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Mesurages des bruit d'utilisation des installations sanitaires dans les constructions en bois

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Presentation

1) Introduction

2) In situ measurements

3) Laboratory measurements

4) Discussion and conclusion

1) Introduction

- **Service equipment noise** is one of the main sources of complaints in building noise
- Noise come not only from standard operation but also by **human manipulation of service equipment**
- Since 1988, the **Swiss Standard SIA181** (Protection against noise in building) introduced a distinction between these two types of noise
- The **measurement methodology** for manipulation noise wasn't reliable enough.

Simulation of manipulation noise

Various devices were tested to simulate user noise

Goals:
- repeatability
- reproducibility
- uncoupling evaluation
- Relation with real noise

- Tapping machine
- Concrete test hammer
- Shaker
- **Pendling hammer**

Validation with laboratory and in situ measurements

Introduction

- Need of more information about **reproducibility and application conditions** of the new methodology
- **SIA181 requirements are often exceeded** (K4 factor to be validated)
- Methodology was developed and tested only in **massive constructions** (most frequent in Switzerland).
  Relevance of this measurement method **for lightweight construction** in which decoupling performances and low frequency are particularly important

2) In situ measurements

Wooden multi-storey building

Measurements in wood constructions

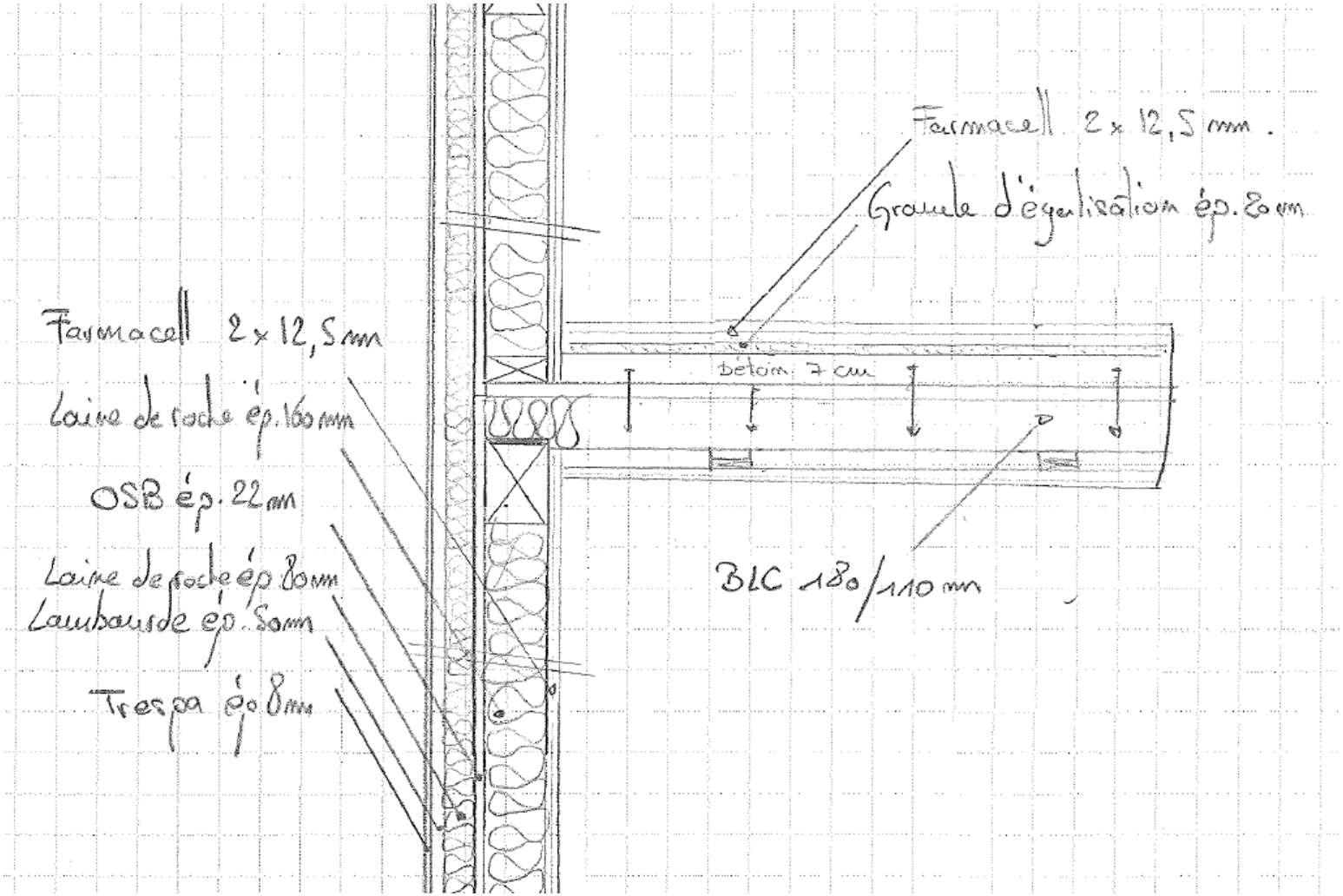
About **3000 hammer measurements** in several configurations and installations in bath rooms (bathtubs, showers, sinks, toilets, shelves) and kitchens (worktops, sinks, cabinets).

- the maximum level $L_{A,F}$ for each hammer impact (min. 12 /SIA181).
- temporal data, spectra and audio recordings
- wideband (1/3 octave from 50 to 5000 Hz) airborne and impact noise insulation.

Five typical swiss wooden constructions types :

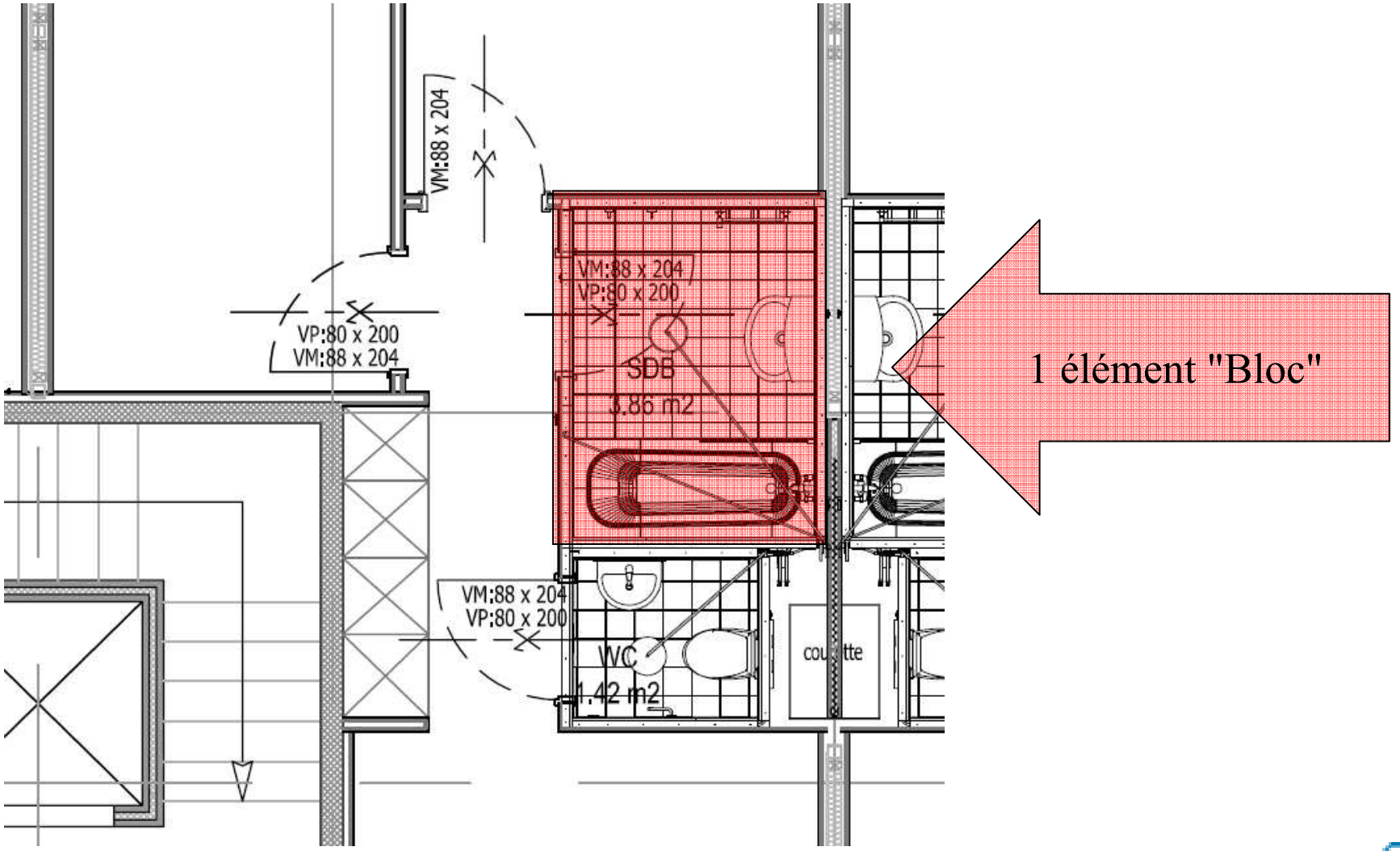
- **E1** standard housing (minimal requirements 2006)
- **E2** student housing (minimal requirements 1988)
- **E3** quality housing (increased requierements 2006)
- **E4** quality housing (increased requierements 2006)
- **E5** quality housing (increased requierements 2006)

Elevation of two storeys Wood-concrete construction (E5)

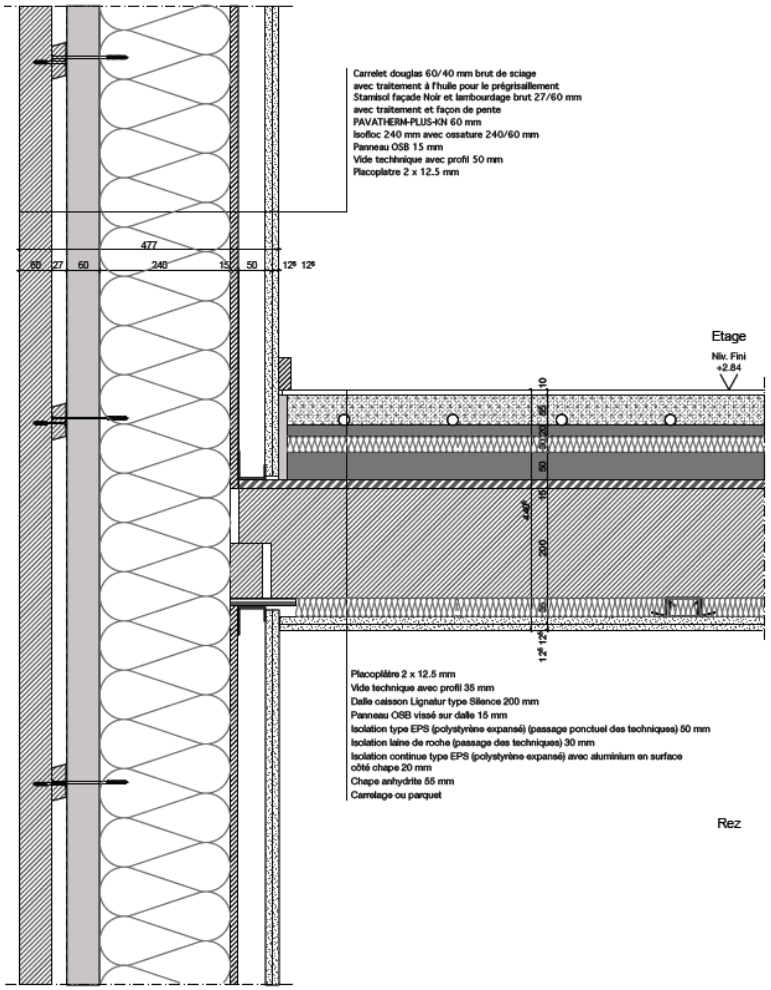


Elevation of two storeys Prefabricated bathroom

Elevation of two storeys Prefabricated bathroom



Quality wood constructions



E3 quality housing
(increased requierements 2006)

Floor: flooring, 5.5 cm anhydrite floor, 2 cm EPS insulation, 3 cm rock wool insulation, 5 cm EPS insulation, 1.5 cm OSB panel, 20 cm wood slab Lignatur Silence, 3 cm plenum, 2x1.25 cm suspended ceiling.

Common walls: 1.25+1.5 cm Fermacell (heavy plasterboard), 2x10 cm frame with Isofloc (cellulose insulation) , 1.25+1.5 cm Fermacell

Results
Type of construction

Minimal Requirements	>52 dB	<53 dB	<38 dBA	# Measurements (% exceeding requirement)	<38 dBA	# Measurements (% exceeding requirement)
Construction	Airborn	Impact	Manipulation in Kitchen		Manipulation in bathroom	
E1	54 ± 1	53 ± 0	44 ± 4	10 (100%)	39 ± 5	16 (62.5%)
E2	50 ± 2	58 ± 4	38 ± 2	4 (50%)	47 ± 4	6 (100%)
E3	55 ± 11	46 ± 7	28 ± 6	2 (0%)	35 ± 5	12 (25%)
E4	60 ± 2	50 ± 0	40 ± 2	8 (75%)	39 ± 7	8 (75%)
E5	64 ± 0	51 ± 12	37 ± 1	4 (0%)	26 ± 1	2 (0%)
Total				28 (64%)		44 (52%)

- For 20% equipment, the average is at least 5 dB higher than the requirements
- Favorable typology leads to the best results (E3 and E5)

Measurements in wood constructions

1) Bruits de courte durée - bruits provoqués par l'utilisateur (marteau)

Local d'émission :	Local de réception:						Lmax - moyen	K4	Niveau $L_{H,tot}$ en dB(A)	Dépassement	Ecart type
Salle de bain, Appartement 12, (1er étage)	Salle de bain, Appartement 2 (rez)										
	K1= 0		V= 50		Cv= 0						
	L_{max}- Position 1			L_{max} - Position 2							
Lavabo	57	56.4	56.9	58.3	57.6	57.7	58	-12	46	3	1.6
	56.5	56.7	57.7	57.5	61.2	57.7					
	58.9	59.2	58.9	57.4	61.1	57.8					
	56	55.9	55.8	60.1	60.7	57.6					
	58.5	56.1	55.8	61.2	57.8	57.9					
Baignoire	65.5	58.4	51.6	64.3	57.3	52.5	59	-12	47	4	4.8
	65.6	58.9	51.8	64.2	57.3	52.7					
	66.3	59.1	51.7	65.2	57.8	52.4					
	66.5	59	51.6	65	57.5	52.5					
	67	58.9	54.4	65.6	57.5	52.4					
	65.1	58.6	54.6	62.3	59.1	54					
	65.2	59.4	54.5	62.4	59.7	53.8					
	65	59.7	54.3	61.1	59.8	54.1					
	65.1	59.7	54.3	61.9	60.2	53.6					
	64.4	59.7	54.3	61.7	60	54.1					
WC	61.2	61.2	61.2	61	61.1	61	61	-7	54	11	0.1
	61.1	61.1		61	61.1						

Quality wood construction E3 bathroom to bathroom with airborne transmission

Insufficient airborne sound insulation (DnT,w=40 dB in E3 due to common ventilation duct) induces significant increase of the manipulation noise of service equipment.

Desarnaulds & Beffa., Marteau EMPA dans les construction en bois

Results- Measurement techniques

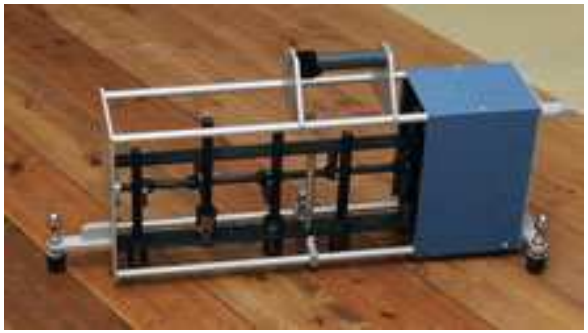
1. La répétabilité des mesurages (d'une même installation)

Ecart type σ	min	max	moyenne	écart type
baignoire	2.6	6.7	**4.4**	1.3
lavabo	0.2	1.6	**1.2**	0.6
WC	0.1	1.3	**0.6**	0.5

Repeatability (12 measurements of a same installation) is good for toilets and sinks, (σ =0.6 and 1.2 dB) but significant disparity for bathtub values (σ = 4.4 dB), difference between the hammer impact on the edge (rigid or semi-rigid contacts) and the bottom of the bathtub.

Results- Measurement techniques

With different methodologies, the requirements are on average 5 dB more severe with the pendulous hammer according to standard tapping machine for the same floating screed floor and a walk-in shower.



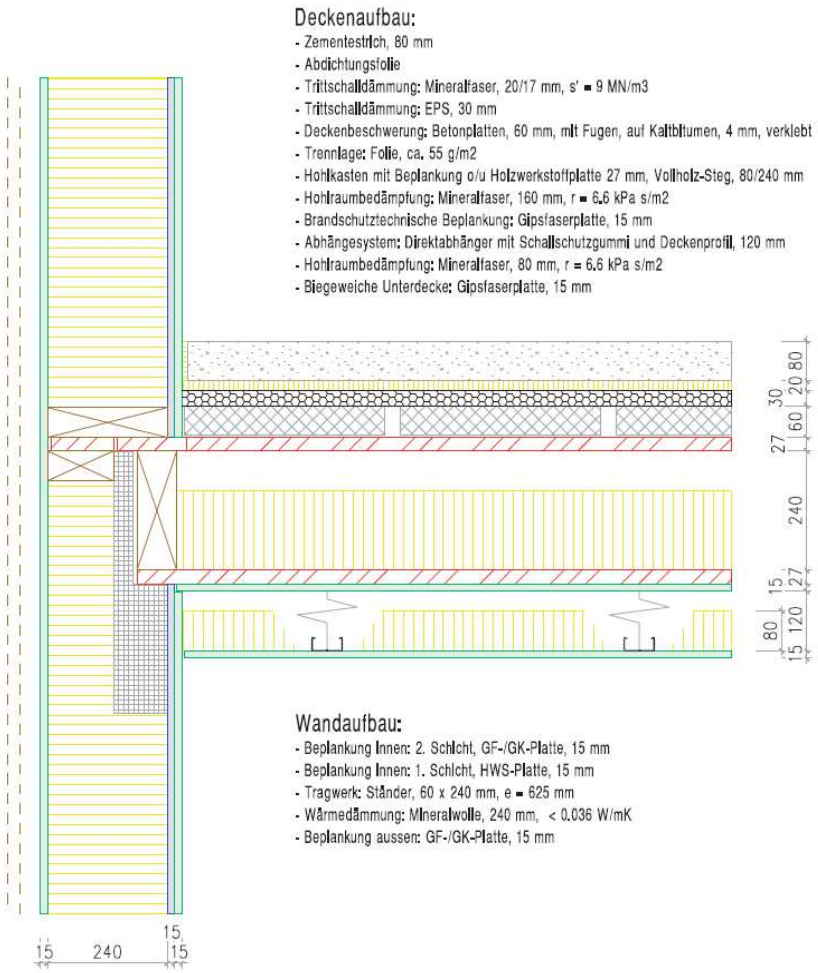
Attenuation and reproducibility

- **Attenuation performances** of a buffer floor (indirect-direct transmission13.6±3.9 dB for E1 and E2) or according to direction (ascending-descending from 1 to 20 dB) **depends on the type of connection between** the wall supporting service equipment and the floor/ceiling.
- **Reproducibility** is weak ($\sigma = 4.3 \pm 2.1$ dB for similar measurements in various apartments on thirteen setups) and correlated only slightly with the type of installation or construction. Implementation and fixation conditions are **highly sensitive to workmanship errors**.

2) Laboratory measurements

EMPA-BFH lightweight laboratory

Laboratory constructions



Cf. E3 quality housing (increased requierements 2006)

Floor: 8 cm concrete, 2 cm glass wool insulation, 3 cm EPS insulation, 6 cm concrete tiles, 2.7 cm OSB panel, 24 cm timber floor, 2.7 cm OSB panel ,12 cm plenum with 8 cm mineral wool, 1.5 cm suspended ceiling.

Wall: 2x1.5 cm plasterboard, 6x24 cm frame with mineral wool, 1.5 cm plasterboard

Laboratory measurements

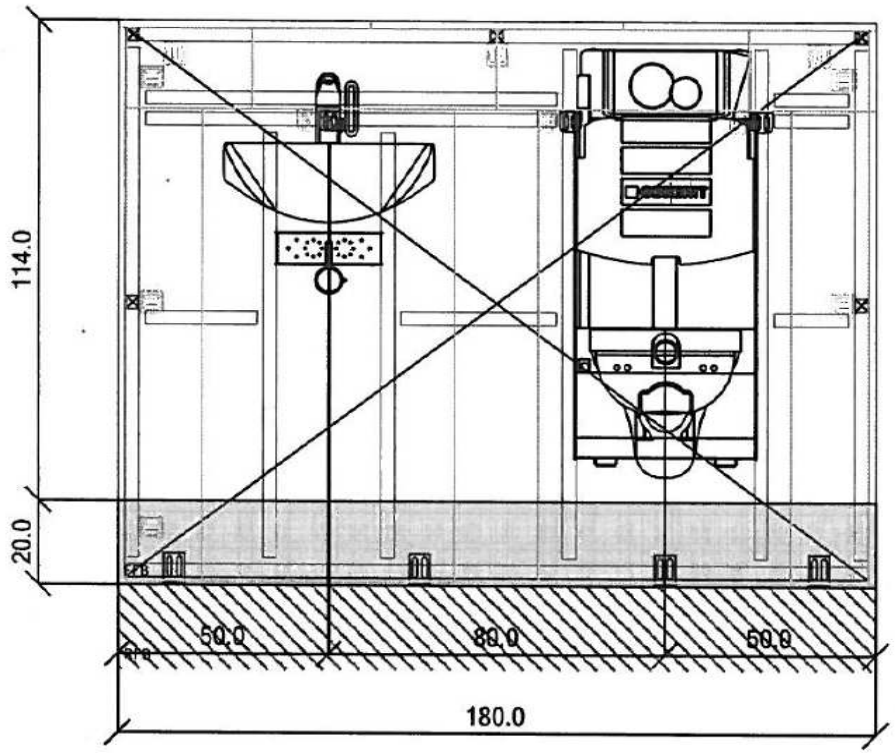
About **1000 hammer measurements** maximum level $L_{A,F}$ for each hammer impact.Wideband spectra (1/3 octave from 50 to 5000 Hz) for EMPA hammer impact noise, airborne and impact noise insulation.

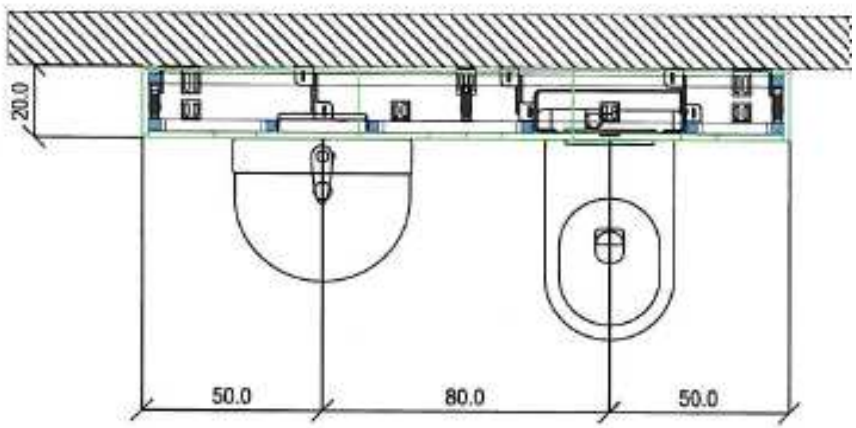


Two typical sanitary constructions types :

- Prefabricated isolated installation + 18 mm plasterboard
- Standard installation directly + 2x12 mm plasterboard.

Laboratory measurements
Prefabricated system





Laboratory measurements
Prefabricated system

Parameters studied
Prefabricated system

The main sound transmission path should be :

- contact in floor (sanitary frame, plaster frame)
- contact in wall (rigid fixation of sanitary frame, flow tube collar, shelf)
- airborne noise

The parameters studied :

- Presence of acoustic set (WC, sink)
- Opening in plasterboard
- Rigid contact between fixation and floor (1 to 4 wedge(s))
- Rigid contact between fixation and wall (1 to 4 wedge(s))
- Rigid contact between shelf and wall (L shape profile)
- Less contact between fixation and floor/wall (4-13 soft washers)

Laboratory constructions
Airborne sound insulation

Schalldämm-Maß nach ISO 10140-2

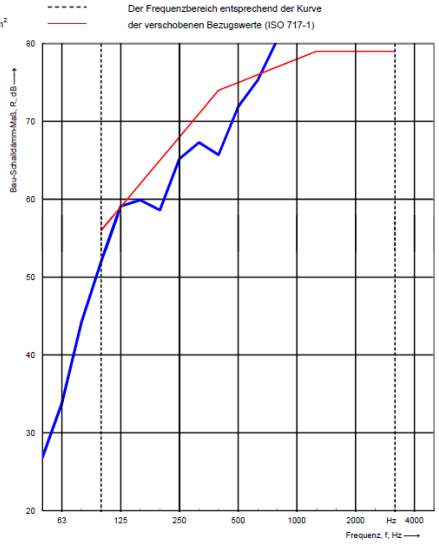
Messung der Luftschalldämmung von Bauteilen im Prüfstand

Auftraggeber: X_R_1_AB_03 Prüfdatum: 01.10.12
Hersteller:
Kennzeichnung der Prüfräume:
Prüfgegenstand eingebaut von:
Produktebezeichnung:

Aufbau des Prüfgegenstandes: Gis installation with cladding

Luftdruck: 967.0 kPa
Fläche S des Prüfgegenstandes: 22.87 m^2
Flächenbezogene Masse: kg/m^2
Temperatur: 18.6 °C
Luftfeuchte: 63 %
Volumen des Senderaumes: 65.836 m^3
Volumen des Empfangsraumes: 63.4 m^3

Frequenz f [Hz]	R Terz [dB]
50	26.8
63	33.8
80	44.2
100	52.0
125	59.1
160	59.9
200	58.6
250	65.2
315	67.3
400	65.7
500	71.9
630	75.3
800	80.5
1000	83.5
1250	83.7
1600	83.8
2000	82.3
2500	80.8
3150	88.3
4000	94.9 [1]
5000	97.9 [1]



[1] Zu hoher Fremdgeräuschpegel

Bewertung nach ISO 717-1
$R_w(C;C_{tr})$ = 75 (-2 ; -7) dB
Die Ermittlung basiert auf Prüfstands-Messergebnissen, die in Terzbändern gewonnen wurden.

$C_{50-3150}$ = -11 dB $C_{50-5000}$ = -10 dB $C_{100-5000}$ = -1 dB
$C_{tr,50-3150}$ = -25 dB $C_{tr,50-5000}$ = -25 dB $C_{tr,100-5000}$ = -7 dB

Name des Prüfinstituts:
Nr. des Prüfberichtes:

Datum: 01.10.2012 Unterschrift:

Airborne sound insulation
With gypsum board closed :
R'w (C, Ctr) = 75 (-2,-7)

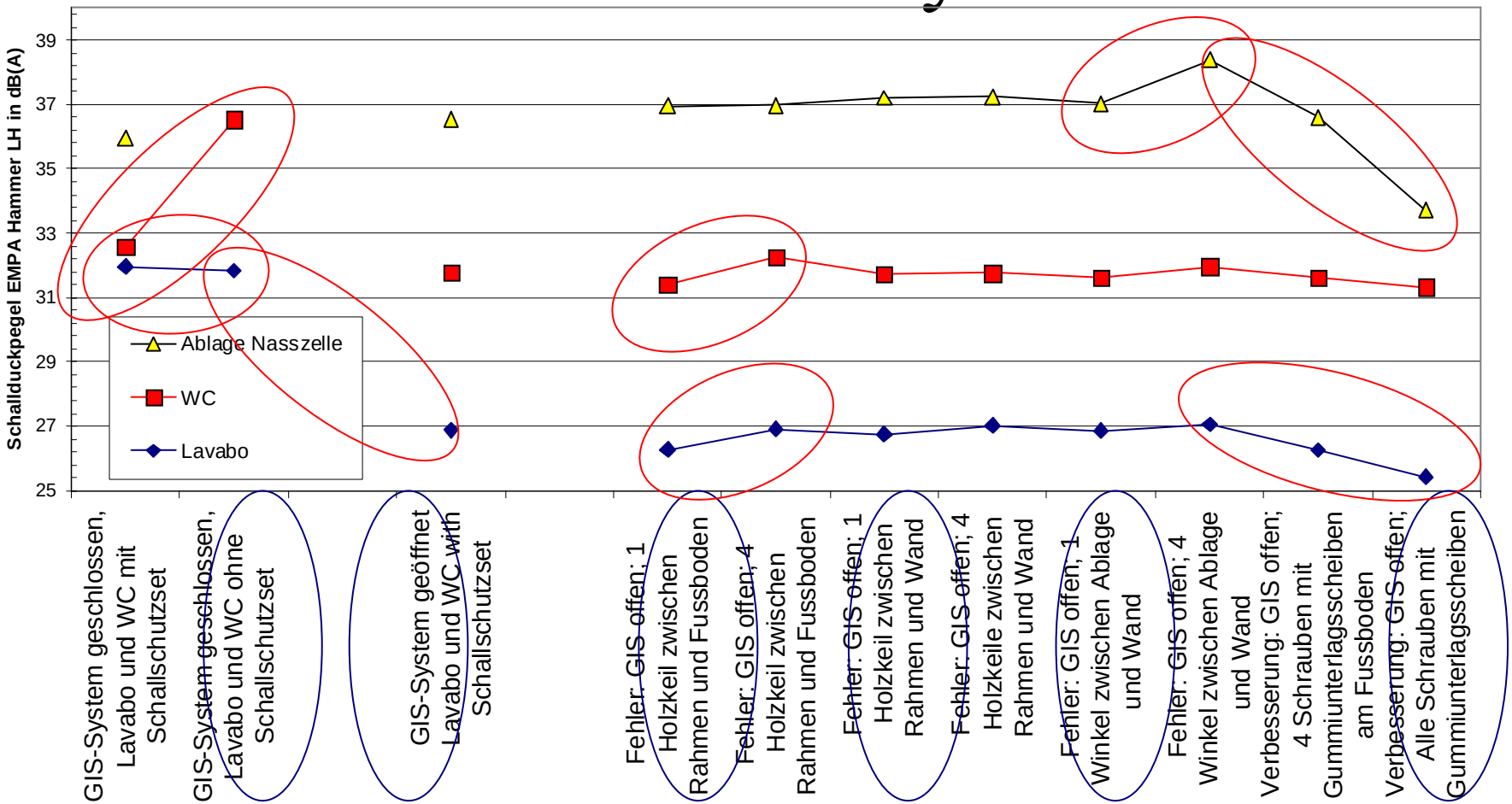
With gypsum board open
R'w (C, Ctr) = 73 (-2,-7)

Maximum level of hammer: $L_{A,F}$

Emission room: 87 -95 dB(A)
Into the sanitary box: 97 -105 dB(A)
Reception room : 40 -51 dB(A)

Backgroud noise : LAeq = 23 dB(A)

Results
Prefabricated system



Main Results
Prefabricated system

- **Quality wood construction, minimal requirements satisfied for all results**
- Airborne path is not determinant
- Presence of acoustic set : -4 dB WC, 0 -4 dB sink (according to workmanship)
- Rigid contact between fixation and floor (1 wedge) + 1dB(A)
- No effect of Opening in plasterboard, rigid contact between fixation wall (1 to 4 wedge(s))
- Rigid contact between shelf and wall + 2 dB for shelf
- Less contact between fixation and floor/wall (4-13 soft washers) : -3 dB for shelf, -2 dB lavabo.

Laboratory measurements
Standard system

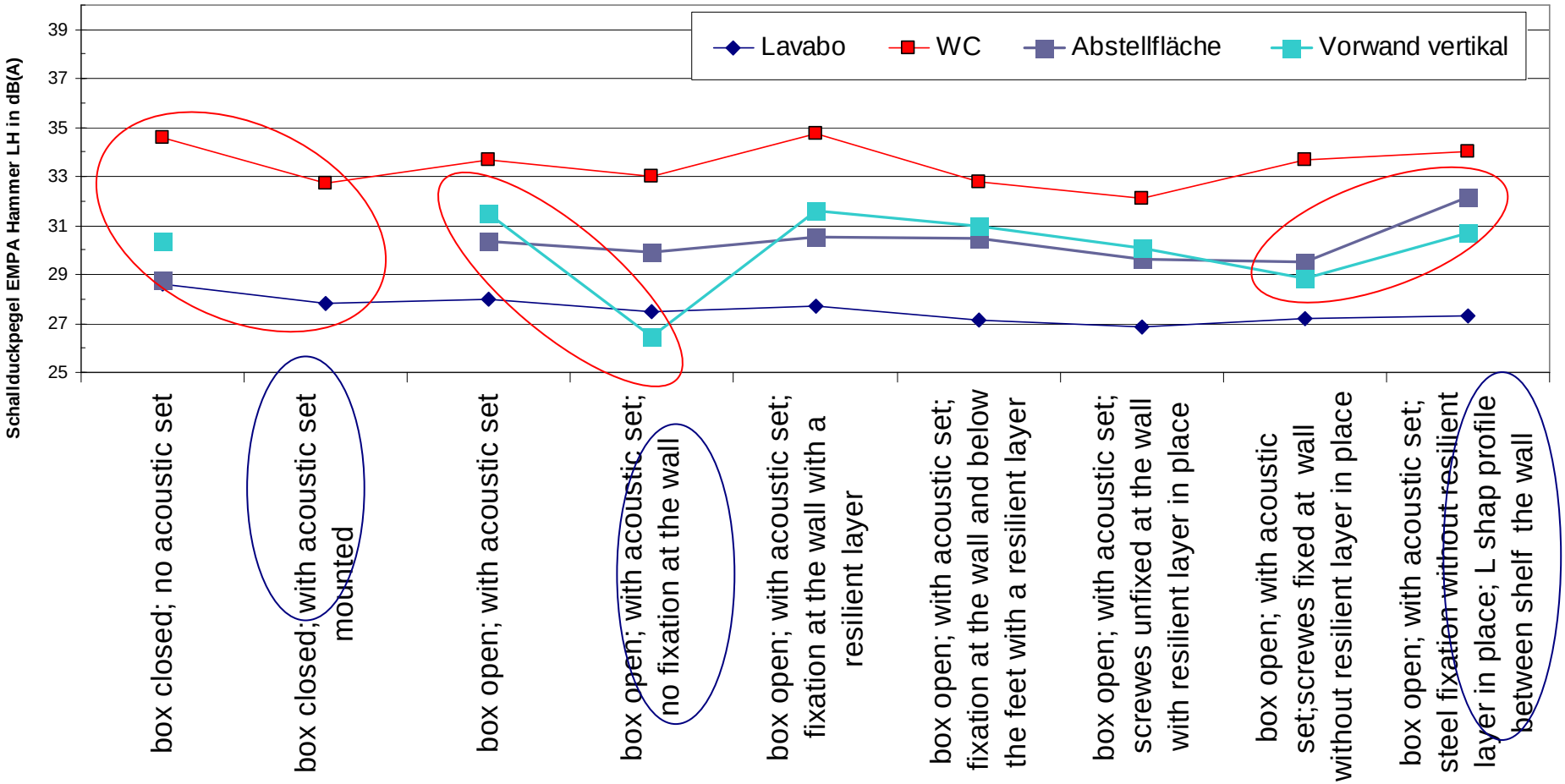
Parameters studied
Standard system

The parameters studied :

- Presence of acoustic set (WC, sink)
- Opening in plasterboard
- Suppression of the contact between fixation and wall
- Resilient layer between fixation and wall
- Resilient layer between fixation and wall + feet
- Resilient layer between fixation and wall + screws unfixed
- No resilient layer between fixation and wall + screws fixed
- Rigid contact between shelf and wall (L shape profiles).

Parameters studied
Standard system

Results
Standard system



Results summary
Standard system

- **With quality wood construction, minimal requirements satisfied for all results**
- Presence of acoustic set -2 dB WC, -1 dB sink
- Openings in plasterboard + 1 dB
- Suppression of the contact between fixation and wall – 6 dB vertical gypsum, -1 dB WC and sink
- Resilient layer between fixation and wall = rigid connection
- Resilient layer between fixation, wall and feet, -1 dB
- No additional effect of screws unfixed
- Rigid contact between shelf and wall (L profiles) +2 dB shelf

4) Conclusion

Sanitary systems / labo-in situ

Type	WC	Sink	Shelf
Prefabricated (labo)	32	27	37
Standard (labo)	34	27	30
Standard (in situ E3)	38	30	

-In situ higher (+4 dB(A) than in laboratory (construction + workmanship)
-WC induce highest levels for standard constructions

Conclusion in situ

- **Swiss minimal requirements are often exceeded** (52% in bathrooms and 64% in kitchens) in wooden structure
- **Improvement of the measurement technique** (definition of the hammer position, airborne contribution) **and evaluation** (consistency with the impact noise requirements)
- the measurement technique highlights the **qualities of junctions** and **workmanship errors** (poor reproducibility).
- **limited efficiency of the fastening uncoupling systems** for lightweight constructions (need for double frame construction)

Conclusion labo

- With **quality wood construction**, SIA181 minimal requirements are satisfied for all results
- Presence of acoustic set: 0 to -4 dB
- Less contact between fixation and floor/wall (4-13 soft washers): -2 to -3 dB for prefabricated systems.
- Rigid contact between shelf and wall (L profiles): +2 dB
- Little effect (<2 dB) of oopenings in plasterboard, additional rigid contact between fixation and wall, resilient layer between fixation, wall and feet, screws unfixed
- More effect in average wood construction (without suspended ceiling)?

Discussion

- **Comparison of massive/lightweight** constructions:
  → database for both types of construction
  → study of specific facilities (bath and shower tubs)
  → frequency and time analysis

- **SIA181 standard clarifications** regarding:
  →the number+position of measurements for bath and showertubs
  →Airborne insulation should fulfill minimum requirements
  →harmonization with impact noise requirements (K4 coefficient)

Acknowledgment

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Thank you for your attention
Any question?
SANITAS TROESCH