2

TECHNICAL MANUAL

WASTE SYSTEMS

Noise in waste systems

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QUALITY FOR PLUMBING

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NOISE IN WASTE SYSTEMS

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NOISE IN WASTE SYSTEMS

2.1 Introduction

One of the primary factors contributing to today's cities' declining quality of life is noise. In fact, while there has been a decrease in the highest levels of noise in areas at greater risk in individual environments, there has been a parallel amplification of trouble areas, resulting in an increase in the population exposed.
The most widely debated topic today is noise pollution. However, there is a tendency to focus on the causes of external noise, such as air and road traffic, while overlooking and underestimating the causes of internal noise in buildings, such as lifts, heating, air conditioning, and last but not least, waste systems, which is the subject of this document. Moreover, to overlook the problem of "noise" in waste systems means, to ignore the Standards and Regulations in force that establish the project boundaries and the restrictions in noise levels. If we focus our attention on the Italian market, the reference document regarding the limits in noise levels for technological installations is the Decree dated December 5 1997 published in the Official Paper No. 297 on December 22 1997 that will be dealt with in the following chapters.

2.2 Sound

Sound is the propagation of mechanical energy in a medium (elastic solid, gas or liquid) through fluctuation waves (sound waves) that propagate at a typical speed depending on the medium.

Table 2.1 Sound propagation velocity.

Medium	Velocity c [m/s]
Air	331
Helium	970
Hydrogen	1269
Oxygen	317
Water	1441
Salt water (marine)	1504
Methyl alcohol	1240
Bricks	3700
Cement	3100
Glass	6000
Lead	1200
Aluminium	5200
Marble	3800
Ice	3200
Cork	500
Mahogany	4000
Birch wood	3600
Hard rubber	1400
Soft rubber	70

The velocity in a gaseous medium is given by:

$$c = \sqrt{\gamma \cdot R \cdot T} \qquad [2.1]$$

where γ is the ratio between the specific heat at a constant pressure and the specific heat at a constant volume (for air in standard conditions it is equal to 1.4), R is the characteristic constant of the gas and T is the absolute temperature [K].

In particular, for air, it is possible to use an approximate expression as a function of temperature T_1 in Celsius degrees [°C]:

$$c = 331.4 + 0.62 \cdot T_1 \qquad [2.2]$$

The velocity in a liquid or in a solid is given by:

$$c = \sqrt{E/\rho} \qquad [2.3]$$

where E is the elastic modulus and ρ is the density.

A sound wave is characterised by a wave length λ (measured in m) and a frequency f (measured in Hz) that are connected to the velocity of propagation in the medium c (measured in m/s).

$$c = \lambda \cdot f \qquad [2.4]$$

The human ear is unable to hear all the sounds that exist in nature. The field of sounds that can be heard by man is limited to a frequency range of 20 Hz to 20 kHz approximately. We therefore define:

- **Infrasounds** as pressure oscillations with frequencies below 20 Hz, that therefore cannot be heard by the human ear.
- **Sounds** as pressure oscillations with frequencies between 20 Hz and 20 kHz.
- **Ultrasounds** as pressure oscillations with frequencies above 20 kHz, that therefore can be heard by the human ear.

The sound intensity is the quantity of power J transported by the sound wave per surface unit perpendicular to the propagation direction and it is represented by the following relation:

$$J = \frac{p_{eff}^{\,2}}{\rho \cdot c} \qquad [2.5]$$

where ρ is the density of the medium in which the sound is propagated [kg/m³].

Absolute sound intensity is difficult to quantify. As a consequence, it is preferable to measure the relative intensity of a sound in Bell or in tenths of a Bell (dB). The dB is a value that indicates the logarithm on a base of 10 of the ratio between the intensity J (or the pressure p or the power W) of a sound and the reference intensity J_0 (or the pressure p_0 or the power W_0). The following are some definitions.
The sound pressure level:

$$L_p = 20 \cdot \log_{10}\left(\frac{p}{p_0}\right) = 10 \cdot \log_{10}\left(\frac{p}{p_0}\right)^2 \qquad [2.6]$$

The sound intensity level:

$$L_J = 10 \cdot \log_{10}\left(\frac{J}{J_0}\right) \qquad [2.7]$$

The level of sound power:

$$L_W = 10 \cdot \log_{10}\left(\frac{W}{W_0}\right) \qquad [2.8]$$

where $p_0 = 2 \cdot 10^{-5}$ Pa corresponds to the lowest pressure perceptible by the human ear at a frequency of 1000 Hz, $J_0 = 10^{-12}$ W/m^2 corresponds to the sound intensity of a sound wave the pressure of which is equal to the minimum threshold of hearing p_0 e $W_0 = 10^{-12}$ W corresponds to the power of a source that produces on a spherical surface of 1 m^2 the pressure equal to the minimum hearing threshold p_0.

The use of the dB as a measurement unit has some advantages:
- The dB is the smallest variation in sound power that the human ear can detect.
- Acoustic pressures have a wide range of variability, and using the logarithmic scale narrows the range and simplifies it.

2.3 Noise and its measurement

Noise can be defined in different ways:

- From a physical point of view, it is the irrational mixing of sounds with different frequencies and intensities.
- From a psychological point of view, it is any type of unwanted sound (ANSI definition) or an acoustic phenomena that produces a hearing sensation considered unpleasant.

To measure noise levels phonometers are employed, and with such instruments it is possible to determine the noise intensity in dB.
Since the sensitivity of the human ear depends on the noise frequency (a sound of 20 dB is below the hearing threshold if issued at 100 Hz whereas it can be heard if issued at 2500 Hz), the measurement of the noise intensity must be “contemplated” to keep in consideration the different response of the human ear.

For this reason the level of noise is expressed as 10 times the decimal logarithm of the sum of the squares of the ratios between the components p_i of the noise pressure (measured at different frequencies) and the reference pressure p_0:

$$L = 10 \cdot \log_{10} \left[\sum \left(k_i \frac{p_i}{p_0} \right)^2 \right] \qquad [2.9]$$

The weights k_i assigned to each pressure component define the contemplation curve that can be of the A, B and C type. The A type curve is the one that most commonly takes into consideration the response of the human ear and therefore such observations are indicated with the symbol dB(A).
The following table gives an idea of the noise levels in relation to the source:

Table 2.2 Noise levels.

Level in dB(A)	Description
0	Hearing threshold
20	Whispered voice
40	Quiet office
60	Normal conversation
80	Car, orchestra
100	The inside of a car at 120 km/h
120	Pneumatic drill (pain threshold)
140	Plane

In the case of several noise sources, the total level is not given by the sum of the single levels expressed in dB but by expressing in dB the sum of the squares of the noise pressures. To clarify this concept an example will be made.
Consider two noise sources, each at 80 dB, for which we must evacuate the total level of noise. The levels of noise pressure of the sources are given by the following expression:

$$L = 10 \cdot \log_{10} \left(\frac{p}{p_0} \right)^2 = 80 \text{ dB} \qquad [2.10]$$

from which, by inverting it, we get:

$$\left(\frac{p}{p_0} \right)^2 = 10^{\frac{L}{10}} = 10^8 \qquad [2.11]$$

The sum of the levels of pressure is given by the sum of the squares of the noise pressures and therefore:

$$L_{tot} = 10 \cdot \log_{10}\left[\left(\frac{p}{p_0}\right)^2 + \left(\frac{p}{p_0}\right)^2\right] = 10 \cdot \log_{10}\left(10^8 + 10^8\right) = 83 \text{ dB} \qquad [2.12]$$

This means that doubling the noise power (or intensity) is the same as increasing the noise levels by 3 dB or differences of 3 dB are equal to noise sources with noise energies (or intensities) that are double compared to the other. Let's now suppose that we halve the noise power (or intensity) and we want to evaluate the reduction in dB. If we consider the same noise pressure corresponding to 80 dB and we halve it, we obtain:

$$L_{tot} = 10 \cdot \log_{10}\left[\frac{1}{2} \cdot \left(\frac{p}{p_0}\right)^2\right] = 10 \cdot \log_{10}\left(0.5 \cdot 10^8\right) = 77 \text{ dB} \qquad [2.13]$$

This means that halving the noise power (or intensity) is the equivalent of reducing the levels of noise by 3 dB. And what happens if we multiply the noise energy (or intensity) by a factor of ten?

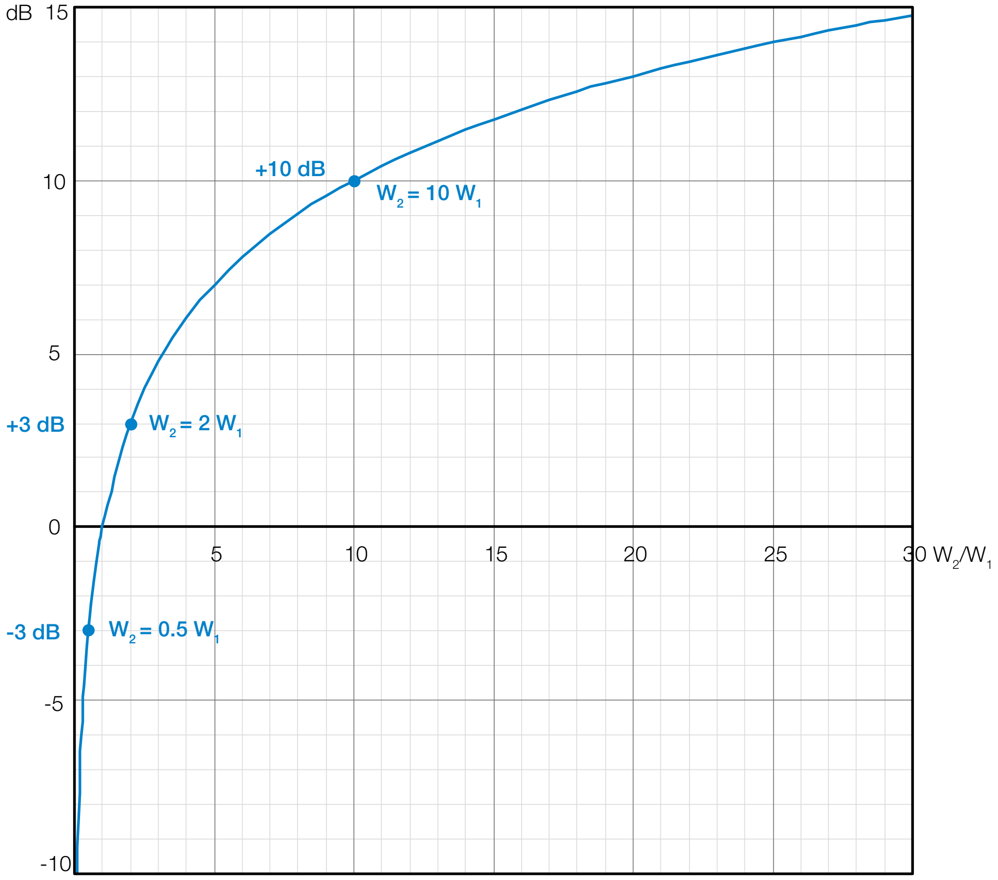
$$L_{tot} = 10 \cdot \log_{10}\left[10 \cdot \left(\frac{p}{p_0}\right)^2\right] = 10 \cdot \log_{10}\left(10 \cdot 10^8\right) = 90 \text{ dB} \qquad [2.14]$$

the noise levels are increased by 10 dB!

The concepts just dealt with are clearly shown in the curve in Figure 2.1 where we see that:

- Doubling the sound power is equivalent to increasing the noise levels by 3 dB.
- Multiplying the sound power by a factor of ten is equivalent to increasing the noise levels by 10 dB.
- Halving the sound power is the equivalent of reducing the noise levels by 3 dB.

Figure 2.1 Difference in dB between two sound sources with sound energies of W_1 and W_2 (or intensity J_1 and J_2).



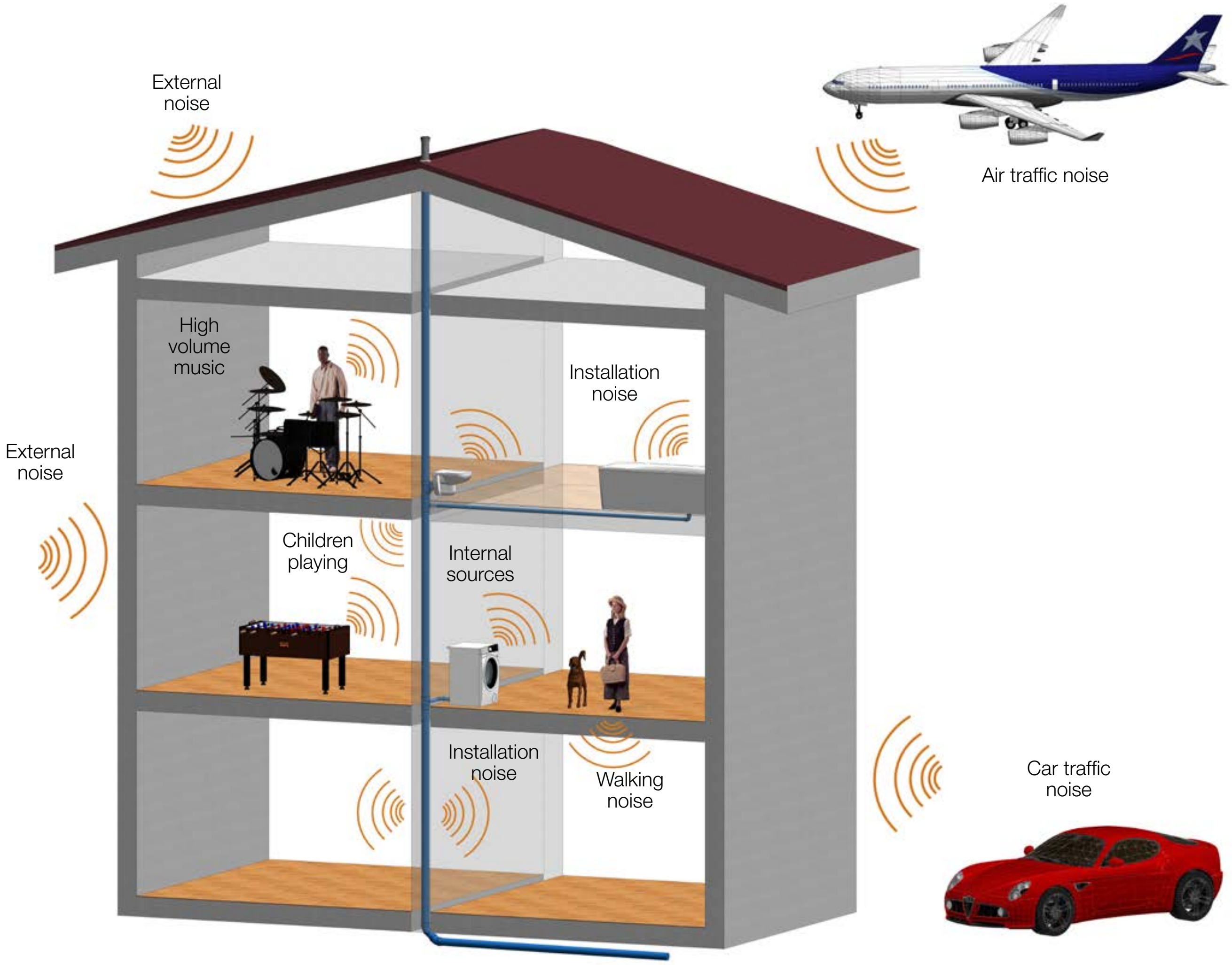
2.4 Noise in buildings

In recent years there has been an increase in the problems relating to noise emissions produced inside buildings that involve different aspects from urban development to constructions techniques, from the distribution of rooms to the level of silence of plumbing systems. Respect for the conditions of acoustic well-being in homes and workplaces has become an essential requirement in construction.
Surroundings can be considered satisfactory in terms of acoustic comfort when the noise that the inhabitants must tolerate is such that it does not harm their health and provides adequate conditions for relaxation and work.

There are numerous sources of noise that affect life inside buildings:

- External noises caused by automobile traffic, airplanes, etc.
- Noises caused by walking, by children playing or by particular lifestyles (diffusion of music or televisions at full volume, the use of musical instruments), etc.
- Noises caused by installations such as air-conditioners, heating systems, pumps, drains, etc.

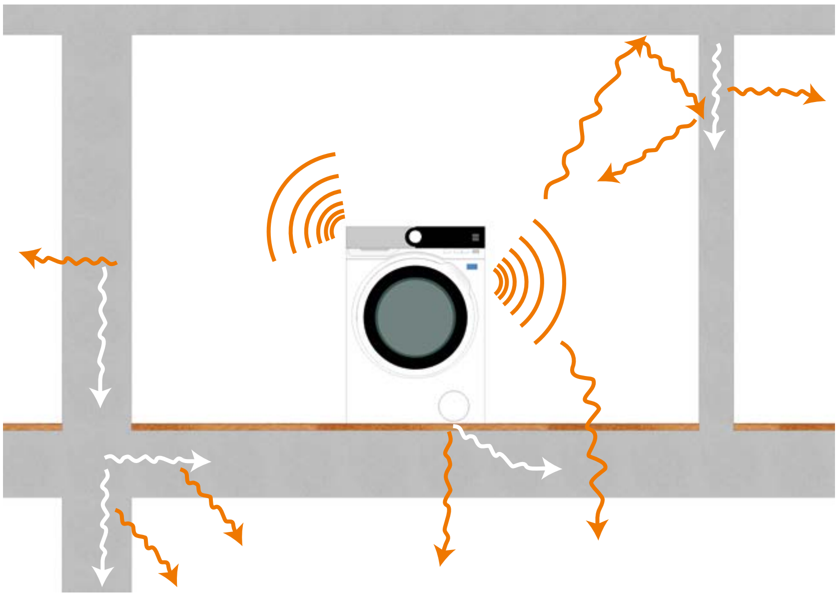
Figure 2.2 Noises in households.



And their propagation mode can be:

- airborne, when the sound waves, either directly or through partition walls, are transmitted from the source to the listener;
- structure borne, when the sound waves that reach the listener, are generated by blows and vibrations produced on the structures of the building in which the disturbed room is located.

Figure 2.3 The propagation of noise in households.



2.5 The Italian legislative and regulatory framework

2.5.1 Framework law on noise pollution and DPCM 12/97

The legislative document that establishes the fundamental principles on the protection of the living environment from noise pollution (pursuant to and in accordance with article 117 of the Constitution) is the ordinary law of the Parliament no. 447 of 26/10/1995 also known as the **"Framework law on noise pollution"** (published on the Ordinary Supplement to the Official Journal no. 254 of 30/10/1995).

In order to organically regulate the matter of noise in buildings, the framework law provided for the issuance of documents for:

a) the definition of responsibilities and control bodies;
b) the determination of the techniques for detecting and measuring noise pollution;
c) the definition of criteria for the design, implementation and renovation of buildings;
d) the determination of passive acoustic requirements for buildings and their components in order to reduce human exposure to noise.

Point d) of the above mentioned list has been addressed in the **Prime Minister's Decree of December 5, 1997** (published in the Official Journal no. 297 of December 22, 1997) which, with the aim of reducing human exposure to noise, establishes:

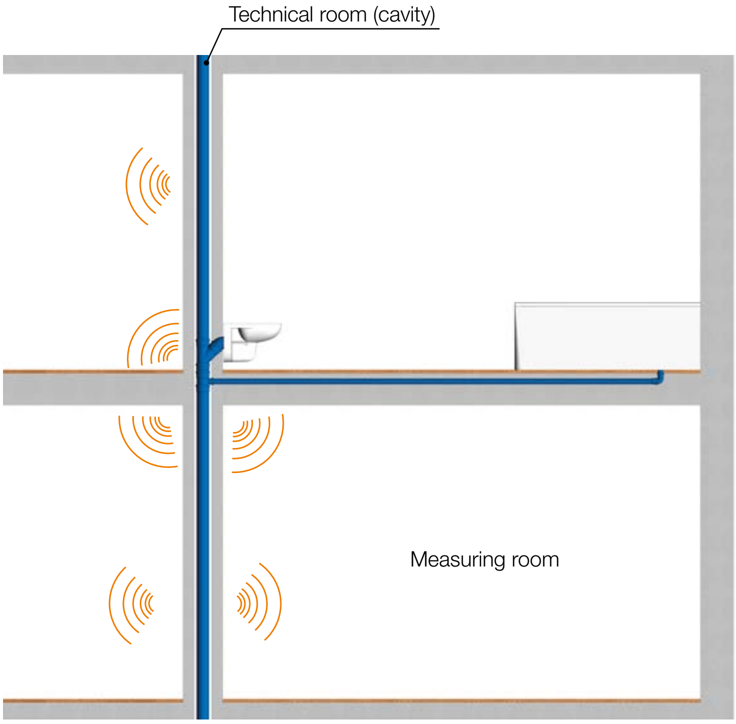
1) the acoustic requirements of internal sound sources (technological systems),
2) the passive acoustic requirements of buildings and their components (vertical and horizontal partitions).

In particular, the noise level of technological equipment and systems (services) must comply with the following limits:

- **$L_{ASmax} \leq 35$ dB(A)** for intermittently operated services (lifts, **soil pipes**, bathrooms and bathroom appliances);
- **$L_{Aeq} \leq 25$ dB(A)** for continuously operated services (heating and air conditioning systems).

Noise must be measured in the room where the noise level is the highest and this same must not be the room where the noise originates.

Figure 2.4 Noise level measurement of systems.



The decree classifies domestic environments in relation to their intended use according to the following table.

Table 2.3 Classification of buildings (D.P.C.M. 5/12/1997).

Category	Intended use
A	Buildings used for residences or similar
B	Buildings used for offices or similar
C	Buildings used for hotels, guest houses or similar functions
D	Buildings used as hospitals, clinics, nursing homes or similar
E	Buildings used as schools or similar
F	Buildings used for activities of recreation or worship or similar
G	Buildings used as retail stores or similar

For each of the environment types, it defines not only the limits for technological systems, but also those for the quantities that define passive acoustic requirements of building components and indoor sound sources. The table below shows how wall insulation power, façade sound insulation and footstep noise are taken into account.

Table 2.4 Limits established for each type of building (D.P.C.M. 5/12/1997).

Category	Apparent sound proofing power of room separation elements	Facade standardised acoustic insulation	Normalised level of walking noise	Maximum level of sound pressure for technological installations	Equivalent continuous level of sound pressure for technological insulations
	R_w	$D_{2m,nT,w}$	$L_{nT,w}$	L_{ASmax}	L_{Aeq}
Hospitals	55	45	58	35	25
Residences, hotels and guesthouses	50	40	63	35	35
Schools	50	48	58	35	25
Offices, places of worship, recreational and shopping activities	50	42	55	35	35

The introduction of the Framework Law 447/1995 for protection from noise pollution has contributed to strengthening the commitment to creating techniques and methods for calculating the “acoustic behaviour of construction technologies” with the aim of reducing the noise transmitted and received by buildings.

2.5.2 Prediction of the sound performance of buildings

The prediction of passive acoustic requirements is an extremely important topic for planners during project design when choosing construction and plant technologies that meet the limits imposed by the Prime Minister's Decree "Determination of the passive acoustic requirements of buildings" of December 5, 1997.
The regulatory document that meets these requirements is the European Standard **UNI EN 12354 "Building Acoustics - Estimation of acoustic performance in buildings from the performance of elements"** divided into six parts:

- Part 1: Airborne sound insulation between rooms.
- Part 2: Impact sound insulation between rooms.
- Part 3: Airborne sound insulation against outdoor sound.
- Part 4: Transmission of indoor sound to the outside.
- Part 5: Sounds levels due to the service equipment.
- Part 6: Sound absorption in enclosed spaces.

Each part of the standard proposes calculation models for the prediction of the acoustic behaviour of buildings, which in some cases can be quite complicated to implement and require specific software for calculation.

Part 5 is pertinent to the topics covered in this publication. Its goal is to provide a practical basic approach for calculating the sound produced by systems and their impact on a building's acoustic insulation, as well as some recommendations for proper installation.

The topic is very complex and difficult to deal with analytically because:

- constructions involve a high number of structural types,
- constructions involve a high number of system configurations,
- the techniques used to construct the systems are very diverse and chaotic.

The document contains calculation methods for the estimation of sound inside the buildings caused by service facilities such as water supply and waste and drainage systems, mechanical ventilation systems, heating and air-conditioning systems, immersion boilers, lifts, pumps, and other related facilities.
According to the provisions of UNI EN 12354-5, the results obtained from tests performes in laboratories in compliance with UNI EN 14366 can be used for the prior determination of the levels of sounds associated with certain systems.

2.5.3 Acoustic classification of buildings and expected developments

It should be noted that the information in this paragraph is considered valid at the time of preparation of this edition of the manual. Should the scenario change, Valsir will be responsible for updating future editions.

The coming into force of the DPCM 12/97 had the merit of spreading greater awareness in the field of acoustics among planners, firms and citizens, changing methods of construction and leading them to seek solutions with an even better performance. On the other hand, the failure to achieve the minimum requirements over the years has often been the subject of numerous lawsuits between purchasers of property and sellers or builders of the same. This is due, at least initially, to the request for acoustic performances that were much higher than the construction standards at that time and also, in more recent times, to the difficulty of providing in situ, the performance values that were calculated according to UNI EN 12354, that were often difficult to apply within the context of Italian construction.

In recent years, therefore, the necessity to modify the contents of the DPCM 12/97 has arisen and for this reason, the Italian Organisation for Standardisation (UNI) has set up a working group for the development of a new standard on the acoustic classification of buildings that could be the starting point for the definition of a new legal framework.

The outcome of these efforts is the **UNI 11367 “Building Acoustics - Acoustic classification of building units - Evaluation procedure and in situ measurements”**.

First of all, the introduction of performance classes - a concept that is already widespread both in the building sector (for instance, the energy classification of buildings) and in the domestic sector (with the certification of the energy consumption of electrical appliances) - makes the task of interpreting the acoustic quality of the property more simple and transparent for the purchaser. Secondly, the use of performance classes is independent from the concept of suitability/unsuitability envisaged by the decree currently in force, favouring the progressive evolution of construction techniques that aim at performances (and therefore acoustic classes) that are gradually increased.

A comprehension of the contents of the Standard, which is very rich and varied, goes beyond the scope of this publication. We will, however, indicate a few fundamental points, with the awareness that in order to fully comprehend it, the Standard needs to be read in its entirety.

First of all, it should be noted that the acoustic classification refers to the single property units of a building on the basis of the average values (logarithmic averaging) of the acoustic performance of its components measured in situ.

According to this Standard, “building units” are defined as a portion of a building or a building that possesses functional and financial autonomy. The use of logarithmic averaging, for a given indicator, allows a result to be obtained that is significantly influenced by the performance of the worst component, to the advantage of the future users of the building unit.

The following table indicates the limit values of the various indicators for each class:

Table 2.5 Limits established for each indicator and for each acoustic class according to UNI 11367.

Class (performance)	**Apparent sound insulating power of the walls separating two different dwellings**	**Normalised acoustic insulation of the building’s facade**	**Normalised level of foot-traffic noise between rooms of different building units**	**Maximum sound pressure level from service equipment with discontinuous operation**	**Sound pressure level from service equipment with continuous operation**
	R'_w	$D_{2m,nT,w}$	L'_{nw}	L_{id}	L_{ic}
Class I (very good)	≥ 56	≥ 43	≤ 53	≤ 30	≤ 25
Class II (good)	≥ 53	≥ 40	≤ 58	≤ 33	≤ 28
Class III (basic)	≥ 50	≥ 37	≤ 63	≤ 37	≤ 32
Class IV (modest)	≥ 45	≥ 32	≤ 68	≤ 42	≤ 37

The indicators used by the UNI 11367 are the same as those provided by the DPCM 12/97, except for those in relation to technological systems: L_{ic} (systems operating continuously) and L_{id} (systems operating intermittently) are corrected depending on the reverberation time of the room in which the measurement is made, so that the same is not influenced, for example, by the presence of elements of furnishing.

For each class, also the description of the expected performance is indicated and it should be noted that class III, defined as “basic”, presents values that are quite similar to those imposed by DPCM 12/97. For this reason, it is believed that in the future, class III will set the minimum requirements allowed by the new legislation on building acoustics. It is likely that a new Legislative Decree will soon be approved and will completely replace DPCM 12/97, which would be revoked.

This new document will have two fundamental objectives:

1) To acknowledge the standard UNI 11367:2010, making the acoustic classification of buildings mandatory and fixing a minimum value for performance which, as already mentioned, could match the class III.
2) To protect all the parties involved in the purchase and sale of property (buyers, builders, municipalities, etc.) and to protect from future disputes.

The determination of the sound class is calculated as the arithmetic average of the single reference values in their respective class, rounded to the nearest whole number. To guarantee transparency, as well as the total classification it's required to provide the classes of all the reference values. In fact, in the following table it can be noted that a building in class III can have indicators that, if considered individually, do not fall into the same class:

Table 2.6 Example of acoustic classification: both the class of the building unit and the various indicators shall be reported.

Sound class UI	R'_w	$D_{2m,nT,w}$	L'_{nw}	L_{id}	L_{ic}
Class III	IV	IV	II	III	NP

NP = not pertinent.

Just like buildings with a higher energy certificate rating have greater market values, so do building units with good sound-reducing properties, thanks to the greater comfort that these buildings are capable of providing. It is in this light that it is important to continue to pay attention to the topic of acoustics: when choosing technological systems it is fundamental to choose high performance products and make sure that they are installed correctly.

2.5.4 Ministerial Decree 37/2008

Although this document doesn't deal specifically with aspects that relate to acoustics, it is at any rate worth mentioning the Ministerial Decree n°37 of 2008.

The DM 37/08 "Regulation governing the reorganization of provisions regarding the installation of systems inside buildings" came into force on 22 January, 2008, and it deals with systems that serve the building, regardless of the building's intended use, installed inside the same and relative appliances.

If the system is connected to distribution networks, it applies starting from the supplier's delivery point.
The systems are classified under point 1 of the decree and in particular, point d) deals with "water supply and waste systems of any type or nature". Therefore, it should be noted that **water supply and waste systems are given the same importance as all the other technological service systems and, similarly to these, according to article 5, the development of a project, complete with graphical report, is mandatory and must be done by a planner that is registered with a professional association or by a technician employed by the installation firm**, subject to the necessity of observing the standard regulations.

According to the DM 37/2008, a project has been prepared "according to standard regulations" when it has been drawn up in accordance with a UNI or CEI standard or with a standard of another European standardisation body. Thanks to the obligation of design evaluation, the quality of the technological systems has continuously improved.

2.6 Acoustic performance of Valsir waste pipes according to EN 14366 and DIN 4109

In 1997, Valsir started a thorough research and verification of the acoustic insulation capacity of pipes for use in waste systems. The tests carried out in the Fraunhofer Institut fur Bauphysik in Stuttgart, recognised as being the best laboratory for acoustic tests, evaluated the sound absorption capacity of the products and determined whether they meet the requirements of the laws and standards in force.

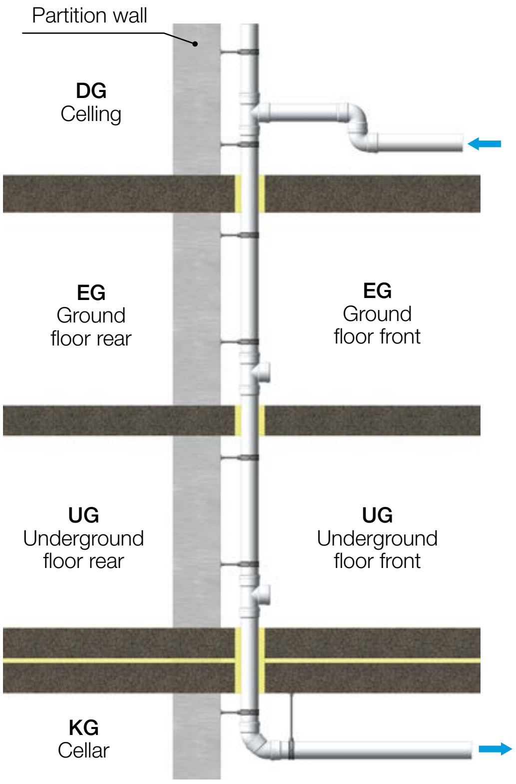
2.6.1 The test methods

The reference standards used for the tests are the UNI EN 14366:2004 and the DIN 4109:1989 (together with DIN 52219:1993) that specify the measurement methods and the results' evaluation.

The test building is located inside the Fraunhofer Institute and it is completely insulated through very thick walls made of the highest quality soundproofing materials. It is a real building of four floors (with internal height of 3050 mm), two of which, shown in the figure with EG and UG, are the reference floors for measurements divided by a wall made of concrete, with a weight of 220 kg/m^2 according to the Standard DIN 4109 (250 kg/m^2 for European standard EN 14366), to which the waste stack is anchored.

The measurement floors are each divided into two rooms: the front room is where the pipe is installed, the back room is free from any installation and it is affected by the noise vibrations transferred to the partition wall; the back rooms have a volume of 70.4 m^3 (surface area of about 23 m^2) while the front rooms are 52.6 m^3 (surface area of about 17 m^2).

Figure 2.5 Layout of test system.



A pumping station with a precision of 5% ensures a continuous waste flow and supplies different levels of flow in relation to the internal diameter of the pipe, as can be seen in Table 2.7. The acoustic pressure levels are measured in third octaves with frequencies from 100 Hz to 5000 Hz.

Table 2.7 Measurement flow in relation to the dimensions of the waste pipe to be tested.

Internal diameter of the pipe [mm]	70 ≤ ID < 100	100 ≤ ID < 125	125 ≤ ID < 150
Measurement flows [l/s]	0.5 - 1	0.5 - 1 - 2 - 4	0.5 - 1 - 2 - 4 - 8

2.6.2 The results

The testing campaign involved numerous tests being carried out in 1997, 1998, 2004, 2006, 2014 and 2019 and the excellent results obtained following the development of the Valsir waste systems are indicated in the diagrams and tables which follow. The tests were carried out both with 2 clips and with 1 clip per floor as the latter represents the typical installation configuration in residential buildings. Consider that the values obtained were rounded up to whole numbers as requested by the reference standards.

Table 2.8 Levels of sound pressure measured behind the installation wall for the Valsir Silere® 110x5.6 pipe, measurements performed and formulated by the Fraunhofer Institute of Stuttgart (Germany).

Test pipes: Valsir Silere®						
Test conditions	**Meas-urement floor**	**Flow rate of water**				**Reference standard (Certificate)(a)**
		0.5 l/s	**1 l/s**	**2 l/s**	**4 l/s**	
		Sound level				
Index $L_{SC,A}$ measured behind the installation wall, with 2 clips per floor, pipe diameter OD 110 mm	UG	-2 dB(A)	1 dB(A)	6 dB(A)	14 dB(A)	EN 14366
Index L_{IN} measured behind the installation wall, with 2 clips per floor, pipe diameter OD 110 mm	EG	1 dB(A)	4 dB(A)	8 dB(A)	17 dB(A)	DIN 4109
	UG	2 dB(A)	5 dB(A)	9 dB(A)	17 dB(A)	
Index L_{IN} measured behind the installation wall, with 1 clip per floor, pipe diameter OD 110 mm	EG	-1 dB(A)	2 dB(A)	6 dB(A)	14 dB(A)	DIN 4109
	UG	1 dB(A)	5 dB(A)	9 dB(A)	15 dB(A)	

Table 2.9 Levels of sound pressure measured behind the installation wall for the Valsir Triplus® 110x3.4 pipe, measurements performed and formulated by the Fraunhofer Institute of Stuttgart (Germany).

Test pipes: Valsir Triplus®						
Test conditions	**Meas-urement floor**	**Flow rate of water**				**Reference standard (Certificate)(b)**
		0.5 l/s	**1 l/s**	**2 l/s**	**4 l/s**	
		Sound level				
Index $L_{SC,A}$ measured behind the installation wall, with 2 clips per floor, pipe diameter OD 110 mm	UG	1 dB(A)	6 dB(A)	12 dB(A)	16 dB(A)	EN 14366
Index L_{IN} measured behind the installation wall, with 2 clips per floor, pipe diameter OD 110 mm	EG	3 dB(A)	8 dB(A)	12 dB(A)	19 dB(A)	DIN 4109
	UG	4 dB(A)	9 dB(A)	15 dB(A)	19 dB(A)	
Index L_{IN} measured behind the installation wall, with 1 clip per floor, pipe diameter OD 110 mm	EG	1 dB(A)	5 dB(A)	10 dB(A)	16 dB(A)	DIN 4109
	UG	2 dB(A)	6 dB(A)	11 dB(A)	15 dB(A)	

Table 2.10 Levels of sound pressure measured behind the installation wall for the Valsir Blackfire® 110x3.4 pipe, measurements performed and formulated by the Fraunhofer Institute of Stuttgart (Germany).

Test pipes: Valsir Blackfire®						
Test conditions	**Meas-urement floor**	**Flow rate of water**				**Reference standard (Certificate)(b)**
		0.5 l/s	**1 l/s**	**2 l/s**	**4 l/s**	
		Sound level				
Index $L_{SC,A}$ measured behind the installation wall, with 2 clips per floor, pipe diameter OD 110 mm	UG	<10 dB(A)	13 dB(A)	16 dB(A)	19 dB(A)	EN 14366
Index L_{IN} measured behind the installation wall, with 2 clips per floor, pipe diameter OD 110 mm	UG	<10 dB(A)	15 dB(A)	18 dB(A)	21 dB(A)	DIN 4109
Index L_{IN} measured behind the installation wall, with 1 clip per floor, pipe diameter OD 110 mm	UG	<10 dB(A)	11 dB(A)	16 dB(A)	19 dB(A)	DIN 4109

Table 2.11 Levels of sound pressure measured behind the installation wall for the Valsir PP3® 110x2.7 pipe, measurements performed and formulated by the Fraunhofer Institute of Stuttgart (Germany).

Test pipes: Valsir PP3®						
Test conditions	Measurement floor	Flow rate of water				Reference standard (Certificate)(c)
		0.5 l/s	1 l/s	2 l/s	4 l/s	
		Sound level				
Index $L_{SC,A}$ measured behind the installation wall, with 2 clips per floor, pipe diameter OD 110 mm	UG	<10 dB(A)	13 dB(A)	17 dB(A)	23 dB(A)	EN 14366
Index L_{IN} measured behind the installation wall, with 2 clips per floor, pipe diameter OD 110 mm	EG UG	10 dB(A) 12 dB(A)	14 dB(A) 16 dB(A)	17 dB(A) 20 dB(A)	23 dB(A) 26 dB(A)	DIN 4109
Index L_{IN} measured behind the installation wall, with 1 clip per floor, pipe diameter OD 110 mm	EG UG	10 dB(A) 11 dB(A)	12 dB(A) 14 dB(A)	16 dB(A) 18 dB(A)	22 dB(A) 24 dB(A)	DIN 4109

(a) Certificates n. P-BA 221/2006, P-BA 222/2006, P-BA 223/2006
(b) Certificates n. P-BA 225/2006, P-BA 226/2006, P-BA 227/2006
(c) Certificates n. P-BA 258/dupl2019e, P-BA 259/2019e
(d) Certificates n. P-BA 91/2014e, P-BA 92/2014e

Figure 2.6 Layout of the test system with 2 clips per floor.

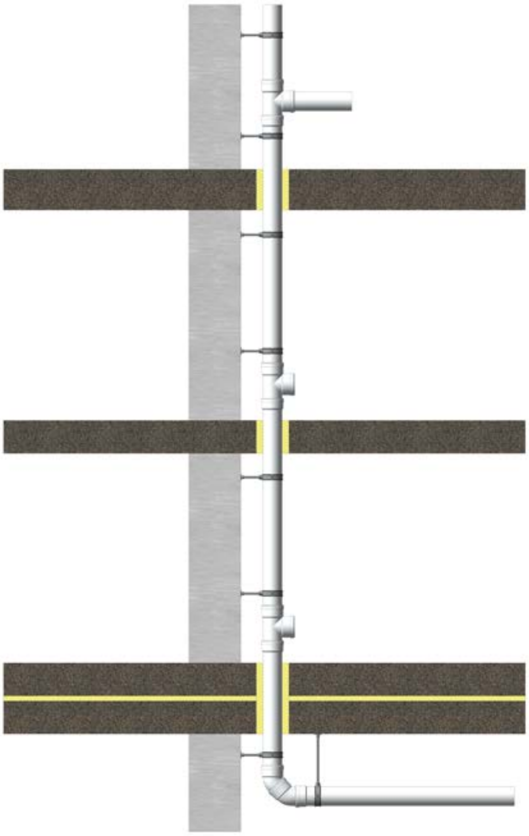
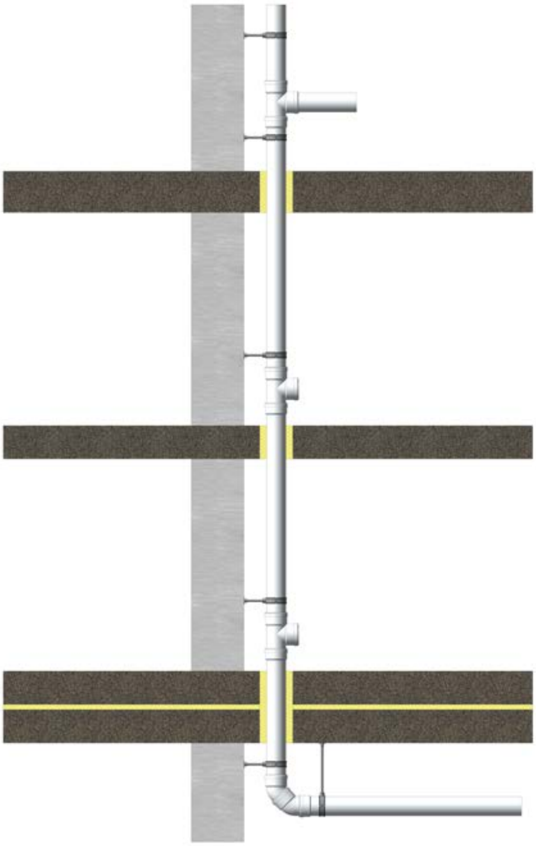


Figure 2.7 Layout of the test system with 1 clip per floor.



It can be observed that by eliminating an anchor clip the levels of sound pressure in the measurement room located behind the installation wall of the waste stack are reduced by several dB. This behaviour stems from the fact that the vibrations transferred to the installation wall through the clips are reduced.

Negative values correspond to very low sound pressure levels that are not detected by the human ear and are near to the detection threshold of the laboratory instruments (for more details see chapter 2.2).

Over the years, the Fraunhofer Institut für Bauphysik in Stuttgart has changed the report processing method of tested products. In recent years, for measurements below 10 dB(A), the actual measured values are no longer provided and replaced by the indication <10 dB(A). In addition, only the values measured in the basement UG are provided, whereas the values measured in the ground floor EG are not.

Similar tests were carried out with the goal of evaluating the difference among the noise levels of the Silere® system, traditional single-layer systems in polypropylene (PP) and those in cast iron. The results achieved are shown in the following diagram and table and demonstrate the difference in the noise levels compared to those obtained with cast iron expressed in dB(A).

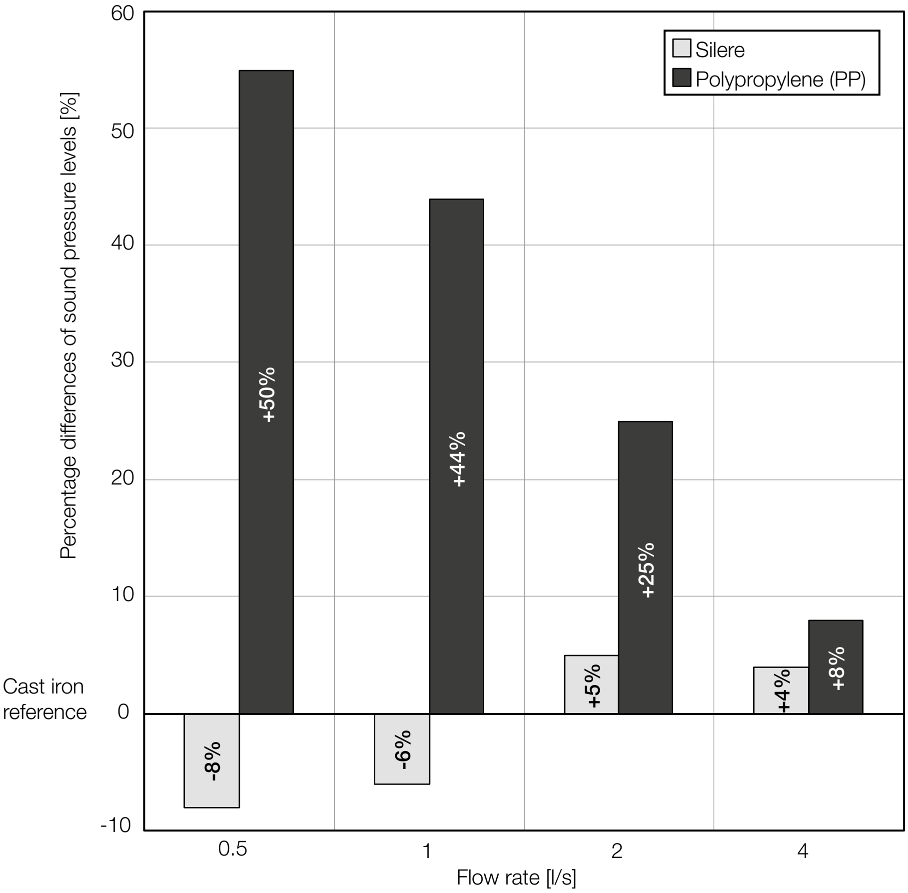
Table 2.12 Difference in the levels of noise pressure $L_{sc,A}$ expressed in dB(A) measured on the ground floor behind the installation wall for Silere® pipes 110x5.6 and polypropylene pipes 110x2.7 compared with the levels of noise of cast iron 100x3.5 in compliance with DIN 4109. The results were obtained by the Fraunhofer Institute in Stuttgart, using acoustically insulated pipe clips (certificate P-BA 113/2004e).

Pipe	**Flow rate [l/s]**			
	0.5	**1**	**2**	**4**
	Difference in the levels of noise pressure dB(A) compared with cast iron pipes			
Cast iron	Reference			
Polypropylene (PP)	+ 50%	+ 44%	+ 25%	+ 8%
Silere®	- 8%	- 6%	+ 5%	+ 4%

From the results obtained it is clear that the performance of Silere® pipes is similar to the cast iron one despite the fact that the specific weight of cast iron is 7.2 g/cm³ and that of Silere® is 1.6 g/cm³, therefore over four times lower. Flow rates of 2 and 4 l/s produce a difference of 4 to 5% but with flows of 0.5 and 1 l/s the difference is negative making Silere® one of the most high performing soundproofing waste systems.

From what has emerged, it can be concluded that the specific weight is not the predominant factor in determining the acoustic characteristics of a plastic waste system. Wall thickness, flexibility, the combination of the plastic and mineral fillers used and, the use, if any, of layers of a different material (as with PP3®, Blackfire® and Triplus®) are fundamental factors that contribute to the performance of these systems as well.

Figure 2.8 Percentage difference of the sound pressure levels $L_{sc,A}$ measured on the ground floor behind the installation wall for Silere® 110x5.6 and polypropylene (PP) 110x2.7 relative to the noise levels of cast iron 100x3.5 to DIN 4109. The results were obtained by the Fraunhofer Institute in Stuttgart using soundproofing pipe clips (certificate P-BA 113/2004e).



2.7 Acoustic performance of Valsir waste pipes according to the Building Code of Australia

In 2013 in Australia, Valsir commenced a test program to determine the sound reducing performance of the Valsir Triplus® and Silere® waste systems to verify compliance with the requirements of paragraph F5.6 of the Building Code of Australia (National Construction Code 2013) as shown:

F5.6 Sound insulation rating of services

a) *If a duct, soil, waste or water supply pipe, including a duct or pipe that is located in a wall or floor cavity, serves or passes through more than one sole-occupancy unit, the duct or pipe must be separated from the rooms of any sole-occupancy unit by construction with an* $R_w + C_{tr}$ *(airborne) not less than-*
   (i) 40 if the adjacent room is a habitable room (other than a kitchen); or
   (ii) 25 if the adjacent room is a kitchen or non-habitable room.

b) *If a storm water pipe passes through a sole-occupancy unit it must be separated in accordance with (a)(i) and (ii).*

The Building Code of Australia specifies that if a pipe is located in a wall or floor cavity of a habitable room (other than a kitchen), the level of sound insulation guaranteed by the pipe together with the separating structure must be greater than 40. If the room is a non-habitable room or is a kitchen, the level of insulation to be guaranteed is 25. These values are the sum of two values, R_w and C_{tr}, that represent the index of acoustic insulation (airborne) where:

- R_w (weighted sound reduction index) rates the effectiveness of the pipe and the separating structure as a noise insulator,
- C_{tr} is a spectrum adaptation term used to modify a measured sound insulation performance introduced with the new version of the NCC and takes into account the low frequency noise. This value is used to correct the values measured in laboratories to make them as similar as possible to those that would be obtained on site. The C_{tr} is a negative number and therefore it reduces the R_w value and it varies according to the insulating material employed. For example, a 90 mm cavity brick masonry wall has a C_{tr} value of -6.

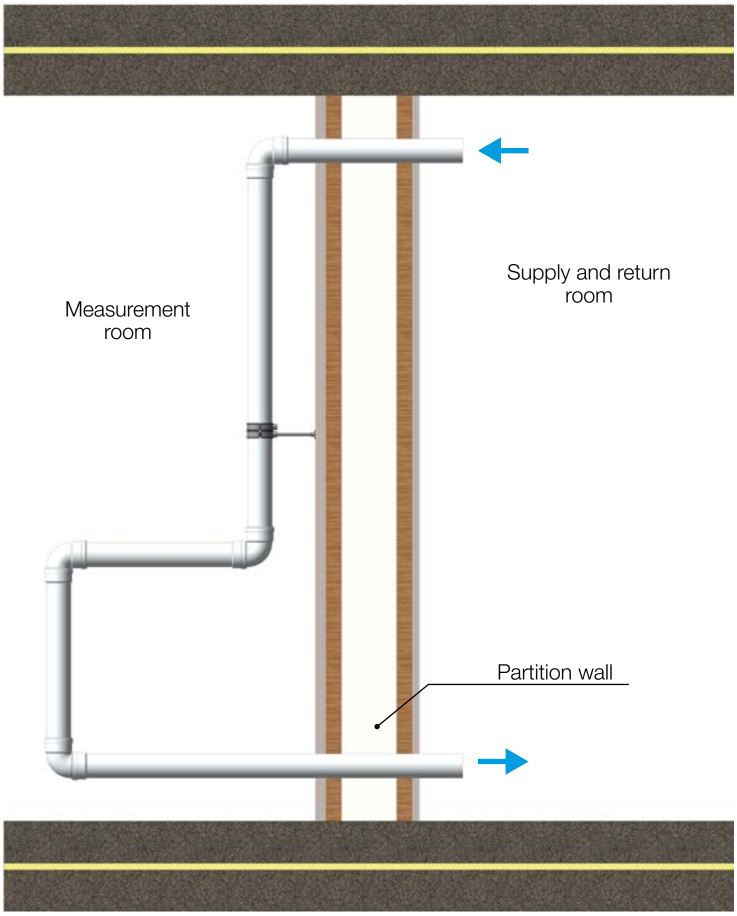
The tests were conducted in the Institute CSIRO (Commonwealth Scientific and Industrial Research Organisation) in Highett (Victoria) and analysed by Day Design (Sydney), a company that provides professional acoustical consultancy. The following waste systems were taken into consideration:

1) PVC pipes, diameter 110 mm (standard product commonly used on the market).
2) PVC pipe, diameter 110 mm acoustically insulated with Pyrotek 4525C (standard product commonly used on the market).
3) Valsir Triplus® pipe, diameter 110 mm.
4) Valsir Silere® pipe, diameter 110 mm.

The room in which the measurements were made is separated from the flow supply room by a wall with a thickness of approximately 470 mm, suitably built and insulated in order to avoid measuring the noises generated by the supply pump and the discharge of the flow into the return tank.

The flow rates taken into consideration were 2 and 4 l/s. Moreover, the test circuit configuration was chosen in order to replicate the tests already performed by the National Acoustic Laboratory (NAL) which commenced in 1995 to analyse the sound pressure levels generated by the PVC waste systems installed in civil and industrial buildings. The system height is about 3 m and the particular configuration, made up of several changes in direction, has the aim of increasing the noise levels generated and simulating not only the waste stacks, but also the horizontal branches that are installed inside the ceiling plenums.

Figure 2.9 Test system layout.



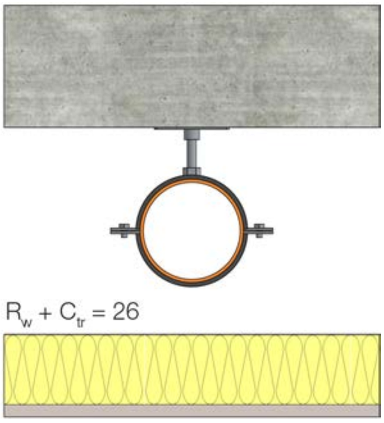
The results obtained demonstrate the extraordinary performance of the Triplus® and the Silere® waste systems, demonstrating that the use of these products does not require the employment of soundproofing lagging in order to meet the requirements of the BCA/NCC 2013 which require a $R_w + C_{tr}$ value greater than or equal to 40. The following table gives the values for different installation conditions.

Table 2.13 $R_w + C_{tr}$ values for different waste systems.

Piping	Installation conditions	$R_w + C_{tr}$ value	References
PVC	Un-lagged pipe. Wall consisting of 13 mm plasterboard and 75 mm R1.5 insulation.	26	Figure 2.10 (Scheme A) Figure 2.11
PVC	Pipe with Pyrotec 4525C lagging. Wall consisting of 13 mm plasterboard and 75 mm R1.5 insulation	40	Figure 2.10 (Scheme B) Figure 2.11
Triplus®	Un-lagged pipe. Wall consisting of 13 mm plasterboard and 75 mm R1.5 insulation.	42	Figure 2.10 (Scheme C) Figure 2.11
Silere®	Un-lagged pipe. Wall consisting of 13 mm plasterboard and 75 mm R1.5 insulation.	46	Figure 2.10 (Scheme D) Figure 2.11
Silere®	Un-lagged pipe. Wall consisting of 13 mm plasterboar.	40	Figure 2.10 (Scheme E)
Silere®	Un-lagged pipe. Wall consisting of 10 mm plasterboard and 75 mm R1.5 insulation.	43	Figure 2.10 (Scheme F)

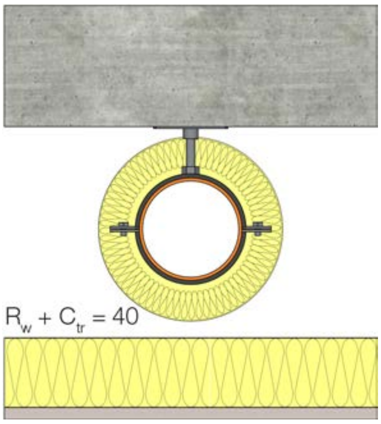
Figure 2.10 Installation conditions.

Scheme A



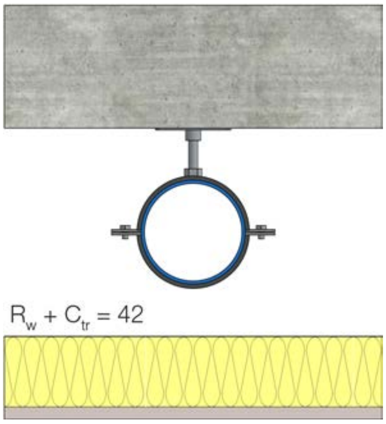
Un-lagged PVC pipe. Wall consisting of 13 mm plasterboard and 75 mm R1.5 insulation.

Scheme B



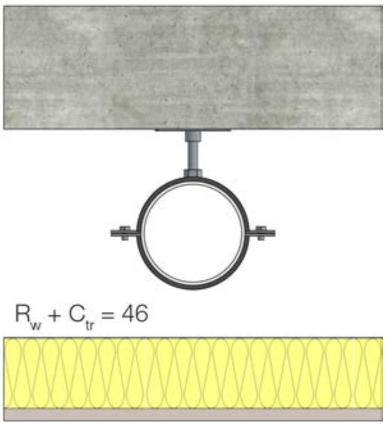
PVC pipe with lagging. Wall consisting of 13 mm plasterboard and 75 mm R1.5 insulation.

Scheme C



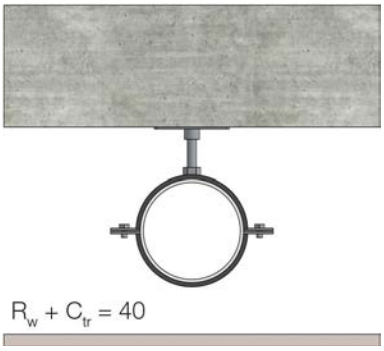
Un-lagged Triplus® pipe. Wall consisting of 13 mm plasterboard and 75 mm R1.5 insulation.

Scheme D



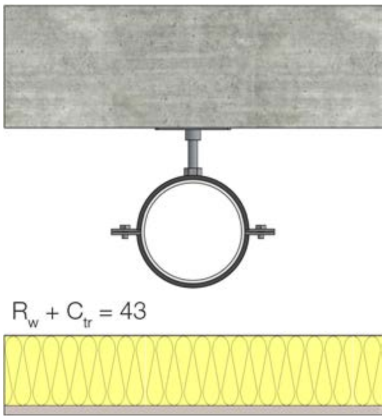
Un-lagged Silere® pipe. Wall consisting of 13 mm plasterboard and 75 mm R1.5 insulation.

Scheme E



Un-lagged Silere® pipe. Wall consisting of 13 mm plasterboard without insulation.

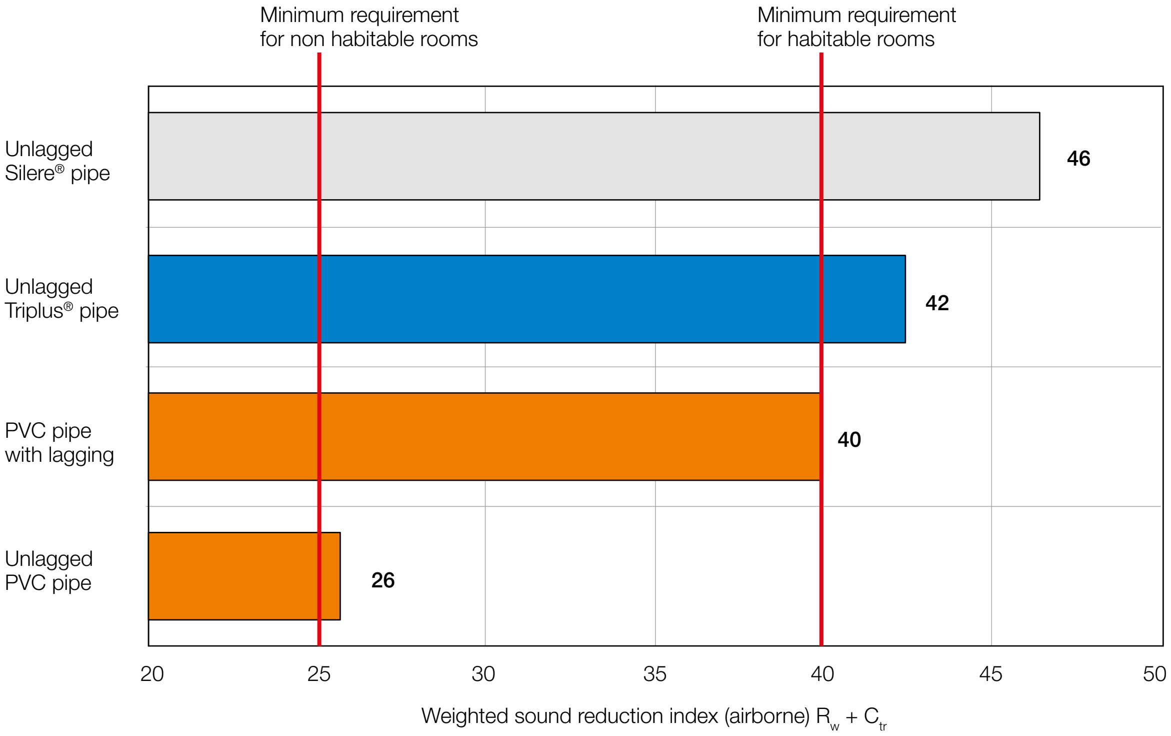
Scheme F



Un-lagged Silere® pipe. Wall consisting of 10 mm plasterboard and 75 mm R1.5 insulation.

The performance differences between Valsir waste systems and systems made with lagged and unlagged PVC are shown in the diagram below. It shows how **Triplus® and Silere® products largely meet the requirements of BCA/NCC 2013 without the need to lag pipes with soundproofing lagging**.

Figure 2.11 Comparison of acoustic performance.



2.8 Acoustic performance of Valsir's Triplus® waste system according to French DTA

Acoustic tests on the Triplus® drainage system by Valsir were performed at the CSTBat laboratory in Grenoble (France) in order to evaluate its acoustic performance according to the indications described in the DTA (Document Technique d'Application).

The DTA is a document issued by the CSTBat body that explains how to prepare an application for a "Avis Technique" request for a drainage system with acoustic performance, which is a prerequisite for marketing and installing products on the French market.

The waste system is intended for gravity drainage inside the buildings and should have acoustic characteristics in ESA4 or ESA5 classes.

The ESA classification of a system is given by performing acoustic tests of L_{an} airborne noise at 2 l/s measured in the installation room both on the vertical stack and on the collector pipes. If a system falls into one class with the measurement in the stack and another class with the measurement on the collector pipe, it is assigned the lowest ESA classification.

The ESA classes are defined by the French noise regulation and are also reported in the DTA.

Table 2.14 ESA classification.

ESA class	Riser stack (dB)	Horizontal pipe (dB)	Description
ESA3	$53 < L_{an} \leq 57$	$59 < L_{an} \leq 63$	Pipes and fittings that do not have acoustic performance.
ESA4	$49 < L_{an} \leq 53$	$51 < L_{an} \leq 59$	Pipes and fittings with acoustic performance.
ESA5	$L_{an} \leq 49$	$L_{an} \leq 51$	Pipes and fittings with advanced acoustic performance.

In order to have acoustic characteristics, the waste system must also have a structural noise value L_{sc} less than or equal to 25 dB at a flow rate of 2 l/s measured in the vertical stack; this value is obtained with an acoustic test performed according to the NF EN 14366 standard.

The French regulation therefore classifies waste systems with acoustic characteristics, both with tests of L_{an} airborne (tests performed on both the vertical stack and the collector pipe) and with L_{an} structural noise tests (test performed on the vertical stack). The DTA also limits to OD 160 the range of an acoustic waste system and requires that at least OD 100 or OD 110 is always included in the test.

The following waste systems are excluded from the acoustic certification:

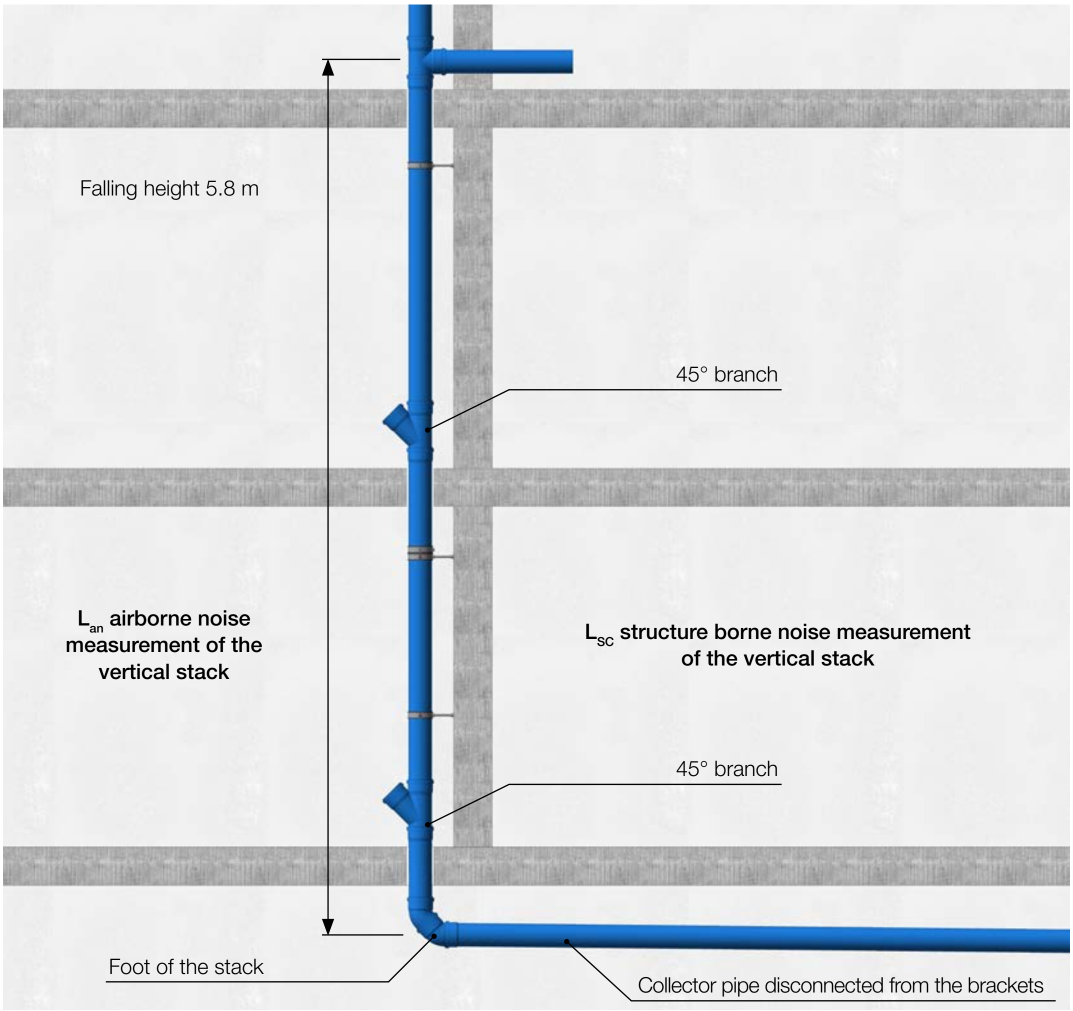
- Buried in the ground within the building structure.
- For sewerage outside the building structure.
- Used for the drainage of waste water from kitchens or industrial laundries.

2.8.1 Description of the acoustic tests performed at the CSTBat laboratory in Grenoble

2.8.1.1 Acoustic tests on the vertical stack

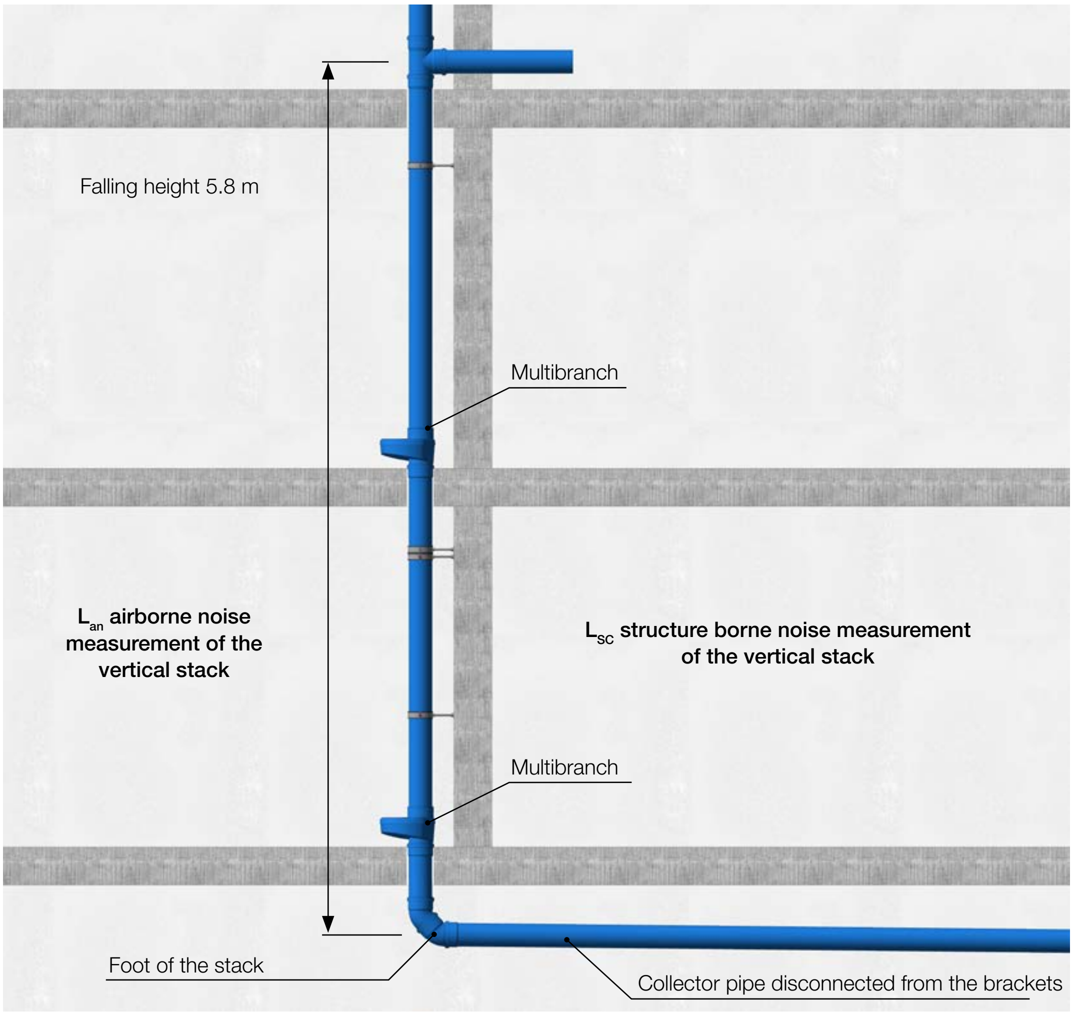
The configuration used for the tests is according to the NF EN 14366 standard which provides, in the first instance, both the measurement of the airborne noise L_{an} (using the measurement room on the installation side) and of the structure borne noise L_{sc} (using the measurement room behind the installation wall) of the vertical stack. During these measurements the collector pipe located on the lower floor is disconnected from the respective brackets so that the noise caused from it does not affect the results.
The separation wall used by the laboratory has a weight of 220 kg/m^2; the falling height is 5.6 m and on the stack there are two 45° branches complete with plugs that simulate the connection to the utilities.

Figure 2.12 Scheme of the system for acoustic tests of the waste stack with branches at 45°.



Valsir also performed these tests with the Multibranch fitting (see chapter 3.5.3 - Solution F), in this case the two 45° branches installed in the column are replaced with two Multibranch fittings, both plugged in all their inlets.

Figure 2.13 Scheme of the system for acoustic tests of the waste stack with Multibranch fitting.



In all the tests performed, the foot of the stack is done using two 45° bends without the aid of particular or dedicated fittings. The stack is fixed to the wall with two clips per floor: a fixed-point clip with high acoustic performance, made using two clips with anti-vibration rubber and installed according to what described in this technical manual at chapter 7.2.8.4, and a sliding point clip with anti-vibration rubber placed about one meter from the floor and installed as described in this manual at chapter 7.2.8.3. The tests are performed with flow rates equal to 0.5-1-2-4 l/s in accordance with the NF EN 14366 standard.

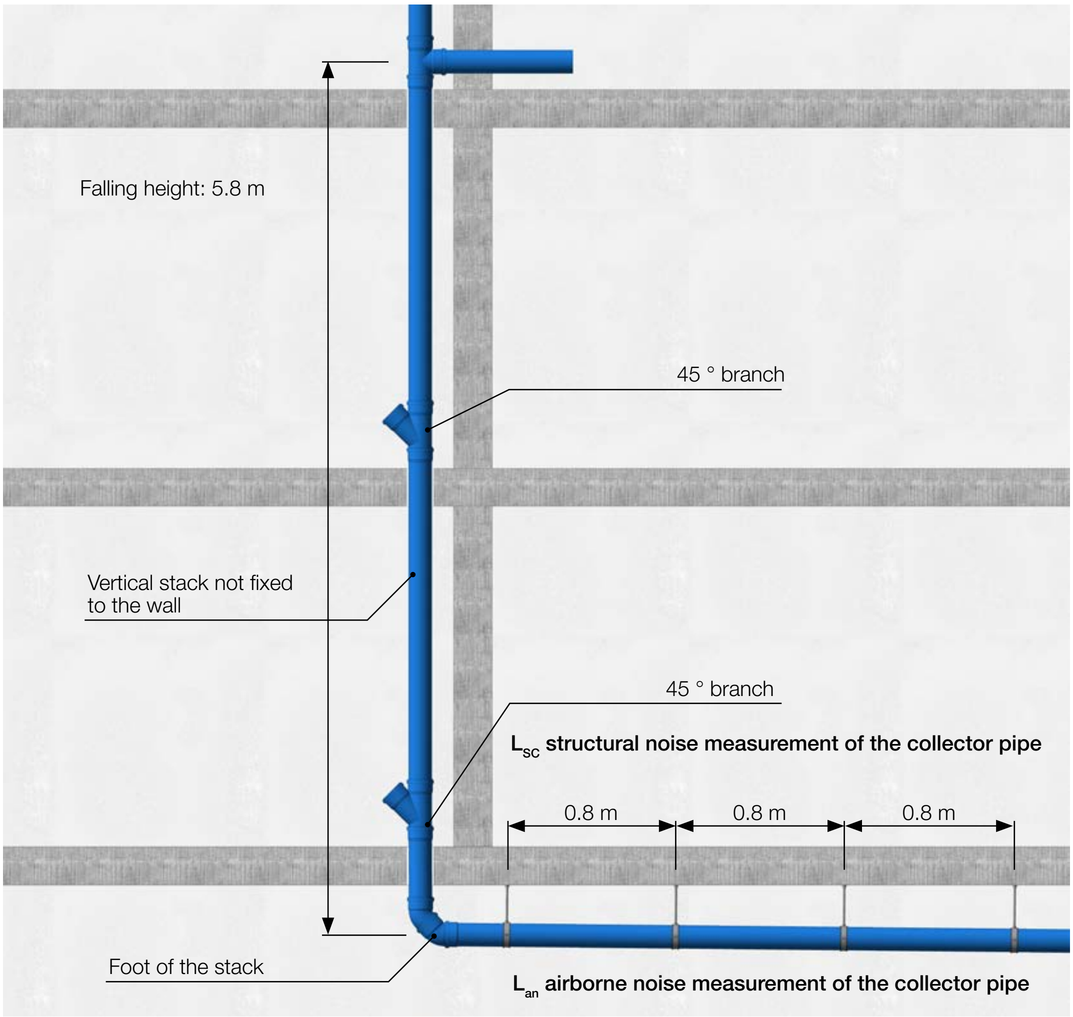
2.8.1.2 Acoustic tests on the collector pipe installed on the ceiling

The evaluation of the airborne noise L_{an} and the structural borne noise L_{sc} of the collector pipe is performed using respectively the installation room of the collector pipe and the room above.

Both tests are performed with OD 110 and OD 160, although the DTA only provides for the aerial measurement L_{an} and only on OD 110.

The results obtained on the collector pipe are particularly influenced by the foot of the stack which is the noisiest point of the system; the pipe was clamped with 4 fixed point clips as described in the chapter 7.2.8.4 of this manual, with a distance between them of 0.8 m. The weight of the slab is 400 kg/m^2 for a height of about 180 mm of concrete according to the test protocol described in the DTA.

Figure 2.14 Scheme of the system for acoustic tests of the collector pipe with 45° branch.



The acoustic tests conducted by Valsir on the Triplus® system are the following:

Table 2.15 Configuration of the acoustic tests conducted at the CSTBat laboratory in Grenoble on waste system Triplus®.

System	Airborne noise vertical stack	Structure borne noise vertical stack	Airborne noise collector pipe	Structure borne noise collector pipe
Triplus® system OD 110 with branch and 2x45° bends at the foot of the stack	X	X	X	X*
Triplus® system OD 160 with branch and 2x45° bends at the foot of the stack	X	X	X*	X*
Triplus® system OD 160 with multibranch and 2x45 ° bends at the foot of the stack	X	X	-	-

* Test not foreseen by the DTA.

2.8.1.3 Results

Below are the summarized values in dB of the airborne noise L_{an} and structural L_{sc} measured for the stack and for the collector pipes at the various flow rates, using both the branch and the Multibranch. The results shown below cannot be compared with those achieved at the Fraunhofer Institute, as obtained using different system configurations, different environments and different clips.

Table 2.16 Triplus® OD 110 system with branch.

Flow rate (l/s)	L_{an} stack (dB)	L_{sc} stack (dB)	L_{an} collector (dB)	L_{sc} collector (dB)
0.5	47	16	53	18
1	48	16	55	18
2	52	19	58	22
4	55	21	62	24

Table 2.17 Triplus® OD 110 system with Multibranch.

Flow rate (l/s)	L_{an} stack (dB)	L_{sc} stack (dB)	L_{an} collector (dB)	L_{sc} collector (dB)
0.5	44	15	-	-
1	46	17	-	-
2	52	21	-	-
4	55	23	-	-

Table 2.18 Triplus® OD 160 system with branch.

Flow rate (l/s)	L_{an} stack (dB)	L_{sc} stack (dB)	L_{an} collector (dB)	L_{sc} collector (dB)
0.5	46	13	55	17
1	49	15	57	16
2	51	16	59	20
4	53	19	62	22

The Triplus® system, thanks to the results obtained during the tests described above, falls into the ESA4 category, both for waste system with 45° branch and with Multibranch.

2.9 Acoustics in the planning of soil and waste systems

2.9.1 Introduction

First and foremost, proper acoustic design of waste systems necessitates determining the sources of noise within the system itself; it is extremely important to identify the critical points within the system and take measures to reduce noise transmission which can be both airborne or structure borne.

Figure 2.15 Airborne sound from a waste stack.

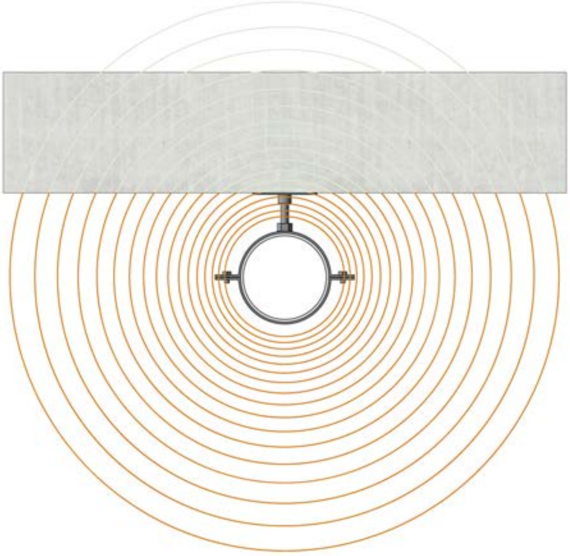
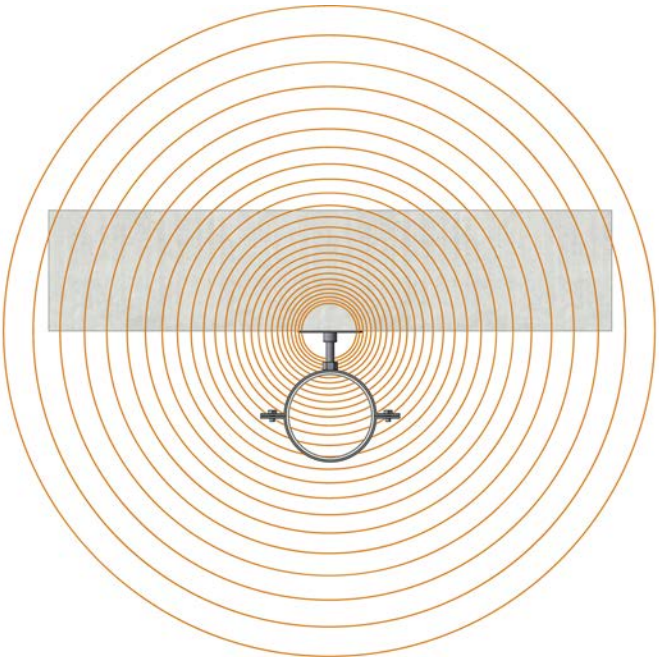


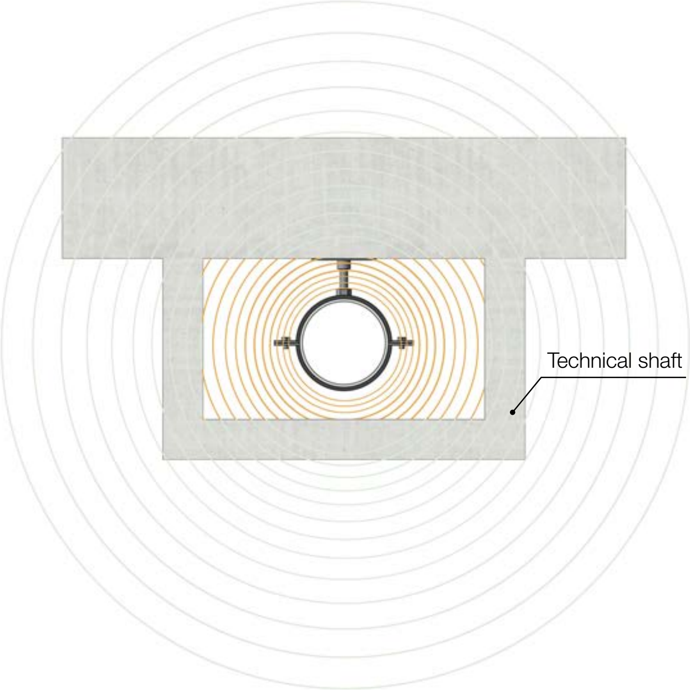
Figure 2.16 Structure borne sound from a waste stack that is anchored without an anti-vibration clip.



Waste systems are characterised by airborne and structure bornee sound transmission; it is therefore necessary to adopt measures in planning and installation aimed at reducing both. To reduce airborne sound transmission the pipework must be insulated acoustically by placing walls between the pipework itself and the room in which the noise impact needs to be reduced (sound insulation).

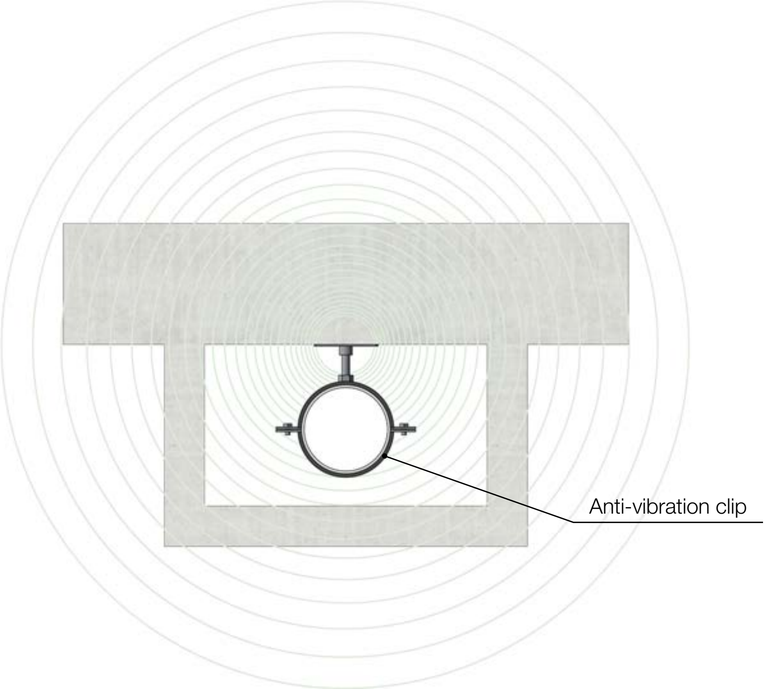
In this case, the type of partition wall, and especially its weight, are key elements in efficient soundproofing.

Figure 2.17 Reduction of airborne noise of a waste stack with a technical shaft.



To reduce the structure borne noise generated by a waste system, it is necessary to insulate the piping from the building structure by using clips equipped with anti-vibration rubber. These clips act as springs reducing the vibrations that the pipe tends to transfer to the walls. The construction characteristics of the clip are of fundamental importance; the acoustic performance of the system can be harmed by factors such as the rubber lining's lack of elasticity or the pipe's excessively tight anchoring.

Figure 2.18 Reduction of structure borne noise of a waste stack with anti-vibration pipe clips.



2.9.2 Noise in waste systems

When a waste system is operating, noises originate inside the pipe, which then starts to vibrate due to the fall of the discharged liquid, which:

- Hits against the walls of the vertical stack.
- Hits against the walls of the collector pipes due to changes of direction.
- Draws air upstream compressing the air downstream (siphoning).

Significant portion of the noise is produced inside the pipe itself but the vibrations generated are transmitted from the pipe walls to the surrounding area and to the bracketing systems and consequently the building structure.

Noise propagation inside a waste system depends on:

- The characteristics of the pipe clips.
- The changes of direction.
- The absence or under-sizing of ventilation systems.
- The arrangement of the building structure.

But it is also determined by the pipe's propensity to vibrate, which is strictly related to its structural characteristics, in particular:

- Its mass.
- Its elasticity, which depends on its modulus of elasticity and its geometry.
- Its dampening capacity which depends on the pipe structure (possible combination of different materials).

Ultimately, in order to reduce the level of noise caused by waste systems, it is advisable to:

- Choose **a pipe with good soundproofing** characteristics.
- Make sure **that the planning is carried out correctly**.
- Make sure **that the installation is carried out correctly** by using suitable products.

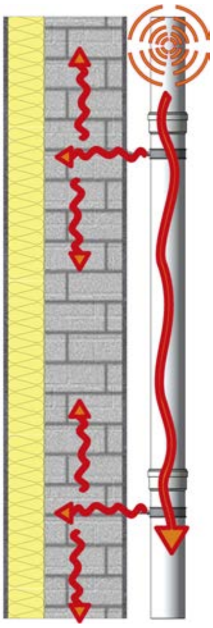


Figure 2.19 Noise transmission in waste systems.

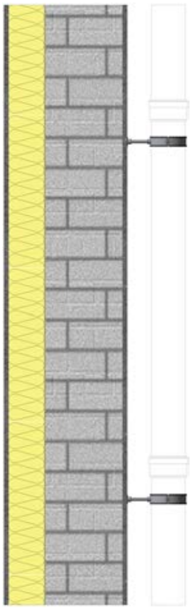


Figure 2.20 Influence of structure and clips on noise levels.

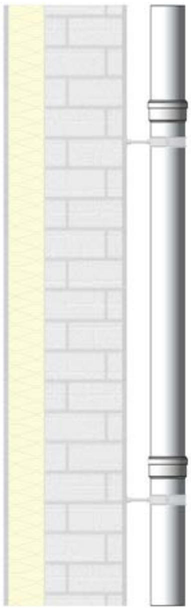


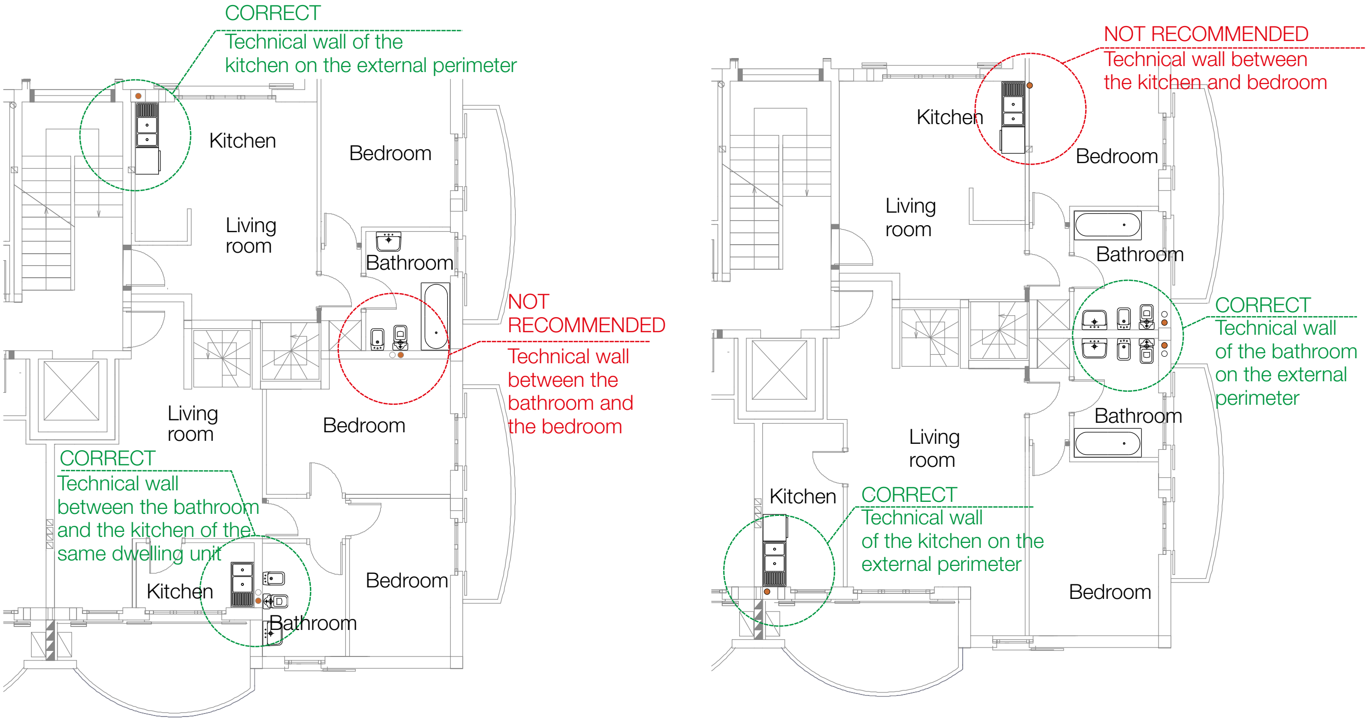
Figure 2.21 Influence of pipe on noise levels.

2.9.3 Acoustic design

In planning waste and soil systems several architectural acoustics criteria for controlling the noise produced by systems need to be followed. Whether these criteria can be applied or not, obviously depends on the structure and geometry of the property and it is therefore strongly recommended consulting those involved in architectural engineering.

- Sanitary fixtures and corresponding waste pipes must be positioned in technical walls that are not adjacent to bedrooms or living rooms.
- It is advisable to create technical shafts in which the waste pipes are installed and to position them in the same area of the sanitary fixtures.
- The sanitary fixtures of each floor must be positioned above each other in order to reduce the necessity of stack offsets, which are a source of noise.
- If the above is not possible, then measures must be taken to protect against the noise by increasing the acoustic insulation of the installation walls and the pipes themselves.

Figure 2.22 Positioning of technical walls for pipework installation.



- Positioning of the pipes inside the technical shaft must be on the thickest wall and, when possible, in the corner. Pipes installed on thin walls and, particularly in the center of the wall, can aid in the diffusion of structure bornee noise caused by wall vibrations.

Figure 2.23 Solution to avoid for pipe installation in the technical shaft.

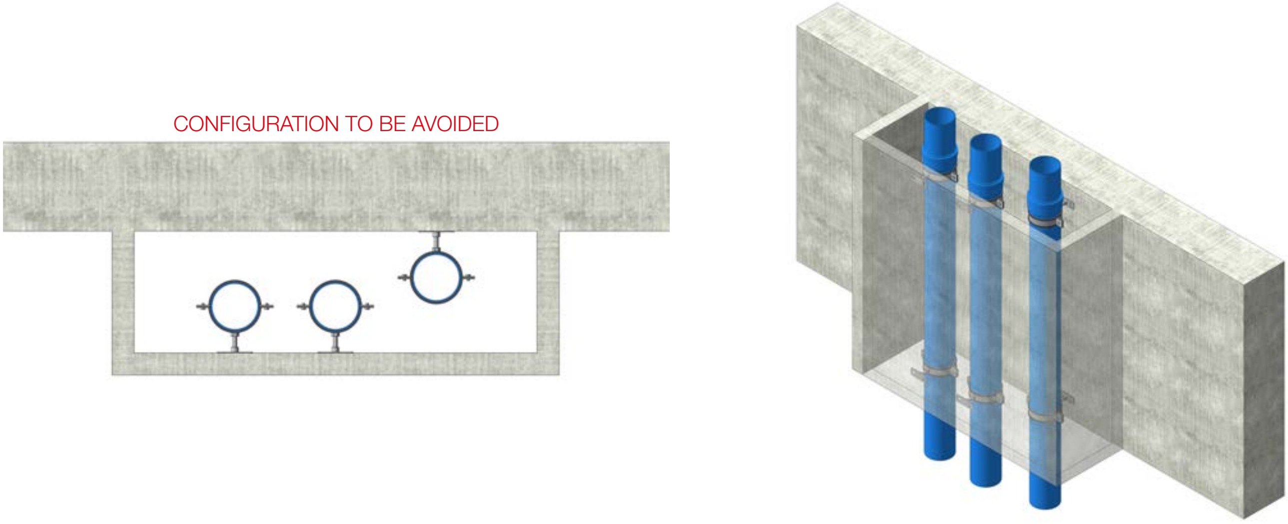
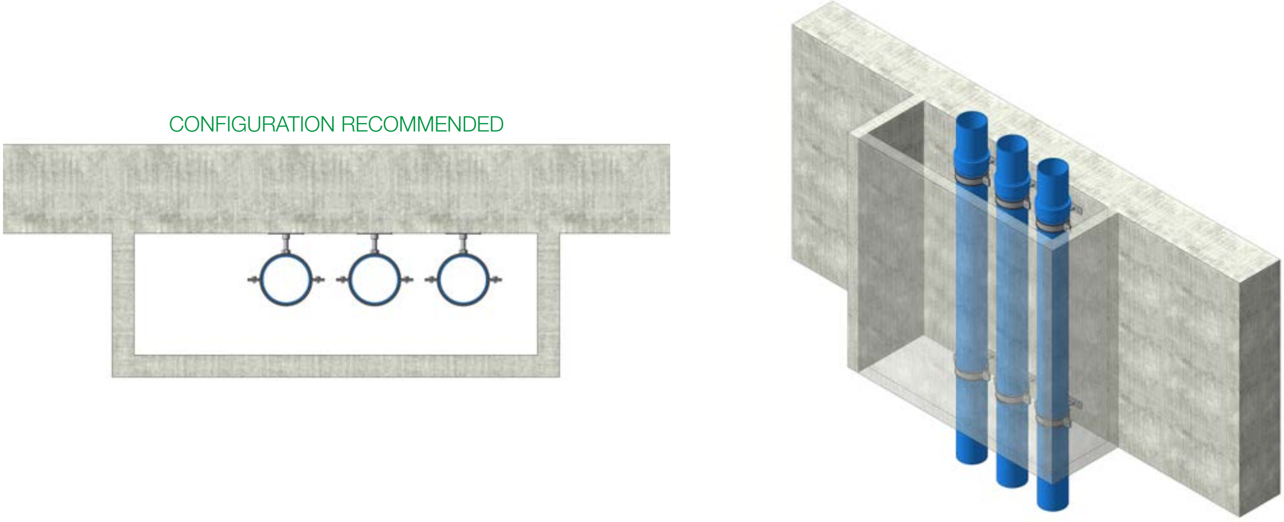
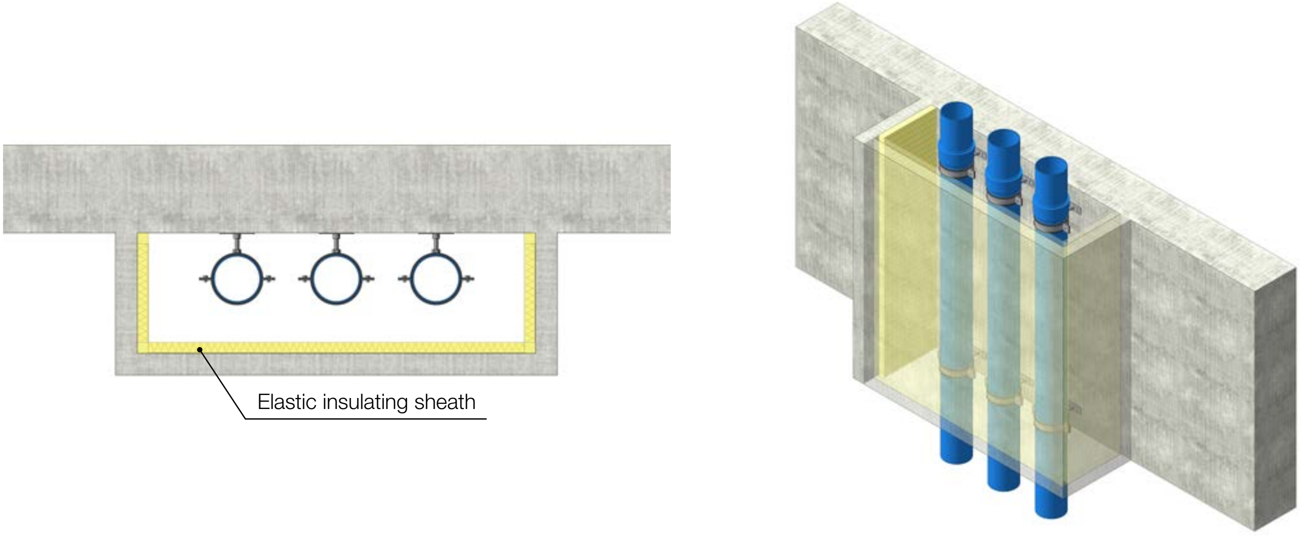


Figure 2.24 Solution recommended for pipe installation in the technical shaft.



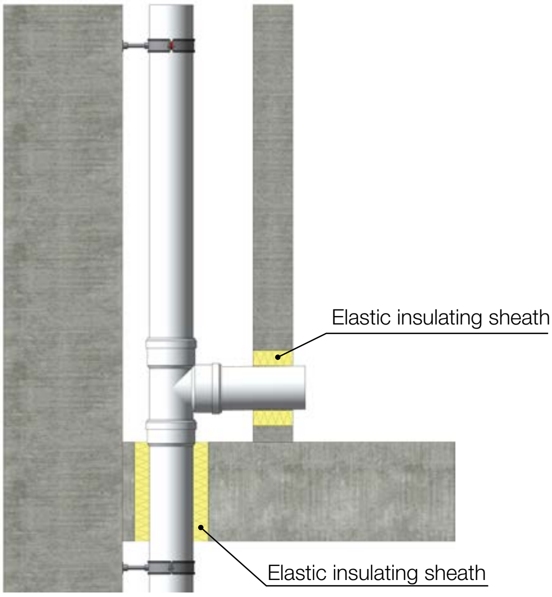
- To limit airborne noise, it is therefore recommended to install the waste pipes inside a technical shaft, which, due to the acoustic insulation properties of the walls, reduces the noise transmitted to the outside. The technical shaft however, can result in an increase in the level of airborne noise inside the wall due to the "resonance chamber" effect thus, in some degree, neutralising the insulation effect of the walls themselves. This increase is influenced by the geometry of the technical shaft and by the surface of the wall of the technical shaft adjacent to the measurement room; values of about 6 dB to 10 dB can be measured for cavity walls where the wall next to the measurement room has a depth of 0.3 m to 1 m.
- To reduce the "resonance chamber" effect it is recommended to cover part of the internal walls with a sound-absorbing material such as mineral wool, for example, with a thickness of 40 mm that can completely cancel the increase in noise.

Figure 2.25 Installation of pipes in the technical shaft partially covered with a sound-absorbing material.



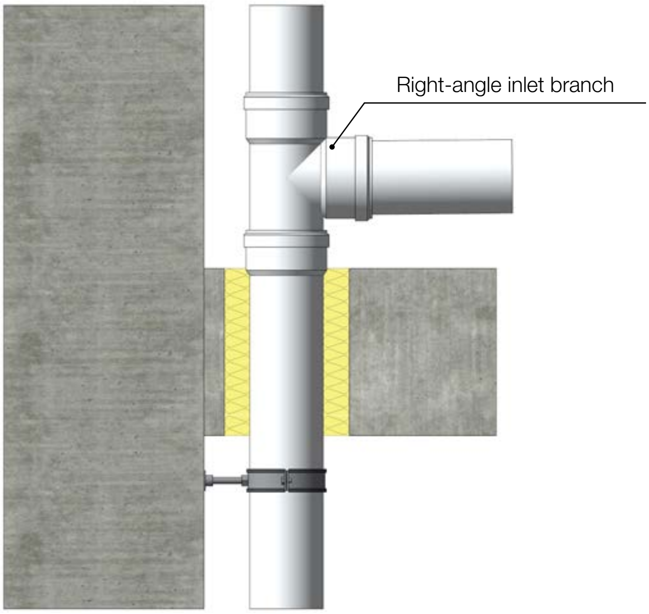
- Passage through floor slabs and walls must be carried out in such a way as to acoustically separate the pipework from the building structure in order to reduce the transmission of vibrations, produced during operation of the waste system. It is therefore suggested to cover the pipes with an elastic insulating sheath with a minimum thickness of 5 mm.
- If the pipe needs to be embedded in the wall it is recommended to create gaps in order to create the “shaft” effect thus avoiding contact between the pipe and the building structure. If there are contact points with the bricks or there is the risk that contact could be created during vibration of the pipe, it is suggested to cover the stack with an elastic insulating sheath with a minimum thickness of 5 mm.
- If the pipe is completely embedded in the concrete it is not required to insulate it because the mass of concrete is enough to contain the noise transmission. With a layer of 50 mm of concrete the level of noise is reduced by about 30 dB.
- To limit the structure borne noise it is recommended to reduce the contact points with the wall to a minimum; to control vibration transmission to the structure, the number of clips must be kept to a minimum; at most, the passage through the floor slab can be used as an anchor point.

Figure 2.26 Passage through a floor slab and a wall.



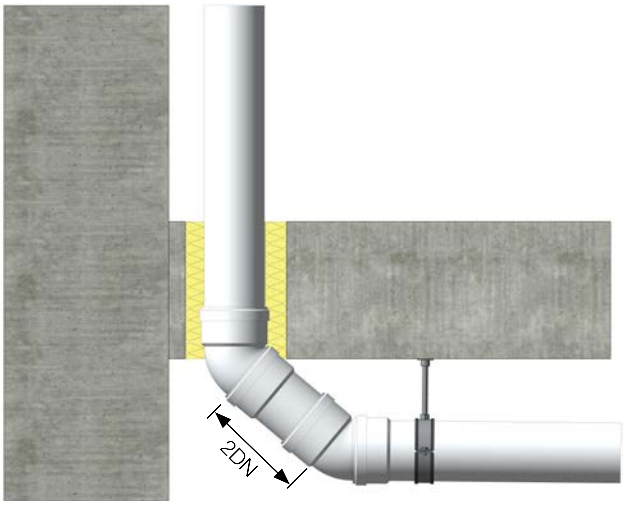
- The connection of the branches must be made with 87.5° branches (or 88.5° depending on the type of waste system) because, compared to the 45° branches, they ensure a slower flow into the waste stack and lower levels of noise (for more details, see chapter 3.5.3).

Figure 2.27 Connection to waste stack.



- The foot of the stack must also be studied in order to reduce the impact caused by deviation of the flow that proceeds from the waste stack to the horizontal collector pipe. The use of two 45° bends separated by a piece of pipe whose length is equal to twice the nominal diameter of the stack ensures the lowest level of pressure and noise (for more detail see chapter 3.5.4).

Figure 2.28 Configuration of the foot of the stack.



2.9.4 Impact of system geometry on noise levels

To estimate the noise of a system from a design point of view it is necessary not only to consider the airborne noise but also to consider the structure borne noise, the latter being decidedly complex in that it is influenced by the type of building envelope, the quality of the anchors and the installation geometry.
The simplistic analysis of some technical documents, which can also be found on the Internet, can lead to unrealistic results; an analysis that considers only the effect of the technical shaft (if present) and the dampening effect of the wall, leads to results that are decidedly lower than those obtained in practise, that also consider the influence of the structure: **the level of structure borne noise is usually greater than the level of airborne noise and therefore it cannot be disregarded**. A complete evaluation should also be carried out on the analyses at the various frequencies and not on the sound level measured.

The values indicated in this chapter, if not otherwise specified, have been obtained from measurements of airborne noise (normalised noise level $L_{a,A}$) made in front of the waste pipe and their sole scope is to give an idea of the impact of the waste system geometry on the level of noise generated. For a complete analysis (that also takes the noise transmitted by the building into account) measurements must be made on-site as established by D.P.C.M. 5/12/1997.

Phonometric measurements that are carried out in the laboratory (in compliance with the standards DIN 4109 and EN 14366 in force) employ a continuous flow of water with values of 0.5 l/s, 1 l/s, 2 l/s and 4 l/s; in practise, however, the maximum level of noise reached is generated by toilet flushing. In this case, we have a discontinuous flow caused by the actuation of a flush tank that discharges a predefined volume of water.

It was found that the level of noise caused by the use of a WC flush cistern, regardless of the volume of water discharged (from 4.5 l to 9 l) is the same as the noise produced by a continuous flow of water of 3 l/s. For this reason the values that follow relate to such a flow that is defined as reference flow.

All the values that follow, that can be taken into consideration for all the Valsir waste and soil systems, are provided only as a guideline.

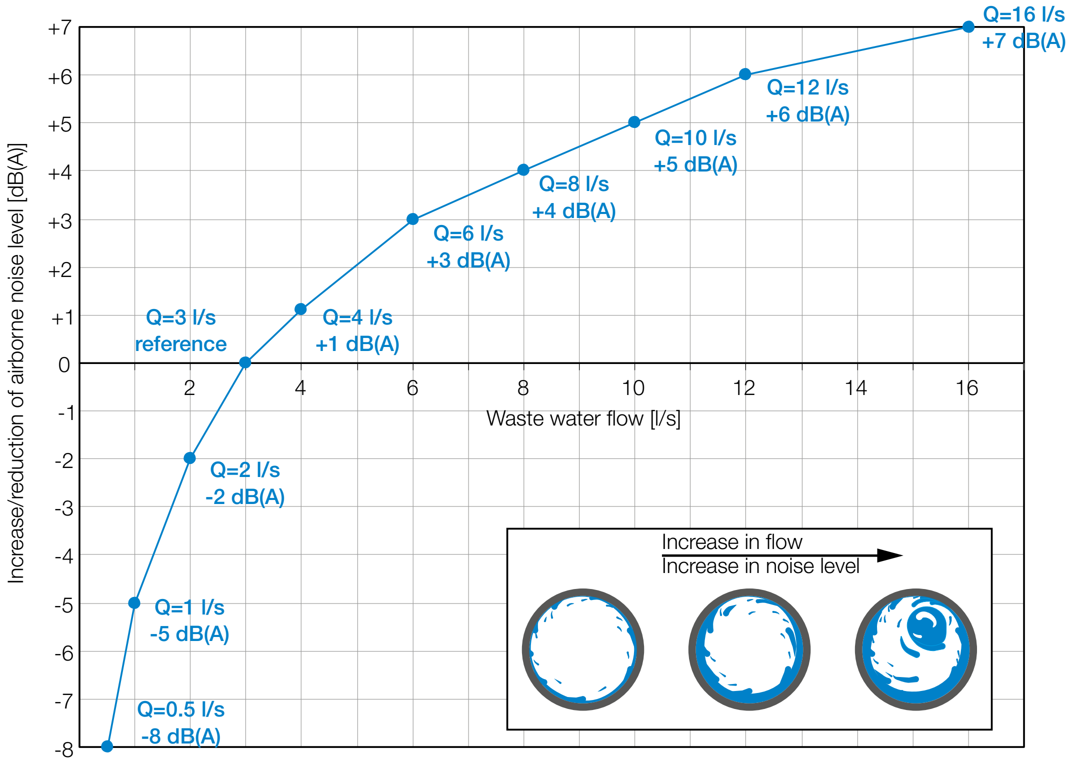
2.9.4.1 Localization of noise

The most elevated level of noise in a waste system can be measured at the foot of the waste stack. For this reason the stack foot must be created by following the suggestions given previously. In any event, the waste stack emits a noise level of about 5 dB lower than the noise emitted at the foot of the stack, whereas the collector pipe emits a noise level of about 10 dB lower than the foot of the stack.

2.9.4.2 Flow of waste water

The influence of the waste flow is such that when it is doubled, noise levels increase by approximately 3 dB(A). The values shown in the figure relate to a OD 110 mm vertical waste stack and represent the increase or the reduction in the level of noise regarding a reference flow rate of 3 l/s.

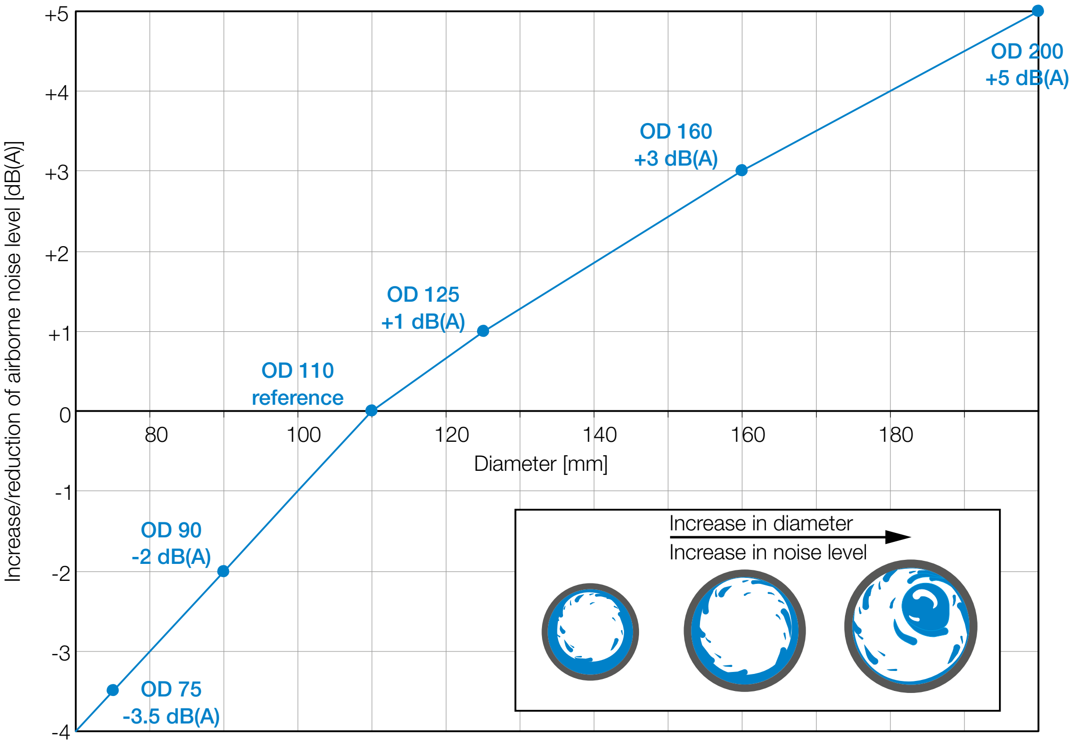
Figure 2.29 Influence of the waste flow on the level of airborne noise, measurements conducted with OD 110 mm vertical waste stack.



2.9.4.3 Vertical stack diameter

The diameter of the vertical waste stack plays a rather important role as well; with the increase of the pipe diameter, the radiating surface increases too and so does the noise level. The values shown in the figure refer to a flow rate of 3 l/s and represent the increase or the reduction in the level of noise for a reference stack of diameter 110 mm. An increase in size of the vertical waste stack from 110 mm to 125 mm can lead to an increase in the level of airborne noise of 1 dB(A).

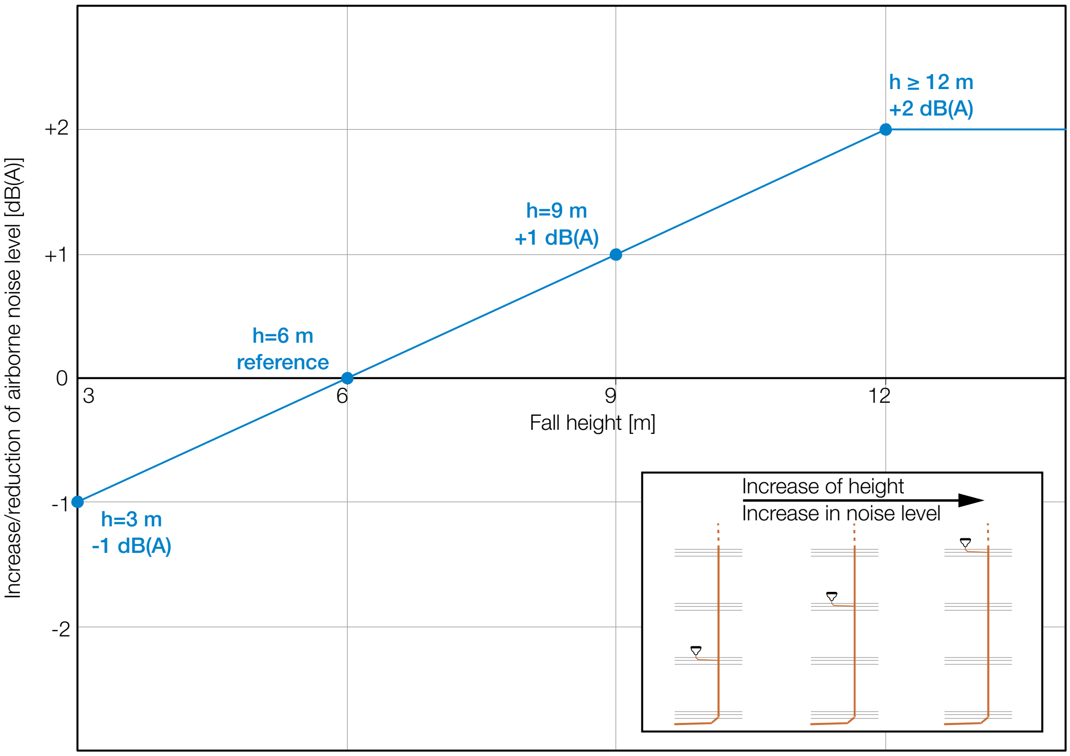
Figure 2.30 Influence of the stack diameter on the level of airborne noise, measurements with a flow rate of 3 l/s.



2.9.4.4 Fall height

The fall height, measured as the distance between the connection point of the branch pipe and the foot of the stack, has an influence such as to increase the level of airborne noise by 3 dB(A) going from 3 m to 12 m. Beyond 12 m the flow reaches a constant velocity and therefore sound emissions do not increase any further.

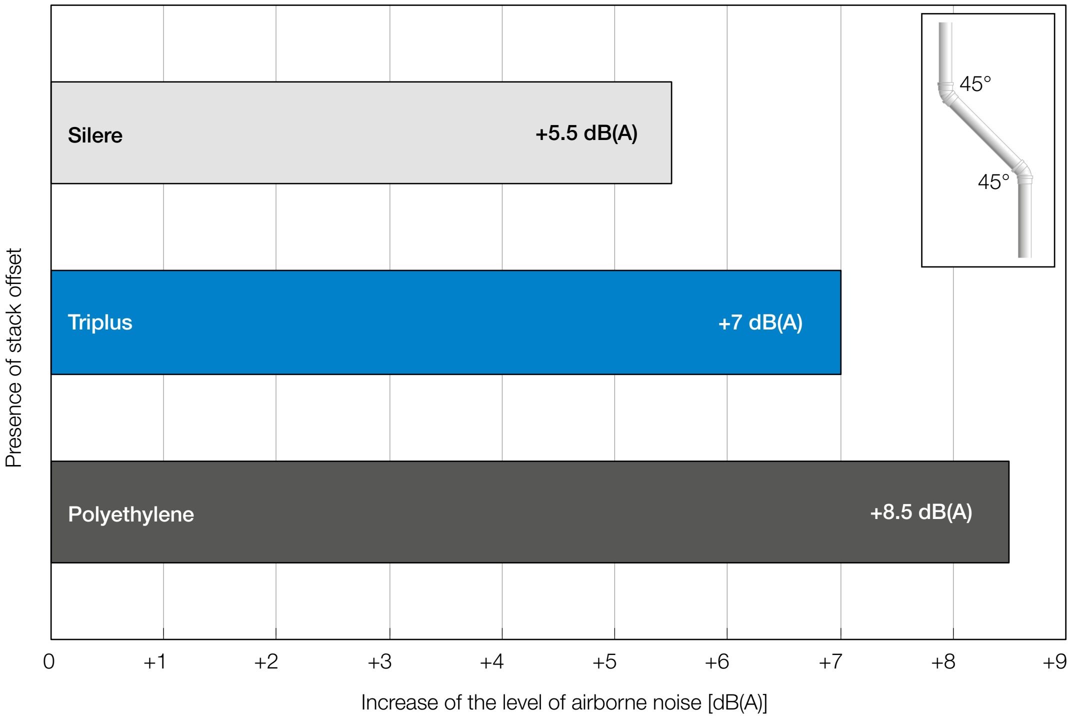
Figure 2.31 Influence of the fall height on the level of airborne noise.



2.9.4.5 Stack offset

The creation of a stack offset composed of two 45° bends on the same measurement floor leads to an increase in airborne noise of 8.5 dB(A) in a polyethylene waste system and 5.5 dB(A) in the Silere® waste system.

Figure 2.32 Influence of the stack offset on the level of airborne noise.

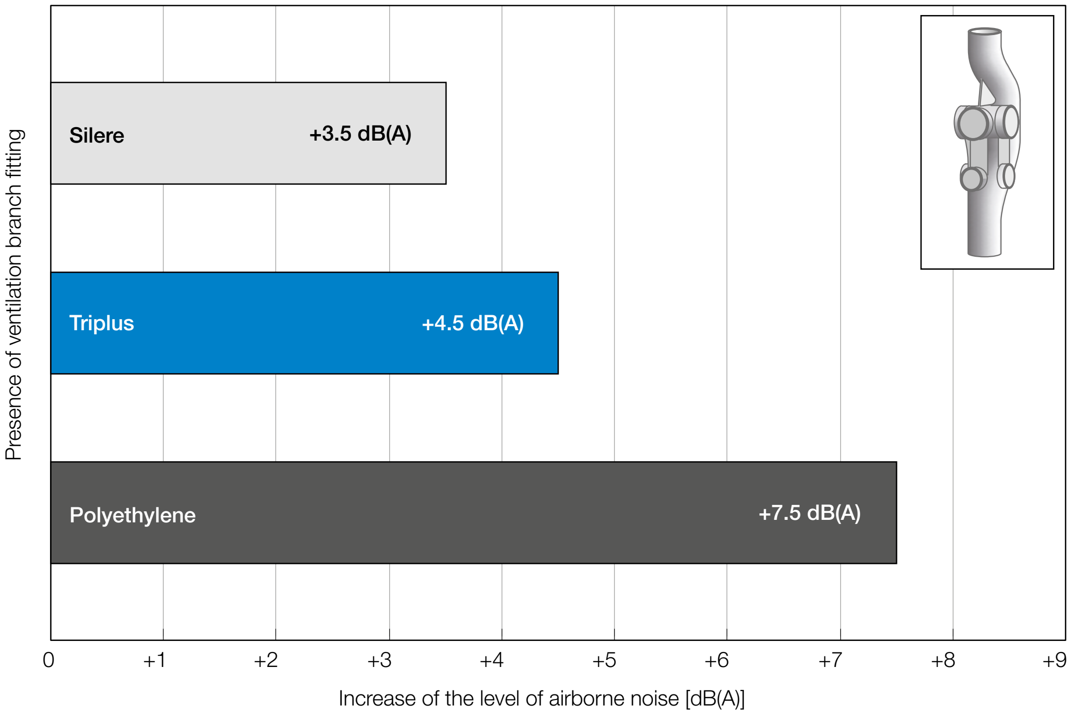


2.9.4.6 System with ventilation branch fittings

From an acoustic point of view, a ventilation branch fitting is similar to a stack offset, therefore it represents a critical point in a waste system. Valsir was the first to develop the technology to produce ventilation branch fittings in materials that are characteristic of the Silere® and the Triplus® waste systems and the results were of immediate interest.

In fact, waste systems that incorporate Triplus® and Silere® ventilation branch fittings reduce airborne noise levels by 3 and 4 dB(A) compared to waste systems that incorporate polyethylene ventilation branch fittings. These solutions enable the creation of waste systems with ventilation branch fittings that, in many cases, compared to polyethylene waste systems, do not require lagging with soundproofing materials.

Figure 2.33 Influence of the ventilation branch fitting on the level of airborne noise.



2.9.4.7 Bracketing of the vertical waste stack

The transmission of structure borne noise produced by a waste system depends on numerous factors among which the type of pipework, the characteristics of the wall onto which the pipe is secured and the bracketing system employed.

The fewer the number of brackets employed to anchor the pipe, the lower the transmission of structure borne noise. From the laboratory tests, it was revealed that, regardless of the type of waste system used (HDPE, PP/PP3®, Blackfire®, Triplus®, Silere®), going from two clips per floor to one clip per floor, the level of noise is reduced by approximately 2÷3 dB(A).
Nonetheless, brackets with anti-vibration rubber inserts must be used to reduce vibrations transmitted from the pipe to the wall.

WASTE SYSTEMS

SUPPLY SYSTEMS

GAS SYSTEMS

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VALSIR S.p.A. - Società a Socio Unico
Località Merlaro, 2
25078 Vestone (BS) - Italy
Tel. +39 0365 877.011
Fax +39 0365 81.268
e-mail: valsir@valsir.it
www.valsir.it
Soggetta all'attività di direzione e coordinamento ex art. 2497 bis C.C.
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