MADRID
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NOISE CONTROL FOR A BETTER ENVIRONMENT

Round Robin Test on Building Acoustics with High Sound Insulation

Lechner Christoph[1]

Kernöcker Robert[2]

[1] christoph.lechner@oal.at

[2] Robert.Kernoecker@ooe.gv.at

Conceptual Formulation

ÖAL
Christoph Lechner

Round Robin´s since 1995 (Prof. Judith Lang)

2001 building acoustics measurements the extended frequency range

facing the problem of low frequencies in building acoustics

testing laboratories certification need to demonstrate participation in interlaboratory comparisons

ÖAL offers the opportunity to prove their quality management

20 Austrian laboratories

Research Questions

Christoph Lechner

Are the confidence intervals for the single number values in the standard and extended frequency ranges still valid?

Is there an Influence of the high sound insulation on the uncertainty of the single number values?

Are there differences in the allowed measurement methods on the single number values?

Conceptual Formulation

Christoph Lechner

measurements of airborne and impact sound insulation

EN ISO 16283-1 and EN ISO 16283-2

specially designed reference sheet

- separate sheets for airborne and impact sound
- as well as for the reverberation time

Object music school of Steyregg in Upper Austria

Description of the Rooms

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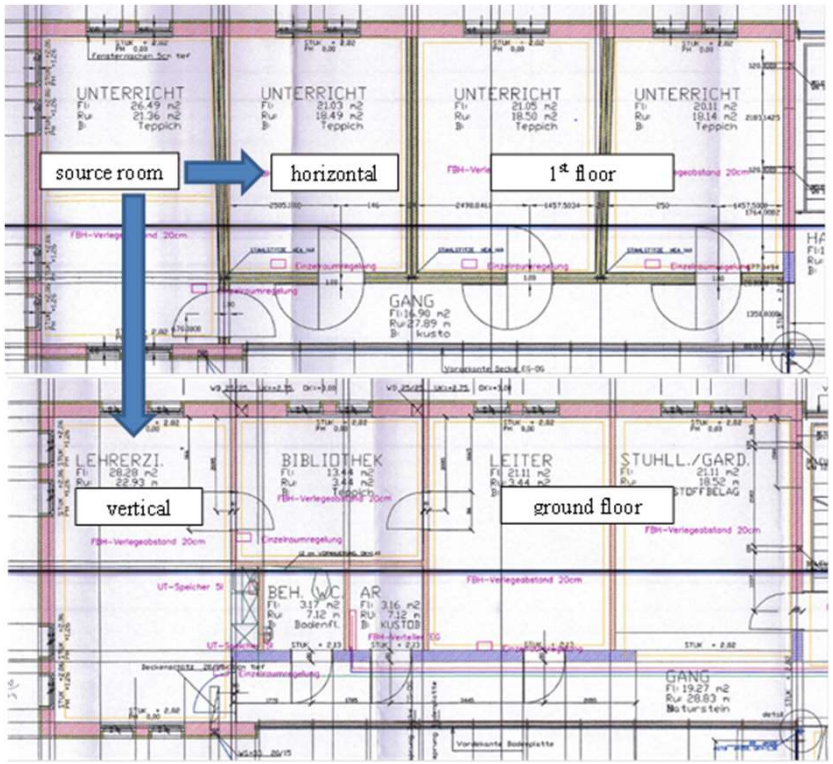
function	description	area [m²]	volume [m³]
source room	piano exercise room	26	74
receiving room horizontal	classroom	21	59
receiving room vertical	conference room	28	79
separating element horizontal	lightweight gypsum 5 layer	15	-
separating element vertical	reinforced-concrete floor with additional gypsum ceiling	26	-



Description of the Rooms

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Measurement Methods

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One- or two-channel airborne sound measurement

Source spectrum for airborne sound (pink or white)

Type of microphone positioning

- fixed on tripod, moved mechanical or moved manually;

Determination of the reverberation time

- procedure of the interrupted noise method or
- the integrated impulse response method,

Person presence in the source and in the receiving room.

Means of single number quantities in dB

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airborne sound insulation			impact sound insulation		
	vertical	horizontal		vertical	horizontal
$D_{nT,w}$	65,0	62,4	$L'_{nT,w}$	36,8	34,6
C	–2,2	–4,1	C_I	–4,6	–2,0
C_{tr}	–5,9	–11,1	$C_{I,50\text{-}2500}$	8,3	2,3
$C_{50\text{-}3150}$	–3,8	–7,3			
$C_{50\text{-}5000}$	–2,8	–6,4			
$C_{100\text{-}5000}$	–1,4	–3,2			
$C_{tr,50\text{-}3150}$	–12,9	–18,5			
$C_{tr,50\text{-}5000}$	–12,9	–18,5			
$C_{tr,100\text{-}5000}$	–6,0	–11,1			

Statistical Calculation

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prepared and evaluated according EN ISO 12999-1

repeatability and reproduceability ISO 5725-1

statistical outliers ISO 5725-2 (Grubb´s and Cochran´s test)

number of laboratorities p (n - 1) ≥ 35 -> 20 (5 – 1) = 80 ≥ 35

comparison of methods by using single number values and adaption terms in the extended frequency range

- Mann-Whitney-U-test (in case of two methods), Kruskal-Wallis-test (for microphone positions) and for group comparisons Chi²-test

ceiling vertical
airborne sound insulation

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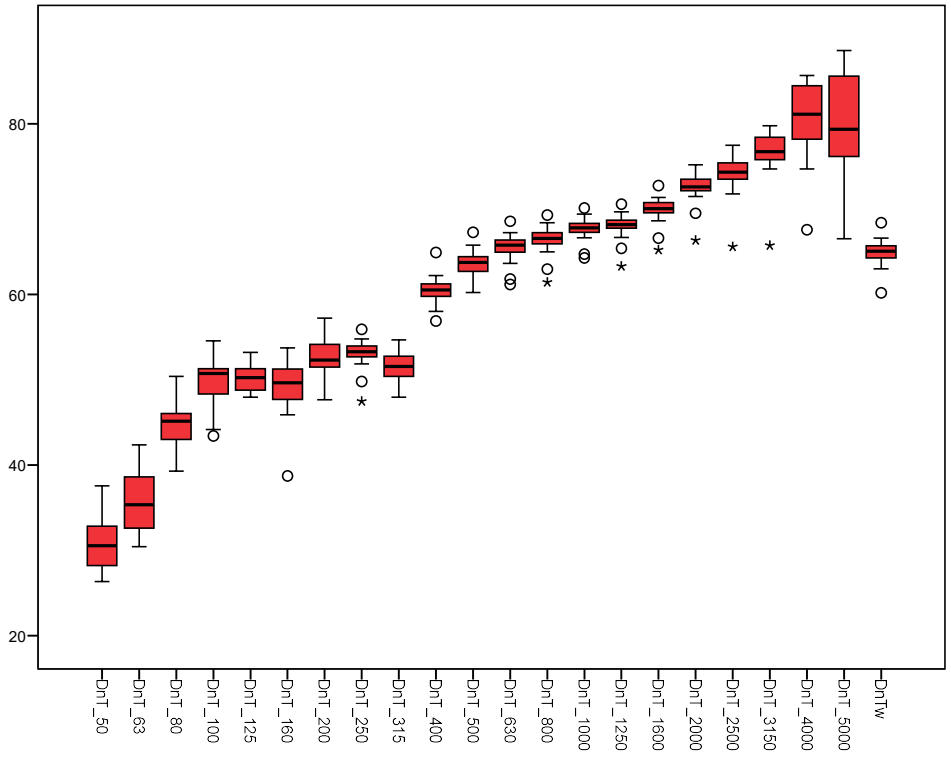

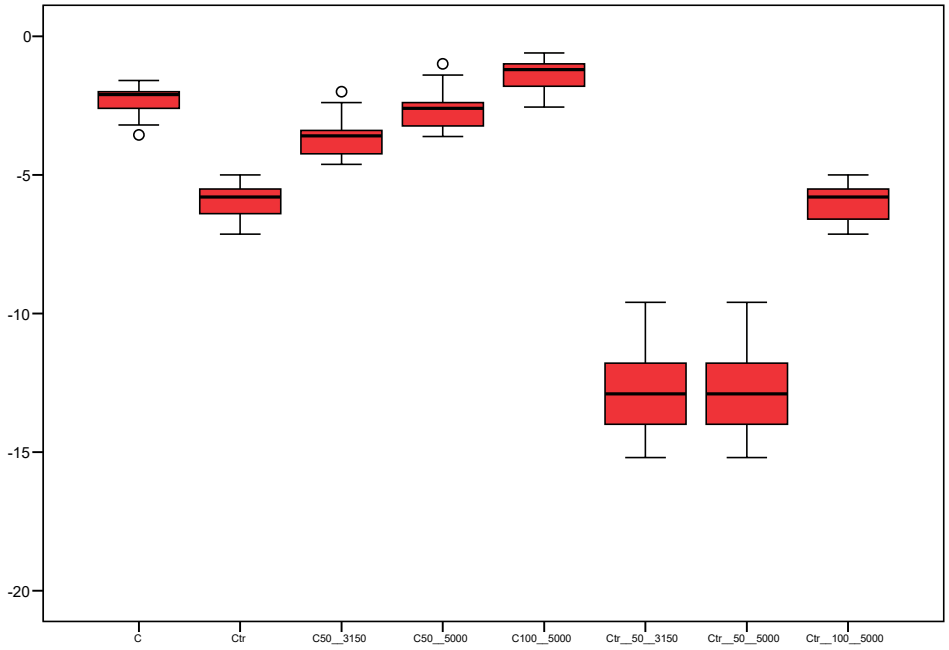

ceiling vertical
impact sound insulation

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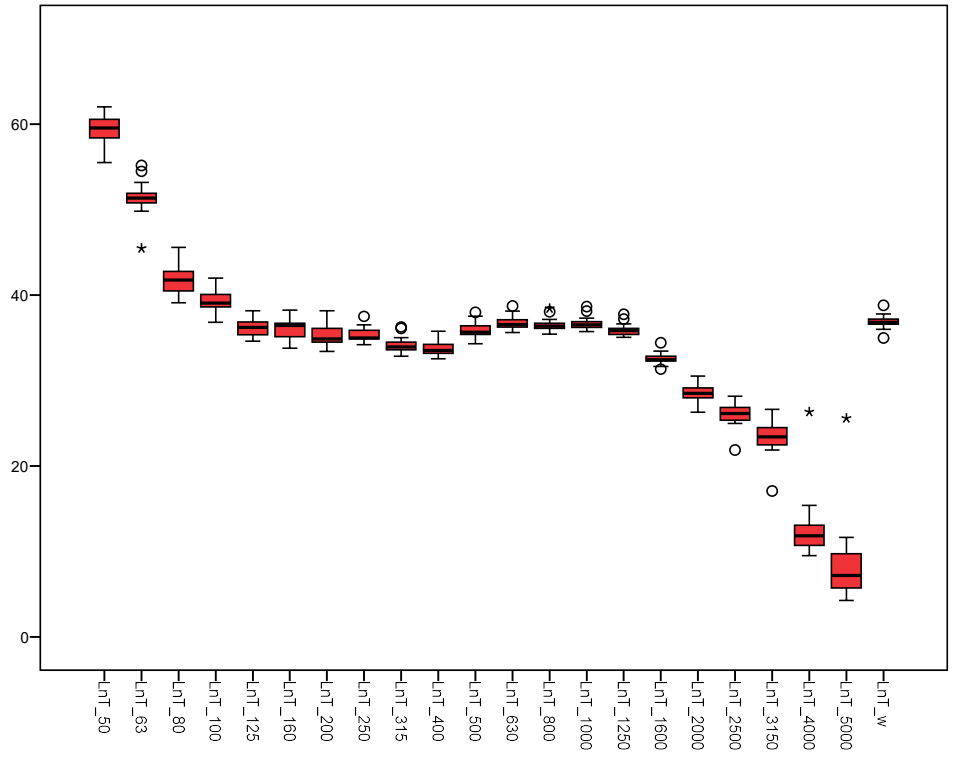

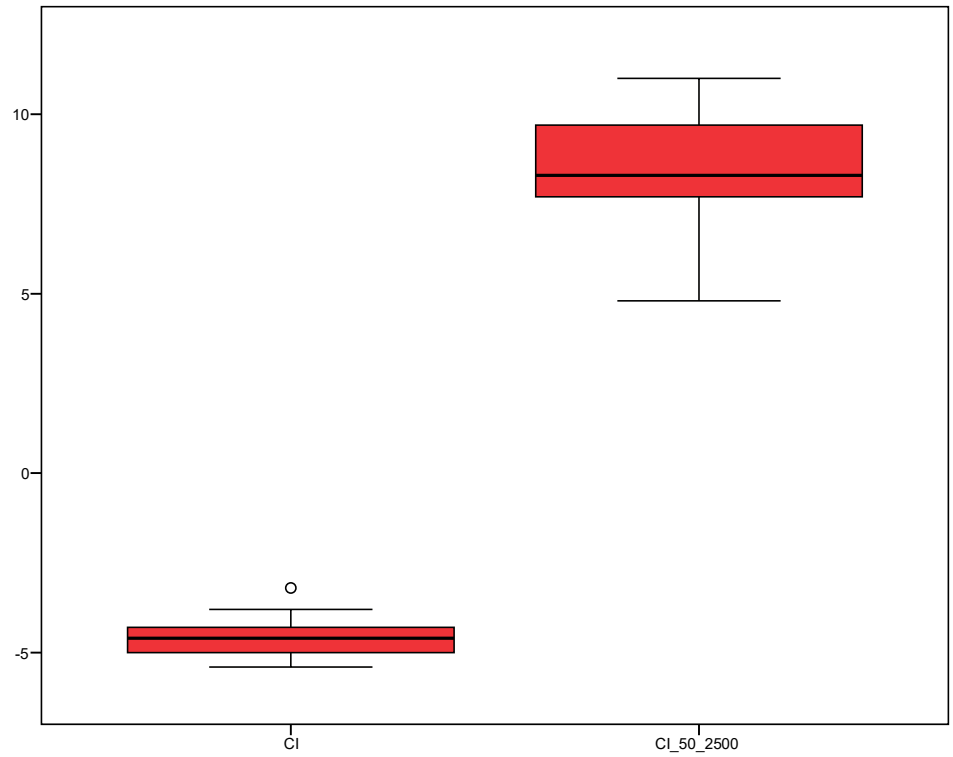

wall horizontal
airborne sound insulation

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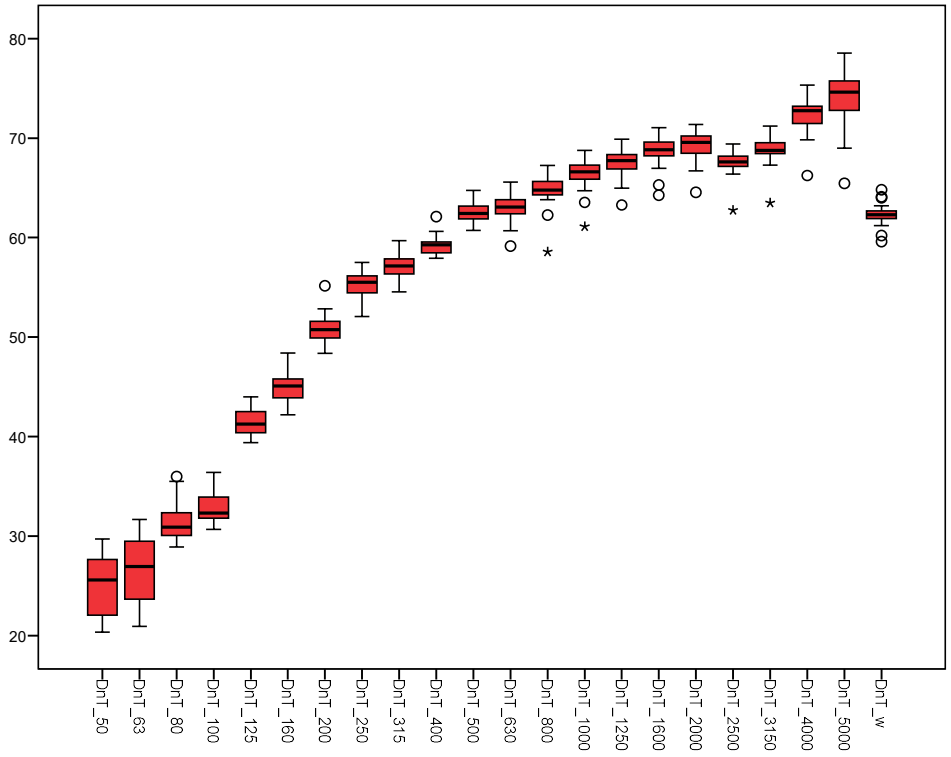

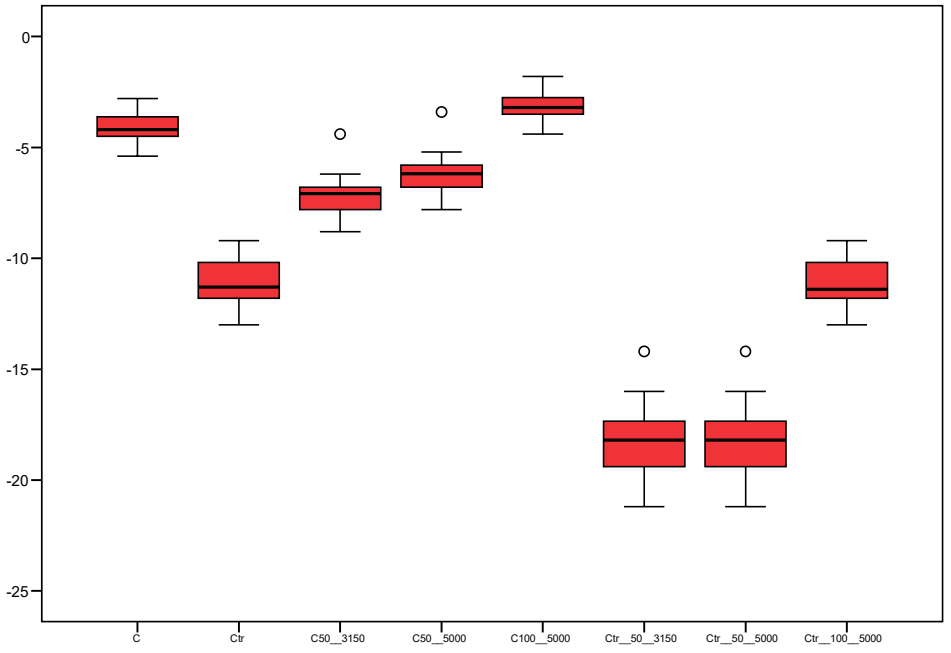

wall horizontal
impact sound insulation

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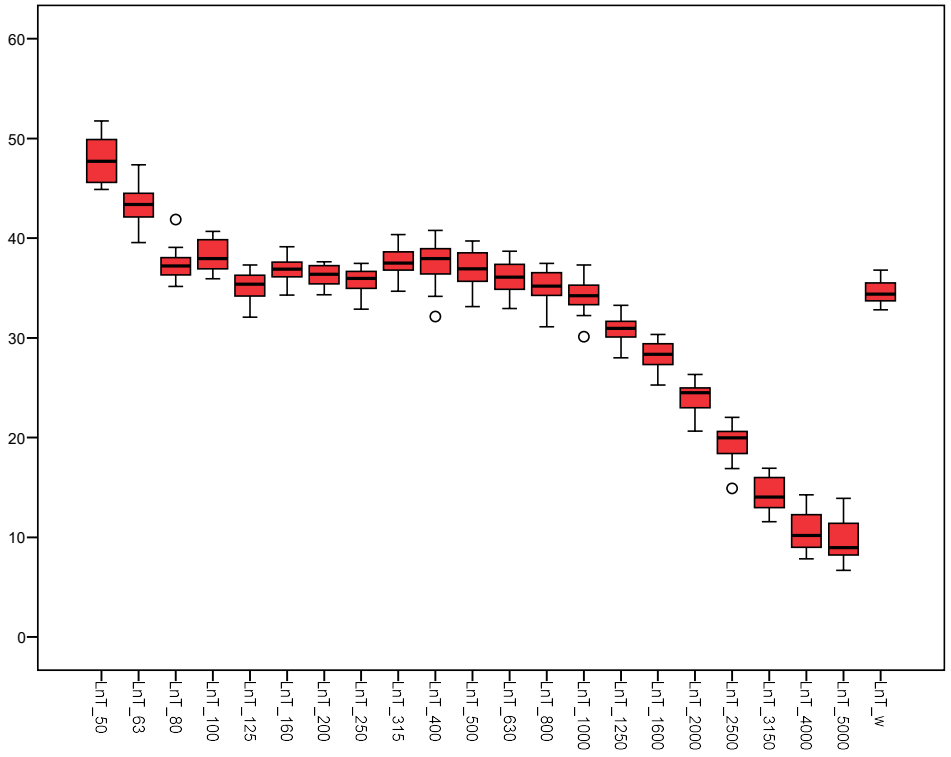

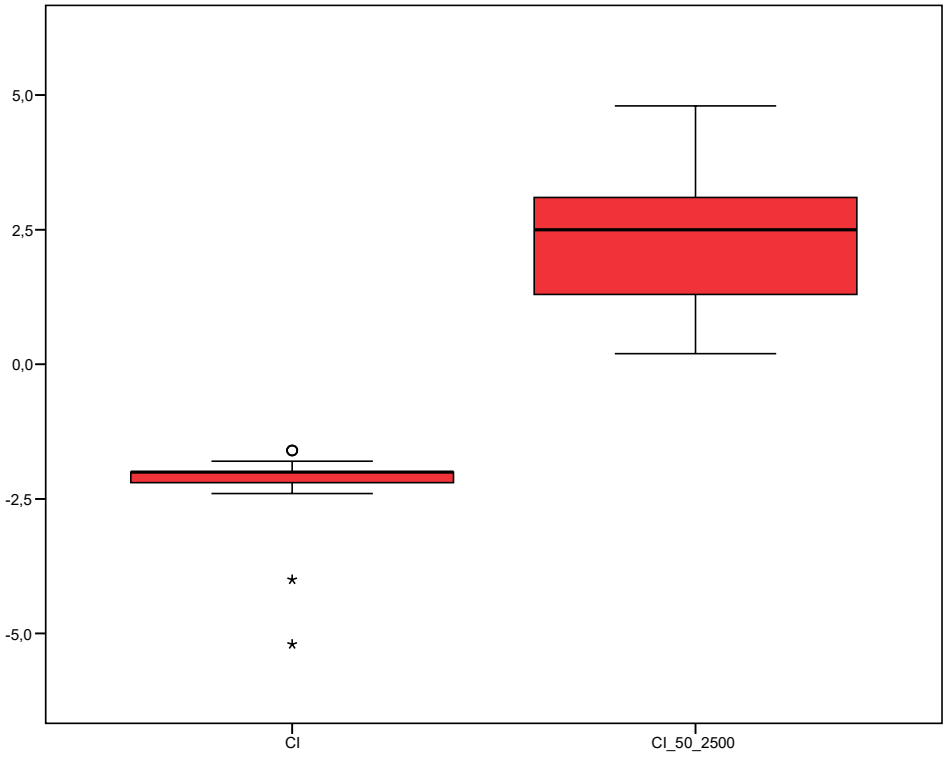

Comparison with ISO 12999 ceiling vertical

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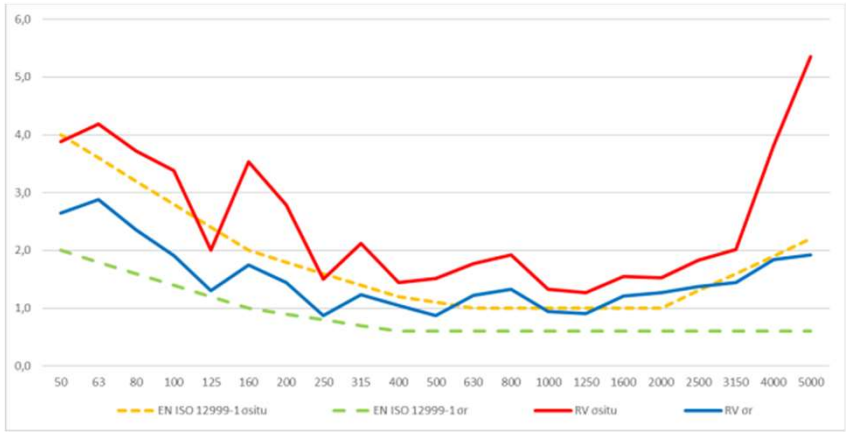
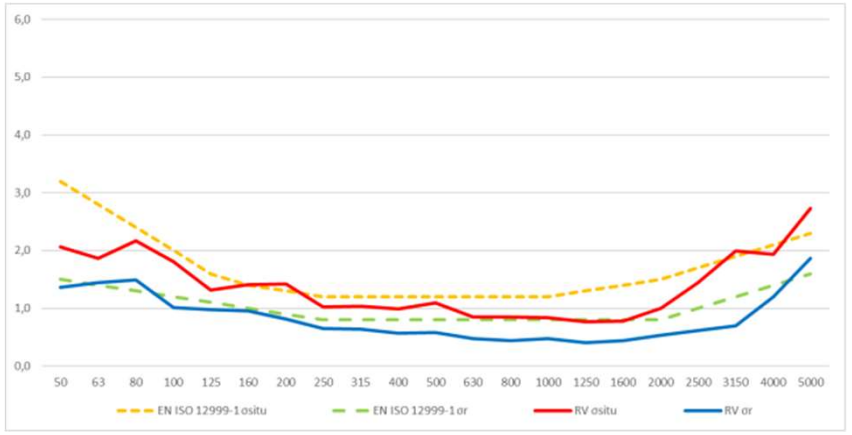


airborne sound insulation



impact sound insulation

Comparison with ISO 12999 wall horizontal

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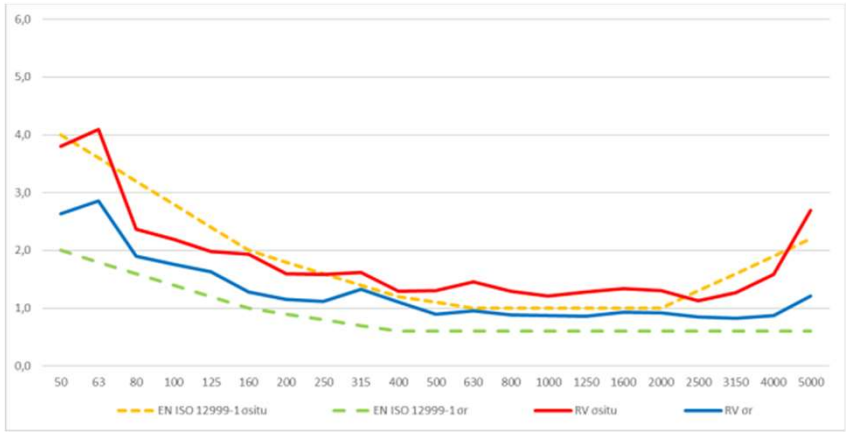
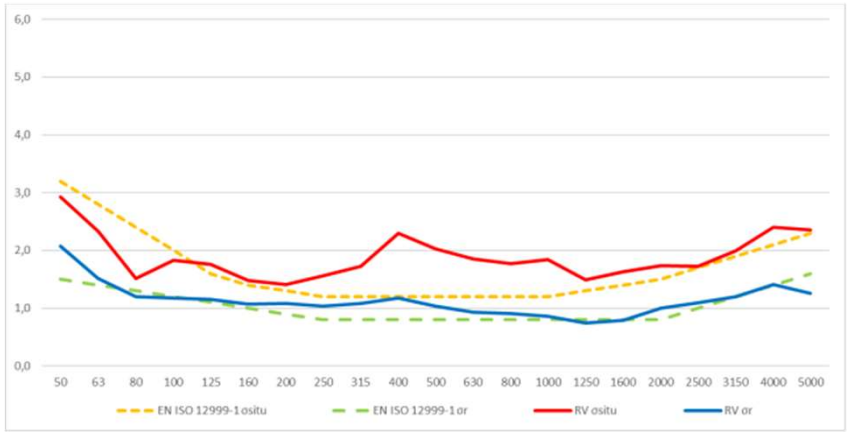


airborne sound insulation



impact sound insulation

Comparison of Methods

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excursus p-value

for statistical hypothesis testing to weigh the strength of the evidence

A small p-value (typically ≤ 0.05) indicates strong evidence against the null hypothesis, so you reject the null hypothesis H_0.

A large p-value (> 0.05) indicates weak evidence against the null hypothesis H_0, so you fail to reject the null hypothesis H_0.

Comparison of Methods

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H_A: There is an influence of the number of measurement channels on the single number values
H_A: There is an influence of airborne sound spectrum on the single number values

airborne sound measurement	ceiling vertical		wall horizontal	
	$D_{nT,w}$	$C_{tr,50–5000}$	$D_{nT,w}$	$C_{tr,50–5000}$
1 or 2 channel measurement	0,436	0,529	0,739	0,739
pink / white noise	0,682	0,335	0,892	0,75

H_A: There is an influence of microphone position on the single number values

microphone position fixed / manual / mechanical moved	airborne sound		impact sound	
	$D_{nT,w}$	$C_{tr,50-5000}$	$L'_{nT,w}$	$C_{I,50-2500}$
ceiling vertical	0,999	0,646	0,418	0,382
wall horizontal	0,669	0,512	0,318	0,693

Comparison of Methods

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H_A: There is an influence of measurement duration on the single number values.

measurement duration	airborne Sound		impact sound	
	$D_{nT,w}$	$C_{tr,50\text{-}5000}$	$L'_{nT,w}$	$C_{I,50\text{-}2500}$
ceiling vertical	0,053	0,698	0,027	0,232
wall horizontal	0,557	0,821	0,067	0,249

H_A: There is an influence of reverberation time measurement duration on the single number values.

reverberation	airborne Sound		impact sound	
	$D_{nT,w}$	$C_{tr,50\text{-}5000}$	$L'_{nT,w}$	$C_{I,50\text{-}2500}$
ceiling vertical	0,552	0,132	0,811	0,026
wall horizontal	0,937	0,361	0,874	0,691

Comparison of Methods

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H_A: There is an influence of persons present in the measurement rooms on the single number values.

person presence	ceiling vertical		wall horizontal	
airborne sound	$D_{nT,w}$	$C_{tr,50\text{-}5000}$	$D_{nT,w}$	$C_{tr,50\text{-}5000}$
person in transmitting room	0,732	0,82	0,08	0,79
person in receiver room	0,137	0,68	0,649	0,869
impact sound	$L'_{nT,w}$	$C_{I,50\text{-}2500}$	$L'_{nT,w}$	$C_{I,50\text{-}2500}$
person in receiver room	0,158	0,934	0,457	0,231

Confidence Intervals

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main outcome of an interlaboratory experiment is the estimation of the **confidence interval**

If a single laboratory performs only a single determination γ of the quantity to be measured, the confidence interval for the true value μ (for example, a requirement or a value specified in a contract) is defined due to equation

$$\left(\gamma - \frac{R}{\sqrt{2}}\right) < \mu < \left(\gamma + \frac{R}{\sqrt{2}}\right)$$

Confidence Intervals

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airborne sound measurement			impact sound		
	vertical	horizontal		vertical	horizontal
$D_{nT,w}$	2,23	1,82	$L'_{nT,w}$	1,43	2,52
C	1,29	1,89	C_I	1,40	0,81
C_{tr}	1,83	2,90	$C_{I,50\text{-}2500}$	4,76	2,93
$C_{50\text{-}3150}$	1,86	2,42			
$C_{50\text{-}5000}$	1,90	2,42			
$C_{100\text{-}5000}$	1,46	1,86			
$C_{tr,50\text{-}3150}$	4,50	3,99			
$C_{tr,50\text{-}5000}$	4,50	3,99			
$C_{tr,100\text{-}5000}$	1,86	2,90			

Conclusions

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the confidence intervals have **not changed essentially** since the last round robin test

high sound insulation level can also be tested with **good reproducibility**

It is **not recommended** to define high standards in sound insulation by use of the single number vaues in the **extended frequency range** due to confidence intervals there are very large

an **effective formulation** of requirements is **difficult**

Conclusions

Christoph Lechner

no statistically significant correlations

- single or multi-channel measurement
- by selecting the transmission spectrum
- microphone positions
- type of reverberation time measurement and
- presence of persons in transmission and reception rooms.

a slight influence on the single number values

- duration of the measurement

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Acknowledgement

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Thank Your for Attention!