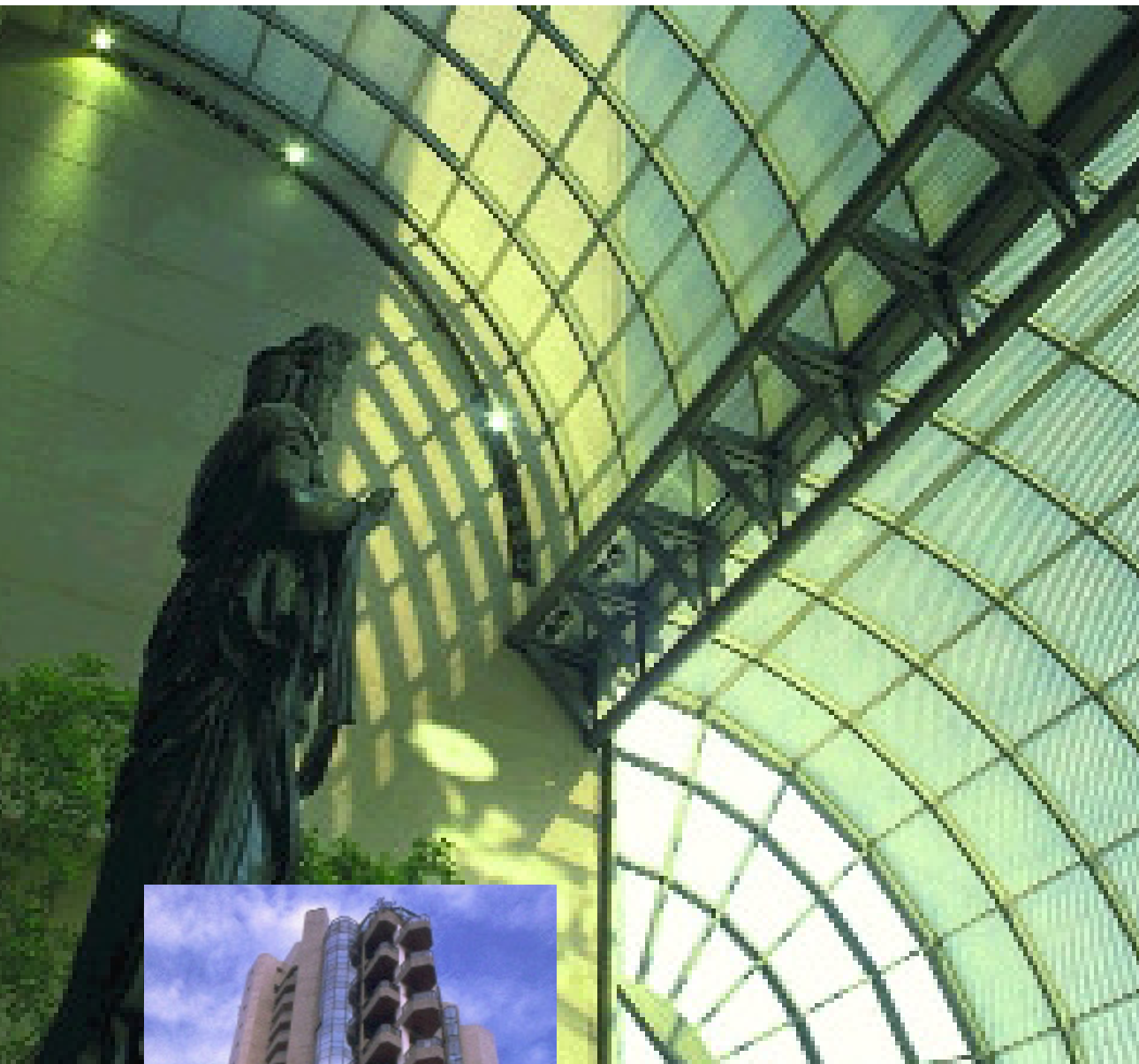
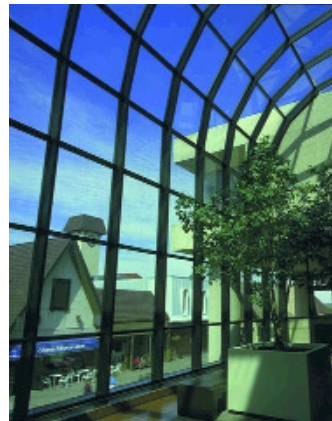


Sealants



Sealant Compatibility: A Study of Laminated Architectural Glass

LAMINATED GLASS WITH
SAFLEX INTERLAYER



Saflex polyvinyl butyral (PVB) interlayer by Solutia Inc. is an extremely tough, resilient polymer which is supplied in sheet form on rolls to glass laminators.

ACKNOWLEDGEMENTS

Solutia Inc. wishes to extend our appreciation to the following companies for their cooperation, sample selection and supply of sealants in order for us to perform an evaluation of sealant compatibility between commercially available sealant products and laminated glass with Saflex:

ADCO PRODUCTS

ADMARK

DAP

DOW CORNING CORPORATION

GENERAL ELECTRIC COMPANY

OSI

PECORA

PRODUCT RESEARCH AND CHEMICAL CORPORATION

PROTECTIVE SYSTEMS INC.

PTI

RHONE-POULENC INC.

SASHCO

SCHNEE MOREHEAD

SIKA CORPORATION

SIMSON

SONNEBORNE

TREMCO INC.

VULKEM



Sealant Compatibility Testing Data

contents

	Acknowledgements		Inside Front Cover
	Introduction to Saflex	Performance and Applications	2
	Objectives and Scope	Research Objectives Limitations	2 2
section 1	Sealants and Laminated Glass	Sealant Selection	3
section 2	Laminated Glass Edge Effects	Causes of Edge Effects	4
section 3	Sealant Evaluation Program	Sealant Types Test Procedure Sample Preparation Accelerated Exposure Sealant Compatibility Rating	5 5 5 6 7
section 4	Evaluation Program Results	Summary Table of Compatibility Results Conclusions	Insert Insert
	Summary	Sealant Suitability	8

Introduction to Saflex

PERFORMANCE AND APPLICATIONS

Saflex polyvinyl butyral (PVB) interlayer by Solutia Inc. is an extremely tough, resilient polymer which is supplied in sheet form on rolls to glass laminators. It is designed specifically as an interlayer for laminated safety glass comprised of two or more plies and is available in various thicknesses of clear and light stable colors. The major applications for Saflex PVB products are laminated architectural glass windows, residential windows and doors, aircraft windscreens and automotive windshields. Traditional processing of the interlayer transforms

standard annealed glass into a safety glazing that is accepted by all the national and international codes. Laminated glass with Saflex interlayer can break upon impact but it tends to retain the glass shards and particles and therefore minimizes the potential of injury from flying or falling broken glass. Adequately designed configurations of laminated glass can provide a virtually invisible permanent passive protection system from windborne debris, forced entry through glazing, ballistic missiles and bomb blast attacks. Saflex interlayer is also very effective in controlling sound and solar transmission, especially in the UV range.

Objectives and Scope

RESEARCH OBJECTIVES

The information contained in this publication is based upon data compiled on laminated glass with Saflex by Solutia Inc. through 1997. This information is taken from evaluation programs designed to objectively measure the effect of various commercially available sealants when applied in direct contact with the Saflex interlayer in laminated glass.

The research presented here was conducted on laminated glass fabricated with Saflex PVB interlayer. Extrapolation to other systems whether PVB based or not should be avoided.

The objectives of this study were (1) to determine comparative compatibility with laminated architectural glass by testing a number of commercially available products from several classes of sealants, (2) update the existing published data and (3) present data in clear and concise form for sealant product comparison.

LIMITATIONS

Although no recommendation as to the selection of one sealant product over another is made, the information generated in this study should provide improved understanding of sealant interaction with Saflex PVB interlayer in laminated architectural glass. This will assist architects and other industry professionals in making more informed judgments regarding sealant selection for use

with laminated glass. The data presented on the following pages is derived from tests that intentionally place the sealant in intimate contact with the PVB at the edge of the glass. This test method simulates a butt-glazed system that is known to give rise to the most severe sealant edge effects. In butt glazing practices, the sealant is in intimate contact with the PVB at the edge of the laminate. Most standard glazing practices, however, require the sealant to be caulked between the face of the glass and the frame, a practice that usually results in limited or no contact of the sealant with the laminate edge. The established glazing practices of weep systems and adequate tolerances should always be utilized.

Given the practical limitations of this study, not all commercially available glazing sealants could be evaluated. In addition, observations of sealant performance not related to compatibility were not in the scope of this evaluation. Factors such as modulus, adhesion to substrates, sealant durability and others are critical in the selection of a properly performing sealant. Consult the sealant manufacturers for information and guidance in the selection of a sealant taking into account an overall balance of properties for the application.

Sealants and Laminated Glass

section 1

SEALANT SELECTION

Architects, engineers and glaziers are faced with a complex decision when selecting sealants to best satisfy building project requirements. There are a number of generic type sealants, each with its own base material. Within a generic type, individual sealant formulations will have varying quantities of plasticizers, solvents, curing agents and/or fillers. Each product is specifically formulated to provide properties making it suitable for some applications but not for others. Understanding these products and their inherent properties is a critical requirement in making the proper overall sealant choice.

When installing laminated glass, manufacturers generally recommend resilient non-hardening sealant compounds, tapes or elastomeric gaskets (wet or dry glazing). Generic wet glazing compounds include butyl or polybutylene tapes, acrylics, polyurethanes, polysulfides, and silicones. The most generally used products are essentially 100% solid. The glazing techniques typically followed are set forth in the Glass Association of North America's *Glazing Manual*. These guidelines state that laminated glass should not be exposed to direct contact with organic solvents, and weep systems should be incorporated to prevent exposure to water for prolonged periods. Either exposure can lead to delamination or haziness along the laminated edge. Laminators recommend that sealant compatibility be checked for the same reasons.

Gaskets and tapes are by definition normally non-flowing in form. Therefore, contact between the PVB and gaskets or tapes are rare. If contact does occur, it is usually due to a specific design that intentionally places the material in direct contact with the laminated glass edge. Setting blocks will come in contact with the laminated glass edge and the compatibility of such elements should be considered. Setting block compatibility is outside the scope of this study. Past glazing practices and applications have indicated that non-staining EPDM rubber or Santoprene material have been successfully used as a setting block material in conjunction with laminated glass with Saflex interlayer.

When selecting a sealant for a glazing system, the specifier must consider a number of influences including:

- 1 Resistance to water penetration into the structure under all weathering conditions.
- 2 Sealant weatherability. Does it deteriorate or change physically over time?
- 3 Initial and life cycle economics. (Sealants should be evaluated using the same life cycle criteria as glazing.)
- 4 Mechanical properties, such as the ability to accommodate thermal movement, adhesion, etc.
- 5 Compatibility with the other elements in the glazing system, including the laminated glass where the sealant or sealant by-products are likely to contact one another.

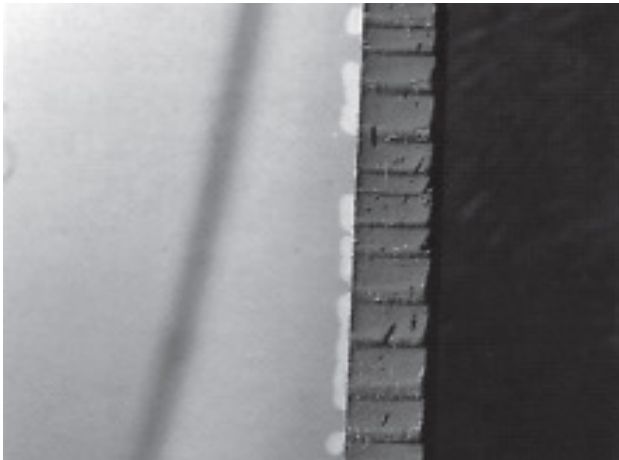
Laminated Glass Edge Effects

section 2

CAUSES OF EDGE EFFECTS

There are different edge effects that can be seen in laminated glass. Each edge effect has a primary cause, but most are due to a combination of factors. One form of known edge effects is normally caused by intimate sealant contact with the PVB at the edge of laminated glass. This is typically seen as very small “bubble shaped let-goes” which are usually not continuous along a laminate edge. The maximum depth of this type of let-go from the laminate edge has been recorded at no greater than 12 mm during the course of this study. This edge effect is caused only when the sealant material comes into intimate contact with the laminate edge. These are most common in butt-glazed systems or in heel or toe bead applications. The edge effect normally does not occur when glazed in a traditional four-side support system. In a four-side support system, the sealant is typically caulked between the face of the glass and the frame; it is not intended to come in contact with the Saflex interlayer at the laminated glass edge.

FIGURE A Typical Sealant Edge Effect



Edge effects that can result from a combination of factors are known as edge blush, discoloration, and delamination. Edge blush is a whitish haze that will develop between the two lites of glass after prolonged and excessive exposure to water. Usually edge blush is seen if the glass has not been properly stored prior to installation or if moisture is allowed to enter the glazing frame and proper weep systems are not provided. Edge blush is easily visible and consumes a larger area than most any other edge effect in laminated glass. The area affected will be altered depending upon environmental conditions and may appear to “vanish” during dry climate while re-appearing during times of high humidity. Edge blush usually can be traced to an edge origin or isolated in a location where the PVB has been exposed and can absorb moisture over time (e.g., glass broken on impact that is not replaced for an extended period of time).

Discoloration is sometimes referred to as edge blush due to the whitish nature of the formation. Discoloration from a component of the sealant (colorant or sulfur) can also occur but is much less common.

The other type of edge effect seen in laminated glass is known as delamination. Delamination will not occur unless there is a combination of factors acting on the glass unit. The most common factors are some combination of glass mismatch, excessive moisture, contamination, glass stress, and/or PVB thinning.

This bulletin addresses sealant compatibility with laminated glass.

Sealant Evaluation Program

section 3

SEALANT TYPES

In most installations where the sealant is used as a weather seal, the sealant material rarely comes into contact with the glass edge. However, in butt joint glazing (structural glazing), in installations where a heel or toe bead is applied, and in organically sealed insulated glass units, the sealant will come into contact with the edge of the glass and possibly with the interlayer in laminated glass. It is in this area that questions about compatibility arise. This is the focus of the sealant evaluation program by Solutia Inc.

An objective of this program was to develop information on a variety of sealant products that might be used in conjunction with Saflex laminated glass. Sealant products from five generic groups were chosen for evaluation. One or more commercial products from each class were tested. Some sealant groups had less damaging effects on the laminate edge than others did. Also within the groups, some individual sealant products affected the edge less than others did. The five groups examined in this study were:

Acrylics

Polyurethanes

Silicones

Butyls

Polysulfides

Sealants were tested for compatibility when applied to the laminate edge, in direct contact with the Saflex interlayer and then exposed to specified accelerated weathering conditions. The data should be used for comparative evaluations only. Extrapolation to in-field applications cannot be guaranteed.

TEST PROCEDURE

The following test procedure is used by Solutia Inc. to evaluate sealant compatibility with laminated glass. The test method is utilized to yield data that is comparative in nature to other samples examined using the same procedure. Variations in sealant manufacturing and laminator processing are not accounted for in this study. This program is run using controlled laboratory practices and conditions to closely simulate natural weathering. It is recognized that alternate preparation methods, modifications of sealant components, variation in test procedures and in field installation practices may result in different data.

SAMPLE PREPARATION

All exposure test samples are made by preparing 2" x 12" (50 x 305 mm) laminates with Saflex interlayer. The samples are flush trimmed to the aligned edges of the glass after tacking. These laminates are then put through the final bonding in an air autoclave using a standard heat and pressure cycle. All edges tested for sealant compatibility are autoclaved. Laminates with edges exposed by cutting after autoclaving are no longer used for sealant compatibility testing. It is generally accepted that an autoclaved edge will have the best stability on an overall basis regardless of sealant application. This is due to the various cutting methods employed by the industry. Solutia is unable to replicate the cutting techniques used in the field on a laboratory scale; therefore, we felt that reporting on cut laminate edges would not yield data that correlates to the industry. In considering cut laminated glass edges and sealant application, it is prudent to assume that an increase in the depth and area affected by sealant incompatibility effects will be increased over the average data presented in this bulletin if the sealant is in intimate contact with the cut edge. The amount of increase is dependent upon the amount of stress and manipulation the interlayer undergoes during laminate cutting. If laminated architectural glass is to be used in an installation where edge defect must be minimized, such as butt glazing, field cutting should

Sealant Evaluation Program

be kept to a minimum. If field cutting is necessary, care should be taken to limit the degree to which the inter-layer is stretched and special consideration should be given to compatibility during the sealant selection.

Sample retainer platforms are covered with a taut polyethylene sheeting to facilitate easy release of the cured sealant product and allow movement of prepared samples to the designated curing location without disturbance. Sample dividers with non-stick tape applied to the edges that will come in contact with the sealant are laid on the retainer platforms and secured with double-faced adhesive tape. These dividers are placed approximately 3" (76 mm) apart. The opening that is created must be large enough to receive the 2" (50 mm) laminate and allow for 3/8" to 1/2" (10-12 mm) of sealant to be caulked between the laminate and the non-stick divider edge. The front and back flat faces of the laminate can be protected with a removable tape for easier caulking and cleaning.

Once the retainer and divider system is secured, wiping with a lint free cloth moistened with methyl ethyl ketone (MEK) cleans the laminate edges. The cleaned laminates are placed in the middle of the dividers with equal gap distance on each side. The laminates are secured to the retainer system and sealant is carefully caulked into the gap on either side of the laminate. The sealant is tooled to ensure intimate contact with the sealant and the laminate edge.

These samples are allowed to cure under ambient (70°F, 50% RH) conditions for 21 days. These samples are then removed from the retainer system, evaluated for zero

time exposure ratings (initial screening test) and placed in the accelerated weathering chamber for the intended duration of exposure. Samples are rated in predetermined intervals to study the formation and propagation of edge effects during exposure.

A laminate with no sealant applied (bare edge) is placed in each weathering unit to serve as a laminate control.

An initial evaluation or screening test can be performed prior to placing the samples in the weathering chamber. If severe delaminations are visible at this time, the sealant can be deemed as grossly incompatible and no further testing is performed. If additional data on rate of edge effect propagation with weathering is desired, it is then recommended that the sample be weathered.

ACCELERATED EXPOSURE

The accelerated test was developed to simulate actual outdoor exposure results as closely as possible in a reduced amount of time and still be capable of producing data that could yield a reasonable estimate of sealant compatibility. From previous studies we estimate that 3,200 hours of accelerated exposure using the set conditions of UV and condensation described below will yield comparable results to 2.5 years of natural exposure in Florida.

The accelerated weathering chamber allows close control of alternating cycles of UV radiation and condensation at selected temperatures. The cycle used to predict natural Florida exposure is: 16 hours of UV (no condensation) at 150°F (66°C), followed by eight (8) hours of condensation (no UV light) at 140°F (60°C). The UV lamps

FIGURE B Cleaning



FIGURE C Application

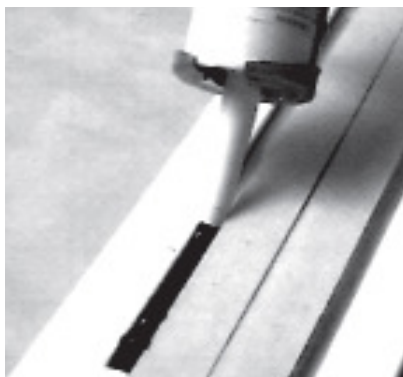
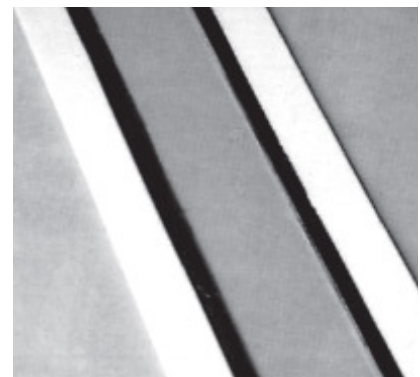


FIGURE D Curing



used in this study are UVB-313. Due to their shortwave UV emission and high energy, these lamps quickly induce sealant-curing reactions which can propagate migration of volatiles and/or plasticizers into or out of the PVB. They can also cause aging and other changes in the sealant which could promote edge effects in the laminate edges contacting the sealant.

The condensation cycle which alternates with the UV cycle serves as an accelerator in the curing and aging of the sealant. It also helps to detect glass-to-sealant adhesion loss that could be detrimental to a laminate if left undetected. The effects of water vapor transmission are assessed through use of the condensation cycle.

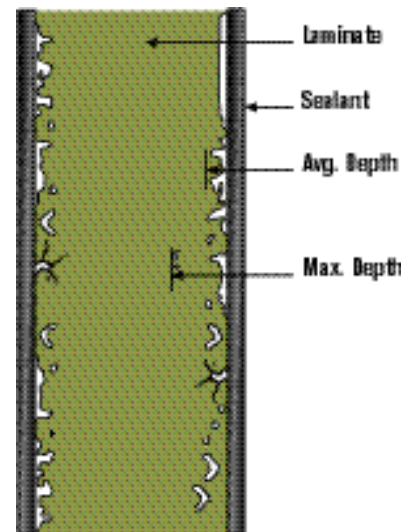
The test protocol was specifically designed to give a severe sealant-interlayer exposure condition to accelerate possible interactions and permit comparison of results among various sealant types.

The effects of accelerated aging do not mean a sealant showing edge effects from sealant compatibility in the accelerated tests cannot be used successfully in a properly designed system. It also does not guarantee good performance with a sealant showing good performance in these tests. Other factors in preparing the glass or frame in an actual installation, sealant production, sealant formulation changes and shelf life, which were outside the scope of this program also, may have an effect. For the conditions tested, however, the results provide a reasonable basis for comparing and predicting the interactions of these sealants with Saflex interlayer in laminated glass. Consideration of the visible effects of sealants and an understanding of their development by the party accepting the design are recommended.

SEALANT COMPATIBILITY RATING

The results of Solutia's sealant compatibility test program are based on the exposure of numerous sealants to accelerated weathering. These data are summarized in the following tables and graphs. The data reported in the following have been rated and defined as follows (Figure 1):

FIGURE 1 Sealant Compatibility



Average Depth Edge Effect: The average depth, measured in millimeters, in which bubbles, discoloration or haze were observed to penetrate from the laminate edge during the exposure period.

Maximum Depth Edge Effect: The maximum depth, for any laminate in the set, measured in millimeters, in which bubbles, discoloration or haze were observed to penetrate from the laminate edge during any exposure period.

Length Affected: The sum of the length of the laminate edge to which sealant is applied, measured in millimeters, of which bubbles, discoloration, or haze was observed during the exposure period.

Percent Length Affected: The average length affected by edge effects divided by the total length of the laminate to which the sealant was applied.

Average Area Affected: The average depth of edge effect observed multiplied by the average length.

Delamination Plateau: No change in the average depth of defect greater than 2 mm (+/-) for the final three consecutive rating periods of the accelerated exposure. "Y" indicates that a plateau in the edge effect has occurred; "N" indicates no plateau in edge effect formation has occurred.

Summary

SEALANT SUITABILITY

This testing was designed to maximize contact between sealant and interlayer. These conditions were chosen deliberately in order to investigate comparative effects on Saflex PVB interlayer of the commercially available sealants tested. In order to maximize the effects, it was necessary to use severe conditions. The suitability of a sealant for field use will depend on many factors other than just sealant/interlayer compatibility.

Among these factors are:

- 1 The ability of the sealant to meet the overall performance requirements of the installation.
- 2 The severity of the actual exposure conditions and the weatherability of the sealant.
- 3 The sill depth or the depth of the channel in which the glazing is mounted.
- 4 The degree of contact between the sealant and the edge of the glass. This emphasizes the importance of following good installation practices.

Careful consideration should be given to all aspects of sealant selection with sealant/interlayer compatibility being just one of many criteria. The data presented in this report are intended to contribute to a more informed sealant selection decision for laminated architectural glass. The results suggested that sealants can be used successfully in laminated glass systems. Solutia will provide detailed test procedures and guidance for anyone wishing to conduct similar evaluations.

Saflex Regional Sales Offices

St. Louis

P.O. Box 66760
St. Louis, MO 63166-6760
tel 314-674-1000
fax 314-674-5468

Belgium

Solutia Europe N.V./S.A.
Rue Laid Burniat, 3
Parc Scientific-Fleming
B-1348 Louvain-la-Neuve (Sud)
Belgium
tel 32.10.48.12.11
fax 32.10.48.12.12

South America

Solutia Brazil Ltda.
Rua Gomes de Carvalho
1306-60 Andar 04547-005
Sao Paulo, SP, Brazil
tel 55-11-5087-3000
fax 55-11-5087-3030

Singapore

Solutia Singapore Pte. Ltd.
101 Thomson Road
#19-00 United Square
Singapore 307591
tel 65-355-7239
fax 65-254-3138

For more information on laminated glass with Saflex interlayer, visit our Website on the Internet at www.saflex.com or call (800) 24-TOUGH [800-248-6844].

Notice Although the information and recommendations set forth herein (hereafter "Information") are presented in good faith and believed to be correct as of the date hereof, Solutia Inc. makes no representations or warranties as to the completeness or accuracy thereof. Information is supplied upon the condition that the persons receiving same will make their own determination as to its suitability for their purposes prior to use. In no event will Solutia Inc. be responsible for damages of any nature whatsoever resulting from the use of or reliance upon Information or the product to which Information refers. Nothing contained herein is to be construed as a recommendation to use any product, process, equipment or formulation in conflict with any patent, and Solutia Inc. makes no representation or warranty, express or implied, that the use thereof will not infringe any patent. NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, OR MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR OF ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO INFORMATION OR THE PRODUCT TO WHICH INFORMATION REFERS.