F. ALTON EVEREST

Glass in the Studio, Part II

Here, author Everest returns to discuss the effects of absorption, dissimilar planes, different types of glass, and other topics relating to acoustical holes in the studio.

WE HAVE SEEN that the control of standing waves in the cavity between the two panes of a double glazed window requires absorption. The TL advantage in using such absorption is revealed by measurements plotted in FIGURE 1, in which two 5/32-inch (4mm) glass panes are separated two inches (50mm). This arrangement is not particularly desirable for a practical window because of the small spacing and deep coincidence dip; it is, however, excellent as an actual "before" and "after" controlled demonstration of placing absorbing material on the reveals of the window cavity, yielding, in this example, STC 33 without absorbent and STC 37 with absorbent. A gain of 4 points is therefore directly attributable to the absorbent. The TL gain in using an absorbent at the edges is less with heavier glass, but it is still desirable to use peripheral absorbent in all double glazed windows.

Quirt has also verified the value of absorbent lining around the interpane perimeter of double glazed windows.[1] With 1-inch glass fiber lining he found a TL gain at 4 kHz of about 5 dB, coming down to about 1 dB at 1 kHz, and negligible effect at lower frequencies. Low frequency TL can be improved, of course, by use of thicker absorbent to suppress axial and tangential modes in the interpane cavity.

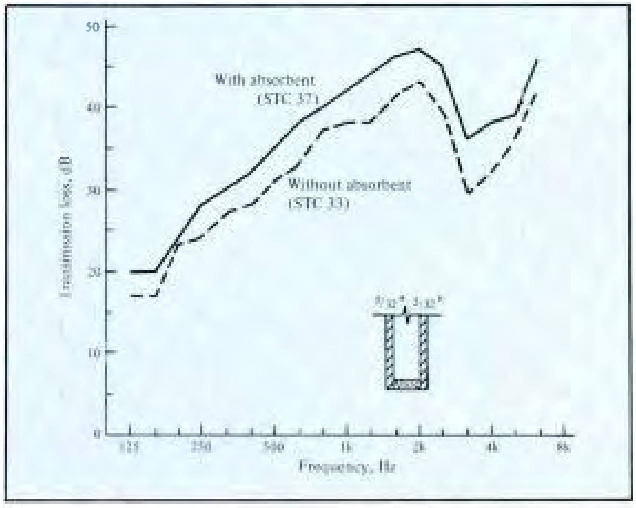

Figure 1. Actual measurements showing improvement of transmission loss of double glazed windows by covering the edges of the interpane activity with sound absorbing material. A gain of 4 STC points is attributable to the absorbent. In this case, 5/32-inch (4mm) glass is used. Improvement of TL due to absorbent is greater with thin than with heavier glass. (Adapted, with permission, from A. Cops et al.)

EFFECT OF DISSIMILAR PANES

If both glass panes in a double glazed window are of the same thickness, their coincidence dips appear at the same frequency, deepening the dip. For this reason, it is standard practice to use glass panes of different thicknesses to minimize the effect. Measurements verifying and quantifying the effect are shown in FIGURE 2.[1] Measured TL of two ¼-inch (6mm) glass panes placed 2½ inches apart are compared to an almost identical situation, except that one glass is ⅛ inch (3mm) in thickness. The window of FIGURE 2A, having two ¼-inch panes, has a coincidence dip around 2 kHz as predicted by Equation 5. The window of FIGURE 2B, having panes of dissimilar thicknesses, eliminate, or at least moderate, the coincidence dip. In this frequency region, higher TL is obtained in the window having the thinner glass.

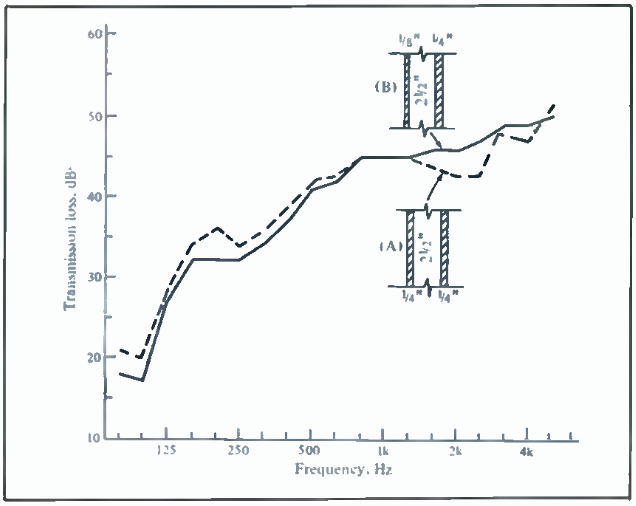

Figure 2. The use of glass of different thickness in double glazed windows serves to minimize the coincidence irregularities by staggering the two coincidence frequencies. Curve A is for a window utilizing two panes of ¼-inch (6mm) thickness spaced 2½ inches (63mm). Curve B is the same window with one glass reduced to ⅛ inch (3mm). (Adapted, with permission, from Quirt, Ref. 1.)

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EFFECT OF LAMINATED GLASS

The mass law discussed in Part 1 (April, '84) applies only to a limp mass, i.e., one having no stiffness. Glass panels would offer greater TL if stiffness could be reduced. One way to do this is to laminate the glass. In FIGURE 3, the measured TLs of two typical double glazed windows are displayed, each having one ¼-inch pane and one ½-inch pane with a 6-inch spacing between them.[4] The ¼-inch pane of FIGURE 3B, however, is made up of two ⅛-inch panes with a 0.045-inch plastic interpaner. This plastic sheet in the sandwich makes the pane behave more like a limp mass, and a significant improvement in TL results. The improvement in this particular window is greatest in the 1 to 2 kHz coincidence region. The cost of laminated glass runs something like 50 percent more than plain glass plate or float.

PLASTIC INSTEAD OF GLASS

There may be conditions in which the properties of plastic sheets (such as flexibility and being nearly shatterproof) might be preferred to those of glass for

The Language of STC

The effectiveness of glass or other materials as sound barriers is measured by the sound transmission loss offered. A graph of transmission loss (TL) vs. frequency describes the effectiveness of such a barrier completely and accurately. It is convenient, however, to be able to represent such a graph by a single number . The arbitrary concept of Sound Transmission Class (STC)[1] is designed to do just that. An STC single number rating, while not perfect, is designed to correlate with subjective impressions of common noises penetrating partitions in homes and offices and is commonly applied to audio rooms as well. The standard STC contour, shown in FIGURE 1, reflects the lower sensitivity of the human ear to low frequency sounds. It can be readily plotted to any convenient scale by connecting the three following points by straight lines: 125 Hz/TL of 24 dB, 400 Hz/TL of 39 dB, and 1250 Hz/TL of 44 dB. The measured transmission loss of the barrier is plotted against frequency, and the standard STC contour, plotted as an overlay to the same scale on tracing paper, is adjusted vertically until the following conditions are fulfilled for the 1/3 octave points from 125 Hz to 4 kHz: 1) the sum of the deviations below the contour at 1/3 octave intervals shall not be greater than 32 dB and 2) the maximum deficiency at any single 1/3 octave point shall not exceed 8 dB. When the contour is adjusted to the highest value that meets these requirements, the STC of the barrier is the TL value corresponding to the intersection of the contour and the 500 Hz ordinate.

As an example, the determination of the STC for the measured values of transmission loss for a partition[2] of ½ inch plasterboard on either side of 2×4 studs, 16 inches on centers, is illustrated in FIGURE 2. Setting the STC overlay first at an estimated STC 38, the deficiencies of the plasterboard walls total 40 dB. Lowering the STC overlay to intersect the 500 Hz ordinate at 37 dB (STC 37), the deficiencies total 33 dB. This is close to the 32 dB mentioned the first condition above, establishing the STC single figure rating for the plasterboard wall of FIGURE 2 at STC 37.

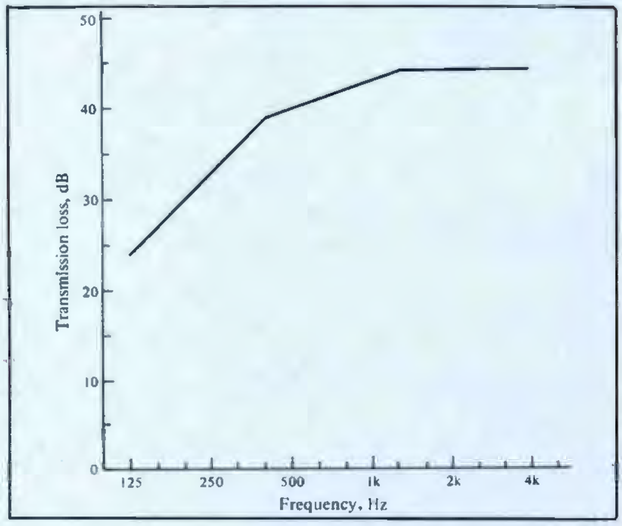

Figure 1. The standard STC contour.

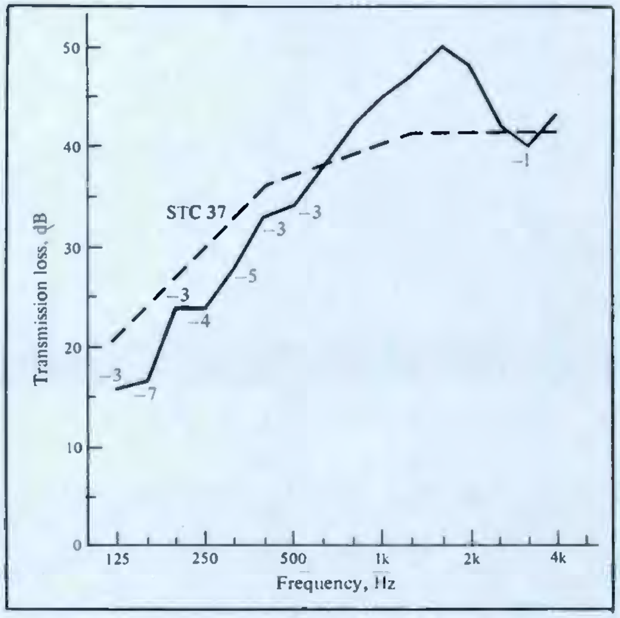

Figure 2. The determination of the STC for the measured values of transmission loss for a partition of ½-inch plasterboard.

References

1. "Determination of Sound Transmission Loss." *ASTM* E413-70T.

2. Northwood, T. D. *Transmission Loss of Plasterboard Walls.* Building Research Note No. 66 (revised July 1970), National Research Council, Ottawa, Canada.

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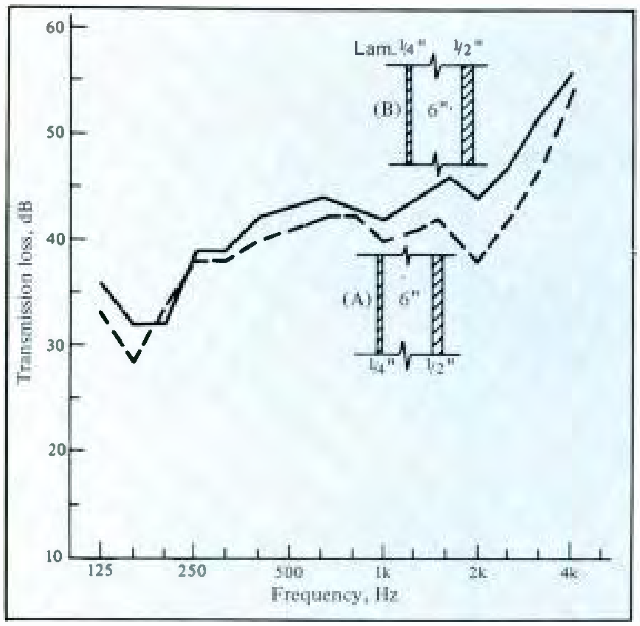

Figure 3. Laminated glass offers less stiffness than comparable solid glass: (A) Normal double glazed window of 1/4-inch and 1/2-inch glass sheets spaced 6 inches; (B) the same window except the 1/4-inch solid sheet has been replaced by two 1/8-inch sheets laminated with 0.045 inch plastic. The window with the laminated sheet shows the greater transmission loss. (Libby Owens Ford, Ref. 3.)

sound insulating windows. What are the trade-offs? For one thing, greater thicknesses of plastic would be required for a given TL because the density of plastic is about half that of glass. Plastic sheets may be cold-bent on the job to form convex windows.[5] It is feasible to use a convex plastic sheet on the studio side of an observation window to control slap-back reflection problems, backing it up with one or more spaced, heavy glass sheets to make up for its lower TL. Modern plastic materials offer reasonably good light transparency and low optical distortion.

HOW ABOUT THERMAL-TYPE GLASS?

There are many forms of proprietary glass utilizing two glass sheets with an airspace between them that are very effective for thermal insulation. If the spacing between the two glass sheets is small (¼-in. to ½-in. is common), thermal properties might be quite satisfactory. But for sound insulation the performance of such units, as previously noted, is the same as a single glass plate of combined surface mass. Only when the airspace exceeds one inch or so does the TL begin to exceed the mass law value.

HOW ABOUT SLIDING GLASS DOORS?

Sliding glass doors are very popular these days for closing off an isolation booth or drum booth or even as an entrance to the studio. Specifications for such doors show great concern for security, weathertightness, and ease of operation, but, to my knowledge, no test results for sound transmission loss. Because of the growing number of sound sensitive applications of sliding glass doors, the justification for the expense of such tests should be forthcoming.

A few generalizations are in order for sliding glass doors to be used as sound barriers. The two main paths for sound to traverse such a door are a) through the glass (mass law) and b) leakage around the door edges. There is little point in paying a high price for heavy glass when leakage is great. Look for the glass doors that have excellent sealing wipers around the entire periphery of each moving unit.

Measurements made by the writer on an ordinary 6-ft., 9-in. by 10-ft. home-type sliding door to an isolation booth in one studio gave the following noise reduction values:

Frequency, Hz	*Noise Reduction, dB*
63	18
125	21
250	25
500	29
1000	25
2000	25
4000	29

(The above "noise reduction" values are those made *in situ* without corrections for room absorption or knowledge of flanking paths; hence they apply only to that particular overall setup rather than being transmission loss values characteristic of the sliding door alone.)

SHALL WE SLANT THE GLASS?

Speaking of double glazed windows, Rettinger says, "The vertical angle of the panes should not be less than six degrees in respect to each other, to avoid a strong standing wave between the sheets of glass when a prolonged note is incident on the window."[6] He is probably referring to the axial modes set up in the interpane cavity. What do recent measurements have to say about the value of inclining one or both of the glass panes? Again we turn to Quirt's recent report of his exhaustive measurements.[1] His tests embrace four glass thicknesses with interpane separation three times greater at one end than the other, varying from ½ inch to 4 inches on the average. His results are as follows:

(a) If the parallel glass separation is equal to the *maximum* separation of the slanting glass, the parallel glass windows show superior transmission loss of 1 to 2 dB across the frequency band.

(b) If the parallel glass separation is equal to the *average* separation of the slanting glass, the two perform equally well across the band.

(c) If the parallel glass separation is equal to the *minimum* separation of the slanting glass, the slanted glass is definitely superior by 1 to 4 dB across the band, an average of 3 dB. These tests, which focus attention on the importance of *average* interpane separation, led Quirt to say, "nonparallel glazing does not appear to offer any significant benefits." *Quid est demonstratum* (QED).

The above discussion pertains only to transmission loss. Other external factors may be affected by how the glass is inclined. For example, light reflections in the window are affected by inclination of the glass, but recessed light sources control such reflections much better. The effect of acoustical reflections on the studio side may sometimes be a minor consideration to program quality.

WEAK WINDOWS IN A STRONG WALL

It is much more difficult and expensive to build an STC 55 window than an STC 55 wall between studio and control room. A nice little trick is to build the wall heavier than required to compensate for a weaker window because the sound penetrating the partition involves the window area, the remaining wall area, and the STC values of each. Let us say that a window of 32 square

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feet is set in a 12- by 20-ft. wall (240-32=208 sq. ft.), and that the favored window construction yields STC 45 and the wall construction yields STC 55. The STC rating of the wall-window combination may be found by the following formula:

$$\text{Combined STC} = 10 \log \left(\frac{S_g}{10^{\frac{STC_g}{10}}} + \frac{S_w}{10^{\frac{STC_w}{10}}} \right) \quad (1)$$

where:

S_g = fractional surface of glass window,
S_w = fractional surface of wall,
STC_g = STC rating of glass window,
STC_w = STC rating of wall.

The fractional window area is 32/240 = 0.133. The fractional wall area is 208/240 = 0.867. Substituting these figures and the STC values in equation (1) yields:

$$\text{Combined STC} = 10 \log \left(\frac{0.133}{10^{\frac{45}{10}}} + \frac{0.867}{10^{\frac{55}{10}}} \right) \quad (2)$$

where:

Combined STC = 51.6

The STC 45 window can then be tolerated if STC 50 were the overall goal for the partition.

PROPRIETARY WINDOWS

Many studio windows are built by workmen who have never built one before and who do not appreciate the fine points of resiliently mounting the glass panes, caulking, etc. The same may often be said of the supervisor. Unless constantly watched by someone knowledgeable in acoustically significant details, the transmission loss of the resulting window can easily be degraded in spite of good intentions. For these reasons, the use of proprietary windows may make good sense. Excellent prefabricated windows of known performance are available at reasonable prices from numerous sources.

Typical prefab windows in the recording studio of the U.S. Naval Training Devices Center, Orlando, Florida, are shown in FIGURE 4. These windows were supplied by Industrial Acoustics Company.[7] The construction of several high TL windows supplied by IAC is illustrated in FIGURE 5. Sound Transmission Class ratings of STC 47 and higher are available in double glazed and even higher in custom-designed triple glazed windows.

Figure 4. Proprietary windows in the recording studio of the U.S. Naval Training Devices Center, Orlando, Florida.
(Courtesy Industrial Acoustics.)

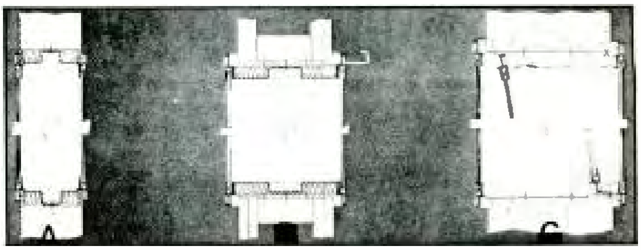

Figure 5. Constructional features of high transmission loss windows supplied by Industrial Acoustics Company: (A) Standard Noise-Lock Window, 4-inch (25mm) Moduline® Panel; (B) standard double glazed Noise-Lock Window utilizing split frame for new or existing openings; (C) custom triple glazed design for split or fixed frame.

SUMMARY: OPTIMIZING THE DOUBLE GLAZED WINDOW

To increase window transmission loss:

- Use large interpane spacing
  (3 dB TL gain for each doubling of space)
- Use heavy glass
  (6 dB per doubling of surface mass)
- Use different thicknesses of glass
  (Stagger coincidence dips by 2:1 in frequency)
- Use thick absorbent on edges of interpane cavity
  (To control interpane cavity modes)
- Use laminated glass
  (For very high TL windows)
- Inclining glass panels not justified by transmission loss measurements. ■

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1. Quirt, J. D. "Sound Transmission Through Windows—I Single and Double Glazing." *Jour. Acous. Soc. Am.*, Vol. 72, No. 3 (September 1982) pp 834-844.
2. *Breaking The Sound Barrier*. Brochure AR-3, Libby Owens Ford Company.
3. Rettinger, Michael. "Angled Control-Room Window Sound Diffraction Phenomena—A Practical Solution Using Laxon Plastic Panels." *Recording Engr./Prod., Vol. 12 No. 2 (April 1981) pp 58, 60.*
4. *Rettinger, Michael, Studio Acoustics*, Chemical Publ. Co., Inc., New York (1981), page 82.
5. Industrial Acoustics Company, 1160 Commerce Ave., Bronx, New York 10462, phone (212) 931-8000. Their bulletin 3.1002 describes standard and Custom Noise-Lock® Window details.

Other Helpful Papers

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Quirt, J. D. *Measurements of the Sound Transmission Loss of Windows*. Division of Building Research Note No. 172 (April 1981), National Research Council of Canada, Ottawa.

Cops, A. and H. Myncke, "Sound Insulation of Glass By Means of Scale Models." *Acustica*, Vol. 31 (1974) pp 143-149.

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