Proceedings of the Institute of Acoustics

# THE RELEVANCE TO THE REAL WORLD OF EC INTERCOMPARISON STUDIES ON THE SOUND INSULATION OF WINDOWS

A J Jones (1), G Kerry (2)

(1) Acoustical Investigation & Research Organisation Limited
(2) Department of Applied Acoustics, University of Salford

## 1. INTRODUCTION

As part of the EC research and development programme into the field of applied metrology and reference materials the Community Bureau of Reference (BCR) instigated an intercomparison study into the measurement of sound insulation of window panes in thirteen European laboratories. The results of this study have been published [1] and in an earlier paper [2] the contribution made by the two UK participating laboratories AIRO and SALFORD was described along with the more important findings.

That study raised a number of important issues and BCR agreed to support further work aimed at both improving measurement confidence and at introducing factors relevant to real installations. These included:

A) Intercomparison of measurements of noise attenuation by double glazed windows in frames.

B) The effect of window pane mounting methods on noise attenuation measurements.

C) The development of guidelines for the choice of loudspeaker positions for building acoustic laboratory measurements.

In addition, as part of studies A and B, participating laboratories were asked to extend their measurements down to 50Hz.

Seventeen European laboratories took part in A and seven laboratories in B but C was restricted to three participants. SALFORD took part in A and B and AIRO in A.

## 2. INTERCOMPARISON OF MEASUREMENTS OF NOISE ATTENUATION BY GLAZED WINDOWS IN FRAMES

This work was co-ordinated by the Belgian laboratory C.S.T.C. and the French laboratory C.S.T.B.[3]. It was planned as a continuation of the previous study but using real building elements and the prescribed test procedure, which, from the previous study was shown to produce closer results than those obtained by the various laboratories using their normal procedures. The test specimens were full opening windows and each laboratory received one frame and two sets of windows pre-mounted with two different panes, namely:-

Glass A - 6(16)6, a sealed double glazed unit comprising two leaves of 6mm monolithic glass separated by a 16mm airspace.

Glass B - 4L4(6)8, a sealed double glazed unit comprising one leaf of 4mm glass laminated to a second 4mm glass and separated by a 6mm airspace from a second leaf of 8mm monolithic glass.

These "real" window test specimens differed from the panes previously tested in that the glass was smaller, the airtightness of the specimen was questionable, and a complex mounting method was introduced between the window frame and the test opening.

The test opening was the same as that defined previously (as in ISO 140-1, 1990) although each test laboratory was free to make up the filler wall depending upon its own circumstances.

As in the previous intercomparison a set of test specimens for each participating laboratory was manufactured and the homogeneity checked by one laboratory before distribution.

The test programme involved the measurement of the sound reduction index R for each test sample:

i. using the prescribed mounting and measuring methods

ii. using the mounting and measuring methods normally used in the laboratory

iii. using the prescribed mounting and measuring methods with additional sealing between opening and fixed parts

iv. using a sound intensity technique (optional)

In addition, by measuring the 4L4(6)8 specimen six times using the prescribed mounting and measuring methods, the repeatability in respect of measurement method was determined. A similar set of measurements but with the specimen removed and replaced six times enabled the mounting repeatability to be determined. A third set of repeatability measurements was made with the sashes fully sealed with a suitable medium such as adhesive tape in order to determine the performance when fully airtight.

Each laboratory determined the maximum insulation it was capable of measuring in that configuration by replacing the test specimens with the double and single metal sheets provided for the previous test programme [1].

Laboratory number 17 did not supply results in accordance with the project requirements and the initial analysis of Laboratory number 6 was unacceptable. Therefore the main body of the report, 384 pages, is based upon results from the remaining fifteen laboratories. With a report of this length it is only possible to summarise certain aspects.

Table 1 summarises the results of tests in terms of Weighted Sound Reduction Index (calculated to 0.1dB for the purposes of the study) for the two window types. In Figures 1 and 2 the relevant results from AIRO and SALFORD are compared with the mean from all 15 laboratories which participated in the standard range tests.

SOUND INSULATION OF WINDOWS

Figure 1
Glass Type A 6/16/6

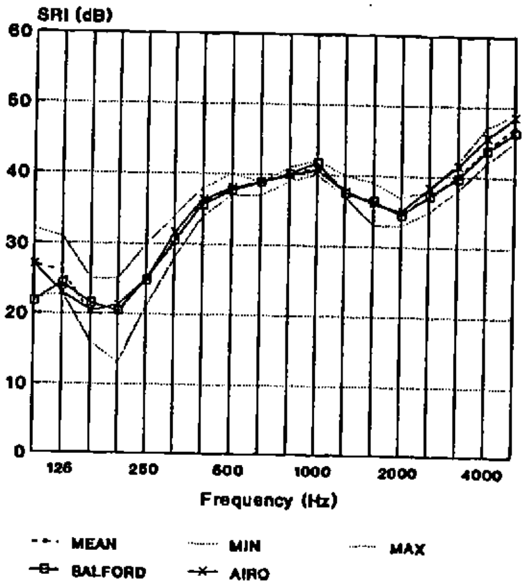



Figure 2
Glass Type B 4L4/6/8

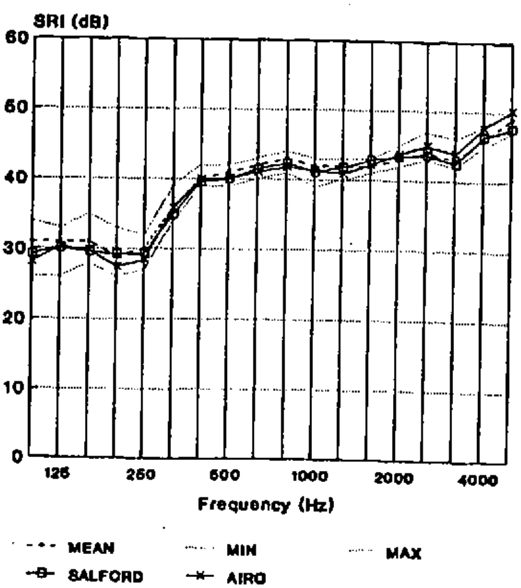


Table 1 Statistical Analysis of Weighted Sound Reduction Index values with different measurement techniques for the two window types

| Test Sample | Measurement Technique | Weighted Sound Reduction Index (Rw in dB) Mean | Spread | Std Dev |
|---|---|---|---|---|
| Glass A | Prescribed | 36.2 | 4.7 | 1.2 |
| 6(16)6 | Normal | 36.2 | 3.2 | 0.9 |
| Glass B | Prescribed | 41.9 | 2.2 | 0.6 |
| 4L4(6)8 | Normal | 41.8 | 3.4 | 0.8 |
| R'max | Prescribed | 62.5 | 15.0 | 4.3 |

The spreads of results for the two windows are comparatively small, but are however larger than in the previous study [1]. This may of course be due to differences in these samples as they were openable. The large spread in R'max is attributed primarily to the type of construction used. Some laboratories used the methodology of the previous study (double and single metal panels) whilst others reconstructed the masonry wall, and a third group, which included those participating in the study for the first time, tried to produce their own metal panels. A standard methodology for obtaining the maximum sound insulation was not included in the project instructions and this may therefore have contributed to the wide range of results for this aspect. However, in all but a few cases the maximum sound insulation was significantly above that of the test windows so as to not influence the main body of results.

Glass A of this study and the glass pane of the previous study both had the same 6(16)6 construction. Figure 3 compares the mean result from the two studies in terms of the prescribed mounting and measuring methods.

This shows that the resonant and coincident frequencies have not changed and are not influenced by the window frame. The sound insulation has however changed and is approximately 2dB higher at resonance, 5dB higher at coincidence and 4dB higher overall when mounted in the frame. Analysis of the data indicates repeatability is better but that reproducibility, although better at mid and high frequencies, is worse at low frequencies. It has been suggested that these may have been influenced by the choice of test samples.

SOUND INSULATION OF WINDOWS

Figure 3
Glass A Comparison with Previous Test

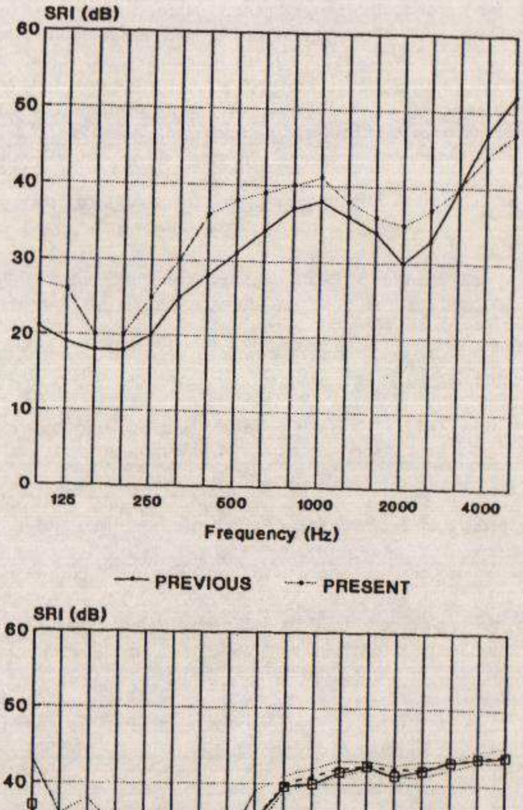
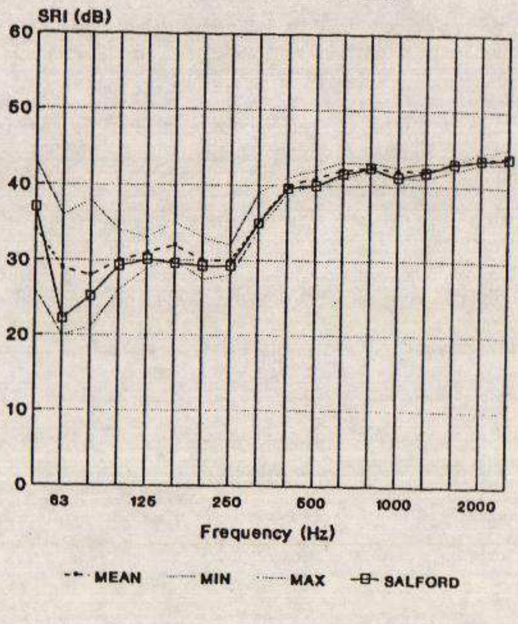



Figure 4
Glass Type B
(Low Frequency Results)



SOUND INSULATION OF WINDOWS

Nine laboratories performed the optional very low frequency (50 to 80 Hz) measurements. Data from one laboratory (No. 8) was unsatisfactory and therefore further analysis was based on 8 laboratories only. Figure 4 shows the range of Sound Reduction Index measurement for the 8 laboratories (1 measurement /laboratory) for Glass B. Unsurprisingly, the spread of results is greater at the very low frequencies. What may be surprising is that the interlaboratory repeatability is never greater than 3.5dB in these bands and is better than the ISO requirement of 4.5dB at 100Hz.

## 3. THE EFFECT OF WINDOW PANE MOUNTING METHOD ON NOISE ATTENUATION MEASUREMENTS

These measurements were carried out on window panes using the prescribed measuring method used in the previous study. Three test specimens were provided for each laboratory:

Glass I – 6/16/6, a sealed double glazed unit comprising two leaves of 6mm monolithic glass separated by a 16mm airspace (used in the previous study).

Glass II – 6/12/4, a sealed double glazed unit comprising one leaf of 6mm monolithic glass separated from a second leaf of 4mm monolithic glass by a gas filled 12mm space.

Glass III – 13L/16/9, a sealed double glazed unit comprising one leaf of 13mm laminated glass separated from a second leaf of 9mm monolithic glass by a 16mm airspace.

Homogeneity testing was carried out by one laboratory before distribution.

Each test specimen was to be tested when mounted in the test aperture defined as in the previous study using three methods. These methods follow mounting procedures generally practiced in different countries in the EC.

Method A – using putty and timber lists (beads) and a defined installation procedure;
Method B – dry mounting using compressed rubber;
Method C – dry mounting using rubber press–in profiles and slatted timber lists.

Additional variations on dry mounting methods B and C were:

i. the gap between the test specimen and the side of the test opening was either left empty, filled with the uncompressed mineral wool or filled with foam.

ii. the joint was sealed with a top sealant of adhesive tape or silicone.

The results were analysed by Physikalisch–Technische Bundesanstalt, (PTB, Germany).

SOUND INSULATION OF WINDOWS

OVERALL MEASURED SOUND INSULATION Rw (dB)

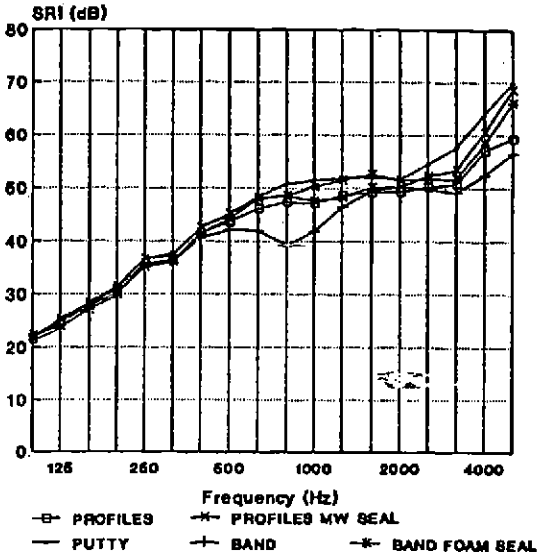
| Method | Infill | Seal | 6/16/6 | Class Type 6/12/4g | 13L/16/9 |
|---|---|---|---|---|---|
| Putty | | | 32.5 | 35.9 | 46.2 |
| Band | | | 30.7 | 34.3 | 43.1 |
| Band | | tape | 30.8 | 34.8 | 45.3 |
| Band | Min wool | | 30.9 | 34.5 | 44.4 |
| Band | Min wool | tape | 31.2 | 34.9 | 45.1 |
| Band | Foam | | 30.7 | 34.3 | 43.9 |
| Band | Foam | tape | 30.9 | 34.8 | 45.1 |
| Band | Foam | silicone | 31.0 | 34.8 | 45.2 |
| Profiles | | | 31.1 | 34.5 | 45.3 |
| Profiles | | tape | 31.4 | 34.8 | 45.8 |
| Profiles | Min wool | | 31.2 | 34.5 | 45.7 |
| Profiles | Min wool | tape | 31.5 | 34.9 | 45.9 |
| Profiles | Foam | | 31.1 | 34.5 | 45.7 |
| Profiles | Foam | tape | 31.4 | 34.7 | 45.7 |

The results of the measurements obtained at Salford [4] are summarised in the above table in terms of the Rw index. These results are similar to those produced in the other laboratories and may be used to illustrate the conclusions. Examples of some of the SRI curves obtained with the laminated glass are given in figure 5.

The putty method of mounting gave not only the highest Rw for each type of glass but also the most reproducible result between laboratories. Quite clearly, effective sealing of the glass is important but making the joint airtight is not enough – it is also necessary to fill the joint with a material with some weight.

Press-in rubber profiles are also preferable to simple rubber bands but top sealing is necessary in order to maintain performance at high frequencies.

Figure 5
Laminated Glass 13L/16/9




## 4. THE DEVELOPMENTS OF GUIDELINES FOR THE CHOICE OF LOUDSPEAKER POSITIONS FOR BUILDING ACOUSTIC LABORATORY MEASUREMENTS

This work was carried out by three laboratories, Physikalisch-Technische Bundesanstalt (PTB-Germany), Jysk Teknologist (JYTEK-Denmark) and TNO Institute of Applied Physics (TNO-Netherlands).

They carried out a series of systematic measurements and calculations of average sound pressure levels in the diffuse sound fields for a great number of loudspeaker positions together with an investigation of the sound field close to the test specimen, modal analysis of the sound fields in the source room and a statistical study of the measurement precision.

The general conclusions given in [5] indicate that moving the sound source results in large variations in the difference between source and receiving room levels. In addition the location of the source relative to the room boundaries, the size of the rooms and even the position of the test specimen in the common wall and their absorptive characteristics, all effect the reproducibility of an SRI measurement.

An experimental procedure was proposed by which a set of optimum loudspeaker positions could be established and which when used should ensure that the total reproducibility is only slightly affected by the adoption of a limited number of loudspeaker positions.

This procedure has been adopted by the ISO committee revising ISO 140 (BS 2750) and appears in [6].

## 5. THE RELEVANCE OF BCR BUILDING ACOUSTICS PROJECTS TO THE EUROPEAN FREE MARKET

It should be obvious from the above that BCR studies have had a significant influence on European Laboratories and the interpretation of test results.

The original intercomparison not only highlighted obvious faults in the test procedure, it also enhanced the confidence of those laboratories taking part and led to the adoption of a common mounting and measuring method. Laboratories which produced results significantly removed from the average were able to investigate further their techniques.

The second intercomparison moved a little closer to reality and highlighted the problems in testing real windows, especially the effect of airtightness which is a difficult variable to control. National preferences in window frame design can influence results.

The work on window mountings clearly showed up the differences likely to be encountered when glass is installed using "local practices". Such detail possibly accounts for many of the differences observed in data from windows ostensibly of the same make up.

The loudspeaker investigation should lead to improved reproducibility when the experimental procedure proposed is adopted by test laboratories.

The work of BCR is aimed primarily at removing trade barriers between the Community countries. Recently revisions of ISO 140 Part 1 and 2 have been published and incorporate many of the findings from the various BCR projects. Unfortunately the BS versions of Part 1 and 2 have yet to be published. Part 3 is still with the ISO working group but should be published in the near future, whilst further works are also in progress to revise the remaining parts of ISO 140.

The future should be an interesting period in building acoustics for the test laboratories as they modify their procedures to meet the revised Standards. The BCR work has so far been based on small samples and it therefore remains to be seen how these procedures, particularly the loudspeaker positions, will adapt when full size samples are tested.

## REFERENCES

[1] Intercomparison of Laboratory Sound Insulation Measurements on Window Panes. Report EUR 11576 EN.

[2] A J Jones & G Kerry, EEC Intercomparison Studies on Window Insulation, PROC IOA Vol. 10, Part 8, (1988)

[3] Intercomparison of Measurements of Noise Attenuation by Double Glazed Windows in Frames. CSTB Study No. 188.002/2 (1991).

[4] G Kerry, The Effect of Window Pane Mounting Methods on Noise Attenuation Measurements. University of Salford report prepared under BCR Contract 3159/1/0/078/87/7-BCR-D(30), 1989.

[5] The Development of Guidelines for the Choice of Loudspeaker Positions for Building Acoustic Laboratory Measurements. Report EUR 13380 En.

[6] Draft for ISO DIS 140-3 (ISO/TC 43/SC 2 N473 March 1991).