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FIELD MEASUREMENT OF ROOM ACOUSTICS

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Abstract.

With the increasing number of acoustical standards and the increased complexity of measurement, there is a need for a field measurement method that that assures adherence to both national and international standards in addition to being less susceptible to problems that make a re-measurement necessary. For example, it is advantageous to analyse the validity of the measurement conditions before making the measurements in addition to analysing the results before finishing the test. A software program has been developed with four modules; reverberation time, sound transmission loss, noise and loudness ratings, and impact isolation. The program is active in that the measurement system is controlled automatically by the software. The conditions of measurement are reported prior to completion of the tests, for example in transmission loss, contamination by excess background noise is detected and reported before the rating is calculated so that a valid measurement can be made the first time. Other features include the direct calculation of measurement uncertainty estimates which can examined for errors immediately after each test. The reverberation time module has some unique features such as the automatic detection of double decay rates and the ability to use both time history and Schroeder methods for impulse measurements.

1.0 Introduction.

In the past few years, the number of neighbourhood noise complaints has risen sharply [1]* . There are a variety of possible explanations which may account in whole or in part for this occurrence; first there has been a lowering of the public's tolerance to noise, second neighbours are becoming increasingly noisy and finally that the standard of sound insulation between respective dwellings is insufficient or indeed deteriorating. In order to identify which of these reasons is the actual cause for complaint, it is necessary to determine the sound insulation of the relevant buildings and their components accurately and efficiently in the field whilst remaining confident that the measurement has been carried out in line with the procedures laid down in the relevant National or International Standards. With this

* Indicates the number of the reference listed at the end of this paper.

in mind, a software program has been developed with four inter-connected modules; reverberation time, sound transmission loss, noise and loudness ratings and impact isolation. The software is used to control a real time frequency analyser which actually performs the measurements. The system is active such that the measurement parameters for each test are controlled by the software and adjusted according to individual site conditions; for example, problems associated with high background noise levels are detected and reported prior to the calculation of the respective rating enabling a valid test to be performed the first time. Other features included in the software are, for example, in the reverberation time module, the ability to automatically detect double decay rates as well as the option to use both the time history and Schroeder [2] methods.

2.0 Measurement Procedures for Sound Transmission Loss.

Although the measurement system is capable of performing room acoustics tests to meet the requirements of both ASTM and ISO standards, reference to ISO alone will be made here.

The measurement system is configured, generally as shown in Fig.1, such that at least one microphone channel is positioned either side of the partition. The frequency range from 100 Hz to 5 kHz is covered in 1/3 octave bands for up to 12 microphone positions on either side of the partition. In order to obtain reliable results first time, the user is stepped through the measurement procedure firstly, performing measurements in the receiving area, secondly in the source area and finally, returning to the receiving area to measure the reverberation time as required. From the time history data collected for each microphone position and each frequency band of interest, test-averaged data for both source and receiving areas are obtained. From these averages, the uncertainties of respective measurements are calculated and displayed automatically by considering the range in dB in which 95% of the measurements have fallen. Receiving room measurements are automatically corrected for background noise down to the background level.

In the receiving room, the acoustic performance of the partition and the location of the sound source in the neighbouring room will determine the level at specific microphone locations. If these levels are not sufficiently far above the background level the measurement accuracy is compromised. Using the software, the maximum background noise level at each microphone position is measured and considered in terms of the receiving room noise levels. In this way inadequate source levels can be detected and corrected before any measurements are taken and stored.

If field transmission loss results are required, rather than simply the noise level difference, the final stage of the measurement is invoked. In this module the user elects to measure the receiving room reverberation time using a number of different options. For example the measurement may be undertaken using either a steady or an impulsive noise source, if a steady noise source is chosen, white or pink noise may be chosen. In addition to this, the reverberation time software also contains some unique features. Adequate level range is obtained by considering the maximum background level in terms of either minimum levels for a steady source or maximum levels of a transient source. It is recommended that the source level be at least 35 dB above background [3], by allowing the source levels to be checked prior to the measurement being taken good data can be readily obtained for all frequencies of interest. Again, the time histories are corrected automatically for background levels in each band.

Other features include the automatic detection of double decay rates. Under certain acoustical conditions, the measured decay of sound in the room comprises of several individual decay rates. A method has been developed whereby the time history, of each 1/3 octave, is examined to determine whether the early decay rate is more rapid than the late decay rate by at least 10%. If this condition is satisfied respective data are separated into early and late decay parts, such that data collected before the 15 dB down point is used to calculate the early decay rate whilst the remaining data determines the late decay rate, Fig.2. The limiting assumption of this method is that the respective early and late decay are uncorrelated and that both are uncorrelated with the background noise. On this basis the time history is iteratively corrected for the other as well as the background sound until a stable separation point is found. From these data, an "early", "late" and "overall" RT are all calculated using linear regression.

In addition to time history methods for calculating reverberation time, the software also contains algorithms to calculate RT using the Schroeder reverse integral method [2]. For further details of this method, the reader attention is drawn to the original paper [2], and for its application in terms of the field measurement of room acoustics, [4].

3.0 Results.

Once all the necessary tests have been performed by the frequency analyser, the permanent data files stored by the analyser are then downloaded to the portable computer for further manipulation and display. As minimum the following test-averaged measures are given as a function of frequency over the range of interest; Source sound pressure level, receiver sound pressure level, noise reduction across the partition, normalized sound reduction (D_{nT}), apparent or field transmission loss (R') and the receiving room reverberation time (if measured). If sufficient individual micrrohone measurement positions have been used the software also calculates respective measurement uncertainties for sound reduction, normalized sound reduction and apparent transmission loss.

The program also calculates directly the single number rating weighted sound reduction index (R_w). In addition to this, in line with the requirements of ISO 717/1-1982 [5], unfavourable deviations of more than 8 dB at a given frequency are also reported. Other ratings are also calculated such as Sound Transmission Class (STC), Noise Isolation Class (NIC) and Articulation Class (AC), the latter being very relevant to speech privacy.

4.0 Discussion and Conclusion.

Traditional methods for the field measurement of room acoustics, in particular transmission loss, have often proved time-consuming, equipment and labour intensive. Computer software has now been developed to work in conjunction with a real-time frequency analyser to simplify the measurement process considerably. In addition to this, because the program is active it allows the measurement system setup to be altered during a measurement to suit individual site conditions thus enabling accurate and appropriate results to obtained ***first time***.

References.

[1] The Independent on Sunday, page 9, 18th December 1994.

[2] M.R. Schroeder. New method of measuring reverberation time. Journal of the Acoustical Society of America, 37, p409, (1969)

[3] ISO 3382/WG. Measurement of reverberation time of rooms with reference to other acoustical parameters.

[4] R.C. Chanaud. A method for field measurement of reverberation time. Proceedings of the Institute of Acoustics, Vol 17, Part 5,(1995)

[5] ISO 717/1-1982. Acoustics - rating of sound insulation in buildings and of building elements - Part: 1, Airborne sound insulation in buildings and in interior building elements.

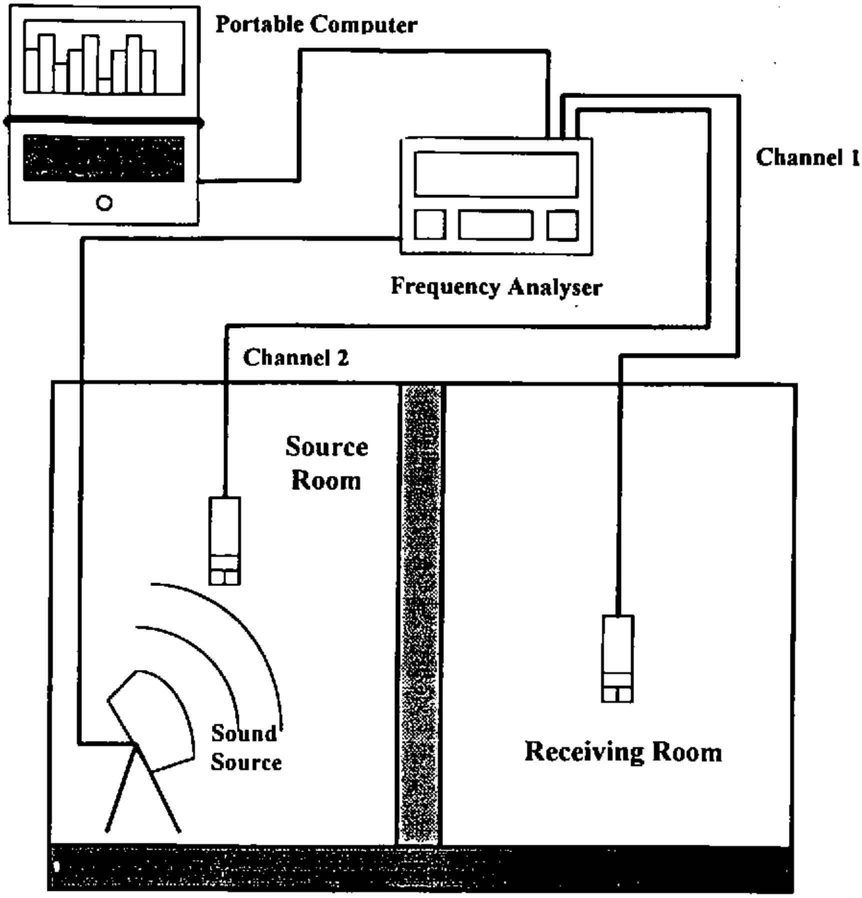

Fig. 1 Schematic representation of the test and instrumentation layout for a typical field transmission loss measurement.

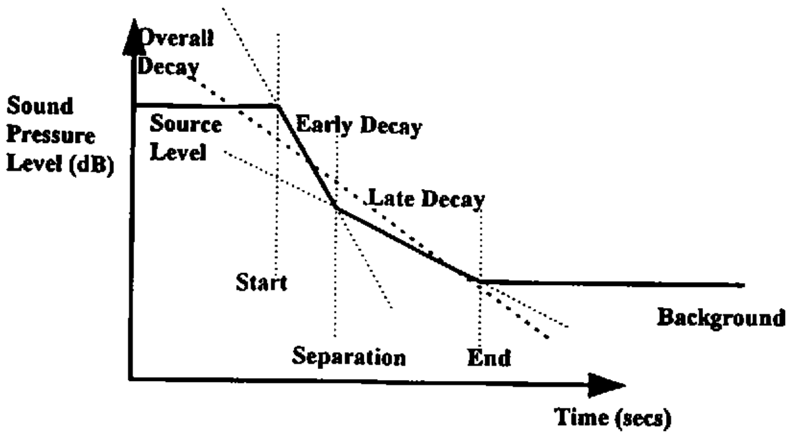

Fig.2 A typical double decay rate.

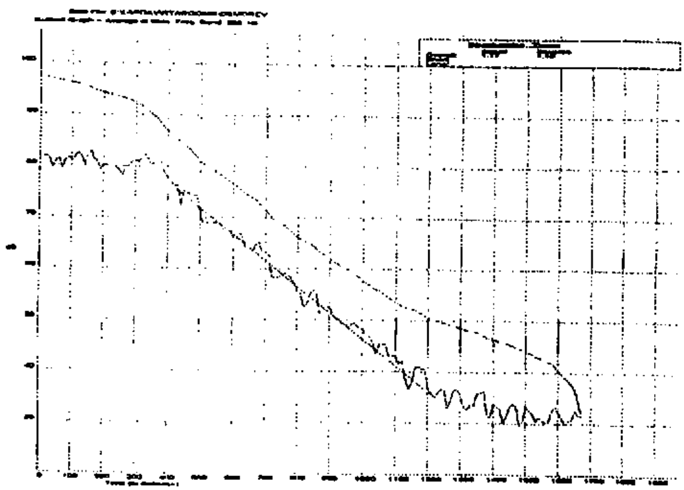

Fig. 3 A typical Rev.Time Result