ALHYANGE Acoustique

INGENIERIE ACOUSTIQUE & VIBRATOIRE

OUR AGENCIES:

BRITANNY

14, rue du Rouz
29900 **CONCARNEAU**
02.98.90.48.15
bzh@alhyange.com

23, rue Stanislas Dupuy de Lôme
56000 **VANNES**
02.57.62.06.22
bzh@alhyange.com

GRAND-OUEST/CENTRE

1, boulevard Paul Chabas
44100 **NANTES**
02.85.67.00.80
grandouest@alhyange.com

51-53, avenue du Grésillé
49000 **ANGERS**
02.52.35.21.23
valdeloire@alhyange.com

64, rue Michaël Faraday
37170 **CHAMBRAY-LèS-TOURS**
02.46.65.58.60
valdeloire@alhyange.com

IDF/NORTH-EAST

17, passage Saint-Bernard
75011 **PARIS**
01.43.14.29.01
acoustique@alhyange.com

SOUTH-EAST

102, rue Masséna
69006 **LYON**
04.82.53.89.69
acoustique@alhyange.com

www.alhyange.com

CHARACTERISATION OF SOUNDPROOF ENCLOSURE

DAIKIN

FLASSY (58)

ACOUSTIC DIAGNOSIS WITH SOUND INSULATION ENCLOSURE

RECIPIENT

DAIKIN France Marketing Department
ZA du Petit Nanterre
31, rue des Hautes Pâtures
92737 Nanterre

EDITORIAL	:	Valentin MARCHAND
APPROVAL	:	Cédric RAMAUGE

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SUMMARY

1. SUBJECT

The objective of this acoustic assignment is to characterise from an acoustic point of view a DAIKIN Sky-Air heat pump unit before and after installation of a soundproof enclosure.

This report summarises the results of the acoustic measurements carried out on Thursday, 22 April 2021 before installation of the sound insulation enclosure and the acoustic measurements carried out on Tuesday, 6 June 2021 after installation of the sound insulation enclosure.

2. REGULATORY CONTEXT

The installation of heating/air conditioning units must comply with the "neighbourhood noise" regulations, as set out below:

Decree no. 2006-1099 of 31 August 2006 on combating neighbourhood noise

This text limits the permissible emergence of ambient sound (including noise disturbance) over the residual sound level during the day (7 am – 10 pm) and at night (10 pm – 7 am).

- **Overall emergence in dB(A)**

Period considered	Daytime (7 am – 10 pm)	Nighttime (10 pm – 7 am)
Maximum permitted emergence	+5 dB(A)	+3 dB(A)

The maximum values for overall emergence must be weighted according to the duration of the noise disturbance:

Cumulative duration of occurrence of the particular noise	Correction term in dB(A)
T ≤ 1 minute	+6
1 minute < T ≤ 5 minutes	+5
5 minutes < T ≤ 20 minutes	+4
20 minutes < T ≤ 2 hours	+3
2 hours < T ≤ 4 hours	+2
4 hours < T ≤ 8 hours	+1
8 hours > T	+0

- **Spectral emergence by octave band**

Spectral emergence is defined as the difference between the ambient sound level (including the noise disturbance) and the residual sound level in each octave band.

Octave band	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Maximum permitted emergence	+7 dB	+7 dB	+5 dB	+5 dB	+5 dB	+5 dB

- **Special case**

Global and spectral emergences are only investigated when the ambient noise level including the particular noise is:

- greater than 25 dB(A) if measured inside a dwelling;
- greater than 30 dB(A) if measured outside a dwelling;

Note: this regulation only applies to a third party. In this study, the measurements were carried out in the property, so it is not strictly applicable.

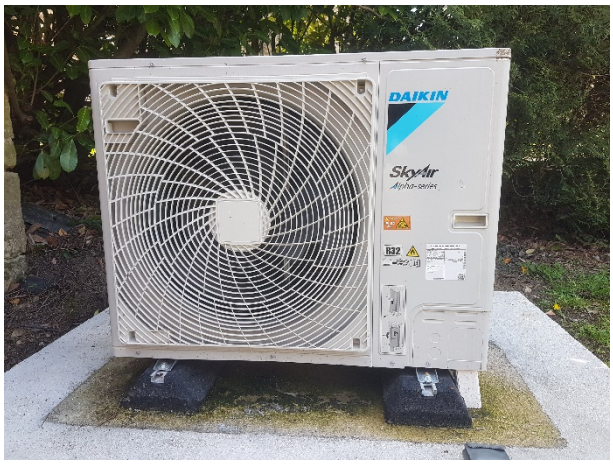
3. OUTLINE OF UNIT AND MEASUREMENTS

3.1. Unit

The unit tested was a DAIKIN Sky-Air heat pump, type RZAG125N7V1B, whose main characteristics are presented below (values in the technical data table for RZAG-NV1 available on the DAIKIN website):

- Dimensions (height x width x depth): 870 x 1100 x 460 mm
- Weight: 95 kg
- Sound power level (cooling/heating): 69 dB(A) / 68 dB(A)

The following pictures show the DAIKIN Sky-Air heat pump described.



3.2. Enclosure

The enclosure is a DAIKIN type EKLN140A sound insulation enclosure, the main characteristics of which are shown below (values in the technical documentation for the enclosure provided by DAIKIN).

- Dimensions (height x width x depth): 1,100 x 1,400 x 1,500 mm
- Weight: 152 kg
- Construction: sheet metal + internal absorbent, including under the louvres

The following pictures show the insulating enclosure of the DAIKIN Sky-Air heat pump described.

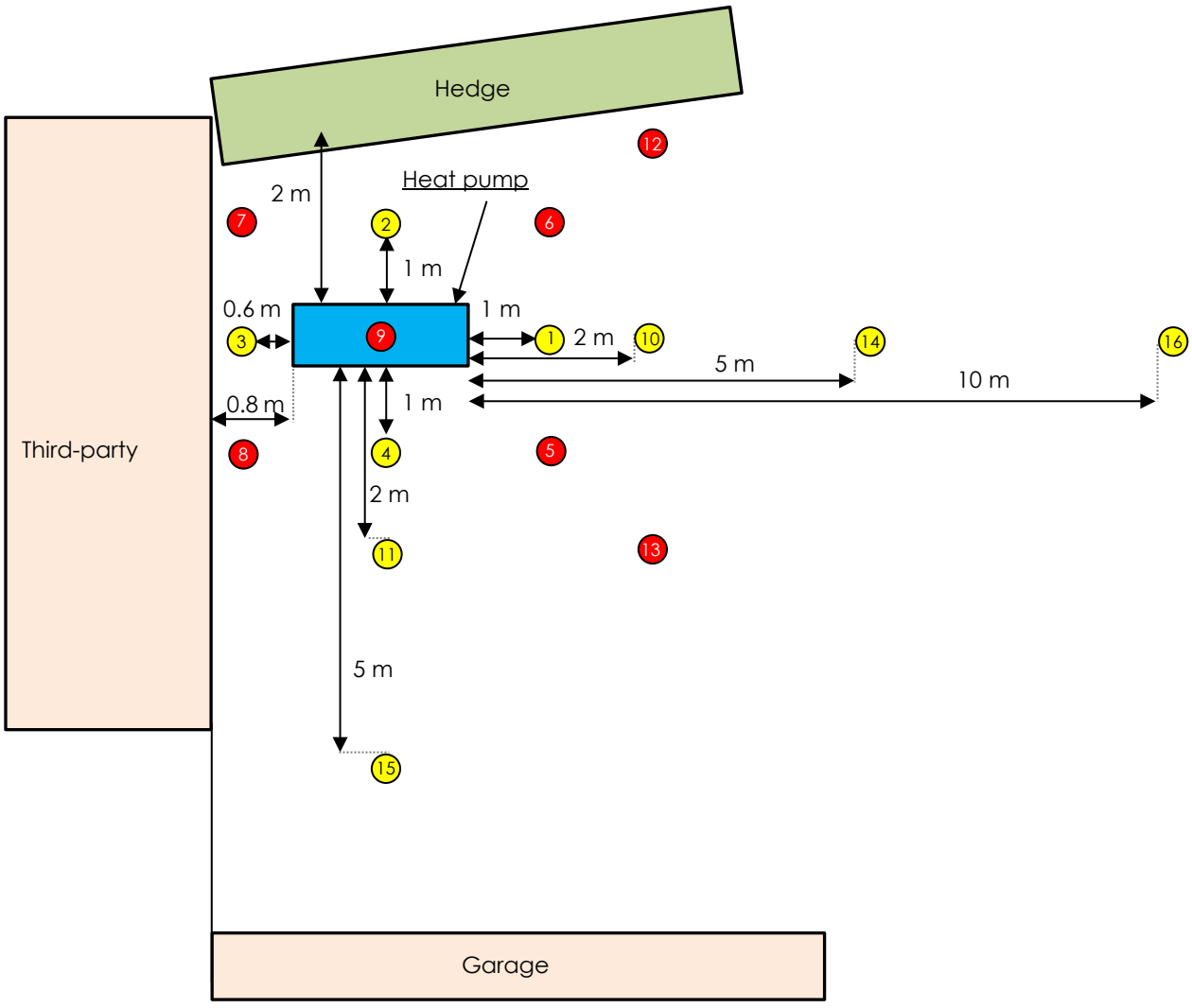
3.3. Measurements

The measurements were taken in the garden and in the house in Flassy (58).

A series of sound pressure level measurements were carried out at 2 heights in a field close to the unit in order to characterise the DAIKIN Ski-Air heat pump.

- Height equal to the upper edge of the unit (approximately 1.2 m above ground level) at the points shown in yellow ;
- Height equal to the upper edge of the unit + 1 m (approximately 2.2 m above ground level) at the points shown in red.

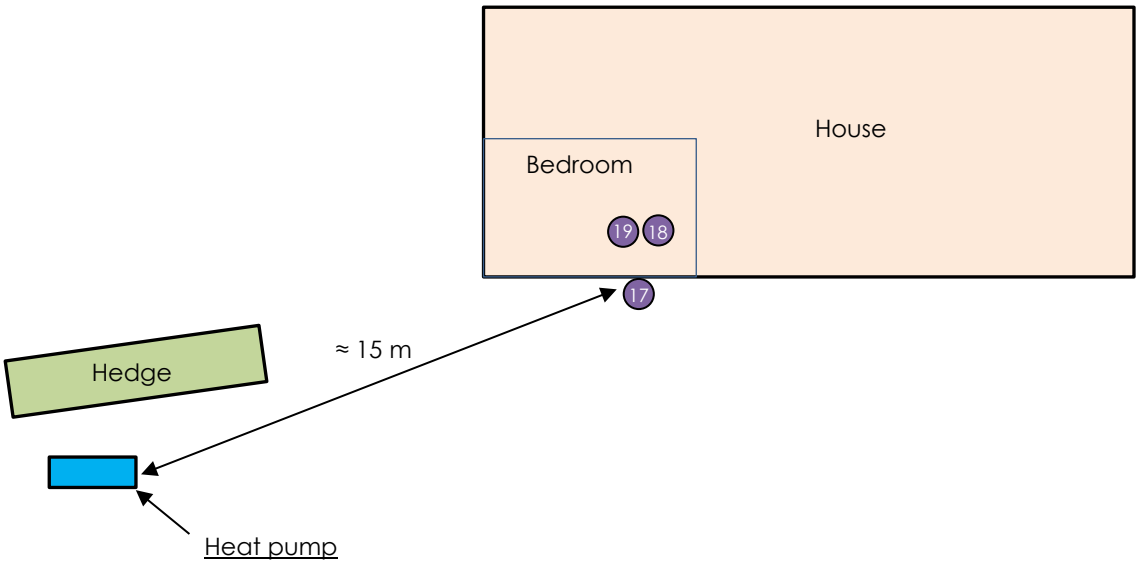
The measurement points, the unit itself and the surrounding buildings are shown in the diagram below.



Three measurements were also taken at the house:

- outside, at the window of the main bedroom (17)
- inside, window open, in the bedroom (18)
- inside, window closed, in the bedroom (19)

The following diagram shows the measurement locations and the location of the house in relation to the unit being measured:



At the time of the measurements, the unit was in heating mode, with the setpoint in the bedrooms at a minimum of 25°C. The operation of the unit is considered representative and equivalent between the two measurement series.

Each measurement was taken for a period of at least 30 seconds.

3.4. Standards considered

The sound power is determined according to **NF EN ISO 3744** "Determination of sound power levels of noise sources using sound pressure – Engineering methods for conditions approximating open space over a reflecting plane" using the following formula:

$$Lw = Lp + 10\log(S)$$

where $S = ab + 2(ac + bc)$ for a rectangular parallelepiped, with:

- a = length + 2 metres
- b = width + 2 metres
- c = height

3.5. Date of the measurements

The measurements were carried out by Valentin Marchand on Thursday, 22 April and Tuesday, 6 June 2021.

3.6. Measurement equipment

The measurement equipment is shown in the appendix.

The settings were as follows:

- 1/3 octave band measurements from 20 Hz to 20 kHz
- Integration time of 1s

4. RESULTS OF THE MEASUREMENT SERIES WITHOUT ENCLOSURE

4.1. Sound power levels

The following table shows the results of the sound power levels (Lw) calculated from the noise levels measured at 1 metre around the unit, by octave band and overall.
Values are rounded to the nearest ½ dB or dB(A).

Measure-ment no.	Sound power level **Lw** in dB per octave band in Hz								**Overall Lw level in dB(A)**
	63	125	250	500	1.000	2.000	4.000	8.000	
1	69.5	69.0	65.0	60.0	58.5	55.5	54.5	47.5	**64.0**
2	71.5	69.5	68.5	67.5	61.5	61.0	58.0	53.0	**69.0**
3	66.0	72.5	67.0	63.5	65.0	61.0	57.0	51.5	**69.0**
4	71.5	69.0	66.0	66.0	60.0	57.0	55.0	47.5	**67.0**
Average	**69.5**	**70.0**	**66.5**	**64.5**	**61.5**	**58.5**	**56.0**	**50.0**	**67.5**

The sound power level Lw of the unit is calculated at 67.5 dB(A), which is very close to the sound power level Lw claimed by DAIKIN, which is 68 dB(A) (see §3.1).

4.2. Sound pressure levels

The following tables show the measured sound pressure levels (Lp), by octave band and overall.
Values are rounded to the nearest ½ dB or dB(A).

- **Around the unit**

Measure-ment no.	Sound pressure level **Lp** in dB per octave band in Hz								**Overall Lp level in dB(A)**
	63	125	250	500	1.000	2.000	4.000	8.000	
1	57.5	57.0	53.0	48.0	46.5	43.5	42.5	35.5	**52.5**
2	59.5	57.5	56.5	55.5	49.5	49.0	46.0	41.0	**57.0**
3	64.0	60.5	55.0	51.5	53.0	49.0	45.0	39.5	**57.0**
4	59.5	57.0	54.0	54.0	48.0	45.0	43.0	35.5	**55.0**
5	62.0	56.0	50.5	54.0	46.5	43.5	42.5	36.0	**54.0**
6	58.5	55.0	52.5	48.0	46.5	42.5	40.5	35.0	**52.0**
7	61.0	57.5	50.5	53.0	47.0	45.5	41.5	34.5	**54.0**
8	57.0	55.0	53.5	51.0	44.5	45.5	42.0	34.0	**53.0**
9	61.5	54.0	59.0	51.5	45.0	42.5	42.0	32.0	**54.0**
10	58.0	59.5	51.5	51.5	44.0	41.5	40.5	33.5	**52.5**
11	62.0	56.0	51.0	54.5	46.0	45.5	41.0	35.5	**54.5**
12	55.0	54.0	48.0	47.5	43.5	41.5	42.5	33.0	**50.5**

Measure-ment no.	Sound pressure level **Lp** in dB per octave band in Hz								**Overall Lp level in dB(A)**
	63	125	250	500	1.000	2.000	4.000	8.000	
13	55.5	49.5	47.0	47.0	42.0	39.0	37.5	30.0	**48.5**
14	56.5	52.5	49.0	45.0	36.0	38.5	34.5	26.5	**47.0**
15	56.0	56.0	47.0	43.5	40.0	37.0	33.0	25.5	**47.0**
16	51.0	50.0	46.0	38.5	33.5	33.0	32.0	20.5	**42.5**

- **At the house**

Measure-ment no.	Sound pressure level **Lp** in dB per octave band in Hz								**Overall Lp level in dB(A)**
	63	125	250	500	1.000	2.000	4.000	8.000	
17	58.0	51.0	43.0	38.5	36.0	34.0	32.5	20.0	**43.0**
18	33.5	30.0	24.0	23.0	19.0	18.5	18.5	12.0	**26.5**
19	32.0	29.0	20.0	18.0	12.0	11.0	9.5	9.5	**21.5**

Note: A map of the measured sound levels is given in chapter 6.3.

5. RESULTS OF THE MEASUREMENT SERIES WITH ENCLOSURE

5.1. Sound power levels

The following table shows the sound power results (Lw) calculated from the noise levels measured at 1 metre around the unit, by octave band and overall.
Values are rounded to the nearest ½ dB or dB(A).

Measure-ment no.	Sound power level Lw in dB per octave band in Hz								Overall Lw level in dB(A)
	63	125	250	500	1.000	2.000	4.000	8.000	
1	64.5	65.0	56.0	48.0	41.5	37.5	43.5	31.5	64.5
2	69.5	74.5	64.0	53.0	42.5	41.5	42.5	37.0	69.5
3	66.0	62.0	51.5	46.0	39.0	36.5	49.5	34.0	66.0
4	71.5	69.5	62.5	55.5	44.5	41.5	48.0	34.5	71.5
Average	**68.0**	**68.0**	**58.5**	**50.5**	**42.0**	**39.5**	**46.0**	**34.5**	**57.5**

5.2. Sound pressure levels

The following tables show the results of the measured sound pressure levels (Lp), by octave band and overall.
Values are rounded to the nearest ½ dB or dB(A).

- **Around the unit**

Measure-ment no.	Sound pressure level Lp in dB per octave band in Hz								Overall Lp level in dB(A)
	63	125	250	500	1.000	2.000	4.000	8.000	
1	52.5	53.0	44.0	36.0	29.5	25.5	31.5	19.5	**42.5**
2	57.5	62.5	52.0	41.0	30.5	29.5	30.5	25.0	**49.0**
3	54.0	50.0	39.5	34.0	27.0	24.5	37.5	22.0	**43.0**
4	59.5	57.5	50.5	43.5	32.5	29.5	33.5	22.5	**47.5**
5	52.0	53.5	44.5	36.5	30.0	29.5	32.0	20.0	**42.5**
6	52.0	53.5	44.5	36.5	30.0	29.5	32.0	20.0	**42.5**
7	56.0	58.5	47.0	41.5	32.5	31.5	33.5	25.5	**46.5**
8	58.0	58.5	45.5	41.0	35.0	32.0	31.5	22.5	**46.0**
9	57.5	58.5	45.5	41.0	34.5	31.5	30.5	21.0	**45.0**
10	53.0	52.5	44.5	36.5	30.5	29.5	28.5	17.5	**41.5**
11	58.0	55.0	49.5	42.5	31.0	29.5	29.0	19.5	**45.5**
12	51.5	51.5	43.5	38.0	33.0	31.5	33.0	21.0	**42.5**
13	56.0	54.0	43.5	40.0	36.5	33.5	32.5	23.5	**44.5**
14	52.5	51.5	42.0	34.5	32.0	30.0	31.0	20.5	**41.0**

Measure-ment no.	Sound pressure level **Lp** in dB per octave band in Hz								**Overall Lp level in dB(A)**
	63	125	250	500	1.000	2.000	4.000	8.000	
15	54.0	56.0	46.0	35.5	31.5	32.0	33.0	23.5	**43.0**
16	49.0	50.5	41.5	33.0	32.0	30.5	27.5	18.0	**40.5**

- **At the house**

Measure-ment no.	Sound pressure level **Lp** in dB per octave band in Hz								**Overall Lp level in dB(A)**
	63	125	250	500	1.000	2.000	4.000	8.000	
17	47.5	44.0	36.0	34.5	33.5	32.0	30.5	22.5	**39.0**
18	33.5	29.5	23.5	24.5	19.0	16.0	15.0	13.0	**25.5**
19	29.5	28.5	18.0	17.0	14.5	11.5	12.5	12.5	**21.0**

Note: A map of the measured sound levels is given in chapter 6.3.

6. COMPARISON OF MEASUREMENT RESULTS

6.1. Comparison of the overall noise level

The two tables below show the overall results measured with and without the sound insulation enclosure, as well as the difference in sound level between these two measurements.

Measure-ment no.	Overall Lp level in dB(A)		Difference in dB(A)
	Without enclosure	With enclosure	
1	52.5	42.5	**-10.0**
2	57.0	49.0	**-8.0**
3	57.0	43.0	**-14.0**
4	55.0	47.5	**-7.5**
5	54.0	42.0	**-12.0**
6	52.0	42.5	**-9.5**
7	54.0	46.5	**-7.5**
8	53.0	46.0	**-7.0**
9	54.0	45.0	**-9.0**
10	52.5	41.5	**-11.0**
11	54.5	45.5	**-9.0**
12	50.5	42.5	**-8.0**
13	48.5	44.5	**-4.0**
14	47.0	41.0	**-6.0**
15	47.0	43.0	**-4.0**
16	42.5	40.5	**-2.0**
17	43.0	39.0	**- 4.0**
18	26.5	25.5	**- 1.0**
19	21.5	21.0	**- 0.5**

We observe a reduction in the noise level of up to -14.0 dB(A) at 1 m from the unit (measurement 3). Due to the design of the enclosure (perforated front and rear panels and solid sides), the sound level reductions are greater on the sides of the enclosure than on the front and rear panels.

6.2. Comparison of the spectral sound level at measurement point 4

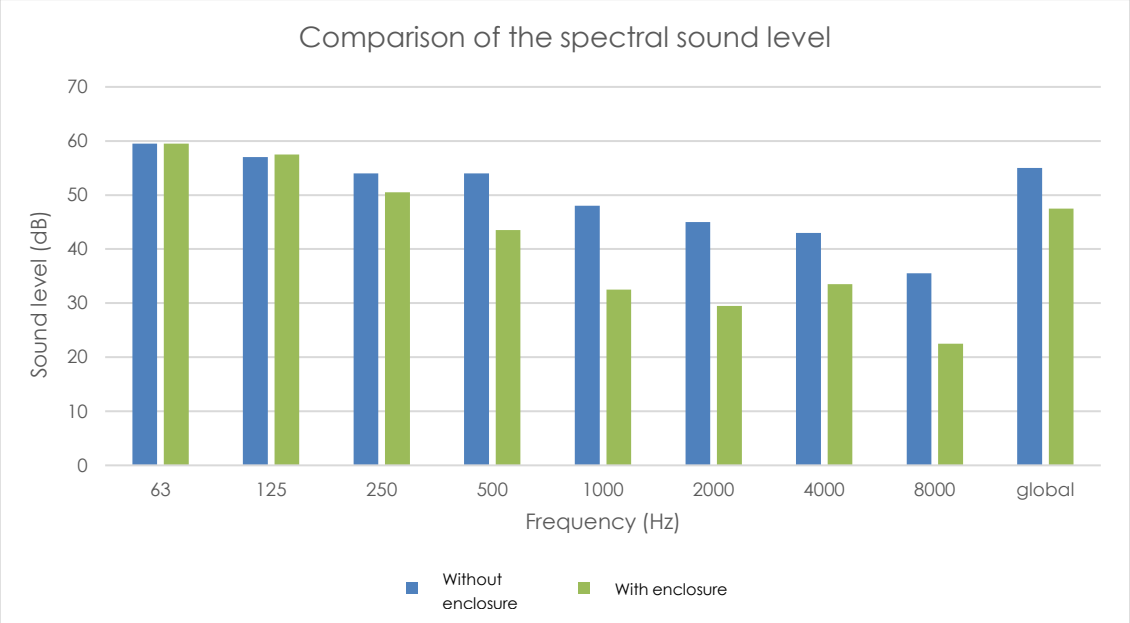
As the measurement at this point was taken at a distance of 1 m in front of the unit, it can be considered as a reference measurement.

It is therefore interesting to look at the sound level drops per frequency band.

The table below shows the sound level values per octave band, measured at point 4:

Enclosure	Sound pressure level **Lp** in dB per octave band in Hz								**Overall Lp level in dB(A)**
	63	125	250	500	1.000	2.000	4.000	8.000	
Without	59.5	57.0	54.0	54.0	48.0	45.0	43.0	35.5	55.0
With	59.5	57.5	50.5	43.5	32.5	29.5	33.5	22.5	47.5
Delta	**0.0**	**0.5**	**-3.5**	**-10.5**	**-15.5**	**-15.5**	**-9.5**	**-13.0**	**-7.5**

The graph below shows the sound levels measured at point 4:

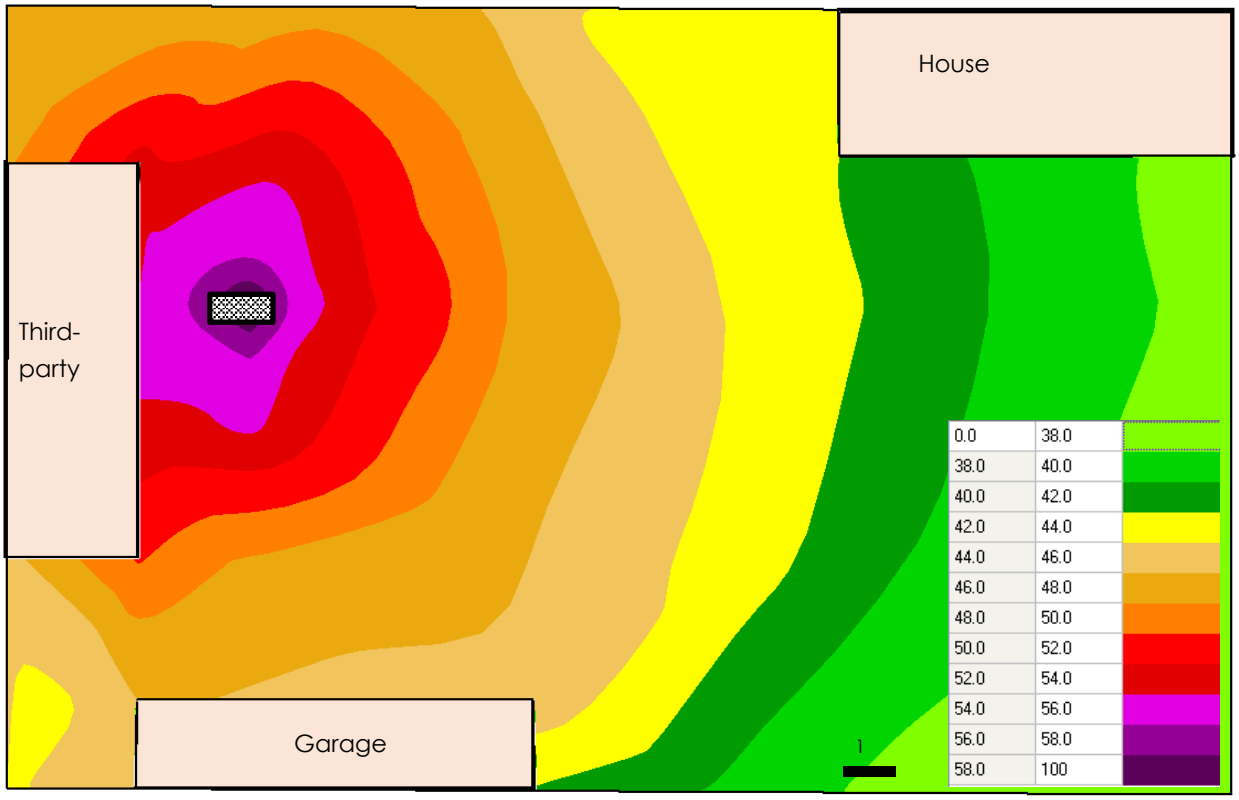


We notice a significant decrease in sound levels from 500 Hz onwards, and at all higher frequencies. The most significant decreases are located in the 1,000 and 2,000 Hz frequency bands.

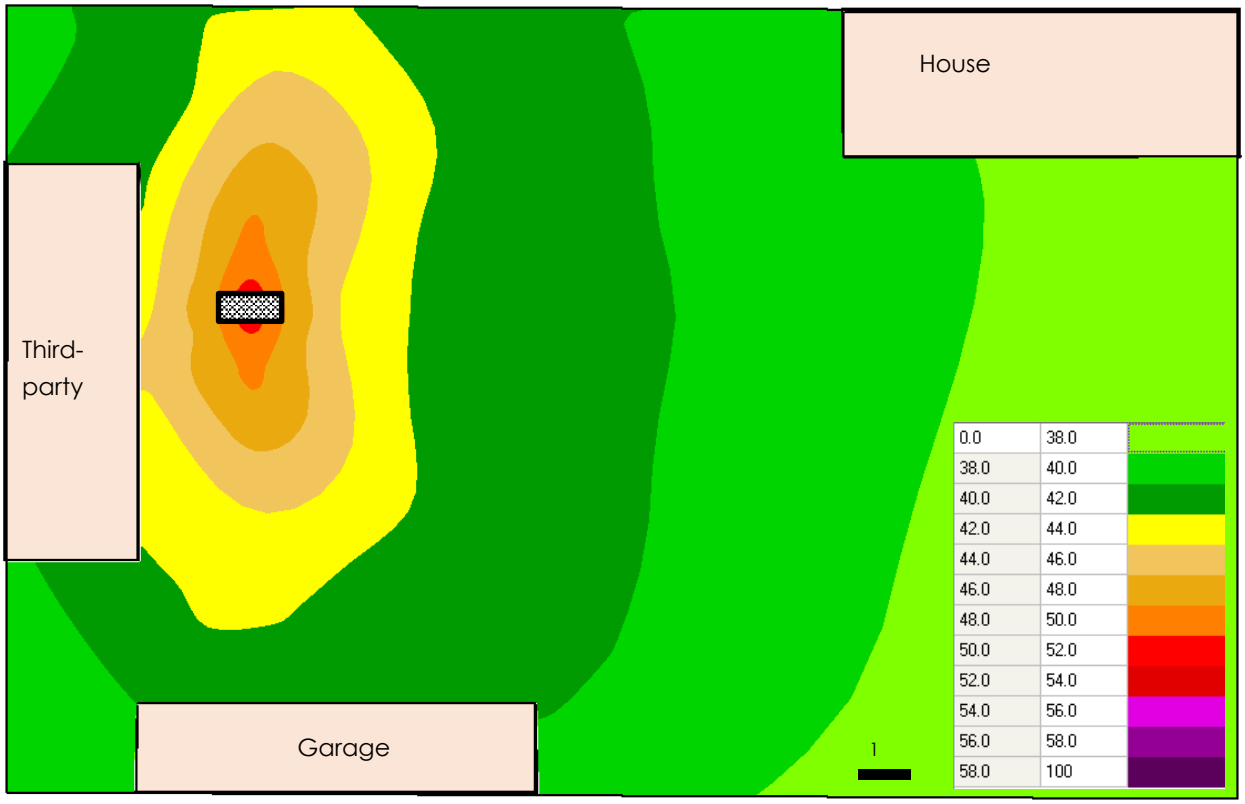
6.3. Map of measured sound levels

The two maps on the following page show the ranges of sound levels measured in-situ, plus a colour scale.

Maps of sound levels without the sound insulation enclosure:



Maps of sound levels with the sound insulation enclosure:



7. ANNEXES

- **EQUIPMENT USED**
- **ACOUSTIC CONCEPTS**

7.1. Equipment used

Acoustic measurement device

Make/Model	ID	Serial no.	Preamp.	Micro.	Calibrator	
					Type	No.
01 dB / DUO	D9	12621	-	330777	CAL 21	50441936
01 dB / FUSION	F15	12337	-	331437	CAL 21	50441936

Note:

- Class 1 integrating sound level meters, according to NF S 31-009 (NF EN 60804);
- Calibrated in the laboratory before each measurement series.

Software

Software	Version	Description
dB line	6.0	Acoustic measurements analysis

7.2. Acoustic concepts

Lp
Sound pressure level given at a distance from the source and detected at that point; it is expressed in dB(A).

Lw
A sound power level characteristic of the device and used as a basis for calculating a pressure at a given distance. It is expressed in dB(A) and does not depend on the distance – it is a value intrinsic to the source.

ISO / NR curve
The curve to which a measured spectrum can be compared. It allows qualification and quantification of the measured sound according to frequency (as per standard NF S 30-010).

Residual noise
This is the average sound pressure level of the ambient noise at the place and time of measurement in the absence of the particular noise considered to be disturbing.

LX fractile indices
A-weighted sound pressure level exceeded for X% of the time interval under consideration. L90 and L50 (sound levels exceeded for 90 and 50% of the time) are the most commonly used to characterise a noise environment.

Emergence
A temporal change in the ambient noise level induced by the appearance or disappearance of a particular noise.

Perception at human ear
20 Hz – 20,000 Hz

Comparative sound level scale
The following scale is provided as a guide in order to better understand the sound levels shown.