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THE PROBLEMS OF USING SINGLE FIGURE INDICES TO DESCRIBE THE ACOUSTIC PERFORMANCE OF TRADITIONAL AND NEWLY DEVELOPED WINDOWS

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INTRODUCTION

A recently completed comprehensive test programme has been used to investigate the acoustic performance of traditional glazing and to develop new types of windows with enhanced acoustic properties.

When compiling the data the opportunity was taken to calculate single figure ratings such as R_w and STC alongside the normal one third octave band sound reduction indices to provide a simple means of describing the acoustic performance of the glasses.

The use of the R_w index has become increasingly popular since its introduction into the United Kingdom in 1980 [1] and comparisons of published data on building elements on an international basis are now common place and indeed have been made easier with the introduction of the unified standard under the auspices of the International Organisation for Standardisation [3].

The R_w index is basically similar to, though not quite the same as, the American STC rating [2] which was originally devised to describe the acoustic performance of internal partitions and not facade elements.

To test the effectiveness of the R_w index to describe window performance the insulation of a number of glazing units of increasing complexity has been compared in terms of one third octave band SRI, R_w, STC and arithmetic mean value R_m. To facilitate comparisons with the practical situation a further unit has been devised known as the traffic noise rating $R_{traffic}$ and is computed by calculating the 'A' weighted insulation with reference to an idealised traffic noise spectrum.

MONOLITHIC GLASS

Laboratory measurements have been made over a variety of thicknesses from 3 to 25mm and single figure indices calculated for each. A comparison is made in figure 1 which shows the relationship between each index and glass thickness and hence mass/unit area. The influence of the coincidence resonance on the insulation curve readily explains the small deviations (figure 2).

LAMINATES

Previous work has shown the acoustic value of laminating single panes of glass and its dependence on the properties of the laminating material [4]. Table 1 shows the effect of increasing the thickness for both polyvinyl butyrate (PVB) and polymethylmethacrylate (PMMA) interlayers.

Table 1.

GLAZING		R_m	R_w	STC	$R_{traffic}$
Laminate PMMA	3/1/3	32.5	36	36	29.9
	3/1.3/3	33.3	37	37	31.1
	3/1.5/3	33.4	37	37	31.0
	3/1.9/3	33.8	38	38	31.0
	3/3/3	34.4	38	38	31.9
Laminate PVB	3/.38/3	29.5	33	33	28.4
	3/.76/3	30.7	34	34	29.4
	6/1.52/6	36.5	37	37	33.2
	4/.38/4/.38/4	35.0	38	38	33.5
	3/.38/3.38/3/.38/3	35.0	38	38	33.5
	3/.38/2/.38/2/.38/2.38/3	35.7	39	39	34.0

Increasing the thickness of PMMA laminates from 1 to 3mm produces a 2dB increase in all indices. The lower insulation of glazing constructed with the stiffer PVB laminate is also demonstrated with each index although the $R_{traffic}$ is relatively higher than the others. The laminates 3/1.5/3 (PMMA) and 6/1.52/6 (PVB) exhibit the same R_w (=37dB) but $R_{traffic}$ for the heavier unit is 2.2dB higher due to a better low frequency performance.

The additional insulation gained by multiple laminating as reflected by the indices is shown in table 1. The improvements are small and exaggerated slightly by the R_w index.

SEALED UNITS

The values of single figure ratings for various double glazed sealed units are shown in table 2. The improvement in insulation obtained by increasing the thickness of one pane to avoid coincidence resonance is demonstrated by all indices.

Table 2.

GLAZING		R_m	R_w	STC	$R_{traffic}$
Double glazed	4-12-4	29.0	31	31	24.8
	4-12-6	31.5	34	34	26.8
	4-12-10	33.8	36	36	27.9
Triple glazed	4-12-4-12-4	31.6	32	32	24.9

The situation becomes more complex with the introduction of triple glazing. Although the improvement in acoustic insulation is marginal (R_m = 1.6dB, R_w = 1dB) when coupled with the apparent gains in thermal insulation the triple glazed unit appears to have much to offer. However a more pronounced mass-air-mass resonance has held down the $R_{traffic}$ and recent advances in coatings technology have produced a double glazed unit of comparable thermal performance. By increasing the thickness of one pane to give dissimilar glasses, a much improved lighter and thinner unit is produced. If constructed with coated glass both the acoustic and thermal insulation properties are better than those of a triple glazed construction (figure 3) e.g. Kappafloat.

Increasing the complexity of multiple glazing based on 6mm glass effects the following changes in performance.

Table 3.

GLAZING		R_m	R_w	STC	$R_{traffic}$
Double glazed	6-12-6	30.0	33	33	26
	6-12-3/.38/3	30.9	34	34	27
	6-12-10	34.1	38	38	32
Triple glazed	6-12-6-12-10	35.0	39	39	31

Laminating one pane smooths the coincidence resonance slightly but the basic spectrum is otherwise little changed (figure 4).

On employing one pane of significantly different thickness a more favourable and radical change in performance is achieved, not only in R_m and R_w but more pertinently in $R_{traffic}$.

If this configuration is extended to include a further pane of 6mm glass the extra cavity produces a deep low frequency resonance which is not identified by changes in R_m and R_w, indeed a marginal improvement is indicated. $R_{traffic}$ however decreases and therefore gives due weight to the modified spectrum.

Table 4.

GLAZING			R_m	R_w	STC	$R_{traffic}$
Double glazed :	with air	4-12-6	31.5	34	34	26.8
	with argon	4-12-6	31.5	34	34	26.3
	with SF_6	4-12-6	33.5	36	33	26.1

Gas filling is a technique which has been introduced to improve the performance of the narrow airspace sealed units. In particular the heavy molecule gas, sulphur hexafluoride (SF_6), has a significant influence on R_w but not necessarily to practical advantage since there is a reduction in $R_{traffic}$. This is largely due to the low frequency resonance, as yet not fully explained, which is a feature of all SF_6 filled units. Interestingly the STC value does take account of this feature and as such is probably a better indicator of performance (figure 5).

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COMMENTS

The above real examples of window performance have highlighted the limitations of R_m and R_w as reliable indicators.

Table 5.

GLAZING	R_m	R_w	STC	$R_{traffic}$
Idealised window	30	30	30	30
Idealised window with LF resonance	28	29	29	22
Practical high performance unit	40.8	45	45	37

To illustrate this point further table 5 and figure 6 show an idealised flat spectrum window and how its associated indices are affected by the introduction of a substantial low frequency resonance. Nowhere does the shortfall exceed 8dB so that the resonance need not even be reported as required by BS5821:1984. By using soft interlayer materials in the unit construction the characteristic resonances can be shifted up the frequency range so that not only are R_m and R_w favourably modified but the attenuation of noise spectra with dominant low frequencies is significant (figure 7).

In general for simple glasses the correlation between all indices and the actual insulation against traffic noise is reasonable but it generally worsens with increasing complexity of construction. In particular R_w is too tolerant of low frequency resonances.

REFERENCES

[1] British Standard BS.5821:1980.

[2] American Society for Testing Materials E413-73.

[3] British Standard BS.5821:1984 (ISO 717-1982).

[4] G Kerry and R D Ford, "Temperature Effects on the Sound Insulation of Laminated Glass", Proc 11 ICA-1983 Vol 7, p191.

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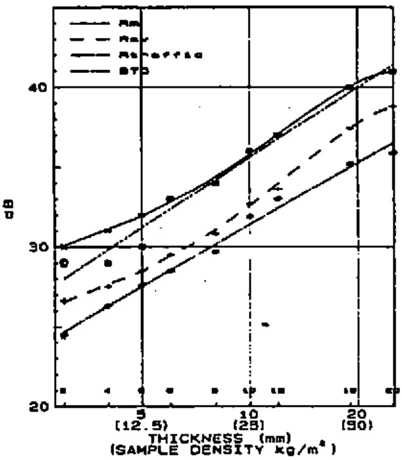

Figure 1

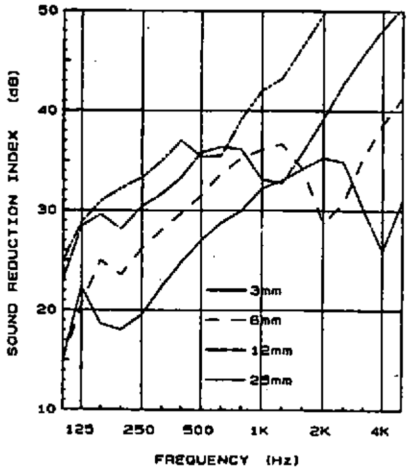

Figure 2

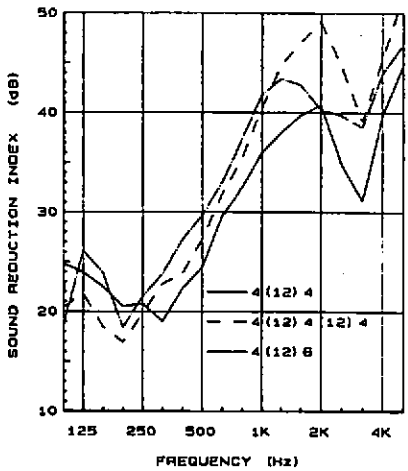

Figure 3

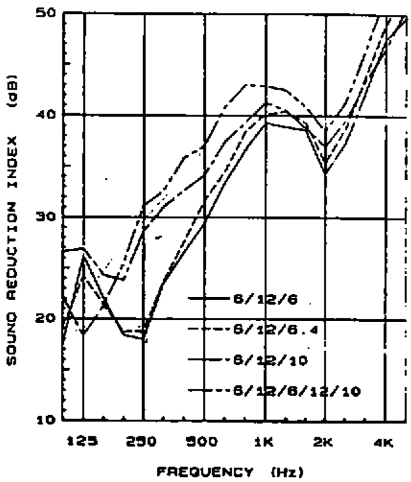

Figure 4

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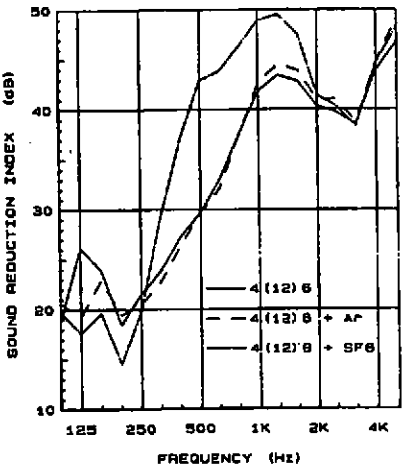

Figure 5

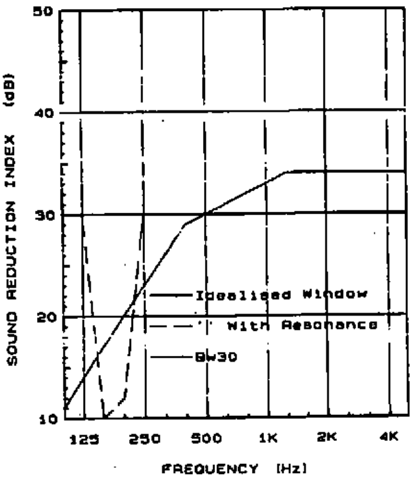

Figure 6

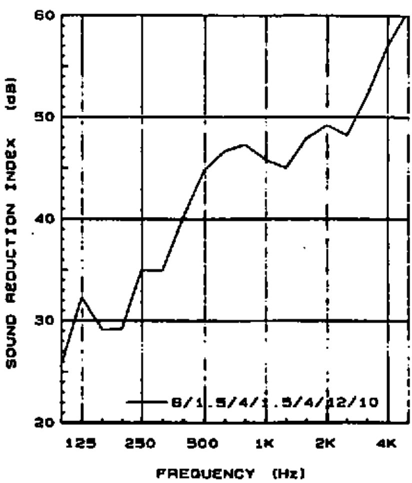

Figure 7