"Acoustic Interlayers for Laminated Glass – What makes them different and how to estimate performance"

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Abstract: (127 words)

Laminated glass is well known for staying together when broken, reducing the likelihood of glass fall-out and reducing injuries. As our built environment becomes denser, noise becomes a large concern. This paper will look at the advances of interlayers for laminated glass as they have been specifically designed for noise abatement. An examination of performance versus glass construction, a review of the single number rating systems and a mechanism for estimating performance with acoustic tri-layer interlayers will be covered. The attending will be familiar with the similarities and differences between the interlayers as well as understand how to make effective estimates on performance with this unique product.

Introduction to Laminated Glass

Laminated glass is well known for staying together when broken, reducing the likelihood of glass fall-out and reducing injuries. Comprised of two pieces of glass that are bonded together with heat and pressure to make a single glazing unit, laminated glass has multiple uses on the exterior and interior of buildings, everything from full curtain walls to interior glass shelves and dividers. Although laminated glass is often specified just for its sound damping characteristics, typically the other benefits of safety performance, glass shard retention, structural capacity, security enhancement and UV screening properties make it a high value add product.

Laminated glass with properly selected glass and interlayer combinations is capable of meeting the federal safety glazing requirements for human impact such as ANSI Z97.1, AS/NZ 2208, CPSC 16 CFR 1201, EN 12600, JIS 3205 as well as other similar tests.

Background to Sound

It is well known that sound transmission through glass exhibits coincident and resonance effects. Monolithic glass has specific critical or coincident frequency at which the speed of incident sound in air matches that of bending wave of glass. This critical frequency changes with the glass thickness, in effect moving towards lower frequencies as the glass gets thicker. Although the exact critical frequency occurs at a single point, the dip associated with this frequency as measured in accordance with ASTM E 90 and ISO 717 is a valley, thus allowing transmittance of noise around the critical frequency, which unfortunately is where human hearing and conversation are concentrated. Figure 1 shows the associated dip in transmission loss near and at the coincident frequency of various monolithic glass thicknesses. Resonances inherent to glass at natural frequencies also permit sound transmission and affect the low frequency performance of glass. The thicker the glass the better the low frequency performance and the more shallow the critical frequency valley.

However, the use of very thick glass is not always possible or desirable due to availability, weight, cost and color options. In the past, the common noise abatement strategy for architectural glazing has been to install insulating glass units. The air space, or gas filled space between two lites of glass, does contribute to noise abatement; however symmetrical configurations, which are the most common in the industry, do not yield the best results. The early forms of acoustically attenuating architectural glass were designed considering glass thickness and insulating spaces, These methods of design depend on mass or unit thickness, later studies reveal damping as a good source of noise attenuation that is practical, economical and bring with it additional glazing performance that is desirable and in some cases mandated for safety.

Single Number Rating System

The ability to reduce noise as perceived by the human ear can be measured. The ability of a material to minimize the passage of sound through it is quantified using the sound transmission coefficient. This is defined as the ration of the sound energy transmitted through a material to the sound energy indecent on the material. The transmission loss (TL) of a sample is measured by mounting a sample of the material in an opening of a wall separating two reverberant test rooms. Broad-band sound is played into one room (the source room). The difference between the sound levels in the source room and the other room (the receiving room) is defined at the noise reductions (NR).

The following test standards are used in the evaluation of glass or glazing systems for sound transmittance:

- ASTM E 90 – Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
- ASTM E 413 – Classification for Rating Sound Insulation
- ASTM E 1332 - Standard Classification for Determination of Outdoor-Indoor Transmission Class
- ISO 717-1 - Acoustics -- Rating of sound insulation in buildings and of building elements -- Part 1: Airborne sound insulation
- ISO 10140-1 – Acoustics - - Laboratory measurement of sound insulation of building elements -- Part 1: Application rules for specific products
- ISO 16940 Glass in building -- Glazing and airborne sound insulation -- Measurement of the mechanical impedance of laminated glass

These tests provide a single number acoustical rating through which a comparison of products can be initiated. The mechanism of calculating STC and

Rw values from ASTM E90 and ISO 717 data is a contour fit mechanism (Outside Inside Transmission Class (OITC; ASTM E 1332 is a calculation), because of this, the performance at specific frequencies is left out. Due to the fit procedures, it may require a closer look at the frequency data to enable the proper selection of glazing to meet design intention. In many cases there can be large reductions in the amount of sound, or sound transmission loss (STL), that occurs, but that improvement is not conveyed through the single number rating. There are activities and studies being pursued to come up with alternate rating systems that make improvements and deficiencies easier to identify but they are in the preliminary stages.

Three configuration options are typically used in the design of acoustical glazing: 1.) glass mass, 2.) insulating air space and 3.) interlayer damping. Glass stiffness is controlled by mass and usually influences the frequencies below 1000 Hz. The insulating space has an overall affect on the transmission, but the selection of air versus gas filled has a limited influence on overall performance unless specific gas like SF_6 is chosen. The damping, which is like putting your hand over a ringing tuning fork or clasping a sounding bell, is provided by the interlayer of laminated glass.

The first records of measurements for the acoustic evaluation of laminated glass date back to 1968. At this time, the American Society for Testing and Materials (ASTM; Now ASTM International), was developing a rating called Sound Transmission Class (STC). The principle of the test was to send know frequencies and decibels through an isolated material and measure what came through it. This procedure has been used since that time to categorized materials for their sound transmission loss properties. Over the years the practice has been refined, the standard procedure updated and the data acquisition equipment, microphones, and receivers have become much more technically advanced. It is doubtful that the same material measured today would be evaluated the same as 10 – 15 years ago based on these refinements and advances.

During this time frame, the International Organization on Standardization (ISO) has also developed and published a similar procedure which is also used to establish the sound transmission loss of materials. Both standards are similar in practice. Obtaining transmission loss values at the one-third octave bands typically between 80 Hz and 5000 Hz is essentially the same. Samples size, room criteria and reporting practice differs as STC uses 125 Hz to 4000 Hz and Rw uses 100Hz to 3150 Hz. The one-third octave band transmission loss values are used to calculate weighted reduction (Rw), for ISO and sound transmission class (STC) or Outdoor-Indoor Transmission Class (OITC) for ASTM International.

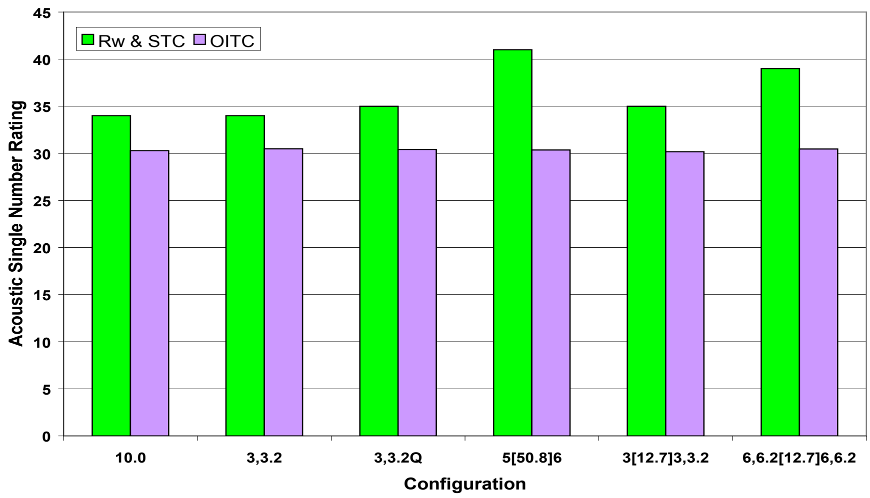

Figure 1: Differentiation of products via OTIC

The Rw and STC values are derived from a contour fitting methodology where a fixed shape contour is fitted to the sound transmission loss data. This contour is adjusted until the criteria for each standard is met. The common rule between the two standards is to allow only 32 decibels, at the one-third octave bands to fall below the contour. Upon reaching the maximum number of deficiencies below the contour, but not exceeding 32, the Rw can be obtained. The STC value has additional criteria beyond Rw that does not allow any single one-third octave band reading to fall more than 8 dB below the curve. For laminated glass, the Rw and STC numbers are almost always the same, as the 8 dB rule does not typically come into play. For monolithic and insulting glass, this is not always the case and Rw and STC values may differ.

STC and Rw have been successfully used in product selection for reducing sound between interior spaces and from outdoor to indoor – although outdoor to indoor transmittance is not the in the scope of the standards for STC ratings. An outdoor to indoor rating is supposed to be evaluated by the use of the OITC standard (ASTM E 1332). ASTM E 1332 uses the same one-third octave band data as STC, with an additional of a reading at 80 and 100 Hz. The calculation however is not a contour fitting procedure, but rather a weighted calculation.

Although the scope of ASTM E 1332 indicates that it is to be used for outdoor-indoor sound transfer, the sensitivity and ability to discern between glazing products is not accomplished. In some test cases the OITC for monolithic glass is the same as a double laminated insulating unit (Figure 1), which is known to differ significantly in actual use as related to the reduction of perceived noise. Although the scope of the standard for OITC is technically meant for the calculation of outdoor to Indoor noise reduction, and it may be very effective for other materials, it does not provide the level of differentiation needed for the assessment of acoustical glazing.

This is why Rw and STC have been the mainstays of acoustical evaluation for glazing. They have been used effectively for a long time and are widely accepted, albeit not perfect, for sound transmission loss both for interior and exterior glazing.

Single number ratings are used to provide the consumer a mechanism to select one product over the other. The issues with Rw and STC are not in the rating, it is with the interpretation of the sensitivity of the rating. Most specifications give a single Rw or STC value, not appreciating the variation of the test and the applicability of the rating. The following table (Table 1) shows the deviation of nominal 3 mm glass measured at different laboratories. This deviation can be due to the nominal thickness of the glass, but in some cases this was the same glass simply measured at different times. Although they are similar the deviation from 28 – 30 STC is not typically considered in architectural specifications. As a range, this describes typical 3 mm float glass, as an absolute value, it does not. It must also be noted that the Rw/STC values for different products can be the same, but the performance of the specimen is drastically different. This is dependant upon the one-third octave band performance for the products and where it falls in the deficiency rating. Based on this a target with +/- 1 Rw/STC unit would be sufficient to describe the performance.

Table 1: Typical Acoustic Values for 3 mm glass

Configuration (mm)	STC	OITC	Def Sum	Rw
3.0	28	23	28	29
3.0	29	25	25	30
3.0	30	25	31	30
3.0	28	25	24	29
3.0	29	24	32	29
3.0	29	25	27	30
Average	29	25	28	30

As seen below in Figure 2, two glazing configurations with the same Rw/STC have different performance in the frequencies above 1000 Hz. This is not taken into account because both Rw and STC do not account for any performance enhancement above the contour.

In order to take the above mentioned issues into account and provide the end user with a number they can relate to known performance, the current test data is being reported in a different manner. This new method is called the Decibel Reduction (DR). Using the same data as Rw, STC and OITC, the transmission loss values are rated against a control. In the case of glazing that control is a nominal 3 mm piece of glass. This glass should ideally be tested at the same time as the panels being rated and the DR calculated from this piece of glass, this is known as $DR_{3,}$ the 3 signifying that

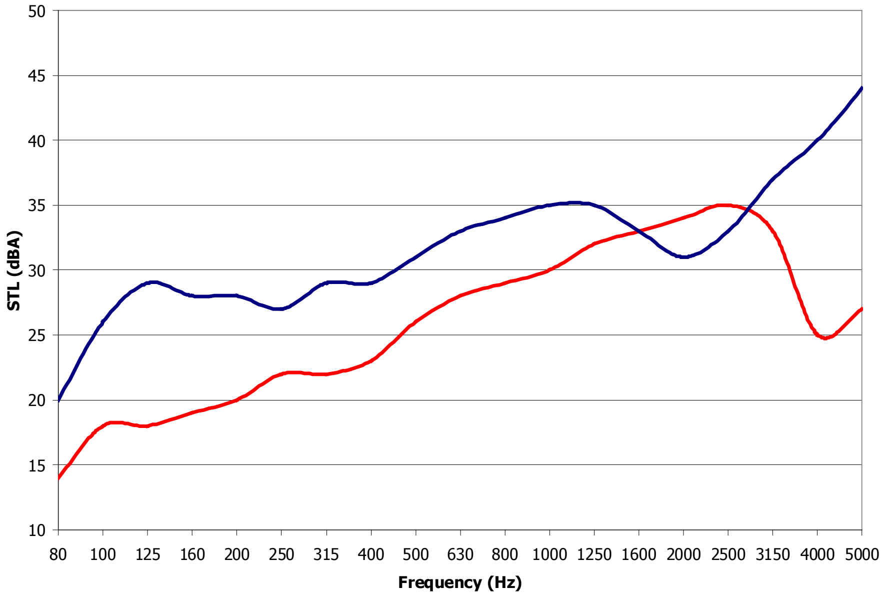

Figure 3: Decibel Reduction (DR) rating methodology for Baseline 3 mm and Laminated Glass

it was tested and used as the control. With so much testing being done in the past, it was necessary to set up a baseline DR for 3 mm glass, DR_b. This base DR control is an average of testing that had been done on nominal 3 mm glass up through 2010 as well as accounting for the "control" transmission loss indicated in the ISO standards. For consistency purposes, this baseline control curve will not be modified with additional testing as the DR_b numbers could potentially be under constant flux and make the numbers confusing. Both DR_b and DR_3 can be reported. It would be critical to know which is being used when comparing products.

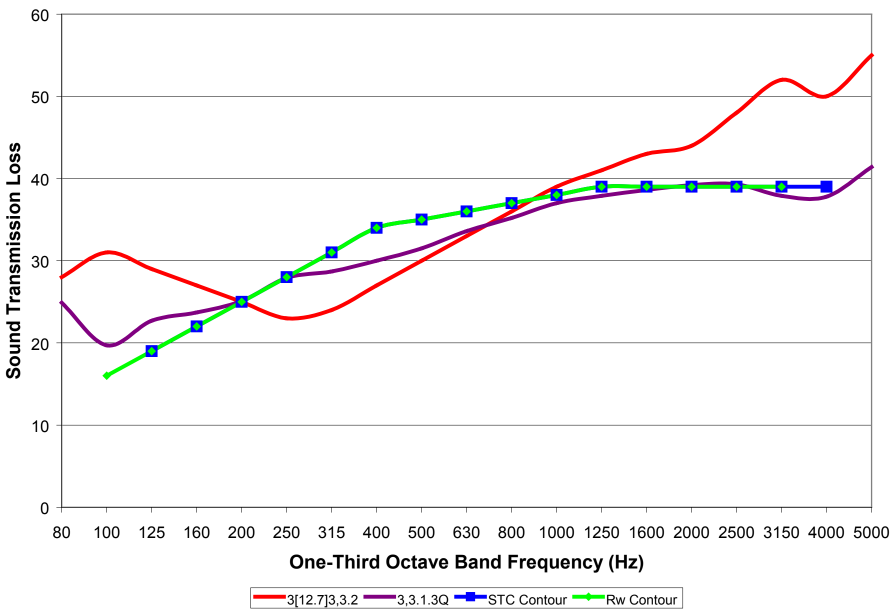

Figure 2: Sound Transmission Loss Data (STL) with Same Rw/STC

In the calculation of either DR, the sound transmission loss (STL) values that sit above the STL values of the 3 mm glass base are summed from 80 Hz through 5000 Hz with those above the DR contour being added and those below being deducted from the sum (Figure 3). The sum is then reported as the DR. This is in turn interpreted as the total number of decibels that are not transmitted through the test glazing versus a known glazing. It still will require the user to look at specific frequency data for complex design, but it does provide an effective method of differentiating the new higher performance configurations and glazing materials that are being specified on the market today.

Some typical DR_b data for configurations common in the acoustical glazing market can be seen below in Table 2.

Use of laminated for Sound Control

Damping is most active for laminated glass in the 1000 Hz to 3000 Hz range. Note worthy performance for laminated glass is the capability to reduce the coincidence dip, or the frequency at which sound travels through the glass mostly unimpeded. The coincidence dip is often referred to as the critical frequency as it tends to be the limiting frequency for performance rating. The affect of various glazing configurations on transmission loss go hand in hand with more glass, more insulating space and the proper interlayer all equal better performance. An increase or upgrade of any of the three will provide better

Table 2: Decibel Reduction (DRb) values for select glazings

Glazing Type	Configuration (inches)	Configuration (mm)	STC	OITC	Rw	C	CTR	DR3	DRb
Monolithic	1/8	3	28	25	29	-1	-3	0	N/A
Monolithic	1/8	3	29	25	30	-1	-3	0	N/A
Monolithic	3/16	5	30	28	31	-1	-2	42	19
Monolithic	1/4	6	32	29	32	-1	-2	67	41
Monolithic	3/8	10	35	32	35	-1	-2	130	104
Monolithic	1/2	12	37	33	37	-1	-3	164	133
Laminated	1/8-0.030 Saflex®-1/8	3,3.2	33	30	33	0	-2	93	62
Laminated	1/8-0.030 Saflex® Q-1/8	3,3.2Q	36	32	36	-1	-3	143	107
Laminated	3/16-0.030 Saflex® Q-3/16	5,5.2Q	38	34	38	-1	-2	187	143
Laminated	1/4-0.030 Saflex® Q-1/4	6,6.2Q	39	35	39	-1	-2	208	165
Laminated	1/4-0.030 Saflex® Q-1/2	6,12.2Q	41	36	41	-1	-3	N/A	195
Laminated	5/16-0.030 Saflex® Q-5/16	8,8.2Q	40	35	40	-1	-3	218	174
Standard IGU	1/4 [1/2 AS] 1/4	6[12.7]6	38	30	38	-2	-5	177	143
Standard IGU	1/4 [1 AS] 1/4	6[25.4]6	40	32	40	-2	-5	204	168
Laminated IGU	1/4[12 AS]3/16-0.030 Saflex® Q-3/16	6[12]5,5.2Q	44	35	44	-2	-6	282	234
Laminated IGU	1/4[11/16 AS]5/16-0.030 Saflex® Q-5/16	6[18]8,8,2Q	45	35	45	-2	-6	295	246
Dbl. Lam IGU	1/8-Saflex® Q-1/8[1/2 AS]5/16-Saflex® Q-5/16	3,3.2Q[12]8,8.2Q	47	38	47	-2	-5	332	284

acoustics with the most benefit being gained by increased insulating spaces and the addition of laminated glass with special acoustic interlayers to the configuration to increase damping.

Not all laminated glass is the same. The interlayer used in laminated glass can cause a shift in the acoustical performance of the glazing. Standard PVB interlayers, are well known for their contribution to acoustical performance via damping. Standard PVB interlayers are designed to give balanced performance for safety, glass shard retention, impact strength, security and structural capacity. The acoustical performance was a product benefit first noted in the 1960's. Since that time, researchers and designers have been assembling varied combinations of glass, air space and interlayers to optimize the acoustical performance and squeeze out an extra Rw/STC point where ever possible. Traditionally PVB interlayers are homogeneous with regard to formulation through the product thickness. Modification of the formulation can add or detract from damping. In general terms, the more rigid the interlayer is; the less acoustical performance it will yield and the softer the interlayer is, the better the acoustical performance. Figure 4 shows the acoustical difference between select types of interlayer in the same construction between the ranges of 1000 Hz and 3150 Hz.

Acoustical performance can be adjusted with "monolithic" PVB interlayers by changing thickness. The thicker the interlayer, up to about 2.29 mm, the better the acoustical performance will be. Monolithic acoustic interlayers can also provide improved acoustical performance over standard interlayers, however some of the other attributes of the laminated glass, enjoyed by the balanced performance of PVB, may be diminished and need compensation through an adjustment to the glass thickness or type.

Advances in extrusion technology have lead to the creation of multi-layer PVB interlayers that offer the balanced performance commonly associated with PVB interlayers, including the handling ease, wide processing window, impact resistance, UV screening, temperature stability and glass shard containment after breakage, with improved acoustical performance. The engineering of the interlayer is such that in the same nominal 0.76 mm thickness, a thin core of polymer is functioning to provide extra damping to the interlayer and thus

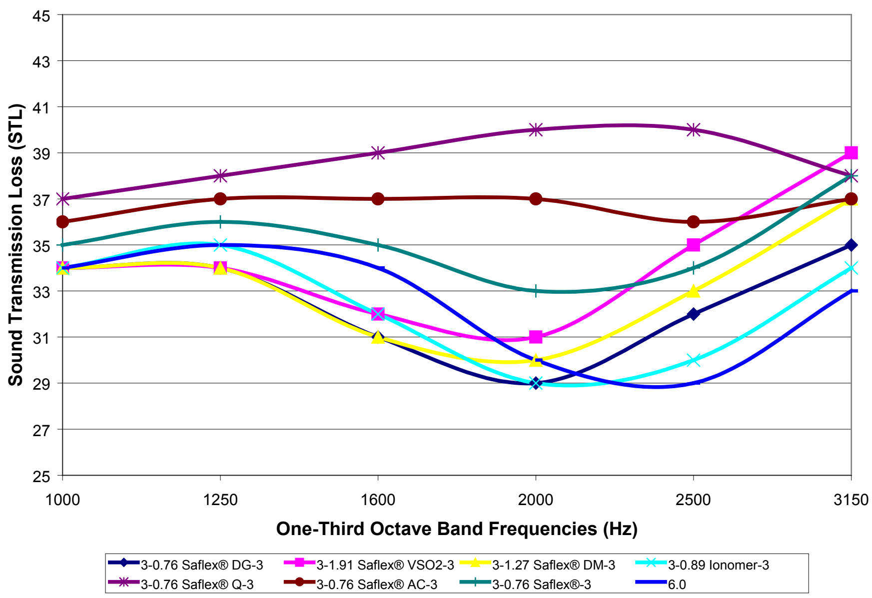

Figure 4: Sound Transmission Loss Data 1000 – 3150 Hz – Various Interlayers

higher performance. (see Figure 5). The outer casing of the sandwich is the same as the balanced PVB interlayers and therefore provides all the attributes one has come to expect. Tests also indicate that the acoustical PVB is beneficial at low temperatures where standard PVB tends to have slightly reduced acoustical performance.

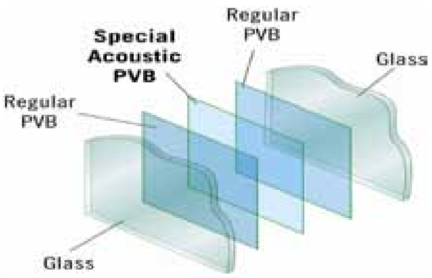

Figure 5: Cut away – multilayer acoustic interlayer

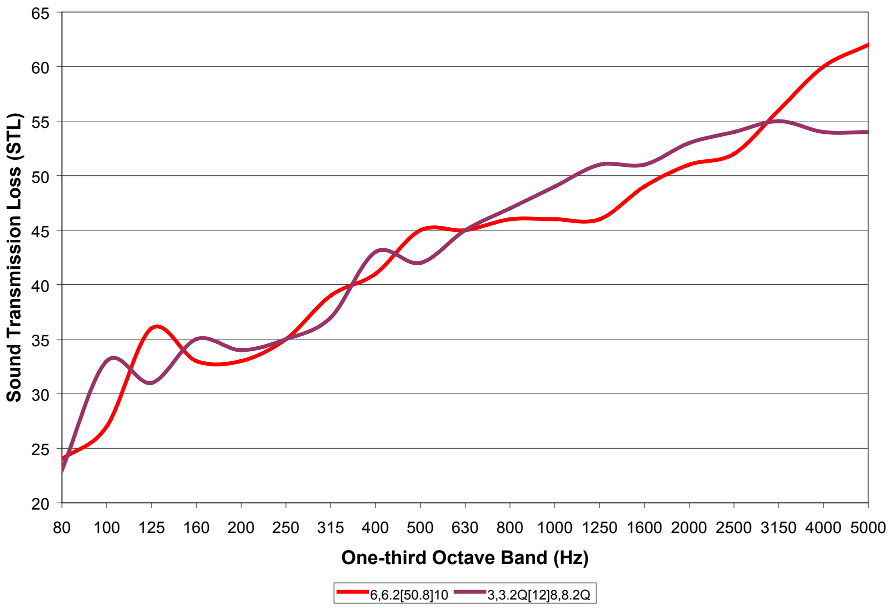

Figure 6: Sound Transmission Loss data comparison

Another benefit of using the acoustic interlayer is the ability to install thinner glazing units. By adjusting the unit type, glass mass and incorporating the acoustical PVB interlayer, an overall thickness savings of over 25 mm can be seen in several glazing configurations as see from the below case studies in Table 3. The one-third octave band sound transmission loss data of the lowest advantage case comparison, Case 3, can be seen in Figure 6. This shows that the advantage of the acoustical interlayer, even in thinner constructions is significant in the 1000 to 3000 Hz frequency range.

Although this "core" of the acoustic interlayer cannot be readily seen with the naked eye, it does require a paradigm shift to the traditional rules of thumb used to estimate acoustical performance in glazing.

Laminated glass with standard PVB interlayer follows the following rules for thumb for acoustical estimation:

- Replace a monolithic lite with laminated (minimum 0.76 mm PVB) + 3 Rw/STC units
- Double the interlayer from 0.76 mm to 1.52 mm + 1 Rw/STC unit
- Replace one lite of an IGU with equivalent thickness laminated + 4 Rw/STC units
- Double the airspace + 3 Rw/STC units
- Double the total glass weight +1 Rw/STC unit
- Change from laminated IGU to double laminated IGU + 3 Rw/STC units

These rules of thumb have been applied to laminated glass constructions with documented success. Typically this estimation will yield a value that is with 2 units of the actual testing. For the multi-layer acoustical interlayer, these rules of thumb do not apply in the same way. In general the performance difference between monolithic, laminated glass with standard PVB and laminated glass with acoustic PVB can be seen in Figure 7.

For each laminate configuration, the general estimation principles are provided for multi-layer acoustical interlayer (Saflex® Q series) followed by the supporting data from which the principles have been derived. It should be noted that any reference to unit reversal and performance has been

Table 3: Overall glazing configuration thickness savings using acoustic interlayer

							Change from Standard	
CASE STUDY 1			STC	OITC	Rw	DRb	Glass Thickness (mm)	Overall Thickness (mm)
RAL: TL06-324	Saflex®	6[114 AS]3-0.76 Saflex®-3	44	36	44	235	--	--
RAL: TL10-157	Saflex® Q	6[12 AS]5-0.76 Saflex® Q-5	44	35	44	234	--	--
							4	-112
CASE STUDY 2								
RAL: TL06-270	Saflex®	6[102 AS]3-0.76 Saflex®-3	45	36	45	237	--	--
RAL: TL10-158	Saflex® Q	6[18 AS]8-0.76 Saflex® Q-8	45	35	45	246	--	--
							10	-94
CASE STUDY 3								
RAL: TL85-196	Saflex®	6,6.2[50.8]10	47	38	46	276	--	--
RAL: TL10-160	Saflex® Q	3,3.2Q[12]8,8.2Q	47	42	47	311	--	--
							12	-38.04

determined based on the temperature being the same for both sides. This test is conducted to show the influence of the sound impacting the glazing. In actual installation, the laminated glass should be installed facing the warmer environment whenever possible.

Single Laminate

- Double glass thickness + 1 Rw/STC unit
- Reversing asymmetrical constructions + 0 Rw/STC units
- Substituting one layer of acoustical PVB for standard PVB + 2 Rw/STC units
- Layering standard PVB with acoustic PVB: no change in Rw or STC from single layer acoustic PVB
- Stacking multiple layers of acoustic PVB: no change from single layer acoustic PVB

Laminated Insulating Glass Unit

- Increase of glass thickness: same as standard products
- Increase of air space: same as standard products
- Reversal of unit orientation: no change to Rw/STC.
- Standard PVB 60 gauge replaced with Standard PVB 30 gauge + Acoustic PVB 30 gauge: + 1 Rw/STC Unit
- Change from standard PVB to acoustic PVB: + 2 units (3/4 inch airspace or above: +1 Rw/STC Unit)

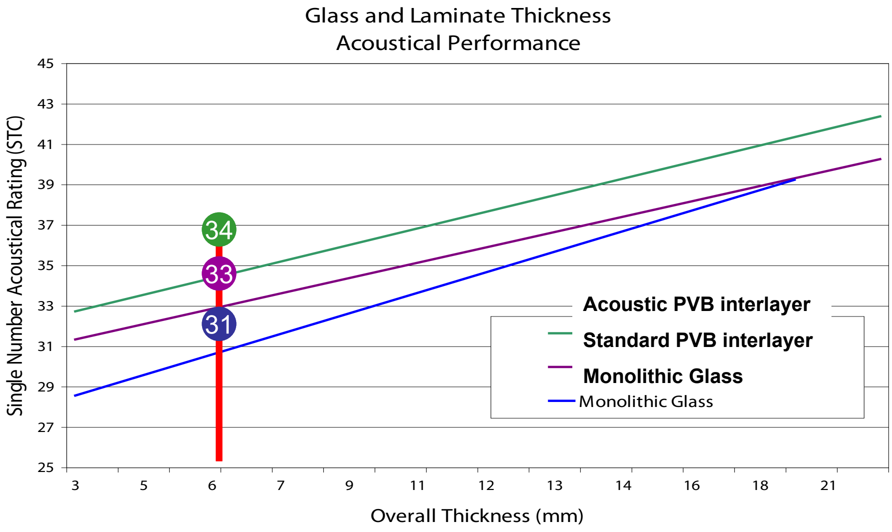

Figure 7: Relationship of Rw/STC with monolithic glass and laminated glasses

Double Laminated Insulating Glass Units

- Replacement of Saflex R series with Saflex Q series in one lite of a double laminated IGU: + 1-2 Rw/STC Units.
- Replacement of Saflex R series with Saflex Q series in more than one additional lite of double laminated IGU: no Rw/STC increase.
- Providing asymmetrical interlayer configurations with an air space in between: +1-2 Rw/STC Units.
- Adding thickness by stacking layers of Saflex Q series in laminated lite of double laminated IGU: + 1 Rw/STC Units (same lite already containing Q series).

The information presented above is intended to assist in the estimation of Weighted Reduction (Rw) or Sound Transmission Class (STC) for untested laminated glass configurations. The values should be considered for estimation purposes only, actual testing and verification should be done for applications where Rw or STC ratings, or noise abatement levels are mandated or where performance at specific frequencies are critical.

Table 4: Laminated Glass Interlayer differential for estimation

Test ID	Glazing Type	Configuration Detail Metric mm (Standard US in.)	Rw/STC
RAL: TL07-205	Laminated	3 – 0.76 Saflex® -3 (1/8-0.030 Saflex®-1/8)	34
RAL: TL09-069	Laminated	3 – 0.76 Saflex® Q – 3 (1/8 – 0.030 Saflex® Q -1/8)	36
RAL: TL07-198	Laminated	3-0.76 Saflex® Q + 0.76 Saflex® R series – 3 (1/8-0.030 Saflex® Q + 0.030 Saflex® R series -1/8)	36
RAL: TL07-207	Laminated	3 – 1.52 Saflex® Q - 3 (1/8-0.060 Saflex® Q-1/8)	36
RAL: TL07-199	Laminated	3 – 2.29 Saflex® Q - 3 (1/8-0.090 Saflex® Q-1/8)	36

Table 5: Laminated insulting glass: Unit reversal influence on acoustical performance

Test ID	Glazing Type	Configuration Detail Metric mm (Standard US in)	Rw/STC
RAL: TL09-075	Laminated IGU	6[12 AS]6-0.76 Saflex® Q + 0.76 Saflex® R series- 6 1/4 [1/2 AS] 1/4 – 0.030 Saflex® Q + 0.030 Saflex® R series - ¼	44
RAL: TL09-076	Laminated IGU	6[12 AS]6-0.76 Saflex® Q + 0.76 Saflex® R series- 6 (reversed) 1/4 [1/2 AS] 1/4 – 0.030 Saflex® Q + 0.030 Saflex® R series - 1/4 (reversed)	44
RAL: TL09-077	Laminated IGU	3[12 AS]3-0.76 Saflex® Q + 0.76 Saflex® R series-3 (1/8 [1/2 AS]1/8-0.030 Saflex® Q + 0.030 Saflex® R series-1/8)	38
RAL: TL09-078	Laminated IGU	3[12 AS]3-0.76 Saflex® Q + 0.76 Saflex® R series-3 (reversed) (1/8 [1/2 AS]1/8-0.030 Saflex® Q + 0.030 Saflex® R series-1/8) (reversed)	38

Table 6: Laminated insulating glass – Interlayer substitution of acoustic interlayer

Test ID	Glazing Type	Configuration Detail Metric mm (Standard US in)	Rw/STC
RAL: TL06-191	Laminated IGU	3[12 AS]3-0.76 Saflex® R series - 3 (1/8[1/2 as]1/8-0.030 Saflex® R series-1/8)	37
RAL: TL04-194	Laminated IGU	3[12 AS]3-1.52 Saflex® R series - 3 (1/8[1/2 AS]1/8-0.060 Saflex® R series-1/8)	37
RAL: TL09-077	Laminated IGU	3[12 AS]3-0.76 Saflex® Q + 0.76 Saflex® R series-3 (1/8 [1/2 AS]1/8-0.030 Saflex® Q + 0.030 Saflex® R series-1/8)	38
RAL: TL04-202	Laminated IGU	6[12 AS]6-0.76 Saflex® R series-6 (1/4[1/2 AS]1/4-0.030 Saflex® R series-1/4)	41
RAL: TL07-222	Laminated IGU	6[12 AS]6-0.76 Saflex® Q-6 (1/4[1/2 AS]1/4-0.030 Saflex® Q-1/4)	43
RAL: TL09-075	Laminated IGU	6[12 AS]6-0.76 Saflex® Q + 0.76 Saflex® R series-6 1/4 [1/2 AS] 1/4 – 0.030 Saflex® Q + 0.030 Saflex® R series - 1/4)	44
RAL: TL07-213	Laminated IGU	6[18 AS]3-0.76 Saflex® R series-3 (1/4[3/4 AS]1/8-0.030 Saflex® R series-1/8)	40
RAL: TL07-214	Laminated IGU	6[18 AS]3-0.76 Saflex® Q -3 (1/4[3/4 AS]1/8-0.030 Saflex® Q-1/8)	41

Table 7: Double Laminated Insulating Units – Acoustical Performance

Test ID	Glazing Type	Configuration Detail Metric mm (Standard US in.)	Rw/STC
RAL: TL06-196	Dbl. Lam IGU	3-0.76 Saflex® R series-3[12 AS]3-0.76 Saflex® R series-3 (1/8-0.030 Saflex® R series-1/8[1/2 as]1/8-0.030 Saflex® R series-1/8)	40
RAL: TL07-210	Dbl. Lam IGU	1/8-0.030 Saflex® Q-1/8[1/2 AS]1/8-0.030 Saflex® Q-1/8	41
RAL: TL07-217	Dbl. Lam IGU	3-0.76 Saflex® Q-3[12 AS]3-0.76 Saflex® R series-3 (1/8-0.030 Saflex® Q-1/8[1/2 AS]1/8-0.030 Saflex® R series-1/8)	42
RAL: TL96-358	Dbl. Lam IGU	3-0.76 Saflex® R series-3[12 AS] 3-2.29 Saflex® R series-3 (1/8-0.030 Saflex® R series-1/8[1/2 AS]1/8-0.090 Saflex® R series-1/8	40
RAL: TL07-218	Dbl. Lam IGU	3-0.76 Saflex® Q-3[12 AS] 3-2.29 Saflex® Q-3 (1/8-0.030 Saflex® Q-1/8[1/2 AS] 1/8-0.090 Saflex® Q-1/8)	42

Conclusions

The dynamic response and sound transmission characteristics of structures are determined by essentially three parameters: mass, stiffness, and damping. In architectural glazing, Mass and stiffness are associated with the glass thickness, while damping occurs due to the spacing of insulting units or the use of interlayers in laminated glass.

Since the mid 1960's standard PVB interlayer has been used in laminated architectural glass to enhance the acoustical performance of window and door systems. Standard PVB laminated architectural glass has already served to reduce the noise level inside the buildings, thus increasing acoustical comfort for the occupants. As time has progressed the need for more and more protection from sound, and thus higher STC and Rw ratings, has given the opportunity for the interlayer to be reformulated into a specialty grade targeted at acoustical control.

The reformulation has generated a multi-layer interlayer system targeted at acoustical control, but with all the benefits normally associated with PVB laminated glass – glass particle retention, safety glazing rating, affordability, UV screening, color options, processing ease and durability. The reduction of the coincident effect of glass by multi-layer acoustical interlayer in laminated architectural glass makes the glass an excellent building acoustical barrier panel by itself or in the insulating glass unit (IGU) for external airborne noise attenuation, wall and dividers within a building and allows for enhanced acoustic comfort for occupants in buildings.

The single number rating systems for the evaluation of acoustical performance of glazing systems are lacking in their ability to accurately discern between the high performance products that are available and in use today. Although no system can take the place of a thorough examination of the one-third octave band data, the decibel reduction (DR_b and DR_3) ratings provide the consumer with a value they can relate to regarding known performance of glass that has historically been used in windows, and thus a baseline from which to understand performance differences.

Lastly, the estimation principles for laminated glass utilizing a high performance acoustic interlayer must be updated. With the acoustical core of the interlayer providing outstanding damping, the overall interlayer thickness can be specified for the safety, security, structural of color requirements of the glazing and decoupled from the thicker requirements traditionally needed to reach the needed noise abatement.   The use of this product opens up the potential for obtaining more noise reduction in hospitals, hotels and most importantly schools – giving our children the best environment to learn. According to the United States Environmental Protection Agency's Office of Noise Abatement and Control, "Noise constitutes a real and present danger to people's health and can produce serious physical and psychological stress."