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C_{tr} – SPECTRUM ADAPTATION TERM - SOUND INSULATION REMEDIAL TREATMENT & MITIGATION

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Introduction

Methods for assessing airborne sound insulation have changed recently with the advent of Approved Document E (2003). The new Approved Document came into force on 1st July this year and incorporates with it the adoption of the spectrum adaptation term (C_{tr}) in the assessment of airborne sound insulation.

The inclusion of the spectrum adaptation term brings a new dimension to the sound insulation assessment process especially focussing on the low frequency performance of the surface under test. Indeed a primary objective of C_{tr} is to weight the assessment of surfaces which perform poorly at low frequency in relation to their performance at high frequency and we will see examples of this later in this paper. The problem with this added descriptor is that it does complicate the assessment procedure, requiring additional calculations to be carried out on the test data. It is also in its infancy as far as field testing is concerned and in the short time it has been in use has caused a certain amount of confusion amongst both the building industry and acoustic consultants alike. The difficulty lies in the fact it is a negative value and "apparently" independent of the more familiar descriptor of airborne performance D_{nTw} (the weighted standardised level difference). In short it is difficult to get a "gut feel" for the spectrum adaptation term contribution in the sound insulation assessment process.

The basis for this paper is to look at a number of hypothetical examples of sound insulation tests to understand in more detail how C_{tr} affects the end result and to address some practical examples of the affect C_{tr} has on the provision of sound insulation treatment in an attempt to enhance the airborne sound insulation performance.

C_{tr}: calculation

The calculation process for the spectrum adaptation term is defined in EN ISO 717-1: 1996 and examples of the calculation are illustrated in Annex C of that document. The calculation process is carried out using the same data that is required in the calculation of the single number quantity for airborne sound insulation D_{nTw}, so no additional measurements have to be made and the spectrum adaptation term can be calculated on older tests which were carried out prior to its mandatory inclusion in the assessment process.

The calculation of C_{tr} uses spectrum No2 from ISO 717-1 and the "tr" in the term stands for "traffic" because the sound pressure spectrum replicates road traffic noise. This is useful in building acoustic terms as the road traffic sound spectrum closely resembles "Disco music" as described in Table A.1 on p10 of En ISO 717-1: 1996.

The calculation of spectrum adaptation term is carried out as follows:

$C_{tr} = X_{A,2} – X_W$ (1) where:

$X_{A,2}$ Characterises the difference between the A-weighted levels in the source room and in the receiving room, for road traffic noise (spectrum No2).

X_W is the relevant single number quantity based on the reference curve; D_{nTw}

$X_{A,2}$ is calculated from

$X_{A,2}$ = -10 Log ? 10 $^{(Li,2 – Xi)/10}$ dB

Where
i = the index for the one third octave bands 100Hz to 3150Hz

$L_{i,2}$ are the levels as given in spectrum No2.

X_i Is the standardised level difference at the measuring frequency i given to the nearest 0.1dB.

So from (1) above it can be seen that C_{tr} has an explicit dependency on D_{nTw} although this is not abundantly clear from the practical examples examined later in this paper.

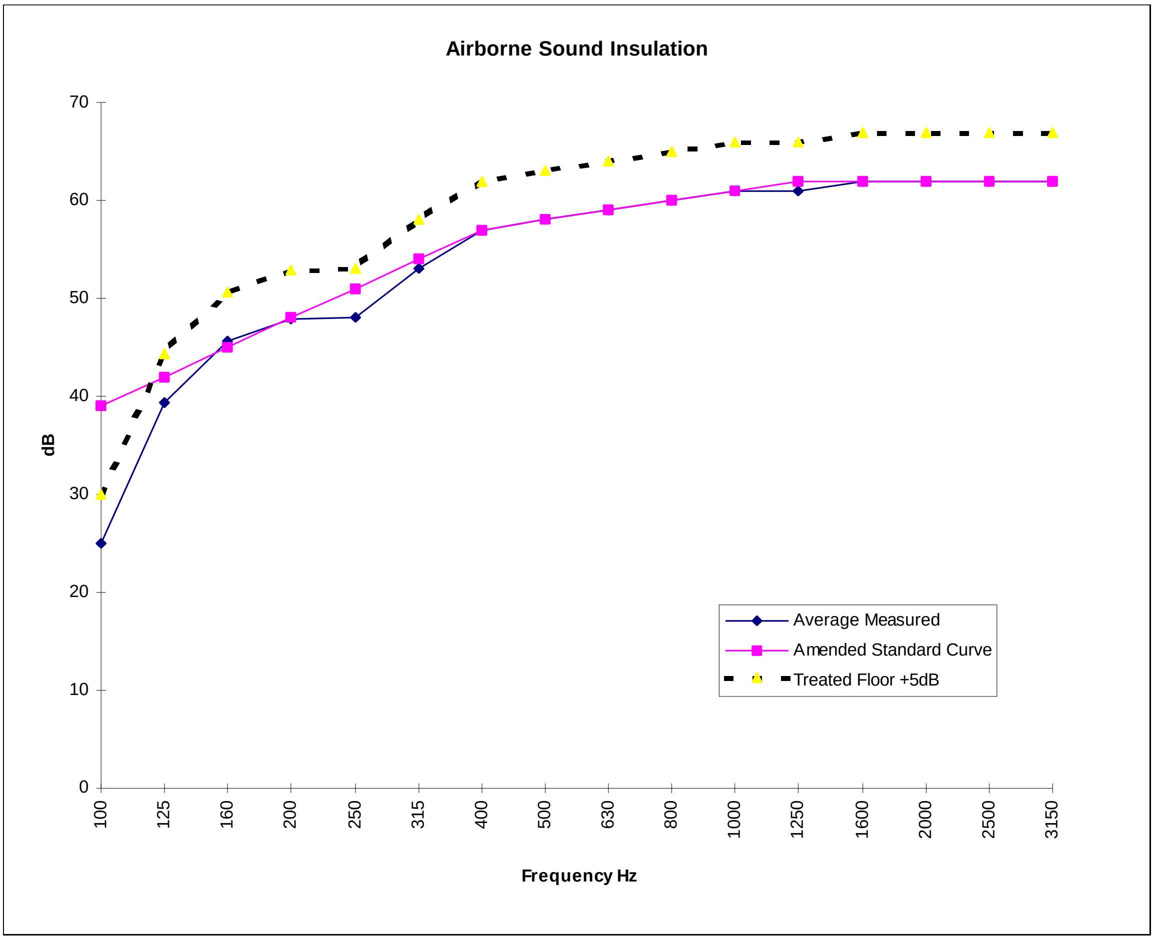
Theoretical Examples

In this section we will look at some hypothetical examples of airborne sound insulation to get a better understanding of how C_{tr} works.

Example 1:

The curves below depict the airborne sound insulation performance of a timber floor. If we assume that a special sound insulation treatment is applied to the floor that increases all the third octave bands by +5dB what will the increase be in C_{tr} and D_{nTw}?

Graph 1:



The answer is: Before performance = 58dB D_{nTw}, -13 C_{tr}
After performance Treated floor = 63dB D_{nTw}, -13 C_{tr}.

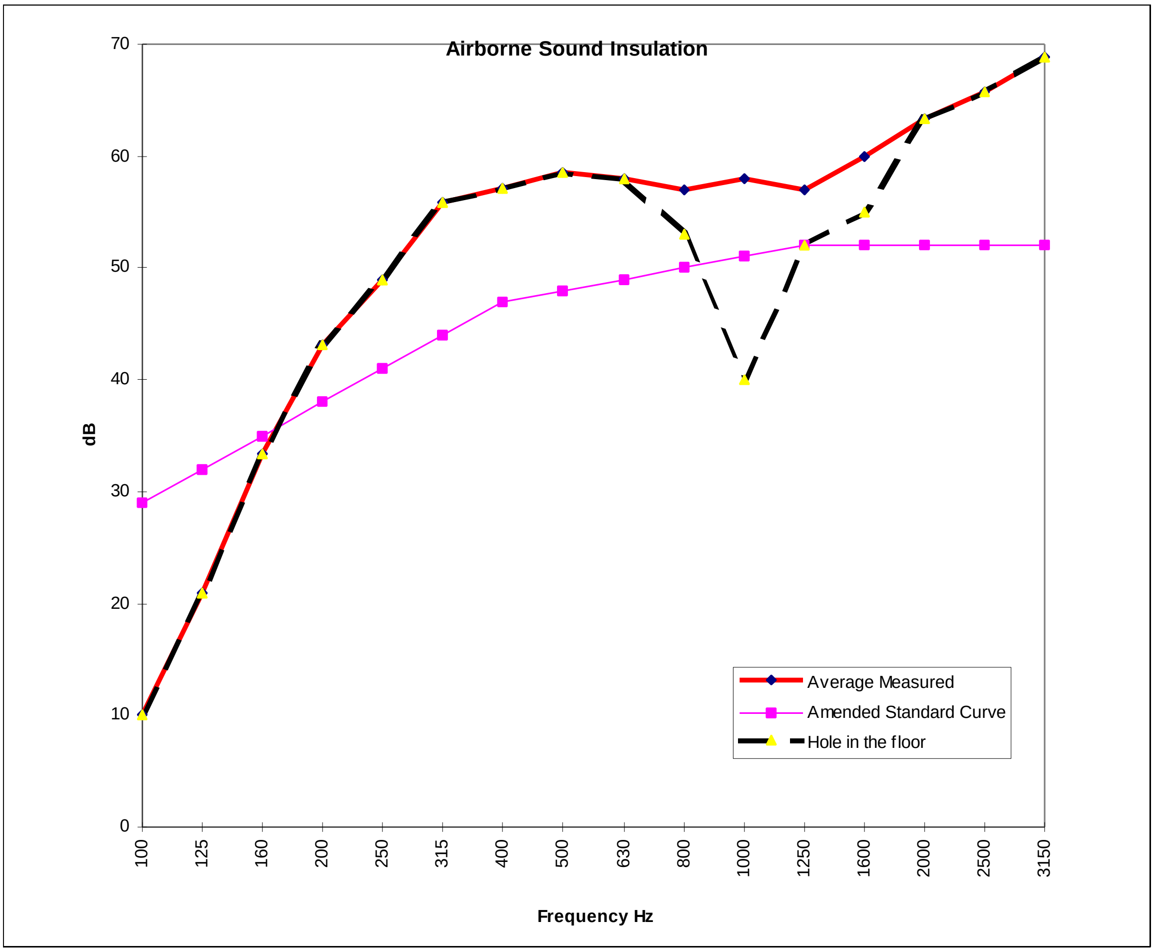
Globally shifting the curve up or down will only affect the D_{nTw} not the C_{tr}. So if this were possible shortfalls in performance on site could be corrected by concentrating on improving the standardised weighted level difference and ignoring the contribution from the spectrum adaptation term.

Lets look at another example to get a better feel for how C_{tr} and D_{nTw} interaction can affect the result.

Example 2:

In this situation a hole in the floor is leaking high frequencies and is compromising the sound insulation of the surface. The floor is tested and the performance is 45dB D_{nTw} , -15dB C_{tr} which is 30dB D_{nTw} + C_{tr}.

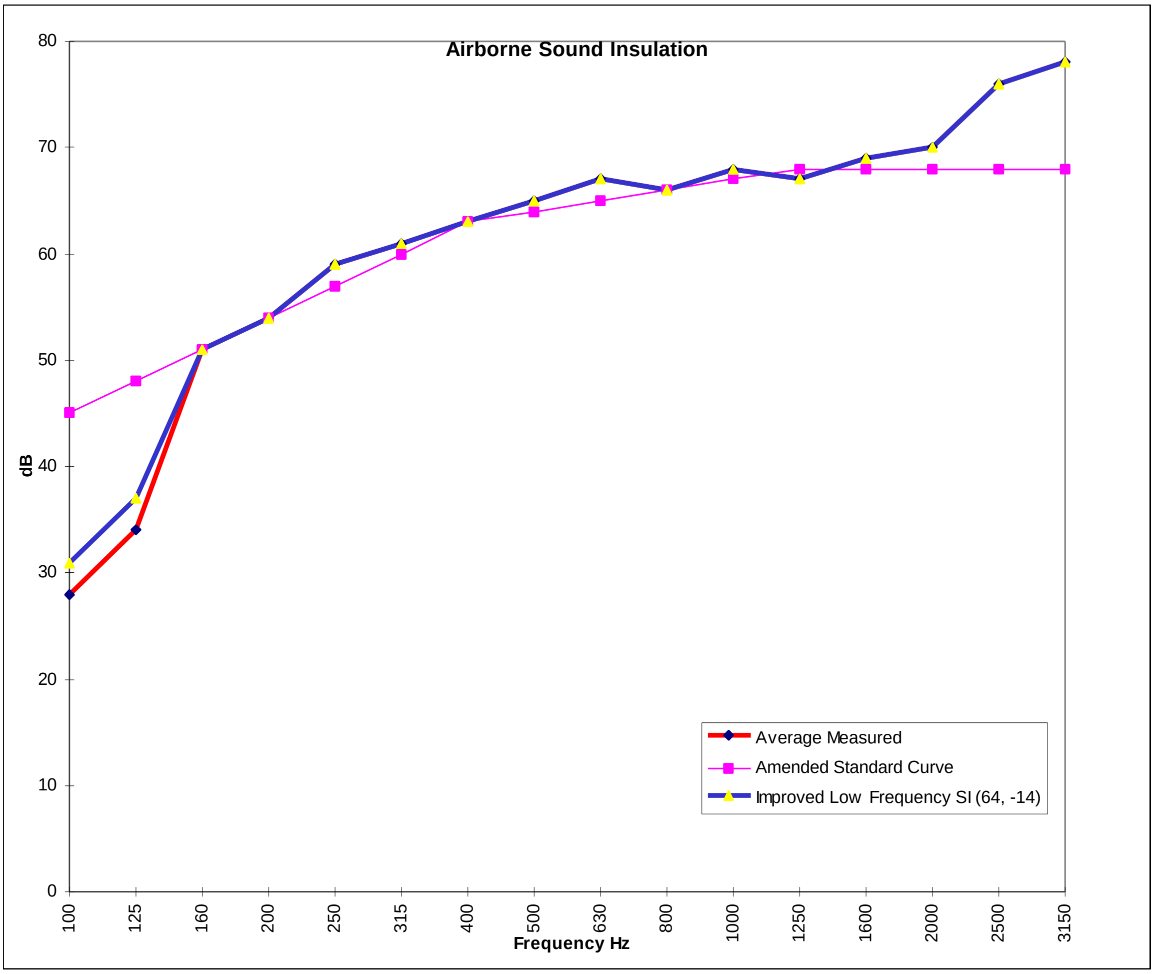
Graph 2:



The hole is filled and the surface retested (see the red solid line between the 630 – 2000Hz bands). The performance is now 48dB D_{nTw} , -18dB C_{tr} = 30dB D_{nTw} + C_{tr}. i.e. no improvement although the sound insulation has clearly improved at the higher frequencies the static low frequency performance means the spectrum adaptation term has worsened by an equivalent amount to swallow this improvement!
Example 3:

In this example, we have a problem at low frequency which is caused by some low frequency resonance in a studwork panel. Isolation of the studwork improves the performance slightly at 100Hz and 125Hz what difference does this make to the overall performance of the floor.

Graph 3:



Before Treatment: 64dB D_{nTw}, -17dB C_{tr}: = 47dB D_{nTw} + C_{tr}
After Treatment: 64dB D_{nTw}, -14dB C_{tr}: = 50dB D_{nTw} + C_{tr}

The improvements in low frequency performance have no impact on the DnTw but they improve the Ctr by 3dB therefore effectively doubling the sound insulation of the floor.

So now we have seen three scenarios where improvements can be made to a floor and leave the C_{tr} unchanged (example 1), D_{nTw} + C_{tr} unchanged (example 2) and finally leave D_{nTw} unchanged (example 3). These are important examples to consider when assessing remedial treatment or mitigation on site.

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Site Testing of Wall & Floor Treatment

A test program of floor & wall sound insulation treatment was carried out on a timber framed Property and the results showed interesting conflicts between the D_{nTw} and Ctr results for different sound insulation treatment combinations. Looking deeper into these results shows how less treatment may give better results under the 2003 testing & assessment regime.

The floor construction was as follows:

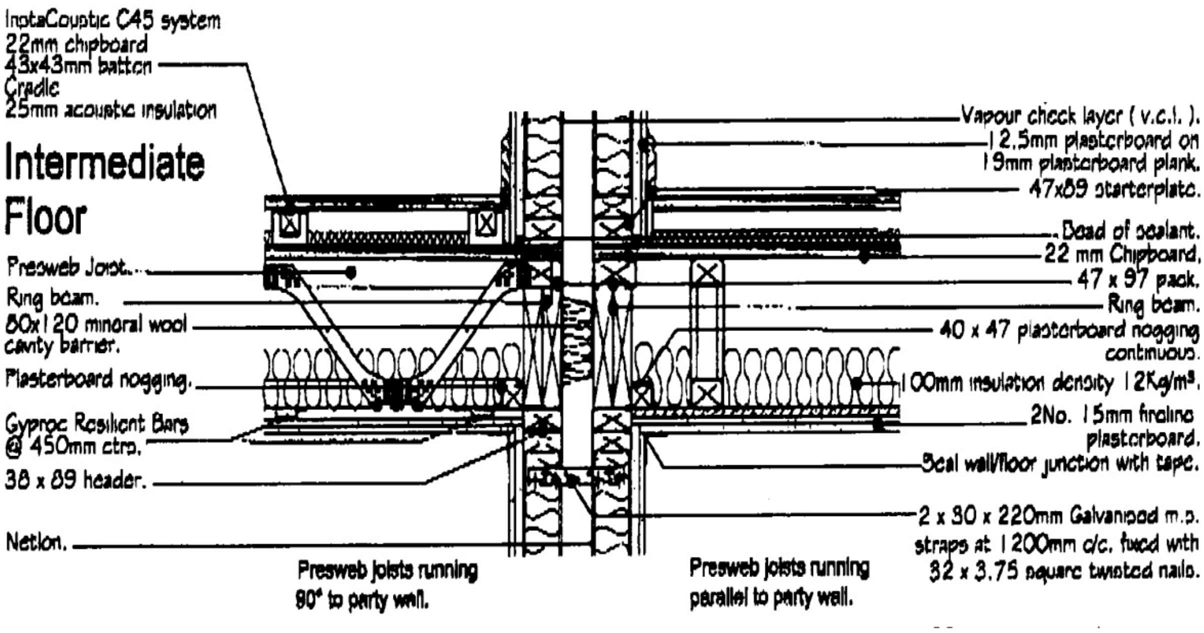


Fig 1: Presweb Floor construction

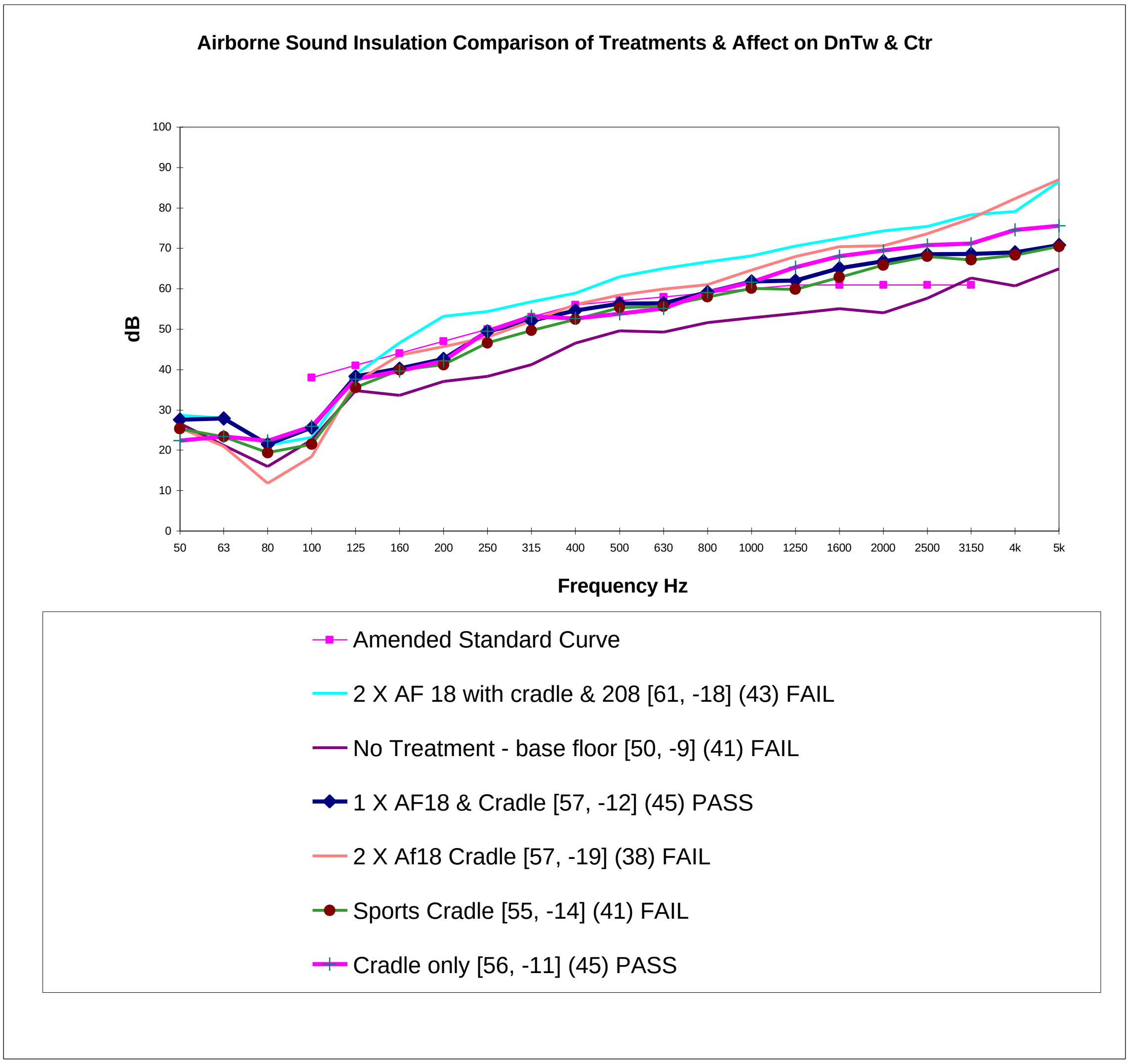
Basic Timber Floor.

- Timber Frame: Presweb Floor Construction
- Basic Floor: 22mm Chipboard Deck
- Basic Ceiling: 2 x 15mm Fireline Board on Resilient Bars 100mm Void Insulation 12Kg/m3 Density.
- Floor Treatment 1: Cradle System @ 450mm Centres
- Floor Treatment 1a: Floor Overlay on top of Cradle Floor (2 alternatives Insta Coustic 108 & 208 floor system).
- Wall Treatment: Decoupled Wall System Insta Coustic AF18 (2 alternatives 1 layer of 12.5mm board or 2 layers)

The base floor was tested on its own and then with a collection of different remedial treatments, the combinations tested are detailed in the table below together with the D_{nTw} and Ctr results..

The sound spectra for each test are detailed in the graph below:

Graph 4:



<u>Summary of Floor Airborne Noise Test Results</u>

Source Room	Receive Room	DnT,w dB	Ctr	DnTw+Ctr	Pass/Fail 2003 standard
Before treatment	Before Treatment	50	-9	**41**	**Fail**

2 X AF18 with Cradle & 208	2 X AF18 with Cradle & 208	61	-18	**43**	**Fail**
2 X AF18 with Cradle	2 X AF18 with Cradle	57	-19	**38**	**Fail**
1 X AF 18 with Cradle	1 X AF 18 with Cradle	57	-12	**45**	**Pass**
Cradle only	Cradle only	56	-11	**45**	**Pass**
Sports Cradle	Sports Cradle	55	-14	**41**	**Fail**

As similar tests had been carried out for this type of floor treatment under the 1992 version of Approved Document E it was already known that the standardised weighted level difference would be high. What was unexpected was the variance in results provided by the inclusion of the spectrum adaptation term, especially when the wall systems were added to the treatment.

Under the assessment criteria in the 1992 Approved Document (D_{nTw}) there is a clear leader namely the base floor complete with the cradle floor system with System 208 overlay and the walls of the source room treated with the decoupled wall system with 2 layers of plasterboard. This gave a high sound insulation value of 61dB D_{nTw} which was 4dB greater than any other combination of system. Unfortunately the spectrum adaptation tern was –18dB which meant that under the current 2003 assessment procedure failed to achieve the new build standard of 45dB D_{nTw} + C_{tr}.

When the 208 floor system was removed from the cradle system and the floor retested the D_{nTw} value dropped to 57dB D_{nTw} and the spectrum adaptation term worsened slightly to –19dB giving a 2003 result of 38dB D_{nTw} + C_{tr} which is actually worst than the base floor. The wall system was reduced to 1 layer of plasterboard and the floor retested with the cradle system only, the D_{nTw} stayed the same at 57dB D_{nTw} but the Ctr improved to –12dB a 7dB improvement. Without the decoupled wall system, the D_{nTw} fell by 1dB to 56dB D_{nTw} and the Ctr improved by 1dB to –11dB. Both of the previous options achieved the pass mark of 45dB D_{nTw} + C_{tr}.

Conclusion

Based on the theoretical examples detailed earlier similarities can be drawn with the test data from the treatments above. Clearly, the situation in example 2 where the improvement at high frequency is counterbalanced by the worsening of C_{tr} applies in this case. It is not until the wall system is reduced to 1 layer of plasterboard that the C_{tr} improves (there does appear to be a tendency here for the wall system with the double plasterboard to exacerbate the poor low frequency performance of the floor!). There is a trade off with the sound insulation treatment where a balance can be made to optimise the D_{nTw} + C_{tr} value. This occurs with the situation with Cradle system only or with the cradle system and wall system with 1 layer of plasterboard. As cost is likely to be an issue, the cradle system on its own would prove to be the obvious choice in this instance.

The above series of tests illustrates that it is no longer sufficient to rely on a high D_{nTw} value to obtain a pass against the new 2003 standards of D_{nTw} + C_{tr}. This has a significant bearing on designers who base their design on old test certification which does not include Ctr. In the test examples above, many of the treatments applied did not significantly improve the low frequency performance of the floor in relation to the improvement at high frequency. Indeed closer scrutiny of the improvement at 100Hz from the base floor (50, -9) to the fully treated floor (61, -18) shows only a 0.6dB improvement, the bias of Spectrum No2 at this frequency ensures a large increase in C_{tr}. Caution is advised where separating surfaces require mitigation and due consideration should be applied to the low frequency improvement of treatment not just the overall rise in D_{nTw}.

Bibliography:

EN ISO 717:1 1997 “Acoustics – Rating of sound insulation in buildings and of building elements.” Part 1 Airborne sound insulation.

The Spectrum Adaptation Terms in BS EN ISO 717-1:1997: Philip Wright MIOA & Les Fothergill FIOA Institute of Acoustics Bulletin Vol 23 No6 November – December 1998.