

New Bonding Technologies for Window Glazing and Assembly Bring Benefits Throughout the Entire Industry Value Chain

Jean-Paul Hautekeer, Markus Plettau, Patrick Vandereecken and Patrice Sauro
Dow Corning SA, Parc Industriel – zone C – Rue Jules Bordet, B-7180 Seneffe, Belgium

Keywords

1=bonding

2=window

3=hot melt

4=sealant

5=silicone

Abstract

The recent introduction of new adhesive technologies are opening new perspectives for the window & door industry in terms of innovative design, efficient manufacturing process, cost reduction and improved performance. A new generation of products are specifically capturing the attention of manufacturers, including reactive hot melts as well as specially formulated two-part materials that can provide immediate green strength during the assembly of windows. Depending on the driving need, specific solutions can be proposed to window producers to improve their productivity, save cost and also gain new market share through innovation and differentiation. Some of the new integrated window/glass systems will also give the glass processing companies a chance to diversify and increase the value of their products.

This paper is specifically reviewing the recently launched technology of silicone reactive hot melt and its possibilities in the manufacturing of next generation window systems. Several examples will be reviewed as well as the description of the key features of this new material.

1. Introduction

The 500 million units global window market is going through major changes and challenges. Window fabricators in developed markets such as in Western Europe and North America are facing relatively slow market growth but, in parallel, are observing increasing needs from customers for improved products, whilst operating in a highly competitive environment with intense price pressure, overcapacity and cost effective imports of raw material and finished products. Window OEM's in developing countries, such as in China and Eastern Europe, have different but even more challenging priorities in order to properly manage their growth and build a sustainable position in these emerging markets, by bringing good quality and cost effective products whilst adopting the latest technologies as quickly as possible.

Similarly, technological trends in windows have evolved around energy saving, well being and affordability. Energy saving has impacted the development of high performing glass and coatings, higher thermally efficient IG and windows and solar and heat generation systems. Well being is linked with the developments around low maintenance products, air quality window ventilation systems, sound insulation, safety and burglar resistant windows while the need has continuously been for more transparency in the design. Considering the challenging economic environment, the new technology options in the windows will need to remain affordable. Its extra cost will not be able to be entirely transferred to the window price, which means that the standard products and components as well as the manufacturing processes will need to become more competitive, which will trigger the need for more productivity improvements, the use of more standard and unitized systems, a push for integration such as the dual fabrication of IG and windows, as well as the need to use multi functional and highly durable sealing and bonding solutions. (sealant, gasket and adhesives)

2. Latest developments in window sealing and adhesive technologies

Sealants and adhesives have always played a key role in the assembly, weatherproofing and installation of windows & doors. Compared to pre-formed or extruded gasket technologies, "wet-applied" sealants and adhesives are able to develop a strong and stable chemical bond that forms a real chemical fusion between the substrates, giving better performance and longer durability.

However, their application properties and ease-of-use have never fully satisfied the requirements of production environments, which has led to an increased share of extruded or co-extruded gaskets or double sided adhesive tapes.

Recently, new adhesive and sealant technologies have been introduced to the market and are opening new

perspectives for the window & door industry in terms of innovative design, efficient manufacturing process, cost reduction and improved performance. A new generation of products is specifically capturing the attention of manufacturers, they include reactive hot melt as well as specially formulated two-part materials that can provide immediate green strength during the assembly of windows. Depending on the driving need, specific solutions can be proposed to the window producers to improve their productivity, save cost and also gain new market share through innovation and differentiation. (1,2,3)

3. Window bonding technology – Advantages throughout the entire value chain.

Not unlike the evolution of the automotive industry with the introduction of bonded connections between the windshield and the car body, the use of high performance adhesives in window assembly can bring a series of key interesting advantages to the manufacturing process and final window properties.

A list of potential advantages is displayed below. Depending on the particular window system and the type of adhesive being used, one or several of these improvements can be achieved.

Benefits for the manufacturers

- Increased productivity of the window glazing process by lowering labor cost, increasing throughput and shortening/simplifying the production process.
- Reduce cost by the use of lighter frame profiles and/or reduction of steel reinforcing elements. (PVC windows)
- Versatility of solutions available for the manufacturers to develop more competitive and diversified products to meet market needs i.e. extending toward new markets or competing in highly price driven market.
- Lower after sales service cost – high reliability of the sealing system – no glazing movement in sash during installations, no gasket leakage and deterioration.

Benefits for the customers

- More features and window functionalities at competitive price.
- Lower maintenance e.g. for bonded wood window system.
- Slimmer or invisible sash frame for better aesthetics and increased daylight opening.
- High thermal, sound and air/wind tightness at similar or lower cost.
- Advantages of durability of proven technologies like e.g. silicone structural glazing.

Benefits for the other players in the window industry value chain.

- PVC system suppliers can increase their earning per linear meter or KG of raw material used in windows. They can support their customers by bringing more competitive or innovative window system to the market.
- Glass manufacturing and processing companies will sometimes need to adapt their products for use in bonded window systems, especially in cases where the glass is used to stiffen the window structure. While this is representing an extra cost, this is also a unique opportunity to sell more added value products. (like stepped IG unit, safety glass, high thermally efficient IG,..).
- Building developers, key construction buyers, DIY companies can get access to higher performance mass produced windows at more competitive conditions.

4. The unique value proposition of silicone solutions in window bonding technology.

Silicone sealants are widely used in the construction industry as high quality weatherproofing and structural glazing adhesives and sealants because of their inherent durability, adhesion and general performance. (4,5) Because of their specific chemical nature linked to their polymer, silicone sealants exhibit unique properties in sealing and bonding applications and they are the material of choice when high quality and high durability are required as typically demanded in construction applications. Compared to transportation and appliance applications, the longer expected lifetime in construction applications requires much higher durability and weather resistance of the materials. The inherent UV stability of silicone materials and their extreme weather resistance makes them the material of choice for such applications as increasingly recognised by Building Standards. (6)

Particularly in window bonding and back-bedding applications, silicones exhibit the following key advantages compared to alternative organic based technologies like polyurethane.

- No need for priming or surface activation on most substrates including glass, uPVC, wood and aluminium.
- Environmental friendly. Low VOC, isocyanate free formulation, no priming, neutral by-products.
- Extremely high durability – unaffected by long term direct and indirect UV exposure.
- A combination of high modulus with high movement capability allows silicone to be used in structural bonding applications while being able to equalize differential thermal dilatation.
- Long life cycle time – low life cycle cost.
- Ability to minimise the stress levels on the insulating Glass when required.
- Easy to process using automatic equipment – hot melt with stable viscosity and pot life (up to 24h), two part adhesive with variable mixing ratio and stable viscosity versus temperature

5. Window bonding technology examples.

5.1. GlassWin

One example of innovative window technology is the GlassWin® system. This innovation is the result of a joint development program made by Dow Corning in cooperation with Profine®. (7) The key concept that has been applied here is an extension of today's structural glazing technology for use in the fabrication of uPVC windows. The use of proven structural silicone technologies (in this case Dow Corning® 993 Structural Glazing Sealant) not only provides the upmost system durability and life span, but also gives a rigidification to the window frame to become a real torsion-free composite unit. The manufacturing processes (8) of such units can be highly automatised, as in the automotive industry, but with the durability of construction silicone.

The sash sizes available for such systems are standard PVC-sash (max. 1,5 m x 1,5 m for windows and 1 m x 2,35 m for doors) The typical sash-thickness is 58mm with a u-value of 1,1 W/m²K. It uses standard hardware and gaskets.

The key advantages of such windows are, amongst others, a reduction in the raw material cost by the reduction

or suppression of the steel bar reinforcement in the sash, bringing in addition a better thermal insulation to the system with the same sash rigidity. The window uses less uPVC and more glass, with an improved U value and a larger vision area. The structural attachment gives better protection from burglary and impact, increasing the value of using a safety glass. The frameless system provides incremental acoustic improvement combined with easier maintenance. Last but not least, the design is very innovative and pleasant, a key benefit for the building owner.

5.2. New developments in silicone reactive hot melt technology

Recently, a new patented, neutral-cure, reactive hot-melt silicone technology has been introduced to the market for automated windows bonding and backbedding applications. When used with standard hot-melt dispensing equipment (9) and automated XY glazing tables or robots, such materials are an ideal total productivity solution for the window and door glazing step.

The main advantages of this technology are linked to productivity and performance. Unlike traditional silicone sealants, this is a reactive hot-melt material designed specifically to deliver instant green strength so windows can be immediately handled and shipped without risking the integrity of the seal or distorting the sash. The long pot life, open time and special rheology profile provides processing flexibility, robust manufacturing and less waste generation compared

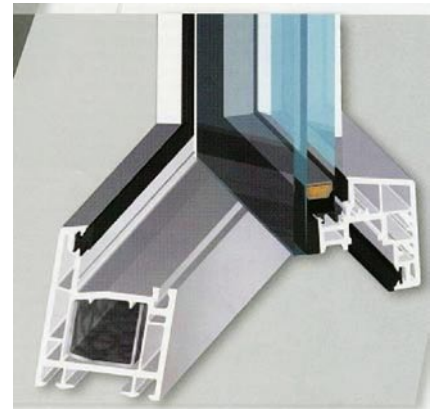
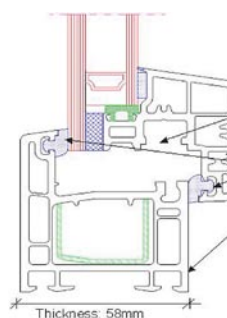


Figure 1
Glasswin® Windows System

Figure 2
Glasswin® Windows System



Window assembly process stays as it is today:

- Hardware: **Standard**
- Sash manufacturing: **Standard**
- Gaskets: **Standard**
- Frame manufacturing: **Standard**
- Frame thickness: **Standard**

New process: structural bonding

Peel Adhesion strength of different glazing material on Windows Frames. Data in kN/m (pli). ASTM C-794	Glass	PVC	Treated Wood	Kynar ®	Anodized Aluminium
Dow Corning® Instant Glaze	9.0 (50)	9.1 (52)	9.5 (53)	9.0 (50)	8.1 (45)
Dow Corning® 1199 Silicone Glazing Sealant	2.7 (15)	2.7 (15)	2.5 (13)	2.2 (12)	2.2 (12)
Glazing Tape	2.2 (12)	3.1 (17)	2.7 (15)	3.6 (20)	2.7 (15)

Kynar ® tradename; Polyester coated aluminium

Figure 3

Peel strenght - ASTM C-794 (12mm/min)

to traditional glazing products. Its proven silicone chemistry can develop compatible and aggressive adhesion with the most common fenestration substrates to create a long life and seamless seals. The technology is a non hazardous formulation, which is low odor and worker friendly. Being reactive after application, it will cure to become a flexible, weather-resistant silicone elastomer with outstanding durability and UV resistance. Last but not least, the products are crystal clear to give improved aesthetics.

Due to its pseudo-plastic behavior, such material usually shows high peel strength on most of the window substrates and also a significant stress relaxation capability that can minimize greatly any residual stress on the insulating glass. The figure 3 reports significantly higher dynamic peel strengths data (as per ASTM C-794 at 12mm/min) for the Silicone reactive hot melt (in this case Dow Corning® InstantGaze Window Assembly Sealant) compared with traditional sealants and double face adhesive tapes, even on low surface energy substrates like PVC and Kynar®. The figure 4 shows a typical stress relaxation curve for the same material under 25% constant elongation.

The figures 5 shows the viscosity/temperature profile for the silicone reactive hot melt, highlighting the desired temperature operating range. (around 125 deg c) Once the product has been applied, the green strength will develop in seconds allowing the material to withstand enough stresses for the assembly pieces to be moved in the production line. At the same time, the material will start to chemically cure (room temperature silicone condensation) to ultimately develop an three-dimensional elastomeric



Figure 6
Dow Corning InstantGlaze

Figure 4
Stress relaxation 25% elongation

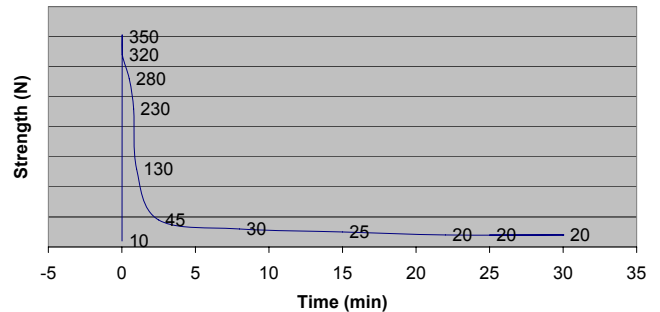
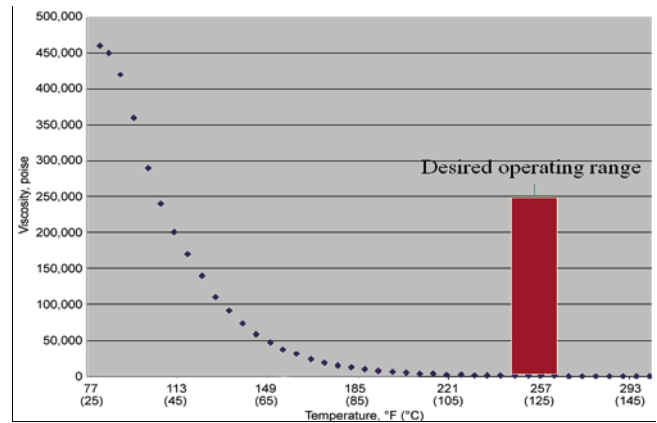


Figure 5
Viscosity/Temperature



network. The figure 6 shows the (crystal clear) appearance of this new silicone technology.

The figure 7 shows a typical robotically applied silicone reactive hot melt bead that forms a seal to hold glass in place immediately.

Besides windows, the development of silicone reactive hot melt technology opens new perspectives for innovative and value added assembly solutions in other areas of construction. Applications such as shower doors, glass blocks, internal and partition walls, solar panels and lamination will undoubtedly benefit from such technology in the near future.

The figure 8 shows a glass-block panel where the instant green strength and clarity of such technology have been adequately used while the figure 9 and 10 show typical internal Partition walls that can also benefit from Silicone based bonding technology.



Figure 7



Figures 8
GlassBlock



Figures 9 and 10

Internal Partition Systems

6. Summary

Availability of newly developed silicone based, liquid applied, fast curing and high green strength adhesives linked to modern engineered application solutions present a unique opportunity for window and door manufacturers as well as construction assembly OEM's. It enables them to better face some of their business challenges by lowering the total cost of their product, particularly within the manufacturing process, whilst addressing the need to

incorporate additional functionalities. Several examples of products and applications have been given in this paper; the material and equipment suppliers are working in collaboration to give additional information to customers in order that they may develop and bring new products to market incorporating this exciting technological advancement.

7. References.

- [1] Window & Door® Magazine – August 2004
- National Glass Association.
- [2] Windays 2003/2005 – Conference proceedings
- Berner fachhochschule – CH-2504 Biel
- [3] Von der Kittfuge zum Structural Glazing –
Dipl.-Ing. Werner Stiel – Glaswelt 3/2000 p56.
- [4] Sealants in Construction, by Jerry Klosowski,
Marcel Dekker Inc 1989, ISBN 0824776771
- [5] Durability of Silicone Sealants. A.T. Wolf,
Durability of Building Sealants RILEM
Publications. 1999. ISBN 2-912143-21-8
- [6] ETAG 002 – Guidelines for European Technical
Approval for Structural Glazing systems.
<http://www.eota.be>
- [7] Bernd Giesel – Profine -
www.profine-group.com
- [8] www.protec-systems.org
- [9] www.nordson.com