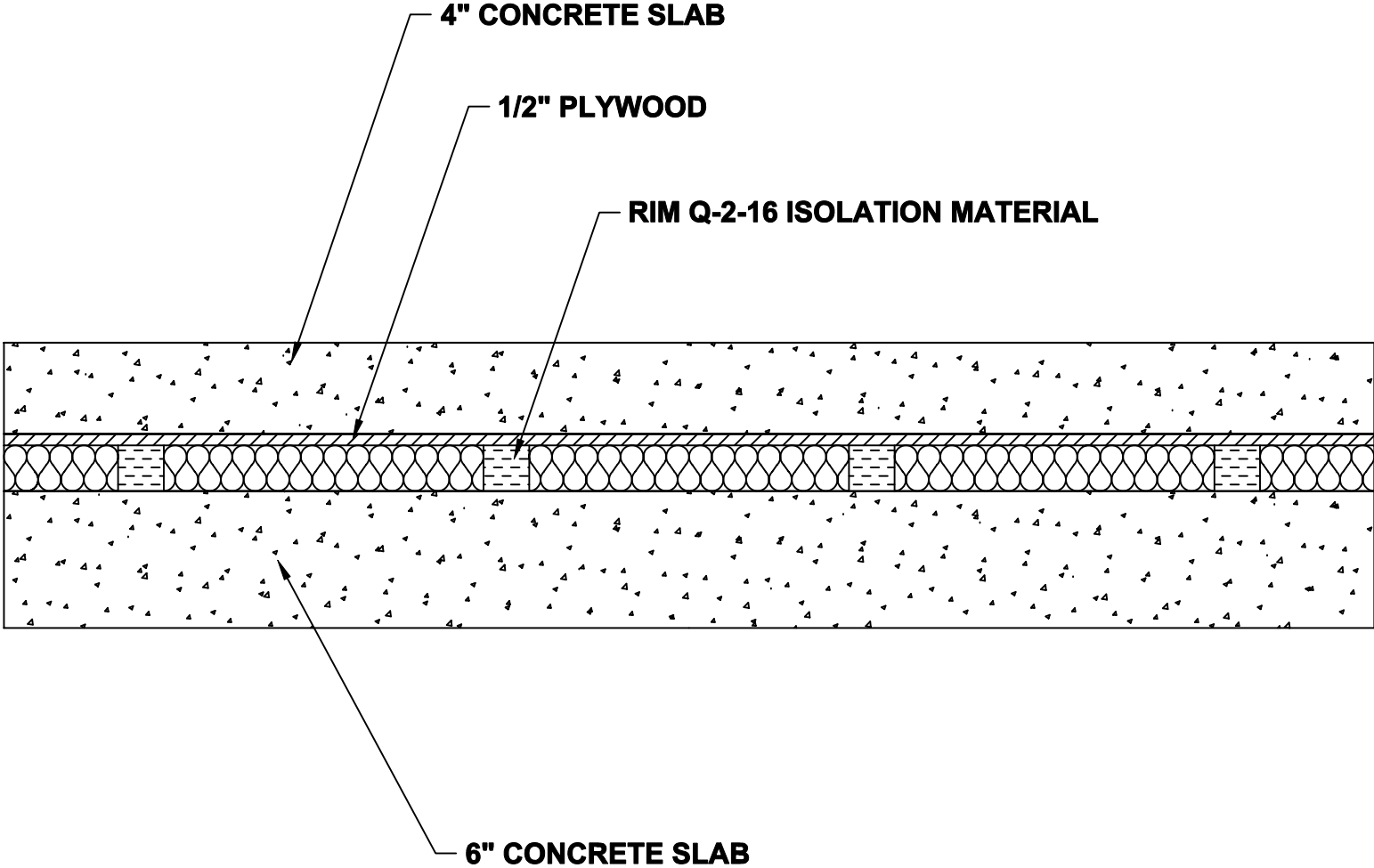


STC 72

IIC 62



National Research Council of Canada

Client Report

B-3448.10

**Airborne Sound Transmission Loss, Impact
Sound Transmission and Special Impact
Tests Measurements Performed on One (1)
Floor Assembly**

for

Kinetics Noise Control
6300 Ireland Place
Dublin, OH, USA
43017-0655

01 May 2007


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Author



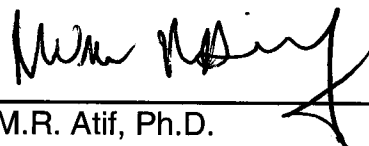
N.L. Brunette

Quality
Assurance



J.D. Quirt, Ph.D.
Group Leader

Approved



M.R. Atif, Ph.D.
Director, Indoor Environment

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Copy No. 4 of 4 copies

INTRODUCTION

Airborne and impact sound transmission measurements were performed on one floor assembly. Special impact tests (tire, walker and ball) were also performed. For report purposes, the floor is identified as Floor "B". Please note that this floor assembly was tested under contract A1068, but an individual report for this specimen was not requested or issued as part of that contract.

SPECIMEN DESCRIPTION

Construction on the series of floor assemblies for this contract started in November 1995 and concluded in March 1996. The airborne and impact sound transmission loss tests for this floor assembly were performed on February 20th, 1996.

Floor "B"

The top layer of Floor "B" comprised a 100 mm thick concrete slab with a layer of 13 mm exterior grade plywood bonded to the bottom. In order to simulate actual construction and to ensure that the 13 mm plywood bonded to the concrete, screws were inserted into the plywood on 914 mm centers within 150 mm of the perimeter edge. These screws protruded 19 mm from the top of the plywood.

The concrete with attached plywood was placed on top of 50 mm square KIP-Q resilient pads on 400 mm centers. One layer of 65 mm thick glass fibre batts were used to fill the space around the resilient pads. The resilient pads were calculated to be compressed by approximately 14 mm when loaded with the 100 mm thick concrete slab with attached 13 mm plywood.

Under these pads was the 150 mm reference concrete slab, provided by NRC, which was installed in the floor test frame. The perimeter of the reference concrete slab is sealed at the top with insulation and covered with metal tape and at the bottom with mortite then covered with metal tape. The density of the concrete slab is 2446 kg/m³.

The following table gives the elements of the specimen, listed from top to bottom.

Table 1: Element breakdown of Floor "B".

Element	Surface weight (kg/m ²)	Mass (kg)
100 mm concrete slab with 13 mm exterior grade plywood attached	233	4,591
50 mm high square KIP-Q resilient pads, 400 mm o.c. (total of 99 pads used), compressed to approximately 36 mm		7
65 mm Noise Stop Blanket glass fibre batts	0.7	14
150 mm concrete slab	356	7,030
TOTAL	589.7	11,642

Measured total thickness: 286 mm

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 m².

RESULTS

Results of the airborne sound transmission loss measurements of Floor "B" 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. Results of the special measurements are given in Table 4, 5, 6 and Figure 3, 4 and 5.

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 sound transmission class.

The Tables also give the 95% confidence limits. Acoustical measurement in rooms is a sampling process and as such has associated with it a degree of uncertainty. By using enough microphone and loudspeaker positions, the uncertainty can be reduced and upper and lower limits assigned to the probable error in the measurement. These limits are called 95% confidence limits. They are calculated for each test according to the procedures in ASTM E90 and E492 and must be less than upper limits given in the standards. These confidence limits do not relate directly to the variation expected when a nominally identical specimen is built, installed and tested (repeatability). Nor do they relate to the differences expected when nominally identical specimens are tested in different laboratories (reproducibility).

Table 2: Airborne sound transmission loss measurements of Floor "B", TLF-96-027.

Frequency (Hz)	Airborne Sound Transmission Loss (dB)	95% Confidence Limits*	Deviation Below the STC Contour
80	50	±2.7	
100	51	±2.8	
125	55	±1.0	-1
160	53	±1.1	-6
200	55	±0.7	-7
250	57	±0.6	-8
315	62	±0.7	-6
400	70	±0.3	-1
500	73	±0.7	
630	77	±0.5	
800	84	±0.4	
1000	87	±0.4	
1250	90	±0.3	
1600	95	0.5±	
2000	98	0.3±	
2500	101	0.3±	
3150	102**	0.2±	
4000	102**	0.3±	
5000	102**	0.4±	
Sound Transmission Class (STC) ¹ = 72			
Weighted Sound Reduction (R _w) ² = 72			

¹ Sound Transmission Class (STC) calculated according to ASTM E413.

² Weighted Sound Reduction (R_w) calculated according to ISO 717.

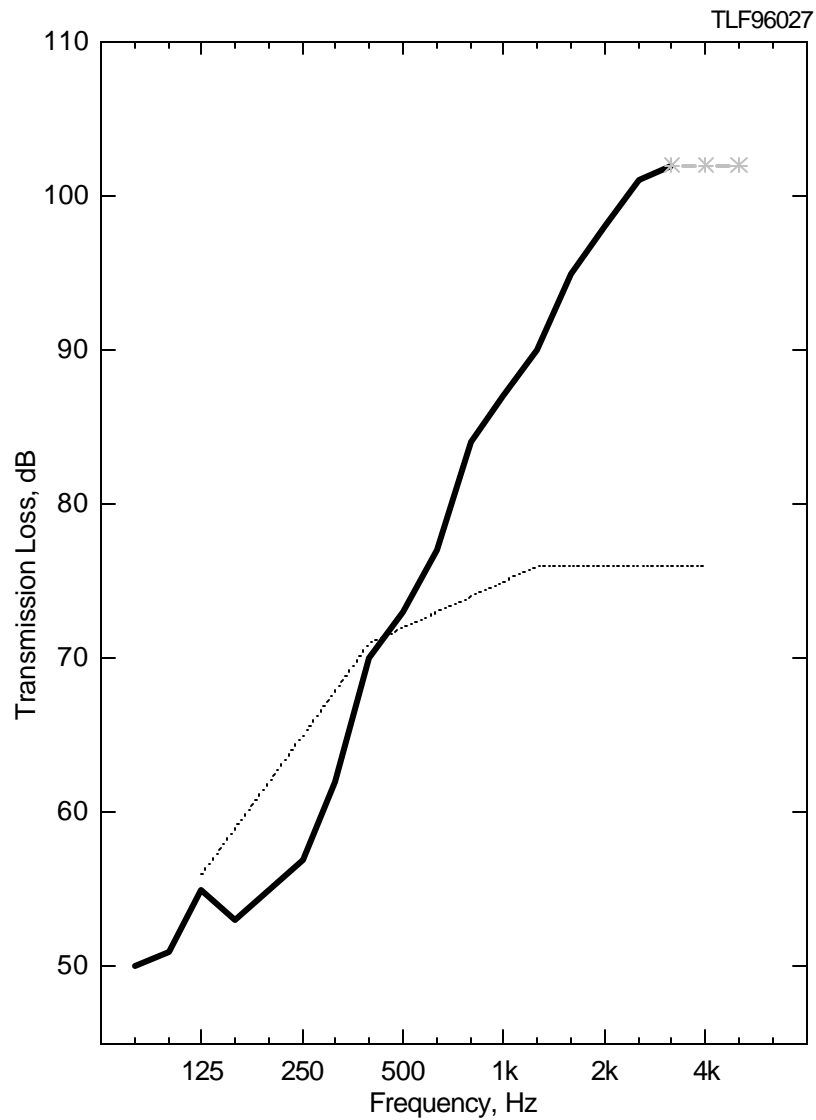


Figure 1: Airborne sound transmission loss measurements of Floor “B”. The solid line is the experimental data, the dotted line is the STC 72 contour and the line with asterisks is the lower limit of the airborne sound transmission loss.

Table 3: Impact sound transmission measurements of Floor "B", IIF-96-004.

Frequency (Hz)	Impact Sound Transmission Loss (dB)	95% Confidence Limits*	Deviation Below the IIC Contour
80	56	±0.9	
100	56	±1.2	-6
125	51	±0.7	-1
160	52	±0.5	-2
200	55	±0.5	-5
250	55	±0.3	-5
315	51	±0.4	-1
400	49	±0.3	
500	49	±0.3	-1
630	47	±0.4	
800	46	±0.2	
1000	45	±0.2	
1250	42	±0.3	
1600	39	±0.2	
2000	40	±0.2	-4
2500	35	±0.2	-2
3150	34	±0.2	-4
4000	34	±0.2	
5000	30	±0.3	
Impact Insulation Class (IIC) ³ = 62 Weighted Normalized Impact Sound Pressure Level (L _{n,w}) ⁴ = 48			

³ Impact Insulation Class (IIC) calculated according to ASTM E989.

⁴ Weighted Normalized Impact Sound Pressure Level (L_{n,w}) calculated according to ISO 717.

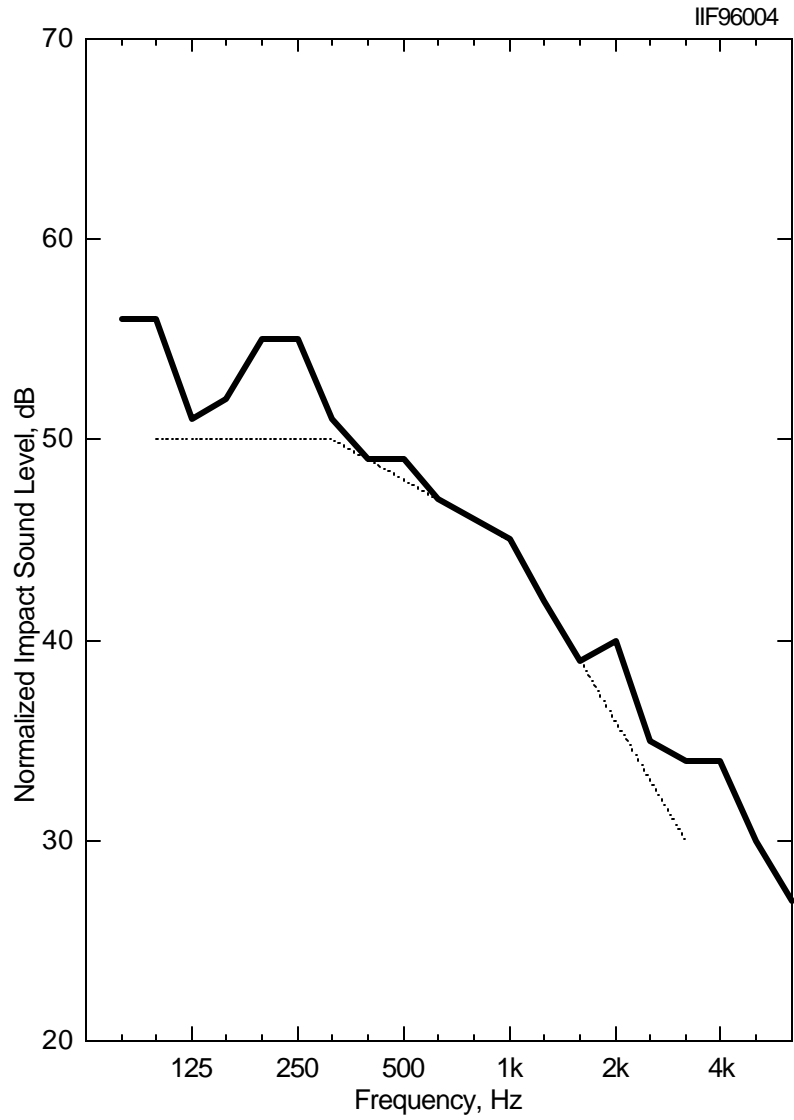


Figure 2: Impact sound transmission measurements of Floor “B”. The solid line is the experimental data and the dotted line is the IIC 62 contour.

Table 4: Peak impact insulation measurements, using Tachibana's ball, of Floor "B", BBF-96-004.

Frequency (Hz)	Impact Sound Pressure Level (dB)
12.5	49
16	51
20	76
25	86
31.5	86
40	78
50	70
63	69
80	74
100	74
125	54
160	51
200	51
250	51
315	42
400	36
500	33
630	29

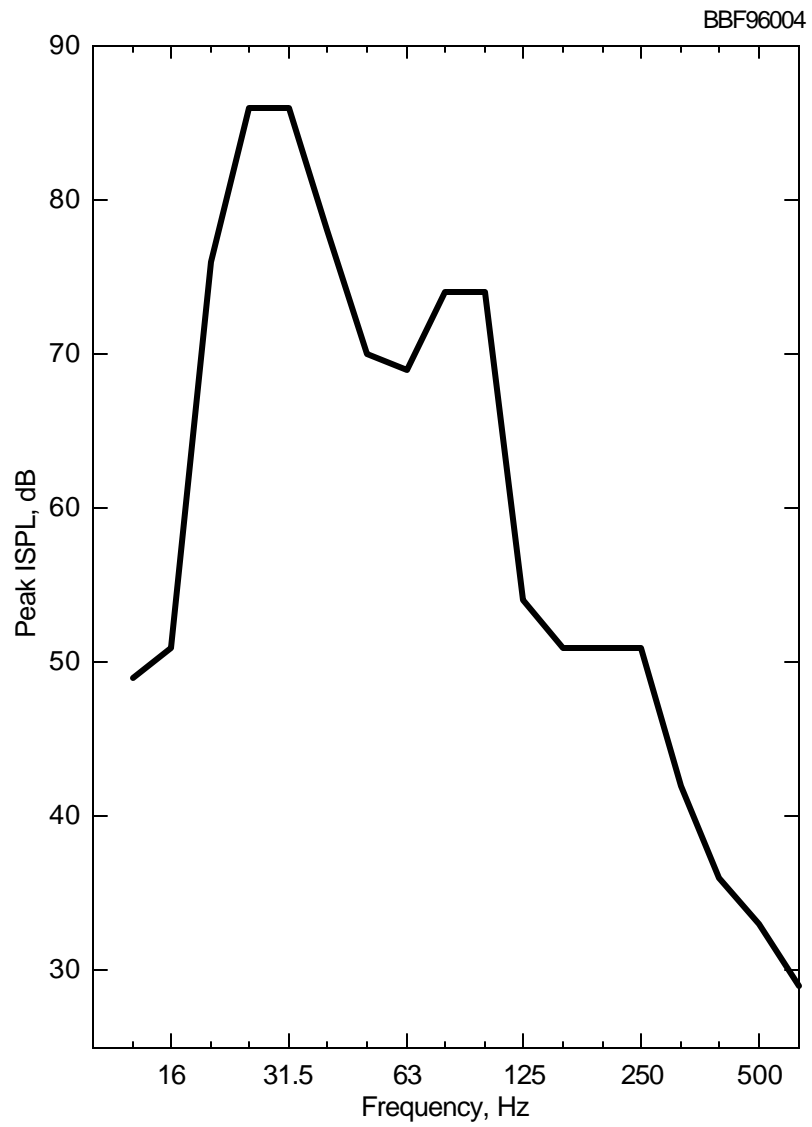


Figure 3: Peak impact insulation measurements, using Tachibana's ball, of Floor "B".

Table 5: Peak impact insulation measurements, using the tire machine, of Floor "B", TYF-96-004.

Frequency (Hz)	Impact Sound Pressure Level (dB)
12.5	59
16	59
20	82
25	93
31.5	93
40	81
50	71
63	65
80	63
100	61
125	48
160	48
200	47
250	46
315	44
400	43
500	44
630	45

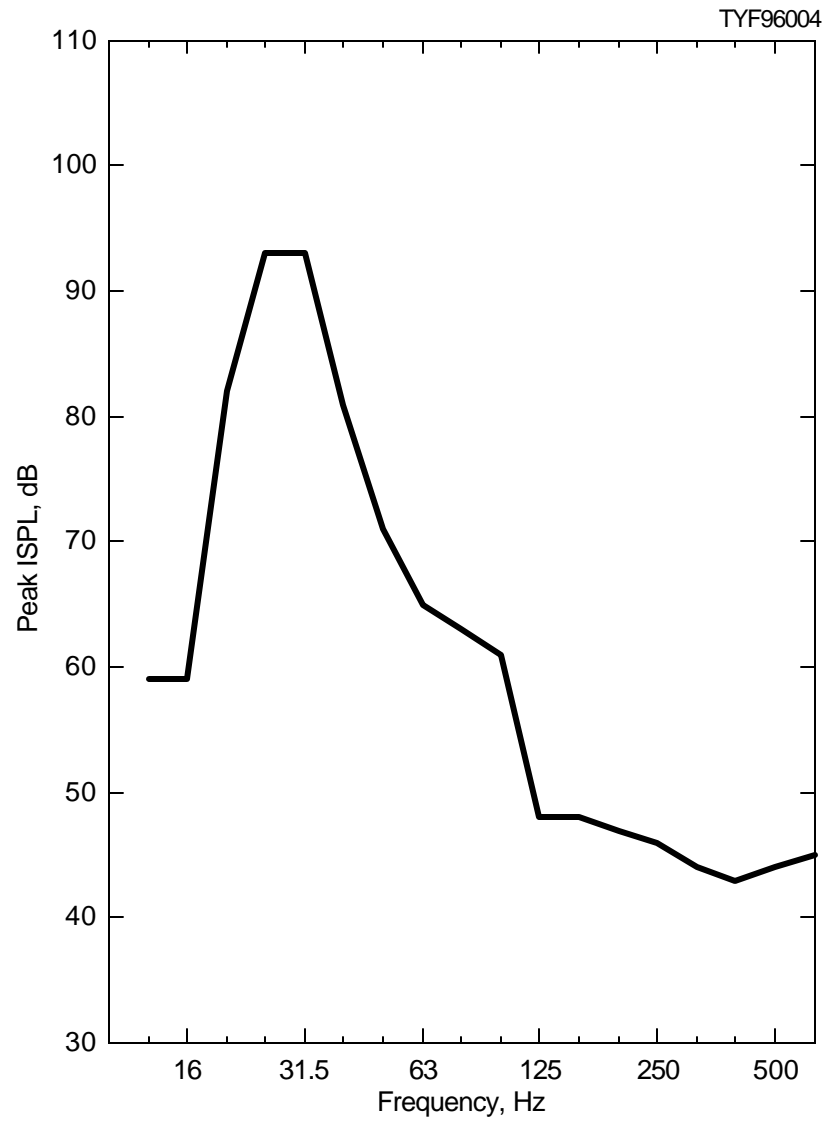


Figure 4: Peak impact insulation measurements, using the tire machine, of Floor "B".

Table 6: Peak impact insulation measurements, using the live walker, of Floor "B", WMF-96-004.

Frequency (Hz)	Impact Sound Pressure Level (dB)
12.5	35
16	33
20	50
25	63
31.5	64
40	49
50	39
63	34
80	41
100	38
125	31
160	31
200	34
250	33
315	27
400	18
500	20
630	12

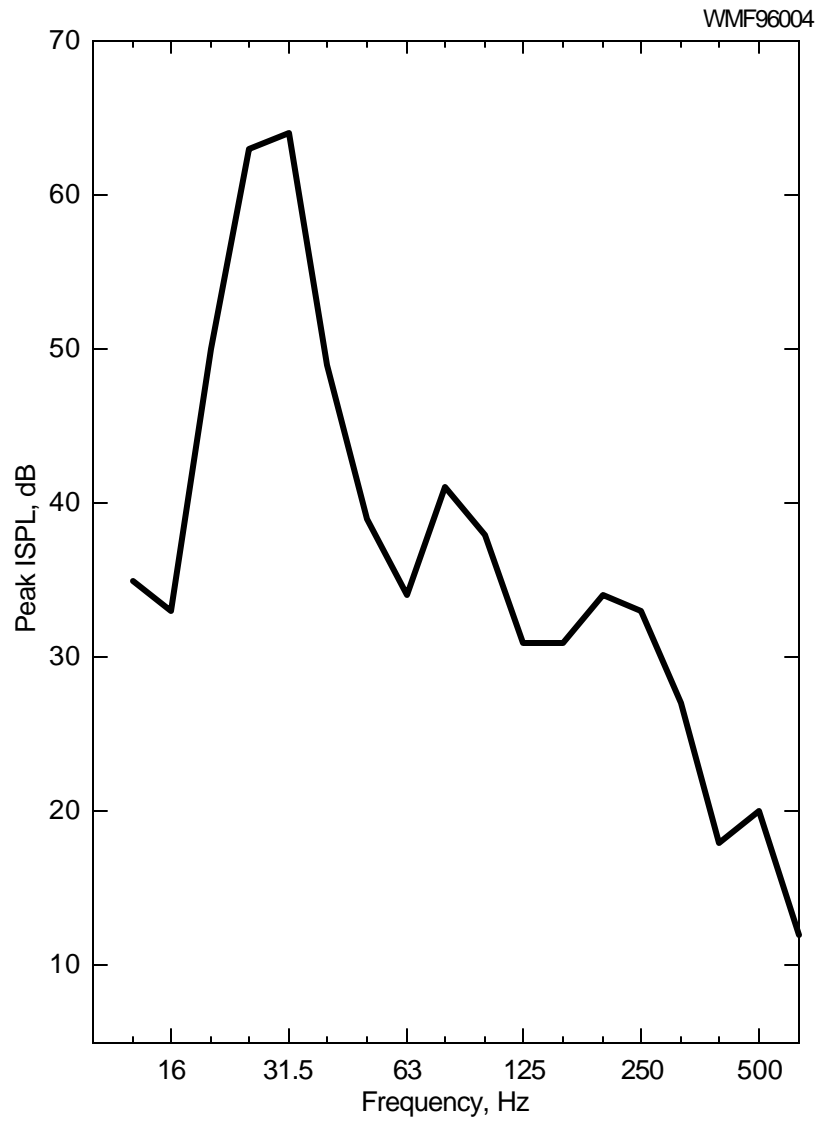


Figure 5: Peak impact insulation measurements, using the live walker, of Floor “B”.

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) (ASTM E989) and the Weighted Normalized Impact Sound Pressure Level ($L_{n,w}$) (ISO 717-2) 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.

The ASTM E989 and the ISO 717 rating curves are identical. The major 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 requirement is not invoked, the two ratings are related by the equation

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

Extended Frequency Range

Standard test procedures require measurements in 1/3-octave bands over a specified frequency range (125 to 4000 Hz for ASTM E90 and 100 to 3150 Hz for ASTM E492). Within those ranges, reproducibility has been assessed by inter-laboratory round robin studies. The standards recommend making measurements and reporting results over a larger frequency range, and this report presents such results, which may be

useful for expert evaluation of the specimen performance. The precision of results outside the standard ranges has not been established, and is expected to depend on laboratory-specific factors such as room size and specimen dimensions.

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 m³.

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 with a type 4166 cartridge 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, "Standard Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions", and of ISO 140-3, "Laboratory Measurement of Airborne Sound Insulation of Building Elements".

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

One-third octave band sound pressure levels were measured for 30 seconds at each microphone position in each 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 average reverberation times for the room.

The average sound pressure levels of both the source and receiving rooms and the 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.

Impact Sound Transmission

Impact sound transmission measurements were made in accordance with ASTM E492, "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, "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 717-2, "Acoustics — 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 30 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.

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

Special Impact Test (Tire, Walker, Ball)

There is no standard test specifying how to measure the sound pressure levels generated by a person walking on a floor. Several years ago in ASTM committee E33, a single microphone measurement technique was proposed and was adopted for use in this laboratory. A single microphone is placed 1 m below the mid-point of the ceiling and the room below is made much less reverberant by placing sound absorbing material in it. The same microphone technique is used for measuring walker, ball and tire levels.

The Japanese measurement standard JIS 1418 specifies a heavy impactor source for evaluating floor constructions. It consists of an automobile tire mounted on an arm attached to motor. The motor lifts the tire and then utilizes cams to drop the tire freely on the floor. The cam system prevents the tire from striking the floor again until it has been lifted to the correct drop height. JIS 1418 specifies many drop positions for the tire and several microphone positions. Earlier research with this machine showed that only a few positions of the tire were necessary. The single microphone position is also considered adequate for comparison of floors tested within a single laboratory.

For the walker tests, a male member of the laboratory walks for about 3 minutes while the computer collects maximum sound levels for each 100 footsteps using a 35 ms time constant.

The ball used in these measurements was developed by H. Tachibana as part of his research. The ball is 180 mm in diameter and weighs 2.5 kg. It is dropped from a height of 900 mm. The force generated is sufficiently repeatable that only 15 impulses need be averaged.