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Client Report

B-3135.4

Airborne and Impact Sound Transmission Measurements Performed on Specimen B3135-4

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Airborne and Impact Sound Transmission Measurements Performed on Specimen B3135-4

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INTRODUCTION

Airborne and impact sound transmission measurements were performed on a floor assembly with 6 mm ceramic tiles, 13 mm cement board, 8 mm Duraflex and a 146 mm thick concrete slab. For report purposes, this specimen is identified Specimen B3135-4. A complete description of the floor assembly is outlined in this report (see Specimen Description Section).

FACILITIES AND EQUIPMENT

The acoustics floor test facility comprises two reverberation rooms with a moveable test frame between the two rooms. Both rooms have a volume of 175 m^3.

Measurements are controlled by a desktop PC-type computer interfaced to a Norwegian Electronics type 830 real time analyser. Each room has a calibrated Bruel & Kjaer condenser microphone cartridge-type 4166 that is moved under computer control to nine positions used for the acoustical measurements. Each room has four loudspeakers driven by separate amplifiers and noise sources. To increase the randomness of the sound field, there are also fixed diffusing panels in each room.

TEST PROCEDURE

Airborne Sound Transmission Loss

Airborne sound transmission measurements were conducted in accordance with the requirements of ASTM E90-90, "Standard Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions", and of ISO 140/III 1978(E), "Laboratory Measurement of Airborne Sound Insulation of Building Elements".

The Sound Transmission Class (STC) was determined in accordance with ASTM E413-87, "Classification for Rating Sound Insulation". The Weighted Sound Reduction Index (R_w) was determined in accordance with ISO 717, "Rating of Sound Insulation in Buildings and of Building Elements, Part 1: Airborne Sound Insulation in Buildings and of Interior Building Elements".

One-third octave band sound pressure levels were measured for 32 seconds at each microphone position and then averaged to get the average sound pressure level in the room. Five sound decays were averaged to get the reverberation time at each microphone position in the receiving room. These times were averaged to get the spatial average reverberation times for the room.

The space average sound pressure levels of both the source and receiving rooms and the spatial average reverberation times of the receiving room were used to calculate sound transmission loss values.

Airborne sound transmission loss tests were performed in the forward (receiving room is the lower room) and reverse (receiving room is the upper room) directions. Results presented in this report are the average of the tests in these two directions.

A complete description of the test procedure, information on the flanking limit of the facility and reference specimen test results are available on request.

The measured temperature and relative humidity in the upper chamber during testing was 27.7°C and 38.8%, respectively. The measured temperature and relative humidity in the lower chamber during testing 25.6°C and 49.7%, respectively.

TEST PROCEDURE

Impact Sound Transmission

Impact sound transmission measurements were made in accordance with ASTM E492-90, "Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine". This test used the standard tapping machine and the prescribed four impact positions on the floor. The Impact Insulation Class (IIC) was determined in accordance with ASTM E989-89, "Standard Classification for Determination of Impact Insulation Class (IIC)".

These measurements are also in accordance with ISO 140-6, "Laboratory Measurements of Impact Sound Insulation of Floors", except that the tapping machine positions are not randomly selected. This difference is believed to be insignificant. The Weighted Normalized Impact Sound Pressure Level ($L_{n,w}$) was determined in accordance with ISO 717, "Rating of Sound Insulation in Buildings and of Building Elements - Part 2: Impact Sound Insulation".

One-third octave band sound pressure levels were measured for 32 seconds at each microphone position in the receiving room and then averaged to get the average sound pressure level in the room. Five sound decays were averaged to get the reverberation time at each microphone

position in the receiving room. These times were averaged to get the spatial average reverberation times for the room.

The space average sound pressure levels and the spatial average reverberation times of the receiving room were used to calculate impact transmission values. For impact sound transmission, the lower room is the receiving room.

In addition to the requirements of this contract, calculations were made according to ISO 717, Rating of sound insulation in buildings and building elements. - Part 2 : Impact sound insulation. These calculations are summarized in the Additional Calculations Section.

A complete description of the test procedure is available on request.

MOUNTING OF SPECIMEN

The test specimen was mounted in the IRC acoustical floor test opening which measures 4.70 m x 3.78 m. The area used for the calculations of impact transmission and airborne sound transmission loss was 17.85 m^2.

SPECIMEN DESCRIPTION

Construction on the floor assembly began on 25-Jun-99. The airborne sound transmission loss tests were performed on 30-Jun-99. The floor assembly comprised the following elements, listed from top to bottom.

Table 1: Element breakdown of Specimen B3135-4.

Element	Surface weight (kg/m^2)	Mass (kg)
6 mm ceramic tiles	15.5	326.1
13 mm cement board	13.4	271.2
8 mm Duracoustic	3.0	60.0
146 mm thick concrete slab	356.3	7029.5
TOTAL		**7686.8**

Total thickness: 173.0 mm

The 146 mm concrete reference slab, provided by NRC, was installed in the floor test frame. Pieces of 8 mm thick shredded rubber material, identified by the client as

"Duraflex"

"Duracoustic", were installed directly on top of the concrete slab. The "Duracoustic" was installed with the rubber side against the concrete slab. 13 mm thick pieces of Westroc Panaroc cement board with Edgetech were installed on top of the "Duracoustic" The joists of the cement board were taped and cemented as per installation instructions. 6 mm thick ceramic tiles were installed on top of the cement board according to the manufacturer's instructions.

RESULTS

Results of the airborne sound transmission loss measurements of Specimen B3135-4 are given in Table 2 and Figure 1. Results of the impact sound transmission measurements of this floor construction are given in Table 3 and Figure 2.

Certain values in the tables are marked. The values marked "*" indicate that the measured background level was less than 5 dB below the combined receiving room level and background level. The reported values provide an estimate of the lower limit of airborne sound transmission loss or impact transmission. These values do not limit the single number ratings. The values marked "c" indicate that the measured background level was between 5 dB and 10 dB below the combined receiving room level and background level. The reported values have been corrected according to the procedure outlined in ASTM E90-97 or ASTM E492-90.

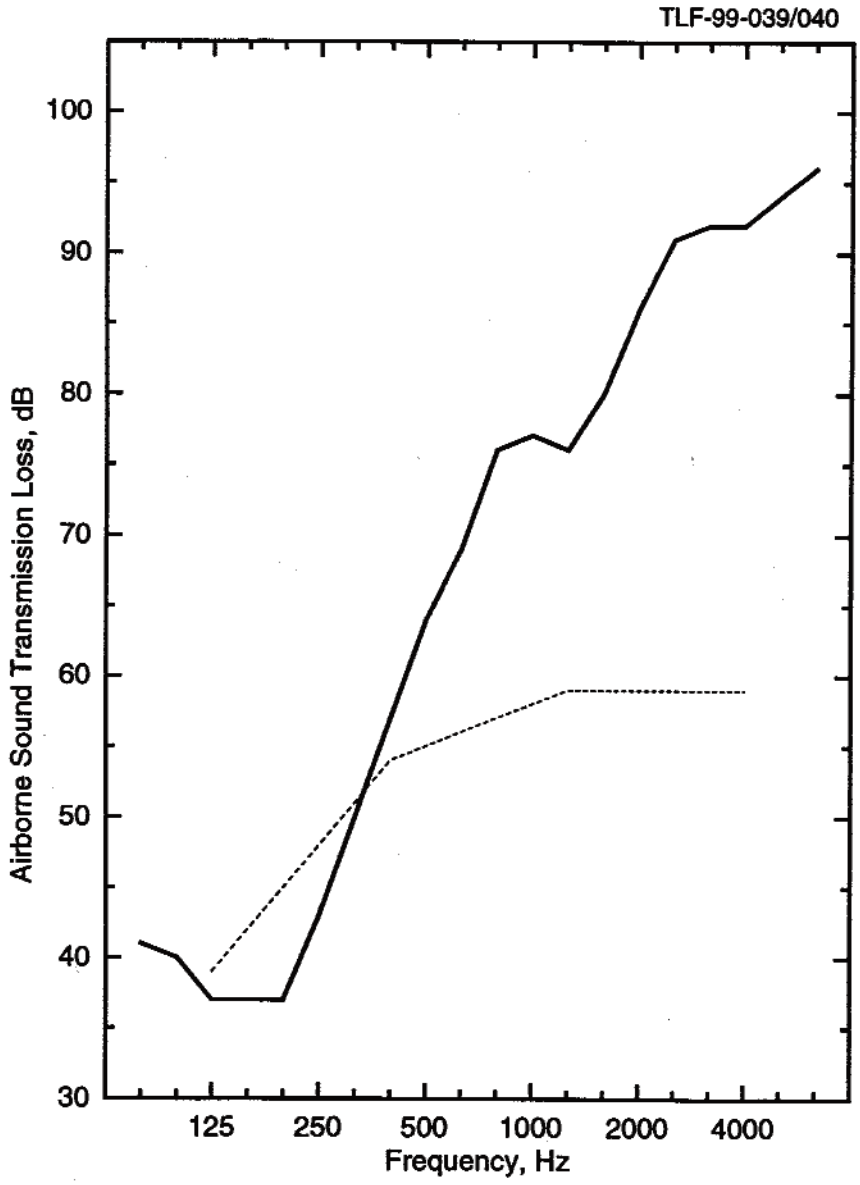
Table 2: Airborne sound transmission loss measurements of Specimen B3135-4, TLF-99-039/040.

Frequency (Hz)	Airborne Sound Transmission Loss (dB)		95% Confidence Limit[1]	Deviation Below the STC Contour
80	41		±2.4	
100	40		±1.4	
125	37		±1.3	2
160	37		±0.9	5
200	37		±0.9	8
250	43		±0.6	5
315	50		±0.6	1
400	57		±0.5	
500	64		±0.4	
630	69		±0.5	
800	76		±0.3	
1000	77		±0.3	
1250	76		±0.3	
1600	80		±0.3	
2000	86		±0.3	
2500	91		±0.3	
3150	92		±0.3	
4000	92	c	±0.4	
5000	94	c	±0.5	
6300	96	*	±0.5	
Sound Transmission Class (STC)[2] = 55				
Weighted Sound Reduction (R_W)[3] = 57				

[1] Acoustical measurement in rooms is a sampling process and as such has associated with it a degree of uncertainty. By correctly performing a number of measurements, the uncertainties can be reduced and upper and lower limits assigned to the probable error in the measurement. These limits are called confidence limits. Thus where a quantity (Q) has associated with it a confidence limit ±C, then one can say with 95% confidence that the true quantity is in the interval Q - C to Q + C.

[2] Sound Transmission Class (STC) calculated according to ASTM E413-94.

[3] Weighted Sound Reduction (R_w) calculated according to ISO 717.



Frequency (Hz)	Airborne Sound Transmission Loss (dB)	
80	41	
100	40	
125	37	
160	37	
200	37	
250	43	
315	50	
400	57	
500	64	
630	69	
800	76	
1000	77	
1250	76	
1600	80	
2000	86	
2500	91	
3150	92	
4000	92	c
5000	94	c
6300	96	*

STC 55

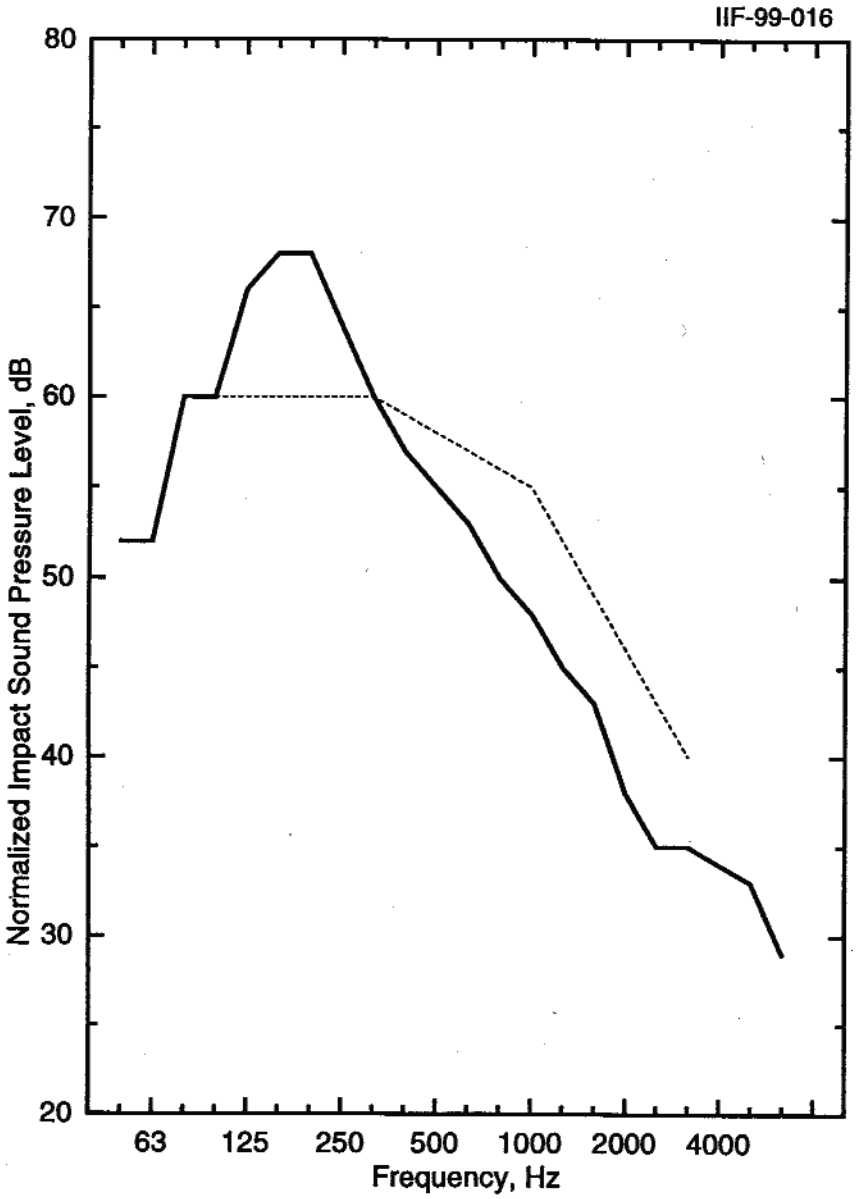
Figure 1: Airborne sound transmission loss measurements of a Specimen B3135-4. The solid line is the experimental data and the dotted line is the STC 55 contour.

Table 3: Impact sound transmission measurements of Specimen B3135-4, IIF-99-016.

Frequency (Hz)	Normalized Impact Sound Pressure Level (dB)	95% Confidence Limit[1]	Deviation Above the IIC Contour
50	52	±1.3	
63	52	±1.5	
80	60	±1.3	
100	60	±0.9	
125	66	±0.7	6
160	68	±0.4	8
200	68	±0.4	8
250	64	±0.3	4
315	60	±0.4	
400	57	±0.2	
500	55	±0.2	
630	53	±0.2	
800	50	±0.1	
1000	48	±0.1	
1250	45	±0.1	
1600	43	±0.1	
2000	38	±0.1	
2500	35	±0.1	
3150	35	±0.1	
4000	34	±0.1	
5000	33	±0.1	
6300	29 c	±0.2	
Impact Insulation Class (IIC)[4] = 52			
Weighted Normalized Impact Sound Pressure Level ($L_{n,w}$)[5] = 58			

[4] Impact Insulation Class (IIC) calculated according to ASTM E989-89.

[5] Weighted Normalized Impact Sound Pressure Level ($L_{n,w}$) calculated according to ISO ISO 717.



Frequency (Hz)	Normalized Impact Sound Pressure Level (dB)
50	52
63	52
80	60
100	60
125	66
160	68
200	68
250	64
315	60
400	57
500	55
630	53
800	50
1000	48
1250	45
1600	43
2000	38
2500	35
3150	35
4000	34
5000	33
6300	29 c

IIC 52

Figure 2: Impact sound transmission measurements of Specimen B3135-4 The solid line is the experimental data and the dotted line is the IIC 52 contour.

ADDITIONAL CALCULATIONS

In addition to the requirements of this contract, calculations were made according to ISO 717 Rating of sound insulation in buildings and building elements. - Part 2: Impact sound insulation.

The calculations for evaluating the weighted impact sound improvement index of floor coverings are shown in the tables below.

The ISO 717 impact sound rating is called the weighted normalized impact sound pressure level and is denoted $L_{n,w}$. The rating curve is identical to that used in calculating the ASTM IIC rating. The sole difference in the fitting procedure is that the ISO standard allows unfavorable deviations to exceed 8 dB; the ASTM E989 standard does not. When this 8 dB limitation is not invoked, the two ratings are related by the equation

$$IIC = 110 - L_{n,w}$$

The ISO reference slab has an IIC rating of 28 and $L_{n,w} = 78$ dB.

Table 4 shows the reduction in normalized impact sound pressure level relative to the 146 mm concrete slab for the specimen tested. Following the procedures in ISO 717, these differences were added to the impact sound levels for the idealized reference floor in that standard. The levels for the reference floor and the estimated levels for the specimen are shown in Table 5. $L_{n,w,r}$ in that table is the estimated value of normalized impact sound pressure level for the tested toppings on the reference ISO slab. ΔL_w is the improvement in weighted normalized impact sound pressure level. This number is not equal to the improvement in IIC because the 8 dB rule was applied when calculating the IIC for the bare 146 mm thick IRC concrete slab.

Table 4: Reduction in normalized impact sound pressure level relative to the 146 mm concrete slab.

Frequency (Hz)	Specimen B3135-4
50	8.0
63	5.1
80	1.9
100	4.2
125	0.8
160	1.6
200	4.1
250	9.3
315	13.7
400	17.8
500	20.9
630	23.1
800	25.4
1000	27.2
1250	29.9
1600	31.9
2000	36.3
2500	39.5
3150	39.0

Table 5: Estimated levels using the ISO Reference Floor.

Frequency (Hz)	ISO Reference Floor	Specimen B3135-4
100	67.0	62.8
125	67.5	66.7
160	68.0	66.4
200	68.5	64.4
250	69.0	59.7
315	69.5	55.8
400	70.0	52.2
500	70.5	49.6
630	71.0	47.9
800	71.5	46.1
1000	72.0	44.8
1250	72.0	42.1
1600	72.0	40.1
2000	72.0	35.7
2500	72.0	32.5
3150	72.0	33.0
$L_{n,w,r}$	78	56
ΔL_w	-	22
IIC_{est}	28	25

NOTES ON THE SIGNIFICANCE OF TEST RESULTS

Sound Transmission Class And Weighted Sound Reduction Index

The Sound Transmission Class (STC) and Weighted Sound Reduction Index (R_w) are single-figure rating schemes intended to rate the acoustical performance of a partition element under typical conditions involving office or dwelling separation. The higher the value of either rating, the better the floor performance. Thus, the rating is intended to correlate with subjective impressions of the sound insulation provided against the sounds of speech, radio, television, music, office machines and similar sources of noise characteristic of offices and dwellings. In applications involving noise spectra that differ markedly from those referred to above (for example, heavy machinery, power transformers, aircraft noise, motor vehicle noise), the STC and R_w are of limited use. Generally, in such applications it is desirable to consider explicitly the noise spectra and the insulation requirements.

Impact Insulation Class And Weighted Normalized Impact Sound Pressure Level

The Impact Insulation Class (IIC) and the Weighted Normalized Impact Sound Pressure Level ($L_{n,w}$) are single-figure rating schemes intended to rate the effectiveness of floor-ceiling assemblies at preventing the transmission of impact sound from the standard tapping machine. The higher the value of the rating, the better the floor performance.