# Airborne Sound Insulation

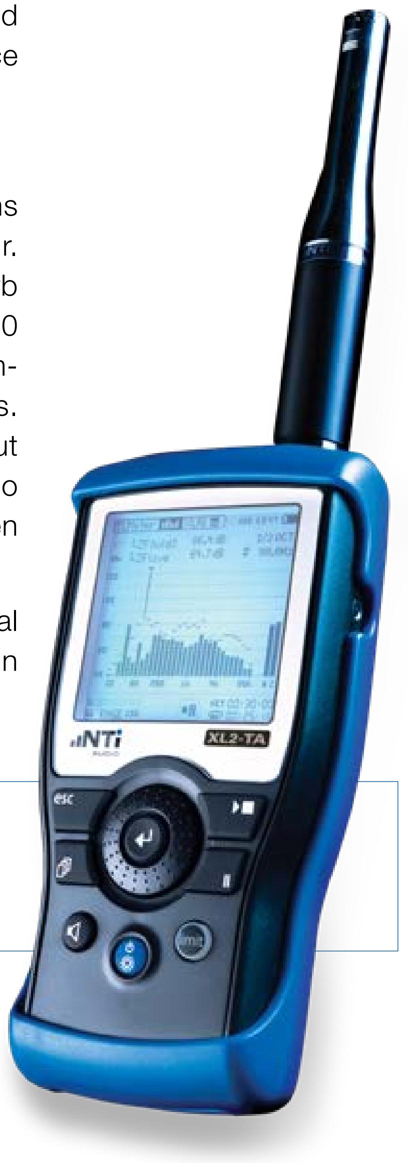
## MEASUREMENT WITH THE XL2 SOUND LEVEL METER

This application note describes how to measure airborne sound insulation in buildings using the XL2 Sound Level Meter in accordance with the ISO 16283-1 standard.

Airborne sound insulation describes the insulation, between rooms separated by a wall or floor partition, of sound transmitted through air. It is calculated by combining multiple sound pressure level and reverb time measurements. The measured frequency range is typically from 50 Hz to 5 kHz. The test results can be used to quantify, assess and compare the airborne sound insulation in unfurnished or furnished rooms. The measured airborne sound insulation is frequency-dependent but can be converted into a single number, the sound reduction index, to characterize the resistance to the passage of airborne sound between rooms.

This application note applies to rooms with a volume larger or equal to 25 $m^3$. Special methods apply to smaller rooms as specified in ISO 16283-1.

XL2-TA



# 1. GETTING READY

## RELATED STANDARDS

| | |
|---|---|
| ISO 16283-1 | Describes the procedures for field measurements of sound insulation in buildings. (replaces the corresponding parts of ISO140-4) |
| ISO 717-1 | Describes the rating of sound insulation in buildings |
| IEC 61672-1 | Specifies the requirements for a class 1 sound level meter |
| IEC 61260-1 | Specifies the requirements for octave-band and 1/3-octave band filters |
| ISO 3382-2 | Specifies the measurement of the reverberation time T |

## INSTRUMENT CONFIGURATION

The sound level meter shall meet the requirements of a class 1 instrument in accordance with the IEC 61672-1 standard. The recommended configuration consists of

- XL2 Sound Level Meter or
  XL2-TA Sound Level Meter for legally traceable measurements (=XL2 with Type Approval Option installed)
- Optional Extended Acoustic Pack installed
  (required for reverberation time measurement in 1/3 octave resolution)
- Sound Insulation Option or an enabled Sound Insulation Reporter 365 annual subscription
- M2230 Measurement Microphone
- ASD Cable
- NTi Audio Precision Calibrator
- Microphone Tripod
- DS3 Dodecahedron Speaker
- PA3 Power Amplifier
- Computer/Tablet with Sound Insulation Reporter Software

Note: The sound pressure level measuring system shall be calibrated at intervals not exceeding two years.

## REQUIRED MEASUREMENTS

— Noise level in the sending room

— Noise level in the receiving room

— Background noise level in the receiving room

— Reverberation time in the receiving room

At the beginning and at the end of each measurement day, the entire sound pressure level measuring system shall be checked with the precision calibrator. This shall meet the class 1 requirements in accordance with IEC 60942.

Note: Wear hearing protection for all measurements!

## ROOM SELECTION

Airborne sound insulation is measured between two rooms. One room is chosen as the sending room and the other one is chosen as the receiving room. In case the volumes of the two rooms differ, then the smaller room shall be used as the receiving room. If one of the rooms is box-shaped and the other has a more complicated geometry, the box-shaped room shall be used as the receiving room.

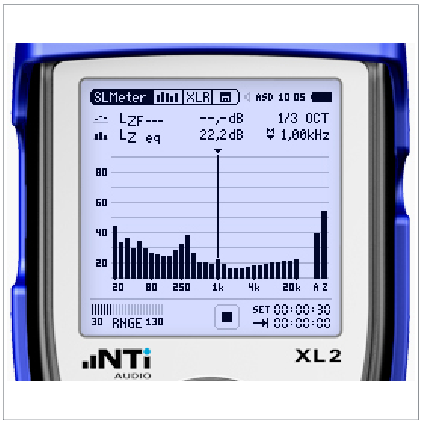
## 2. MEASURE BACKGROUND NOISE LEVEL LB IN RECEIVING ROOM

### PREPARATION

— Select the RTA page in the SLMeter function on the XL2 Sound Level Meter.

— Select 1/3 octave measurement resolution.

— It's recommended to vacate the room during the measurement so that any noise generated by the operator will not affect the measurement.



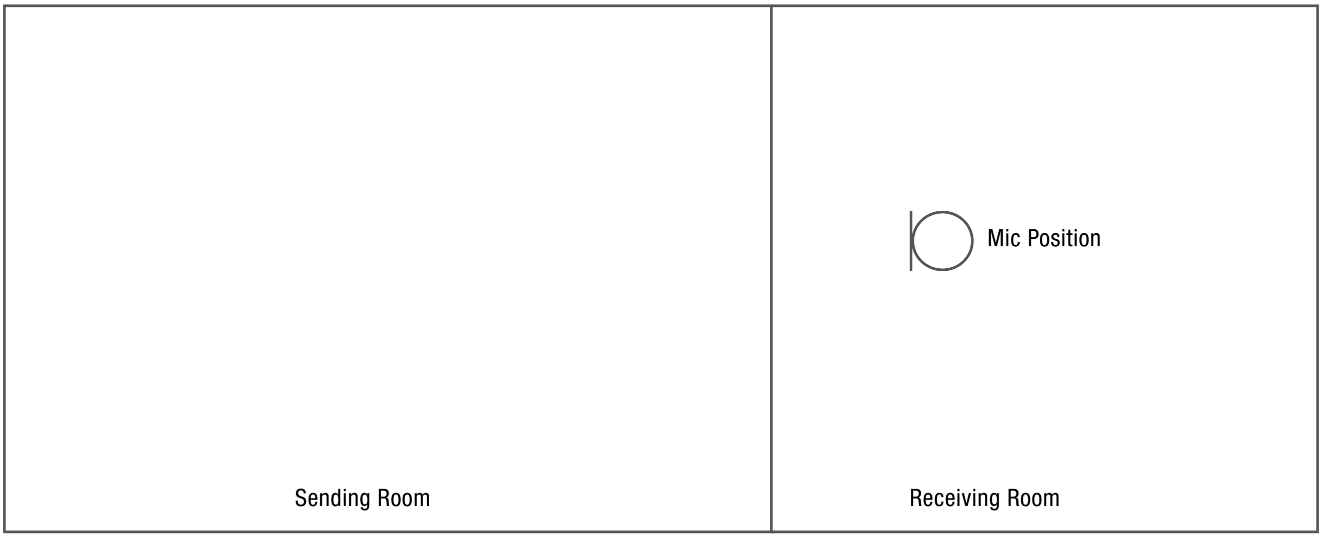

Background Noise Spectrum in the Receiving Room

### MEASUREMENT

— Measure the background noise LZeq in the receiving room for 15 seconds. In case the background noise is not steady and continuous, then a longer measurement period shall be applied, e.g. 30 seconds.

— Store the reading in the XL2. This is required for post calculation of the sound insulation.

— Capture the reading as a reference for the next step. This is required to adjust the speaker output level accordingly.




Measure the Background Noise Level Lb in the Receiving Room

## 3. TEST SIGNAL FOR SOUND LEVEL MEASUREMENT

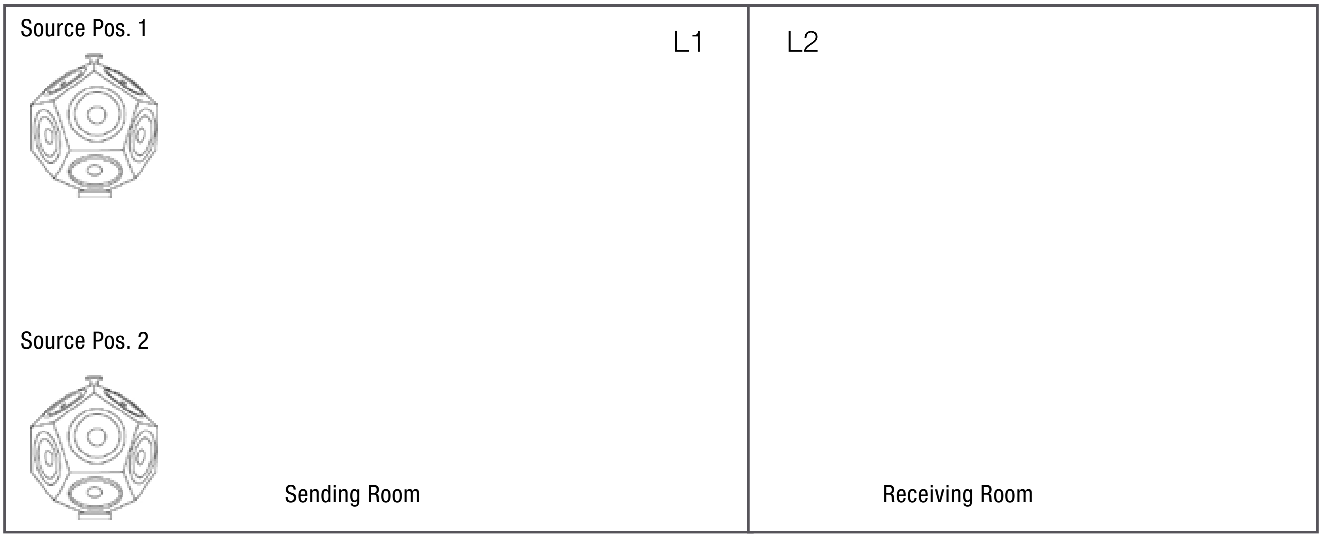
— Position the speaker in the sending room.

— The measurements have to be carried out with at least two different speaker positions.

— Choose position 1 at least 0.5 m from any room boundary and at least 1.0 m from the separating partition. Position 2 shall be similarly chosen, plus be in a different plane relative to the room boundaries, and with a minimum 1.4 m distance to position 1. The distances are measured from the center of the Dodecahedron Speaker DS3. In case the separation partition is a floor and the speaker is in the upper room, then the Dodecahedron Speaker DS3 has to be at least 1 m above the floor.

— Start the pink noise test signal at a low level.

— Increase the level until it is minimum of 10 dB higher, in each frequency band from 50 Hz to 5000 Hz, in the receiving room than the background noise measured in step 2. In case this is not possible, then the Sound Insulation Reporter software in step 7 will automatically apply corrections in accordance with ISO 16283-1.




Positions of the test signal source for the sound level measurements

# 4. MEASURE SOUND LEVELS L1 AND L2 AT SPEAKER POSITION 1

## PREPARATION

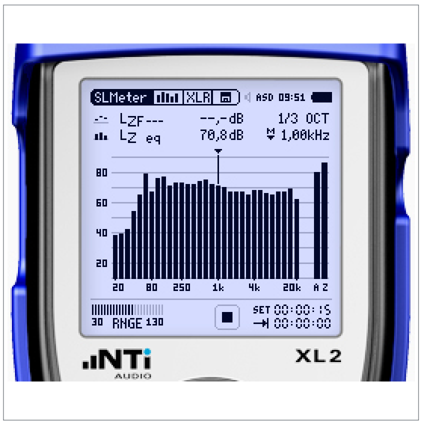
Define five microphone positions in the sending and receiving room, distributed within the maximum permitted space throughout each room. The positions shall be in a different plane relative to the room boundaries and shall not form a regular grid. For example, mark the positions on the floor with a tape. The following minimum distances apply:

— 0.7 m between microphone positions

— 0.5 m between any microphone and any room boundary

— 1.0 m between any microphone position and the speaker

It's recommended to vacate the room during the level measurement as the operator introduces additional absorption.

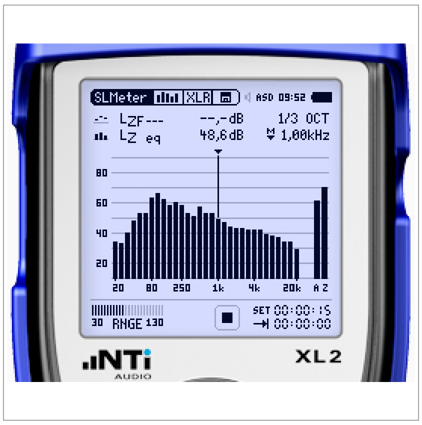



Noise Spectrum in the Sending Room

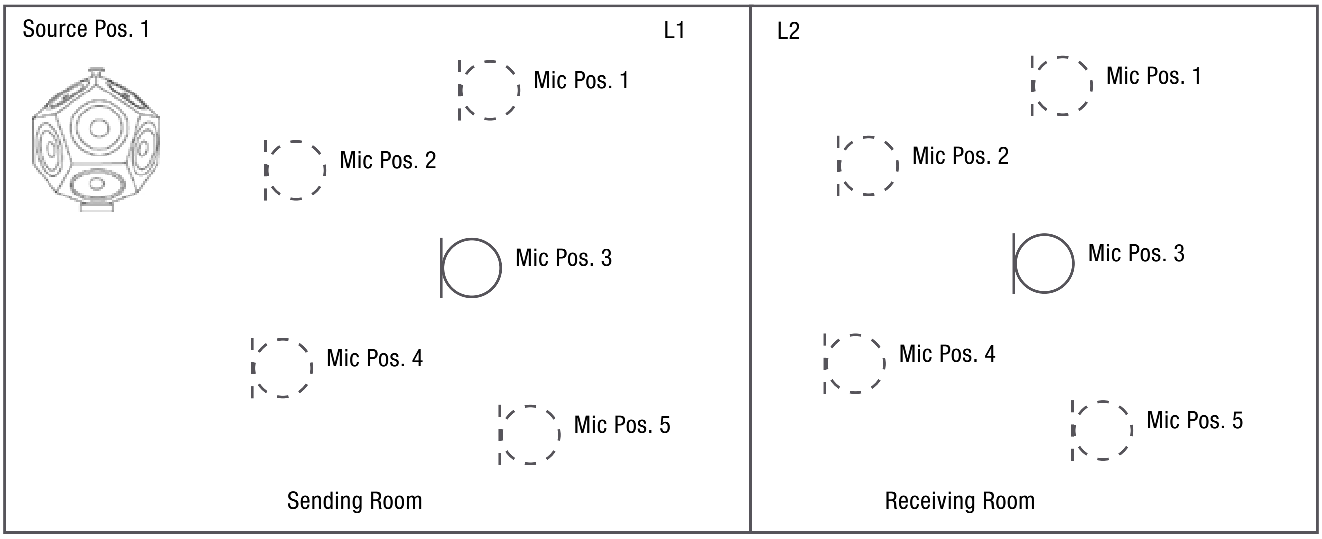
## MEASUREMENTS IN SENDING & RECEIVING ROOM

— Measure the sound level spectrum LZeq in the sending and receiving room at each position for a measurement period of 15 seconds.

— Store the individual readings in the XL2 for post calculation of the sound insulation.




Noise Spectrum in the Receiving Room




Measure the Sound Levels in the Sending and Receiving Room with the Speaker at Position 1

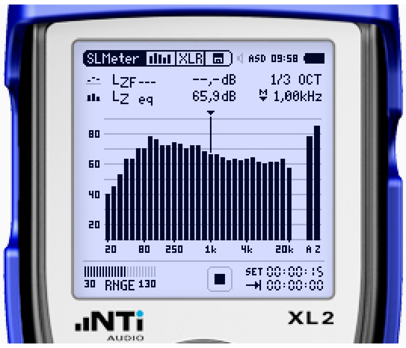
# 5. MEASURE SOUND LEVELS L1 AND L2 AT SPEAKER POSITION 2

Move the Dodecahedron Speaker DS3 to position 2 in the source room.

## MEASUREMENTS IN SENDING ROOM

— Measure the sound level spectrum LZeq in the sending room at each position for a measurement period of 15 seconds.

— Store the individual readings in the XL2 for post calculation of the sound insulation.

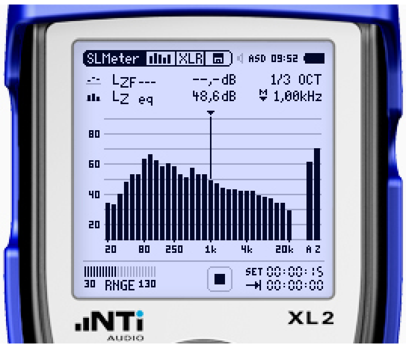



Noise Spectrum in the Sending Room

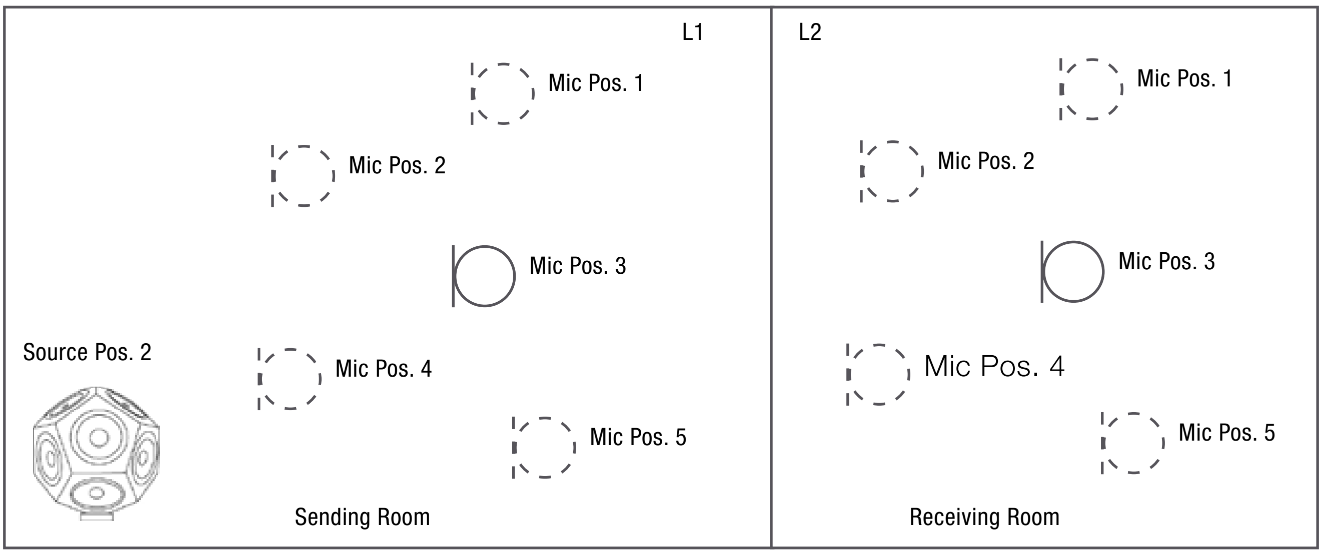
## MEASUREMENTS IN RECEIVING ROOM

— Measure the sound level spectrum LZeq in the receiving room at each position for a measurement period of 15 seconds.

— Store the individual readings in the XL2 for post calculation of the sound insulation.




Noise Spectrum in the Receiving Room

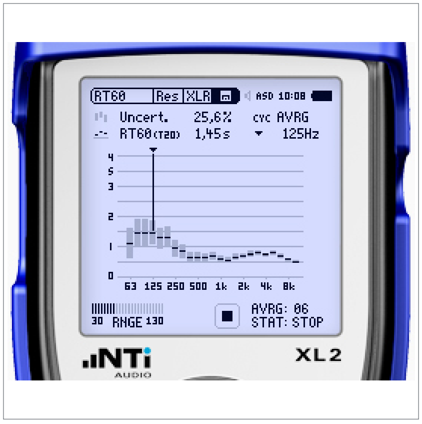



Measure the Sound Levels in the Sending and Receiving Room with the Speaker at Position 2

# 6. MEASURE REVERBERATION TIME T2 IN RECEIVING ROOM

## PREPARATION

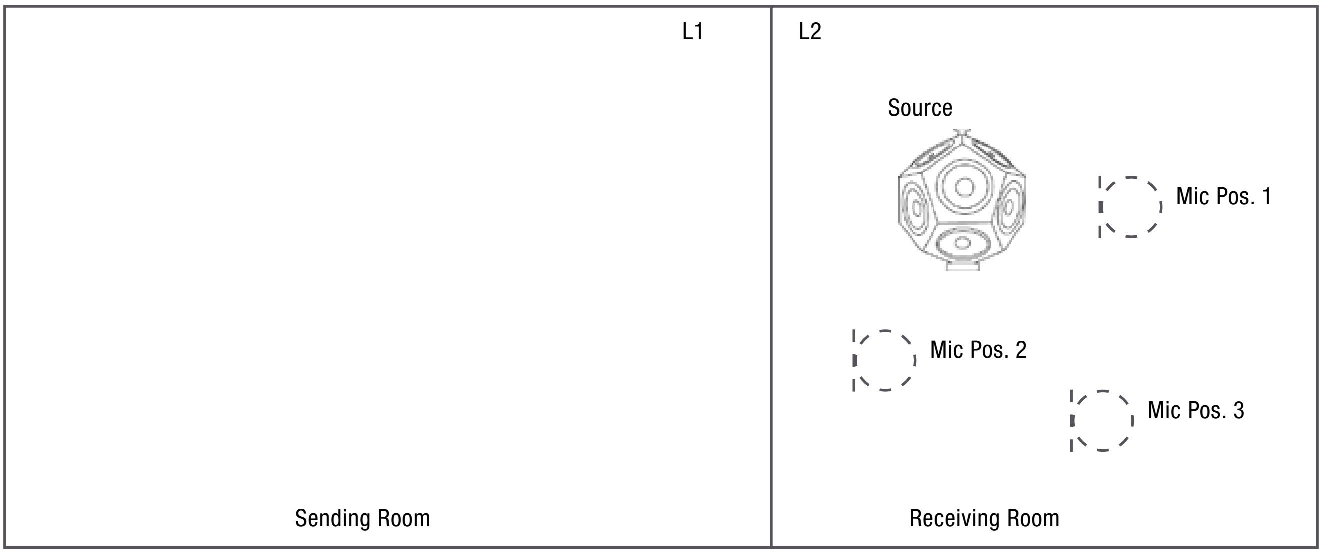
- Move the Dodecahedron Speaker DS3 to the receiving room.
- Select three microphone positions in the receiving room.
- Select the RT60 measurement function on the XL2 Sound Level Meter.
- Select the 1/3 octave resolution on the XL2.



RT60 Reverb Time T in the Receiving Room

## MEASURE THE REVERBERATION TIME T2 IN THE RECEIVING ROOM

- Start the measurement on the XL2.
- Start / stop the test signal.
- Guideline: Set the on/off cycle time for the signal longer than the expected reverberation time.
- Measure at least two decays.
- Stop the measurement on the XL2.
- Repeat the same at the other microphone positions.
- Store the individual readings on the XL2 for post calculation of the sound insulation.



Measure the Reverberation Time T in the Receiving Room

# 7. SOUND INSULATION REPORTER

Verify and document all readings by using the Sound Insulation Reporter software. This is a PC-Software dedicated for building acoustics professionals. Load all measurement records into the software and generate an Airborne Sound Insulation report. The software calculates the level difference Dw, the standardized level difference DnT,w, the normalized level difference Dn,w, and the apparent sound reduction index R'w based on the reference curve shifting method in accordance with the ISO 717-1 standard.

The following calculations are used:

D = L1 – L2

Dn = D - 10 lg (A / 10)

DnT = D + 10 lg (T/0.5)

R' = D + 10 lg (S/A)

A = 0.16 * V / T

| | |
|---|---|
| A | Equivalent absorption area of the receiving room in $m^2$ |
| D | Level difference between the sending and receiving rooms |
| $D_n$ | Normalized level difference (the level difference D is standardized to the equivalent absorption area of 10 $m^2$ in the receiving room) |
| $D_nT$ | Standardized level difference (the level difference D is standardized to the 0.5 seconds reference value of the reverberation time in the receiving room) |
| $D_nT_{,w}$ | Weighted standardized level difference (is the value of the reference curve at 500 Hz after shifting the reference curve) |
| L1 | Sound pressure level in the sending room in dB |
| L2 | Sound pressure level in the receiving room in dB |
| R' | Apparent sound reduction index of field measurement |
| $R'_w$ | Weighted apparent sound reduction index (is the value of the reference curve at 500 Hz after shifting the reference curve) |
| S | Partition area in $m^2$ of the partition between the sending and receiving rooms |
| T | Reverberation time in the receiving room |
| V | Volume of the receiving room in $m^3$ |

The following page shows a sample report.

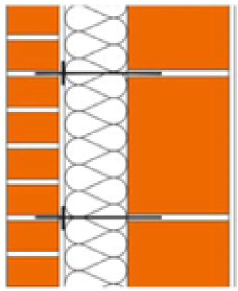
**Standardized level difference in accordance with ISO 16283-1**
**Field measurements of airborne sound insulation between rooms**

Client: Demo

Date of test: 15/11/2017

Location: Partition from Sample Room 1 to Sample Room 2

xxx



XL2 Sound Level Meter: A2A-05850-E0 (M4260: 3285), A2A-05850-E0 (M2210: 1465)

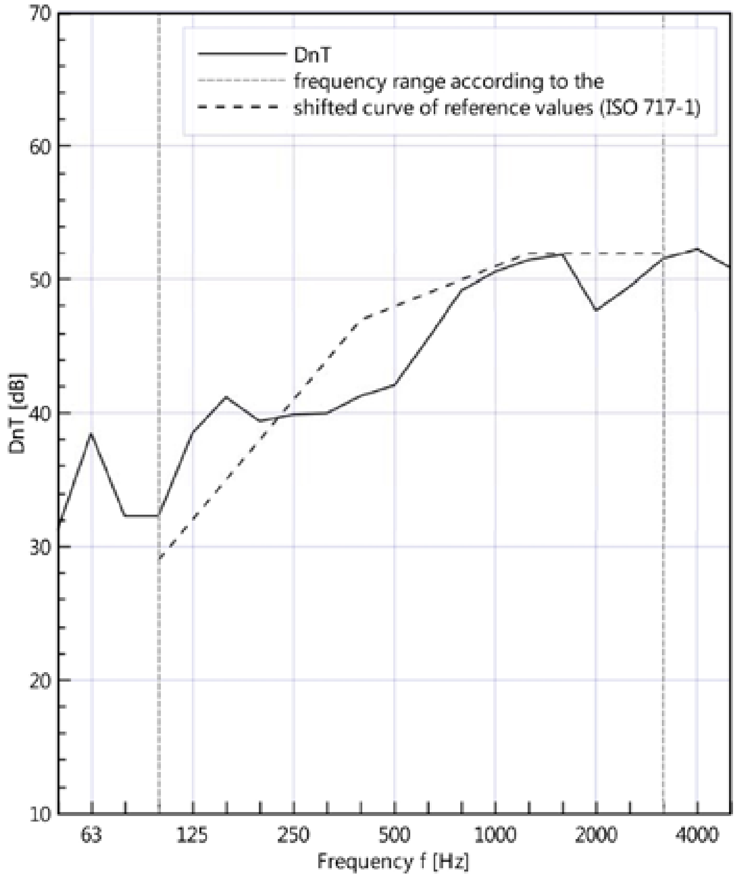
Area of common partition: 15 m²

Source room volume: 50 m³

Receiving room volume: 50 m³

| Frequency f Hz | DnT 1/3 octave dB |
|---|---|
| 50 | 31.2 |
| 63 | 38.5 |
| 80 | 32.3 |
| 100 | 32.3 |
| 125 | 38.5 |
| 160 | 41.2 |
| 200 | 39.4 |
| 250 | 39.9 |
| 315 | 40.0 |
| 400 | 41.3 |
| 500 | 42.1 |
| 630 | 45.6 |
| 800 | 49.2 |
| 1000 | 50.6 |
| 1250 | 51.5 |
| 1600 | 51.9 |
| 2000 | 47.7 |
| 2500 | 49.5 |
| 3150 | 51.6 |
| 4000 | 52.3 * |
| 5000 | 50.9 * |

* 1.3 dB correction applied,
value at the limit of measurement




Rating in accordance with ISO 717-1:

DnT,w(C;Ctr) = 48 (-1; -3) dB

$C_{50\text{-}3150}$ = -1 dB; $C_{50\text{-}5000}$ = -1 dB; $C_{100\text{-}5000}$ = -1 dB

Evaluation based on field measurement using results obtained by an engineering method.

$C_{tr,50\text{-}3150}$ = -4 dB; $C_{tr,50\text{-}5000}$ = -4 dB; $C_{tr,100\text{-}5000}$ = -3 dB

No. of test report: 1234

Date: 20/11/2017

Name of test institute: Building Acoustic Inc.

Signature:

# 8. KNOW HOW

## DIFFUSE SOUND FIELD

One of the assumptions commonly made in sound insulation measurements is that the sound field in a room can be considered as being diffuse (= the sound energy density is uniform throughout the space). This is not strictly correct because diffuse sound fields don't occur in real box-shaped rooms with stationary surfaces and absorbent boundaries. However, in the field situation there are some rooms in which there are close approximations to a diffuse sound field in the mid and high frequency ranges. In frequency bands lower than about 400 Hz in general and especially lower than 100 Hz, no diffuse-field conditions in the test room can be expected especially when room volumes of 50 $m^3$ or less are considered.

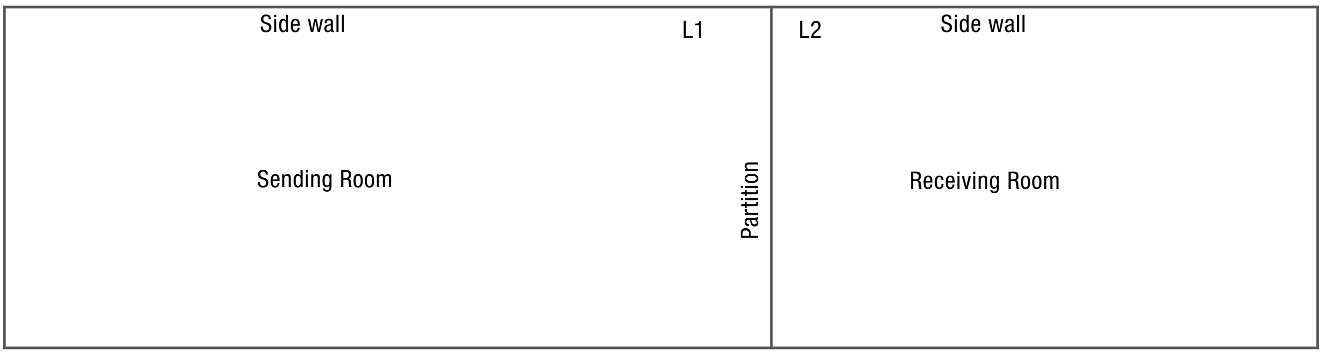
The preceding described measurement procedure allows for measurements to be taken without any knowledge as to whether the sound field can be considered as diffuse or non-diffuse.

## SOURCE POSITION

For field airborne sound insulation measurements in non-diffuse sound fields it is necessary to excite the majority of the modes in the source room. For this reason, loudspeaker positions near the corners are used in box-shaped rooms as well as other shapes of room. Many more modes are excited by the source in a corner position than a central point. In addition, it is necessary to take average measurement from more than one source position. (Sound Insulation by Carl Hopkins, 2007, Elsevier & Revision of international standards by Carl Hopkins, 2015, Elsevier)

## R … SOUND REDUCTION INDEX

The sound insulation capabilities of a particular wall, ceiling, or component can be measured in a laboratory, and a sound reduction index R assigned to it. For such laboratory measurements it's important that the sound transmitted from the sending room into the receiving room not directly through the partition under test (e.g. via the side walls) is at least 15 dB below the sound transmitted directly through the partition.




Default room layout

## R' … APPARENT SOUND REDUCTION INDEX

In an actual building (outside of the laboratory), sound may find a way around the main room-separating partition e.g. through a window or an electric wiring channel; the sound level in the receiving room is not just the sound transmitted through the partition itself. Therefore, the so called Apparent Sound Reduction Index R' is measured.

## NORMALIZED LEVEL DIFFERENCE DN

The normalized level difference Dn is used for situations where there is no common partition area or where the partition area is not easily determined (e.g. fan opening, ventilation, etc). The sound pressure level is measured in the sending and receiving room and the difference D calculated. As the level in the receiving room depends on the absorption within the room, the level difference is normalized with the actual absorption area in the receiving room in relation to a reference absorption area of 10 $m^2$. In relation to the sound insulation index R, a normalized level difference Dn of, for example, 40 dB can be seen as a wall area of 10 $m^2$ with R = 40 dB.


Room layout without common partition area

## STANDARDIZED LEVEL DIFFERENCE DNT

The standardized level difference describes the sound insulation between two rooms. This term is commonly specified in local standards with minimum requirements. The sound pressure level is measured in the sending and receiving room and the difference D calculated. As the level in the receiving room depends on the reverberation time T in the room, the level difference is standardized to the measured reverberation time in the receiving room in relation to a reference reverberation time of 0.5 seconds.