Impact Noise Study employing the ISO 16283-2 / ISO 140-5 Rubber Ball.

Summary:

Edition 3 2019-10-25

The goal of this study was to evaluate the measurement uncertainties of tapping machine (TM) and Ball, this for the most interesting single number quantities (SNQs); further SNQ level differences relevant to the national limits. A suitable method got developed, checked for relevance and applied to (in Asia) popular Ball SNQ's. The TM went along was side car with its traditional Ci100-3150 and Ci50-3150 corrections, later seems to be law only in Sweden.

During the study it became very clear, that the ball emulates walking noise and playing children for real; while the TM just fills the floor with noise - a kind of floor bell.

The correlation to annoyance in the sense of R^2 values was only indirectly used; on the one hand by Asian research results for several Ball SNQ's; on the other hand when checking our method by checking, if SNQ's K2/95%-uncertainties are proportional to "1 minus the R^2 value" of the corresponding SNQ; using R^2 values from other research reports.

Much of the results are well in line with Asian research articles. The only relevant difference is, that we in Switzerland (and presumably EU) require for the ball one octave more low-end range - e.g. a ball range somewhere between 25-630Hz and 25-to-2500Hz. This is given by popular ceiling constructions of 10m to 15m length , unsupported by walls or other elements (e.g. sitting and dining room etc in one line).

Impact Noise Study using the ISO 16283-2 / ISO 140-5 Rubber Ball.

It is well known and documented fact that impact noise measurements using the tapping machine (TM) only above 100 Hz do not delivers all too relevant information on impact noise isolation. The goal of this study was to qualify the improvements resulting from using the Japanese Rubber Impact Ball. Data from 26 floors was available; one of the measurements showed rather dubious results and was eliminated.

It was well known in advance that the rubber ball does well in emulating playing children and walking impact noise, since the ISO rubber ball - other than the tapping machine - is a true impact source, has the «right» amount of energy, the required impedance and acceptable timing. The analysis of the 25 floors surprised with very homogeneous measurement values of high quality.

The result are: Principally the same as in Fraunhofer (e.g. F2918 and other) and many Asian reports: The ball does much better than the tapping machine for impact noise measurement. Further more, we obtained concrete information on how the uncertainties, and signal level change form one SNQ to another SNQ. Due to only 25 floors tested, no concrete value can be given, but the charts give a coarse idea in what dimension the values, relevant for national limits, change. Side result: Moving the TM to Ci50 instead of Ci100 would reduce the uncertainties by about 30%, with a higher signal level of about 5 dB.

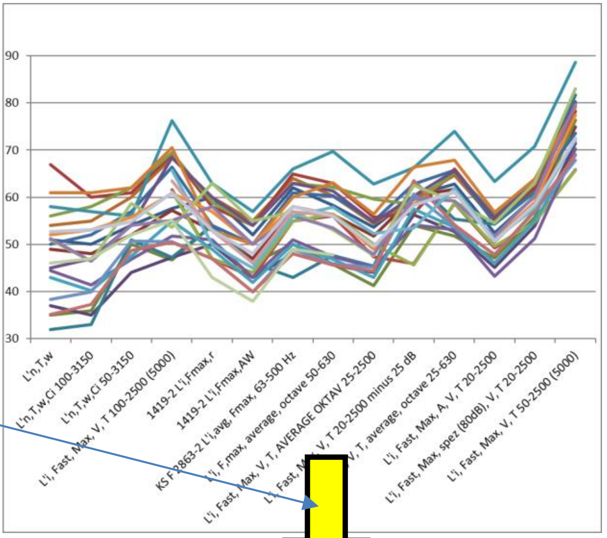
First the method of the analysis gets explained, then the results are discussed, and finally this study highlights weaknesses one should be aware of.

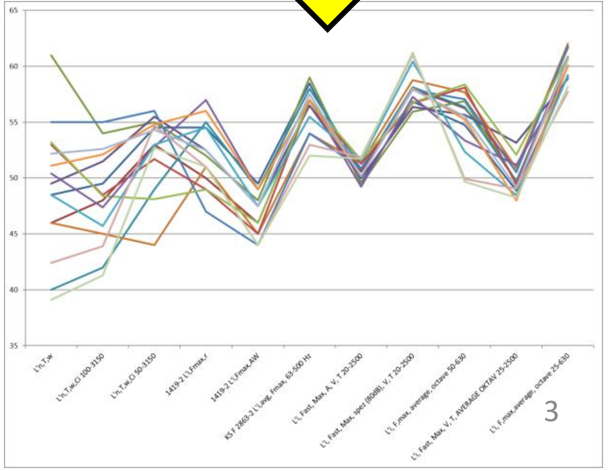
Method

25 floors got analysed, about 40% of them came from team members of this study, the rest of the data was taken from international impact noise studies (of very high quality). These studies published all raw data in detail, enabling other researchers to do ongoing research. The quality of both sources is high, the international studies convince by more consistent results.

The method:

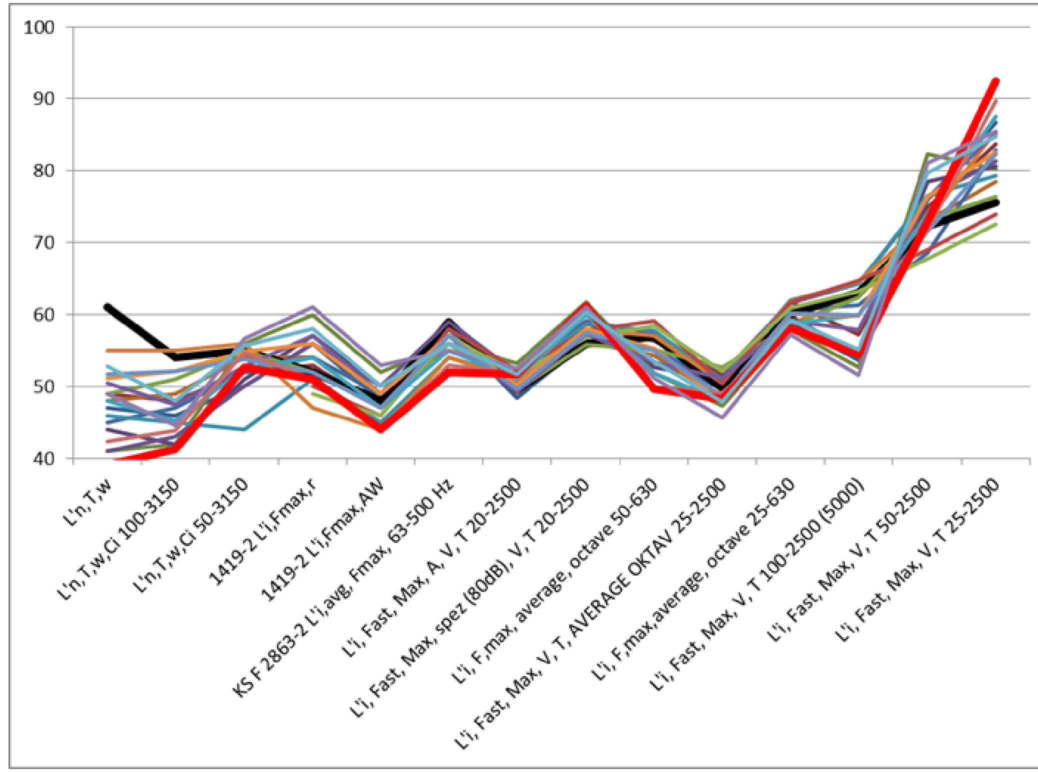
- The raw impact measurement values were first **corrected** according to ISO 16283-2 for the **V- und T influence** of the room.
- Then the curves got **normalized** in their signal level (to a level somewhere in the "bandwidth" over all curves; lower picture on the right) - in such a way, that **for all** SNQ's the variance width is minimal. **This got done, looping over all curves, until the width over all curves, in all SNQs, is as narrow as possible.**
- This got done in such a way, that - one curve after each other - got shifted up/down in 1 dB steps; after each 1 dB shift the uncertainties of all SBQ's got looked at:
- Did only one SNQ profit, at a relevant cost of other SNQ's, the shift was left away. (For this the impact on all SNQ uncertainties got checked).





PS: It was not possible to calculate for all ceilings all SNQs; e.g. 3 measurements have no TM raw data, and not all measurements go down to 20 Hz (some ended at 25 Hz). In the lower picture on the right - for optical reasons to illustrate the effect - only these curves are listed, where all raw values exist; but in the analysis all measurements were used.

The picture on the last slide, slide 3, as well as the picture on the right side, show very nice, how much the width of the of curves-package depends on the SNQ type. Furthermore the picture on the right side shows (**red and black curve**), the individual curve can be in the upper or lower part of the curve plot bandwidth depending on the SNQ - a result coming from the mathematical type of the SNQ calculation (energetic sum, energetic average, arithmetic average of octave values) and the dominance of bass power.

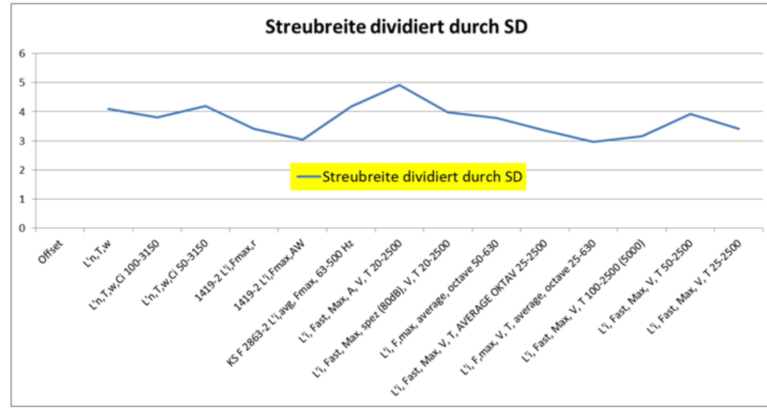


By the way: This process of normalizing the signal level curves over all SNQ's, was easy, because the width of the curves package at each SNQ corresponds well to the uncertainties published in ball research documents [docs 10, 31, 58] **for the different SNQs**. The normalization process description on page 3 sounds more difficult than it was.

The impression quickly arose, that the bandwidth is proportional to the uncertainties of the SNQ's. So two question arise:

- Prove that !
- How much larger / smaller are the uncertainties than the bandwidths ?

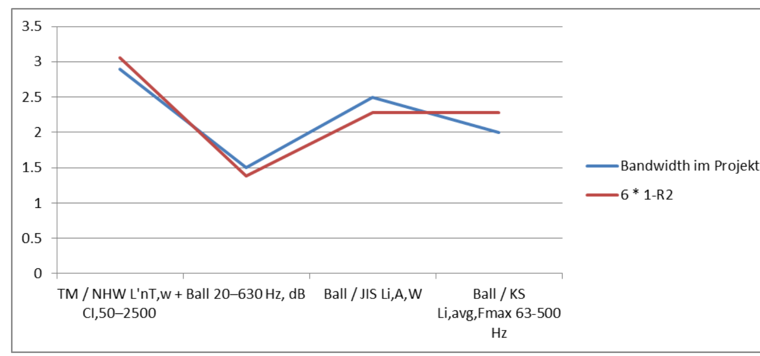
The Rubber Ball is very well documented in about 200 mainly Asian documents in English language, and in a few Fraunhofer Gesellschaft studies. *The fact, that the bandwidth of the curve package in each SNQ slot corresponds well to the uncertainties in ball literature is of course a strong element. It shows that our method reflects the balls capability well to psycho-acoustically adequately represent many types of floors*.



Proof 1 (or at least a strong indicator) is the fact that the bandwidth of the SNQ package, as shown on the slides before, is proportional to the uncertainties of the SNQs, as shown on the right upper graph: Should this be correct, and as we have about 20 curves, the width of the bandwidth would need to be about 4 standard deviations (+/- 2 SD for K2/ 95% reliability). As one can see, this is well enough the case.

Proof 2: One may assume that the uncertainties are somewhat proportional to the annoyance relevance number of the value 1 minus the value of R^2 uncertainty value of the SNQ. In other words: The closer R^2 to the value of one, the smaller the SD must be.

For this purpose, 4 measurements were taken from important research documents and our results were checked for proportionality to them:



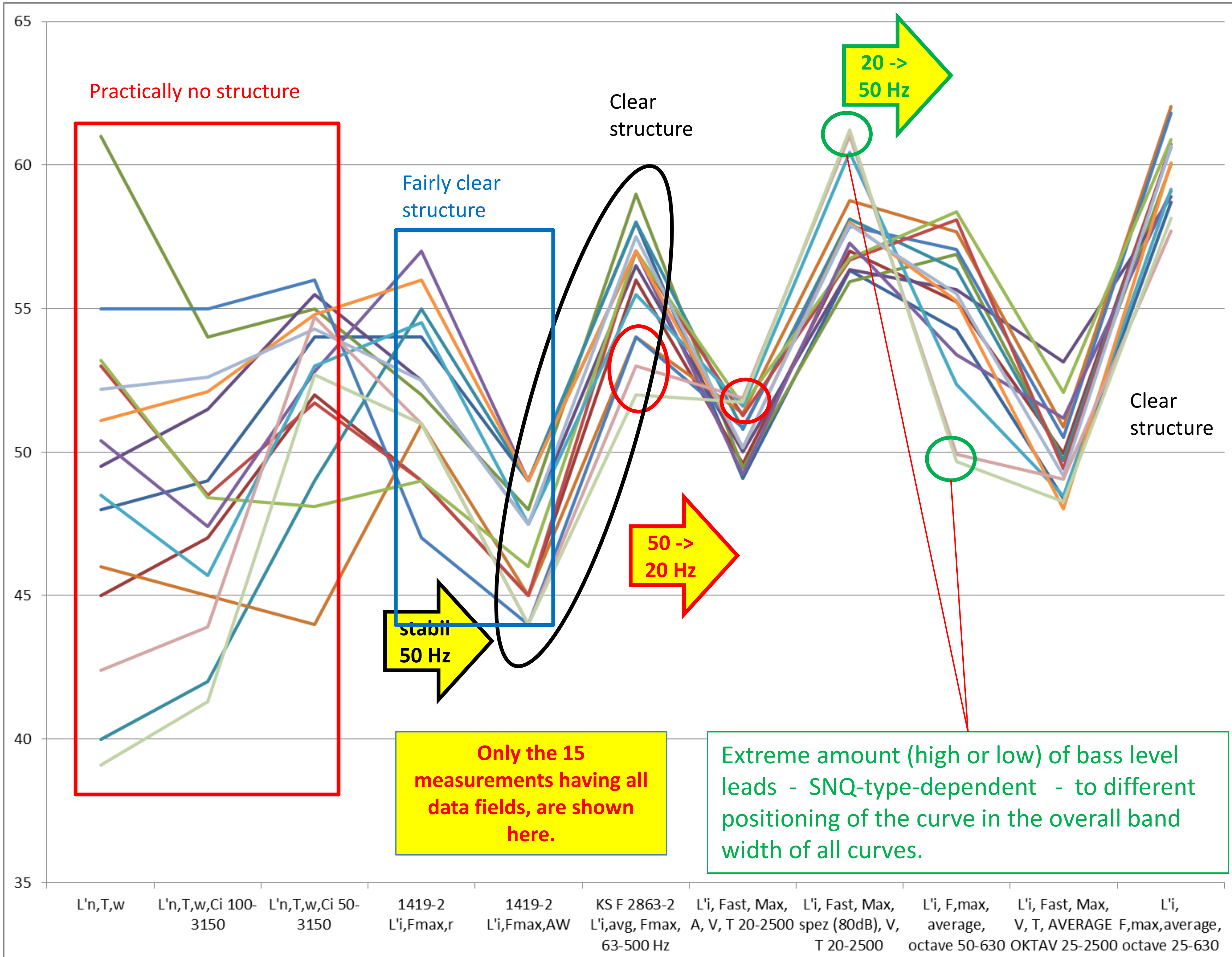
Method	Doc ID	Source	R2	Bandwidth im Projekt	6 * 1-R2
TM / NHW L'nT,w + CI,50–2500	138	Correlation between sound ....PART II	0.49	2.9	3.06
Ball 20–630 Hz, dB	138	Correlation between sound ....PART II	0.77	1.5	1.38
Ball / JIS Li,A,W	31	Fraunhofer	0.62	2.5	2.28
Ball / KS Li,avg,Fmax 63-500 Hz	31	Fraunhofer	0.62	2	2.28

Picture above: SD and R^2 correlation are well proportional; the height of the curve depends on the SD level.

How well does the bandwidth of the SNQ curves correspond to plus / minus K2 / 95% uncertainty ?

We should keep the following aspects in mind:

- We have only 25 measurements - and several with uncomplete data sets. What got checked in this project **is based on a limited amount of measurements of typical houses of one climate zone** (the hotter the climate, the lighter the building - the more difficult acoustical isolation becomes).
- The 1 dB stepping concept of the signal level normalization method leads to too large SD / K2 values; relative to K2 / 95% value of about 0.3 dB (as assumed after some step experiments).
- Our SD estimation here does not take into account, that the K2 / 95% range bandwidth should not cover all 20 curves of a set of 20 curves (one curve should be outside the limits) - leading also to a slightly too high SD or K2/ 95% value.
- Therefore, the numbers in this study got rounded to **integer values**; 8 dB for the TM and 3 dB for the ball. Elsewise a result in 0.1 dB steps would lead to a wrong impression of precision, with only 25 measured ceilings.
- These integer values are expected to be reasonably correct, because the Tapping Machine K2/ 95% integer value of 8 is rounded down and the ball results are not expected to drop by a full value step - further the Acuwood level can logically not drop to zero ! Therefore the author expect these results to be relevant - at least for situations in Switzerland, where we have wood and concrete floors; small to midsized-large rooms of different shapes and strongly varying impact isolation quality (In the normalization process, on page 3, level shifts of nearly 20 dB took place).



65
60
55
50
45
40
35
Practically no structure
Fairly clear structure
Clear structure
20 -> 50 Hz
stabil 50 Hz
50 -> 20 Hz
Clear structure
Only the 15 measurements having all data fields, are shown here.
Extreme amount (high or low) of bass level leads - SNQ-type-dependent - to different positioning of the curve in the overall band width of all curves.
L'n,T,w
L'n,T,w,Ci 100-3150
L'n,T,w,Ci 50-3150
1419-2 L'i,Fmax,r
1419-2 L'i,Fmax,AW
KS F 2863-2 L'i,avg, Fmax, 63-500 Hz
L'i, Fast, Max, A, V, T 20-2500
L'i, Fast, Max, spez (80dB), V, T 20-2500
L'i, F,max, average, octave 50-630
L'i, Fast, Max, V, T, AVERAGE OKTAV 25-2500
L'i, F,max,average, octave 25-630

The up's and downs in the graphs picture, as in the last slide (7), reveal a very fundamental quality of the rubber impact ball: **Not only in the view of one measurement, but also in the view of all measurement we have a curve shape here which brings all the quality SNQs used in this study into a common signal level relationship to each other. All SNQs seem to - over level-relevant variants depending on bandwidth and mathematical summing up of the octave energy values - have a generic signal offset to each other. This is obvious from having uncertainties per SNQ and 2 uncertainties to care about when recalculation from one SNQ to another SNQ.**

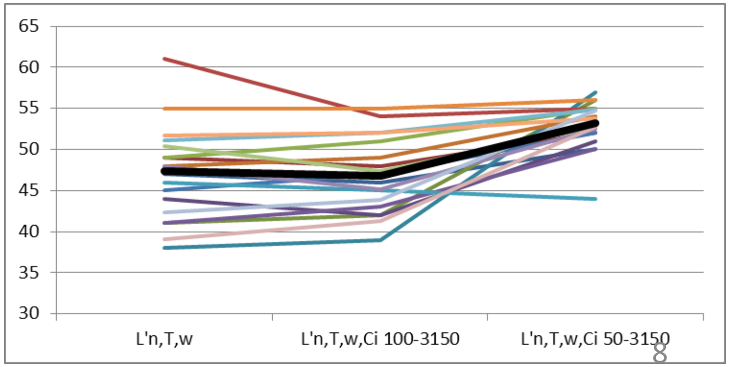
SNQs can deliver - type & bandwidth dependent - **very** different values (up to 40 dB difference). Any value change always correlates with a corresponding psychoacoustic annoyance change. This means the ball-SNQ is, other than with the TM, only a view containing more or less bandwidth and slightly higher or lower bass weighting and a math type dependent signal level.

Or to put it bluntly: The main "intelligence/ capability" for correct results does not come from the SNQ (as with the TM), but from the ball itself. This is also the explanation, why in Asian ball research articles the R^2-correlation factors only vary relatively little, depending on the chosen SNQ formula [docs 10]. **In the end this is the „prove", that the ball - other than the TM - really emulates impact noise. The TM is a „floor bell" and does not emulate impact noise***. Therefore all the ongoing experiments over 30 and more years with super-hyper SNQs never were and never will be successful##**; they only show high correlation values, when designed specifically for, or tailored to a certain building technology**.**

*** see table in slide 11; ## see new setback in doc 138 relative to doc 142. That after over 30 years of SNQ experiments, see doc 126, figure 6.

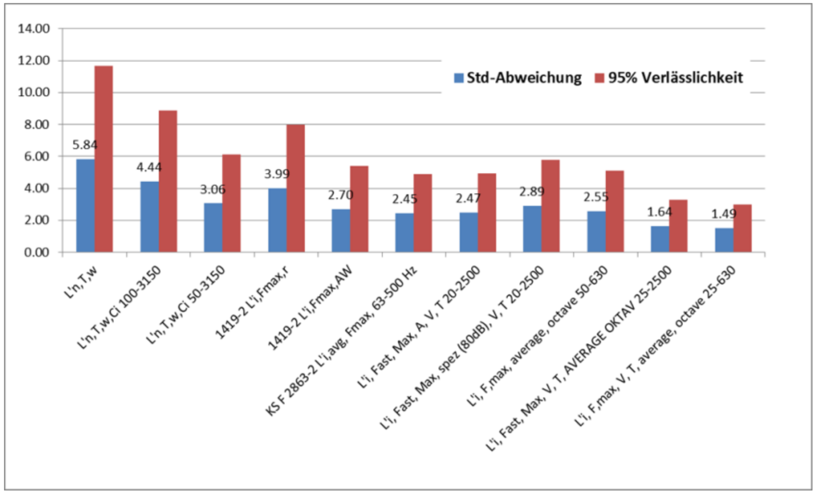
Sidecar result for the tapping machine:

As in the picture on the left, TM uncertainties are much reduced, when Ci50-3150Hz correction is applied instead of Ci100 – 3150Hz correction.



Results (1)

Two results are of main interest: **measurement uncertainty** and **level offsets** to the TM-based national limits; furthermore the signal level difference from one SNQ to another. Larger bandwidth gathers more sound energy and leads to higher values, furthermore the type of mathematical calculation (Energy summation / average / math average) leads to massively different signal levels.



Uncertainties:

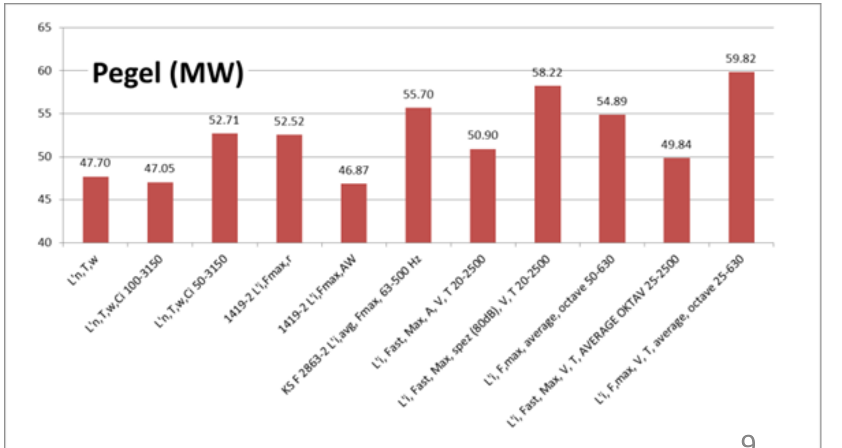
The ball leads by far; but the TM also gains in precision when using Ci50-3150Hz correction term instead of Ci100-3150Hz corrections !

Remark: Based on the method used in this study the K=2/ 95% values are probably at least about 0.3 dB (or slightly more) too high.

Impact on the national limits

Similar to the EMPA "Pendelfallhammer"***,ball based SNQs require (same as TM with Ci50) an offset correction. TM with Ci from 50 Hz upwards delivers a about 5 dB higher level than with Ci from 100 Hz - tzhis could be the reason, that Sweden set the limit at 56dB.

*** a test tool for impact noise in kitchen and bathroom etc using a small hammer.



Results (2)

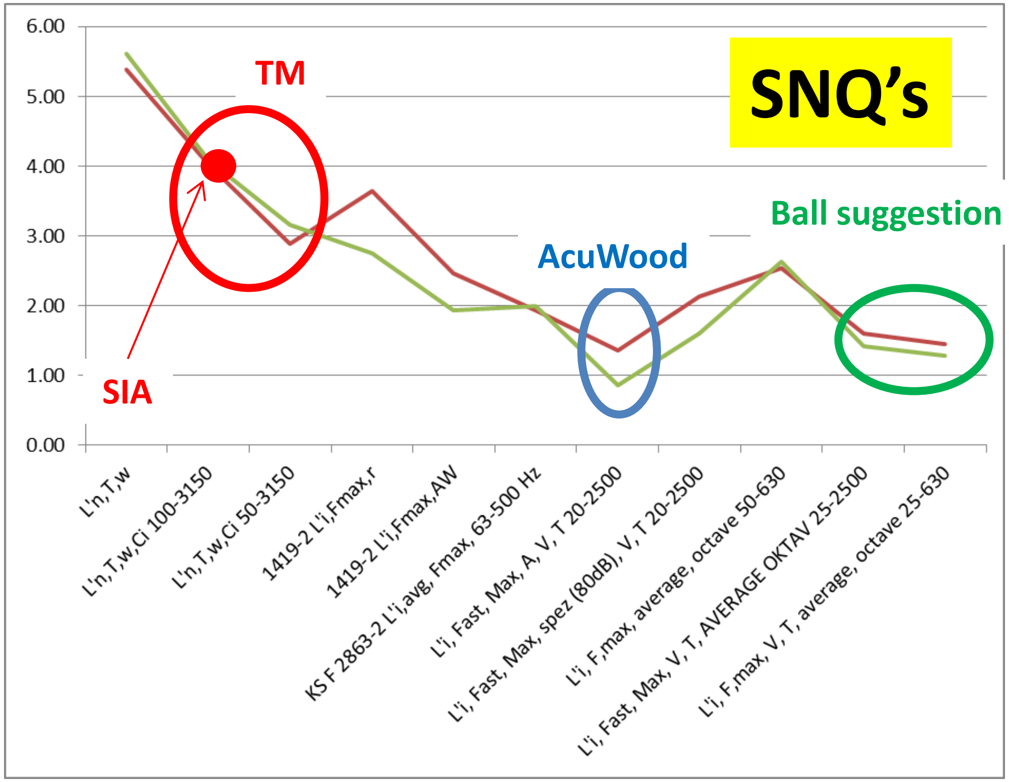
Here the SD „big picture view“. Only SNQs of interest are shown:

The brown curve shows the results coming from our team acousticians measurements (except the ones missing TM). The green curve shows results from international impact noise studies (totally 19 measurements are included in this graph).

The picture shows SD values; but please be aware, that in reality the K=2 / 95% coverage values are relevant.

While the TM, employed from 100 Hz upwards with K=2 shows a tolerance of 8 dB, the ball shines with 2..3 dB. The TM, from 50 Hz uwards, showed a 95%/ K2 tolerance of 5..6 dB.

The Acuwood ball SNQ showed the lowest uncertainty value; coming from the A-filter weighting only weakly reflection the low end frequency situation.

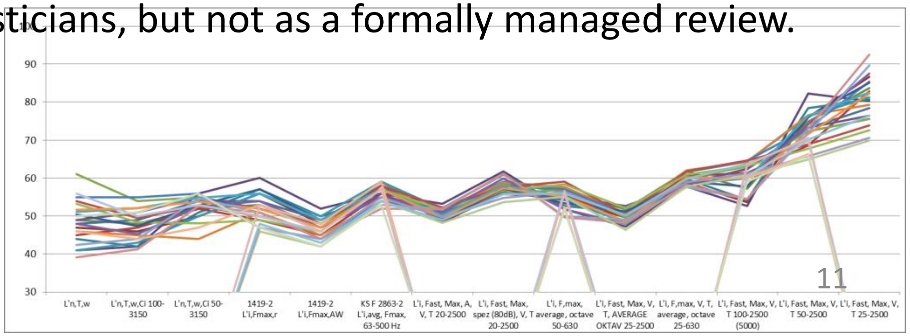


The last two SNQ’s (far right) show the best uncertainty capabilities to reflect the annoyance of impact noise; the first of the two has further the advantage to be (fairly precise) backwards compatible to existing national limit.

Limits of the Study

- The test scope on floors is too small to deliver reasonably solid „SNQ offsets”; the floors data available does not reflect international variances of floor designs.
- The normalization in 1 dB steps is too rough and leads to a slightly too high standard deviation (SD) and 95% uncertainties values. The author estimates the error to be about or slightly above + 0.3 dB .
- A mix of concrete and other floor types was determind by the floor data available. The mix was not arranged to reflect market volumes.
- The floor data does not cover with all measurement all SNQ types require (so only 19 measurements could get used in the uncertainties calculation - the picture below illustrates our problem we had with using existing data (the curve breaks away at SNQs with data missing):
  - 3 floors had no T.M results
  - Only 70% of the data sets covered the low end frequency range down to 20 Hz (as required for the Acuwood SNQ). Defacto our Acuwood SNQ does not reflect frequencies below 25 Hz; But this should not be over estimated in its importance; Acuwood’s A-weighting (with -50 dB at 20 Hz) dominates the low end, there are no relevant contributes at 20 Hz to the SNQ.
  - With 4 floors the low end frequency range did not cover the range below 50 Hz.
- The data comes from different acousticians; no team check regarding correctness for all data was made with our own measurements; they were made by one person alone and not by a measurement team. The template was checked by several acousticians, but not as a formally managed review.

Using existing data meant working with partly uncomplete data set - making analysis difficult. 19 measurements included all data to can get used in an overall analysis. The 6 other measurements got checked to be fitting well enough into the overall picture. Reason for this complexity: Missing TM values, missing 50Hz TM values, missing 20 Hz results (ball).



Summing up the balls qualities:

- The ball showed much better precision (lower uncertainties) that the TM.
- The ball results are hardly disturbed by floor toppings and sandwich floor designs.
- The ball covers the relevant frequency part of the annoyance spectra better than Ci 50 or Ci 100 correction terms. Asian SNQ do not cover the low end frequency range below 50 Hz, as we require in Europe due to room/ ceiling sizes beyond 10m. 50 Hz as low end limit is insufficient for a world wide standard; several Asian researchers have also pointed this out.
- 25 Hz would be the better low end range choice that 32 Hz, because it covers a full octave bandwidth. The ball is predestined for in-situ measurements, due to its well chosen impedance and energy level.
- The only emulation weakness of the ball - its too short signal - seems to get fullycompensated by the timing weighting of L,F,Max.

Requirements for Impact Emulation	Ball	Tapping Machine	Comment
True impact noise source, capable of emulating floor impact noise of walking people an playing children.	✓	👎	TM: Ongoing sound source
Energy impacts in the range of 1 - 10 m*kg (Weight * ball dropping height)	✓	👎	Ball: 2.5 m*Kg; **TM has less than 1% of that**
Impedance corresponds to walking legs resp. playing children	✓	👎	Ball: See studies TM: Hardened steel
Impact energy does not simply "evaporate" when hitting soft toppings, but goes into the ceiling.	✓	👎	See Fraunhofer Report F2918
Modest measurement requirements	👎	✓	Ball requires advanced tools; or: an alternative A-weighted broadband solution could come up.

Referenced Literature

ID	Title	Year	Author	Ref	Content
4	Review of the Impact Ball in Evaluating Floor Impact Sound	2006	including Tachibana	HAL Id: hal-01509352	Table IV
10	SUBJECTIVE EVALUATION OF HEAVY/SOFT IMPACT SOUND	2017	JeongHo Jeong et Al	ICSV24, London, 23-27 July 2017	See chapter 3 the graphs and the R2 numbers in the chart.
31	AcuWood – Entwicklung verbesserter Mess- und Bewertungsverfahren für den Schallschutz im Holzbau	2014	Moritz Späh et al	Fraunhofer-Institut für Bauphysik IBP; 14.01.2014	Abschlussbericht AcuWood: Compare table 2 TM and table 3 (Ball) results
58	Review of the Impact Ball in Evaluating Floor Impact Sound	2006	Jeon, Ryu, Joeng	ACTA ACUSTICA UNITED WITH ACUSTICA Vol. 92 (2006) 777 – 786	See table 5
126	Subjective and objective evaluation of impact noise sources in wooden buildings	2013	Moritz Späh et al	noise notes volume 13 number 1	Figure 6 shows that no systematic SNQ development took place. Extremely different approaches got tried, without sucess.
138	Correlation between sound insulation and occupants' perception – Proposal of alternative single number rating of impact sound, part II	2017	Ljunggren, Simmons, Oequvist	Applied Acoustics 123 (2017) 143–151	The SNQ qualities found in PART I did not hold, when in PART II other houses got tested. Ball showed stable results.
142	Correlation between sound insulation and occupants' perception – Proposal of alternative single number rating of impact sound, Part I	2014	Ljunggren, Simmons, Hagberg	Applied Acoustics 85 (2014) 57–68	The SNQ qualities found in PART I did not stand, when other houses got tested in PART II. The Ball showed consistent results.
201	Acoustics in wooden buildings – Correlation analysis of subjective and objective parameters	2014	Moritz Späh et al	AcuWood Report 1 SP Report 2014:14	Table 9

Back-Up Slides

«The big picture»

- The tapping machine is of big importance for raw concrete floors. It is well suited to «load» the floors with (more or less) **white noise** and delivers good reproducibility.
- That changes dramatically, when the floors are of sandwich construction type. Even more so when they include soft top layers like carpets. Then effects turn up, as a result of physical characteristics of the tapping machine e.g. too little energy and miss-fitting impedance to correctly emulate children and walkers.
- In real life today floors and ceilings are mostly of sandwich-design, with soft upper layers, thus letting the TM energy just «evaporate, vanish».
- Therefore the rubber ball is especially well suited for in-situ use, showing little sensitivity to floor /ceiling design types.
- A substitution of the TM by the ball is in Asia well under way - a trend for about 5 years.
- With a simple template - see slide 18 - all popular SNQ can be calculated automatically. This to assess whether a floor would easily pass the requirements in Japan, Korea and also according to Acuwood.
- **For the development of new floor/ceiling concepts the ball is a MUST !**
- Working with the ball is highly efficient and easy, if the measurement equipment enables this.

The Team

- A senior scientist for building acoustics from a Swiss Federal Institute
- Two acousticians from a highly regarded wood construction company, using the ball parallel to the TM as relevant impact noise qualification tool.
- An acoustician with a very hot project regarding impact noise (No wood building). Impact noise is in a new set of apartments much higher than one would expect. Tapping machine values are excellent - and at the same time the people living there are annoyed by hearing their neighbours.
- An acoustician from a Swiss wood sales amplification organisation.
- The author of this paper, an ETH-engineer / retired development manager in high tech areas. After retirement he studied acoustics for 3 semesters at the ETH and passed the SGA (Swiss Acoustic Society) acoustician diploma last year. Specialized in acoustic measurement applications.

Technical issues important to know

- One should be aware of the unique situation we have, with our curve package going over all SNQs: It brings several issues together
  - A (mostly) small bandwidth in every quality SNQ «slot» of the ball - the (good) uncertainty value is based in the balls physics, and not so much on the SNQ.
  - Over all SNQ average values per bandwidth, we have a stable offset from one SNQ to the other. This over all measurement which covers very different room sizes, ceilings and isolation qualities; and even with partly different microphone positioning approaches applied…
  - The different heights of the SNQ-specific average values result from different bandwidth and energy summing types and in a fully transparent way.
  - So here we have very strong structure elements, which are specific to the ball. Therefore , it is assumed, that the bandwidth on the curve package is proportional to the uncertainties of each SNQ-type. With 20 curves, the bandwidth corresponds well to the 95% K2 rule for uncertainties. For a precise value, it needs to be adjusted to 20 measurements - here we used 19 curves. However:, we should have many more measurement !
- SNQ energy summation calculation schema: 3 different approaches co-exist (called SNQ-types in this paper):
  - Energy summation over all octaves or 1/3 octave values. The result is the same in both cases; the resulting value depends on the bandwidth. It uses the standard acoustic approach to add up sound levels: Calculate the linear energy value of the dB values, add them up and convert the result back to dB. The result is typically high, e.g. 85…90 dB. Therefore large offsets to existing national limits are required.
  - Energy average: same as above, but reduced by 10*log(X), when X is the amount of octave bands used (with 1/3 octave is principally also possible). So if the bandwidth is 5 octave bands, the value here is the same as above minus 7 dB.
  - Arithmetical energy average: the numbers of all octave bands get added and divided by the number of octaves used. This formula has the big advantage, that by adding upper octave bands beyond 500 Hz (630 Hz for 1/3 octave) it is possible to render the value compatible to existing national limits. (By the way: The Acuwood formula also delivers a backwards compatible result value - at a price of poorly reflecting the low-end energy)).
  - Many interesting SNQ numbers have no weighting, other than the Asian and Acuwood formula, which use inverse A-weighting as reference values (Asian), respectively A-weighting in the energy summation (Acuwood).
- Some Asian SNQ use A-weighting (invers A curve as reference) . This sometimes gets interpreted as a common A-weighting, as with road noise etc. The contrary is true: The rubber ball has - due to the physics, that the sound level increases in square logic with the impact force, too much bass energy. The A-weighting has the task to reduce the extreme bass amount to a psycho-acoustical sensible amount.
- The Acuwood SNQ, which has excellent uncertainty results, has a poorly designed low-end: On the one side, it goes down to 20 Hz, on the other it uses unlimited A-weighing down to 20 Hz - simply killing any noticeable energy contribution below about 32 Hz. 20 Hz sounds good, but is a poor choice not only from this point, but also because it brings in 1/3 of a new octave - making «condensation of the value to an octave» impossible.
- The ball is highly suitable for in-situ measurement thanks to its adaptive, mid-range impedance not sensitive to floor toppings; carpets have no relevant impact on the measured signal level - just as in real life carpets don't help much against impact noise from walkers and playing children.

Technical issues important to know (2)

- The Rubber Ball is in measurement aspects a (very) demanding source. Best solution is an IR tool used in the balloon banging mode (for RT-measurements). However, this method requires (other than with balloons) to start the recording before the ball drop occurs. Using IR technique of a short recording with 64'000 samples at 48 kHz creates a neat solution. But which tool supports this - fairly none. One can record by ARTA and use other tools for the L,F,max measurements - but that is complicated. The author uses B&K's DIRAC with a hardware workaround: On channel one, a microphone gets used as acoustical detector of the ball falling before** or at the moment it touches the ground - this microphone sits on a mini tripod near the drop location in about 10 cm height. (** requires a speaker driven sound reflection detection as in the picture on the right). Going from one to the other dropping location you need to pull the channel 1 microphone along. **PS:** DIRAC gets used with a RME Fireface UC USB-"sound-card" device for ADC & DAC conversion.

- The setup for the ball dropping positions and the microphones, is not the same in Asia as in the ISO standard. That will result in minor signal level differences, when used in a Asia-ISO combination, as some acousticians do: They drop the ball directly over the microphone in a ISO position.

- No SNQ signal value offset table is supplied in this study, showing how much the national limit would need to be modified, when changing from one SNQ to an other; e.g. going with the tapping machine from 100 Hz Ci to 50 Hz Ci. The reason: We have far too little data to deliver solid values. Especially the broad international variance in building technologies is in no way reflected in this study. But the graph on slide 9 (below) shows you roughly, how big the values are.

- Impact measurement are often made in raw buildings without any absorbing / diffusing furniture. Make sure, that your RT60-measuring device is capable of handling flatter echo - something not all products manage well. When the RT60 value are surprisingly short and vary little over frequency, that can be a warning, that the device only evaluates the first flatter interval.

- The ball poorly emulates the **timing** of walkers or play children. But together with the L,F,Max time weighting that does not seem to have negative impacts on the psycho-acoustical correlation results. But one should be fully aware: The ball does not emulate the different phases of noise production a foot has when "rolling" over the floor.

Picture below shows the author's measuring setup: An IR source spreads a red light "carpet" in the heights of 1.00 meters; the speaker / microphone below is used to detect the falling ball before it touches the floor.
The loudspeaker can get left away, the «plop» is mostly loud enough to trigger the recording without active ball pass detection by sound reflection.

The IR light line on the walls allow you to position the bottom of the ball before dropping it.

Datenaufbereitung

Version V7 / 2019-04-24

template

Name der Decke	For Docu

Import Normhammerwerkresultate

Band [Hz]			20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000
L',nT							63.7	57.7	49.9	47.75	41.4	40.7	35.1	37.2	36.9	37.6	36.1	31.2	31	30.2	30.5	28.1	20	12.6	12.1	12.7	13.6
L'n,T,w	35									37	37	37	37	37	37	36	35	34	33	32	29	26	23	20	17	12	7
Ci	100-3150	1																									
Ci	50-3150	15							Dateneingabe																		

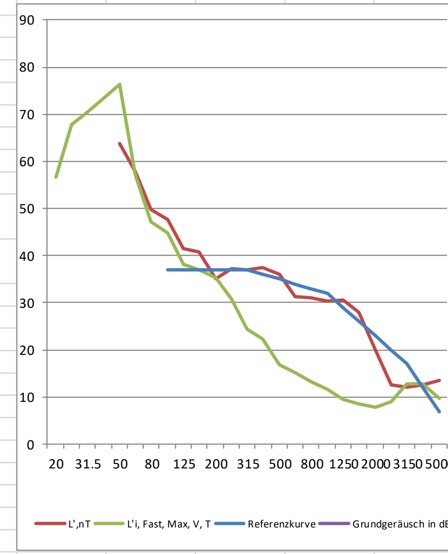
Import Ball Rohdaten

Anzahl Zeilen:	12	Band [Hz]	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000
Ball Position	Mik Position	Mik Höhe																									
			57.6	66.6	71.1	78.1	73.7	66.9	44.4	38.4	45.6	46.4	37.6	32.2	29.8	26.3	20.8	20.7	18.8	18.9	15.7	13.4	11.8	12.7	12.6	14.6	11.3
			56.6	66.6	71.9	78.1	73.7	45.7	53.2	53.9	40.5	39.8	40.7	35.8	27.6	27.1	19.3	20.1	17.4	15.6	14.0	11.8	10.8	11.0	14.1	15.8	10.6
			62.1	71.3	71.3	73.7	71.2	61.4	48.5	46.4	43.8	44.1	41.4	34.2	30.1	29.2	25.1	21.5	18.5	17.9	14.4	13.1	11.2	11.8	14.3	13.4	11.3
			63.0	74.4	78.2	63.1	72.2	55.1	55.0	49.6	45.0	43.7	37.8	37.2	26.7	29.2	22.8	20.7	18.5	16.1	14.6	12.9	11.0	12.8	18.1	14.1	11.7
			62.9	65.1	61.3	70.2	77.3	61.2	49.3	43.8	45.0	42.3	39.2	36.8	27.8	26.9	21.6	19.2	17.7	16.1	13.7	13.3	13.0	12.1	14.6	13.8	11.7
			61.7	70.1	71.7	66.1	75.3	51.1	43.9	47.9	42.9	45.0	45.3	36.2	32.6	26.4	19.4	18.4	16.5	14.9	12.3	11.0	10.1	10.3	15.1	17.5	11.2
			59.6	72.2	72.2	80.8	77.7	66.1	46.7	37.7	45.7	37.4	44.1	32.2	28.5	27.0	22.7	20.7	19.0	16.6	14.2	12.0	11.4	11.7	11.4	12.6	10.6
			58.8	73.5	73.4	69.0	67.1	49.2	54.4	42.9	45.9	39.8	37.4	38.0	28.8	29.1	21.5	21.3	18.1	15.9	12.7	11.2	9.4	10.5	15.5	12.3	11.0
			59.8	74.3	78.3	82.0	78.5	52.0	50.3	53.4	40.1	40.5	41.3	34.1	29.6	26.1	19.9	18.3	16.4	12.7	10.9	10.7	10.1	12.5	18.1	16.9	12.2
			58.8	72.8	76.1	74.1	77.6	52.9	55.4	51.1	42.2	37.6	35.8	38.9	29.6	26.1	19.9	18.3	16.4	12.7	10.9	10.7	10.1	12.5	18.1	16.9	12.2
			55.6	65.5	68.6	77.2	81.0	62.2	42.7	42.0	39.3	39.9	36.2	36.6	30.2	23.2	20.8	18.6	16.8	15.5	13.7	12.2	12.0	13.0	13.1	13.4	13.0
			57.3	63.3	65.2	74.5	77.4	51.6	53.3	45.5	39.9	39.9	35.5	32.4	30.4	23.0	20.5	17.7	14.3	13.0	9.9	9.4	9.5	9.6	11.8	15.5	11.0
L'i,fast,max	dB	Terz	60.13	71.09	73.7	76.71	76.51	60.79	51.62	48.74	43.61	42.27	40.54	35.9	29.6	27	21.5	19.8	17.6	15.96	13.52	12.15	11.22	12.02	15.43	15.15	11.74
Grundgeräusch in dB		Terz																									
L'i,fast,max ohne Noise		Terz	60.1	71.1	73.7	76.7	76.5	60.8	51.6	48.7	43.6	42.3	40.5	35.9	29.6	27.0	21.5	19.8	17.6	16.0	13.5	12.1	11.2	12.0	15.4	15.2	11.7
L'i,fast,max ohne Noise		Oktav			79.20			76.64			50.59			42.08			28.72			20.77			16.58			19.17	

Example of a mid-sized room; clearly smaller than a sitting room.

Import der Nachhallzeit (gemittelt)

			20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000
RT60			1.3	1.3	1.3	1.3	0.42	1.43	2.06	1.663	3.7	3.22	3.09	3.1	2.87	2.53	2.38	2.37	2.03	1.92	1.65	1.38	1.27	1.11	0.97	0.86	0.74
V	41.4																										
C0=	0.289																										
C=		Sec	0.75	0.75	0.75	0.75	0.24	0.83	1.19	0.964	2.14	1.87	1.79	1.8	1.66	1.47	1.38	1.37	1.18	1.11	0.96	0.8	0.73	0.64	0.56	0.5	0.43
T corr =		dB	2.59	2.59	2.59	2.59	-0.6	2.81	3.6	3.154	4.68	4.45	4.38	4.39	4.25	4.01	3.9	3.89	3.58	3.47	3.14	2.73	2.53	2.2	1.85	1.54	1.13
V corr =			-0.8	-0.82	-0.8	-0.8	-0.8	-0.8	-0.8	-0.82	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.82	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
Lineare Bewertung			20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000
L'i, Fast, Max, V, T		dB	**56.7**	**67.7**	**70.3**	**73.3**	**76.3**	**57.2**	**47.2**	**44.8**	**38.1**	**37.0**	**35.3**	**30.7**	**24.5**	**22.2**	**16.8**	**15.1**	**13.2**	**11.7**	**9.6**	**8.6**	**7.9**	**9.0**	**12.8**	**12.8**	**9.8**
Octav					75.79			76.32			46.17			36.88			23.93			16.50			13.28			16.76	
A-Kurve			-50.5	-44.7	-39.4	-34.6	-30.2	-26.2	-22.5	-19.1	-16.1	-13.4	-10.9	-8.6	-6.6	-4.8	-3.2	-1.9	-0.8	0.0	0.6	1.0	1.2	1.3	1.2	1.0	0.5
L'i, A, Fast, Max, V, T			6.22	23	30.9	38.7	46.1	31	24.7	25.66	22	23.6	24.4	22.1	17.9	17.4	13.6	13.2	12.4	11.7	10.2	9.6	9.07	10.3	14	13.8	10.3
Octav					39.46			46.22			28.79			27.01			19.97			16.28			14.45			17.74	
90 Phon Bewertungskurve			-33.00	-27.00	-21.00	-21.00	-17.00	-14.00	-11.00	-8.00	-6.00	-4.00	-3.00	-2.50	-2.00	-1.50	-1.00	-0.80	0.00	0.60	1.00	1.20	1.30	1.20	1.00	0.50	0.50
L'i, spez, Fast, Max, V, T			23.72	40.68	49.29	52.30	59.26	43.17	36.19	36.76	32.11	33.00	32.34	28.22	22.51	20.71	15.83	14.34	13.20	12.27	10.56	9.80	9.17	10.20	13.75	13.29	10.29
80 Phon Bewertungskurve			38.98	34.22	29.64	25.33	21.71	18.62	15.16	12.47	10.08	7.81	5.91	4.30	2.88	1.67	0.85	0.16	-0.34	0.00	2.47	3.73	0.58	-2.13	-2.94	-1.70	1.61
L'i, spez, Fast, Max, V, T			17.74	33.46	40.65	47.97	54.55	38.55	32.03	32.29	28.03	29.19	29.43	26.42	21.63	20.54	15.98	14.98	13.54	11.67	7.09	4.87	7.29	11.13	15.69	14.49	8.18



Asiatische Auswertungen

Auswertung nach JIS A 1419-2 L'i,Fmax,r	53
Auswertung nach JIS A 1419-2 L'i,Fmax,AW	46
Auswertung nach KS F 2863-2 L'i,avg, Fmax	50

Auswertungen mit arithmetischem Mittelwert

L'i, Fast, Max, V, T, arithm. AVGERAGE				
25-2500	25-2500	50-5000	100-5000	
34.11	34.11	25.74	19.99	Terz
41.27	41.27	32.83	25.59	Octave
L'i, Fast, Max, **A**, V, T, arithm. AVGERAGE				
20.83	20.83	18.24	15.62	Terz
		50 - 630	25-630	
L'i, F,max,average, octave		45.83	51.82	

Auswertungen mit energetischen Summen

				L'n,T,w &Ci
				100-3150
L'i, Fast, Max, V, T				36
20-2500	25-5000	50-5000	100-5000	50-3150
79.10	79.08	76.32	46.69	50

AkuWood

L'i, Fast, Max, **A,** V, T				40-2500
47.18	47.18	46.38	31.73	47.06

20-2500

L'i, Fast, Max, spez (90dB), V, T			
60.59	60.59	59.44	40.51

Akuwood modified

L'i, Fast, Max, spez (80dB), V, T			
55.74	55.74	54.76	36.94

Template page for Asian values

Auswertung nach JIS A 1419-2 L'i,Fmax,r

2018-07-06 / Alastair Gurtner *eff. Frequenzbereich: 45 - 2840 Hz* *V und T werden nicht berücksichtigt bei dieser Messung (von der Norm her)*

Freq.	Noise AVG
20	0.00
25	0.00
32	0.00
40	0.00
50	0.00
63	0.00
80	0.00
100	0.00
125	0.00
160	0.00
200	0.00
250	0.00
315	0.00
400	0.00
500	0.00
630	0.00
800	0.00
1000	0.00
1250	0.00
1600	0.00
2000	0.00
2500	0.00
3150	0.00
4000	0.00
5000	0.00

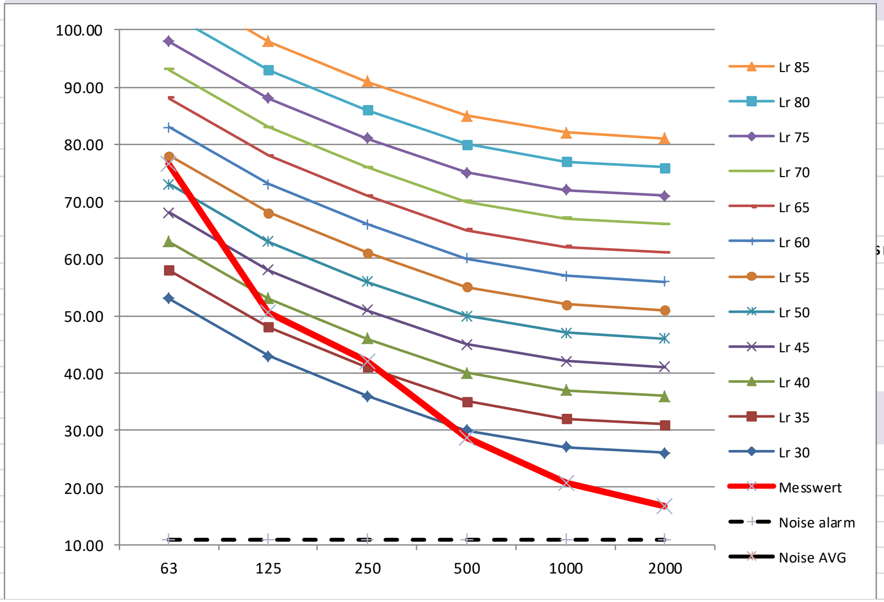
Grenzwerte

Freq.	Lr 30	Lr 35	Lr 40	Lr 45	Lr 50	Lr 55	Lr 60	Lr 65	Lr 70	Lr 75	Lr 80	Lr 85
32												
63	53.00	58.00	63.00	68.00	73.00	78.00	83.00	88.00	93.00	98.00	103.00	108.00
125	43.00	48.00	53.00	58.00	63.00	68.00	73.00	78.00	83.00	88.00	93.00	98.00
250	36.00	41.00	46.00	51.00	56.00	61.00	66.00	71.00	76.00	81.00	86.00	91.00
500	30.00	35.00	40.00	45.00	50.00	55.00	60.00	65.00	70.00	75.00	80.00	85.00
1000	27.00	32.00	37.00	42.00	47.00	52.00	57.00	62.00	67.00	72.00	77.00	82.00
2000	26.00	31.00	36.00	41.00	46.00	51.00	56.00	61.00	66.00	71.00	76.00	81.00

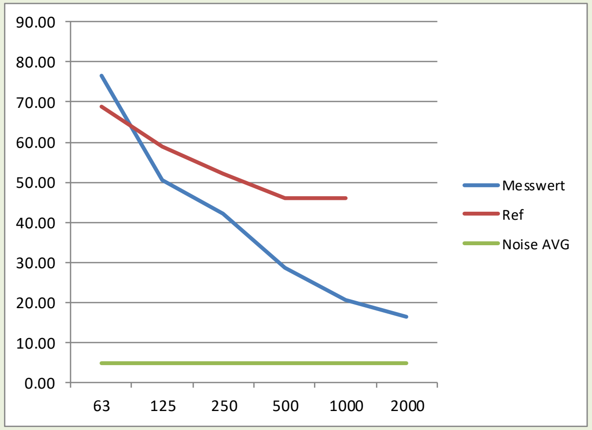
Messwerte

Freq.	Mess wert	Noise AVG	Result corr	Noise alarm
32	79.20	76.64	#######	#######
63	76.64	4.77	76.64	10.77
125	50.59	4.77	50.59	10.77
250	42.08	4.77	42.08	10.77
500	28.72	4.77	28.71	10.77
1000	20.77	4.77	20.66	10.77
2000	16.58	4.77	16.29	10.77

Selection: 54 dB Hier muss die Zahl von Hand eingegeben werden, nach 1 Oktav, 2 dB Regel-Check



Auswertung nach JIS A 1419-2 L'i,Fmax,AW



Ref	Diff.
69.00	7.64
59.00	-8.41
52.00	-9.92
46.00	-17.28
46	7.64

Max 8 !!

Zahl im gelben Feld verändern bis die 8 dB Regel eingehalten ist.

Auswertung nach KS F 2863-2 L'i,avg, Fmax

S F 2863-2 L'i,avg, Fr	50

Glossar (I)

- **Tapping Machine:** The TM got invented about 80 years ago and since about 79 years it gets criticised for delivering poorly relevant numbers for the psycho-acoustic annoyance of floor impact sound. It received over all the years several improvement like a motor driven cam-shaft; really relevant steps were:
  - Introducing Ci correction factors for better psycho-acoustic relevance (ISO-based)
  - Introduction - also in ISO the standard - of modifications, where the hammers drop on an precisely defined "rubber" mat laying on the floor. This improves the relevance of the measurements, but reduces the signal level to a critically low level. This approach was no success, partly due to mechanical stability problems.
  - Further modification of the modified TM: Only one hammers works and hits the mat as described above, reducing the signal level further by 7 dB. Of no practical importance, although this is the TM version with the highest correlation between the annoyance and the measurement value - but far to low signal level to can be used in real world.

- **The Japanese Rubber Ball:** The Rubber Ball, as used in out tests, is the 3rd generation of pneumatic, thick walled rubber banging devices: First the tire, often called "Banging Machine", got used - already with quite reasonable correlation quality between measurement value and psycho-acoustic annoyance qualities of the floor under test. Later the Rubber Ball was developed, especially designed for floor impact noise measurements, which well fulfils the requirements for such a task (-> Page 12). 2004 it got redesigned, mainly the rubber material got replaced by silicon, making the Rubber Ball highly insensitive to environmental temperature.

- **SNQ** (Single number quantity) is a number, which should represent, instead on many detailed values, with one number the relevant sound isolation quality. A well known non-acoustic SNQ example: The eye doctors seeing rating in percent ("you have a 80% seeing capability and therefore need no glasses for driving a car"). As you many have experienced yourself, such a number can be of very limited help - if one sees poorly at night or when reading a book. With the Ball - other than TM - the SNQ is just a kind of "summing up" view and has little impact on the relevance of the result - but one must know, with formula was used for generating the SNQ.

Glossar (II)

- **Room modes** The impact noise measurement gets much influenced by the room modes of the receiving room. Modes are the frequencies, where resonances in a room occur. The lowest mode represents the lowest frequency a room can live up to. Room modes are fully dependent of the rooms size - and that sets the lowest 1/3 octave (or octave) the impact noise measurement must include.

- **L,F,max** is the measurement type used with the Rubber Ball, it is a quasi peak measurement weighting concept using 125 milliseconds integration time. We are here in the area of transient measurements; a technic which only got reasonably possible in real world, when the Sound Level Meters received microprocessor intelligence. In advance, the Leq measurements needed to get used - something the TM delivers. Therefore, for many years, the TM was the only practical option. But that changed gradually over the years 1985 to 2000.