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
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Test Report P-BA 23/2021e

Determination of the acoustic performance of a shower area with a shower channel in the laboratory

Client: Kessel AG
Bahnhofstraße 31
85101 Lenting

Test object: Shower channel, type: "Linearis Infinity 60" with floor drain body, fixed with "sound and settlement absorber" of Kessel AG, as line drainage system for a ground levelled shower area, installed on the floor and the wall in a floating screed.

Content:

Test date: The measurement was carried out on January 27, 2021 in the test facilities of the Fraunhofer Institute for Building Physics in Stuttgart.

Stuttgart, June 16, 2021

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

The test was carried out in a laboratory, accredited according to DIN EN ISO/IEC 17025:2018 by DAkkS. The accreditation certificate is D-PL-11140-11-01.

Determination of Installation Sound Level $L_{AFeq,n}$ in the Laboratory

P-BA 23/2021e

Results sheet 1

Client: Kessel AG, Bahnhofstraße 31, 85101 Lenting

Test specimen: Shower channel, type: "Linearis Infinity 60" with floor drain body, fixed with "sound and settlement absorber" of Kessel AG, as line drainage system for a ground levelled shower area, installed on the floor and the wall in a floating screed (test specimen: S-11601-1); see figure 3 – 5.

Test set-up: Shower area consisting of a partial floating screed area with shower channel type: "Linearis Infinity 60" of Kessel AG. Drain body installed with sound insulation dowels, type: "KESSEL sound and settlement absorbers" to the floor and acoustic decoupling to the wall. The plastic drain body was fixed to the floor with "settlement absorbers" (left corner of the test facility).

Floor drain system:

- Plastic drain body (PP) installed according assembly instructions on the floor with 4 hanger bolts screwed into sound insulation dowels, type "KESSEL sound and settlement absorbers"; acoustic decoupling to the wall was made out of a 4 mm thick moulded part out of foam between drain body an wall. Waterproofing membrane was installed and drainage pipe (DN 40) with pipe insulation was connected to the drain body.
- mineral fibre - impact sound insulation boards (thickness: 25 mm, dynamic stiffness s' = < 10 MN/m³, manufacturer specifications)) were laid on the floor and covered with PE-foil. The area of bolts and dowels as well as of the drain body and pipe were left out. Foil fixed to the drain body and drainage pipe by tape.

Partial floating screed area: with edge insulation strips at the walls (strips left out in the area of the rear side of the floor drain body). Setup from bottom to top:

- mineral fibre - impact sound insulation board (thickness: 25 mm, dynamic stiffness s' = < 10 MN/m³, manufacturer specifications)) covered by PE-foil as separating layer (penetrations were taped),
- min. 55 mm cement screed with a slope to the drainage. The shower channel and the shower area were sealed with sealing tapes and liquid sealing and subsequently tiles were laid on the screed (15 mm tiles with adhesive).

Total height: approx. 85 mm - 100 mm.
All connection joints were sealed with foam round cord and commercial silicone.
The wastewater is drained low-noise into a basin in the installation room EG front.
Preparation of the shower area by a handicraft enterprise ordered by 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 (19 cm concrete). Installation room: EG front; measuring rooms: UG front, UG rear and EG rear. (For further details, please refer to Annex P.)

Test method: Measurement following DIN EN ISO 10052:2010-10 and DIN 4109-4:2016-07 at excitation by standard source for structure-borne noise (KGN, Annex B, F, G). Additional calculation of the measurements for comparison with requirements in VDI 4100:2012-10, ÖNORM B 8115-2:2006 and SIA 181:2006 (see table 1). Additional measurement of the impact sound reduction following DIN EN ISO 16283-2:2016-05 (see figure 1).

Result:

Shower channel, type: "Linearis Infinity 60" with floor drain body, fixed with "sound and settlement absorber" of Kessel AG, as line drainage system for a ground levelled shower area, installed on the floor and the wall in a floating screed (test specimen: S-11601-1).	measurement room		
	UG front (vertical)	UG rear (diagonal)	EG rear (horizontal)
Installation Sound Level $L_{AFeq,n}$ in dB(A) following DIN 4109			
standard source for structure-borne noise (KGN) on shower tray	19[1)]	17	23[1)]

1) The requirements of German standard DIN 4109 apply in the present building situation only for the test room UG rear.

Test date: January 27, 2021

Notes: - Compared to the generated sound level the excitation by a KGN is the upper limit of commercial shower heads and draw-off taps.

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Fraunhofer IBP

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Stuttgart, June 16, 2021
Head of Laboratory:

Evaluation of the measurements in accordance with:

- VDI 4100:2012-10 (Sound insulation between rooms in buildings -Dwellings- Assessment and proposals for enhanced sound insulation between rooms; details in Annex V).
- ÖNorm B 8115-2:2006 (Sound insulation and room acoustics in building constructions – Part 2: Requirements for sound insulation; informative).
- SIA 181:2020 (Swiss standard – sound insulation in building constructions; informative)

Test specimen:

Shower channel, type: "Linearis Infinity 60" with floor drain body, fixed with "sound and settlement absorber" of Kessel AG, as line drainage system for a ground levelled shower area, installed on the floor and the wall in a floating screed (test specimen: S-11601-1).

For further details on the test set-up, see results sheet 1 and figures 3 to 5.

Results:

Shower channel, type: "Linearis Infinity 60" with floor drain body, fixed with "sound and settlement absorber" of Kessel AG, as line drainage system for a ground levelled shower area, installed on the floor and the wall in a floating screed (test specimen: S-11601-1).	measurement room		
	UG front (vertical)	UG rear (diagonal)	EG front (horizontal)
Installation Sound Level $\overline{L_{AFeq,nT}}$ in dB(A) following VDI 4100			
Standard source for structure-borne noise (KGN) on shower tray	17[1)]	14	19[1)]
Anlagengeräuschpegel $L_{AFeq,nT}$ in dB(A) following ÖNorm B 8115-2			
standard source for structure-borne noise (KGN) on shower tray	17	14	19
Total value $L_{H,tot}$ in dB(A) following SIA 181			
Operation noise: standard source for structure-borne noise (KGN)	17	14	19
User noise: EMPA-Pendelfallhammer	31	28	32

1) The requirements of VDI 4100 apply in the present building situation "bathroom (EG front) above bathroom (UG front - vertical)" only for the test room UG rear (diagonal).

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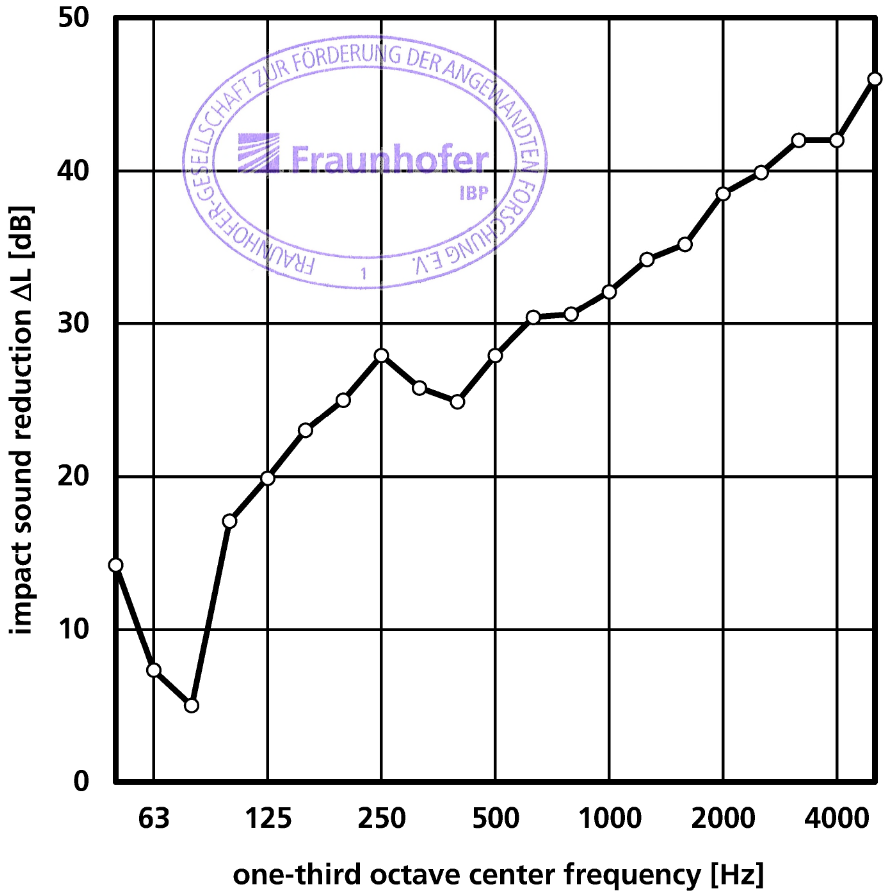


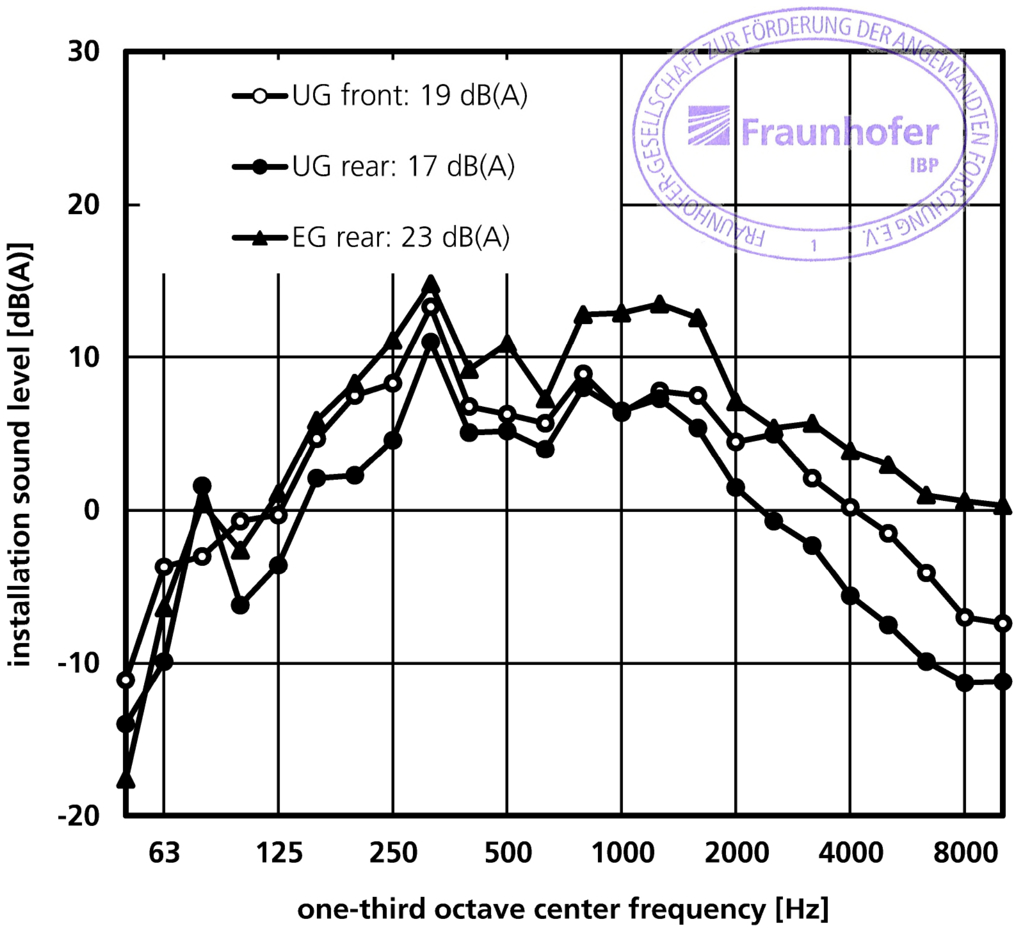
Weighted impact sound reduction index and spectrum adaption term acc. to DIN EN ISO 717-2
ΔL_w ($C_{I,\Delta 100\text{-}2500}$) = 35 (-8) dB

The measurements were performed following DIN EN ISO 16283-2 by excitation with a standard tapping machine. The impact sound level was measured in the test room UG front (vertical) by excitation both on the shower tray and on the laboratory floor.

Test specimen:

Shower channel, type: "Linearis Infinity 60" with floor drain body, fixed with "sound and settlement absorber" of Kessel AG, as line drainage system for a ground levelled shower area, installed on the floor and the wall in a floating screed (test specimen: S-11601-1).

For further details on the test set-up, see results sheet 1 and figures 3 to 5.



Frequency response of installation sound level by noise excitation with a standard source for structure-borne noise (KGN), measured in the test rooms UG front (vertical), UG rear (diagonal) and EG rear (horizontal). The installation sound levels $L_{AFeq,n}$ in dB(A) according DIN 4109, for the reproduced frequency range from 100 to 5000 Hz, are represented in the legend.

Test specimen:

Shower channel, type: "Linearis Infinity 60" with floor drain body, fixed with "sound and settlement absorber" of Kessel AG, as line drainage system for a ground levelled shower area, installed on the floor and the wall in a floating screed (test specimen: S-11601-1). The waste water is drained low-noise into a basin in the installation room EG front.

For further details on the test set-up, see results sheet 1 and figures 3 to 5.

<u>Top left:</u> Plastic drain body (PP) installed on the floor with 4 hanger bolts screwed into sound insulation dowels, type "KESSEL sound and settlement absorbers"; acoustic decoupling to the wall out of a 4 mm thick moulded part out of foam between drain body an wall. Insulation strip at the wall was left out in the area of the rear side of the floor drain body.

<u>Top right</u>: mineral fibre - impact sound insulation boards (thickness: 25 mm, dynamic stiffness s' = < 10 MN/m³, manufacturer specifications)) were laid on the floor. The area of bolts and dowels as well as of the drain body and pipe were left out.

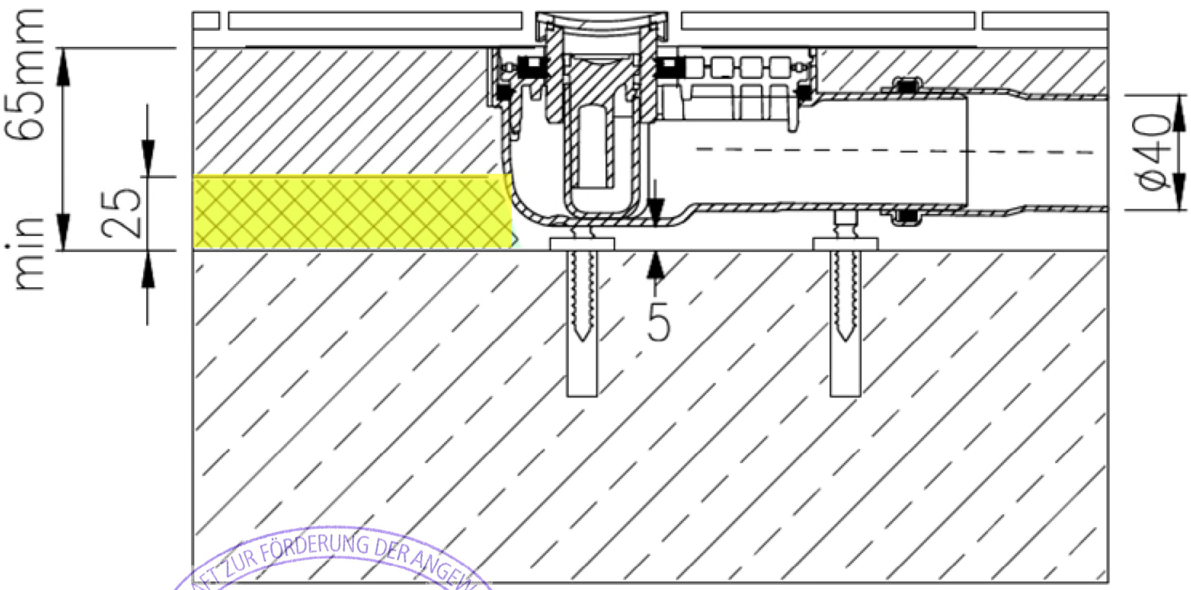
<u>Bottom left</u>: Partial floating screed area with edge insulation strips at the walls (strips left out in the area of the rear side of the floor drain body). Mineral fibre below the screed covered with PE-foil

<u>Bottom right:</u> Finished installation. Setup from bottom to top:

- mineral fibre - impact sound insulation board (thickness: 25 mm, dynamic stiffness s' = < 10 MN/m³, manufacturer specifications)) covered by PE-foil as separating layer (penetrations were taped),
- min. 55 mm cement screed with a slope to the drainage. The shower channel and the shower area were sealed with sealing tapes and liquid sealing and subsequently tiles were laid on the screed (15 mm tiles with adhesive).

All connection joints were sealed with foam round cord and commercial silicone.

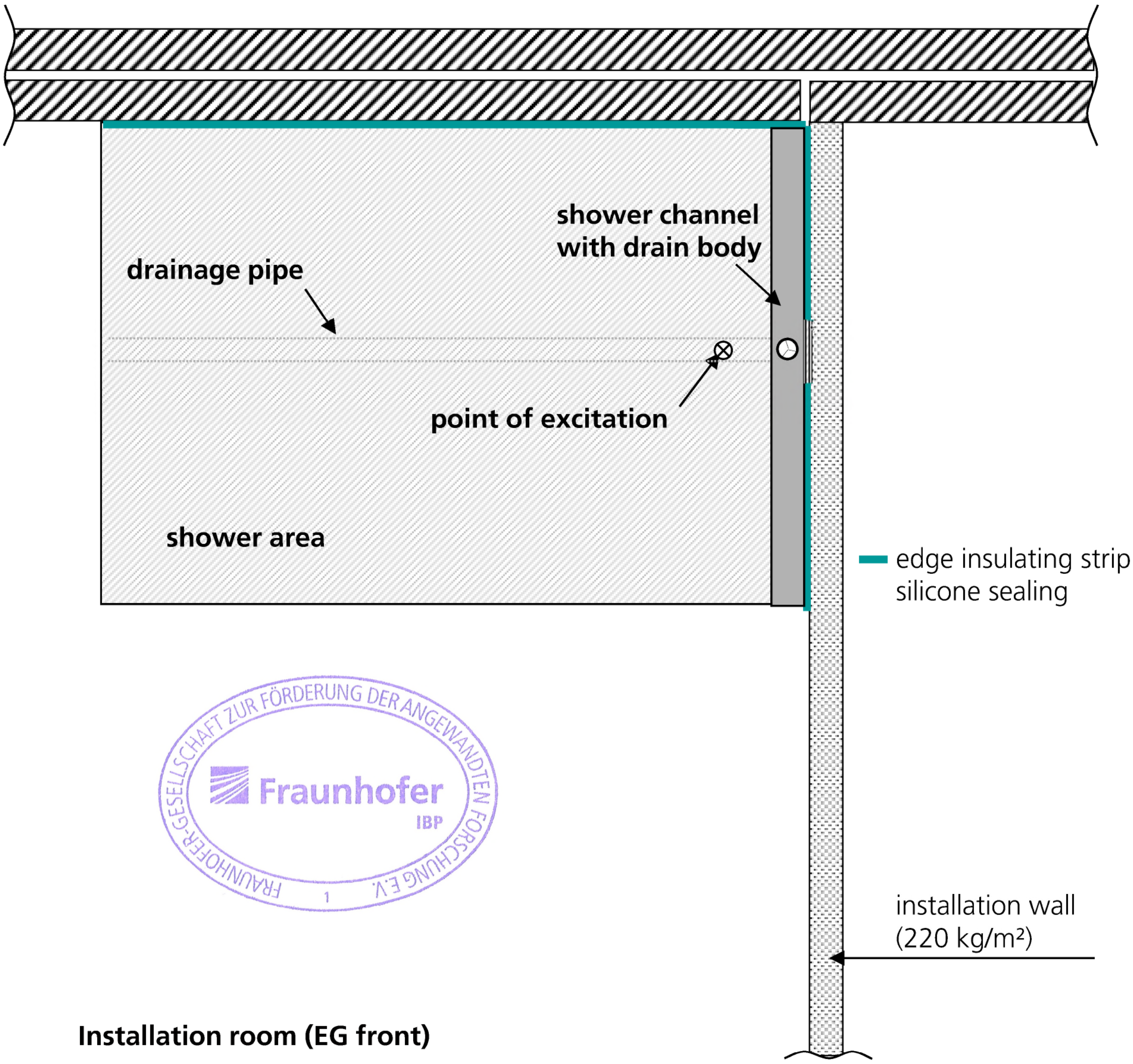
For further details on the test set-up, see results sheet 1 and figures 3 to 5.



Sectional drawing of the test set-up (drawing and information of the client).

Shower channel, type: "Linearis Infinity 60" with floor drain body, fixed with "sound and settlement absorber" of Kessel AG, as line drainage system for a ground levelled shower area, installed on the floor and the wall in a floating screed (test specimen: S-11601-1).

For further details on the test set-up, see results sheet 1 and figures 3 to 5.



Position of the test set-up in the installation room (EG front).

Shower channel, type: "Linearis Infinity 60" with floor drain body, fixed with "sound and settlement absorber" of Kessel AG, as line drainage system for a ground levelled shower area, installed on the floor and the wall in a floating screed (test specimen: S-11601-1).

For further details on the test set-up, see results sheet 1 and figures 3 to 5.

Realization of measurement and determination of acoustic parameters

The measurements are performed following German standards DIN EN ISO 10052 and DIN 4109-4, which describes acoustical measurements of water installations in buildings. The noise excitation occurs by using a standard source for structure-borne noise (KGN) which is developed and proved from the Fraunhofer-Institute of Building Physics. A standardized source for installation noise (IGN) according to DIN EN ISO 3822-1 is used as a jet nozzle. The KGN generates a steady jet of water which hits under exactly defined geometrical conditions on the tub or the water surface and allows thus a practical and reproducible noise excitation. The use of the KGN as a consistent source of excitation enables a comparison of the noise behavior of different sanitary objects. The KGN is operated with a pressure of 0.3 MPa and a steady water flow of 0.25 l/s (±4 %).

Compared to the generated sound level the excitation by a KGN is the upper limit of commercial shower heads and draw-off taps. The variation of the excitation area and of the filling level allows simulating the impact noise of the drops of water on the tubs surface or water surface originated by showering as well as the noise originated by filling the tub. At this the following kinds of excitation are possible:

<u>KGN, tub without water</u>
At a height of 50 cm above the bottom of the tub the KGN is fixed and adjusted in a manner that the jet hits the tubs surface vertically in a distance of 10 cm to the water drain. The measurement is performed with an opened water drain.

<u>KGN, tub partly water-filled</u>
The same procedure as described above but with a partly water-filled tub (level of the water: 12 cm) so that the jet hits the water surface.

<u>KGN as a draw-off tap (water intake)</u>
The KGN is installed at the position of the water intake of a commercial draw-off tap at a height of 50 cm above the bottom of the tub and the jet point's vertical upwards. The KGN is operated by a plugged drain of the tub until the tub is filled. This measurement can be performed in addition to the method described in the German standard DIN EN ISO 10052.

<u>Commercial shower heads or draw-off taps</u>
Instead of the KGN alternatively commercial shower heads or draw-off taps can be used to excite the test specimen. The shower head will be mounted in a height of 100 cm and adjusted in such a way that the water jet hits the tubs surface vertically in a distance of 10 cm to the water drain. Because of the numerous commercial shower heads or draw-off taps and their different setting possibilities, a universally valid statement about the installation noise level is impossible.

Excitation by aggregates (whirl systems)
The excitation of the test specimen occurs by the aggregates of the system (pumps, air and water jets, etc.), whereas in general different operation states are possible. The loudest operation state of the whirl system will be determined while recording the highest sound pressure level (measurement at one microphone position) with different settings of the aggregates. Therefore the tub is filled with water until 5 cm below the overflow. Nevertheless, on reason of the numerous operation states, it is not excluded completely that in special cases a little higher level can be recorded.

General information about the measuring
To account the influence of a person sitting or standing in the tub, all measurements are performed by a static preload (except for measurements of whirl systems or during the filling of the tub). Therefore, a plastic barrel filled with 60 l of water is placed on two bricks (separated from the bottom of the tub with a rubber) in the tub with a distance to the point of excitation with the KGN from ca. 40 cm. The weight of the barrel averages 65 kg and the foot print is approximately 2 x 200 cm².

The waste water is drained low-noise through structure-borne sound isolated pipes. By this it is ensured that the noise of the waste water has no effect onto the measured sound pressure level.

While performing measurements with stationary noise, the sound pressure level is recorded - differing from German standard DIN EN ISO 10052 - the sound pressure level is recorded at six points spread 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. The value that was determined in this way is used as the installation sound level $L_{AFeq,n}$ in the laboratory.

Measurements which are noise variable with time (WC-flushing, KGN as s draw-off tap) are performed with only one microphone position. The sound pressure level is recorded during e.g. the flushing of the WC. The installation sound pressure level ($L_{AFmax,n}$) is equivalent to the highest measured value.

Evaluation of Measurements

Stationary noise

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.

Time-dependent noise

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 at the same place with a time interval of 0.125 s. The evaluation is performed in the same way as in the case of stationary noise, with the exception that background noise correction is not performed. After evaluation the maximum value ($L_{AFmax,n}$) is determined from the measured time response.

Scope of measurements (DIN 4109)

Transferability of the results to other building situations
The determined installation sound level depends on both the properties of the examined installation and other influences like mounting conditions, building construction and the arrangement of sending and receiving room. Therefore, the values given in the test report only applies to the architectural conditions in the installation test facility. Transfer to other constructions is only possible if the architectural conditions are similar and the installation is mounted in the same way. In this context, even small changes of the mounting conditions (as for example the use of different fastening elements or insulating materials) can cause large acoustic changes. The same applies to faulty workmanship which can cause structure-borne sound bridges.

Proof of noise control requirements
The noise control requirements given in the German standard DIN 4109 refer to the in situ noise situation in buildings. The installation sound level $L_{AFmax,n}$ (or $L_{AFeq,n}$ for stationary noise) is the decisive acoustic parameter for noise caused by water installations and other technical equipment in buildings. It has to be measured in accordance with German standard DIN 4109-4 and the international standard ISO 10052. So far noise peaks caused by manual operation are not considered. According to the current version of DIN 4109 the following requirements apply to the installation sound level:

Living- and bedrooms: $L_{AFmax,n} \leq 30$ dB (A)
Class- and workrooms: $L_{AFmax,n} \leq 35$ dB (A)

Measurements in a prototype building are the only existing possibility to prove the compliance with the noise control requirements in the planning phase already. In this case, the prototype building and the planned construction must be of the same kind. Otherwise, regarding the transmission of installation noise it must be guaranteed that the planned construction has no smaller sound insulation than the prototype building.

For the present measurements the test facility for water installations in the Fraunhofer-Institute of Building Physics serves as prototype building. Concerning its acoustical properties, the Fraunhofer test facility represents a usual residential building in massive construction. If the transferability of the results to other building situations is ensured (see above), the installation sound level determined in this test facility can be directly used to confirm the noise control requirements given in DIN 4109. Since the installation is mostly mounted in the room EG front, the measuring room UG rear represents the noise sensitive room according to DIN 4109. For that reason, the installation sound level measured in this room has to meet the noise control requirements mentioned above.

Statement on measurement uncertainty
Values for the uncertainty by measuring installation noise in buildings can be found in DIN 4109-4. The measurement uncertainty can be adopted for the results determined in prototype buildings as mentioned in the test report.

The measurement uncertainty is given as follows

$$u_{situ} = \begin{cases} 5.0\ \text{dB} - 0.1 \times L_{AF,\ldots}, & \text{for } L_{AF,\ldots} < 35\ \text{dB} \\ 1.5\ \text{dB}, & \text{for } L_{AF,\ldots} \geq 35\ \text{dB} \end{cases}$$

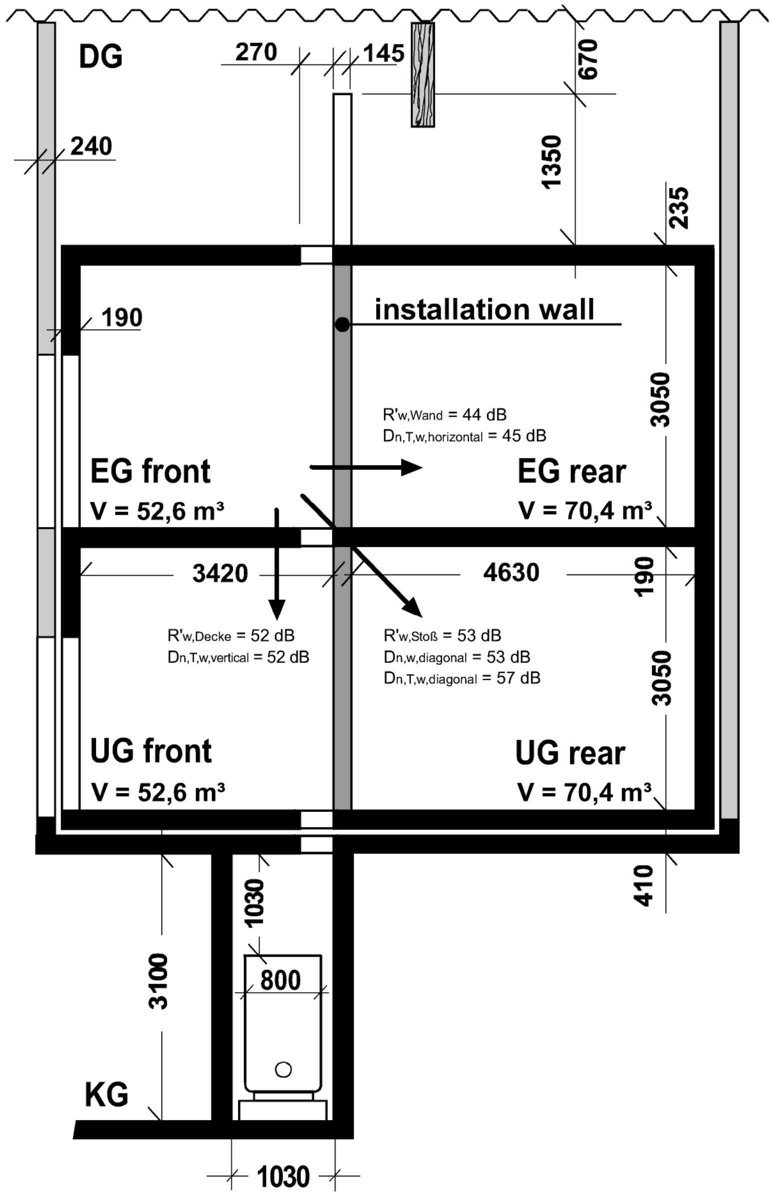
with

u_{situ} uncertainty by measuring installation noise in buildings (situ),
$L_{AF,\ldots}$ measured value $L_{AF,max,n}$ oder $L_{AF,max,nT}$ bzw. $L_{AFeq,n}$ oder $L_{AFeq,nT}$.

For a measured value of 30 dB the measurement uncertainty would be 2.0 dB. At lower installation sound levels, the uncertainty will increase. For example, a measured value of 20 dB will lead to a measurement uncertainty of 3.0 dB.

Conformity statements in test reports, e.g. for the approval of sound protection requirements, are made by taking in account the measurement uncertainties according to the procedures (e.g. standard or guideline) mentioned in the test report. The metrological traceability on reference measurement standards is given for all calibrated measurement equipment.

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/m^2 (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/m^2, 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.

Assessment of increased noise protection according to VDI 4100

The directive VDI 4100 contains suggestions for increased sound insulation in apartments. These suggestions outreach the minimum requirements of DIN 4109, and in addition, can be agreed by the client and the responsible company.

The measurement of noise of sanitary installations is equally carried out in accordance with VDI 4100 and DIN 4109. Details of the method and the evaluation of the results are described in Annex F. The only difference between the two standards is that the measured sound levels in DIN 4109 are related to the equivalent sound absorption area of $A_0 = 10\ m^2$, whereas in VDI 4100 the reverberation time of $T_0 = 0.5$ s is used as a reference value. The relation between the two sound levels is as follows:

$$L_{AF,nT} = L_{AF,n} - 10\ lg(V) + 15$$

with $L_{AF,nT}$ = standardized sound level of noise of sanitary installations according to VDI 4100 [dB(A)]
$L_{AF,n}$ = normalized sound level of noise of sanitary installations according to DIN 4109 [dB(A)]
V = volume of the receiving room [m^3]

The indices A and F describe the frequency weighting "A" and the time weighting "Fast". Depending on whether a time-averaged value or a maximum level is measured, the index "eq" or "max" is added to theses indices. This equally applies for the standardized and normalized sound level, for example $L_{AFeq,nT}$ or $L_{AFmax,n}$.

The standardized sound level according to VDI 4100 and the normalized sound level according to DIN 4109 differ in a constant value which is only dependent on the volume of the receiving room. Whereas the normalized sound level (DIN 4109) is independent of the room volume, the standardized sound level (VDI 4100) is reduced by an increasing room volume. Since the requirements of sound insulation of VDI 4100 are related to the standardized sound level, the values measured in the test facilities of noise of sanitary installations of the IBP must be converted to the volume of the in-situ rooms in need of protection as verification of the requirements. Conversion is carried out according to the following relation:

$$L_{AF,nT,Building} = L_{AF,nT,Lab} + 10\ lg(V_{Lab}/V_{Building})$$

with $L_{AF,nT,Building}$ = standardized sound level of the tested installation at the building
$L_{AF,nT,Lab}$ = standardized sound level of the tested installation in the test facility
V_{Lab} = volume of the receiving room in the test facility
$V_{Building}$ = volume of the room in the building in need of protection

The volumes of the three receiving rooms in the sanitary installation noise test facility of the IBP and diagrams of the previous calculation formula for direct reading of the results can be found in the following:

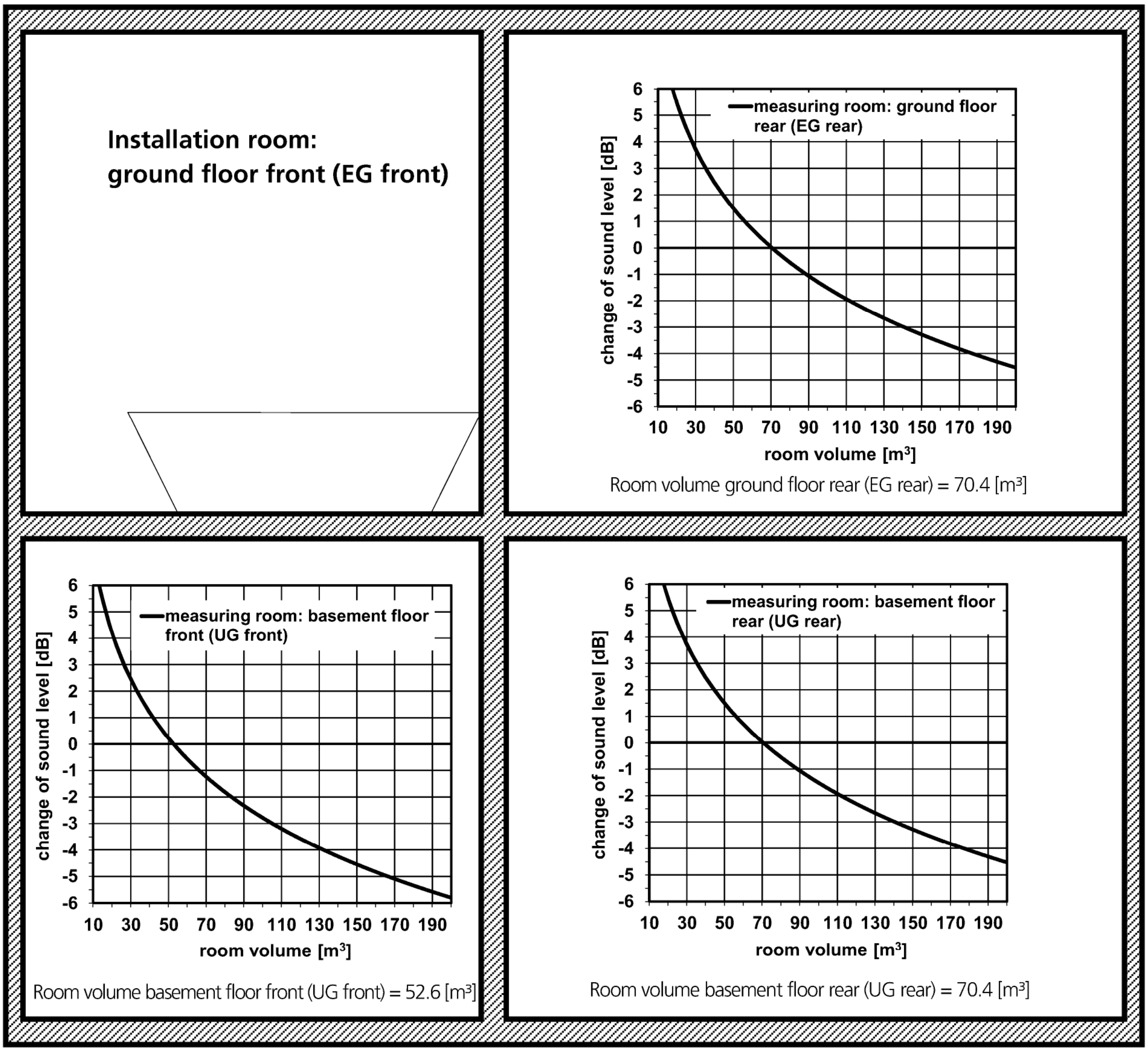


Fig. 1: Modification of the standardized sound level measured in the installation test facility P12 for rooms with deviating volume. The resulting change of sound level in comparison to the measured value indicated in the test report in dependence of the new room volume is specified in the diagrams for the three measuring rooms basement floor front (UG front), basement floor rear (UG rear), and ground floor rear (EG rear). If the volumes of the new room comply with the respective measuring room, the sound level will remain unchanged (modification of level $\Delta L = 0$ dB). If the new room is larger than the respective measuring room, the sound level will be reduced ($\Delta L < 0$). If it is smaller, the sound level will increase ($\Delta L > 0$).

Requirements

According to VDI 4100 all rooms in an apartment with a ground area ≥ 8 m² are considered as rooms in need of protection. Kitchens, bathrooms, WCs, halls and side rooms, however, are explicitly exempted from building installation noise and from impact sound. For common floor plan configuration (bathroom above bathroom) normally the room in the basement floor rear (UG rear) is for the values measured in the test facility the one to be primarily considered as room in need of protection.

The required values are divided according to the sound insulation levels (SSt) in VDI 4100 complying with various comfort levels:

Table 1: Comfort level and acoustic situation for the sound insulation levels I to III according to VDI 4100.

SSt I	„raised in the design and construction compared to a simple one regarding design and construction features“
	„unreasonable annoyance are in general avoided “
SSt II	„average requirements of comfort“
	„in general not disturbing“
SSt III	„special comfort requirements“
	„not or only seldom disturbing“

Different requirements are indicated respectively for the three sound protection levels in VDI 4100. Since sound insulation level III represents the highest comfort level the strictest requirements must be applied, i.e. sound levels allowable for noise of sanitary installations are lowest in this case. The required values for apartment houses or one-family terrace houses and one-family semi-detached houses are represented in the following table:

Table 2: The requirements of sound insulation of building service equipment in for apartment houses or one-family terrace houses and one-family semi-detached houses according to VDI 4100 for sound protection levels I to III. The requirements apply for sound transmission between separated apartments. Noise from water supply installations and sewage systems are considered together.

Building	**Acoustic parameter [dB(A)]**	**Sound protection level I**	**Sound protection level II**	**Sound protection level III**
Apartment houses	$\overline{L_{AFmax,nT}}$ or $\overline{L_{AFeq,nT}}$ a) b)	**≤ 30**	**≤ 27**	**≤ 24**
One-family terrace houses and one-family semi-detached houses	$\overline{L_{AFmax,nT}}$ or $\overline{L_{AFeq,nT}}$ a) b)	**≤ 30**	**≤ 25**	**≤ 22**

a) Individual short-term noise peaks during actuation (opening, closing, adjusting, interrupting, etc.) the fittings and equipment of the plumbing system should not exceed the characteristic values of SSt II and SSt III by more than 10 dB. Here, the intended use is required.

b) Since noise of sanitary installations are frequently temporary changing signals, VDI 4100 provides for the measurement the maximum level $\overline{L_{AFmax,nT}}$. For stationary signals such as impact noise from water jets, however, it is more efficient to determine the average noise level $\overline{L_{AFeq,nT}}$ instead, since only in this way it is possible to observe the requirements for reproducibility and accuracy obligatory for measurements in the test facility. The measured average noise level is generally slightly lower than the maximum level, however, the difference is not more than a maximum of 2 to 3 dB according to extensive experience.

Besides the previously described requirements for sound transmission between separate apartments, VDI 4100 also contains recommendations for sound protection in one's own living space. The effective required values and the importance of the respective sound protection levels can be found in VDI 4100.

Conformity statements in test reports, e.g. for the approval of sound protection requirements, are made by taking in account the measurement uncertainties (following DIN 4109-4) according to the procedures (e.g. standard or guideline) mentioned in the test report. The metrological traceability on reference measurement standards is given for all calibrated measurement equipment.

Note to handle noise emitted by users in VDI 4100:
For user noises, which often result in complaints (e.g. putting down a toothbrush tumbler on a storage board, opening and closing the toilet cover, use of toilets, sliding in the bath tub, striking the doors – also of wall cabinets and built-in cabinets, etc.) neither to the noise control classes SSt II and SSt III no characteristic values were specified, since these noises are very difficult to reproduce and depend on the specific building situation. It is assumed, however, that these noises – by intended use – are reduced as much as possible by application of conventional arrangements for the impact sound insulation when mounting the sanitary equipment.