Acoustics Forum

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CRITIQUE OF ISO 354 (ACOUSTICS – MEASUREMENT OF SOUND ABSORPTION IN A REVERBERATION ROOM)

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The University of Adelaide has an acoustics facility in which transmission loss, absorption and sound power measurements are regularly performed. The facility is used for teaching, research and external consulting. A recent series of sound absorption tests performed there used ISO 354 as the test procedure.

Three sections in the "standard" were considered to be too vague to be easily understood: section 7.2.2 Averaging, the definitions of m_1 and m_2 in 8.1.2.1 and 8.1.2.2 respectively, and equation (8) in 8.1.2.3

AVERAGING.

In section 7.2.2, two methods are stated as being possible for averaging the reverberation times; ensemble averaging and arithmetic averaging. Ensemble averaging averages the decay curves and the resultant "averaged" reverberation time is used in the calculations. I have two difficulties with this method: First, the time domain synchronisation of each decay curve should be within 1% of the shortest decay time. In our lab that would be about 15 ms, otherwise errors will occur in the time domain averaging. Second, while this method does produce an average, on most analysers no variance is calculated. I believe that an average value requires knowledge of the variance to be useful. In fact, the "standard" includes a section (8.2.2) on the use of the reverberation time standard deviation in determining the repeatability of the measurements.

This quote concerns arithmetic averaging: "the single decay curves shall be evaluated first and the resulting reverberation times shall be averaged using arithmetic averaging". The theory relating reverberation time T to the sound absorption uses the decay rate, i.e. a quantity proportional to the reciprocal of reverberation time. A more accurate estimate of sound absorption would be obtained from the arithmetic average of 1/T rather than that of T. In this case the standard deviation can also be easily calculated and the published equation (10) for the relative standard deviation would be replaced with:

$$\varepsilon_{20}(1/T)/(1/T) = \sqrt{\frac{2.42 + 3.59/N}{fT}} \qquad \text{(a)}$$

If knowledge of the repeatability of the measurements of acoustic absorption is required, then arithmetic averaging of the individual decay rates is the best way to proceed.

DEFINITIONS OF m (THE POWER ATTENUATION COEFFICIENT).

In section 8.1.2.1, m_1 is calculated "in the empty reverberation room during the measurement" – I presume that this means during the measurement of the reverberation times for the empty room, i.e. without the test sample.

Then in section 8.1.2.2 m_2 is defined in exactly the same way – but I presume that it should be during the measurement of the reverberation times with the test sample in the empty room.

CALCULATION OF THE EQUIVALENT SOUND ABSORPTION AREA, EQ (8).

The equation in the "standard" used for calculating the sound absorption (8) is a reduced form of the theoretically rigorous:

$$S\bar{\alpha} = \frac{55.25V}{c}\left[\frac{1}{T_{60}} - \frac{(S'-S)}{S'T'_{60}}\right] \qquad \text{(b)}$$

The difference between equation (b) and equation (8) is the term:

$$\frac{S}{S'T'_{60}} \qquad \text{(c)}$$

where S' and T' refer to the empty room

This term is not negligible; if the sample is 10 m^2 and the room ~200 m^2 then the term reduces 1/T' by 5%. This is demonstrated in the table, taken from one of our recent tests.

In one of the bands the difference is a factor of 6. Even in bands where the absorption is >0.5 the difference is ~5% which exceeds the published standard's requirement for reproducibility.

Band	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600
eq(b)	0.04	0.02	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.08	0.11	0.20	0.51	0.87	0.61
eq(8)	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.05	0.08	0.17	0.48	0.84	0.58