ACOUSTICS FOR GLASS AND LAMINATES

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ABSTRACT

Glazing chosen for window vision panels can affect interior noise quality. Both empirical and theoretical differences exist between monolithic and laminated glasses and multiple-pane glazing units which affect performance. Test guidelines for measuring third-octave band transmission loss and classifying acoustic properties of glazing units without frames are being developed. Single-value parameters, such as STC and Rw, can be useful for ranking materials. However, an improved approach to full octave band representation is possible, which can have significant advantages for product design and applications.

INTRODUCTION

It is extremely important that glass products industries world-wide anticipate and accelerate preparations for future applications involving ever- increasing demands for extended product performance data and technology upgrades in the highly competitive market places of the next millennium.

This is particularly relevant for products such as laminated glass, monolithic glass and multiply-leaved units comprising combinations thereof, including gas-spaced arrays of such structures. Product optimization and differentiation, new products, improved field applications and installations, product quality, value and overall performance will all be realized and enhanced, going forward, as the paradigm shift to use octave band (and in some cases one-third octave band) data, as proposed herein, is implemented.

Key points are:

- Design by analysis is the future for optimizing performance.
- A systems approach to wall design is essential.
- Octave band data (at minimum) are more appropriate to these design processes than single ratings.
- Variability in laboratory test data for gas-spaced double windows requires further investigation.

Safety and acoustical performance can be synergistically combined uniquely and compactly in laminated glass structures to enhance product value, particularly where the frequency range of the offending noise spectrum receives detailed, frequency band by frequency band consideration in specific applications, including those governed by octave band criteria, for example Preferred Noise Criteria (PNC).

Glass products industries world-wide have for many decades invested large sums of money conducting acoustical product performance evaluations, particularly Transmission Loss (TL) tests, using procedures specified in ASTM E90-90, ASTM E336-1984 and ISO140, Part 1, 1978, for example. For the most part, these classical tests have been performed in world renowned laboratories capable of producing impeccable data, for example Riverbank Acoustical Laboratory, founded earlier in this century by the eminent Wallace Sabine, Professor at Harvard University.

The overriding historical challenge has been how to best interpret and apply laboratory performance data to real world, on site applications, particularly as required by architects, engineers, contractors, builders, and other practitioners faced with meeting specific, quantitative, and subjective performance goals and objectives.

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The underlying technical question is: Can the aforementioned laboratory test data acquired primarily for purposes of product comparison and differentiation on a relative basis, be used to determine scientifically and objectively expected product performance in specific field applications with a reasonable and acceptable degree of predictability?

We shall address these questions and related problems in this discussion and provide some insight into key areas that are significant determinants of the acoustical performance of laminated glass as an example of how the inevitable paradigm shift noted earlier can be implemented in a timely manner going forward.

LABORATORY TEST DATA AND ITS APPLICATIONS

Standard formats for laboratory test records documenting Transmission Loss (see the aforementioned test procedures) present third-octave band data, usually between 100 and 8000 Hertz (Hz). We recommend the addition of the 10,000 Hz and 80 Hz third-octave band measurements (with appropriate qualifications) to the existing test procedures. It is understood that many practitioners prefer to have this data reduced to a single number rating such as STC, OITC, and Rw, for example. It is not the purpose here to dissuade those who find these ratings useful for comparative purposes and/or in day-to-day applications of products. However, we wish to point out that there are many sophisticated product potentials and applications that will gain discovery and increasing importance, progressively becoming easier to implement, as high performance computational acoustics advance this technology into the next century. This is particularly true where the technology for application of third-octave and octave band data sets can be used with computer codes and advancing software to compare expected field performance with quantitatively and spectrally defined specifications as the future bases for product evaluation, selection, product differentiation and establishment of system compatible installation requirements. The emerging and major upgrades of the near future involve incorporation of finite geometries and realistic boundary conditions that characterize real-world installations.

Consider the many well-accepted approaches to limiting noise penetration from outdoor source arrays to indoor spaces, for example applications of laminated glass products, particularly those characterized by octave band specific PNC criterion curves, NC, NCB and the like. In such cases, it is most convenient, for example by methods of ASTM E90-90, to convert standard third-octave band test data to octave band Transmission Loss values. Using these data, in conjunction with appropriate adjustments accounting for the practical physical boundaries and installation requirements, with applicable computer codes, product candidates can be selected or designed to meet the requirements specified for interior spaces, given a defined spectrum for the outdoor, or otherwise impinging, noise on the exterior surface(s) of the structure.

In these typical applications, third-octave and derivative octave-band test data are critical to estimating and evaluating on-site product performance. Such applications represent the future for glass structures as well as other architectural and building products in an evolving design by analysis and systems engineering environment.

Since existing noise criterion curves are in octave bands, not to be exceeded when specified, it must be recognized that corresponding or equivalent single number ratings, including for example, the equivalent dB(A) level for each curve, will in general be non-unique. That is to say, for example, that compatible NC Criterion Curves cannot be derived uniquely from a given equivalent dB(A) level which may be used to provide or specify a single number criterion limit.

In "Acoustics in Physics and Engineering," Acustica, 52, No. 3, pp 128-147, the published account of Dr. K. U. Ingard's honors lecture presented as recipient of the Institute of Acoustic's Rayleigh Medal, it was pointed out that there are important differences between the transmission loss characteristics of single, laminated, and double windows which can have significant practical consequences. The variability in test data for double windows was particularly noteworthy.

For example, the average transmission loss of a double window can vary markedly from one test laboratory or installation to another. This historical fact regarding test data precludes any meaningful or practically useful tabulation of generic performance data, for example that proposed in Table 1 of the CEN DRAFT PrEN 12758-1, "Glass in Building—Glazing and Airborne Sound Insulation," as constituted in its current stage of development. It is intended that these matters will be discussed in more detail in the near future, particularly concerning adaptations of transmission

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loss data to glass structures of finite size and future implications concerning laboratory testing of gas-spaced units. The tools and computer codes necessary for advanced product design and application by analysis are not currently available in the public domain.

Finally, it is well known that for laminated glass structures comprising two or more leaves of glass with elastomeric inner layer(s), structural damping is extremely important in determining transmission loss as a function of frequency and, inversely, temperature. Since structural damping is operative in the resonance and coincidence regimes for laminated structures, performance will depend upon the damping efficiency in these regimes.

While single number ratings tend to obscure these product-differentiating features, octave band criteria (and/or third octave band criteria) highlight opportunities for optimization of structural damping, particularly where specific and unique aspects of performance are essential in designing products by analysis to meet specifications that are not necessarily limited to single numbers.

For example, in designing laminated glass products that function in defense of the intrusion of road noise, specific low-frequency performance objectives could be considered paramount. In such applications, the technological advances identified with the paradigm shift recommended in this discussion, in addition to the demonstrated capabilities using appropriate elastomeric materials (polyvinyl butyral, Butacite®, for example), can prove extremely helpful to users in achieving criteria specified as not-to-be- exceeded noise level limits in octave bands.

CONCLUSION

It is extremely important to realize the maximum use of test data obtained under standardized methods and procedures. Future growth of the glass products industry world-wide will depend upon the development of new technology to facilitate product and application design by analysis as a value-adding approach to better satisfy existing customers and ease penetration of new markets. Some key aspects and features of the paradigm shift necessary to trigger this progression to a new "high-tech" threshold for the next century have been discussed, and the intention is to continue these discussions in appropriate forums as technology and insight continue to evolve in this area.

It should be noted that the United States Technical Advisory Group (USA TAG) to ISO/TC160/SC2/WG3 on "Airborne Sound Insulation of Glazing" is currently drafting a method that is directed to facilitate implementation of the path forward outlined in this discussion.

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