Acoustic glazing based on different PVB interlayers

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1= Architectural Glass
2= Acoustic laminated glazing
3= Acoustic PVB tri-layer
4= Acoustic PVB monolayer
5= Laminated glass defects

Abstract
More than 15 years ago acoustic PVB interlayers started to replace cast in place resins in the architectural glazing market. Since then there has been a lot of improvements and this is still ongoing. The following paper will cover a few acoustic damping basics, the performance advantages and challenges of the 2 main PVB acoustic interlayer types in architectural laminated glass. Based on that technical solutions and possible future developments will also be discussed.

Introduction
In the 80ties and 90ties of the last century laminated safety glass on the base of PVB interlayer was the standard also for sound insulating glazing, including both monolithic laminated glass as well as insulating double glass. Some acoustic improvements were made by replacing standard PVB with silicone or polyurethane based cast in place resin products, but beside improved acoustic performance most of the other technical properties and higher processing and glazing costs were disadvantageous versus PVB. End of the 90ties the first acoustic multilayer PVB film was launched in the glass market and was immediately successful in both automotive and architectural laminated safety glass. Main reasons were equal processing compared to standard PVB yielding in significant improvements of laminated glass output per cycle, lower material costs and outperforming properties in acoustic damping as well as with the most relevant safety and security glazing properties.

This first acoustic PVB interlayer consisted of a tri-layer PVB composition, containing a soft core symmetrically positioned between two standard outer PVB layers. Originally developed for the automotive market for the use in windscreens and side lights, where optical quality is obviously vital, it was soon adapted for architectural use. To undergo patent protection issues, a sound damping (and soft) PVB monolayer film was launched by Kuraray shortly after the tri-layer film, having comparable acoustic performance and only little lower performance in penetration resistant properties. Until today both type of acoustic PVB interlayers are in the market showing different benefits and weaker points depending on the laminator’s and glazing application perspective to be discussed in the following chapter.

Acoustic damping with PVB

The design choice of high quality sound attenuating glass is influenced by the following factors:
- External noise source
- Internal desired sound levels
- Thick glass configurations
- Asymmetric glass make-ups
- Air spaces between glass panes (double/triple Insulating Glass Unit IGU)
- Gases in air space
- Acoustic performance PVB interlayers in laminated glass

The sound insulation of different glass units in monolithic and insulating glass is shown in figure 2. A measure for the sound insulating of glass is expressed as Rw value (or STC value in American standard), which is an average value measured in decibels (dB). The sensitivity of the human ear to frequencies, sound volumes and pitch is taken into account.

The difference between monolithic glazing made of standard PVB and acoustic PVB varies both about 2-3 dB, in double IGU the difference is similar but can increase to 4-6 dB in case of double laminated IGU or triple IGU with 2 laminated glass panes. The above listed factors influences the sound damping of different IGU’s make ups as shown in figure 3. The Rw values of double and triple glazing compositions with acoustic tri-layer and monolayer are in most cases on the same level.

Arguments for tri-layer acoustic PVB film

Due to the fact that acoustic PVB tri-layer has a dominant use both in architectural and automotive glass application volume wise, most PVB film suppliers are limited in their acoustic monolayer offerings with this type. The main arguments for tri-layer PVB film are:
- Improved handling and processing -like standard PVB
- Optimized acoustic performance also in interlayer thickness of 0.50 mm
- Better penetration resistance in LSG of the same thickness (e.g. ball drop test P2A with LSG 44.2 acc. to standard EN 356)
- Combination with standard (colored) PVB in one layer possible

With these performance values the acoustic PVB tri-layer fulfills the major part of laminated acoustic glazing in the building skin. But more and more complex glass configurations based on the above mentioned tri-layer acoustic PVB film are still to be discussed.

Figure 1: Schematic make up of acoustic tri-layer (left) and monolayer (right)
Figure 2: Comparison of laminated monolithic glass with float (left) and IGU (right) using standard (BG) and acoustic (SC) PVB

Figure 3: Optimization of sound damping by using (more) layers of acoustic Laminated Safety Glass (LSG)

on heat-strengthened, fully tempered and/or curved glass limit in practice the use of the multi-layer acoustic film.

Weak points for tri-layer acoustic PVB film

Field observations in façade and rooftop glazing on the base of acoustic PVB tri-layer and difficulties in the processing of the interlayer itself and the final glass laminates have shown some limitations in the past few years. Some of the weak points are:

- Film extrusion process partly less stable due to the thickness distribution in the central soft layer of the multilayer film
- Not recyclable multi-layer film and not possible trim collection and re-use decreases yield and increases production costs
- Significant optical distortion in the final laminate in by using 2 sheets of tri-layer acoustic film to reach 1.52 mm layer thickness or more
- Lamination process difficulties when thicker and (badly tempered) glass is used to compensate internal stress (also on soft/hard layer), danger of delamination between the layers
- Not adjusted glass adhesion in tempered or heat-strengthened glass laminated may proceed the instability
- Complex façade mounting in combination with thicker acoustic glass laminates can also decrease the long-term stability of the glazing
- In double IGU with sound damping values higher than 44 dB 2 laminates with tri-layer acoustic PVB are necessary. This is a visible disadvantage in terms of optical performance.

In these critical cases an acoustic monolayer film can have significant benefits over the mayor in-use tri-layer PVB film. Its homogenous layer structure equal to the standard PVB overcomes some of the described disadvantages. But there is another effect caused by not optimized lamination process which makes the monolayer PVB film an attractive alternative.

Field defect in laminated acoustic glazing

With the introduction of the tri-layer acoustic PVB film the glass manufacturers and their customers are faced with a problem, that is not detectable during the lamination process, but later in the field inspection. This defect, which is called “ice-flowers”, is rather complicated because it is a delayed defect that will appear typically after exposure to changing climate conditions, and therefore may create a lot of claims and external waste costs.

The root-cause of this defect starts in the early stage of the lamination process with tri-layer film. During the de-airing process some amount of trapped air cause little and not easy detectable bubbles in the PVB, which can be named as “supersaturating” phenomena. Small amounts of trapped air will under changing climate conditions start to penetrate through the tri-layer and accumulate into one region of the laminated glass causing visible bubbles. In the final step those bubbles will become visible as “ice-flowers” as shown in Figure 4.

Figure 4: Acoustic tri-layer laminate showing “ice-flower” defect

Other theory is that there is a relation to tiny amounts of residual moisture left behind from the washing process being trapped between the laminate. Excess moisture could also penetrate in a laminate at permanent high humid conditions and not edge protection of the laminated glazing. To avoid this defect carefully de-airing of the laminate in the pre-nip oven under temperature/pressure control has to take place. Also careful drying of glass sheet pair may hinder the moisture penetration into the tri-layer structure.
Conclusions and outlook

The above described possible defects which can occur more or less in glasses laminated with acoustic tri-layer is a consequence of more complex, thick and tempered/curved glass configurations, unusual shapes and glass geometries together with higher complex mounting systems. Being installed in hot and humid extreme outdoor weather conditions, the risk of partly failure of laminates and expensive replacement in facades and roofs will stay high. One solution by the PVB interlayer suppliers is to make the tri-layer PVB film thicker to minimize the risk. One more safer option is to replace acoustic tri-layer by monolayer PVB film, which avoids the described defects safely. It contributes to a long term stability of acoustic safety glass which is comparable with standard PVB based laminates and is demonstrated with large areas of already installed laminated safety glass in the field under extreme outdoor conditions.

References

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