Fraunhofer
IBP

Institution for testing, supervision and certification, officially recognized by the building supervisory authority. Approvals of new building materials, components and types of construction

Director
Prof. Dr. Philip Leistner
Prof. Dr. Klaus Peter Sedlbauer

Test Report P-BA 158/2018e

Noise behaviour of a pipe clamp with elastomer inlay for waste water systems in the laboratory

Client: Abey Australia Pty Ltd
57-81 Abey Road
Cobblebank
VIC 3338
Australia

Test object: Steel pipe clamp with elastomer inlay "Acoustic Clamp" (Item no.: AC12, "100 mm PVC ACOUSTIC CLIP"), manufacturer: Abey, mounted with a commercial plastic wastewater system OD 110.

Content:

Results sheet 1:	Summary of test results
Figures 1 to 3:	Detailed results
Figures 4 and 5:	Test specimen, measurement set-up
Annex H1:	Realization of measurement, noise excitation and evaluation parameters, measurement set-up, evaluation of measuring data and determination of acoustic parameters
Annex P:	Description of test facility

Test date: The measurement was carried out on May 24, 2018 in the test facilities of the Fraunhofer Institute for Building Physics in Stuttgart.

Stuttgart, August 22, 2018

Responsible Test Engineer:	Head of Laboratory:
M.Sc. B. Kaltbeitzel	M.BP. Dipl.-Ing.(FH) S. Öhler

The test was carried out in a laboratory, accredited according to DIN EN ISO/IEC 17025:2005 by DAkkS. The accreditation certificate is D-PL-11140-11-01.

Determination of the A-sound pressure level reduction $\Delta L_{AFeq,n}$ in the Laboratory	P-BA 158/2018e Results sheet 1

Client: Abey Australia Pty Ltd, 57-81 Abey Road, Cobblebank, VIC 3338, Australia

Test specimen: Steel pipe clamp "Acoustic Clamp" (Item no.: AC12, "100 mm PVC ACOUSTIC CLIP") with elastomer inlay, manufacturer: Abey, mounted with a commercial plastic wastewater system OD 110 (test object no.: 11212-1; see figure 4 and 5).

Test set-up: Steel pipe clamp "Acoustic Clamp" (Item no.: AC12, "100 mm PVC ACOUSTIC CLIP") with elastomer inlay, manufacturer: Abey. The pipe clamps were closed with a tightening torque of 3 Nm (completely closed).

Commercial wastewater system (one-layer pipes: Material PP. Wall thickness 4.6 mm, weight 2.7 kg/m, density 1.8 g/cm³, values measured by IBP.) consisting of wastewater pipes (nominal size OD 110), 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 (see figure 4 and 5). The wastewater system was installed in the installation test facility P12 (installation rooms: attics, EG front, UG front and lower basement; see figure 5 and Annex P).

- **Reference set-up**: Rigid attachment of the waste water pipe system with 110 mm steel pipe clamps without elastomer inlays (Item No.: 5174, "100 mm PVC WELDED NUT CLIP", Abey), closed with a tightening torque of 3 Nm (completely closed).

- **Test set-up**: Attachment of the waste water pipe system with steel pipe clamp "Acoustic Clamp" (Item no.: AC12, "100 mm PVC ACOUSTIC CLIP") with elastomer inlay, manufacturer: Abey. The pipe clamps were closed with a tightening torque of 3 Nm (completely closed).

The pipe clamps were fixed to the installation wall with dowels and thread rods.

The test set-up was mounted by a technician under the authority of Fraunhofer IBP. (see figure 4 and 5).

Test facility: Installation test facility P12, mass per unit area of the installation wall: 220 kg/m², mass per unit area of the ceiling: 440 kg/m². Installation rooms: top floor (DG), ground floor (EG) front, basement (UG) front and sub-basement (KG); measuring room: basement UG front and UG rear. (For further details, please refer to Annex H1 and P.)

Test method: The measurements were performed following to EN 14366; noise excitation by steady water flow with 0.5 l/s, 1.0 l/s, 2.0 l/s and 4.0 l/s. Evaluation for comparison with requirements following German standards DIN 4109-1:2018 (details in Annex H1).

Result:

Test specimen: Steel pipe clamp "Acoustic Clamp" (Item no.: AC12, "100 mm PVC ACOUSTIC CLIP") with elastomer inlay, manufacturer: Abey, mounted with a commercial plastic wastewater system OD 110 (test object no.: 11212-1; see figure 4 and 5). The pipe clamps were closed with a tightening torque of 3 Nm (completely closed).	Flow-rate [l/s]			
	0.5	1.0	2.0	4.0
A-sound pressure level reduction $\Delta L_{AFeq,n}$ [dB], measured and calculated for the basement test-room UG rear	8	6	8	8
Installation Sound Level $L_{AFeq,n}$ [dB(A)], following DIN 4109 for the basement test-room UG rear	< 10	13	16	20

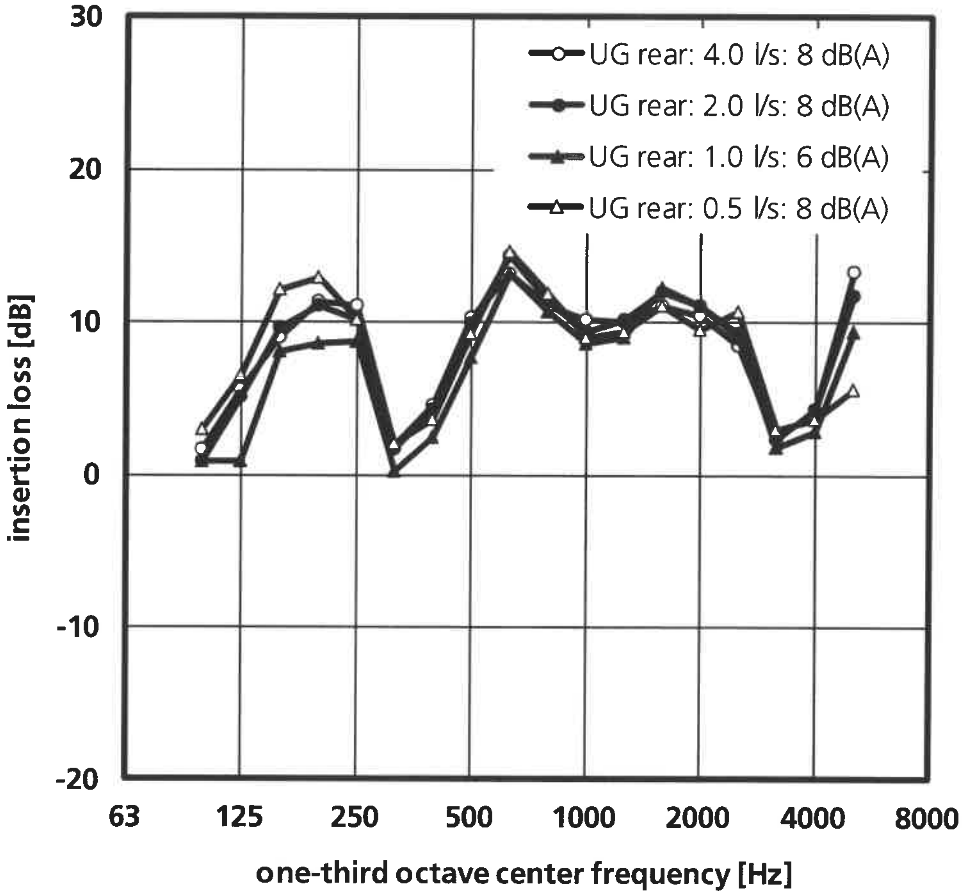
Test date: May 24, 2018

Notes:
- The reduction of the A-weighted sound level represents a measure for the decrease of noise felt by human ear using elastic mounting elements. It refers exclusively to the noise spectrum while exciting the pipe system by stationary water flow (as used at the measurements) and cannot be transferred directly to other types of noise sources.
- Sound levels below 10 dB(A) are not mentioned in the test report, since they are subject to an increased measurement uncertainty and moreover are not noticeable in a normal living environment.

Fraunhofer IBP

The test was carried out in a laboratory, accredited according to DIN EN ISO/IEC 17025:2005 by DAkkS. The accreditation certificate is D-PL-11140-11-01.

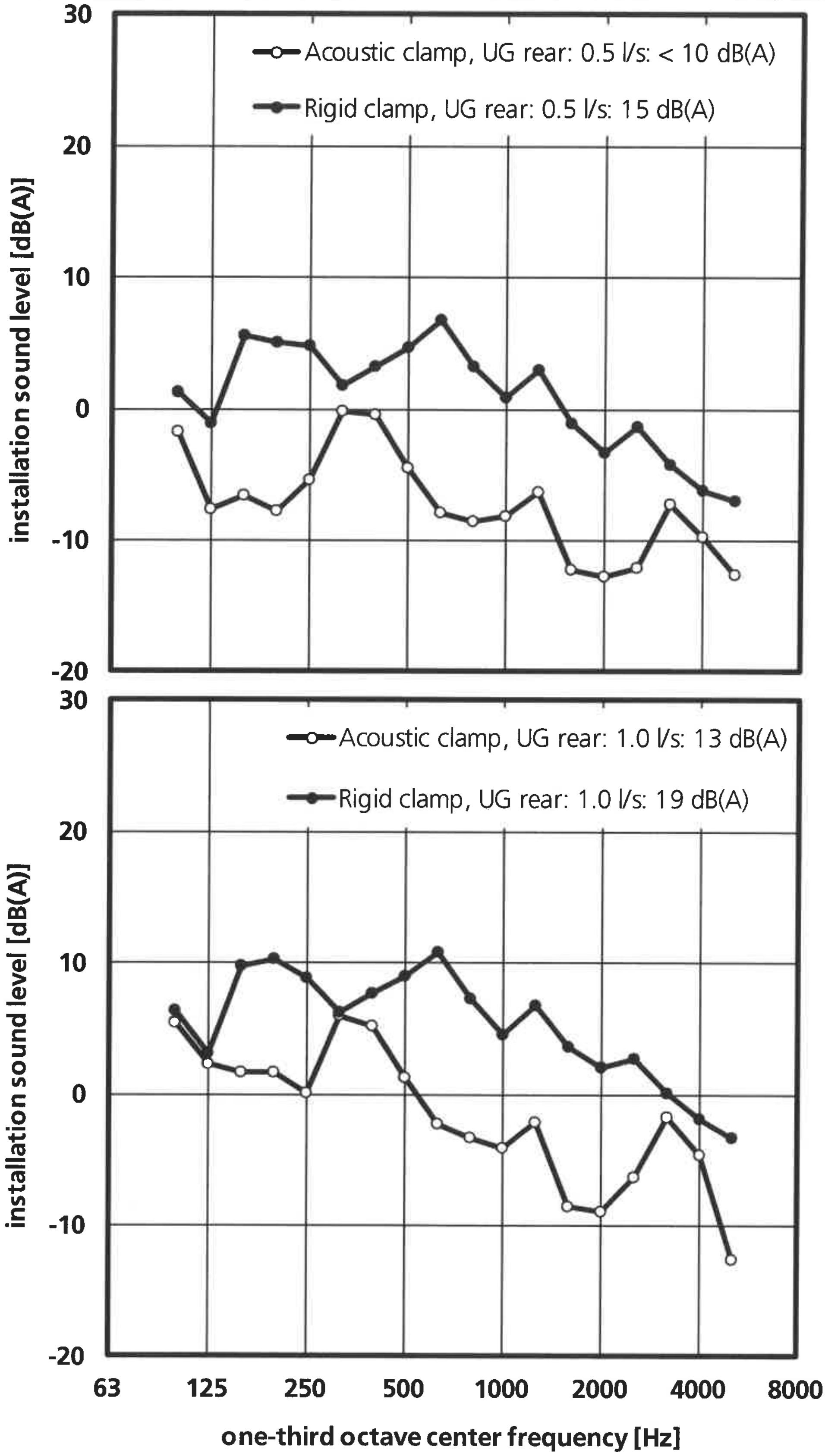
Stuttgart, August 22, 2018
Head of Laboratory:



Frequency response of the insertion loss D_e by noise excitation at various flow rates 4.0 l/s, 2.0 l/s, 1.0 l/s and 0.5 l/s, measured in the test room UG rear. The A-weighted reduction of sound level $\Delta L_{AFeq,n}$ (referring to excitation by the various flow rates), for the reproduced frequency range from 100 to 5000 Hz, are represented in the legend.

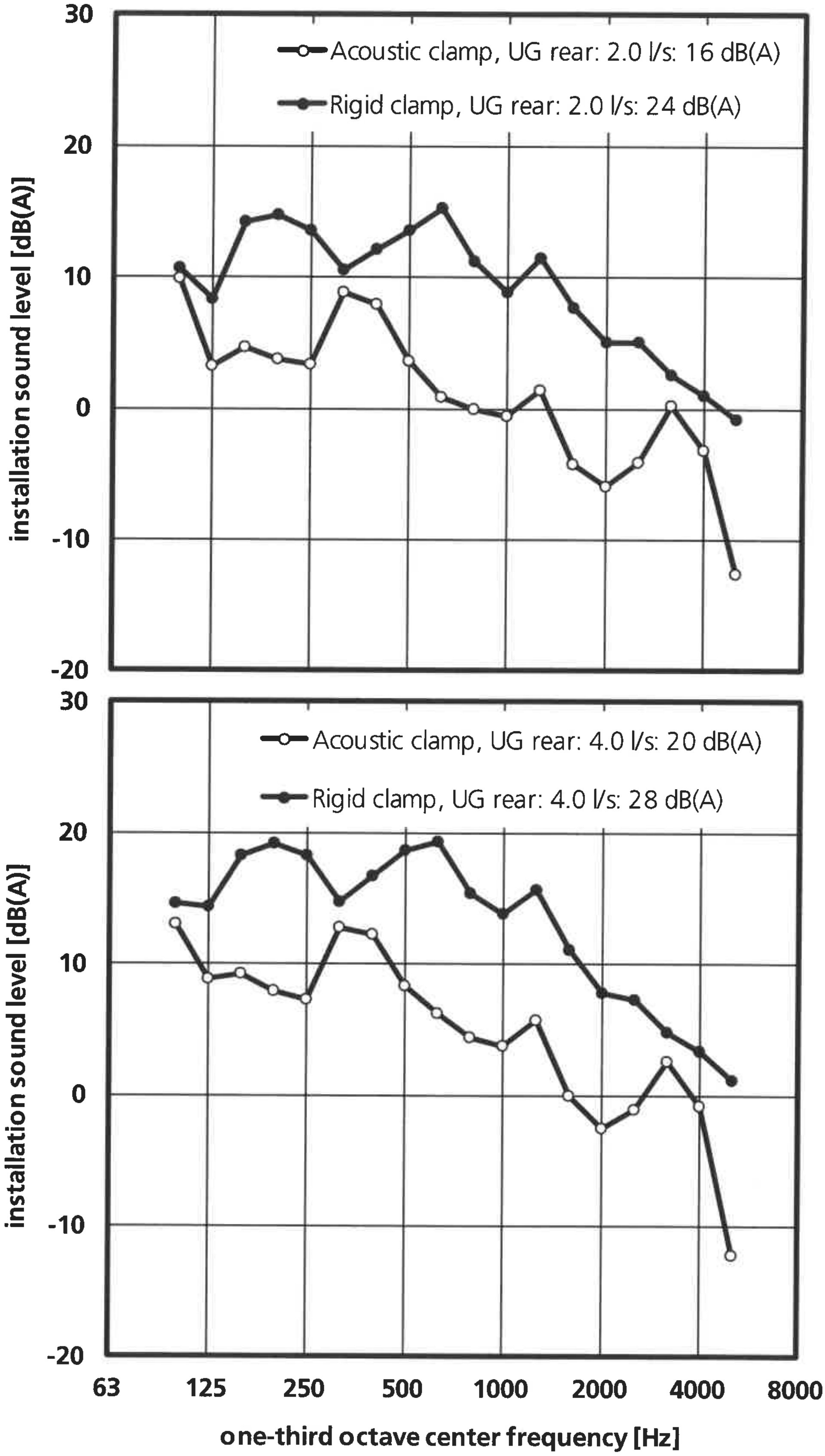
Test specimen: Steel pipe clamp "Acoustic Clamp" (Item no.: AC12, "100 mm PVC ACOUSTIC CLIP") with elastomer inlay, manufacturer: Abey, mounted with a commercial plastic wastewater system OD 110 (test object no.: 11212-1; see figure 4 and 5). The pipe clamps were closed with a tightening torque of 3 Nm (completely closed).
Details about the test set-up in results sheet 1.

Detailed results	**P-BA 158/2018e**
Client: Abey Australia Pty Ltd, 57-81 Abey Road, Cobblebank, VIC 3338, Australia	**figure 2**

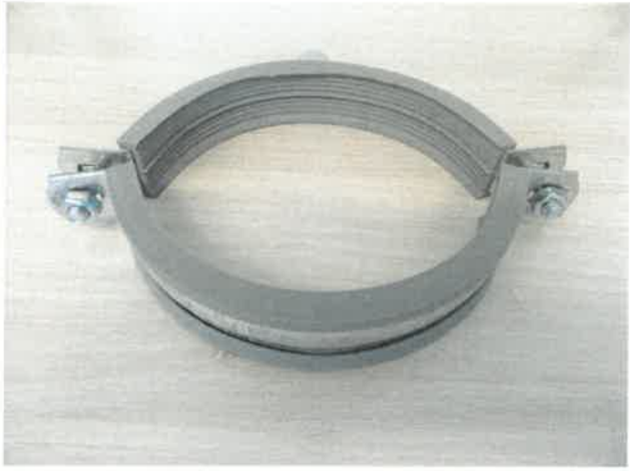


Frequency response of the installation-sound level $L_{AFeq,n}$ for the reference set-up (pipe clamps without elastomer inlay) and for the test set-up (pipe clamps with elastomer inlay) for a flow rate of 0.5 l/s (upper picture) and 1.0 l/s (lower picture) measured in the room UG rear behind the installation wall.
Test specimen: Steel pipe clamp "Acoustic Clamp" (Item no.: AC12, "100 mm PVC ACOUSTIC CLIP") with elastomer inlay, manufacturer: Abey, mounted with a commercial plastic wastewater system OD 110 (test object no.: 11212-1; see figure 4 and 5). The pipe clamps were closed with a tightening torque of 3 Nm (completely closed). Details about the test set-up in results sheet 1.

Detailed results	**P-BA 158/2018e**
Client: Abey Australia Pty Ltd, 57-81 Abey Road, Cobblebank, VIC 3338, Australia	**figure 3**

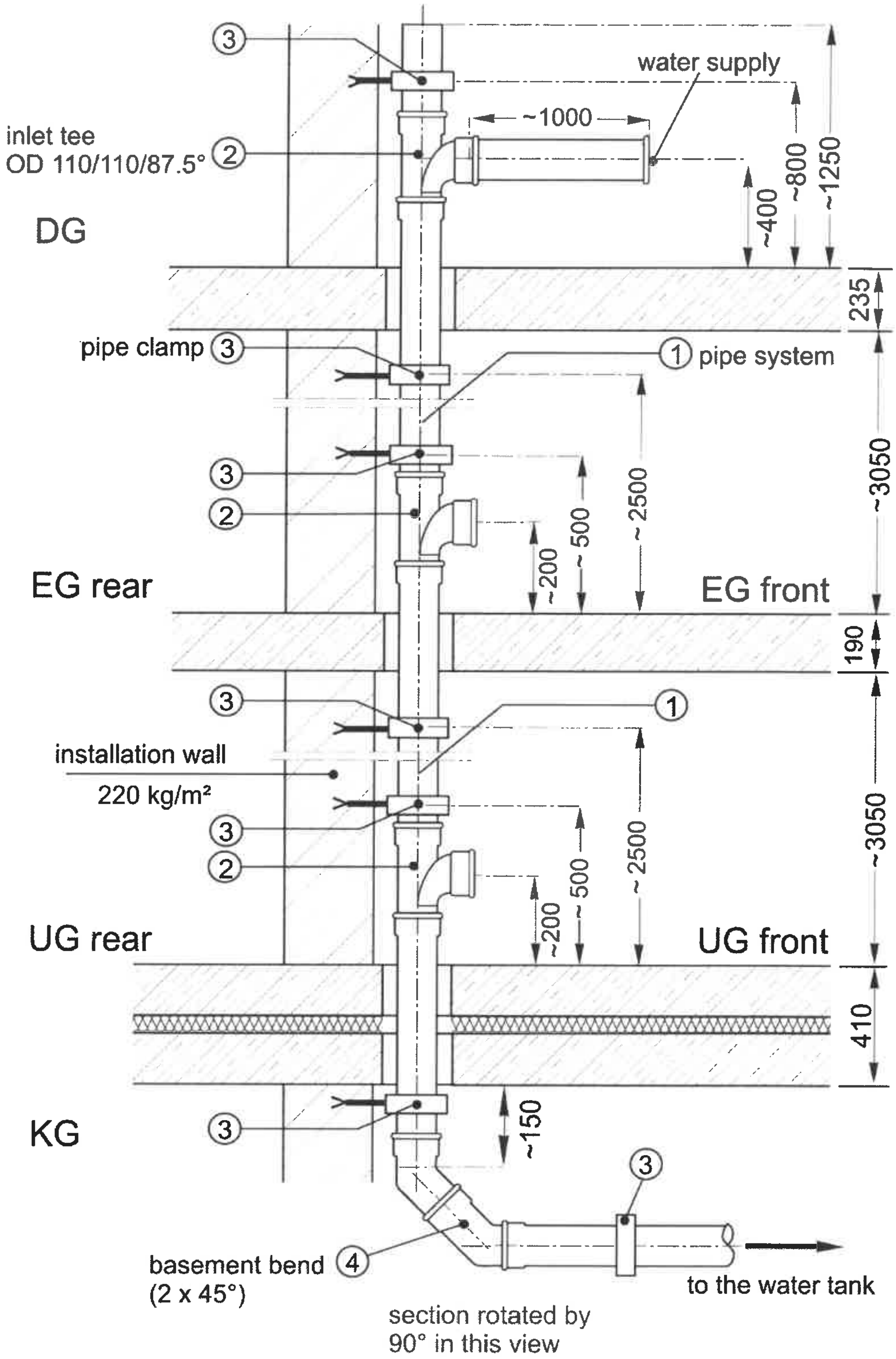


Frequency response of the installation-sound level $L_{AFeq,n}$ for the reference set-up (pipe clamps without elastomer inlay) and for the test set-up (pipe clamps with elastomer inlay) for a flow rate of 2.0 l/s (upper picture) and 4.0 l/s (lower picture) measured in the room UG rear behind the installation wall.
Test specimen: Steel pipe clamp "Acoustic Clamp" (Item no.: AC12, "100 mm PVC ACOUSTIC CLIP") with elastomer inlay, manufacturer: Abey, mounted with a commercial plastic wastewater system OD 110 (test object no.: 11212-1; see figure 4 and 5). The pipe clamps were closed with a tightening torque of 3 Nm (completely closed). Details about the test set-up in results sheet 1.



Test specimen: Steel pipe clamp "Acoustic Clamp" (Item no.: AC12, "100 mm PVC ACOUSTIC CLIP") with elastomer inlay, manufacturer: Abey, mounted with a commercial plastic wastewater system OD 110 (test object no.: 11212-1; see figure 4 and 5). The pipe clamps were closed with a tightening torque of 3 Nm (completely closed). Details about the test set-up in results sheet 1.

Test specimen, measurement set-up	**P-BA 158/2018e**
Client: Abey Australia Pty Ltd, 57-81 Abey Road, Cobblebank, VIC 3338, Australia	**figure 5**



Installation plan of the test set-up in the test facility. Illustration simplified, schematically drawn and not to scale.

<u>Test specimen</u>: Wastewater installation system consisting of plastic pipes and fittings. Steel pipe clamp "Acoustic Clamp" (Item no.: AC12, "100 mm PVC ACOUSTIC CLIP") with elastomer inlay, manufacturer: Abey, mounted with a commercial plastic wastewater system OD 110 (test object no.: 11212-1; see figure 4 and 5).

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 or airborne 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 following to DIN EN 14366 and the German standards DIN EN ISO 10052, DIN 4109 and VDI 4100, in which in situ measurements of the noise behavior of 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. According to DIN EN ISO 10140-4 the sound pressure level is picked up at six points in the room, to be space and time-averaged and corrected for the background noise.

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 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.

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 time and space averaged one-third octave spectrum in the frequency range between 100 Hz and 5 kHz. First, the measured value is corrected for background noise. Subsequently, it is normalized to an equivalent sound absorption area of A_0 = 10 m² and A-weighted:

(1) $$L_{i,AFeq,n} = 10 \cdot \lg\left(10^{\frac{L_{i,F}}{10}} - 10^{\frac{L_{i,F,GG}}{10}}\right) + 10 \cdot \lg\frac{A_i}{A_0} + k(A)_i \quad [\text{dB(A)}]$$

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

If the difference between 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 test result (as largest possible value). The total sound pressure level is obtained by energetically adding the one-third octave values.

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

where i indicates the number of one-third octave bands from 100 Hz to 5 kHz. The calculated level $L_{AFeq,n}$ corresponds to the sound pressure level that would arise in a sparsely furnished reception room under otherwise equal conditions. The value represents the installation sound level in the test facility.

With stationary signals (e.g. waste water noise with a constant flow rate), in deviation from DIN 4109-4 and DIN EN ISO 10052 or VDI 4100 it is not the maximum value ($L_{AFmax,n}$, or $\overline{L_{AFmax,nT}}$) but rather the temporally and spatially averaged level ($L_{AFeq,n}$, or $\overline{L_{AFeq,nT}}$) that is measured. This guarantees compliance with the reproducibility and accuracy requirements that are mandatory for test bench measurements (e.g. through the possibility of background noise correction), which would not be realisable with use of the maximum level that is determined according to the aforementioned standards for measurements on the building. On the basis of extensive experience, it is necessary to assume that the difference between $L_{AFmax,n}$ and $L_{AFeq,n}$, or between $\overline{L_{AFmax,nT}}$ and $\overline{L_{AFeq,nT}}$ is a maximum 2-3 dB under normal circumstances.

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 $D_{i,e}$ are the difference between the one-third octave levels $L_{i,AFeq,n-0}$, measured with rigid pipe clamps, and the levels $L_{i,AFeq,n-1}$, measured with the insulating tube or the elastic mounting element under test

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

Additionally the reduction of the A-weighted sound level $\Delta L_{AFeq,n}$ 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.

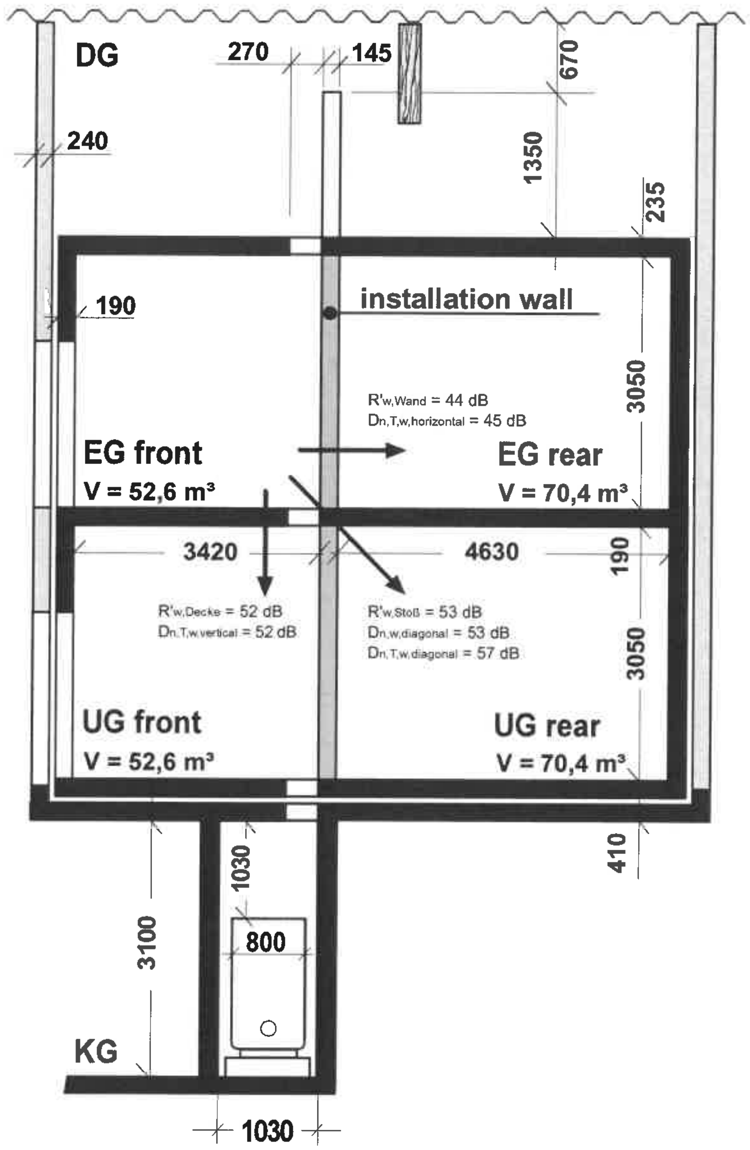
(4) $$\Delta L_{AFeq,n} = L_{AFeq,n-0} - L_{AFeq,n-1} \quad \text{[dB]}$$

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

<u>Transferability of the results to other building situations</u>
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.

Test facility



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.

Measurement equipment

Following measurement equipment was used for the measurments in the installation test facility P12 of the Fraunhofer-Institute for Building Physics:

Device	Type	Manufacturer
Analyser	Soundbook_MK2_8L	Sinus Messtechnik
½"-microphone-Set	46 AF (cartridge: Typ 40 AF-Free Field; pre-amp: Typ 26 TK)	G.R.A.S
½"-microphone-Set (IEPE)	46 AE (cartridge: Typ 40 AE-Free Field; pre-amp: Typ 26 CA)	G.R.A.S
1"-microphone-Set	40HF (cartridge: Typ 40EH-LowNoise; pre-amp: Typ 26HF; Power Module: Typ 12HF)	G.R.A.S
1"-microphone	4179	Bruel & Kjær
1"-preamplifier	2660	Bruel & Kjær
Microphone-calibrator	4231	Bruel & Kjær
Accelerometer	4371 and 4370	Bruel & Kjær
Conditioning amplifier	Nexus 2692-A-0I4	Bruel & Kjær
Accelerometer (IEPE)	352B	PCB Piezotronics, Inc.
Accelerometer-calibrator	VC11	MMF
Amplifier	LBB 1935/20	Bosch Plena
Loudspeaker	MLS 82	Lanny
Reference sound source	382	Rox
Standard tapping machine	211	Norsonic

The used Analyser is a type-approved Class 1 sound level meter. All measurement devices are tested frequently by internal and external testing laboratories, are calibrated and if necessary gauged.

Fraunhofer
IBP

Institution for testing, supervision and certification, officially recognized by the building supervisory authority. Approvals of new building materials, components and types of construction

Director
Prof. Dr. Philip Leistner
Prof. Dr. Klaus Peter Sedlbauer

Test Report P-BA 159/2018e

Noise behaviour of insulation material for wastewater installation systems

Client: Abey Australia Pty Ltd
57-81 Abey Road
Cobblebank
VIC 3338
Australia

Test object: Acoustic lagging for wastewater installation systems "Soundlag 4525C" (manufacturer: Pyrotek) in combination with an "Acoustic Clamp" (Item no.: AC12, "100 mm PVC ACOUSTIC CLIP", manufacturer: Abey) and a wastewater system consisting of plastic pipes (OD 110 x 3.4).

Content:

Test date: The measurement was carried out on May 24, 2018 in the test facilities of the Fraunhofer Institute for Building Physics in Stuttgart.

Stuttgart, August 22, 2018

Responsible Test Engineer: Head of Laboratory:

M.Sc. B. Kaltbeitzel M.BP. Dipl.-Ing.(FH) S. Öhler

The test was carried out in a laboratory, accredited according to DIN EN ISO/IEC 17025:2005 by DAkkS. The accreditation certificate is D-PL-11140-11-01.

Fraunhofer-Institut für Bauphysik - Prüflabor Bauakustik und Schallimmissionsschutz
Nobelstraße 12, D-70569 Stuttgart
Telefon +49(0) 711/970-3314; Fax -3406
akustik@ibp.fraunhofer.de
www.pruefstellen.ibp.fraunhofer.de/de/akkreditierte-prueflabore.html

ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-PL-11140-11-01

Determination of the A-sound pressure level reduction $\Delta L_{AFeq,n}$ in the Laboratory

P-BA 159/2018e

Results sheet 1

Client: Abey Australia Pty Ltd, 57-81 Abey Road, Cobblebank, VIC 3338, Australia

Test specimen: Acoustic lagging for wastewater installation systems "Soundlag 4525C" (manufacturer: Pyrotek) in combination with an "Acoustic Clamp" (Item no.: AC12, "100 mm PVC ACOUSTIC CLIP", manufacturer: Abey) and a wastewater system consisting of plastic pipes (OD 110 x 3.4) (test object no.: 11212-2; see figure 5, 6 and 7).

Test set-up:

- Acoustic lagging for wastewater installation systems "Soundlag 4525C" (manufacturer: Pyrotek), made of elastomer foam (blue convoluted foam) with outer mass loaded layer and foil facing. Standard thickness of 27 mm and a barrier weight of 5 kg/m² (manufacturer's information). All straight pipes, fittings and pipe clamps were covered with cut sheet material of "Soundlag 4525C".
- Commercial wastewater system (one-layer pipes: Material PP, wall thickness 4.6 mm, weight 2.7 kg/m, density 1.8 g/cm³, values measured by IBP.) consisting of wastewater pipes (nominal size OD 110), 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 (see figure 5 and 6).
- Pipe clamps "Acoustic Clamp" (Item no.: AC12, "100 mm PVC ACOUSTIC CLIP", Abey), tightening torque 3 Nm (completely closed), mounted with plastic dowels and thread rods to the installation wall. In each storey (EG and UG) two pipe clamps were installed.
- **Reference set-up**: Wastewater system with bare (unlagged) pipe, plus "Acoustic Clamp" (Abey). Pipe installed according to EN 14366 with foam in the floor openings (pipe not grouted into ceiling and floor openings, see figure 5 and 7).
- **Test set-up**: Wastewater system with acoustic lagging "Soundlag 4525C" (Pyrotek), plus "Acoustic Clamp" (Abey). Pipe grouted into ceiling and floor openings (between the installation rooms EG front, UG front and sub-basement) with 50mm mortar around the insulation, resulting in acoustic isolation of the pipe from the ceiling and floor (see figure 6 and 7).

The test set-up was mounted by a technician under the authority of Fraunhofer IBP.

Test facility: Installation test facility P12, mass per unit area of the installation wall: 220 kg/m², mass per unit area of the ceiling: 440 kg/m². Installation rooms: top floor (DG), ground floor (EG) front, basement (UG) front and sub-basement (KG); measuring room: basement UG front and UG rear. (For further details, please refer to Annex P.)

Test method: The measurements were performed following DIN 4109 and EN 14366; 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 H3 and P).

Result:

Installation Sound Level $L_{AFeq,n}$ [dB(A)], following to DIN 4109					
Flow rate [l/s]		0.5	1.0	2.0	4.0
Reference set-up: Wastewater system with bare (unlagged) pipe, plus "Acoustic Clamp" (Abey). Pipe installed according to EN 14366 with foam in the floor openings.	UG front	41	45	47	50
	UG rear	< 10	13	16	20
Test set-up: Wastewater system with acoustic lagging "Soundlag 4525C" (Pyrotek), plus "Acoustic Clamp" (Abey). Pipe grouted into ceiling and floor openings with mortar around the insulation.	UG front	20	26	29	34
	UG rear	< 10	10	13	18
A-sound pressure level reduction $\Delta L_{AFeq,n}$ in dB	UG front	21	19	18	16
	UG rear	4	3	3	2

Test date: May 24, 2018

Notes:

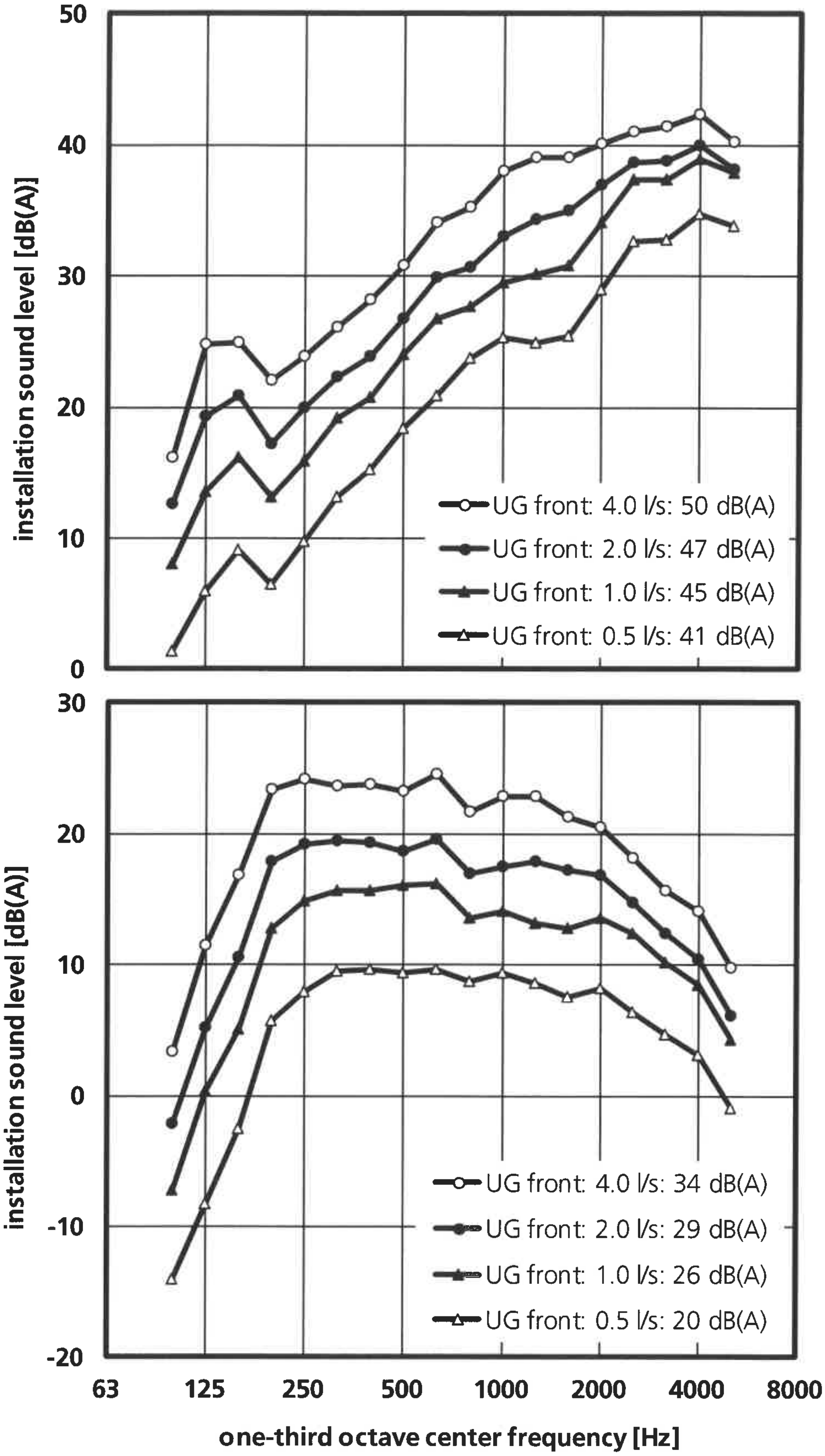
- The reduction of the A-weighted sound level represents a measure for the decrease of noise felt by human ear using structure-borne sound insulating tubes or elastic mounting elements. It refers exclusively to the noise spectrum while exciting the pipe system by stationary water flow (as used at the measurements) and can't be transferred directly to other types of noise sources.
- Sound levels below 10 dB(A) are not mentioned in the test report, since they are subject to an increased measurement uncertainty and moreover are not noticeable in a normal living environment.

Fraunhofer IBP

The test was carried out in a laboratory, accredited according to DIN EN ISO/IEC 17025:2005 by DAkkS. The accreditation certificate is D-PL-11140-11-01.

Stuttgart, August 22, 2018

Head of Laboratory:



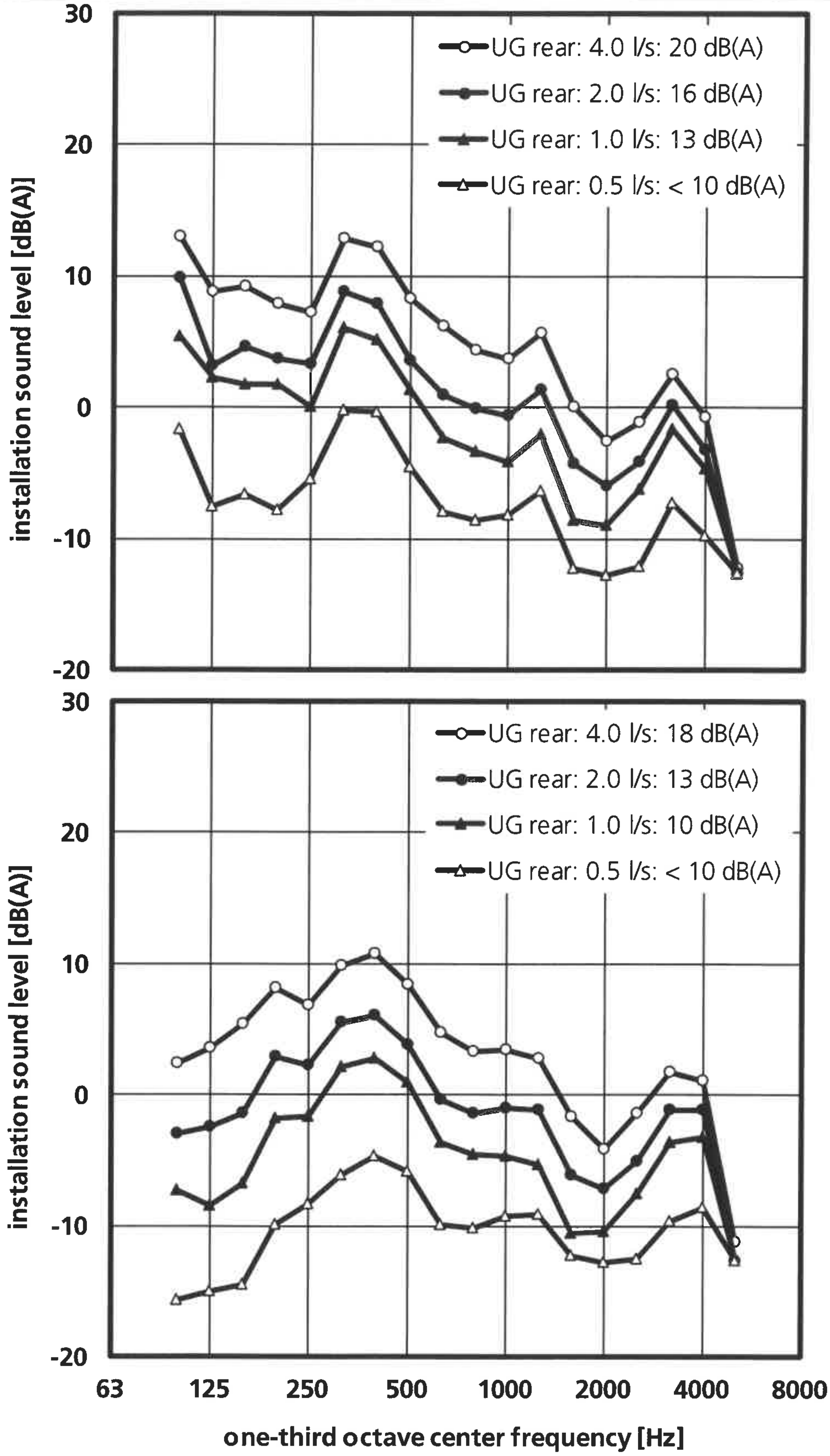
Frequency response of the installation sound level $L_{AFeq,n}$ measured at various flow rates in the test room **UG front** for

Reference set-up (above): Wastewater system with bare (unlagged) pipe, plus "Acoustic Clamp" (Abey). Pipe installed according to EN 14366 with foam in the floor openings.

Test set-up (below): Wastewater system with acoustic lagging "Soundlag 4525C" (Pyrotek), plus "Acoustic Clamp" (Abey). Pipe grouted into ceiling and floor openings with mortar around the insulation.

The installation sound levels $L_{AFeq,n}$ in dB(A) following DIN 4109, for the reproduced frequency range from 100 to 5000 Hz, are represented in the legend.

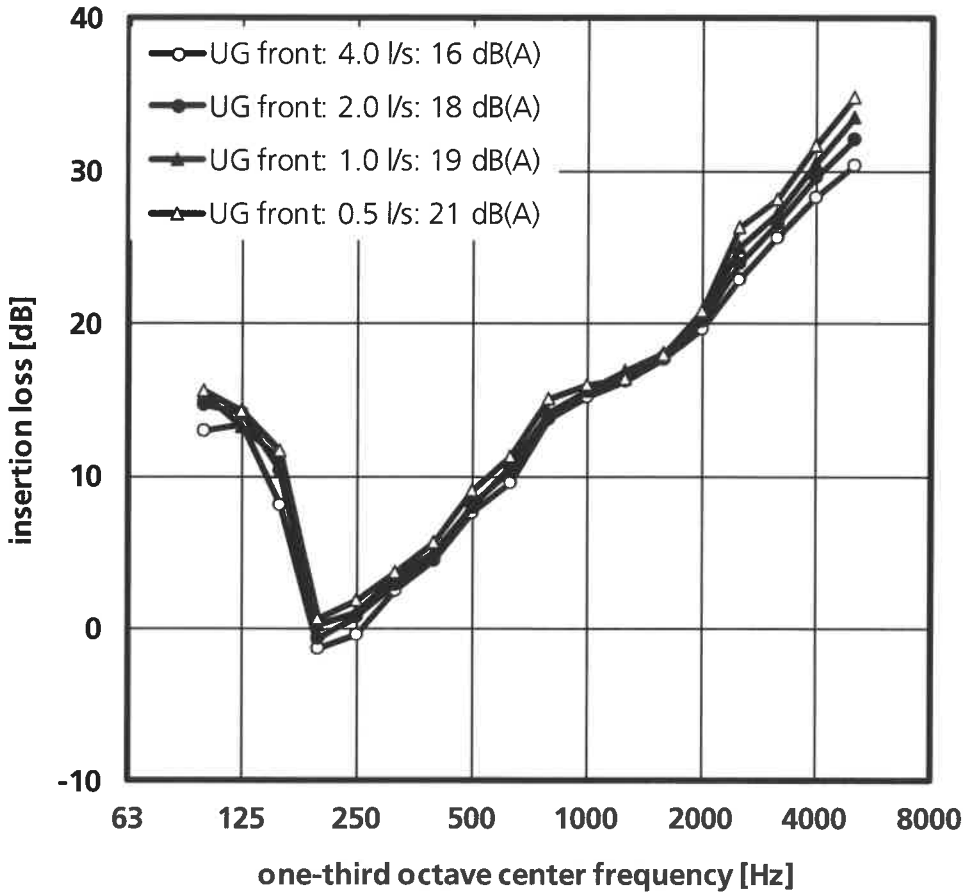
Detailed results	**P-BA 159/2018e**
Client: Abey Australia Pty Ltd, 57-81 Abey Road, Cobblebank, VIC 3338, Australia	**figure 2**



Frequency response of the installation sound level $L_{AFeq,n}$ measured at various flow rates in the test room **UG rear** for
Reference set-up (above): Wastewater system with bare (unlagged) pipe, plus "Acoustic Clamp" (Abey). Pipe installed according to EN 14366 with foam in the floor openings.
Test set-up (below):Wastewater system with acoustic lagging "Soundlag 4525C" (Pyrotek), plus "Acoustic Clamp" (Abey). Pipe grouted into ceiling and floor openings with mortar around the insulation.
The installation sound levels $L_{AFeq,n}$ in dB(A) following DIN 4109, for the reproduced frequency range from 100 to 5000 Hz, are represented in the legend.

Fraunhofer IBP

The test was carried out in a laboratory, accredited according to DIN EN ISO/IEC 17025:2005 by DAkkS. The accreditation certificate is D-PL-11140-11-01.



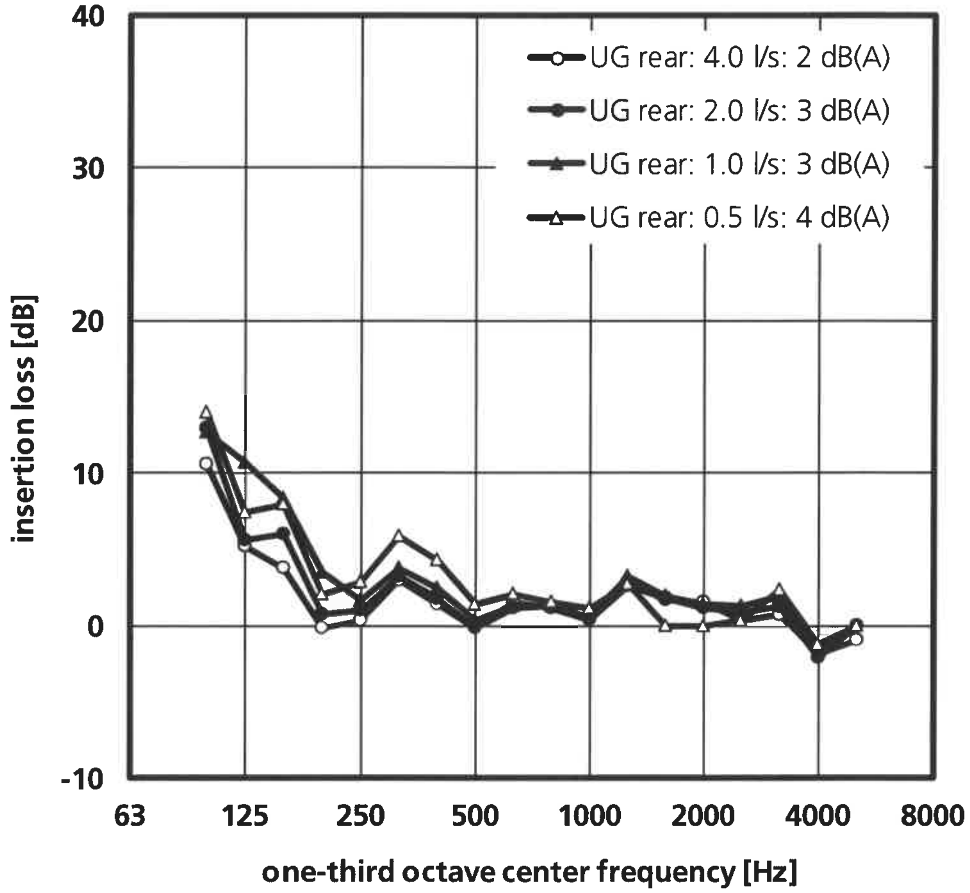
Frequency response of insertion loss D_e by noise excitation at various flow rates 4.0 l/s, 2.0 l/s, 1.0 l/s and 0.5 l/s, measured in the test room **UG front**. The A-weighted reduction of sound level $\Delta L_{AFeq,n}$ (referring to excitation by the various flow rates), for the reproduced frequency range from 100 to 5000 Hz, are represented in the legend.

Test specimens:

Reference set-up: Wastewater system with bare (unlagged) pipe, plus "Acoustic Clamp" (Abey). Pipe installed according to EN 14366 with foam in the floor openings.

Test set-up:Wastewater system with acoustic lagging "Soundlag 4525C" (Pyrotek), plus "Acoustic Clamp" (Abey). Pipe grouted into ceiling and floor openings with mortar around the insulation.

Details about the test set-up in results sheet 1.



Frequency response of insertion loss D_e by noise excitation at various flow rates 4.0 l/s, 2.0 l/s, 1.0 l/s and 0.5 l/s, measured in the test room **UG rear**. The A-weighted reduction of sound level $\Delta L_{AFeq,n}$ (referring to excitation by the various flow rates), for the reproduced frequency range from 100 to 5000 Hz, are represented in the legend.

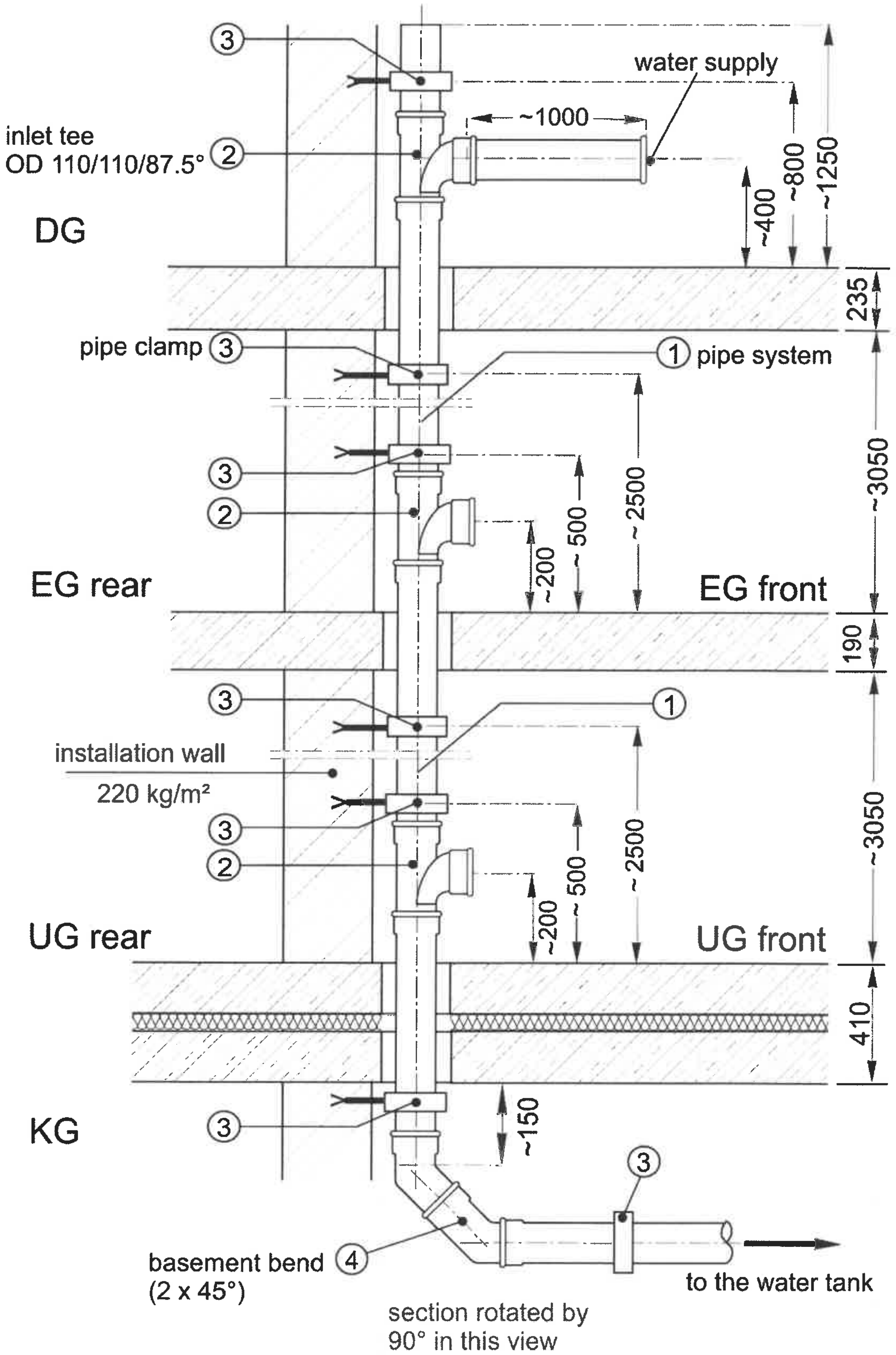
Test specimens:

Reference set-up: Wastewater system with bare (unlagged) pipe, plus "Acoustic Clamp" (Abey). Pipe installed according to EN 14366 with foam in the floor openings.

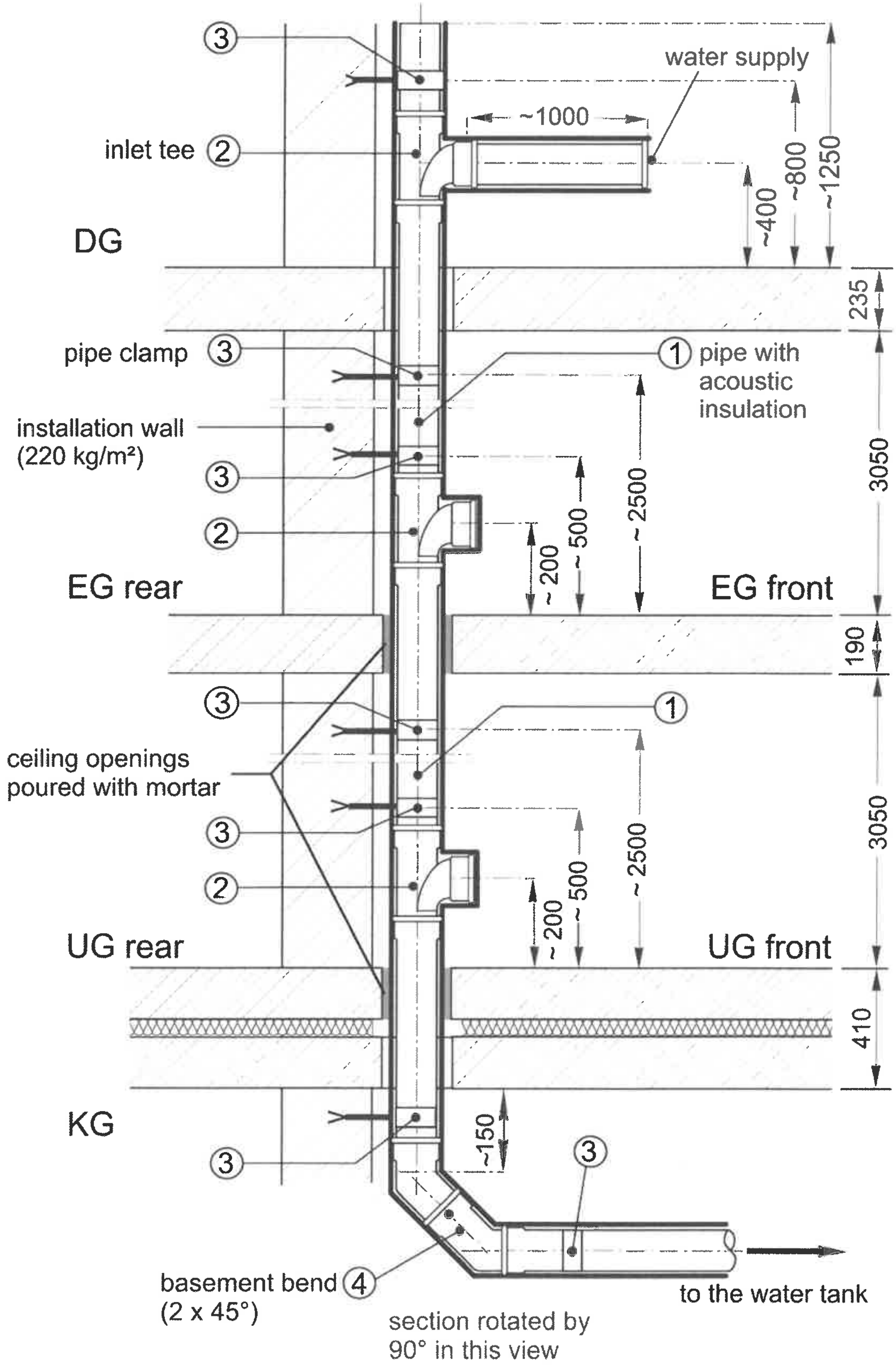
Test set-up: Wastewater system with acoustic lagging "Soundlag 4525C" (Pyrotek), plus "Acoustic Clamp" (Abey). Pipe grouted into ceiling and floor openings with mortar around the insulation.

Details about the test set-up in results sheet 1.

Test specimen, reference set-up	**P-BA 159/2018e**
Client: Abey Australia Pty Ltd, 57-81 Abey Road, Cobblebank, VIC 3338, Australia	**figure 5**



Installation plan of the reference set-up. Wastewater system consisting of plastic pipes (OD 110 x 3.4) and "Acoustic Clamp", Abey (drawing not to scale, dimensions in mm).



Installation plan of the acoustic lagging "Soundlag 4525C", Pyrotek, for wastewater installation systems, in combination with a wastewater system consisting of plastic pipes (OD 110 x 3.4) and "Acoustic Clamp", Abey (drawing not to scale, dimensions in mm). Pipe fully grouted into ceiling and floor openings.

Installation of the acoustic lagging "Soundlag 4525C", Pyrotek, for wastewater installation systems, in combination with a wastewater system consisting of plastic pipes (OD 110 x 3.4) and "Acoustic Clamp", Abey. Pipe fully grouted into ceiling and floor openings.
Reference set-up (above): Wastewater system with bare (unlagged) pipe, plus "Acoustic Clamp" (Abey). Pipe installed according to EN 14366 with foam in the floor openings.
Test set-up (below):Wastewater system with acoustic lagging "Soundlag 4525C" (Pyrotek), plus "Acoustic Clamp" (Abey). Pipe grouted into ceiling and floor openings with mortar around the insulation.

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 compared to an unlagged pipe. The measurements are performed following to DIN EN 14366 and the German standards DIN EN ISO 10052 and DIN 4109, in which in situ measurements of the noise behavior of 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 bare (unlagged) pipe. Pipe installed according to EN 14366 with foam in the floor openings (pipe not grouted into ceiling and floor openings).
2. Measurement of the installation sound level of the same pipe supplied with the structure-borne sound insulating tube under test. Pipe grouted into ceiling and floor openings (between the installation rooms EG front, UG front and sub-basement) with 50mm mortar around the insulation, resulting in acoustic isolation of the pipe from the ceiling and floor.

Noise excitation and evaluation parameters

Any defined and metrological reproducible noise excitation requires steady state flow conditions inside the wastewater 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 ceiling and 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. According to DIN EN ISO 10140-4 the sound pressure level is picked up at six points in the room, to be space and time-averaged and corrected for the background noise.

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.

Reference set-up

To determin the insertion loss of the samples a bare waste water pipe is installed according to EN 14366 with foam in the floor openings (pipe not grouted into ceiling and floor openings). The test facility is shown schematically in annex P. The reference set-up resembles in all details (except for the pipe insulating material) 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 pipe is covered by the pipe insulation under test befor it is additionally grouted into ceiling and floor openings. In case of structure-borne sound insulating tubes the pipe is completely encased in the insulating material.

Evaluation of measuring data and determination of acoustic parameters

The measured sound pressure level is given as time and space averaged one-third octave spectrum in the frequency range between 100 Hz and 5 kHz. First, the measured value is corrected for background noise. Subsequently, it is normalized to an equivalent sound absorption area of A_0 = 10 m² and A-weighted:

(1) $$L_{i,AFeq,n} = 10 \cdot \lg\left(10^{\frac{L_{i,F}}{10}} - 10^{\frac{L_{i,F,GG}}{10}}\right) + 10 \cdot \lg\frac{A_i}{A_0} + k(A)_i$$ [dB(A)]

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

If the difference between 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 test result (as largest possible value). The total sound pressure level is obtained by energetically adding the one-third octave values.

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

where i indicates the number of one-third octave bands from 100 Hz to 5 kHz. The calculated level $L_{AFeq,n}$ corresponds to the sound pressure level that would arise in a sparsely furnished reception room under otherwise equal conditions. The value represents the installation sound level in the test facility.

With stationary signals (e.g. waste water noise with a constant flow rate), in deviation from DIN 4109-4 and DIN EN ISO 10052 or VDI 4100 it is not the maximum value ($L_{AFmax,n}$, or $\overline{L_{AFmax,nT}}$) but rather the temporally and spatially averaged level ($L_{AFeq,n}$, or $\overline{L_{AFeq,nT}}$) that is measured. This guarantees compliance with the reproducibility and accuracy requirements that are mandatory for test bench measurements (e.g. through the possibility of background noise correction), which would not be realisable with use of the maximum level that is determined according to the aforementioned standards for measurements on the building. On the basis of extensive experience, it is necessary to assume that the difference between $L_{AFmax,n}$ and $L_{AFeq,n}$, or between $\overline{L}_{AFmax,nT}$ and $\overline{L}_{AFeq,nT}$ is a maximum 2-3 dB under normal circumstances.

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 $D_{i,e}$ are the difference between the one-third octave levels $L_{i,AFeq,n-0}$, measured with rigid pipe clamps, and the levels $L_{i,AFeq,n-1}$, measured with the insulating tube or the elastic mounting element under test

(3) $$D_{i,e} = L_{i,AFeq,n-0} - L_{i,AFeq,n-1}$$ [dB]

Additionally the reduction of the A-weighted sound level $\Delta L_{AFeq,n}$ 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.

(4) $$\Delta L_{AFeq,n} = L_{AFeq,n-0} - L_{AFeq,n-1}$$ [dB]

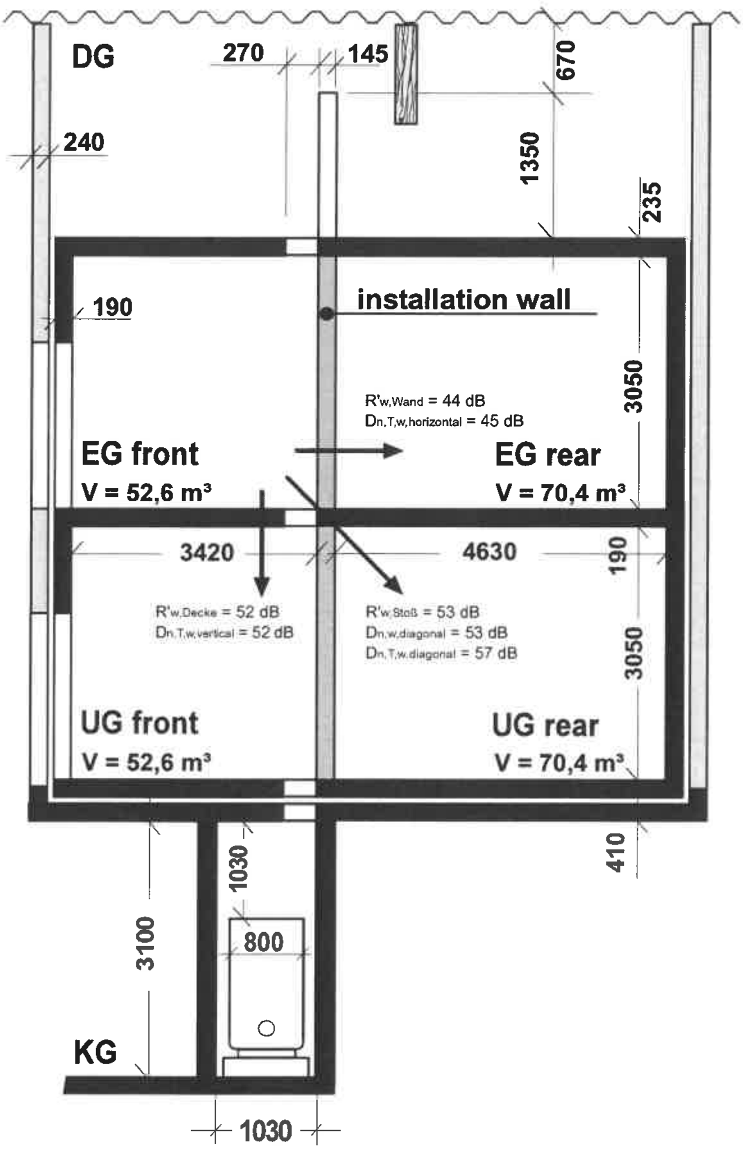
The reduction of the A-weighted sound level represents a measure for the decrease of noise felt by human ear using structure-borne sound insulating tubes or elastic mounting elements. It refers exclusively to the noise spectrum while excitating the pipe system by a stationary water flow (as used at the 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.

Test facility



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.

Measurement equipment

Following measurement equipment was used for the measurments in the installation test facility P12 of the Fraunhofer-Institute for Building Physics:

Device	Type	Manufacturer
Analyser	Soundbook_MK2_8L	Sinus Messtechnik
½"-microphone-Set	46 AF (cartridge: Typ 40 AF-Free Field; pre-amp: Typ 26 TK)	G.R.A.S
½"-microphone-Set (IEPE)	46 AE (cartridge: Typ 40 AE-Free Field; pre-amp: Typ 26 CA)	G.R.A.S
1"-microphone-Set	40HF (cartridge: Typ 40EH-LowNoise; pre-amp: Typ 26HF; Power Module: Typ 12HF)	G.R.A.S
1"-microphone	4179	Bruel & Kjær
1"-preamplifier	2660	Bruel & Kjær
Microphone-calibrator	4231	Bruel & Kjær
Accelerometer	4371 and 4370	Bruel & Kjær
Conditioning amplifier	Nexus 2692-A-0I4	Bruel & Kjær
Accelerometer (IEPE)	352B	PCB Piezotronics, Inc.
Accelerometer-calibrator	VC11	MMF
Amplifier	LBB 1935/20	Bosch Plena
Loudspeaker	MLS 82	Lanny
Reference sound source	382	Rox
Standard tapping machine	211	Norsonic

The used Analyser is a type-approved Class 1 sound level meter. All measurement devices are tested frequently by internal and external testing laboratories, are calibrated and if necessary gauged.

Fraunhofer
IBP

Institution for testing, supervision and certification, officially recognized by the building supervisory authority. Approvals of new building materials, components and types of construction

Director
Prof. Dr. Philip Leistner
Prof. Dr. Klaus Peter Sedlbauer

Test Report P-BA 160/2018e

Noise behaviour of insulation material for wastewater installation systems

Client: Abey Australia Pty Ltd
57-81 Abey Road
Cobblebank
VIC 3338
Australia

Test object: Acoustic lagging for wastewater installation systems "Soundlag 4525C" (manufacturer: Pyrotek) in combination with a "Rigid Clamp" (Item no.: 5174, "100 mm PVC WELDED NUT CLIP", manufacturer: Abey) and a wastewater system consisting of plastic pipes (OD 110 x 3.4).

Content:

Results sheet 1:	Summary of test results
Figure 1 and 2:	Detailed results, installation sound level
Figure 3 and 4:	Detailed results, insertion loss
Figure 5 to 7:	Test specimen, measurement set-up
Annex H3:	Realisation of measurement, Evaluation of measuring data and determination of acoustic parameters, Scope of the measurements
Annex P:	Description of test facility

Test date: The measurement was carried out on May 23, 2018 in the test facilities of the Fraunhofer Institute for Building Physics in Stuttgart.

Stuttgart, August 22, 2018

Responsible Test Engineer: Head of Laboratory:

M.Sc. B. Kaltbeitzel M.BP. Dipl.-Ing.(FH) S. Öhler

The test was carried out in a laboratory, accredited according to DIN EN ISO/IEC 17025:2005 by DAkkS. The accreditation certificate is D-PL-11140-11-01.

Fraunhofer-Institut für Bauphysik - Prüflabor Bauakustik und Schallimmissionsschutz
Nobelstraße 12, D-70569 Stuttgart
Telefon +49(0) 711/970-3314; Fax -3406
akustik@ibp.fraunhofer.de
www.pruefstellen.ibp.fraunhofer.de/de/akkreditierte-prueflabore.html

ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-PL-11140-11-01

Determination of the A-sound pressure level reduction $\Delta L_{AFeq,n}$ in the Laboratory

P-BA 160/2018e

Results sheet 1

Client: Abey Australia Pty Ltd, 57-81 Abey Road, Cobblebank, VIC 3338, Australia

Test specimen: Acoustic lagging for wastewater installation systems "Soundlag 4525C" (manufacturer: Pyrotek) in combination with a "Rigid Clamp" (Item no.: 5174, "100 mm PVC WELDED NUT CLIP", manufacturer: Abey) and a wastewater system consisting of plastic pipes (OD 110 x 3.4) (test object no.: 11212-3; see figure 5, 6 and 7).

Test set-up:

- Acoustic lagging for wastewater installation systems "Soundlag 4525C" (manufacturer: Pyrotek), made of elastomer foam (blue convoluted foam) with outer mass loaded layer and foil facing. Standard thickness of 27 mm and a barrier weight of 5 kg/m² (manufacturer's information). All straight pipes, fittings and pipe clamps were covered with cut sheet material of "Soundlag 4525C".
- Commercial wastewater system (one-layer pipes: Material PP, wall thickness 4.6 mm, weight 2.7 kg/m, density 1.8 g/cm³, values measured by IBP.) consisting of wastewater pipes (nominal size OD 110), 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 (see figure 5 and 6).
- Pipe clamps "Rigid Clamp" (Item no.: 5174, "100 mm PVC WELDED NUT CLIP", Abey), tightening torque 3 Nm (completely closed), mounted with plastic dowels and thread rods to the installation wall. In each storey (EG and UG) two pipe clamps were installed.
- **Reference set-up**: Wastewater system with bare (unlagged) pipe, plus "Rigid Clamp" (Abey). Pipe installed according to EN 14366 with foam in the floor openings (pipe not grouted into ceiling and floor openings, see figure 5 and 7).
- **Test set-up**: Wastewater system with acoustic lagging "Soundlag 4525C" (Pyrotek), plus "Rigid Clamp" (Abey). Pipe grouted into ceiling and floor openings (between the installation rooms EG front, UG front and sub-basement) with 50mm mortar around the insulation, resulting in acoustic isolation of the pipe from the ceiling and floor (see figure 6 and 7).

The test set-up was mounted by a technician under the authority of Fraunhofer IBP.

Test facility: Installation test facility P12, mass per unit area of the installation wall: 220 kg/m², mass per unit area of the ceiling: 440 kg/m². Installation rooms: top floor (DG), ground floor (EG) front, basement (UG) front and sub-basement (KG); measuring room: basement UG front and UG rear. (For further details, please refer to Annex P.)

Test method: The measurements were performed following DIN 4109 and EN 14366; 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 H3 and P).

Result:

Installation Sound Level $L_{AFeq,n}$ [dB(A)], following to DIN 4109					
Flow rate [l/s]		0.5	1.0	2.0	4.0
Reference set-up: Wastewater system with bare (unlagged) pipe, plus "Rigid Clamp" (Abey). Pipe installed according to EN 14366 with foam in the floor openings.	UG front	41	45	47	50
	UG rear	15	19	24	28
Test set-up: Wastewater system with acoustic lagging "Soundlag 4525C" (Pyrotek), plus "Rigid Clamp" (Abey). Pipe grouted into ceiling and floor openings with mortar around the insulation.	UG front	21	25	29	34
	UG rear	13	16	21	25
A-sound pressure level reduction $\Delta L_{AFeq,n}$ in dB	UG front	20	20	18	16
	UG rear	2	3	3	3

Test date: May 23, 2018

Notes:

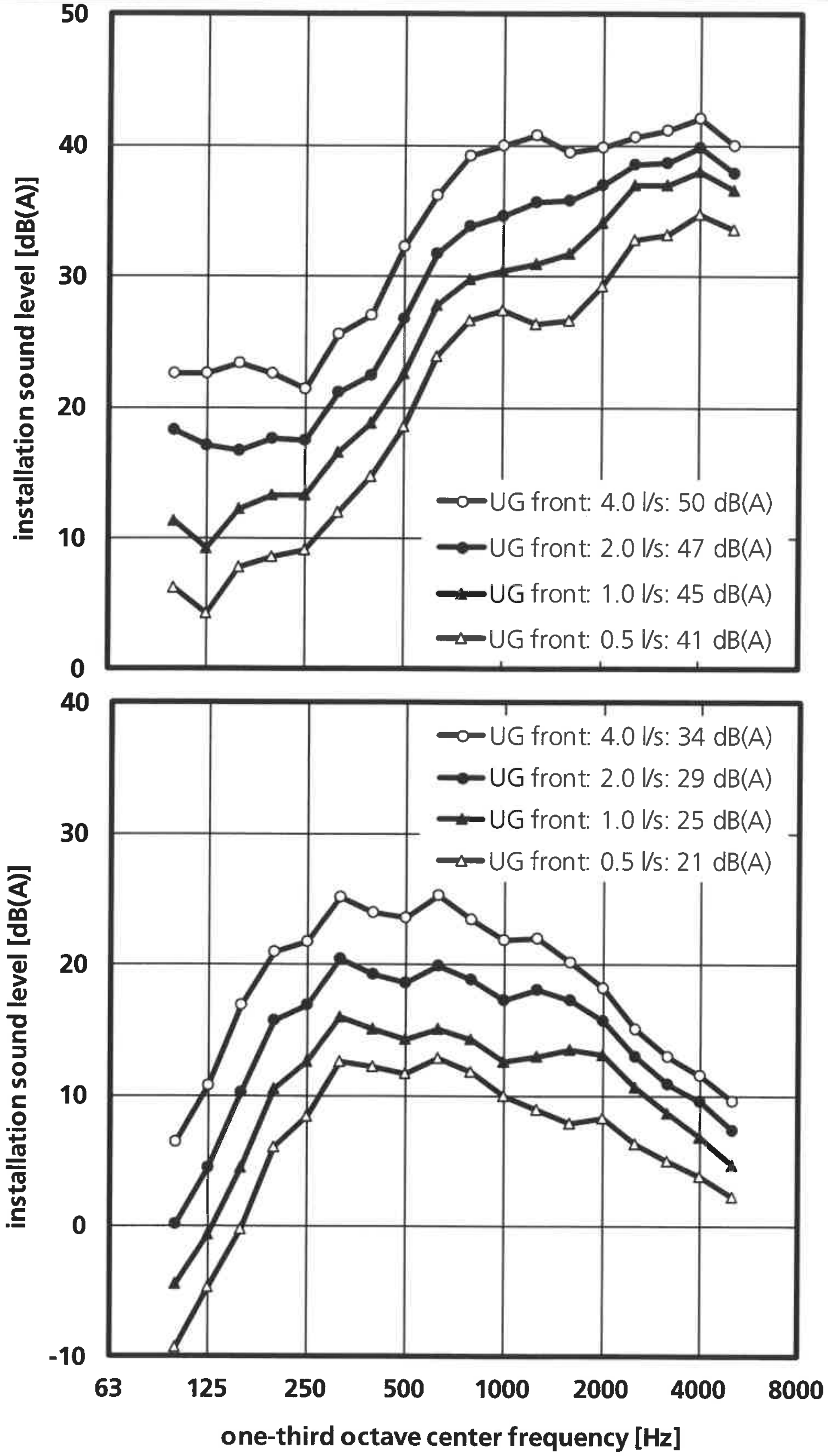
- The reduction of the A-weighted sound level represents a measure for the decrease of noise felt by human ear using structure-borne sound insulating tubes or elastic mounting elements. It refers exclusively to the noise spectrum while exciting the pipe system by stationary water flow (as used at the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

Fraunhofer IBP

The test was carried out in a laboratory, accredited according to DIN EN ISO/IEC 17025:2005 by DAkkS. The accreditation certificate is D-PL-11140-11-01.

Stuttgart, August 22, 2018

Head of Laboratory:



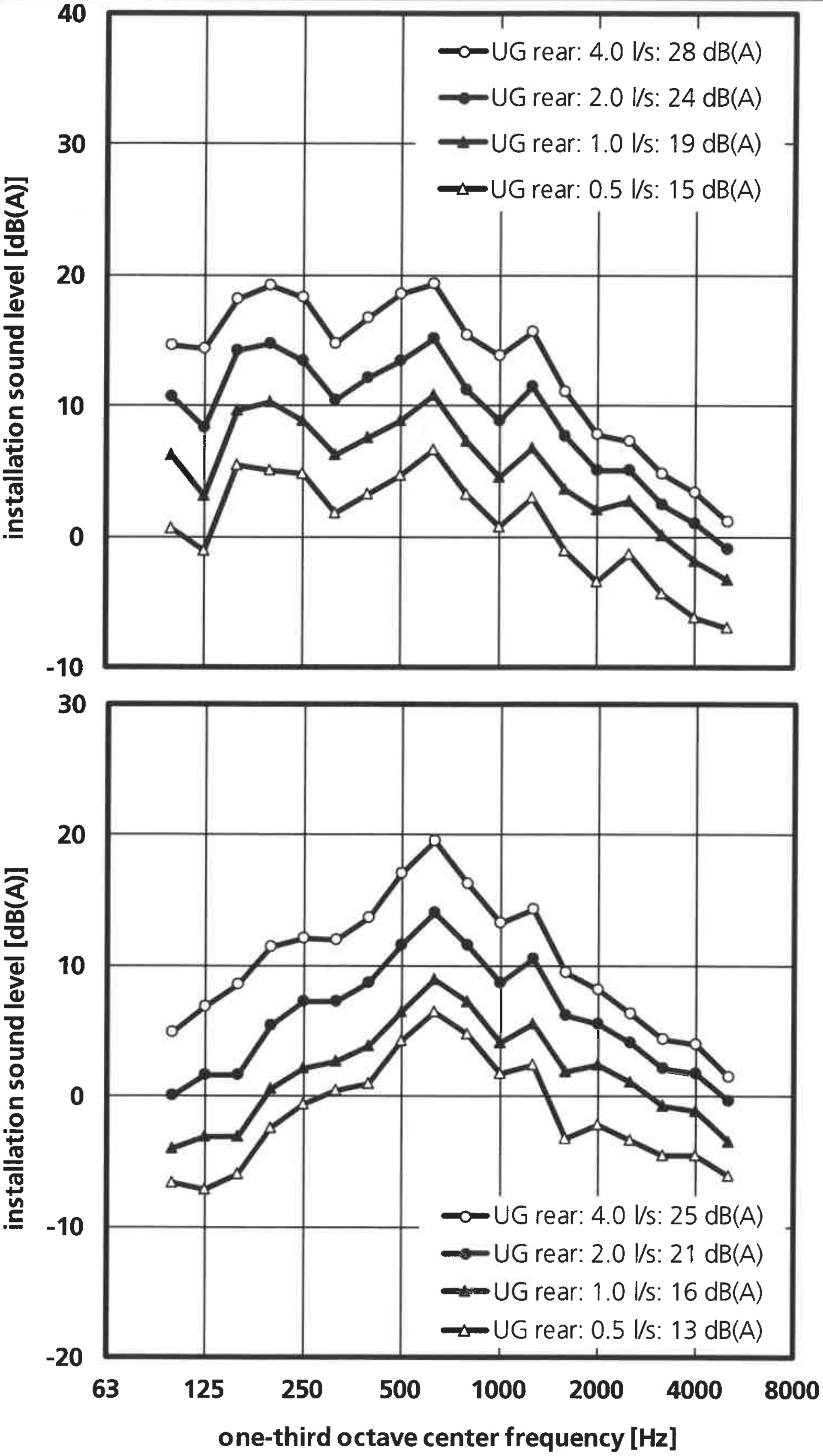
Frequency response of the installation sound level $L_{AFeq,n}$ measured at various flow rates in the test room **UG front** for

Reference set-up (above): Wastewater system with bare (unlagged) pipe, plus "Rigid Clamp" (Abey). Pipe installed according to EN 14366 with foam in the floor openings.

Test set-up (below): Wastewater system with acoustic lagging "Soundlag 4525C" (Pyrotek), plus "Rigid Clamp" (Abey). Pipe grouted into ceiling and floor openings with mortar around the insulation.

The installation sound levels $L_{AFeq,n}$ in dB(A) following DIN 4109, for the reproduced frequency range from 100 to 5000 Hz, are represented in the legend.

Detailed results	P-BA 160/2018e
Client: Abey Australia Pty Ltd, 57-81 Abey Road, Cobblebank, VIC 3338, Australia	figure 2

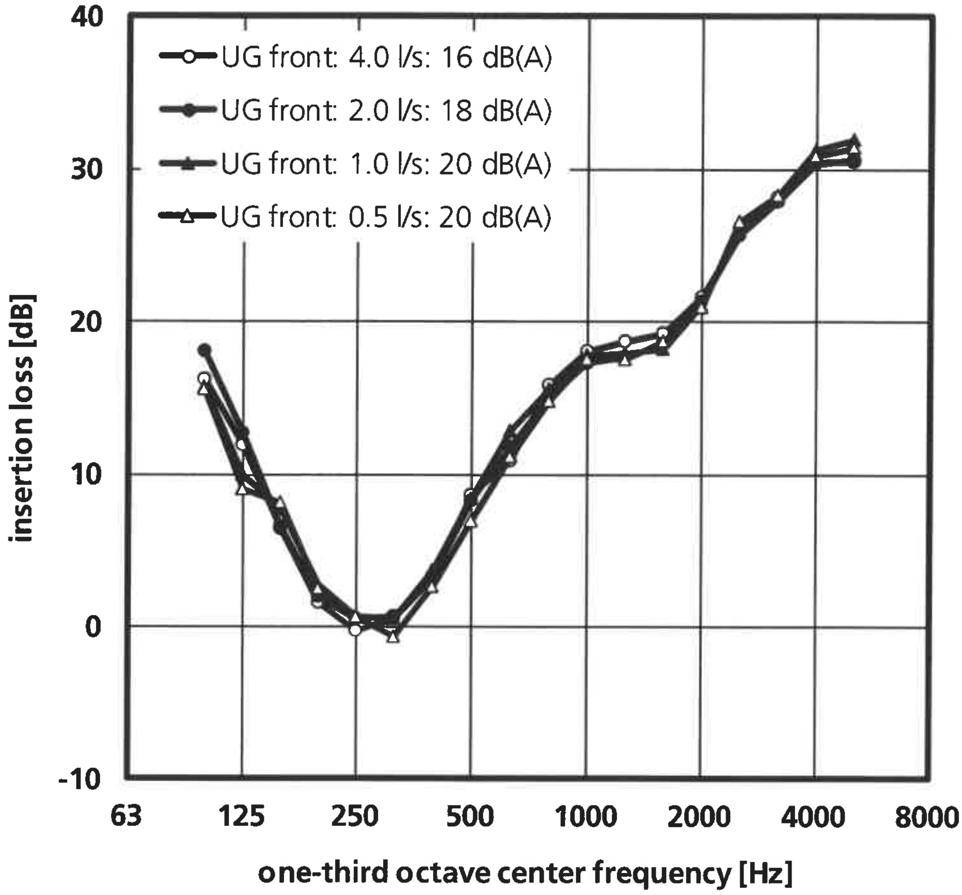


Frequency response of the installation sound level $L_{AFeq,n}$ measured at various flow rates in the test room **UG rear** for

Reference set-up (above): Wastewater system with bare (unlagged) pipe, plus "Rigid Clamp" (Abey). Pipe installed according to EN 14366 with foam in the floor openings.

Test set-up (below):Wastewater system with acoustic lagging "Soundlag 4525C" (Pyrotek), plus "Rigid Clamp" (Abey). Pipe grouted into ceiling and floor openings with mortar around the insulation.

The installation sound levels $L_{AFeq,n}$ in dB(A) following DIN 4109, for the reproduced frequency range from 100 to 5000 Hz, are represented in the legend.



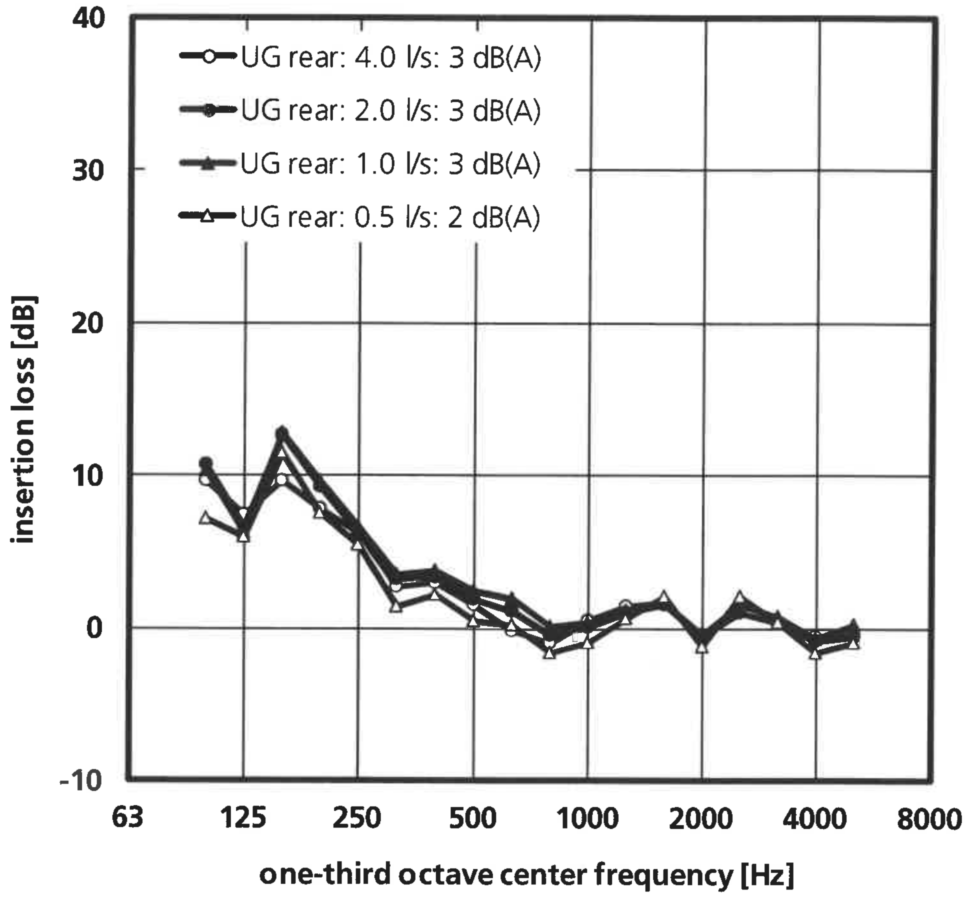
Frequency response of insertion loss D_e by noise excitation at various flow rates 4.0 l/s, 2.0 l/s, 1.0 l/s and 0.5 l/s, measured in the test room **UG front**. The A-weighted reduction of sound level $\Delta L_{AFeq,n}$ (referring to excitation by the various flow rates), for the reproduced frequency range from 100 to 5000 Hz, are represented in the legend.

Test specimens:

Reference set-up: Wastewater system with bare (unlagged) pipe, plus "Rigid Clamp" (Abey). Pipe installed according to EN 14366 with foam in the floor openings.

Test set-up:Wastewater system with acoustic lagging "Soundlag 4525C" (Pyrotek), plus "Rigid Clamp" (Abey). Pipe grouted into ceiling and floor openings with mortar around the insulation.

Details about the test set-up in results sheet 1.



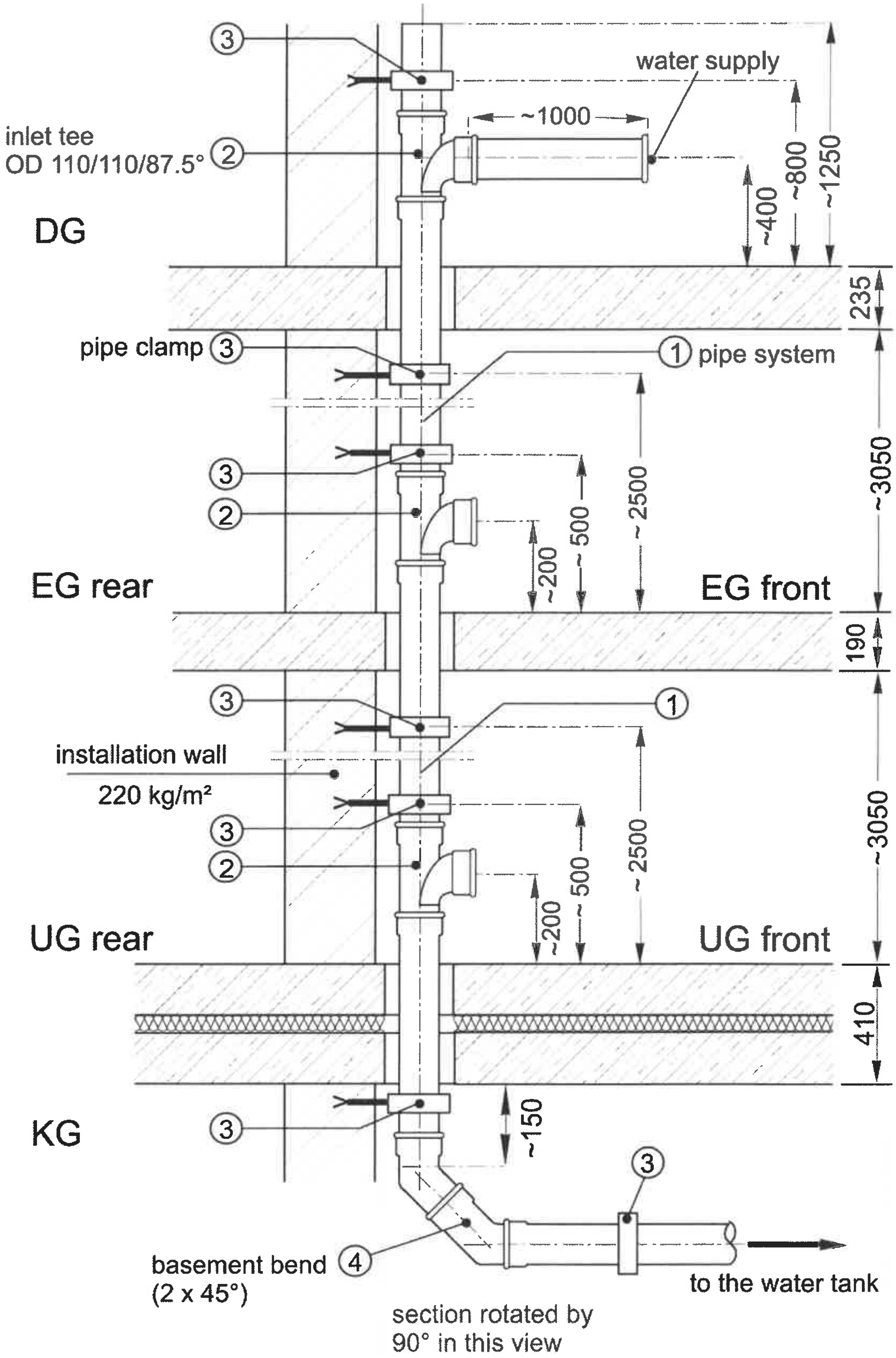
Frequency response of insertion loss D_e by noise excitation at various flow rates 4.0 l/s, 2.0 l/s, 1.0 l/s and 0.5 l/s, measured in the test room **UG rear**. The A-weighted reduction of sound level $\Delta L_{AFeq,n}$ (referring to excitation by the various flow rates), for the reproduced frequency range from 100 to 5000 Hz, are represented in the legend.

Test specimens:

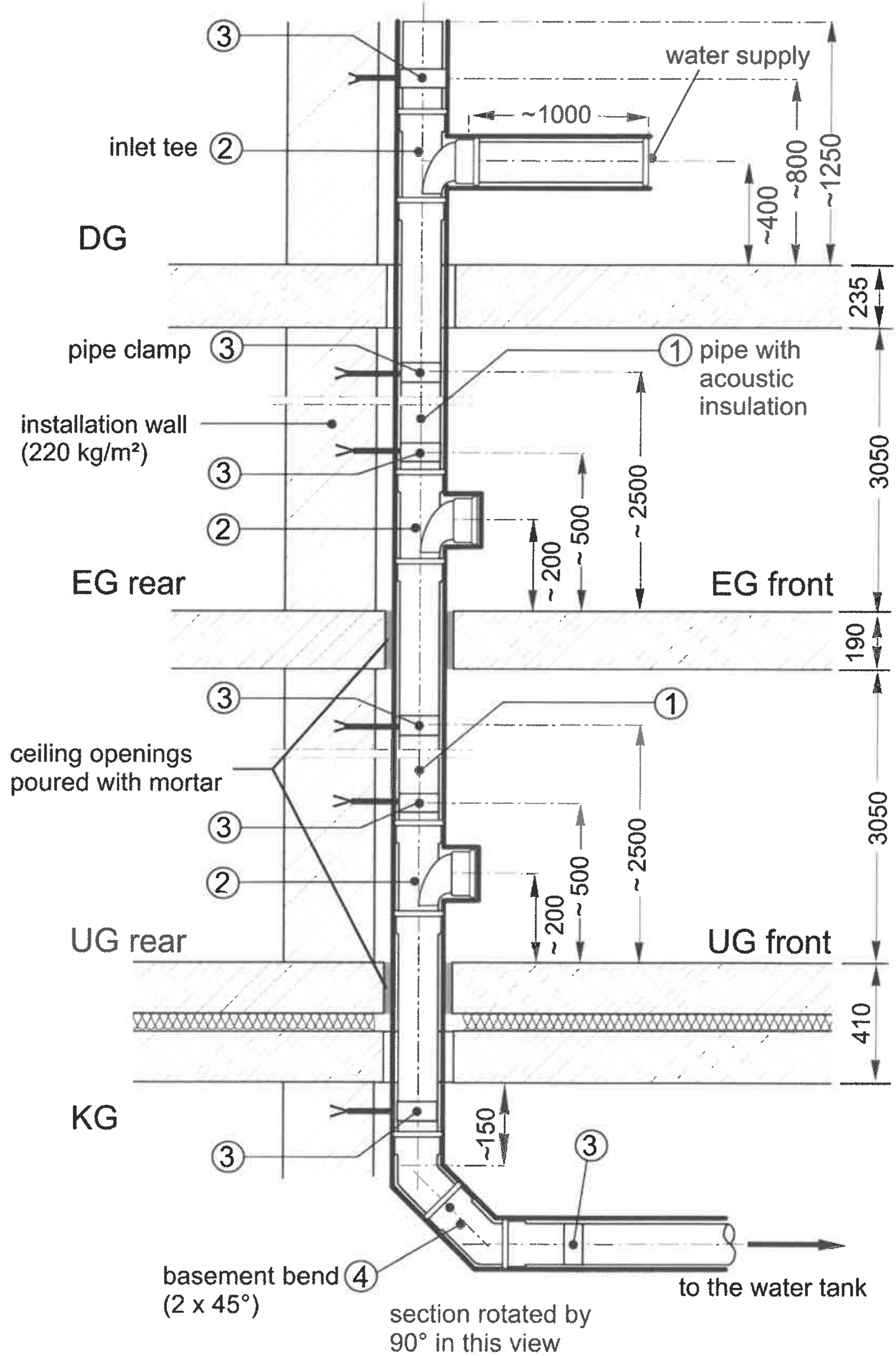
Reference set-up: Wastewater system with bare (unlagged) pipe, plus "Rigid Clamp" (Abey). Pipe installed according to EN 14366 with foam in the floor openings.

Test set-up: Wastewater system with acoustic lagging "Soundlag 4525C" (Pyrotek), plus "Rigid Clamp" (Abey). Pipe grouted into ceiling and floor openings with mortar around the insulation.

Details about the test set-up in results sheet 1.



Installation plan of the reference set-up. Wastewater system consisting of plastic pipes (OD 110 x 3.4) and "Rigid Clamp", Abey (drawing not to scale, dimensions in mm).



Installation plan of the acoustic lagging "Soundlag 4525C", Pyrotek, for wastewater installation systems, in combination with a wastewater system consisting of plastic pipes (OD 110 x 3.4) and "Rigid Clamp", Abey (drawing not to scale, dimensions in mm). Pipe fully grouted into ceiling and floor openings.

Installation of the acoustic lagging "Soundlag 4525C", Pyrotek, for wastewater installation systems, in combination with a wastewater system consisting of plastic pipes (OD 110 x 3.4) and "Rigid Clamp", Abey. Pipe fully grouted into ceiling and floor openings.
Reference set-up (above): Wastewater system with bare (unlagged) pipe, plus "Rigid Clamp" (Abey). Pipe installed according to EN 14366 with foam in the floor openings.
Test set-up (below):Wastewater system with acoustic lagging "Soundlag 4525C" (Pyrotek), plus "Rigid Clamp" (Abey). Pipe grouted into ceiling and floor openings with mortar around the insulation.

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 compared to an unlagged pipe. The measurements are performed following to DIN EN 14366 and the German standards DIN EN ISO 10052 and DIN 4109, in which in situ measurements of the noise behavior of 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 bare (unlagged) pipe. Pipe installed according to EN 14366 with foam in the floor openings (pipe not grouted into ceiling and floor openings).
2. Measurement of the installation sound level of the same pipe supplied with the structure-borne sound insulating tube under test. Pipe grouted into ceiling and floor openings (between the installation rooms EG front, UG front and sub-basement) with 50mm mortar around the insulation, resulting in acoustic isolation of the pipe from the ceiling and floor.

Noise excitation and evaluation parameters

Any defined and metrological reproducible noise excitation requires steady state flow conditions inside the wastewater 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 ceiling and 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. According to DIN EN ISO 10140-4 the sound pressure level is picked up at six points in the room, to be space and time-averaged and corrected for the background noise.

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.

Reference set-up

To determin the insertion loss of the samples a bare waste water pipe is installed according to EN 14366 with foam in the floor openings (pipe not grouted into ceiling and floor openings). The test facility is shown schematically in annex P. The reference set-up resembles in all details (except for the pipe insulating material) 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 pipe is covered by the pipe insulation under test befor it is additionally grouted into ceiling and floor openings. In case of structure-borne sound insulating tubes the pipe is completely encased in the insulating material.

Evaluation of measuring data and determination of acoustic parameters

The measured sound pressure level is given as time and space averaged one-third octave spectrum in the frequency range between 100 Hz and 5 kHz. First, the measured value is corrected for background noise. Subsequently, it is normalized to an equivalent sound absorption area of A_0 = 10 m² and A-weighted:

(1) $$L_{i,AFeq,n} = 10 \cdot \lg\left(10^{\frac{L_{i,F}}{10}} - 10^{\frac{L_{i,F,GG}}{10}}\right) + 10 \cdot \lg\frac{A_i}{A_0} + k(A)_i$$ [dB(A)]

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

If the difference between 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 test result (as largest possible value). The total sound pressure level is obtained by energetically adding the one-third octave values.

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

where i indicates the number of one-third octave bands from 100 Hz to 5 kHz. The calculated level $L_{AFeq,n}$ corresponds to the sound pressure level that would arise in a sparsely furnished reception room under otherwise equal conditions. The value represents the installation sound level in the test facility.

With stationary signals (e.g. waste water noise with a constant flow rate), in deviation from DIN 4109-4 and DIN EN ISO 10052 or VDI 4100 it is not the maximum value ($L_{AFmax,n}$, or $L_{AFmax,nT}$) but rather the temporally and spatially averaged level ($L_{AFeq,n}$, or $L_{AFeq,nT}$) that is measured. This guarantees compliance with the reproducibility and accuracy requirements that are mandatory for test bench measurements (e.g. through the possibility of background noise correction), which would not be realisable with use of the maximum level that is determined according to the aforementioned standards for measurements on the building. On the basis of extensive experience, it is necessary to assume that the difference between $L_{AFmax,n}$ and $L_{AFeq,n}$, or between $\overline{L_{AFmax,nT}}$ and $\overline{L_{AFeq,nT}}$ is a maximum 2-3 dB under normal circumstances.

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 $D_{i,e}$ are the difference between the one-third octave levels $L_{i,AFeq,n-0}$, measured with rigid pipe clamps, and the levels $L_{i,AFeq,n-1}$, measured with the insulating tube or the elastic mounting element under test

(3) $$D_{i,e} = L_{i,AFeq,n-0} - L_{i,AFeq,n-1}$$ [dB]

Additionally the reduction of the A-weighted sound level $\Delta L_{AFeq,n}$ 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.

(4) $$\Delta L_{AFeq,n} = L_{AFeq,n-0} - L_{AFeq,n-1}$$ [dB]

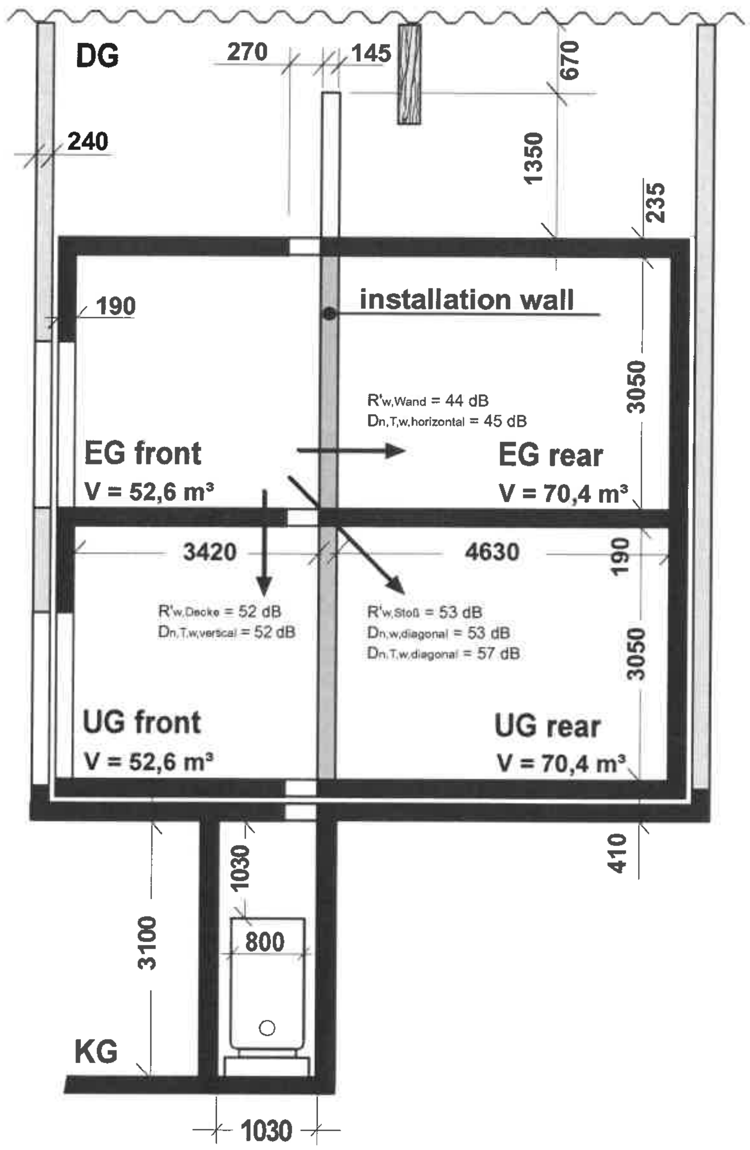
The reduction of the A-weighted sound level represents a measure for the decrease of noise felt by human ear using structure-borne sound insulating tubes or elastic mounting elements. It refers exclusively to the noise spectrum while excitating the pipe system by a stationary water flow (as used at the 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.

Test facility



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.

Measurement equipment

Following measurement equipment was used for the measurments in the installation test facility P12 of the Fraunhofer-Institute for Building Physics:

Device	Type	Manufacturer
Analyser	Soundbook_MK2_8L	Sinus Messtechnik
½"-microphone-Set	46 AF (cartridge: Typ 40 AF-Free Field; pre-amp: Typ 26 TK)	G.R.A.S
½"-microphone-Set (IEPE)	46 AE (cartridge: Typ 40 AE-Free Field; pre-amp: Typ 26 CA)	G.R.A.S
1"-microphone-Set	40HF (cartridge: Typ 40EH-LowNoise; pre-amp: Typ 26HF; Power Module: Typ 12HF)	G.R.A.S
1"-microphone	4179	Bruel & Kjær
1"-preamplifier	2660	Bruel & Kjær
Microphone-calibrator	4231	Bruel & Kjær
Accelerometer	4371 and 4370	Bruel & Kjær
Conditioning amplifier	Nexus 2692-A-0I4	Bruel & Kjær
Accelerometer (IEPE)	352B	PCB Piezotronics, Inc.
Accelerometer-calibrator	VC11	MMF
Amplifier	LBB 1935/20	Bosch Plena
Loudspeaker	MLS 82	Lanny
Reference sound source	382	Rox
Standard tapping machine	211	Norsonic

The used Analyser is a type-approved Class 1 sound level meter. All measurement devices are tested frequently by internal and external testing laboratories, are calibrated and if necessary gauged.

Marshall Day Acoustics Pty Ltd
ABN: 53 470 077 191
6 Gipps Street
Collingwood VIC 3066
Australia
T: +613 9416 1855
www.marshallday.com

14 December 2018

Abey Pty Ltd
57-81 Abey Rd
Cobblebank Vic 3338
Australia

Attention: Ashley Anderson

Dear Ashley,

ABEY ACOUSTIC CLAMP – TEST RESULTS REVIEW

This letter provides an overview of the recent testing undertaken by Abey Pty Ltd at the Fraunhofer Institute in Germany. This letter also provides a summary of the likely reduction in noise when the Abey Acoustic Clamp is used in lieu of a standard clamp for several typical installation scenarios.

The test reports considered for this review are;

P-BA 158/2018e – Noise behaviour of a pipe clamp with elastomer inlay for waste water systems in the laboratory

P-BA 159/2018e - Noise behaviour of insulation material for wastewater installation systems

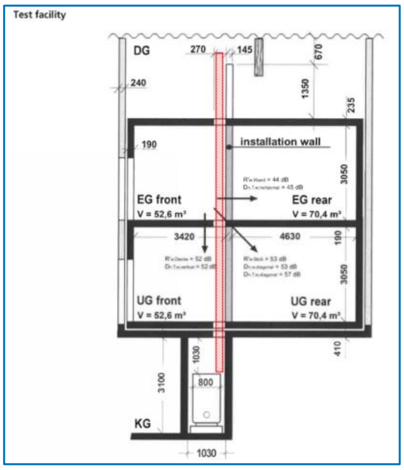
P-BA 160/2018e – Noise behaviour of insulation material for wastewater installation systems

All our estimations are based on the results from these tests undertaken at the Fraunhofer Institute.

INTRODUCTION

The acoustic tests were undertaken at the Fraunhofer Institute in Stuttgart, which has a purpose built concrete facility for measuring noise levels from waste pipes. The waste pipe being tested passes through two 'source' rooms (aka 'front' rooms) before terminating in a basement. The pipe is fixed to a concrete wall which is part of two additional 'receiver' rooms (aka 'rear' rooms) which allows for the structure borne noise measurements. A schematic of the layout is shown in Figure 1 with the pipe shown in red.

Figure 1: Test facility schematic



The results in Table 1 have been sourced from the Fraunhofer reports referenced above.

We have concentrated our review on the test results of the 2 l/s water flow which is the standard flow in most domestic situations. The lagging referred to is Pyrotek 4525C lagging (27mm thick, 5kg/m2).

Table 1: NOISE REDUCTION IN ADJACENT SPACE (HABITABLE ROOM) - Test result summary & comment

Item	Pipe Scenario	Pipe Clamp Type*	Reduction in noise level in ADJACENT SPACE if separated by a concrete wall to which the pipe is fixed**	Comment
1	Pipe is not lagged	Rigid	0dB (reference)	This is the starting condition or reference
2	Pipe is not lagged	Abey Acoustic	-8dB	The Abey acoustic clamps reduce noise levels by a significant 8dB
3	Pipe is lagged	Rigid	-3dB	There is a small reduction of 3dB from lagging the pipes. The clamps are still Rigid.
4	Pipe is lagged	Abey Acoustic	-11dB	By having acoustic clamps AND lagging, the total reduction is 11dB

Table 2: NOISE REDUCTION IN THE SAME SPACE AS THE PIPE - Test result summary & comment

Item	Pipe Scenario	Pipe Clamp Type*	Reduction in noise in the SAME SPACE as where the pipe is located	Comment
5	Pipe is not lagged	Rigid	0 (reference)	This is the starting condition or reference.
6	Pipe is not lagged	Abey Acoustic	0dB	The acoustic clamps do not reduce noise levels when considering noise levels in the same space as the pipe.
7	Pipe is lagged	Rigid	-18dB	Pipe lagging reduces noise levels significantly.
8	Pipe is lagged	Abey Acoustic	-18dB	Pipe lagging reduces noise levels significantly but there is no additional reduction from using the acoustic pipe clamps.

* The Rigid clamps were standard bolted 100mm PVC (non-acoustic). The acoustic clamps were Abey Acoustic 100mm PVC (elastomer lined) – [Patent Pending].

** For example the pipe is in a masonry riser and fixed to the riser wall. The listener is in an adjoining room which shares the riser wall.

DISCUSSION

The tests demonstrate the effect of structure borne noise from a pipe and clamp system.

The tests demonstrate two important concepts:

A) ADJACENT HABITABLE SPACE: When considering the structure borne noise from a pipe and clamp system, the tests demonstrate that the noise levels can be reduced by a further 8dB if using the Abey Acoustic clamp fixed to the dividing wall element. For critical applications where pipes are routed next to sensitive spaces the clamps will provide a high level of structural isolation and will allow the critical space to have a lower background noise level. For example, if a bedroom or recording studio has concrete walls, and if on the outside of those concrete walls, waste or storm water pipes are fixed using normal rigid clamps, noise from those pipes is likely to be audible in the bedroom or studio due to very low background noise levels. If the clamps were replaced with Abey Acoustic clamps, noise levels would be reduced by up to 8dB (as indicated by the tests). This is a substantial reduction that would be clearly noticeable in the adjacent space.

B) PIPE SPACE: When considering the noise levels in the same space as where the pipe is located, for example the pipe is located in a ceiling void or a riser, and one is considering what the acoustic clamp does to noise levels within that space itself, the tests demonstrate that the acoustic clamp does not reduce noise levels in that space. In other words, interchanging between a Rigid clamp and an Abey Acoustic clamp would not change noise levels if you were next to the pipe. Likewise, if the pipe is bare (not lagged) or lagged, using the acoustic clamp does not affect noise levels from the pipe in the same space.

Yours faithfully

MARSHALL DAY ACOUSTICS PTY LTD

Martin Butyn

Associate