ACOUSTICS 3B FACTORS INFLUENCING GLAZING PERFORMANCE

To varying degrees, the sound reduction performance of glazing is dependent on the overall glass thickness, the relative thickness of glass panes, glass types, the cavity width and the gas fill within the cavity.

GLASS THICKNESS

As can be seen from the below, for a single monolithic pane, performance is improved as the glass thickness increases, more mass provides better attenuation.

Table 1 - Single figure performance for monolithic float glass

Glass	Thickness (mm)	R_W	$R_{W,C}$	$R_{W,Ctr}$
PLANICLEAR	3	29	28	26
	4	30	28	28
	5	31	29	29
	6	32	31	30
	8	33	32	31
	10	35	34	33
	12	36	35	34
	15	37	37	35
	19	38	37	35

CRITICAL FREQUENCY

As can be seen from Figure 1, dips in performance are noted for all of the glass thickness, and these occur at what is known as the critical frequency (f_{CRIT}).

Panes of glass have a frequency at which they will vibrate concurrently with the source sound, reducing the level of sound insulation in this region, and generating the coincidence dip. For glass, this frequency (f_{co}) is related to the thickness of the glass pane (t), by the equation;

$$f_{CRIT}(Hz) = \frac{12500}{t}$$

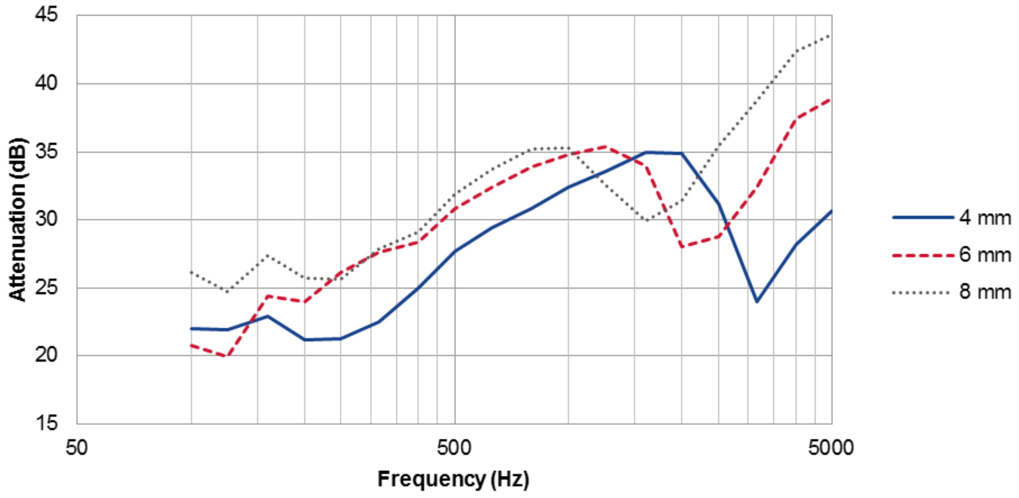

Figure 1 - Coincidence dips for selected glass thicknesses

RELATIVE GLASS THICKNESS

The coincidence dip will also influence the whole unit performance, and if identical thicknesses are used within an IGU, the overlap of the coincidence dips will generate a region where acoustic performance is reduced. In addition, with identical glass thicknesses, sympathetic vibrations occur which cause the glass to vibrate together and transmit sound.

As can be seen from the below data (Figure 2), for two panes of 4 mm float, the overlap of the coincidence dip is present within the double glazing configuration.

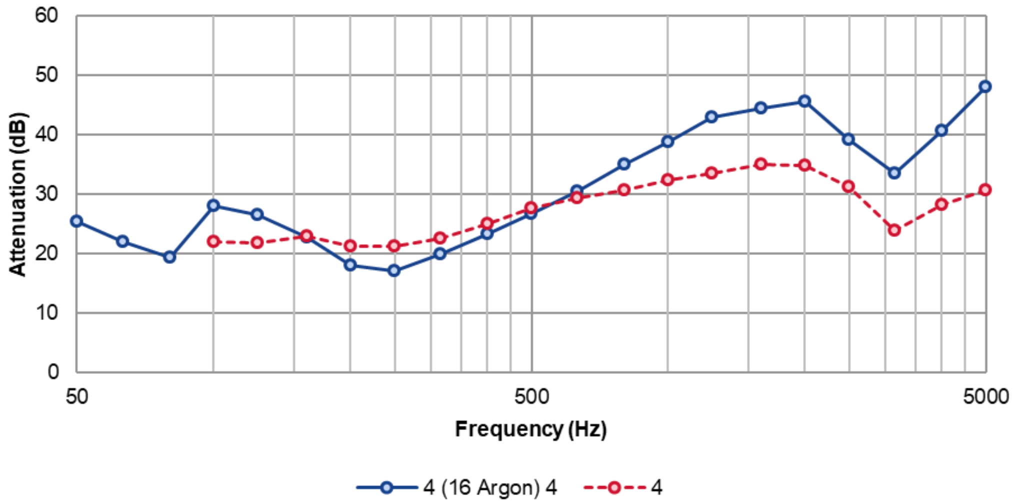

Figure 2 - 1/3 octave centre band performance data, 4 mm and a 4 (16) 4 configuration

Where the glass thickness differs, the effect of the coincidence dip is reduced, as per Figure 3 which shows a 4 mm and an 8 mm nominal thickness pane;

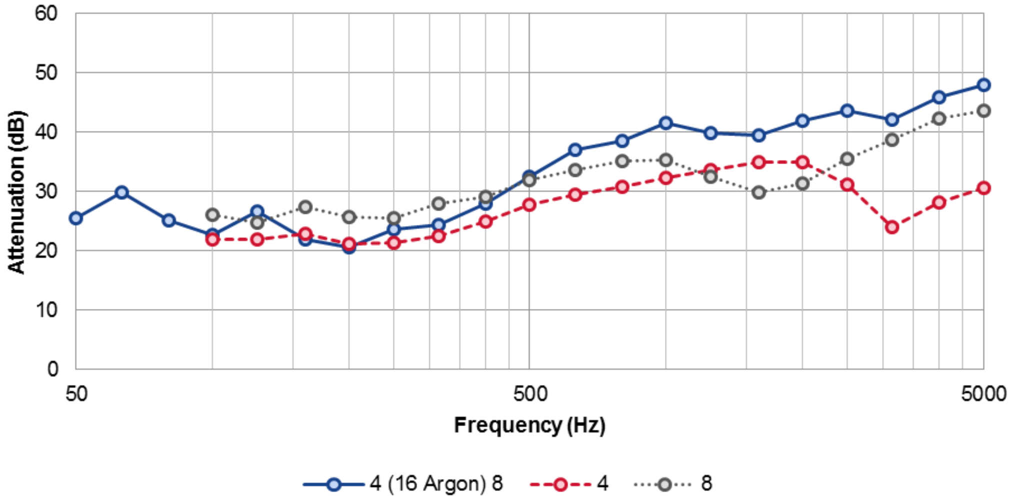

Figure 3 - 1/3 octave centre band performance data, 4 mm, 8 mm and a 4 (16) 8 configuration

GLASS TYPES

Another way to reduce the influence of the coincident dips, and improve performance across the frequency ranges, is to use a laminated glass. A standard SGG STADIP laminate will improve the performance to a small degree by virtue of its improved damping characteristics over glass.

SGG STADIP SILENCE incorporates a PVB interlayer which in itself is a multilayer material, with a softer damping core, which will generally completely remove the influence of the critical frequency of the glass, as shown above.

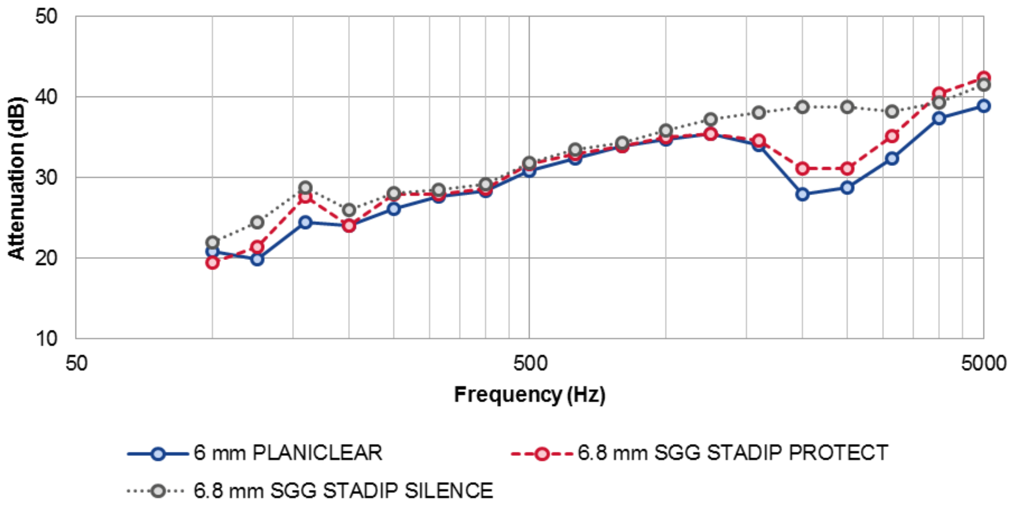

Figure 4 - 1/3 octave centre band performance data for 6 mm equivalent thickness panes

Table 2 - Single Figure performance data for 6 mm equivalent thickness panes

Glass Type	R_w (dB)	C (dB)	C_{tr} (dB)
6 mm PLANICLEAR	32	-1	-2
6.8 mm SGG STADIP	33	-1	-2
6.8 mm SGG STADIP SILENCE	35	0	-3

INTERLAYER THICKNESS

Whilst the interlayer does typically have a better performance than equivalent thickness float glass, there's typically no significant influence observed due to the interlayer thickness. The below illustration shows the performance of a unit which includes a 6 mm pane of float, with a counterpane of a 8.4, 8.8 or 9.5 mm interlayer;

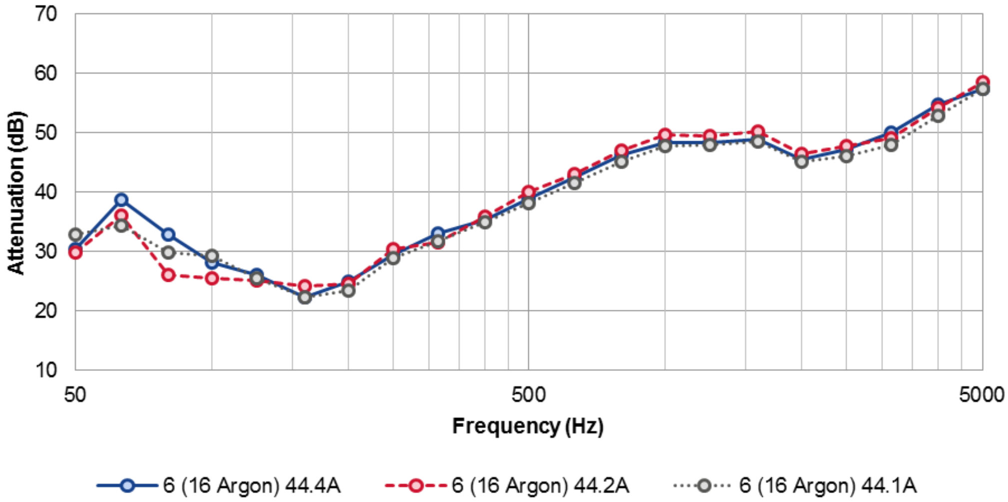

Figure 5 - 1/3 octave centre band performance data for IGU configuration with a 44.X laminate

Table 3 - Single figure performance data for IGU configuration with a 44.X laminate

Construction	R_w (dB)	C (dB)	C_{tr} (dB)
6 (12) 8.4A	38	-1	-4
6 (12) 8.8A	39	-1	-5
6 (12) 9.5A	39	-2	-6

Whilst a small variation is noted in the R_w(C;Ctr) values, this is no more than may be expected from repeat measurements on the same unit construction, and is below the intensity that human hearing would be sensitive to, and within the typical errors associated with testing.

INTERLAYER TEMPERATURE

It is often thought that PVB interlayers at higher temperatures perform better acoustically than at colder temperatures. However, there is some question as to whether this applies to both standard PVB and acoustic PVB interlayers, with some evidence that acoustic PVB interlayers perform better at colder temperatures [1].

Under test conditions, the temperatures are equal in both sides of the room, and so, the unit orientation should make no difference to the measured performance. When installed, facing the laminated pane to the inside should keep it at a more consistent temperature, assuming the building is heated in colder months, and therefore keep the acoustic performance more consistent as well.

THE INFLUENCE OF CAVITY WIDTH

It is generally accepted that the cavity width of an insulating glass unit (IGU) has little influence on the overall acoustic performance. BS EN 12758:2002 [2] states; "*Over the cavity width range (6-16) mm, the corresponding acoustic data for a given glass combination are regarded as constant.*" However, this statement, as worded, is specific to the data provided within this standard, which may be

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considered worst case for that specific cavity width range for each configuration. In addition, the lower frequency range can be influenced by mass-air-mass resonance. As such, this may not be considered true for data provided by manufacturers or processors.

MASS-AIR-MASS RESONANCE

When considering the acoustic performance of insulating glass units at lower frequencies, the mass-air-mass resonance frequency should be considered.

The greatest variation in IGU performance with changes in the cavity width is due to mass-air-mass resonance. At low frequencies, the cavity effectively couples the two panes within the IGU by acting as a spring. The frequency at which this occurs is dependent upon the cavity width (d), the mass per unit area of panes 1 and 2 (m_{P1}, m_{P2}), the gas density within the cavity (ρ_0) and the speed of sound within the cavity gas (c_0) [3].

$$f_{res}(Hz) = \frac{1}{2\pi}\sqrt{\frac{\rho_0 c_0^2}{d}\left(\frac{m_{P1} + m_{P2}}{m_{P1} m_{P2}}\right)}$$

Therefore, if an IGU consisting of a 4 mm and a 6 mm nominal thickness pane is considered, with an air filled cavity, the calculated mass-air-mass resonance frequencies are as below;

Table 4 - Air filled cavity mass-air-mass resonance

Cavity Width	Mass-Air-Mass Resonance Frequency (Hz)
6	316
12	223
16	193
20	173
24	158

CAVITY GAS FILL

BS EN 12758:2002 [2] states that data provided in the standard can be adopted for units filled with air or argon. Some small variations in performance may be exhibited, specifically at lower frequencies where the mass-air-mass resonance effect has a greater influence, and gas density and speed of sound in the gas has an influence. However, in general there is not expected to be any significant effect on the unit performance.

MEASURED DATA

An assessment of measured data for a double glazed unit consisting of a 4 mm and a 6 mm nominal thickness panes, with cavity widths of 6, 12 and 16 mm, shows a small variation at measured frequencies, and consequently on the weighted performance values. Cavity widths of 20 mm and 24 mm show similar attenuation profiles as well, with a small increase in the overall weighted performance.

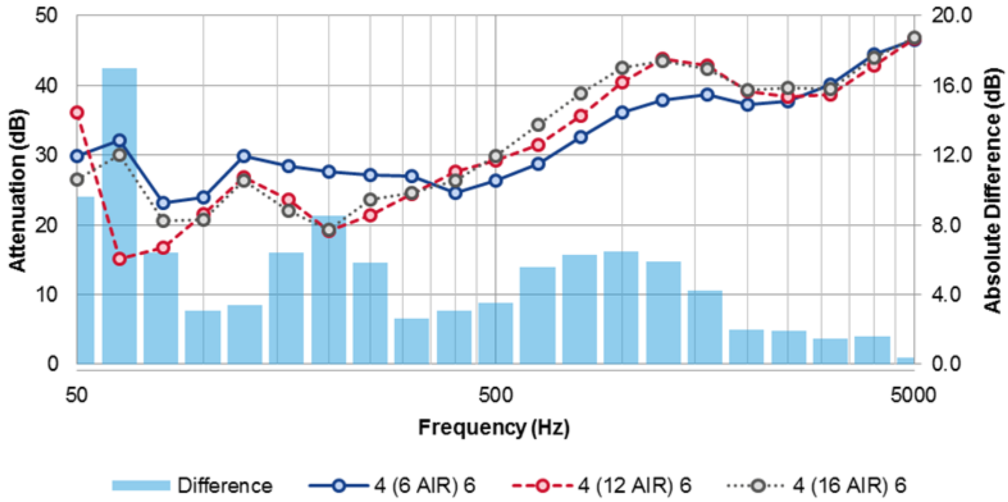

Figure 6 - 1/3 octave centre band performance data, cavity width variation 6 mm to 16 mm

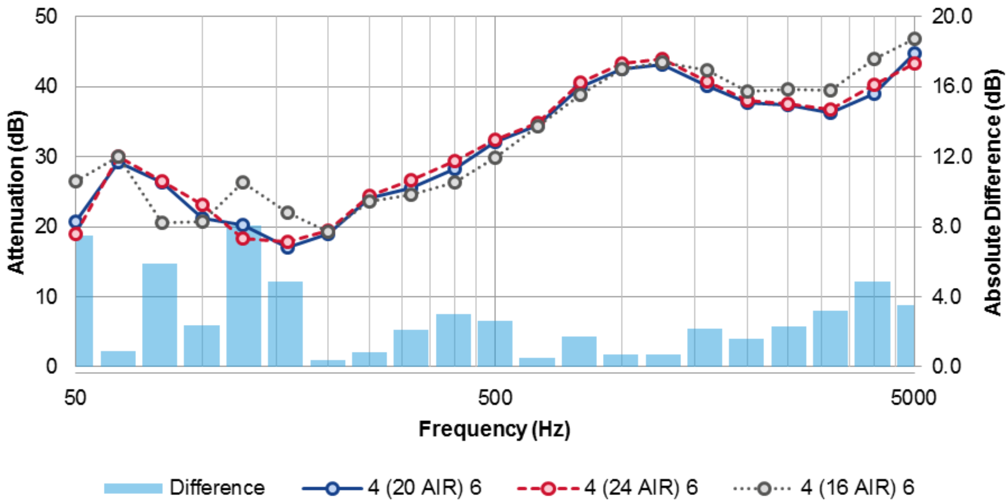

Figure 7 - 1/3 octave centre band performance data, cavity width variation 16 mm to 24 mm

Table 5 - Single figure performance data, cavity width variation 6 mm to 24 mm

Construction	R_w (dB)	C (dB)	C_{tr} (dB)
4 (6) 6	34	-1	-3
4 (12) 6	34	-1	-5
4 (16) 6	34	-1	-4
4 (20) 6	35	-1	-5
4 (24) 6	35	-2	-6

REFERENCES

[1] J. Schimmelpenningh, "Acoustic Interlayers for Laminated Glass - What makes them different and how to estimate performance," *Glass Performance Days,* pp. 2-8, 2012.

[2] European Committee for Standardization, *EN 12758:2002 - Glass in building - Glazing and airborne sound insulation - Product descriptions and determination of properties,* CEN, 2002.

[3] A. J. B. Tadeu and D. M. R. Mateus, "Sound transmission through single, double and triple glazing. Experimental evaluation," *Applied Acoustics,* vol. 62, pp. 307-325, 2001.