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

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Test report P-BA 219/2006e

Determination of the Acoustic Performance of a Wastewater Installation System in the Laboratory

Client: REDI S.p.a
Via Madonna dei Prati, 5/A
40069 ZOLA BREDOSA - BOLOGNA
ITALY

Test specimen: Wastewater installation system consisting of "REDI Phonoline" plastic pipes and fittings (manufacturer: REDI) mounted with pipe clamps "Bismat 1000" (manufacturer: Walraven).

Contents:

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, October 19, 2006

Responsible Test Engineer: Head of Laboratory:

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

P-BA 219/2006e

Table 1

Client: REDI S.p.a, Via Madonna dei Prati 5/A, 40069 ZOLA BREDOSA – BOLOGNA, ITALY

Test specimen: Wastewater installation system (test specimen S 9760-01) consisting of "REDI Phonoline 110x5.0" plastic pipes and fittings (manufacturer: REDI) mounted with pipe clamps "Bismat 1000" (manufacturer: Walraven).

Test set-up:
- The pipe system was mounted according to Figure 4 (see also Annex A).
- The system consisted of wastewater pipes (nominal size OD 101.6), three inlet tees, two 45°-basement bends and a horizontal drain section. The inlet tees in the basement and in the ground floor were closed by lids supplied by the manufacturer. The pipe system was mounted by a plumber enterprise.
- Pipe system "REDI Phonoline": size OD 110, one-layer pipe, material: PVC with mineral filler, wall thickness 5.0 mm, weight 2.9 kg/m, density 1.6 g/cm³. One-layer fittings, size OD 110, material: PVC with mineral filler, wall thickness 3.2 mm, density 1.4 g/cm³. Connection of the pipes by plug-on socket connection.
- Pipe clamps "Bismat 1000": structure born sound insulating support attachment consisting of supporting and fixing clips. Fixed to the installation wall with dowels and thread rods.

Test facility: Installation test facility P12, mass per unit area of the installation wall: 220 kg/m², installation rooms: sub-basement (KG), basement (UG) front, ground floor (EG) front and top floor (DG), measuring rooms: UG front, UG rear (details in Annex P and EN 14366: 2005-02)

Test method: The measurements were performed following EN 14366 and German standard DIN 52 219: 1993-07; noise excitation by constant water flow with 0.5 l/s, 1.0 l/s, 2.0 l/s and 4.0 l/s (details in Annexes A and F).

Results:

Waste water system "REDI Phonoline" with pipe clamps "Bismat 1000"				
Flow rate [l/s]	0,5	1,0	2,0	4,0
Installation sound level L_{In} [dB(A)] measured in the basement test-room UG front	45	48	51	54
Installation sound level L_{In} [dB(A)] measured in the basement test-room UG rear	8	11	15	19
Airborne sound pressure level $L_{a,A}$ [dB(A)] [1])	45	48	51	54
Structure-borne sound characteristic level $L_{sc,A}$ [dB(A)] [1])	3	7	12	16

[1]) Evaluation according to DIN EN 14366.

Date of tests: September 12, 2006

Comments:
- The requirements of DIN 4109 only apply for the installation sound level L_{In} measured in the test room UG rear.
- By using supporting and fixing clips the details of attachment strongly affects the acoustical properties of the system. Only if the assembly instructions of the manufacturer are obeyed exactly and the weight of the system is distributed evenly on all fastening elements, a reproducible acoustical behaviour is reached. Otherwise possibly strong deviations from the measured values may occur.

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, October 19, 2006

Head of Laboratory:

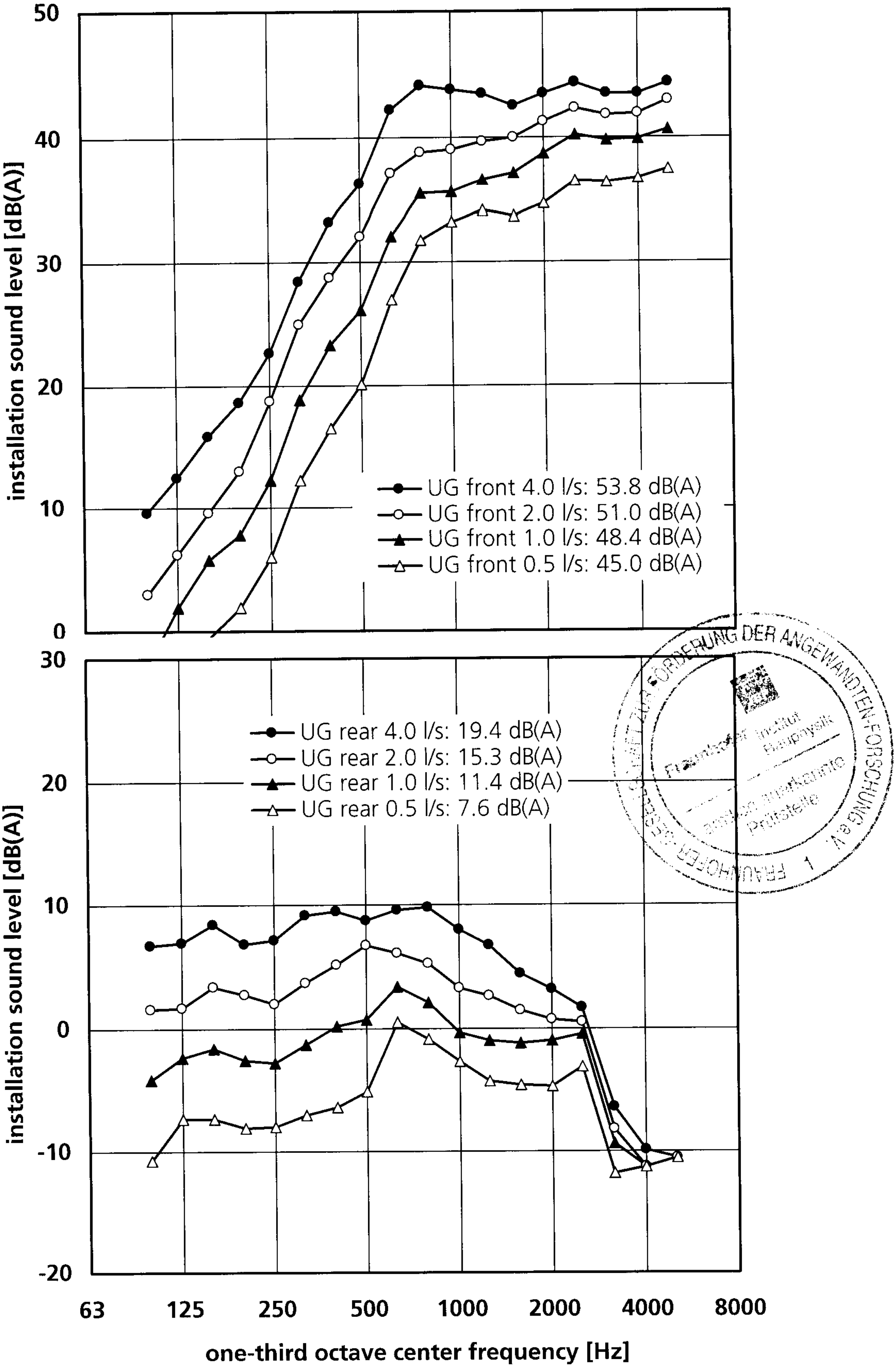


Figure 1 Wastewater pipe system "REDI Phonoline" mounted in sub-basement (KG), basement (UG front), ground floor (EG front) and top floor (DG) using pipe clamps "Bismat 1000". The Installation sound level L_{In} was measured at various flow rates in the test rooms UG front (above) and UG rear (below).

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.

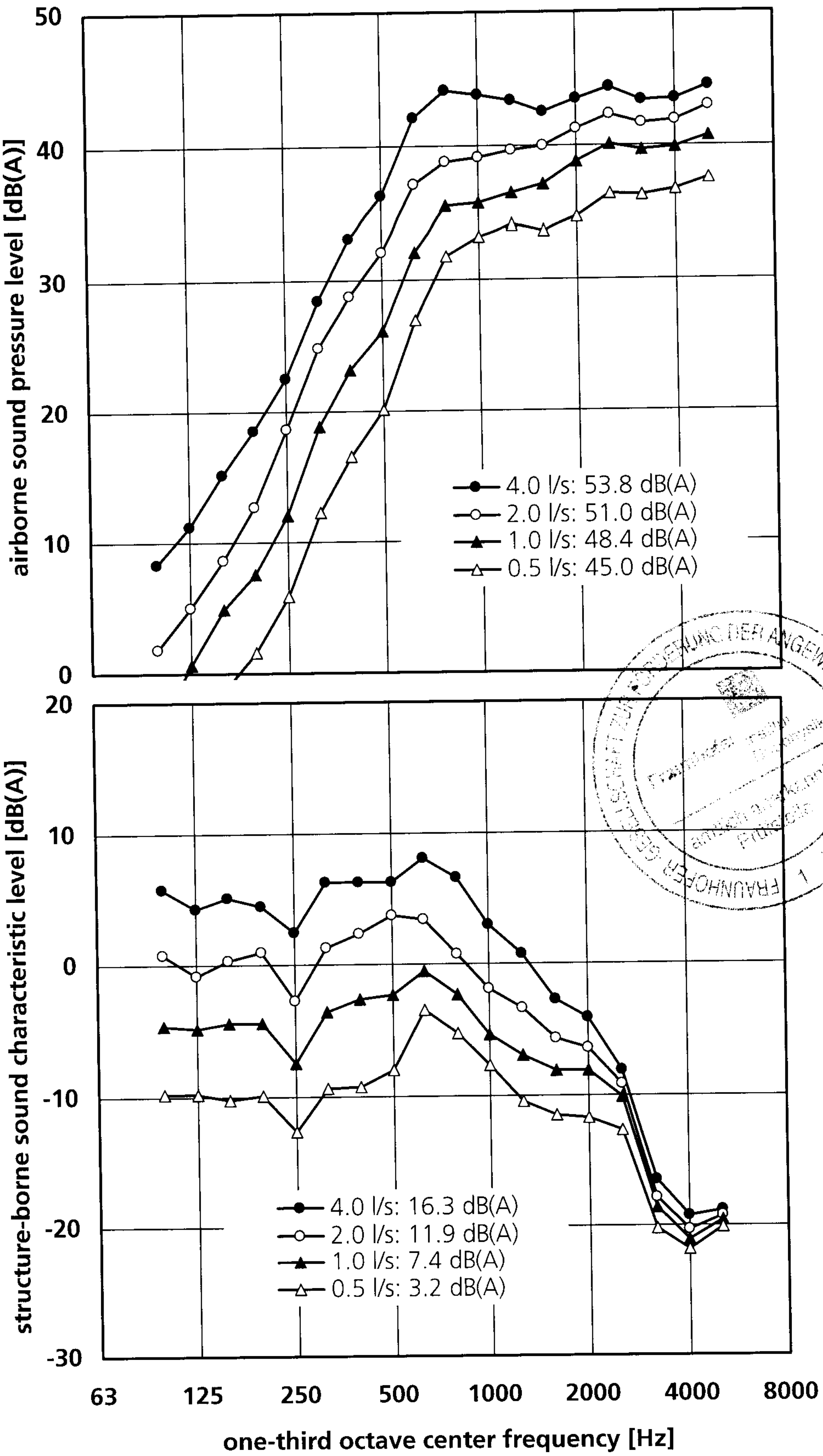


Figure 2 Wastewater pipe system "REDI Phonoline" mounted in sub-basement (KG), basement (UG front), ground floor (EG front) and top floor (DG) using pipe clamps "Bismat 1000". Airborne sound pressure level (above) and structure-borne sound characteristic level (below) measured at various flow rates according to DIN EN 14366.

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.

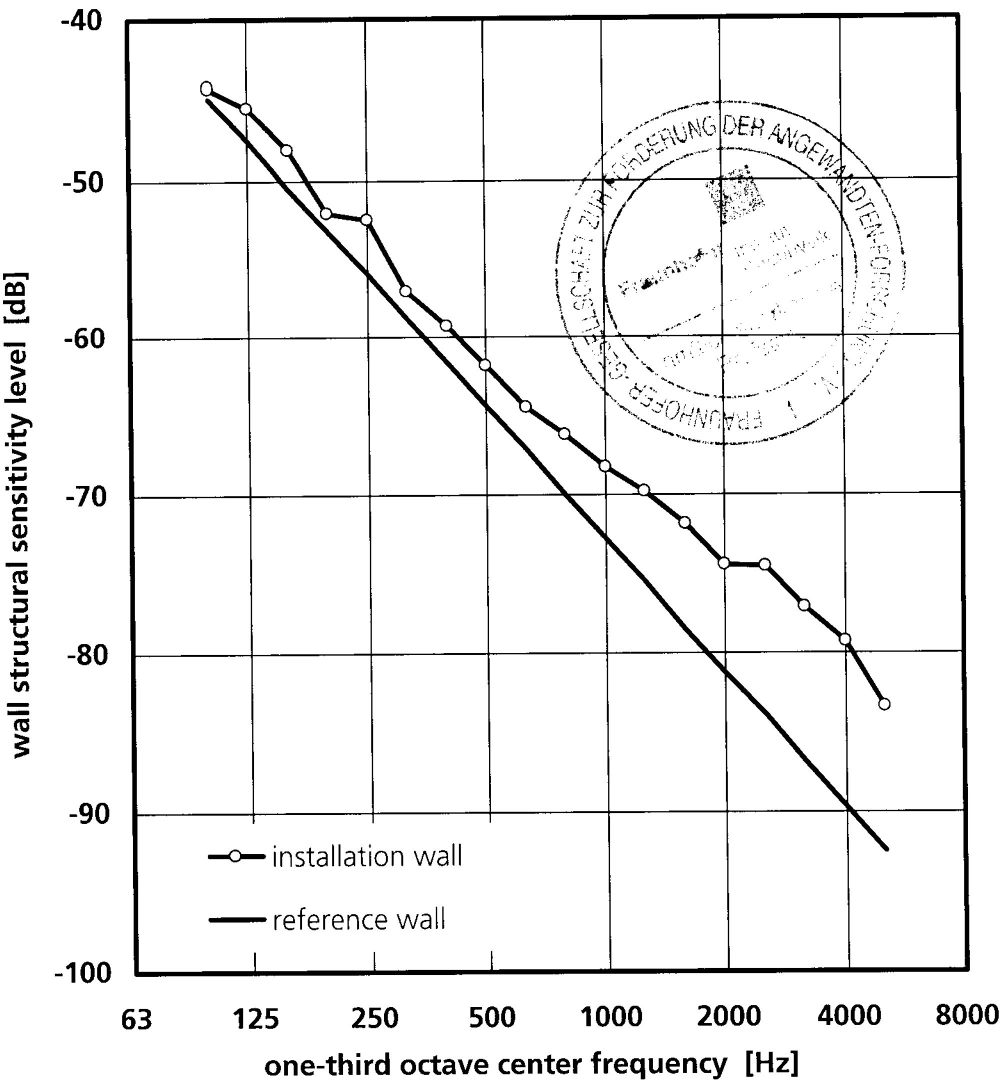


Figure 3 Wall structural sensitivity level L_{SS} of the installation wall between the test rooms UG front and UG rear in the installation test facility in the Fraunhofer-Institute of Building Physics. The installation wall consists of lime stones (thickness 115 mm, ceiled on both sides) with a mass per unit area of 220 kg/m². The indicated structural sensitivity level L_{SS} refers to the mounting position of the waste water system according to figure 4. For comparison the wall structural sensitivity level L_{SSR} of the reference wall is also indicated (evaluation according to DIN EN 14366).

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.

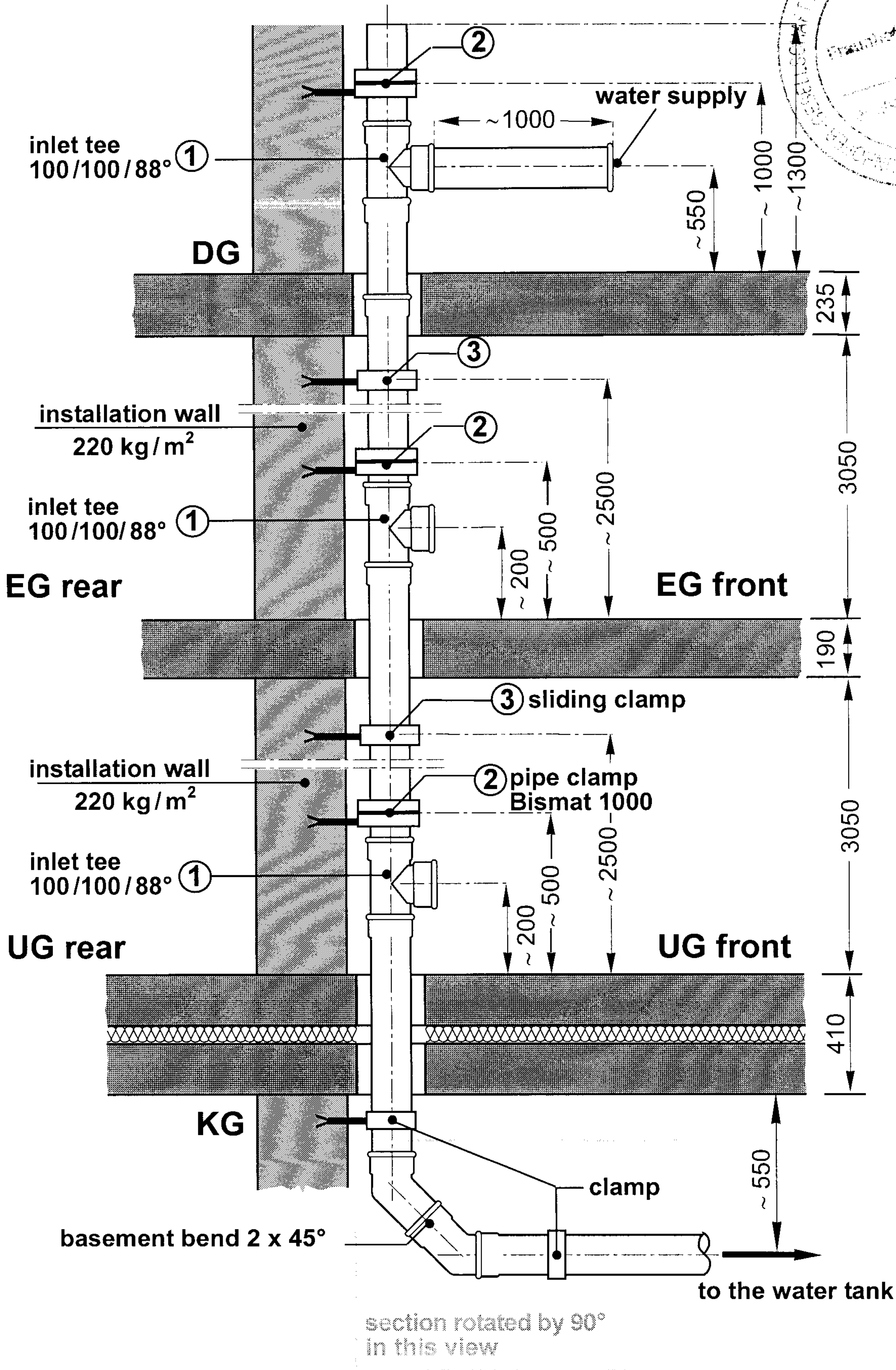


Figure 4 Installation plan of the pipe system "REDI Phonoline", mounted with clamps "Bismat 1000" (drawing not to scale, dimensions in mm).

Measurement set-up, noise excitation and evaluation parameters

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 of February, 2005. In the sub-basement, the down pipe is connected to a bend (2 x 45 degree, 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 $m'' = 220\ kg/m^2$) 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.

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 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 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. In the test room, the sound pressure level is picked up not at just one point, but at six points to be space and time-averaged (this procedure differs from German standard DIN 52 219). In this way, precision and reproducibility of the measurement results are improved, in order to meet the advanced requirements for laboratory measurements. The value that was determined in this way ($L_{AF,10}$) is used as the installation sound level L_{In} in the test facility (Annex F). The airborne sound pressure level $L_{a,A}$ and the structure-born sound characteristic level $L_{sc,A}$ were measured and calculated according to EN 14366.

Evaluation of Measurements

Stationary noise

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	[m^2]
V	volume of test room	[m^3]
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]

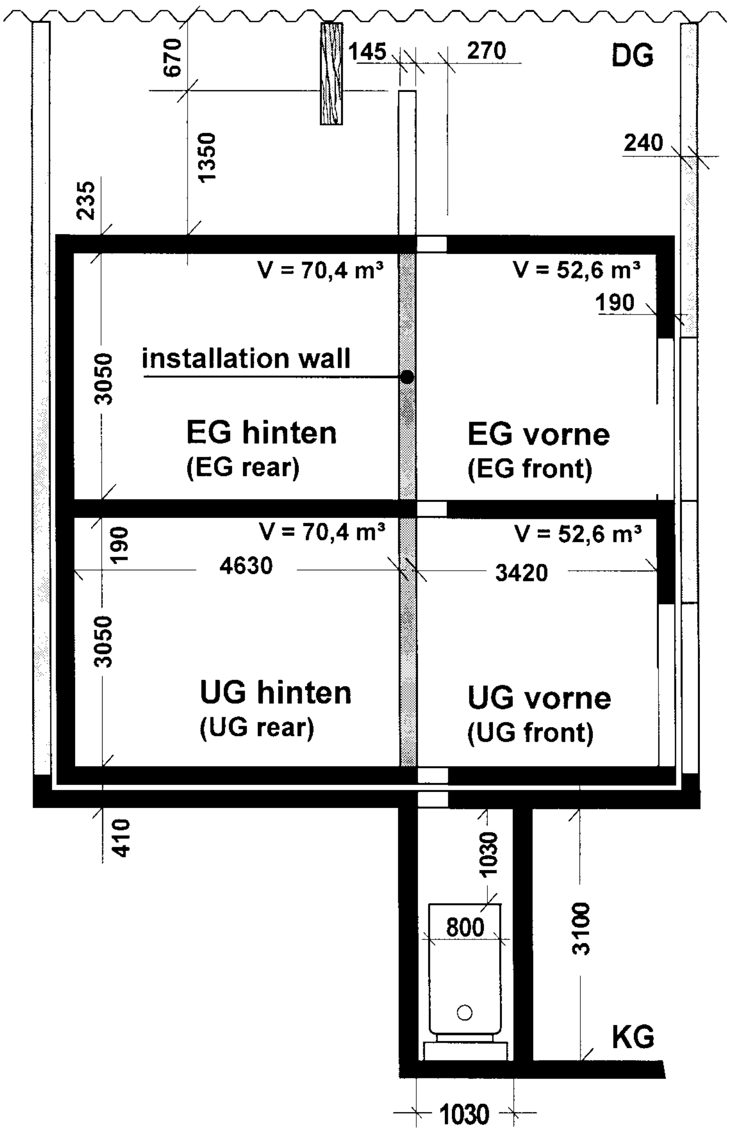
If the difference between the two levels (i.e. the measured one-third octave level and the background noise level) is less than 3 dB, the correction for background noise will not be performed. Instead, the measured background noise level will be used (as an estimated maximum level). The total sound pressure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

(2) $$L_{AF,10} = 10 \cdot \lg\left(\sum_{n=1}^{18} 10^{\frac{L_{n,AF,10}}{10}}\right),$$ [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 value ($L_{AF,10}$) is used as the installation sound level L_{in} in the test facility.

Noise variable with time

In this case, the measurement signal consists of a series of one-third octave spectra (frequency range from 100 Hz through 5 kHz) which are consecutively measured in the same place at a time interval of 0.125 s. The evaluation is performed in the same way as in the case of stationary noise, except for the background noise correction which is dropped. Subsequently, the maximum value ($L_{AF,10,max}$) is determined from the time profile.



Sectional drawing of the installation test facility of the Fraunhofer Institute of Building Physics (dimensions given in mm). The test facility comprises two spaces each on 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 also possible to perform tests on installation systems which extend across several floors, e.g. waste-water installation systems. Both installation walls can be substituted according to actual requirements. In the standard case, single-leaf solid walls with a mass per unit area of 220 kg/m^2 (according to German standard DIN 4109) are used. Since the sound insulation properties 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 spaces to be protected from noise are located diagonally above or below the installation space (in case of a standard ground-plan design). 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 reverberation times are between 1 s and 2 s within the examined frequency range. The flanking parts, with an average mass per unit area of approximately 440 kg/m^2, are made of concrete.