## Acoustically Enhanced Insulated Glass Unit

With the recent environmental noise pollution concerns and the growth in construction of high-rise residential condominiums in noisy urban areas, prescribed acoustic requirements are more prevalent in the design of building envelopes. In contemporary architecture, glass may cover a major portion of the building envelope.

Sound transmission loss (TL) is a measure of sound isolation of building components such as walls and windows. Transmission loss values are measured in test chambers to eliminate the effect of possible flanking of the sound path (noise propagation through other components). Noise reduction (NR) is a measure of the loss of sound intensity across a sound-absorbing material. It is computed by subtracting the sound pressure level of the receiving room (where the sound is travelling to) from the sound pressure levels of the source room (where the sound is generated).

STC (Sound Transmission Class) rating is an industry standard practice for evaluation of the acoustical performance of glass and glazing products. Various glass make-ups have different acoustical performances. A typical glass system has an STC of 35 to 37 (see Table-2). Class ratings of over 40 are expensive and in general not practical. Laminated glass of the same mass performs acoustically superior to single pane glass. Insulated glass of same mass performs acoustically inferior to the single pane glass. Laminated / Insulated glass of the same mass performs acoustically superior to single pane/laminated or insulated glass.

Table 1 . STC Rating

| STC | Subjective Description |
|---|---|
| 30 | Normal speech is heard and clearly understood |
| 40 | Normal speech is heard, but requires some effort to be understood |
| 50 | Loud speech can be heard with some effort. Music is easily heard |
| 60 | Loud speech cannot be heard. Music can be heard faintly |
| 70 | Loud music can be heard faintly. |
| >75 | Most noise is effectively blocked. |

Table 2 . STC Ratings of different glass types

| Glass Type | STC |
|---|---|
| 1/4" glass | 31 |
| 1/2" glass | 36 |
| Laminated glass - two 1/8" glass with 0.03" interlayer | 35 |
| Same as above but with 0.06" interlayer | 35 |
| Laminated glass - two 3/16" glass with 0.03" interlayer | 36 |
| Laminated glass - 1/4" glass, 0.03" interlayer, 1/8" glass | 36 |
| Same as above but with 0.06" interlayer | 37 |
| Laminated glass - two 1/4" glass with 0.06" interlayer | 3□ |
| Laminated glass - 1/2" glass, 0.06" interlayer, 1/4" glass | 41 |
| □nsulating glass unit - 1/4" lam. - 3/8" air sp. - 3/16" | 37 |
| □nsulating glass unit □ 1/4" lam. - 1/2" air sp. - 1/4" | 3□ |
| □nsealed unit - 1/4" lam. - " air sp. - 3/16" | 42 |
| □nsealed unit - 1/4" lam. - 2" air sp. - 3/16" | 45 |
| □nsealed unit - 1/4" lam. - 4" air sp. - 3/16" | 48 |
| □nsealed unit - 1/2" lam. - 4" air sp. - 3/8" | 4□ |
| □nsealed unit - 3/4" lam. - 4" air sp. - 1/8" | 4□ |
| □nsulating glass unit - 1/8" - 1/4" air sp. - 1/8" | 28 |
| □nsulating glass unit - 3/16" - □"air sp. - 3/16" | 35 |
| □nsulating glass unit - 1/4" - 1/2" air sp. - 1/4" | 35 |
| □nsealed unit - 3/16" - 4" air sp. - 3/16" | 44 |

There is a need to have an IGU with a typical (common) composition for an enhanced acoustical performance. The enhancement should raise the STC to 42 to 44 range.

STC rating can be improved by; (a) increasing the sound transmission loss at coincidence frequency and (b) a moderate levels of overall across frequency spectra.

Another possible means of improving the performance of sound transmission is to use dampers. Dampers are devices for mitigating the motion or pressure response of vibrating or moving element or media.

There are different classes of dampers, active, passive, and semi-active. Active damper is a device for mitigating the motion or pressure response of vibrating or moving element or media using external applied energy source (i.e. noise cancelling headphones). Passive dampers reduce the motion or pressure response of vibrating or moving element or media without externally applied energy source for example tuned mass dampers.

Using damping devices it is possible to improve the acoustical performance of glazing units, and achieve a higher STC rating for a similar glazing composition. Helmholtz resonance is the phenomenon of air resonance in a cavity. The name comes from a device created in the 1850s by Hermann von Helmholtz, to show the height of the various tones. An example of Helmholtz resonance is the sound created when one blows across the top of an empty bottle (see Figure 1).

Figure 1. Original Helmholtz resonator set, Different volumes and opening sizes control the resonance frequency.

By placing a series Helmholtz resonators in the spacer of the insulated glass unit it is possible to improve the sound transmission loss for the glazing unit.

The resonators are designed each to dampen a particular sound frequency. They are termed Acoustic Damper Capsules (ADC), and are made of injection molded Super ABS plastics or cast brass or stainless steel.

The damped frequency is a function of the area of the resonator opening (neck) to the volume of the resonator. The damping ratio is a function of the resonator volume to the overall cavity volume of the IGU. The final product will still have the same thermal and weathering characteristics of the typical unit.

Preliminary numerical simulations indicate it is possible to increase the sound transmission loss as much as 6 to 8 dB at the consistence dips and as much as 2 to 4 dB across the entire frequency spectra (see Figure 3). Here the frequency response of a simple insulated 1" IGU (1/4:1/2 air:1/4) is evaluated, with and without two resonant chambers at the sides of the air space. The results indicate an increase in transmission loss in the frequency range of 2500-5000 Hertz, while having no adverse effect on the lower frequencies.

Additional studies are being performed to evaluate over all performance of the system, by utilizing multiple resonant cavities . Upon completion of these parametric simulations, a series of prototype units will be fabricated. The unit will be examined in the laboratory test chamber to evaluate the effectiveness of the concept.

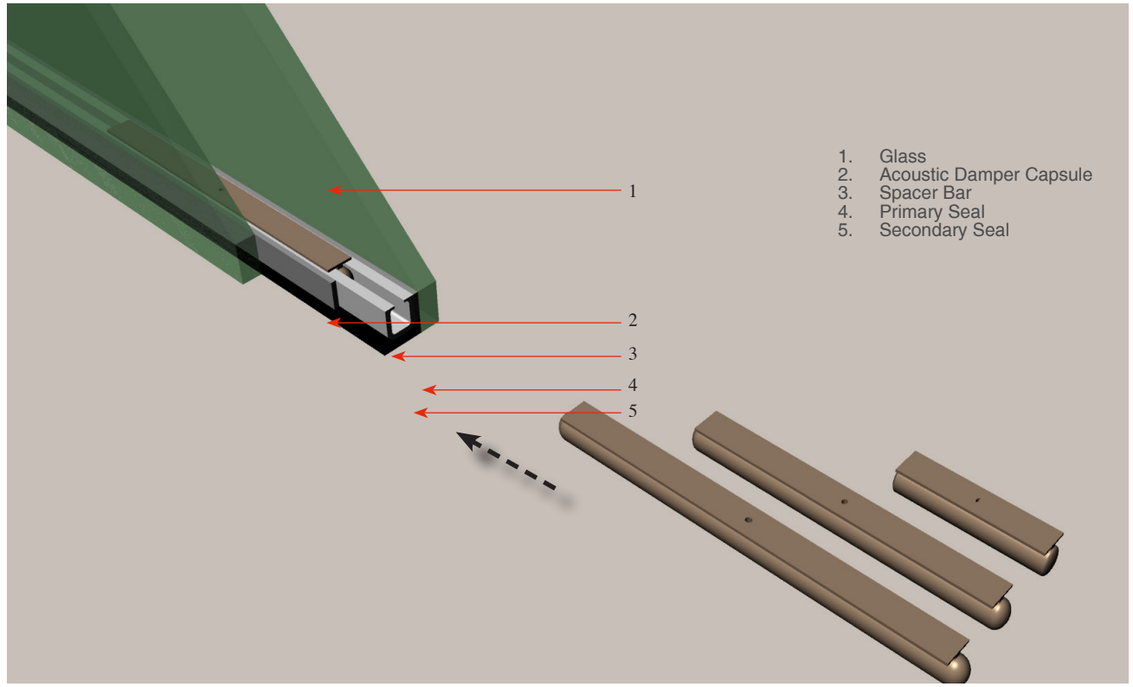


Figure 2. Components of the acoustically enhanced insulated glass unit

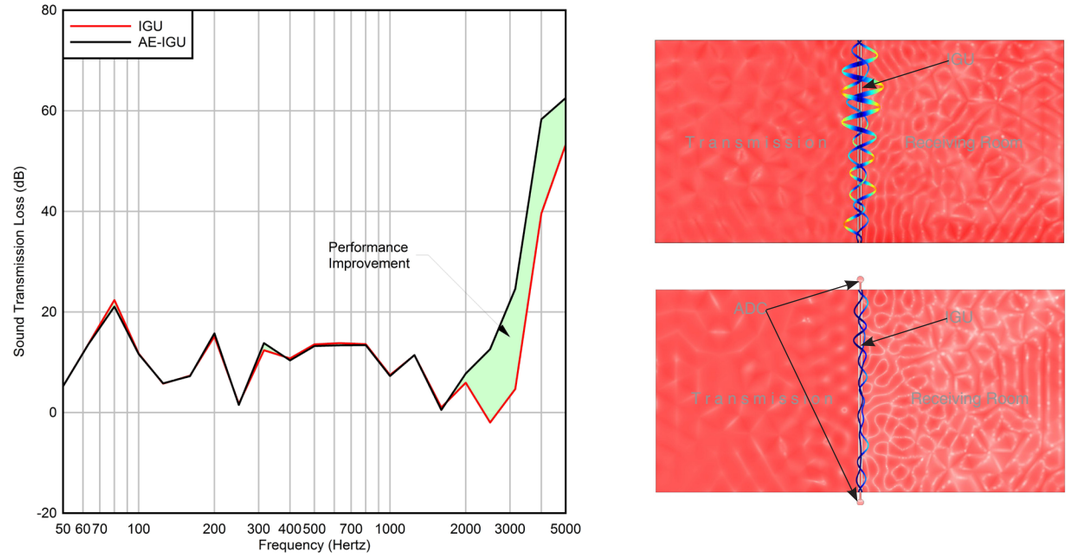


Figure 3. (Left) Frequency Response of 1" insulated glass units with and without the use of an acoustic damper capsule; (Top-right) Sound pressure level, and the glass deformation of the IGU at frequency of 2500 Hertz; (Bottom-right) Sound pressure level, and the glass deformation of the IGU with addition of acoustic damper capsules at frequency of 2500 Hertz.

 