

**kuraray**

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world of interlayers



# SMART SHEETS

FOR FLOORINGS AND WALKWAYS







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Trosifol, part of the Kuraray Group, is a leading global specialist in the development, manufacturing and supply of Trosifol® PVB and SentryGlas® ionoplast interlayers for laminated safety glass applications in the architectural, automotive and photovoltaic industries.

Bangkok city downtown, Thailand

## TROSIFOL - YOUR GLOBAL PARTNER FOR LAMINATED SAFETY GLASS INTERLAYERS

The Kuraray Group conducts research and development to deliver products that benefit consumers, society and industry. The Trosifol business within this Group positions itself as a pioneer of new technologies for the development of innovative solutions for laminated safety glass. All employees live this innovative culture every day. Trosifol® and SentryGlas® are 100% brands of Kuraray.

We offer the world's broadest portfolio of innovative glass-laminating solutions, including structural and functional interlayers for safety & security applications, sound insulation and UV protection. For decorative applications, Trosifol supplies colored interlayers, digitally printable films and other innovative products for interior design projects. Trosifol® UltraClear films exhibit the lowest Yellowness Index (YID) in the industry.

Trosifol® products give applications an expression of strength, clarity and unique character, delivering advanced capabilities that enable engineers, designers and architects to save energy, increase safety and conceptualize with greater design freedom. Applications range from automotive and transportation glazing, to architectural and structural glazing - located overhead, underfoot, and all around some of the world's most fascinating spaces.

Trosifol is in the perfect position to be your preferred partner for laminated safety glass applications - serving the ever-changing demands of the global glass industry with <https://www.trosifol.com/business/locations/> seven worldwide production sites and five R&D centers.

## SMART SHEETS FOR SELECTING THE RIGHT GLASS COMBINATION FOR GLASS FLOORINGS AND WALKWAYS

### Basic design requirements

- The glass flooring should be robust enough to safely bear the imposed live loads (weight of people) in addition to its own weight (dead load) with a reasonable safety factor.
- Glass being a brittle material, a high design redundancy must be ensured to sustain the design loads even if any one of the glass layers break accidentally due to spontaneous breakages, or accidental impact.
- Due to viscoelastic behavior of the interlayer, load duration and temperatures must be considered. A load duration of 1 hour for the imposed live load and 40°C are recommended.
- From serviceability point of view, people should not fear moving on the flooring due to excessive "sagging" (deflection).



Photo: © Kuraray

Mahanakhon Skywalk Bangkok, Thailand

### Design considerations

- The glass floorings have been considered to be supported on all the four edges. The edges have been considered to be "simply supported" in the structural analysis.
- "Sandwich" model used for non linear analysis in FEA tool SJ Mepla 5.0.6 Software
- Imposed loads on the flooring and the load combinations have been considered as per Australian standard AS 1170.1 - 2002. Load safety factor of 1.2 for self weight and 1.5 for imposed live load has been considered.
- Load combination for the scenario "All Layers are Intact" - 1.2 x Self weight + 1.5 x Imposed live load
- Load combination for the scenario "One Layer is Broken" - 1.0 x Self weight + 1.0 x Imposed live load
- Imposed concentrated live loads have been considered to be acting at the center of the panel in area of 150 x 150 mm.
- Permissible stresses for heat strengthened glass = 29.2 MPa (edge locations) and 62.9 MPa for fully tempered glass have been considered as ASTM E 1300 - 2019.
- For Post breakage strength check, the upper glass layer is considered to be broken.
- The maximum values of deflection and stress have been mentioned. For the majority of cases, it occurred for point loads.
- The smart sheet is applicable only to SentryGlas® 5000.

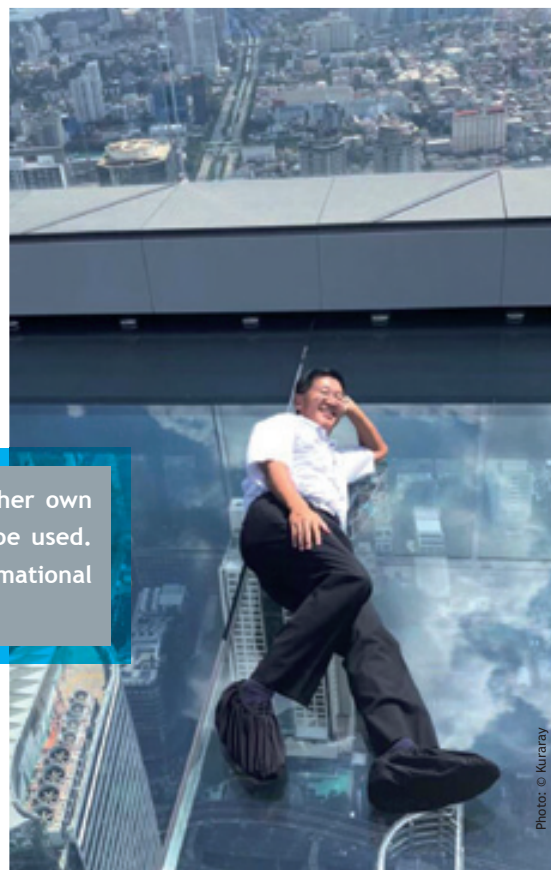


## OTHER IMPORTANT DESIGN CONSIDERATIONS

Making the glass flooring with the combination of HS and FT glass is certainly the most ideal glass combination that not only ensures good resistance to accidental impacts but, also a high post breakage strength. However, below factors give an all FT glass combination an edge over HS-FT glass combination.

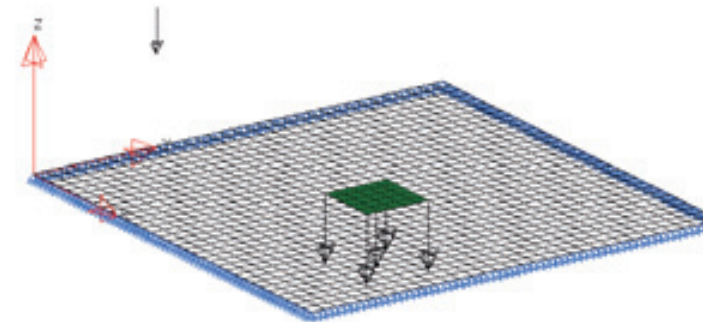
### What glass type should be chosen, fully tempered or heat strengthened?

- FT glass has the highest stress endurance limit but doesn't have a high post breakage strength. Whereas, HS glass has a lower stress endurance limit but, a remarkably higher post breakage strength. Thus, a combination of FT and HS glass would be the ideal combination to get the best of the two worlds. However, assymetric surface waviness of FT and HS glass, laminators, genrally have low confidence for a successful lamination.
- Use of HS glass no doubt ensures high post breakage strength but, it limits the pre-breakage strength as permissible stress for HS glass at the edge locations, for 1 hour load is 29.2 MPa compared to 73.1 MPa for FT glass.
- FT glass is not promoted for flooring applications due to the fear of "wet blanket" effect getting triggered off post the accidental breakage of glass e.g. spontaneous breakages due to NiS or an hard body impact at the edges. FT glass can be very hard to break with impacts at locations other than edges. The probability of break-ages of more than 1 glass layer due to impact at edges is extremely low as only the top layer is vulnerable. Similarly, the probability of spontaneous breakages due to NiS in more than 1 glass layer at the same time is extremely rare. A heat soak test is recommended to rule out any NiS related spontaneous breakages.
- High stiffness of SentryGlas® 5000 should resist "wet blanket" effect to get triggered off to a large extent in four side framed laminates even when tempered glass is used.



Note: The user should make his/her own decision for the type of glass to be used. Above considerations are for informational purposes only.

## FLOORINGS IN PRIVATE RESIDENTIAL AREAS AND OFFICE AREAS FOR GENERAL USE



Glass panel (1.0 x 1.0 Mts) mesh with the point load acting at the center as used for finite element modeling & calculations in Mepla

Load requirements as per table 3.1 of AS 1170.1 2002

### IMPOSED LOADS

1. Uniform Load = 300 kg/m<sup>2</sup>
2. Point Load = 270 kg

LOAD ACTING FOR 1 HOUR @ 40°C TEMP.

Table 3.1 - Reference values of imposed floor actions

Type of activity/occupancy for part of the building or structure	Specific uses	Uniformly distributed actions [kPa]	Concentrated actions [kN]
<b>A Domestic and residential activities (also see category C)</b>			
A1 Self-contained dwellings	General areas, private kitchens and laundries in self-contained dwellings	1.5	1.8 <sup>1</sup>
	Balconies and roofs used for floor type activities, in self-contained dwellings		
	a. less than 1 m above ground level	1.5	1.5 kN/m run along edge
	b. other	2.0	1.8 <sup>1</sup>
	Stairs <sup>1</sup> and landings in self-contained dwellings	2.0	2.7
A2	Non-habitable roof spaces in self-contained dwellings	0.5	1.4 <sup>1</sup>
A2 Other	General areas, bedrooms, hospital wards, hotel rooms, toilet areas	2.0	1.8 <sup>1</sup>
	Communal kitchens	3.0	2.7
	Balconies and roofs used for floor type activities with community access	same as areas providing access but not less than 4.0	1.8
<b>B Offices and work areas not covered elsewhere</b>			
	Operating theatres, X-ray rooms, utility rooms	3.0	4.5
	Work rooms (light industrial) without storage	3.0	3.5
	Offices for general use	3.0	2.7 <sup>1</sup>

<sup>1</sup> Refer to Table 3.1 of AS 1288 - 2006



## STRESS AND DEFLECTION RESULTS FOR MAXIMUM ALLOWABLE FLOORING SIZES

Floorings in private & residential areas/office areas for general use - with 3 x 6 mm/0.24 inch glass + 2 x 1.52 mm/60 mil SentryGlas®

Widths [mm] [in]	Deflection/ Stress	Lengths [mm]		1100		1200		1300		1400		1500		1600	
		Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken
1000 39.37	Deflection	2.59	3.79	2.74	4.06	2.86	4.28	2.96	4.46	3.03	4.6	3.08	4.71	3.12	4.80
	Stress	28.81	32.72	29.52	33.68	30.13	34.5	30.41	34.95	30.79	35.47	31.07	35.88	31.47	36.39
1100 43.31	Deflection	2.74	4.06	2.94	4.41	3.10	4.70	3.23	4.94	3.34	5.15	3.42	5.31	3.49	5.45
	Stress	29.52	33.68	29.47	33.63	30.12	34.50	30.50	35.07	30.97	35.7	31.35	36.22	31.83	36.84
1200 47.24	Deflection	2.86	4.28	3.10	4.70	3.30	5.06	3.47	5.38	3.62	5.65	3.74	5.88	3.83	6.07
	Stress	30.13	34.5	30.12	34.50	30.07	34.44	30.48	35.04	31.04	35.77	31.52	36.38	32.05	37.08
1300 51.18	Deflection	2.96	4.46	3.23	4.94	3.47	5.38								
	Stress	30.41	34.95	30.5	35.07	30.48	35.04								
1400 55.12	Deflection	3.03	4.60	3.34	5.15	3.62	5.65								
	Stress	30.79	35.47	30.97	35.70	31.04	35.77								
1500 59.06	Deflection	3.08	4.71	3.42	5.31	3.74	5.88								
	Stress	31.07	35.88	31.35	36.22	31.52	36.38								
1600 62.99	Deflection	3.120	4.80	3.49	5.45	3.83	6.07								
	Stress	31.47	36.39	31.8	36.84	32.1	37.08								
1700 66.93	Deflection	3.15	4.86	3.54	5.56	3.9	6.23								
	Stress	31.62	36.64	32.05	37.17	32.34	37.51								
1800 70.87	Deflection	3.18	4.91	3.58	5.65										
	Stress	31.73	36.83	32.22	37.45										
1900 74.80	Deflection	3.19	4.95												
	Stress	31.62	36.77												

Widths [mm] [in]	Deflection/ Stress	Lengths [mm]		1800		1900	
		Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken
1000 39.37	Deflection	3.15	4.86	3.18	4.91	3.19	4.95
	Stress	31.62	36.64	31.73	36.83	31.62	36.77
1100 43.31	Deflection	3.54	5.56	3.58	5.65		
	Stress	32.05	37.17	32.22	37.45		
1200 47.24	Deflection	3.90	6.23				
	Stress	32.34	37.51				
1300 51.18	Deflection						
	Stress						
1400 55.12	Deflection						
	Stress						
1500 59.06	Deflection						
	Stress						
1600 62.99	Deflection						
	Stress						
1700 66.93	Deflection						
	Stress						
1800 70.87	Deflection						
	Stress						
1900 74.80	Deflection						
	Stress						

### Glass construction

3 x 6 mm (0.24 in) FT glass  
+ 2 x 1.52 mm (60 mil) SentryGlas®

### Loads and load combinations

Max. uniform live load = 300 kg/m<sup>2</sup>

Point load = 270 kg

### Scenario 1: All layers intact

1.2 x Self weight + 1.5 x Imposed live load

### Scenario 2: Any one layer is accidentally broken

1.0 x Self weight + 1.0 x Imposed live load

### Important notes

- The imposed live load has been considered to be acting for 1 hour @ 40°C.
- Young's Modulus for SentryGlas® E = 27.8 MPa
- Deflection values for one layer broken scenario have been calculated for information only. It may not be design requirements.

Max. allowable deflection considered = Span / 300

The maximum values of deflection and stresses have been mentioned. For the majority of cases, it occurred for the point load case.

Permissible stresses for glass types for 1 hour load

- FT glass = 62.9 MPa
- Heat strengthened glass = 29.2 MPa

## PUBLIC AREAS

# GLASS WALKWAYS FOR PUBLIC AREAS



Mahanakhon Skywalk Bangkok, Thailand

Load requirements as per table 3.1 of AS 1170.1 2002

### IMPOSED LOADS

- Uniform Load = 500 kg/m<sup>2</sup>
- Point Load = 360 kg

LOAD ACTING FOR 1 HOUR @ 40°C TEMP.

Table 3.1 - Reference values of imposed floor actions

Type of activity/occupancy for part of the building or structure	Specific uses	Uniformly distributed actions [kPa]	Concentrated actions [kN]
<b>C Areas where people may congregate</b>			
C4 Areas with possible physical activities	Dance halls and studios, gymnasia	5.0	3.6
	Drill halls and drill rooms	5.0	9.0
C5 Areas susceptible to overcrowding	Assembly areas without fixed seating (concert halls, bars, vestibules, public lounges, places of worship, shopping malls and grandstands)	5.0	3.6
	Stages in public assembly areas	7.5	4.5
<b>D Shopping areas</b>	Shop floors for the sale and display of merchandise	4.0	3.6



## STRESS AND DEFLECTION RESULTS FOR MAXIMUM ALLOWABLE FLOORING SIZES

Floorings in public areas susceptible to overcrowding -  
with 3 x 8 mm / 0.31 inch glass + 2 x 1.52 mm / 60 mil SentryGlas®  
(Commercial & retail spaces where people may assemble in case of emergency)

Widths [mm] [in]	Deflection / Stress	Lengths [mm]		1200		1400		1600		1800		2000		2200		2400		2600		2800		3000		3200		3400		3600	
		Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken	Intact [MPa]	Broken
1200 47.24	Deflection	2.32	3.49	2.54	3.9	2.68	4.19	2.78	4.39	2.84	4.55	2.87	4.88	2.93	5.13	3.03	5.34	3.10	5.50	3.16	5.62	3.20	5.71	3.23	5.78	3.25	5.84		
	Stress	25.09	28.41	25.91	29.70	26.74	30.81	27.18	31.47	27.31	31.8	27.62	32.18	27.72	32.36	27.64	32.37	27.81	32.54	27.82	32.59	27.69	32.52	27.84	32.65	27.84	32.66		
1400 55.12	Deflection	2.54	3.90	2.86	4.54	3.12	5.15	3.43	6.06	3.84	6.86	4.18	7.54	4.46	8.11														
	Stress	25.91	29.70	25.38	29.13	26.33	30.47	26.99	31.45	27.31	32.05	27.77	32.66	27.98	33.022														
1600 62.99	Deflection	2.68	4.19	3.12	5.15	3.74	6.67	4.48	8.13	5.16	9.47																		
	Stress	26.74	30.81	26.33	30.47	26.89	31.01	27.68	32.20	28.17	33.06																		
1800 70.87	Deflection	2.78	4.39	3.43	6.06	4.48	8.13																						
	Stress	27.18	31.47	26.99	31.45	27.68	32.20																						
2000 78.74	Deflection	2.84	4.55	3.84	6.86	5.16	9.47																						
	Stress	27.31	31.80	27.31	32.05	28.17	33.06																						
2200 86.61	Deflection	2.87	4.88	4.18	7.54																								
	Stress	27.62	32.18	27.77	32.66																								
2400 94.49	Deflection	2.93	5.13	4.46	8.11																								
	Stress	27.72	32.36	27.98	33.022																								
2600 102.36	Deflection	3.03	5.34																										
	Stress	27.64	32.37																										
2800 110.24	Deflection	3.10	5.50																										
	Stress	27.81	32.54																										
3000 118.11	Deflection	3.16	5.62																										
	Stress	27.82	32.59																										
3200 125.98	Deflection	3.20	5.71																										
	Stress	27.69	32.52																										
3400 133.86	Deflection	3.23	5.78																										
	Stress	27.84	32.65																										
3600 141.73	Deflection	3.25	5.84																										
	Stress	27.84	32.66																										

Glass construction  
3 x 8 mm (0.31 in) FT glass  
+ 2 x 1.52 mm (60 mil) SentryGlas®

Loads and load combinations  
Max. uniform live load = 500 kg/m<sup>2</sup>  
Point load = 360 kg

Scenario 1: All layers intact  
1.2 x Self weight  
+ 1.5 x Imposed live load

Scenario 2:  
Any one layer is accidentally broken  
1.0 x Self weight  
+ 1.0 x Imposed live load

Important notes  
1. The imposed live load has been considered to be acting for 1 hour @ 40°C.  
2. Young's Modulus for SentryGlas®  
E = 27.8 MPa  
3. Deflection values for one layer broken scenario have been calculated for information only. It may not be design requirements.

Max. allowable deflection considered = Span / 300

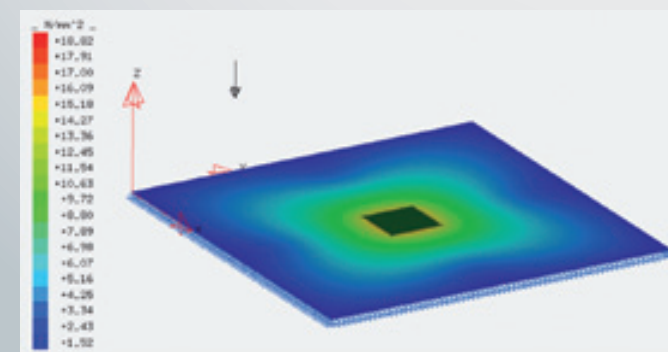
The maximum values of deflection and stresses have been mentioned. For the majority of cases, it occurred for the point load case.

Permissible stresses for glass types for 1 hour load  
■ FT glass = 62.9 MPa  
■ Heat strengthened glass = 29.2 MPa

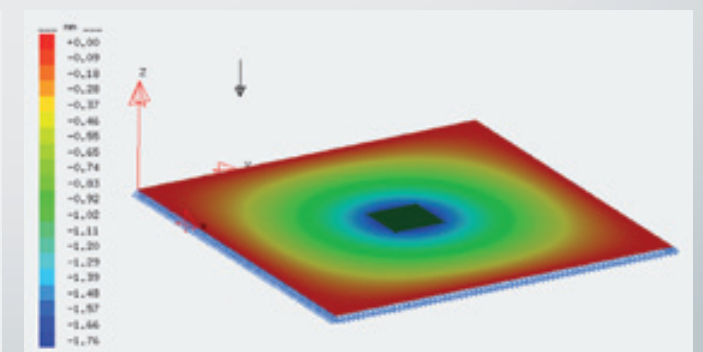


Photo: © King Power Mahanakhon

Mahanakhon Skywalk Bangkok, Thailand



Maximum principal stress contours for the glass panel 1.0 x 1.0 mts under the imposed loads



Maximum deflection contours for glass panel 1.0 x 1.0 Mts under imposed loads

# STRESS AND DEFLECTION RESULTS FOR MAXIMUM ALLOWABLE FLOORING SIZES

## Floorings in public areas susceptible to overcrowding - with 3 x 10 mm/0.39 inch glass + 2 x 1.52 mm/60 mil SentryGlas®

(Commercial & retail spaces where people may assemble in case of emergency)

Widths [mm] [in]	Deflection / Stress	Lengths [mm]		1600 [MPa]		1800 [MPa]		2000 [MPa]		2200 [MPa]		2400 [MPa]		2600 [MPa]		2800 [MPa]		3000 [MPa]		3200 [MPa]		3400 [MPa]		3600 [MPa]	
		Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken
1600 62.99	Deflection Stress	2.21 18.25	3.78 20.98	2.64 18.81	4.60 21.82	3.04 19.19	5.35 22.44	3.38 19.62	6.02 23.05	3.68 19.88	6.61 23.46	3.94 19.98	7.12 23.7	4.15 20.20	7.56 24.01	4.33 20.30	7.92 24.19	4.48 20.29	8.23 24.26	4.60 20.43	8.49 24.44	4.70 20.47	8.71 24.52		
1800 70.87	Deflection Stress	2.64 18.81	4.60 21.82	3.26 18.80	5.77 21.81	3.84 19.25	6.90 22.55	4.37 19.79	7.96 23.31	4.86 20.14	8.92 23.87	5.28 20.34	9.78 24.25	5.65 20.64	10.54 24.68										
2000 78.74	Deflection Stress	3.04 19.19	5.35 22.44	3.84 19.25	6.90 22.55	4.63 18.92	8.46 22.22	5.39 19.48	9.98 23.05																
2200 86.61	Deflection Stress	3.38 19.62	6.02 23.05	4.37 19.79	7.96 23.31	5.39 19.48	9.98 23.05																		
2400 94.49	Deflection Stress	3.68 19.88	6.61 23.46	4.86 20.14	8.92 23.87																				
2600 102.36	Deflection Stress	3.94 19.98	7.12 23.7	5.28 20.34	9.78 24.25																				
2800 110.24	Deflection Stress	4.15 20.20	7.56 24.01	5.65 20.64	10.54 24.68																				
3000 118.11	Deflection Stress	4.33 20.30	7.92 24.19																						
3200 125.98	Deflection Stress	4.48 20.29	8.23 24.26																						
3400 133.86	Deflection Stress	4.60 20.43	8.49 24.44																						
3600 141.73	Deflection Stress	4.70 20.47	8.71 24.52																						

Glass construction  
3 x 10 mm (0.39 in) FT glass + 2 x 1.52 mm (60 mil) SentryGlas®

Loads and load combinations  
Max. uniform live load = 500 kg/m²  
Point load = 360 kg

Scenario 1: All layers intact  
1.2 x Self weight + 1.5 x Imposed live load

Scenario 2: Any one layer is accidentally broken  
1.0 x Self weight + 1.0 x Imposed live load

Important notes  
1. The imposed live load has been considered to be acting for 1 hour @ 40°C.  
2. Young's Modulus for SentryGlas® E = 27.8 MPa  
3. Deflection values for one layer broken scenario have been calculated for information only. It may not be design requirements.

Max. allowable deflection considered = Span / 300

The maximum values of deflection and stresses have been mentioned. For the majority of cases, it occurred for the point load case.

Permissible stresses for glass types for 1 hour load  
▪ FT glass = 62.9 MPa  
▪ Heat strengthened glass = 29.2 MPa

## Floorings in public areas susceptible to overcrowding - with 3 x 12 mm/0.47 inch glass + 2 x 1.52 mm/60 mil SentryGlas®

(Commercial & retail spaces where people may assemble in case of emergency)

Widths [mm] [in]	Deflection / Stress	Lengths [mm]		2000 [MPa]		2200 [MPa]		2400 [MPa]		2600 [MPa]		2800 [MPa]		3000 [MPa]		3200 [MPa]		3400 [MPa]		3600 [MPa]		3800 [MPa]		
		Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	Intact	Broken	
2000 78.74	Deflection Stress	2.99 13.82	5.30 16.2	3.47 14.25	6.24 16.85	3.93 14.59	7.13 15.33	4.34 14.82	7.94 17.79	4.71 15.12	8.69 18.22	5.04 15.31	8.69 18.22	5.33 15.40	9.95 20.89	5.58 15.59	10.48 21.92	5.80 16.14	10.94 22.82	6.00 16.64	11.35 23.61			
2200 86.61	Deflection Stress	3.47 14.25	6.24 16.85	4.12 14.53	7.50 17.14	4.74 14.91	8.72 17.74	5.32 15.20	9.89 17.94	5.85 15.56	10.98 18.77	6.34 15.81	11.98 20.90	6.79 16.33	12.89 22.37									
2400 94.49	Deflection Stress	3.93 14.59	7.13 15.33	4.74 14.91	8.72 17.74	5.54 14.93	10.32 17.77	6.31 15.25	11.88 18.33															
2600 102.36	Deflection Stress	4.34 14.82	7.94 17.79	5.32 15.20	9.89 17.94	6.31 15.25	11.88 18.33																	
2800 110.24	Deflection Stress	4.71 15.12	8.69 18.22	5.85 15.56	10.98 18.77																			
3000 118.11	Deflection Stress	5.04 15.31	8.69 18.22	6.34 15.81	11.98 20.90																			
3200 125.98	Deflection Stress	5.33 15.40	9.95 20.89	6.79 16.33	12.89 22.37																			
3400 133.86	Deflection Stress	5.58 15.59	10.48 21.92																					
3600 141.73	Deflection Stress	5.80 16.14	10.94 22.82																					
3800 149.61	Deflection Stress	6.00 16.64	11.35 23.61																					

Glass construction  
3 x 12 mm (0.47 in) FT glass + 2 x 1.52 mm (60 mil) SentryGlas®

Loads and load combinations  
Max. uniform live load = 500 kg/m²  
Point load = 360 kg

Scenario 1: All layers intact  
1.2 x Self weight + 1.5 x Imposed live load

Scenario 2: Any one layer is accidentally broken  
1.0 x Self weight + 1.0 x Imposed live load

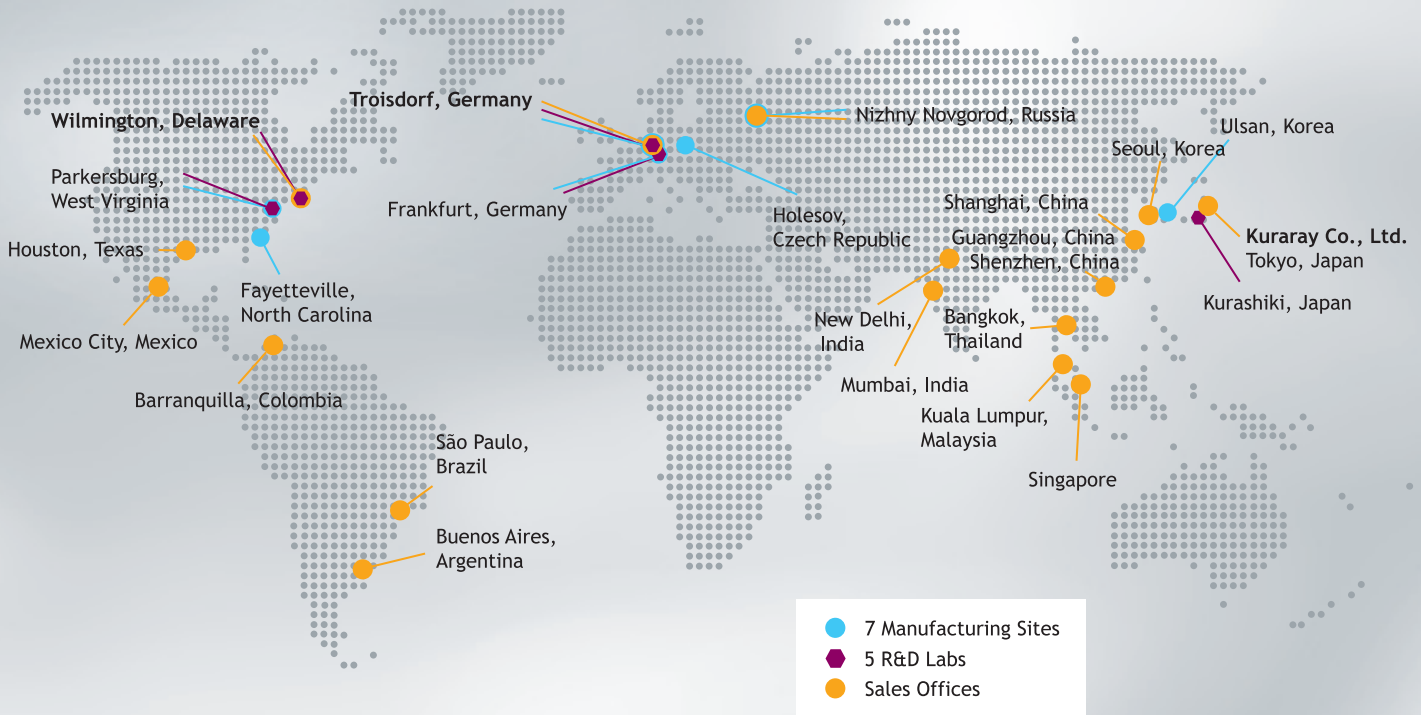
Important notes  
1. The imposed live load has been considered to be acting for 1 hour @ 40°C.  
2. Young's Modulus for SentryGlas® E = 27.8 MPa  
3. Deflection values for one layer broken scenario have been calculated for information only. It may not be design requirements.

Max. allowable deflection considered = Span / 300

The maximum values of deflection and stresses have been mentioned. For the majority of cases, it occurred for the point load case.

Permissible stresses for glass types for 1 hour load  
▪ FT glass = 62.9 MPa  
▪ Heat strengthened glass = 29.2 MPa





For further information on products of Kuraray, please visit [www.kuraray.com](http://www.kuraray.com).  
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