Fraunhofer Institut Bauphysik

Bauaufsichtlich anerkannte Stelle
für Prüfung, Überwachung und
Zertifizierung
Zulassung neuer Baustoffe, Bauteile
und Bauarten
Forschung, Entwicklung,
Demonstration und Beratung auf
den Gebieten der Bauphysik

Institutsleitung
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Test report P-BA 275/2008e

Noise Behaviour of Pipe and Fitting Insulating Coverings for Plastic Wastewater Pipe Systems

Client: ARMACELL UK Ltd.
Mars Street
Oldham, Lancashire
OL9 6LY

Test specimen: Wastewater structure-borne sound insulation system "Tubolit AR Fonowave" (manufacturer: ARMACELL) in combination with a wastewater system consisting of plastic pipes (HT, DN 100/OD 110).

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The tests were performed in a laboratory accredited by the German Accreditation System for Testing (DAP, file no. PL-3743.26) according to standard EN ISO/IEC 17025.

Stuttgart, 13 January 2009

Responsible Test Engineer: Head of Laboratory:

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Determination of the installation sound level L_{In} in the laboratory

P-BA 275/2008e

Table 1

Client: ARMACELL UK Ltd., Mars Street, Oldham, Lancashire, OL9 6LY

Test specimen: Wastewater structure-borne sound insulation system "Tubolit AR Fonowave", manufactured by ARMACELL (test specimen S 10062-01) in combination with a wastewater system consisting of plastic pipes (HT, DN 100/OD 110).

Test set-up: The test set-up included the following components:

- Commercial waste water system (one-layer pipe with attached sleeve (HT), material: Polypropylene (PP), wall thickness 2.7 mm, weight 0.92 kg/m, density 0.95 g/cm³) consisting of wastewater pipes (nominal size OD 110), three inlet tees, one 88°-basement bend and a horizontal drain section. The inlet tees in the basement and in the ground floor were closed by lids (see figure 6).
- Wastewater structure-borne sound insulation system "Tubolit AR Fonowave" (manufacturer ARMACELL) made of half-hard expanded Polyethylene with closed-cell structure (thickness 9 mm). Insulating tubes for straight pipes and yard-ware to insulate the fittings.
- Installation without pipe clamps or other fastening parts.

The waste water system was installed in a brick duct in front of the installation wall (vertically perforated brick, L x W x H = 240 mm x 115 mm x 238 mm). The pipe was covered by a mesh of expanded metal and an additional layer of 25 mm of gypsum plaster. The duct was only installed in the basement of the test facility.

- Reference Set-up: Rigid installation of the waste water pipe system without structure-borne sound insulation system.
- Test Set-up: Installation of the waste water pipe system in the duct with wastewater structure-borne sound insulation system "Tubolit AR Fonowave" (manufacturer ARMACELL).

Test set-up according to figure 6 and 7.

Test facility: Installation test facility P12, mass per unit area of the installation wall: 220 kg/m², installation room: basement (UG) front; measuring room: UG rear (details in Annex P)

Test method: The measurements were performed in accordance with the standards DIN 52 219: 1993, DIN 4109: 1989 and EN 14366: 2005; noise excitation by stationary water flow with 0.5 l/s, 1.0 l/s, 2.0 l/s and 4.0 l/s (details in Annex H).

Results:

Installation sound level L_{In} [dB(A)]				
Wastewater system (Plastic pipes, HT, without pipe clamps) plastered in the installation duct	Flow rate (l/s)			
	0,5	1,0	2,0	4,0
Wastewater structure-borne sound insulation system "Tubolit AR Fonowave", manufactured by ARMACELL (test specimen S 10062-01)	17	22	25	31
without structure-borne sound insulation system	28	31	34	38

FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG e.V. 1 — Fraunhofer Institut Bauphysik — amtlich anerkannte Prüfstelle

Date of tests: 22 September 2008

Comments:

- Measurements were carried out without applying pipe clamps or other fastening elements in order to exclusively determine the sound-insulating properties of the insulation material without additional structure-borne sound via pipe anchorage. Therefore the measured values are the lower limit for the installation sound level, which can be expected with the existence of similar types of structure sound bridges, when applying the analysed waste water structure-borne insulation system.

Fraunhofer Institut Bauphysik

The tests were performed in a laboratory accredited by the German Accreditation System for Testing (DAP, file no. PL-3743.26) according to standard EN ISO/IEC 17025.

Stuttgart, 14 January 2009

Head of Laboratory:

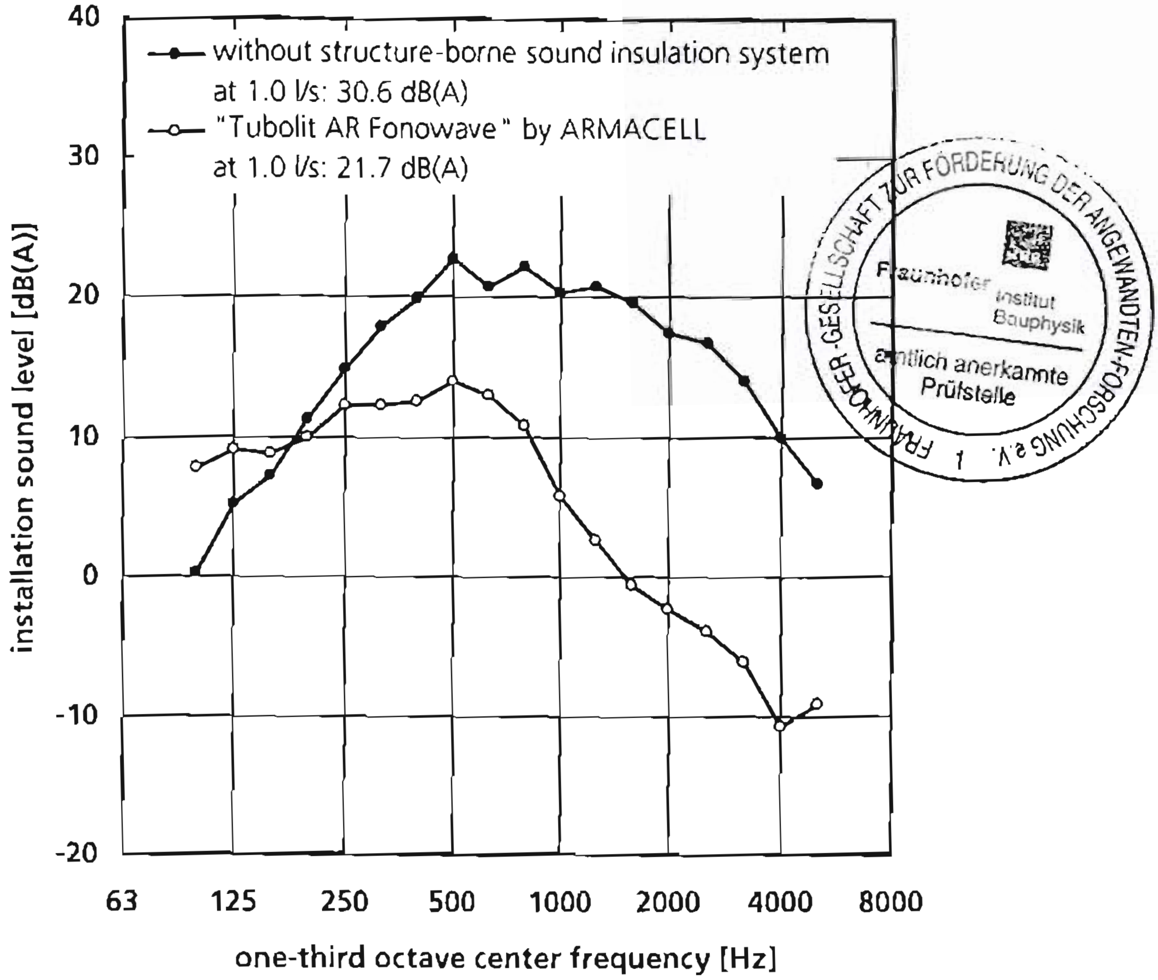

Figure 2 Installation-sound level L_{in} of a waste water pipe system mounted with the structure-borne sound insulation system "Tubolit AR Fonowave", manufactured by ARMACELL (test specimen S 10062-01), as a function of the frequency (referring to excitation by a flow rate of 1.0 l/s), measured in the room UG rear behind the installation wall. The pipe insulation system was mounted to a waste water system (HT; PP). The same waste water pipe system without structure-borne sound insulation system (bare pipe) has been used as Reference set-up.

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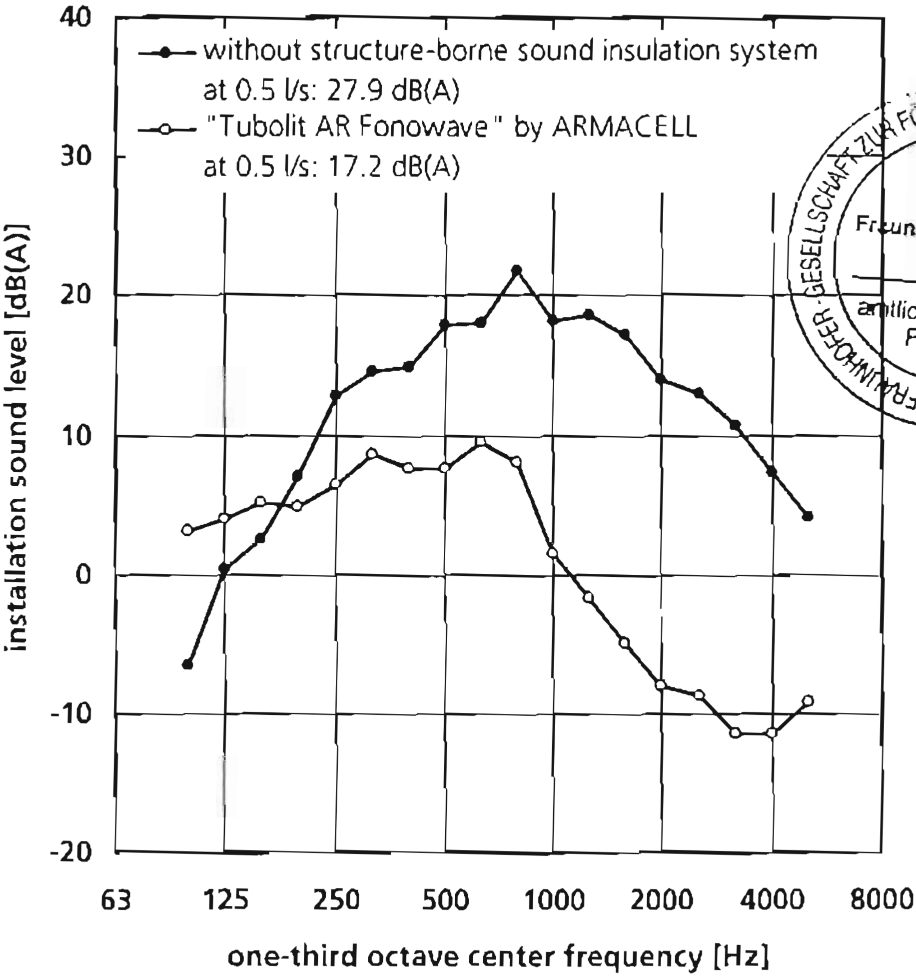

Figure 1 Installation-sound level L_{In} of a waste water pipe system mounted with the structure-borne sound insulation system "Tubolit AR Fonowave", manufactured by ARMACELL (test specimen S 10062-01), as a function of the frequency (referring to excitation by a flow rate of 0.5 l/s), measured in the room UG rear behind the installation wall. The pipe insulation system was mounted to a waste water system (HT; PP). The same waste water pipe system without structure-borne sound insulation system (bare pipe) has been used as Reference set-up.

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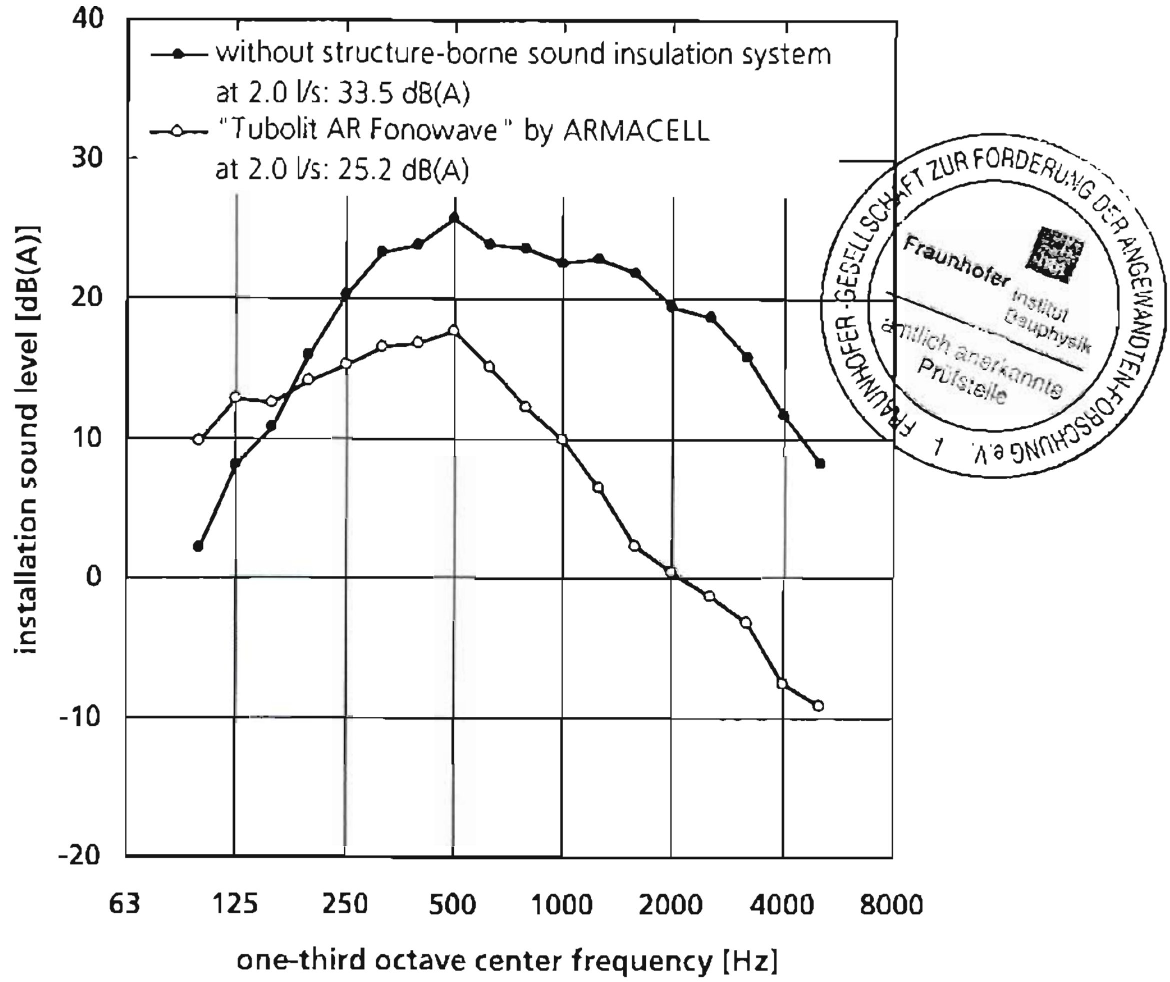

Figure 3 Installation-sound level L_{In} of a waste water pipe system mounted with the structure-borne sound insulation system "Tubolit AR Fonowave", manufactured by ARMACELL (test specimen S 10062-01), as a function of the frequency (referring to excitation by a flow rate of 2.0 l/s), measured in the room UG rear behind the installation wall. The pipe insulation system was mounted to a waste water system (HT; PP). The same waste water pipe system without structure-borne sound insulation system (bare pipe) has been used as Reference set-up.

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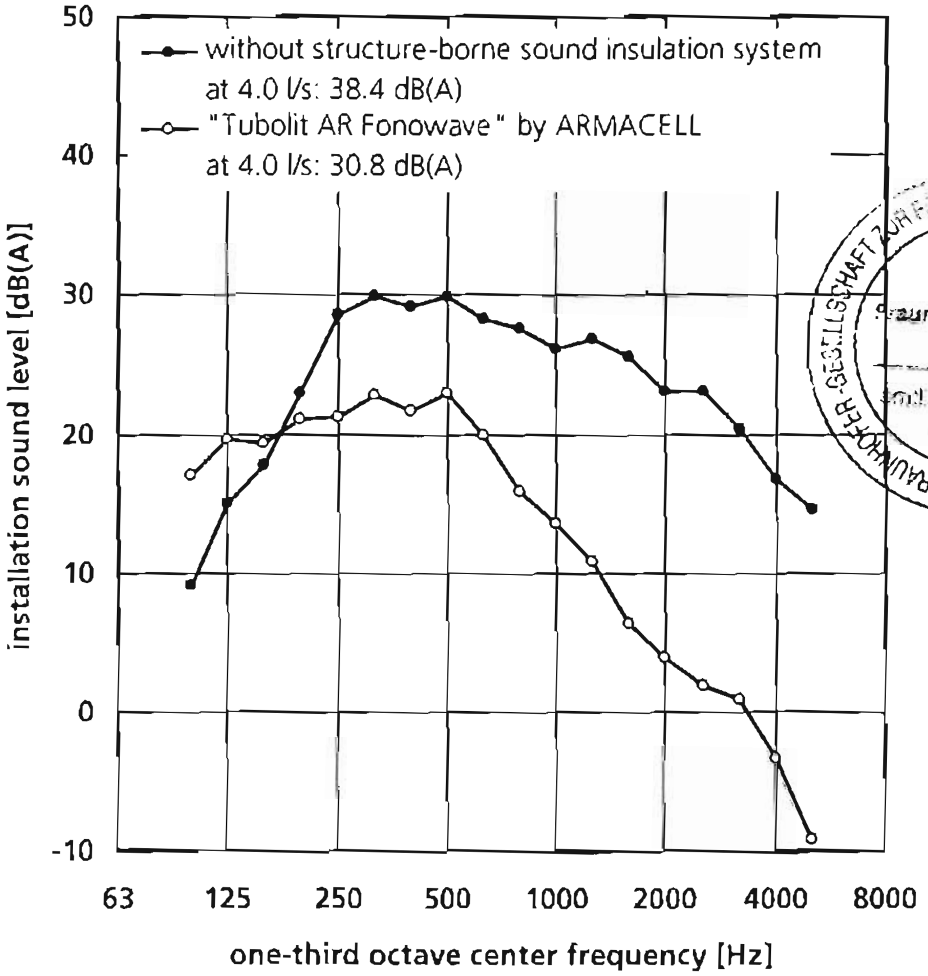

Figure 4 Installation-sound level L_{In} of a waste water pipe system mounted with the structure-borne sound insulation system "Tubolit AR Fonowave", manufactured by ARMACELL (test specimen S 10062-01), as a function of the frequency (referring to excitation by a flow rate of 4.0 l/s), measured in the room UG rear behind the installation wall. The pipe insulation system was mounted to a waste water system (HT; PP). The same waste water pipe system without structure-borne sound insulation system (bare pipe) has been used as Reference set-up.

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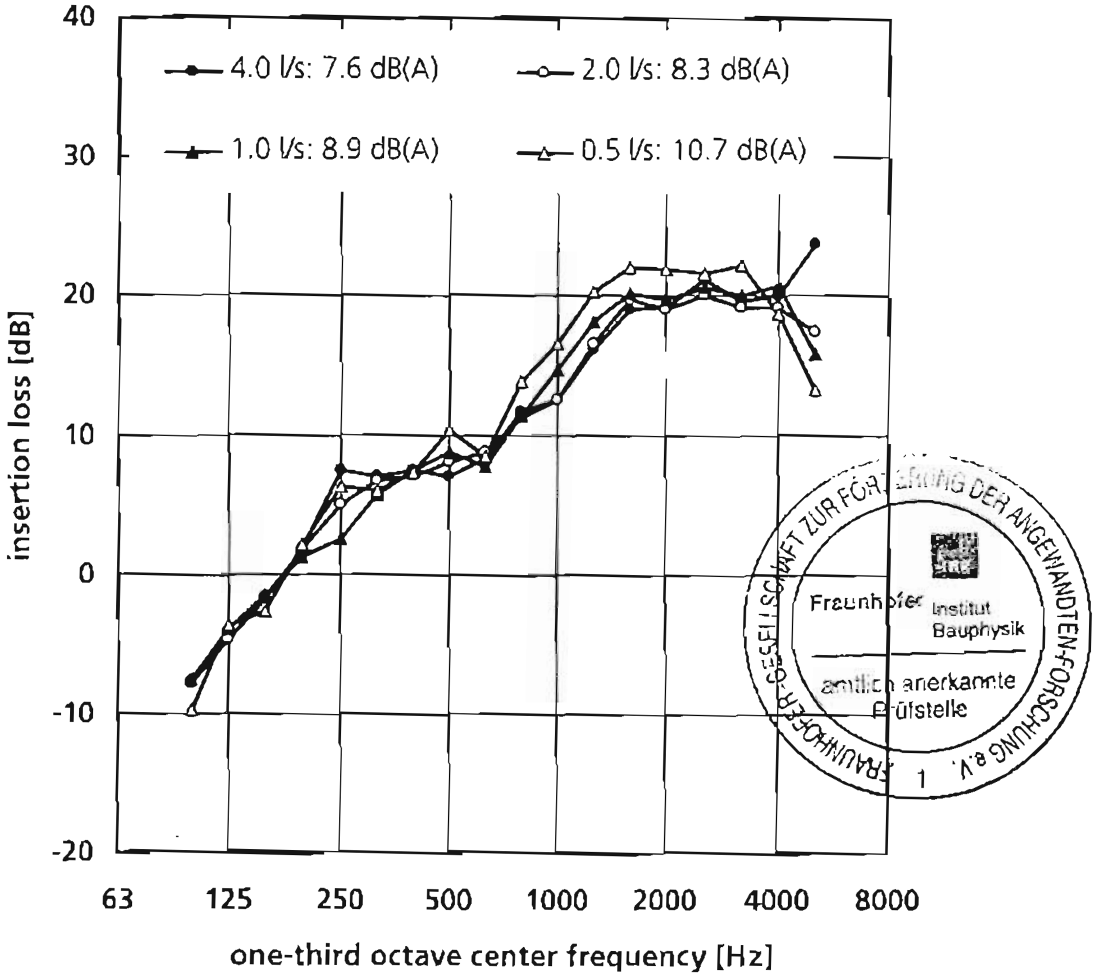


Figure 5 Insertion loss of the structure-borne sound insulation system "Tubolit AR Fonowave", manufactured by ARMACELL (test specimen S 10062-01), as a function of the frequency and A-weighted reduction of sound level (referring to excitation by various flow rates: 0.5 l/s, 1.0 l/s, 2.0 l/s and 4.0 l/s), measured in the room UG rear behind the installation wall. The pipe insulation system was mounted to a waste water system (HT; PP). The same waste water pipe system without structure-borne sound insulation system (bare pipe) has been used as Reference set-up.

The tests were performed in a laboratory accredited by the German Accreditation System for Testing (DAP, file no. PL-3743.26) according to standard EN ISO/IEC 17025.

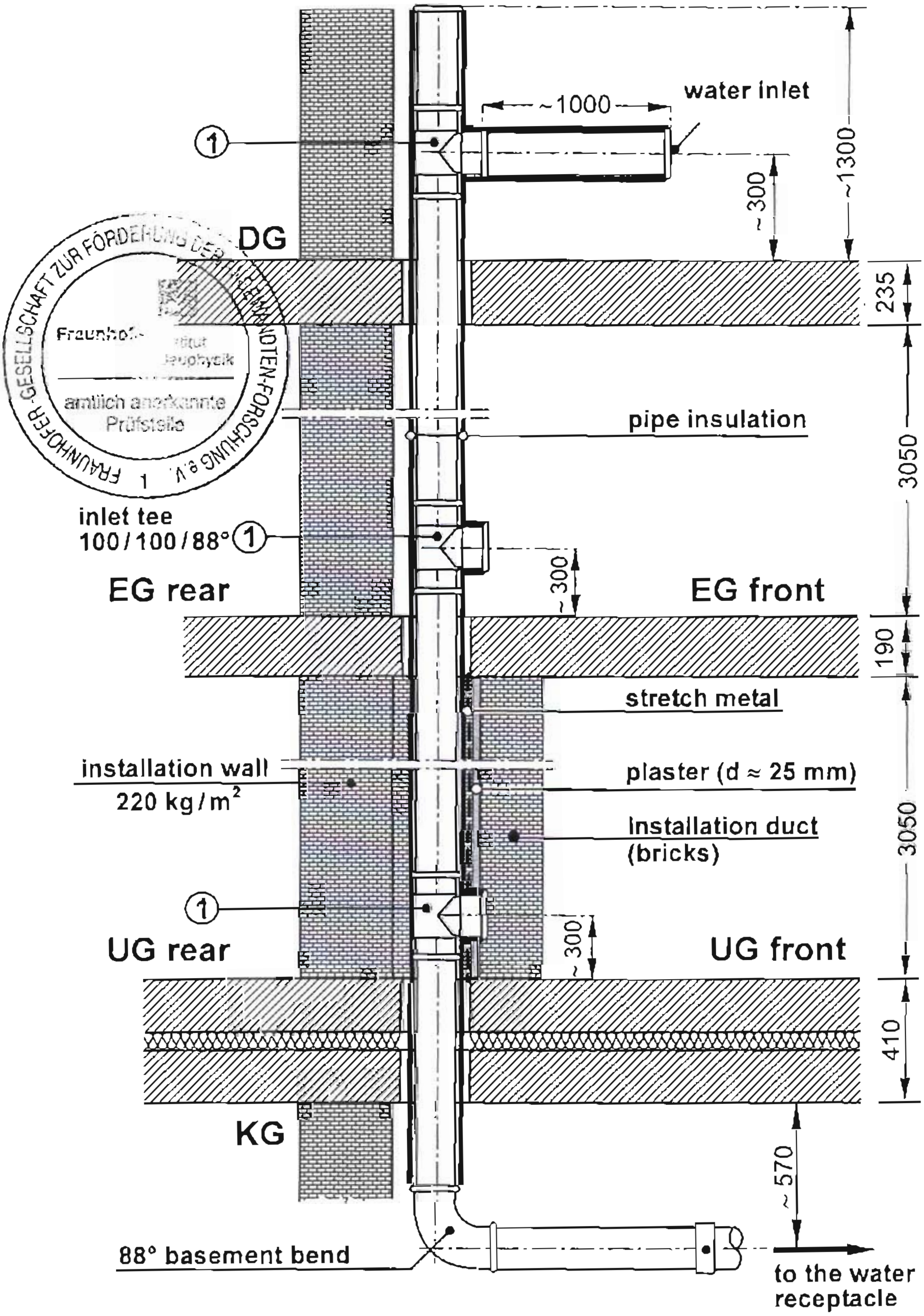


Figure 6 Installation plan of the pipe system (plastic pipes, HT, without pipe clamps) with the structure-borne sound insulation system "Tubolit AR Fonowave", manufactured by ARMACELL (drawing not to scale, dimensions in mm).

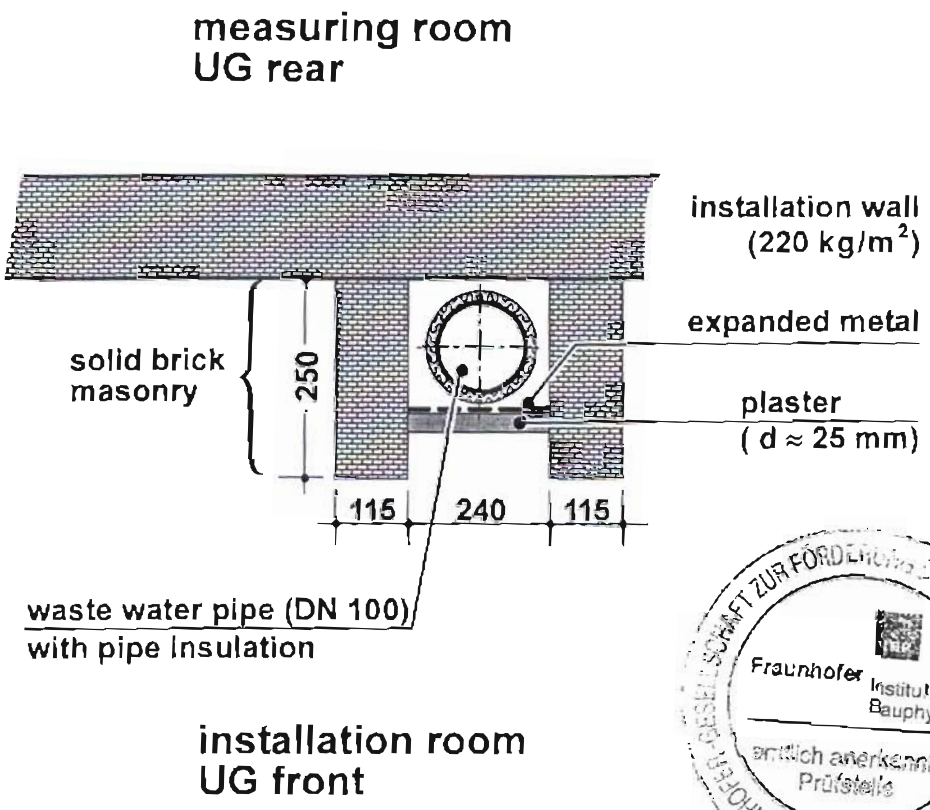


Figure 7 Sectional drawing of the test set-up (horizontal section of the installation duct in the UG front of the installation test facility, drawing not to scale, dimensions in mm).

Realization of measurement

The insertion loss D_e describes the reduction of the installation sound level of waste water pipes by means of structure-borne sound insulating tubes or elastic mounting elements (e.g. pipe clamps) compared to a rigid attachment of the pipe to the wall. The measurements are performed according to DIN EN 14366 and the German standards DIN 52 219 and DIN 4109, in which in situ measurements of the noise behavior of waste water installations are described. The execution of the measurements take place in two steps:

1. Measurement of the installation sound level of a reference set-up with a rigid attachement of the pipe to the installation wall.
2. Measurement of the installation sound level of the same pipe supplied with the structure-borne sound insulating tube or the elastic mounting element under test.

Noise excitation and evaluation parameters
Any defined and metrological reproducible noise excitation requires steady state flow conditions inside the waste-water pipes. As the noise generation in waste water systems depends on the flow rate, noise measurements are usually performed at several flow rates Q which are typically encountered in practice:

(1) Q = 0.5 l/s, corresponding to Q = 30 l/min,
(2) Q = 1.0 l/s, corresponding to Q = 60 l/min,
(3) Q = 2.0 l/s, corresponding to Q = 120 l/min,
(4) Q = 4.0 l/s, corresponding to Q = 240 l/min.

Here, a flow rate of Q = 2.0 l/s roughly corresponds to the average flow rate required for flushing a toilet. According to Prandtl-Colebrook, the highest flow rate used results from the admissible hydraulic charge of the horizontal pipe sections, which is Q_{max} = 4 l/s for OD 110 pipes.

The measurements take place in the room behind the installation wall (UG rear). The water flow generates vibrations of the wastewater pipe. These vibrations are transmitted to the installation wall through pipe clamps and/or other structure-borne sound bridges (e.g. fire protection sleeves), and then radiated by the wall (and to a lesser extent, also by the adjoining building parts) as airborne sound into the test room behind the installation wall. Differing from German standard DIN 52 219 - the sound pressure level is recorded- not only at one measuring point but at six points differing in the receiving room. In this way an averaging in space and time is reached, causing an improvement of exactness and reproducibility of the measuring results to take account to the raised requirements for laboratory measurements. Thereby the rounded $L_{AF,10}$ is equivalent to the installation sound level L_{In} according to DIN 52219 and DIN 4109.

Measurement set-up
In the water-installation test-facility run by the Fraunhofer Institute of Building Physics, a down pipe is installed leading from the top floor (DG) down to the sub-basement (KG) (for further details, please see Annex P). This down pipe is connected to a (OD 110) water inlet pipe on the top-floor level. The water is introduced through an S-shaped bend according to the standard EN 14366. In the sub-basement, the down pipe is connected to a bend (2 x 45°, or 1 x 88°, usually) and merges into a

horizontal discharge section, which in turn is joined to a water receptacle. The waste-water pipe on the ground floor (EG) and in the basement (UG) is fitted with conventional branches from main lines (usually, OD 110). Pipes and fittings are mounted according to the instructions given by the manufacturer. The air gaps between the tube and floor in the entrance and exit openings are stuffed with porous absorber in order to prevent any structure-borne sound bridges influencing the building. The waste-water piping is fastened to the installation wall (mass per unit surface m'' = 220 kg/m²) by means of pipe clamps supplied by the Client, which are adapted to the external diameter of the pipes. The locations of the fixation points and further dimensions are specified in the installation plan that is included in the test report.

Reference set-up

To determin the insertion loss of the samples a waste water pipe is attached to the installation wall (mass per unit area m" = 220 kg/m²) of the installation test facility (as mentioned above). The test facility is shown schematically in annex P. The pipe is attached to the wall by means of pipe clamps without profile rubber lining, adjusted to the outside diameter of the pipe,that are closed completely. The reference set-up resembles in all details (except for the pipe clamps) the measurement set-up with the object under test.

Measurement set-up with test object

The measurement set-up with test object is almost identical with the reference set-up. The only difference is, that the rigid clamps are replaced by the elastic ones under test. In case of structure-borne sound insulating tubes the pipe is completely encased in the insulating material. The rigid clamps are exchanged by clamps, which are adjusted to the outside diameter of the insulating tube and usually have no profile rubber lining.

Evaluation of measuring data and determination of acoustic parameters

The measured sound pressure level is given as a time and space averaged one-third octave spectrum in the frequency range between 100 Hz and 5 kHz. First, the value is corrected for background noise. Subsequently, the measurement signal is normalized to an equivalent sound absorption area $A_0 = 10\ m^2$ and A-weighted:

(1) $$L_{n,AF,10} = 10 \cdot \lg\left(10^{\frac{L_{n,F}}{10}} - 10^{\frac{L_{n,S}}{10}}\right) + 10 \cdot \lg\frac{A_n}{A_0} + k(A)_n$$ [dB(A)]

$L_{n,F}$	space and time averaged sound pressure level in one-third octave band n (time constant: Fast)	[dB]
$L_{n,S}$	background noise level in one-third octave band n	[dB]
$A_n = \frac{0.16 \cdot V}{T_n}$	sound absorption area of test room for one-third octave band n	[m²]
V	volume of test room	[m³]
T_n	reverberation time of test room in one-third octave band n	[s]
$k(A)_n$	A-weighting for one-third octave band n	[dB]

If the difference between the two levels (i.e. the measured one-third octave level and the background noise level) is less than 3 dB, the correction for background noise will not be performed. Instead, the measured background noise level will be used (as an estimated maximum level). The total sound pressure level is obtained by energetically adding the one-third octave values.

$$L_{AF,10} = 10 \cdot lg\left(\sum_{n=1}^{18} 10^{\frac{L_{n,AF,10}}{10}}\right), \quad (2) \quad [dB(A)]$$

where n indicates the number of one-third octave bands from 100 Hz through 5 kHz. The calculated level $L_{AF,10}$ corresponds to the sound pressure level resultant in a sparsely furnished reception room under otherwise equal conditions.

The acoustic influence of the structure-borne sound insulating tube or the elastic mounting element under test is described by the frequency-dependent insertion loss D_e. The one-third octave values of the insertion loss $D_{n,e}$ are the difference between the one-third octave levels $L_{n,AF,10,0}$, measured with rigid pipe clamps, and the levels $L_{n,AF,10,1}$, measured with the insulating tube or the elastic mounting element under test

$$D_{n,e} = L_{n,AF,10,0} - L_{n,AF,10,1} \quad (3) \quad [dB]$$

Additionally the reduction of the A-weighted sound level ΔL_{AF} by the test object is determined. For this purpose the A-weighted total sound pressure levels are subtracted from each other instead of the one-third octave levels.

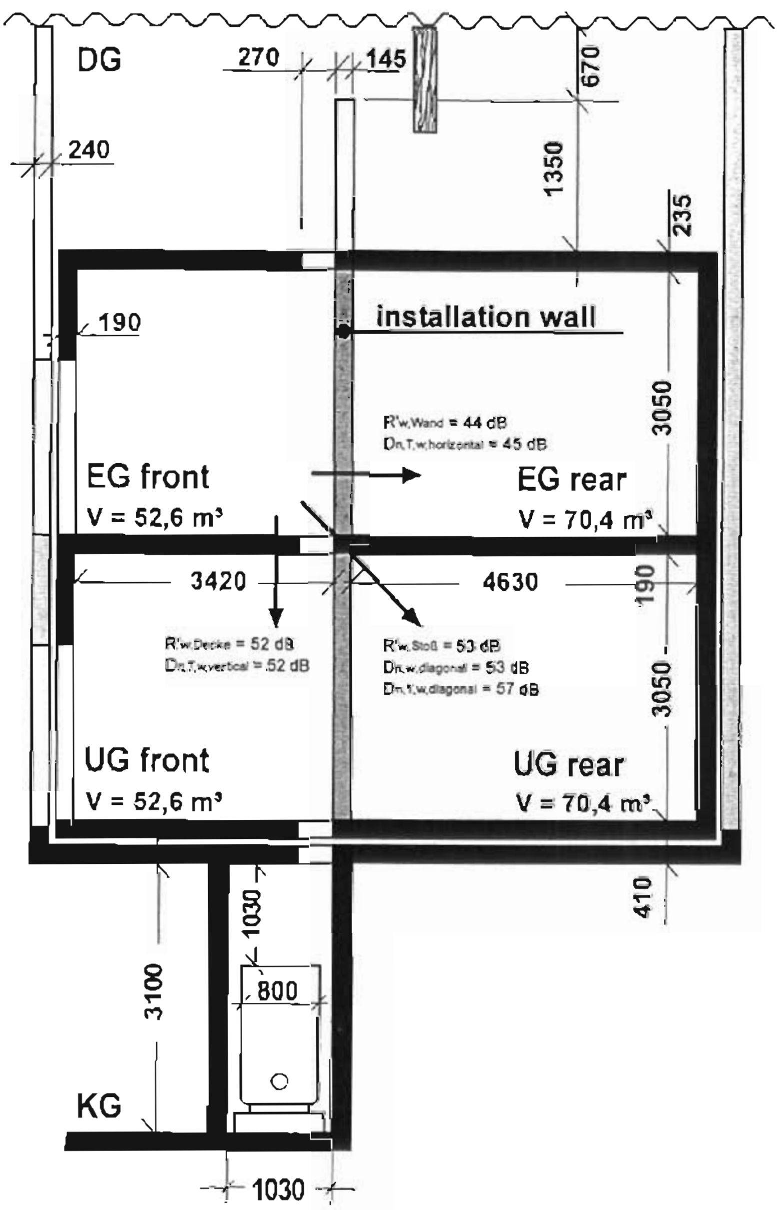
$$\Delta L_{AF} = L_{AF,10,0} - L_{AF,10,1} \quad (4) \quad [dB]$$

The reduction of the A-weighted sound level represents a measure for the decrease of noise felt by human ear using structure-borne sound insulating tubes or elastic mounting elements. It refers exclusively to the noise spectrum while excitating the pipe system by a stationary water flow (as used at the measurements) and can't be transferred directly to other types of noise sources.

Scope of the measurements

Transferability of the results to other building situations

Concerning the practical application of the measuring results it has to be noted that the reduction of the A-weighted sound level achieved in situ can deviate from the value indicated in the test report, if waste water systems are used, whose shape or nominal diameter differs substantially from the system under test. The same applies to waste water systems with different materials (cast iron, steel, or plastic). Different variations of installation, as for example the mounting under plaster, the mounting with other elastic mounting elements, etc., likewise influence the insertion loss. Moreover it has to be considered, that the attainable noise reduction in practice can be decreased by structure-borne sound bridges between the tap or the pipe and the building. In the values given here these side paths are not considered.



Sectional drawing of the installation test facility in the Fraunhofer-Institute of Building Physics (dimensions given in mm). The test facility comprises two couples of rooms in the ground floor (EG) and in the basement (UG) that are located above each other. Due to this construction, including the top floor (DG) and the sub-basement (KG), it is possible to perform tests on installation systems which extend across several floors, e.g. waste-water installation systems. The installation walls in the ground floor and in the basement can be substituted according to actual requirements. In the standard case, single-leaf solid walls with a mass per unit area of 220 kg/m² (according to German standard DIN 4109) are used. Since the sound insulation of these walls do not meet the requirements to be fulfilled by a wall separating different occupancies within the same building ($R'_w \geq 53$ dB), the next adjacent rooms to be protected from noise are located diagonally above or below the installation room (in case of a usual design of the ground plan). Due to its double-leaf construction with an additional structure-borne sound insulation, the installation test facility is particularly suited for measuring low sound pressure levels. The measuring rooms are designed in such a way that the reverberation times are between 1 s and 2 s within the examined frequency range. The flanking walls, with an average mass per unit area of approximately 440 kg/m², are made of concrete.