Proceedings of the Institute of Acoustics

SOUND INSULATION TESTING – SENSITIVITY TO REVERBERATION TIME: T30 V T20.

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INTRODUCTION

The objective of this paper is to examine the effect of the use of either T30 or T20 reverberation times on the Weighted Standardised Level Difference (DnTw) and the Weighted Standardised Sound Pressure Level (LnTw) measurement of sound insulation in separating walls and floors. We also examine the effect on the Spectrum adaptation Term (Ctr) as it applies to DnTw.

The definition of reverberation time is ' *the time taken for the energy in an initially steady reverberant sound field to decay by 60dB'* Dictionary of Acoustics, Academic Press, Christopher L Morphey 2001

We know this definition as T60, however, the measurement of this causes some practical problems as outlined by Tim Turney of the Cassella Group, Sound level equipment manufacturers who states:

' The problem in directly measuring a T60 occurs because of potentially high background noise levels and insufficient power of the noise source. In practice to get a direct and accurate measurement of the T60 an actual level difference of 75dB would be required between the noise source and the background level, which is generally not practical. So therefore measurements of T20 and T30 are taken as they require much lower level differences and will give an accurate prediction of T60 in any practical situation.'

T30 and are defined in the Dictionary of Acoustics:
'In room acoustics, the slope (of decay) is normally obtained by fitting a straight line between the -5dB and -35dB points relative to the initial level. An alternative is to use the -5dB and -25dB points, in which case the result is denoted by T20'

In essence then, the T30 and T20 reverberation times are an extrapolation of a given data set to represent a T60. As the T30 uses a wider range of data, it can be considered to be a more accurate figure.

DATA ANALYSIS

We collected samples of 50 Airborne Wall, 50 Airborne Floor and 50 Impact Floor Tests and analysed each result using both T30 and T20 data. A summary of the results obtained and the differences noted to both LnTw, DnTw and Ctr. The results are tabulated below.

Table 1 – Airborne Floor Test Data

Floor Data									
Record	DnTw T30	DnTw T20	difference	Ctr T30	Ctr T20	difference	DnTw+Ctr T30	DnTw + Ctr T20	difference
1	52	52	0	-6	-6	0	46	46	0
2	48	48	0	-8	-8	0	40	40	0
3	51	51	0	-12	-11	-1	39	40	-1
4	55	55	0	-7	-7	0	48	48	0
5	52	51	1	-5	-4	-1	47	47	0
6	53	53	0	-10	-9	-1	43	44	-1
7	49	49	0	-2	-2	0	47	47	0
8	46	46	0	-5	-5	0	41	41	0
9	48	48	0	-8	-9	1	40	39	1
10	53	53	0	-11	-11	0	42	42	0
11	53	53	0	-10	-10	0	43	43	0
12	55	54	1	-7	-6	-1	48	48	0
13	49	49	0	-3	-3	0	46	46	0
14	55	55	0	-10	-9	-1	45	46	-1
15	54	54	0	-11	-11	0	43	43	0
16	54	53	1	-11	-10	-1	43	43	0
17	57	58	-1	-6	-7	1	51	51	0
18	55	55	0	-6	-6	0	49	49	0
19	56	56	0	-11	-11	0	45	45	0
20	48	49	-1	-4	-4	0	44	45	-1
21	46	46	0	-5	-5	0	41	41	0
22	55	55	0	-14	-15	1	41	40	1
23	53	53	0	-4	-4	0	49	49	0
24	56	56	0	-6	-6	0	50	50	0
25	53	53	0	-5	-5	0	48	48	0
26	56	56	0	-5	-5	0	51	51	0
27	48	48	0	-4	-4	0	44	44	0
28	46	46	0	-5	-5	0	41	41	0
29	46	46	0	-2	-2	0	44	44	0
30	48	48	0	-3	-3	0	45	45	0
31	56	56	0	-6	-6	0	50	50	0
32	58	58	0	-9	-9	0	49	49	0
33	50	50	0	-10	-10	0	40	40	0
34	60	60	0	-10	-10	0	50	50	0
35	50	50	0	-6	-5	-1	44	45	-1
36	55	55	0	-9	-9	0	46	46	0
37	56	56	0	-5	-5	0	51	51	0
38	58	58	0	-8	-9	1	50	49	1
39	53	53	0	-7	-7	0	46	46	0
40	59	59	0	-10	-10	0	49	49	0
41	58	58	0	-8	-8	0	50	50	0
42	57	57	0	-6	-6	0	51	51	0
43	53	53	0	-4	-4	0	49	49	0
44	37	36	1	-3	-2	-1	34	34	0
45	39	39	0	-2	-2	0	37	37	0
46	55	56	-1	-6	-7	1	49	49	0
47	42	42	0	-8	-8	0	34	34	0
48	50	50	0	-6	-6	0	44	44	0
49	43	44	-1	-6	-6	0	37	38	-1
50	57	57	0	-9	-9	0	48	48	0

Table 2 – Airborne Wall Test Data

Wall Data									
Record	DnTw T30	DnTw T20	difference	Ctr T30	Ctr T20	difference	DnTw+Ctr T30	DnTw + Ctr T20	difference
1	56	56	0	-3	-3	0	53	53	0
2	42	42	0	-4	-3	-1	38	39	-1
3	57	57	0	-10	-10	0	47	47	0
4	59	59	0	-10	-9	-1	49	50	-1
5	61	60	1	-12	-12	0	49	48	1
6	59	59	0	-13	-14	1	46	45	1
7	54	54	0	-7	-7	0	47	47	0
8	51	51	0	-3	-3	0	48	48	0
9	56	56	0	-6	-6	0	50	50	0
10	34	34	0	-2	-2	0	32	32	0
11	48	49	-1	-3	-4	1	45	45	0
12	48	48	0	-4	-3	-1	44	45	-1
13	43	43	0	-5	-5	0	38	38	0
14	59	58	1	-11	-10	-1	48	48	0
15	58	57	1	-8	-7	-1	50	50	0
16	63	63	0	-8	-8	0	55	55	0
17	58	57	1	-8	-7	-1	50	50	0
18	63	63	0	-8	-8	0	55	55	0
19	54	54	0	-6	-5	-1	48	49	-1
20	52	52	0	-8	-7	-1	44	45	-1
21	54	54	0	-8	-8	0	46	46	0
22	52	52	0	-7	-7	0	45	45	0
23	55	55	0	-5	-5	0	50	50	0
24	55	55	0	-7	-7	0	48	48	0
25	57	57	0	-9	-8	-1	48	49	-1
26	54	54	0	-10	-10	0	44	44	0
27	53	53	0	-6	-7	1	47	46	1
28	61	61	0	-5	-5	0	56	56	0
29	63	62	1	-10	-9	-1	53	53	0
30	64	64	0	-6	-6	0	58	58	0
31	65	65	0	-7	-6	-1	58	59	-1
32	57	56	1	-5	-4	-1	52	52	0
33	51	51	0	-3	-4	1	48	47	1
34	53	53	0	-2	-3	1	51	50	1
35	49	49	0	-4	-5	1	45	44	1
36	51	51	0	-6	-5	-1	45	46	-1
37	54	54	0	-8	-8	0	46	46	0
38	52	51	1	-7	-6	-1	45	45	0
39	56	56	0	-7	-7	0	49	49	0
40	31	31	0	-3	-3	0	28	28	0
41	55	55	0	-7	-7	0	48	48	0
42	55	55	0	-7	-7	0	48	48	0
43	63	63	0	-11	-11	0	52	52	0
44	64	64	0	-7	-7	0	57	57	0
45	63	63	0	-6	-6	0	57	57	0
46	53	53	0	-4	-4	0	49	49	0
47	35	35	0	-5	-5	0	30	30	0
48	50	50	0	-4	-4	0	46	46	0
49	58	58	0	-10	-10	0	48	48	0
50	49	49	0	-8	-8	0	41	41	0

Table 3 – Impact Test Data

Impact Data			
Record No	LnTw T30	LnTw T20	difference
1	73	73	0
2	58	58	0
3	62	62	0
4	59	59	0
5	60	60	0
6	66	66	0
7	51	51	0
8	56	56	0
9	64	63	1
10	66	66	0
11	70	71	-1
12	56	56	0
13	56	55	1
14	62	62	0
15	61	61	0
16	56	56	0
17	56	56	0
18	60	59	1
19	67	67	0
20	56	56	0
21	51	51	0
22	55	55	0
23	47	47	0
24	49	49	0
25	60	60	0
26	60	61	-1
27	61	61	0
28	55	55	0
29	59	59	0
30	59	59	0
31	87	87	0
32	79	79	0
33	67	67	0
34	69	69	0
35	60	60	0
36	61	61	0
37	59	59	0
38	59	59	0
39	56	56	0
40	71	71	0
41	50	50	0
42	52	52	0
43	51	50	1
44	53	52	1
45	44	44	0
46	63	62	1
47	56	55	1
48	68	68	0
49	58	58	0
50	60	60	0

In our Airborne Floor data set of 50 results, the comparison between the use of T30 data against T20 data showed a difference in the single figure result DnTw + Ctr of +/- 1dB in 9 cases.

The data set includes a spread of results from 34dB to 51dB DnTw+Ctr (T30). The results affected do not appear to group around any particular point in the set and are well spread across the range.

In our Airborne Wall data set of 50 results, the comparison between the use of T30 data against T20 data showed a difference in the single figure result DnTw + Ctr of +/- 1dB in 14 cases.

The data set includes a spread of results from 28dB to 58dB DnTw+Ctr (T30). The results affected do not appear to group around any particular point in the set and are well spread across the range.

In our Impact test data set of 50 results, the comparison between the use of T30 data against T20 data showed a difference in the single figure result LnTw of +/- 1dB in 9 cases.

The data set includes a spread of results from 87dB to 44dB LnTw (T30). The results affected do not appear to group around any particular point in the set and are well spread across the range.

In all cases this suggests that the performance of the surface is not a factor in determining whether the use of T30 over T20 will have an effect.

We then examined the length of the reverberation time itself to determine whether this was a critical factor in affecting the +/- 1db difference recorded. Table 4 shows the differences recorded for airborne floor records and the respective T30 reverberation times.

Table 4 - +/- 1dB: T30 against Reference Level

Floor Data Record	3	6	14	20	22	35	38	49
	0.71	0.33	0.79	0.32	0.5	0.56	0.54	0.39
	0.58	0.53	1.16	0.24	0.79	0.52	0.4	0.29
	0.7	0.54	0.67	0.28	0.88	0.49	0.44	0.3
	0.81	0.6	0.91	0.27	0.81	0.56	0.44	0.31
	0.93	0.81	0.72	0.2	0.9	0.74	0.85	0.34
	1.06	0.71	1.79	0.27	0.99	0.85	0.93	0.27
	1.27	0.74	1.19	0.26	1.09	0.88	1.09	0.28
	1.3	0.63	1.21	0.17	1.09	0.91	1.26	0.3
	1.41	0.71	1.19	0.21	1.18	0.92	1.33	0.27
	1.5	0.67	1.17	0.21	0.96	0.86	1.35	0.26
	1.41	0.68	1.29	0.21	0.87	0.78	1.37	0.24
	1.42	0.66	1.24	0.22	0.8	0.76	1.28	0.26
	1.39	0.68	1.29	0.23	0.75	0.75	1.28	0.28
	1.37	0.69	1.27	0.24	0.69	0.74	1.17	0.25
	1.38	0.69	1.2	0.23	0.69	0.76	1.04	0.26
	1.35	0.7	1.12	0.25	0.76	0.8	0.97	0.28
average rt	1.2	0.6	1.1	0.2	0.9	0.7	1.0	0.3
above/below reference level?	above	above	above	below	above	below	above	below
Difference	-1	-1	-1	-1	1	-1	1	-1

Table 4 shows the differences recorded for airborne wall records and the respective T30 reverberation times.

The spread of +/-1dB difference between reverberant environments above the reference level and those below the reference level does not indicate a pattern. This suggests that the length of the reverberation time is not a critical factor in determining whether the use of T30 or T20 will have an affect.

WHERE DOES THE DIFFERENCE OCCUR, AND WHY?

We examined a selection of Airborne floor data where a difference was shown to occur in the DnTw value when calculated with both T30 and T20. It can be seen from the table and associated graph below that the +/- 1dB difference occurs when the sum of the adverse deviations is close to 32. In this case, the use of T30 data gives a performance of 52dB DnTw. T20 data forces the sum of the adverse deviations over the 32 limit, causing a recalculation to 51dBDnTw

Table 5: DnTw calculated with T30 Record 5

T30 data Record 5 Airborne Floor

Frequency	Average	Amended Standard	Added	Standard	Deviation		
Hz	Measured	Curve	Difference	Curve			
50	31.7						
63	31.9						
80	T30						
100	32.8	33	0	33	-0.2	-0.2	0.2
125	36.4	36	0	36	0.4	0	0.0
160	36.9	39	0	39	-2.1	-2.1	2.1
200	41.6	42	0	42	-0.4	-0.4	0.4
250	41.4	45	0	45	-3.6	-3.6	3.6
315	45.8	48	0	48	-2.2	-2.2	2.2
400	49.2	51	0	51	-1.8	-1.8	1.8
500	53.7	52	0	52	1.7	0	0.0
630	55.0	53	0	53	2.0	0	0.0
800	52.5	54	0	54	-1.5	-1.5	1.5
1000	54.0	55	0	55	-1.0	-1.0	1.0
1250	53.1	56	0	56	-2.9	-2.9	2.9
1600	54.9	56	0	56	-1.1	-1.1	1.1
2000	53.4	56	0	56	-2.6	-2.6	2.6
2500	51.6	56	0	56	-4.4	-4.4	4.4
3150	50.5	56	0	56	-5.5	-5.5	5.5
4k	51.7						
5k	54.5						
DnTw =	52		0				29.1

Graph 1: DnTw calculated with T30

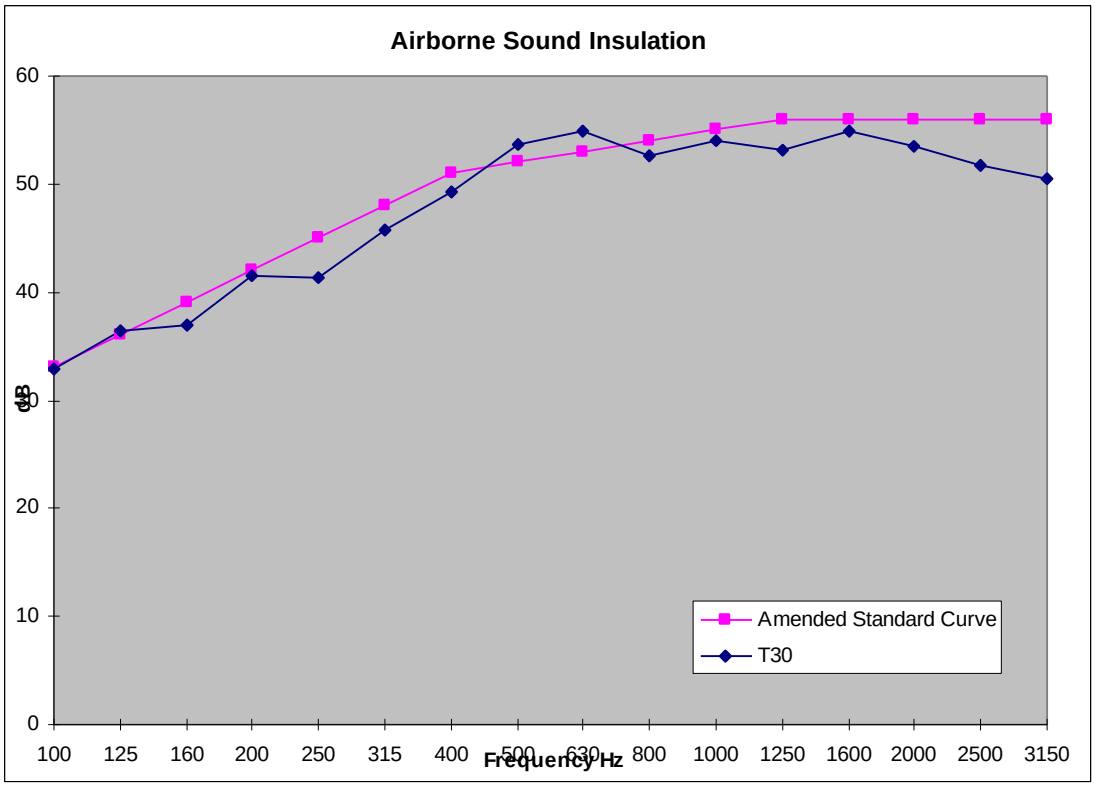
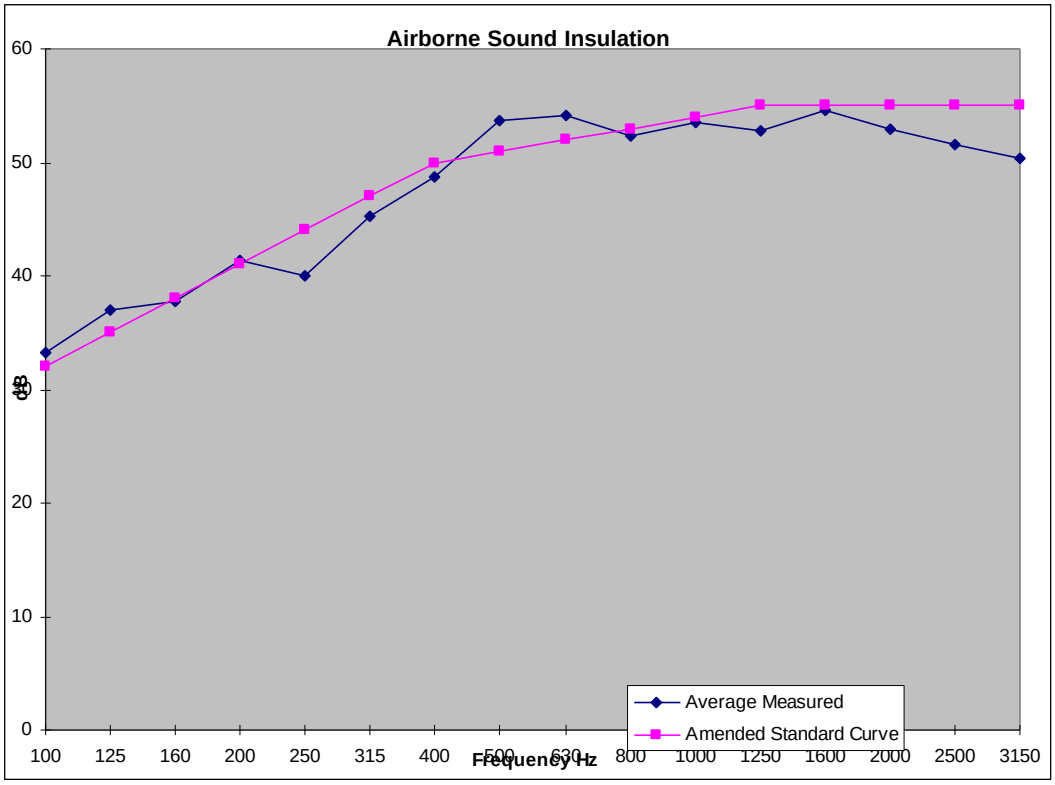


Table 6: DnTw calculated with T20 Record 5.1

T20 data record 5 Airborne Floor

Frequency Hz	Average Measured	Amended Standard Curve	Added Difference	Standard Curve	Deviation		
100	33.3	32	-1	33.0	1.3	0	0.0
125	37.0	35	-1	36.0	2.0	0	0.0
160	37.7	38	-1	39.0	-0.3	-0.3	0.3
200	41.4	41	-1	42.0	0.4	0	0.0
250	40.0	44	-1	45.0	-4.0	-4.0	4.0
315	45.3	47	-1	48.0	-1.7	-1.7	1.7
400	48.7	50	-1	51.0	-1.3	-1.3	1.3
500	53.7	51	-1	52.0	2.7	0	0.0
630	54.1	52	-1	53.0	2.1	0	0.0
800	52.3	53	-1	54.0	-0.7	-0.7	0.7
1000	53.5	54	-1	55.0	-0.5	-0.5	0.5
1250	52.7	55	-1	56.0	-2.3	-2.3	2.3
1600	54.7	55	-1	56.0	-0.3	-0.3	0.3
2000	53.0	55	-1	56.0	-2.0	-2.0	2.0
2500	51.5	55	-1	56.0	-3.5	-3.5	3.5
3150	50.3	55	-1	56.0	-4.7	-4.7	4.7
4k	51.6						
5k	54.5						
DnTw =	51		-1				21.2

Graph 2: DnTw calculated with T20



We examined a selection of Impact floor data where a difference was shown to occur in the LnTw value when calculated with both T30 and T20. Once again it can be seen from the table and associated graph below that the +/- 1dB difference occurs when the sum of the adverse deviations is close to 32., the use of T30 data gives a performance of 51dB LnTw. T20 data allows headroom in sum of the adverse deviations, causing a recalculation to 50dBLnTw

Table 7: LnTw calculated with T30 Record 43

Impact Data

Frequency	Average Measured	Amended Standard	Standard Curve		Deviation		
100	55.0	53	62	-9	-2.0	-2.0	2.0
125	54.1	53	62	-9	-1.1	-1.1	1.1
160	61.7	53	62	-9	-8.7	-8.7	8.7
200	61.6	53	62	-9	-8.6	-8.6	8.6
250	55.0	53	62	-9	-2.0	-2.0	2.0
315	49.9	53	62	-9	3.1	0	0.0
400	44.7	52	61	-9	7.3	0	0.0
500	43.6	51	60	-9	7.4	0	0.0
630	42.0	50	59	-9	8.0	0	0.0
800	38.6	49	58	-9	10.4	0	0.0
1000	35.9	48	57	-9	12.1	0	0.0
1250	34.1	45	54	-9	10.9	0	0.0
1600	34.4	42	51	-9	7.6	0	0.0
2000	34.5	39	48	-9	4.5	0	0.0
2500	39.6	36	45	-9	-3.6	-3.6	3.6
3150	30.0	33	42	-9	3.0	0	0.0
				-9			26.1
L'nTw =	51						

Graph 3: LnTw calculated with T30 Record 43

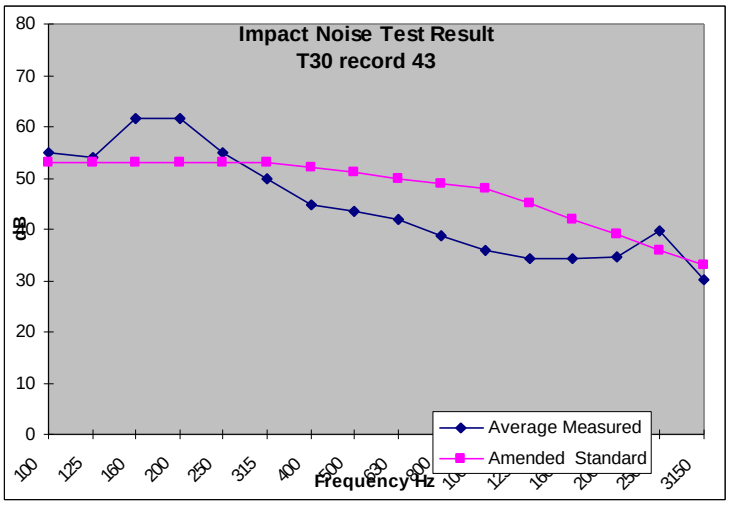
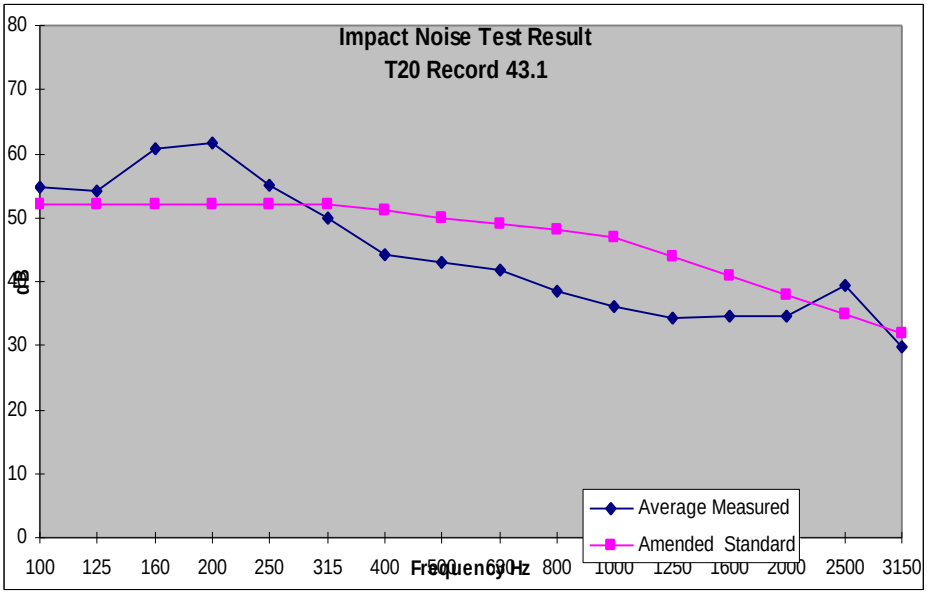


Table 8: LnTw calculated with T20 data Record 43.1

Frequency	Average Measured	Amended Standard	Standard Curve		Deviation		
100	54.6	52	62	-10	-2.6	-2.6	2.6
125	54.2	52	62	-10	-2.2	-2.2	2.2
160	60.70	52	62	-10	-8.7	-8.7	8.7
200	61.7	52	62	-10	-9.7	-9.7	9.7
250	55.0	52	62	-10	-3.0	-3.0	3.0
315	50.1	52	62	-10	1.9	0	0.0
400	44.2	51	61	-10	6.8	0	0.0
500	43.1	50	60	-10	6.9	0	0.0
630	41.8	49	59	-10	7.2	0	0
800	38.6	48	58	-10	9.4	0	0
1000	36.2	47	57	-10	10.8	0	0
1250	34.4	44	54	-10	9.6	0	0
1600	34.6	41	51	-10	6.4	0	0
2000	34.6	38	48	-10	3.4	0	0
2500	39.5	35	45	-10	-4.5	-4.5	5
3150	29.9	32	42	-10	2.1	0	0
				-10			30.7

L'nTw = 50

Graph 4: LnTw calculated with T20 data Record 43.1

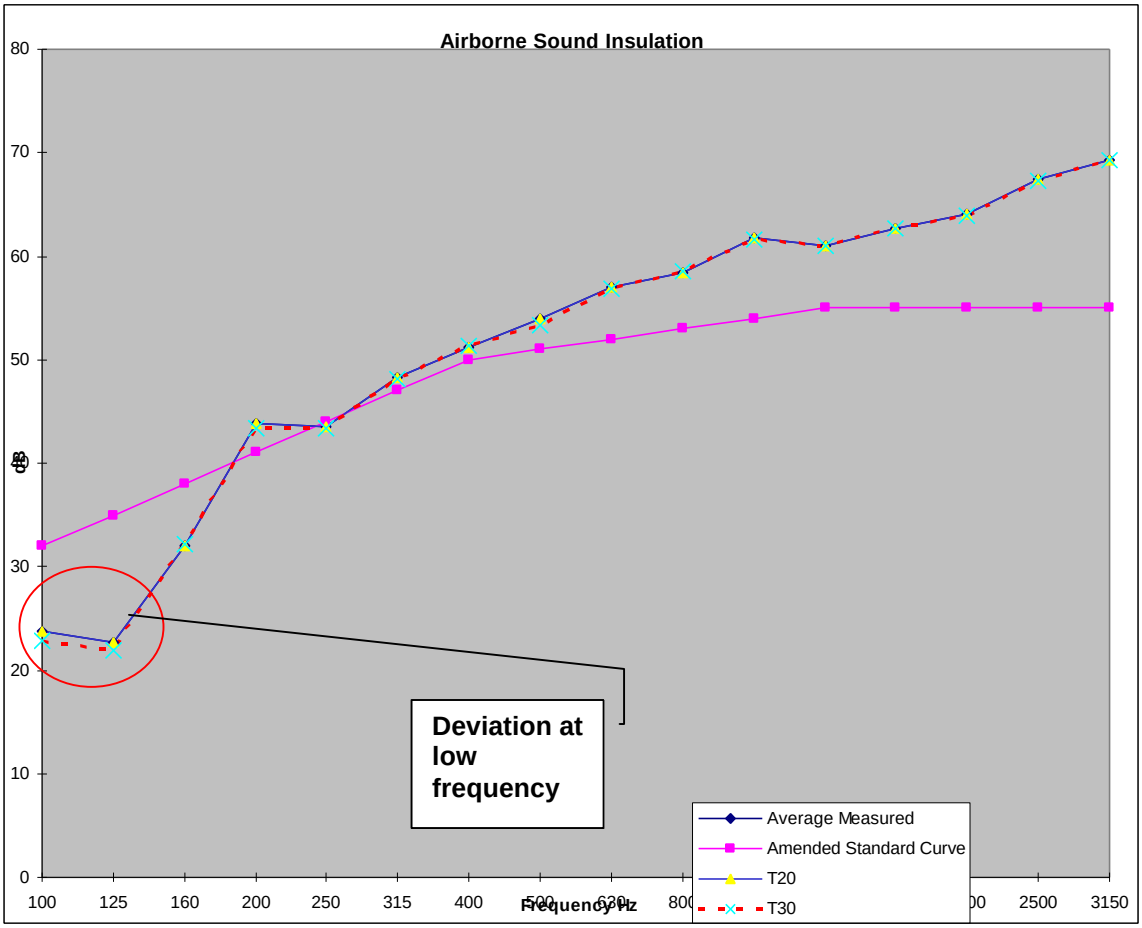


Out of 50 Impact data sets, a change in the LnTw +/- 1dB was shown to occur in 9 cases.

Out of 100 Airborne floor and wall data sets, a change in the DnTw +/- 1dB was shown to occur in 16 cases. The addition of the Spectrum Adaptation Term in the calculation of sound insulation between party surfaces for airborne tests raises the question of whether this change in DnTw affects the overall result. As can be seen in Table 1 & Table 2 of the 16 DnTw results shown to be affected by the use of T30 data against T20 data, in only three cases did the change in DnTw reflect in an overall change to the rating of the performance by +/- 1dB. In the remaining data sets a corresponding change occurred in the Ctr term, effectively cancelling out the change in DnTw.

Out of the 100 Airborne floor and wall data sets, a change in the Ctr of +/- 1dB which reflected a 1dB change in the assessment level was shown to occur in 20 cases. An examination of these data sets shows identifies the difference in the curve of each, an example is given in graph 5 below

Graph 5: T20 v T30 curves, airborne floor record 3



The difference identified above is significant because the spectrum adaptation calculation procedure identified in BS EN ISO 717 – 1 1996 spectrum No 2 for Ctr is biased towards low frequency. The standard calculates Ctr to 1 decimal place, consequently the rev time correction at low frequency in the order of 0.5 dB causes the Ctr to be rounded up or down resulting in +/- 1dB difference in rating levels, as can be seen in the example below:

Table 9: Ctr calculated with T30 Airborne Floor record 3

Frequency		Reference Curve Shifted by:	Unfavourable Deviation	Spectrum No 2	Li2 - DnT,i	10^(Li2 - DnT,I)/10
Hz	dB	-1	dB	Ctr	dB	dB
100	22.824425	32	9.175575348	-20	-42.824425	5.21864E-05
125	21.94509	35	13.05490983	-20	-41.94509	6.38985E-05
160	32.163177	38	5.836823465	-18	-50.163177	9.63124E-06
200	43.306328	41	0	-16	-59.306328	1.17319E-06
250	43.402859	44	0.597140714	-15	-58.402859	1.44449E-06
315	48.094214	47	0	-14	-62.094214	6.17417E-07
400	51.289058	50	0	-13	-64.289058	3.72472E-07
500	53.406045	51	0	-12	-65.406045	2.88002E-07
630	56.93128	52	0	-11	-67.93128	1.61017E-07
800	58.498701	53	0	-9	-67.498701	1.77881E-07
1000	61.580416	54	0	-8	-69.580416	1.10143E-07
1250	60.963282	55	0	-9	-69.963282	1.00849E-07
1600	62.683307	55	0	-10	-72.683307	5.391E-08
2000	63.875837	55	0	-11	-74.875837	3.25399E-08
2500	67.355334	55	0	-13	-80.355334	9.21439E-09
3150	69.229398	55	0	-15	-84.229398	3.77625E-09
					Sum (a)	0.000130261
					Sum x 10^-5	13.02611118
					-10Log(sum (a))	38.85185219
					Ctr =	-12.1
					DnTw + Ctr =	39

Table 10: Ctr calculated with T20 Airborne Floor record 3

Frequency Hz	dB	Reference Curve Shifted by: -1	Unfavourable Deviation dB	Spectrum No 2 Ctr	Li2 - DnT,i dB	10^(Li2 - DnT,I)/10 dB
50						
63						
80						
100	23.805741	32	8.194258769	-20	-43.805741	4.16319E-05
125	22.699301	35	12.30069885	-20	-42.699301	5.37118E-05
160	32.100687	38	5.899312958	-18	-50.100687	9.77083E-06
200	43.859356	41	0	-16	-59.859356	1.03291E-06
250	43.585747	44	0.414252856	-15	-58.585747	1.38492E-06
315	48.333335	47	0	-14	-62.333335	5.84341E-07
400	51.150072	50	0	-13	-64.150072	3.84585E-07
500	53.880291	51	0	-12	-65.880291	2.58209E-07
630	56.961972	52	0	-11	-67.961972	1.59883E-07
800	58.381317	53	0	-9	-67.381317	1.82755E-07
1000	61.761398	54	0	-8	-69.761398	1.05648E-07
1250	60.993759	55	0	-9	-69.993759	1.00144E-07
1600	62.65195	55	0	-10	-72.65195	5.43006E-08
2000	64.122311	55	0	-11	-75.122311	3.07446E-08
2500	67.386691	55	0	-13	-80.386691	9.1481E-09
3150	69.261449	55	0	-15	-84.261449	3.74848E-09
					Sum (a)	0.000109406
					Sum x 10^-5	10.94058574
					-10Log(sum (a))	39.60959426
					Ctr =	-11.4
					DnTw + Ctr =	40

In conclusion, the +/- 1dB difference in rating levels when calculating DnTw+Ctr using either T30 or T20 is shown to be due to the low frequency bias of spectrum 2. Any difference in the Rt correction derived from this data at low frequency may result in a change in the DnTw+Ctr assessment of the surface.
Approved Document E 2003 has moved the assessment level for new build properties away from the 1992 criterion of minimum and mean assessment and introduced a pass/fail value where a 1dB difference in DnTw+Ctr could prove to be significant.

Out of 100 airborne floor and wall records examined, the use of T20 v T 30 data produced a difference in DnTw +/-1dB in 16% of records
Out of 50 impact records examined, the use of T20 v T30 data produced a difference in LnTw +/-1db in 18% of records
The difference in DnTw and LnTw occurs when the sum of adverse deviations is close to 32 with either T30 or T20. Inclusion of the opposing Rt data causing either the sum of adverse deviations to exceed 32 or to create headroom allowing a recalculation to take place
In the records where the use of T20 v T30 data produced a +/- 1dB change to DnTw, three records (3% of total records examined) reflected that change in the DnTw+Ctr assessment level. In all other cases a corresponding shift in Ctr cancelled out the +/-1dB shift.
In 20% of airborne records examined, the use of T20 v T30 data produced a +/- 1dB difference in DnTw+Ctr rating level
This was shown to be the result of a 0.5dB variation in rt correction in the 100Hz and 125Hz bands, coupled with the rounding procedure identified in BS EN ISO 717-1 1996.