performance: Decoration

Decoration enancing interlayers:

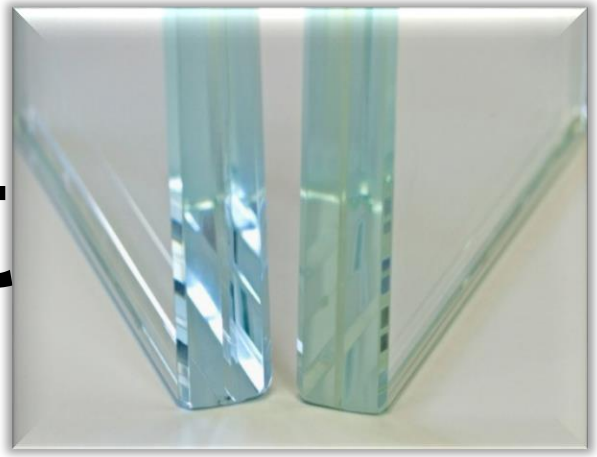
- Coloured interlayers
- Printed Interlayers
- Decorative inclusions
- Embeded materials



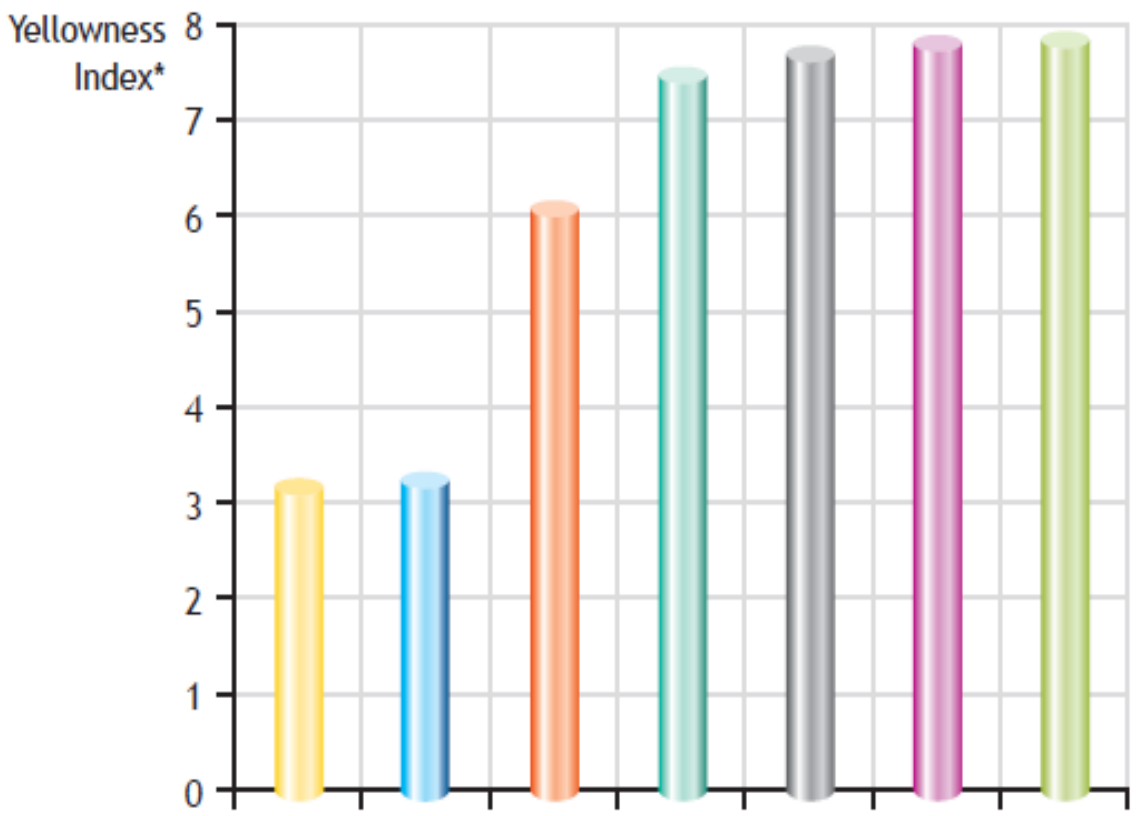


Which interlayer for which application?

Quality: Clarit



Yellowness index



Ionoplast , Light Transmittance 87.6%

PVB A
Light Transmittance 90.2%

PVB B , Light Transmittance 88.7%

PVB C , Light Transmittance 88.2%

PVB D , Light Transmittance 88.4%

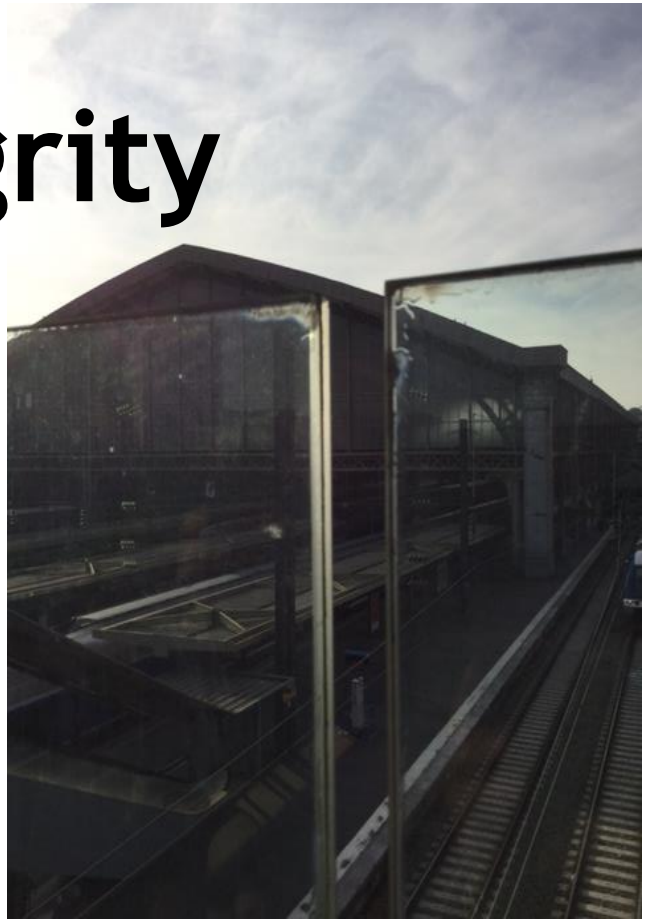
PVB E , Light Transmittance 89.1%

PVB F , Light Transmittance 89.3%

All data measured in accordance with ASTM D 1003 and ASTM E 313 (*) on 3 mm low iron glass / total interlayer thickness approx. 7.6 mm / 3 mm low iron glass.

Which interlayer for which application?

Quality: Edge integrity



Edge integrity

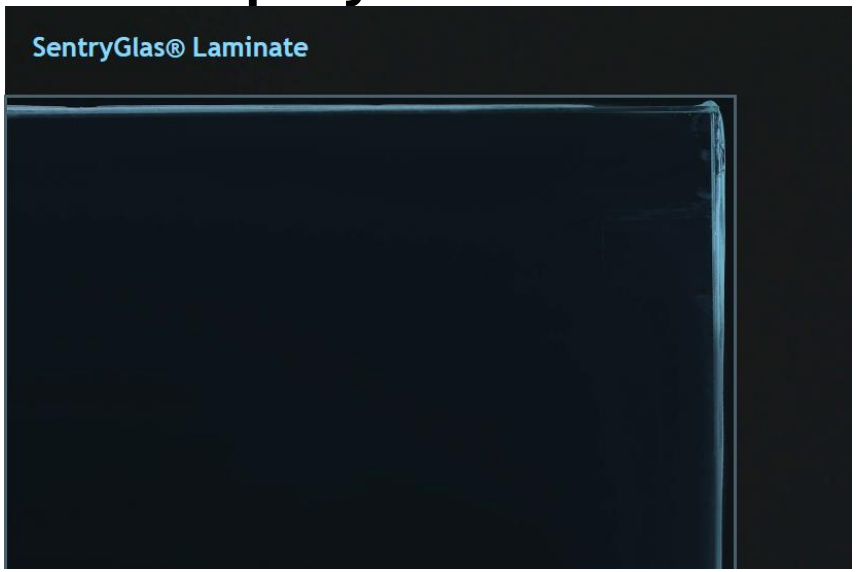
Factors influencing:

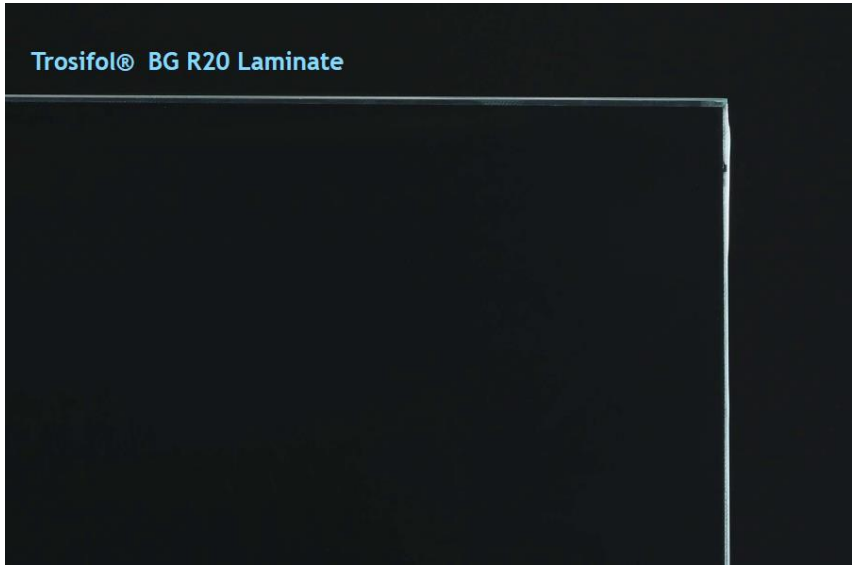
- Lamination process
- Quality of glass flatness
- Cutting process
- Glass Installation
- Fixation system
- Edge exposure to:
  - Moisture
  - Temperature
  - Sealants

And…

- Interlayer selection

Edge discoloration: Salt spray test





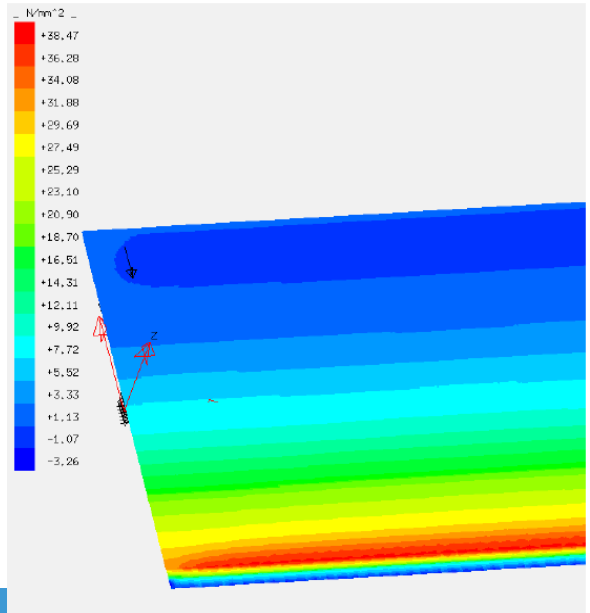
kuraray

trosifol™
world of interlayers

Thank you!

Codes and glass thickness design

- Viscoelastic properties of the interlayer
- E and G modulus
- Poisson coefficient.
- FEMA techniques



Young's Modulus E MPa (psi)		Load Duration						
		1 s	3 s	1 min	1 h	1 day	1 mo	10 yrs
Temperature	10 °C (50 °F)	692. (1.00 E+05)	681. (98745)	651. (94395)	597. (86565)	553. (80185)	499. (72355)	448. (64960)
	20 °C (68 °F)	628. (91060)	612. (88740)	567. (82215)	493. (71485)	428. (62060)	330. (47850)	256. (37120)
	24 °C (75 °F)	581. (84245)	561. (81345)	505. (73225)	416. (60320)	327. (47415)	217. (31465)	129. (18705)
	30 °C (86 °F)	442. (64090)	413. (59885)	324. (46980)	178. (25810)	148. (21460)	34.7 (5032)	15.9 (2306)
	40 °C (104 °F)	228. (33060)	187. (27115)	91.6 (13282)	27.8 (4031)	13.6 (1972)	9.86 (1430)	8.84 (1282)
	50 °C (122 °F)	108. (15660)	78.8 (11426)	33.8 (84901)	12.6 (1827)	8.45 (1225)	6.54 (948.3)	6.00 (870)
	60 °C (140 °F)	35.3 (5119)	24.5 (3553)	10.9 (1581)	5.10 (739.5)	3.87 (561.2)	3.24 (469.8)	2.91 (422)
	70 °C (158 °F)	11.3 (1639)	8.78 (1273)	5.64 (817.8)	2.52 (365.4)	1.77 (256.7)	1.44 (208.8)	1.35 (195.8)
	80 °C (176 °F)	4.65 (674.3)	3.96 (574.2)	2.49 (361.1)	0.96 (139.2)	0.75 (108.8)	0.63 (91.4)	0.54 (78.3)

Codes and glass thickness design

- Coupling factor method
- Example: prEN 16612 & 16613
- Simplified method
- Product family concept
- No optimization per product

$$h_{ef;w} = \sqrt[3]{\sum_k h_k^3 + 12\omega\left(\sum_i h_k h_{m,k}^2\right)}$$

Table 11 — Value of ω associated with interlayer stiffness family and load case

Load case	Family 0	Family 1	Family 2	Family 3
Wind load (Mediterranean areas)	0	0	0.1	0.6
Wind load (other areas)	0	0.1	0.3	0.7
Personal load – normal duty	0	0	0.1	0.5
Personal load – crowds	0	0	0	0.3
Glass for walking on for maintenance	0	0	0	0.1
Snow loads – external canopies	0	0	0.1	0.3
Snow loads – roof	0	0	0	0.1
Permanent loads	0	0	0	0