kuraray

EDGE STABILITY, DURABILITY AND WEATHERING

Despite the long history of the use of laminated glass in buildings, there is still a concern for some architects and designers about the potential for serious delamination problems, durability and edge stability of laminated glass, as well as how well the laminated glass will perform under different climatic conditions, including high humidity, tropical climates, storm zones, low and high temperatures, and high saltwater conditions.

TO LEARN MORE ABOUT PUSHING THE LIMITS OF GLASS, VISIT WWW.SENTRYGLAS.COM

EDGE STABILITY, DURABILITY AND WEATHERING

INTRODUCTION

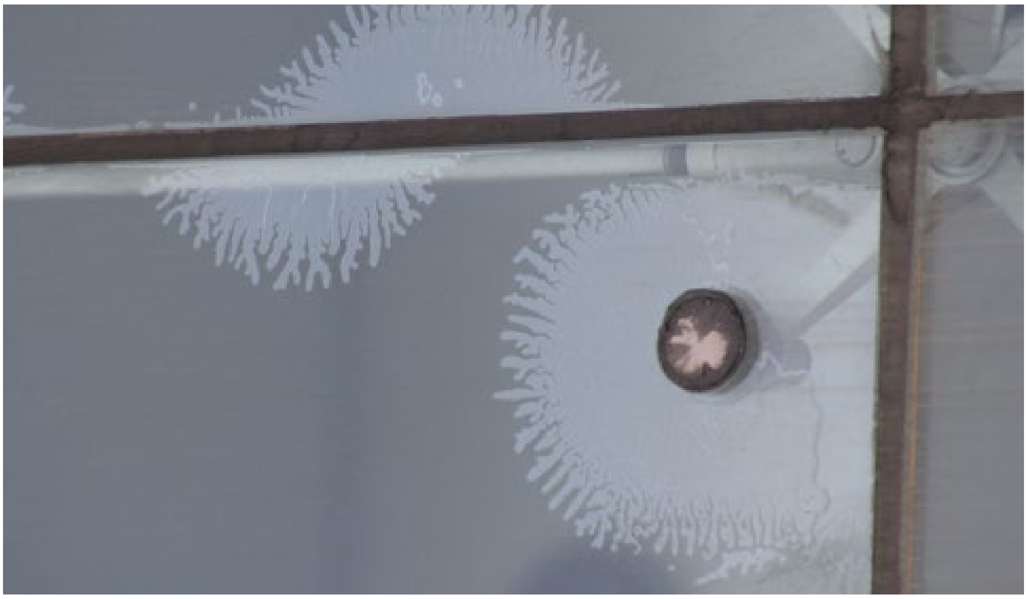
Despite the long history of the use of laminated glass in buildings, there is still a concern for some architects and designers about the potential for serious delamination problems, durability and edge stability of laminated glass, as well as how well the laminated glass will perform under different climatic conditions, including high humidity, tropical climates, storm zones, low and high temperatures, and high saltwater conditions.

This chapter provides some examples of test data on the edge stability and weathering performance of SentryGlas® interlayer, as well as salt spray fog tests, sealant compatibility, ceramic frit compatibility, high temperature bake tests and adhesion to low-E and other solar glass coatings.

WHAT IS EDGE STABILITY?

Edge stability is defined as a laminate’s resistance over time to form defects along its edge. These defects can arise in the form of small ‘bubbles’ in the laminate or as discoloration of the laminate itself. For designers and architects, edge stability is therefore critical. Ideally, laminated glass should show no signs of delamination over the complete life of the building.

Typcial defects caused by delamination.



TESTS AND COMPARISON OF INTERLAYERS

Compared to standard conventional laminated glass interlayers, SentryGlas® ionoplast is more resistant to moisture and the effects of weather, particularly at temperatures between -50 °C (-58 °F) and +82 °C (180 °F). These are the consistent findings of laboratory tests and research in real-life projects.

Due to the exceptional edge stability of SentryGlas® interlayer, no undesired changes such as delamination have been found to date on any of its applications, even on panels with open edges that have been exposed to hot and humid climates such as Florida. This proven edge stability opens up many new design possibilities for SentryGlas®, enabling designers to create stronger, larger expanses of safety glazing including open-edged, structural and butt-glazed installations.

When used in combination with standard silicon sealing material, butt-joined glass elements with SentryGlas® interlayers show no discoloration or other forms of damage to their edges, even after years of weathering. Years later these interlayers still provide the same level of safety and feature the same intact edging, as they did when they were first installed.

FLORIDA 15-YEAR TEST

In 1997 a test programme for laminated glass with SentryGlas® interlayer was started in Florida.The open-edge test samples are installed in open air conditions, fully exposed to the Florida climate. Since their installation, the samples with SentryGlas® interlayer have been tested annually for signs of weathering and delamination.

After 15 years of exposure to the weather, the edges of the laminates with SentryGlas® showed no visible sign of weathering, including no visible moisture ingress or delamination effects in open edge applications. In addition, with silicone butt-joined applications, the edges of the laminated glass also showed no visible moisture intrusion or delamination effects.

The table below shows test results after 149 months of exposure. After this time, SentryGlas® was assigned an Edge Stability Number (ESN). This weighted system assigns higher importance to progressively deeper defects. A laminate with no defects would have an ESN of 0 (zero), while the maximum would be 2 500 (equivalent to continuous defects measuring > 6.4 mm [¼ in] around the entire perimeter).

SENTRYGLAS® INTERLAYER EDGE STABILITY NUMBER (ESN) TEST DATA AFTER 15-YEAR EXPOSURE

Sample ID	Laminate	Defect Length (mm)					
	Perimeter mm (in)	< 1.6	1.6 - 3.1	3.2 - 4.6	4.7 - 6.3	> 6.4	ESN
824-63-1	3912 (154)	0	0	0	0	0	0
824-64-2	3912 (154)	0	0	0	0	0	0
824-48-3	3912 (154)	0	0	0	0	0	0
824-46-4	3912 (154)	0	0	0	0	0	0
824-47-5	3912 (154)	0	0	0	0	0	0
824-44-6	3912 (154)	0	0	0	0	0	0
824-34-7	3912 (154)	0	0	0	0	0	0
824-27-8	3912 (154)	0	0	0	0	0	0
824-16-9	3912 (154)	0	0	0	0	0	0
824-71-10	3912 (154)	0	0	0	0	0	0
824-56-11	3912 (154)	0	0	0	0	0	0
824-75-12	3912 (154)	0	0	0	0	0	0
824-74-13	3912 (154)	0	0	0	0	0	0

ESN data in the table above includes test samples with open-edge exposure, as well as samples that are butt-joined using silicone sealant.

WEATHERING TEST REPORT FOR LAMINATED GLASS WITH SENTRYGLAS®

Samples of laminated glass with SentryGlas® interlayer were weathered according to a test method outlined in ANSI Z97.1-2004: 'Safety Glazing Materials Used in Buildings – Safety Performance Specifications and Methods of Test'. The test results are shown below.

Xenon-Arc Type Operating Light Exposure	
Apparatus	Atlas Ci5000 Xenon Weather-Ometer®
Exposure Time	Specimens were exposed for 3000 hours
Filter Type	Borosilicate inner and outer
Cycle	102 mins of irradiation, 18 mins of irradiation & water spray
Black Panel Temp	70 °C ± 3 °C (158 °F ± 5 °F)
Relative Humidity	50 % ± 5 %
Spray Water	De-ionized
Level of Irradiance	0.35 W/m² @ 340 nm
Exposure	Xenon-Arc Exposure: 3780 kJ/m² @ 340 nm

Note: on average, a 3000-hour Xenon arc exposure approximates to a one-year direct South Florida exposure at 26° North Latitude, facing South.

RESULTS

After the samples of laminated glass with SentryGlas® interlayer were irradiated and conditioned, the exposed samples were examined and compared visually with unexposed controls, as detailed in ANSI Z97.1-2004. These samples were found to be visibly acceptable. No bubbles or delamination effects were visible and no crazing, cracking or discoloration was observed.

APPLICATION EXAMPLES OF THE SUPERIOR EDGE STABILITY OF SENTRYGLAS® INTERLAYER

As well as test reports supporting the superior edge stability performance of SentryGlas®, there are numerous real life examples to support the test data.

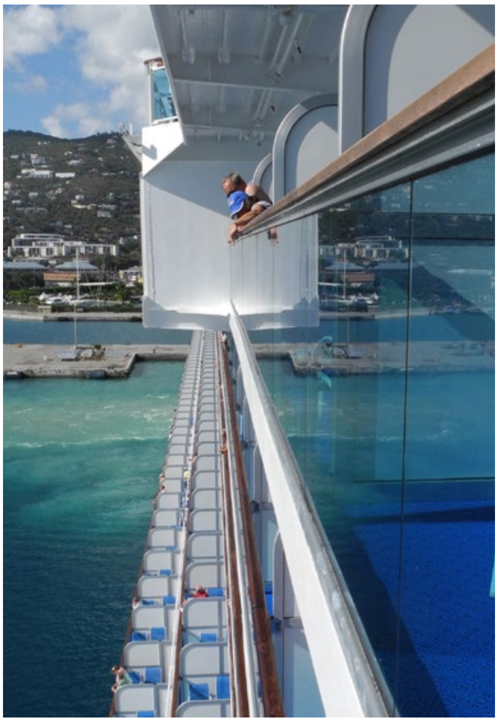
For example, the BellSouth building in Fort Lauderdale, USA, silicone sealed, butt joined safety glass made with SentryGlas® helped the architects deliver panoramic corner office views, while meeting tough wind and storm protection codes.

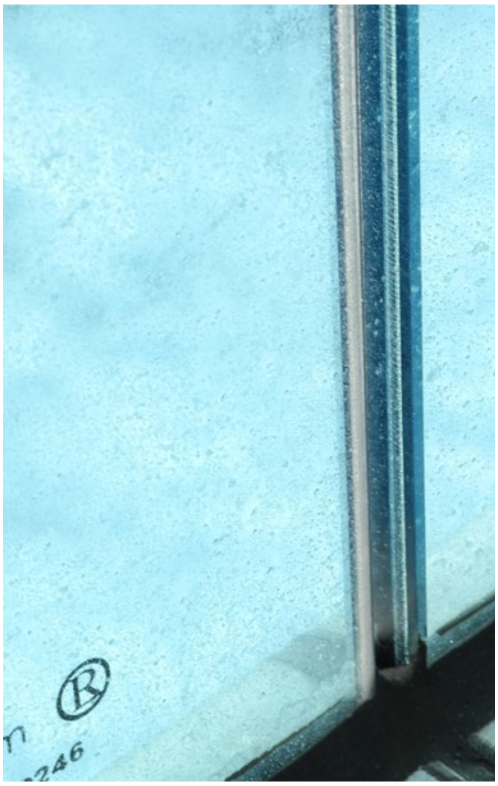
Elsewhere in the USA, cold winters, shadeless summer heat and occasional Mississippi River floodwaters were among the design challenges for a bandshell built on an island in St Paul, Minnesota. Open edged, butt-sealed glazing panels made with SentryGlas® interlayer remain free of any visual defects after years of exposure. The extra strength of the interlayer also helped to create a uniquely shaped overhead structure.

EDGE STABILITY OF LAMINATES WITH SENTRYGLAS® IN COASTAL CLIMATIC CONDITIONS

For all marine and some architectural applications, prolonged exposure to salt water can cause defects in the laminated glass. However, laminates with SentryGlas® demonstrate excellent durability performance in coastal regions or landscapes with high concentration of salt water (e.g. due to high use of road salts due to snow). Extensive product testing, including salt spray fog testing (carried out by TÜV Süd Singapore, according to ASTM B 117-11) during which the glass panels laminates with SentryGlas® with open edges were exposed to salt spray solution continuously for 3000 hours. Three 15 by 10 cm (5.93 by 3.93 in) glass panels were placed in a climatic chamber for 3000 hours under the following experimental conditions:

- NaCl-concentration: 5%
- Volume of condensate: 1.0-2.0 ml/HR/80cm²
- pH of the solution: between 6.5 and 6.9
- Test chamber temperature: 35 +/- 2°C





After the test, the glass panels were visually inspected and evaluated. The results showed that the panels remained unchanged in terms of their transparency. The PVB laminates showed edge clouds after 500 hours of testing. Due to the excellent edge stability of SentryGlas® interlayer, no undesired changes such as edge cloudiness, delamination caused by the humidity occur. Copies of the test report are available on request.

Other salt spray tests have been conducted on laminated glass with SentryGlas® interlayer. In Germany for example, similar tests were carried out on SentryGlas® ionoplast interlayer by the Fachhochschule München as part of a DIBT approval for SentryGlas® ionoplast interlayer(Germany's regulatory body for products used in the construction industry).

SEALANT COMPATIBILITY OF SENTRYGLAS® INTERLAYER

A wide variety of sealants are used by the glazing industry and it is therefore critical to understand the chemical and mechanical compatibility of these sealants with the interlayer produced in a glass laminate. Laminates prepared with SentryGlas® demonstrate excellent compatibility with different types of sealants used in glazing applications. This is supported by tests conducted by Kuraray but also by studies carried out by sealant manufacturers. These tests include accelerated QUV weathering and modified ASTM C1087 compatibility test methods as well as DI guideline, IFT Rosenheim, UV-radiation tests, high-temperature and high humidity test scenarios.

OUTDOOR TESTING

Laminates with SentryGlas® show no edge defect formation, even after 15 years of natural outdoor weathering in Florida when tested with different types of sealants. In these tests, laminates with SentryGlas® have shown no signs of degradation from interactions with any of the sealants tested.

Details of all sealant compatibility tests carried out by Kuraray and by sealant manufacturers are available on request from Kuraray. For a complete list of compatible sealants for SentryGlas® interlayer, please refer to the following table.

SEALANTS FOR GLASS RAILING INSTALLATIONS

Portland cement-based products are not recommended for use with SentryGlas® laminates. Gypsum-based products are acceptable for interior applications only. The following Sika sealants have been tested and found to be acceptable for both interior and exterior railing installations:

Company/Grade	Description	Test Method
Arbosil		
Arbosil 1096	1-component silicone sealant, neutral-cure	
C.R. Laurence		
C.R. Laurence 33SC	1-component silicone sealant, acetic-cure	
C.R. Laurence RTV408AL	1-component silicone sealant, neutral-cure	
999-A, 1199		
Dow Corning		
Dow Corning® 756	1-component silicone sealant, neutral-cure	
Dow Corning® 756-SMS	1-component silicone sealant, neutral-cure	ASTM C1087, ETAG 002, IFT-Guideline DI-02engll/1
Dow Corning® 757	1-component silicone sealant, neutral-cure	ASTM C1087, ETAG 002, IFT-Guideline DI-02engll/1
Dow Corning® 790	1-component silicone sealant, neutral-cure	

Company / Grade	Description	Test Method
Dow Corning® 791	1-component silicone sealant, neutral-cure	
Dow Dorning® 791-T	1-component silicone sealant	ASTM C1087, ETAG 002, IFT-Guideline DI-02engll/1
Dow Corning® 795	1-component silicone sealant, neutral-cure	
Dow Corning® 895	1-component silicone sealant, neutral-cure	ASTM C1087, ETAG 002, IFT-Guideline DI-02engll/1
Dow Corning® 983	2-component silicone sealant, neutral-cure	
Dow Corning® 993	2-component silicone sealant, neutral-cure	
Dow Dorning® 994	Ultra Fast, 2-component silicone sealant, neutral-cure	
Dow Corning® 995	1-component silicone sealant, neutral-cure	
Dow Dorning® 999-A	1-component silicone sealant	
Dow Dorning® 1199	1-component silicone sealant	
Dow Dorning® 3362	2-component silicone sealant	ASTM C1087, ETAG 002, IFT-Guideline DI-02engll/1
Dow Dorning® 3356 HD	2-component, silicone sealant	ASTM C1087, ETAG 002, IFT-Guideline DI-02engll/1
GE Advanced Materials		
GE Silglaze® II SCS2802	1-component silicone sealant, neutral-cure	
GE SilPruf® NB SCS9000	1-component silicone sealant, neutral-cure	
GE UltraGlaze® SSG4000	1-component silicone sealant, neutral-cure	
GE UltraGlaze® SSG4400	2-component silicone sealant, neutral-cure	
Kömmerling		
GD 116	2-component polysulfide sealant, solvent-free	IFT Guideline DI-02/1
GD 677	2-component polyurethane sealant, solvent-free	IFT Guideline DI-02/1
GD 920	2-component silicone sealant, neutral-cure	IFT Guideline DI-02/1
GD 823 N	1-component silicone sealant, neutral-cure	IFT Guideline DI-02/1
GD 826 N	1-component silicone sealant, neutral-cure	IFT Guideline DI-02/1
Ködiglaze S	2-component silicone sealant, neutral-cure	IFT Guideline DI-02/1
Ködiglaze P	1- or 2-component polyurethane, sealant solvent free	IFT Guideline DI-02/1
Pecora		
Pecora 895 NST	1-component silicone sealant, neutral-cure	
Sika		
Icosit® KC-340/7	2-component polyurethane sealant, solvent-free	CQP 593-7
SikaGLaze® GG-735	2-component polyurethane sealant, solvent-free	CQP 593-7
Sikasil® GS-621	1-component silicone sealant, acetic-cure	CQP 593-7
Sikasil® IG-16	1-component silicone sealant, neutral-cure	CQP 593-7
Sikasil® IG-25	2-component silicone sealant, neutral-cure	CQP 593-7
Sikasil® IG-25 HM Plus	2-component silicone sealant, neutral-cure, high modulus	CQP 593-7
Sikasil® SG-18	1-component silicone sealant, neutral-cure	CQP 593-7

Company / Grade	Description	Test Method
Sikasil® SG-20	1-component silicone sealant, neutral-cure	CQP 593-7
Sikasil® SG-500	2-component silicone sealant, neutral curing	CQP 593-7
Sikasil® SG-500 CN	2-component silicone sealant, neutral-cure, high modulus	CQP 593-7
Sikasil® SG-550	2-component silicone sealant, neutral-cure	CQP 593-7
Sikasil® WS-305 CN	1-component silicone sealant, neutral-cure	CQP 593-7
Sikasil® WS-355	1-component silicone sealant, neutral-cure	CQP 593-7
Sikasil® WS-605 S	1-component silicone sealant, neutral-cure	CQP 593-7
Sikasil® WS-680 SC	1-component silicone sealant, neutral-cure	CQP 593-7
Sikasil® WT-480	2-component silicone sealant, neutral-cure, high modulus	CQP 593-7
Sikasil® WT-485	2-component silicone sealant, neutral-cure	CQP 593-7
Tremco		
Spectrem 1	1-component silicone sealant, neutral-cure	
Spectrem 2	1-component silicone sealant, neutral-cure	
Tremglaze S100	1-component silicone sealant, neutral-cure	
Vulkem 116	1-component polyurethane sealant	

HIGH TEMPERATURE PERFORMANCE OF SENTRYGLAS® INTERLAYER

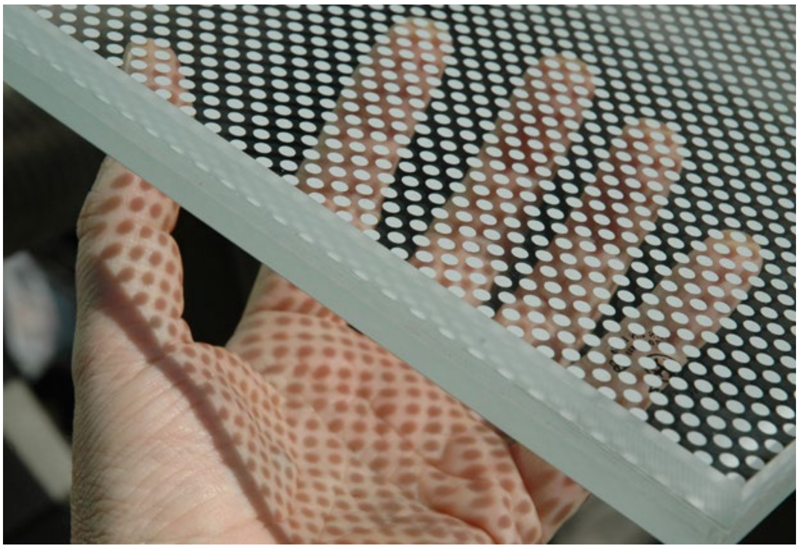
Properly laminated glass made with SentryGlas® interlayer has demonstrated capability of withstanding an environment of 100 °C (212 °F) for at least 16 hours, without bubble formation in the major viewing area. For more prolonged periods of time, of greater than 16 hours, a temperature limit of 82 °C (180 °F) or lower is recommended.

This information is based on the visual inspection of a glass laminate after a high temperature bake test. In this test, a test specimen of laminated glass is heated to a temperature of 100 °C (212 °F). Bubble formation within the major viewing area of the laminate (typically excluding 12 mm or ~1/2 in from the laminate edge) constitutes a failure of this test. Based on this limited data, properly laminated specimens with SentryGlas® appear capable of meeting these test conditions.

As with any application, specific glass constructions and designs may vary and prototype testing of systems is advisable.

COMPATIBILITY WITH CERAMIC FRIT COATINGS

Used for both internal and external decorative glass, ceramic frit coatings can be specified in a wide variety of colors and patterns for improved aesthetics or solar control in laminated glass. These vitreous compounds are applied to the glass by screen-printing, roll coating, spraying or curtain coating, closely following the frit supplier's processing instructions. These are then heat-treated in order to create a permanent coating. When such a fritted surface comes into contact with the glass laminate interlayer, it is important to verify the lasting compatibility between the frit and the interlayer. Moisture and salts, for example, can be detrimental to frit coatings over time. Testing therefore requires extended contact between materials under controlled conditions. The table next page lists the various tests that Kuraray uses to assess the compatibility of interlayers and ceramic frit.



Method	Standard	Intervals
76 Bake Test	Kuraray Internal Method	500 & 1000 hour
Coffin	ANSI Z26.1 (5.3 -3)	2, 5 & 10 weeks
UV (UVA-340)	ASTM G151, 154-06, ISO4892-1 & 4582	30 days
Natural Weathering	ASTM G 7-05 and G 147-02	1 year

Kuraray has conducted these tests on laminates made with SentryGlas® ionoplast and fritted glass, in order to observe changes in color, appearance or defects such as corrosion of the coating, bubbles, delaminations and other defects.

Manufacturer	Product Code	Product Name
FERRO	20-8496-1597	20-8496 ETCHIN 1597 24-8029 BLACK IN 1544
FERRO	24-8029-1544	Medium 24-8075 WARM GREY IN
FERRO	24-8075-1544	1544 Medium
Glass Coating Concept (GCC)	SX8876E808	SPANDREL WHITE
Glass Coating Concept (GCC)	SX3524E808	WARM GRAY

In the tests above, SentryGlas® interlayer showed no visual defects. In addition, adhesion was assessed before and after testing and no measurable differences were found. For other types of frit coatings not listed above, users should conduct their own tests or seek guidance from Kuraray. To ensure that glass meets safety codes, additional testing, including adhesion strength tests, may be required.

COMPATIBILITY WITH SOLAR SHADING OR GLASS COATINGS

The growing importance of the environment, energy efficiency and renewable building technologies are creating added value for glass manufactured with low-E (low emissivity) coatings. Often, in architectural applications, this coated glass also requires high impact strength, which can be achieved by laminating with SentryGlas® ionoplast interlayers.

When placing any interlayer into contact with a glass coating, it is critical to test the chemical and mechanical compatibility between the materials. Moisture and salts can be detrimental to coatings over time. SentryGlas® interlayer shows excellent compatibility with many different low-E coatings, and this compatibility is enhanced by the interlayer's low moisture absorption and low ionic content.
Listed below are low-E coatings that have been independently tested by their manufacturers and shown to be compatible with SentryGlas® interlayer.

Low-E Coatings	
AGC	Comfort Ti-AC 23™, Comfort Ti-AC 36™, Comfort Ti-AC 40™
Cardinal	Cardinal LoE3-366® Glass
Guardian	Guardian SunGuard® SN-68, SunGuard® SN-68 HT
PPG	PPG Solarban® 60, 70, 70XL and R100, Sungate® 400

The long-term performance of a coated glass laminate depends greatly on the laminator's care taken to preserve the integrity of the topcoat that protects the delicate metalized layers of the low-E coating stack. Any compromise of the coating – such as scratches, scuffs, pinholes and fingerprints – will cause the coating to corrode over time.

REGIONAL CONTACT CENTERS

Kuraray Europe GmbH
Business Area PVB
Mülheimer Straße 26
53840 Troisdorf, Deutschland
Tel.: +49 (0) 22 41/25 55 – 220

Kuraray America, Inc.
Business Area PVB
2200 Concord Pike, 11th Flr.
DE 19803, Wilmington, U.S.A.
Tel.: +1-800-635-3182

For further information about SentryGlas®, please visit
www.sentryglas.com