Technical Note

Measurement of emitted noise from three types of panels of 2500 x 1000 mm used in multi-use games areas

Performed for Kompan A/S

TC-101331 Revision 1
Project no.: 118-33049
Page 1 of 27

11 January 2019

DELTA – a part of
FORCE Technology
Venlighedsvej 4
2970 Hørsholm
Denmark

Tel. +45 72 19 40 00
Fax +45 72 19 40 01
www.delta.dk
VAT No. 55117314

Title

Measurement of emitted noise from three types of panels of 2500 x 1000 mm used in multi-use games areas

Journal no.	Project no.	Our ref.
TC-101331 Rev. 1	118-33049	CWC/LSS/ilk

Client

Kompan A/S
C F Tietgens Boulevard 32c
5220 Odense SØ
Denmark

Client ref.

Søren Vangsgaard

Laboratory

DELTA – a part of FORCE Technology
Agro Food Park 13
8200 Aarhus N
Denmark

Test conditions

Guideline IS-1693	Helsedirektoratet "Veileder for støyvurdering ved etablering av nærmiljøanlegg" 2006, rev. 4/2009

Summary

The maximum A-weighted noise level $L_{p,AFmax}$ for a leather football kicked at three different Kompan panels have been measured. At a ball velocity of 80 km/h the $L_{p,AFmax}$ is:

- 78.0 dB for the Steel panel
- 74.8 dB for the HDPE panel
- 78.4 dB for the WPC panel

Remark

The test results apply only to the tested objects.

This report is a revision and replaces the previous report TC-101331 4th of January. The following changes have been applied:

- Editorial changes.
- Width of panels changed from 1420 mm to the correct 2500 mm.
- The section “A brief introduction to noise” has been moved from section 2 (old report) to Annex 10 (this report).
- HDPE and WPC densities changed to correct values.

DELTA – a part of FORCE Technology, 11 January 2019

Christian Weirum Claumarch Specialist, Acoustics	Lars S. Søndergaard Senior Specialist, Acoustics

Contents

1. Introduction

Kompan A/S has given DELTA the assignment of doing measurements of maximum emitted sound level from a multi-use games area (MUGA) used for playing ball. A series of measurements has been conducted on a MUGA at Starup in Denmark. The measurements have been performed at three panels built from different materials.

The purpose of this report is primarily to document the noise levels from the three different materials and secondly to illustrate which sound levels to be expected in the area close to a MUGA

2. Test objects

The test is performed on three different variants of panels all produced by Kompan. The three variants are named “Wood Plastic Composite” (WPC), “High Density Poly Ethylene” (HDPE) and “Steel”. In all cases the test was performed on a panel with dimensions of 2500 by 1000 mm.

All tests were performed in a MUGA measuring 26.5 metres by 19.3 metres made of panels of the HDPE-type. A single panel was replaced for the tests with WPC and Steel panels and therefore the same position could be used for all measurements.

The HDPE panels consist of one large and two smaller plates with intermediate support. The HDPE material has a density of 0.97 g/cm^3.

The WPC panels consist of one large area with seven vertically mounted planks and two smaller areas with three vertically mounted planks. The WPC material has a density of 1.3 g/cm^3.

The Steel panels consist of two rectangular steel bars supported by 26 evenly spaced steel tubes. The steel used in the panel has a density of 7.85 g/cm^3.

For all three panel types the supporting frame is made by steel.

The floor in the MUGA was made by artificial turf.

Photos of the test setup and each panel are shown in Annex 4-7.

3. Acoustic environment

The measurement was carried out in open air with approx. 45 m between the microphone and any acoustically reflecting surfaces (not including the MUGA itself). The ground surface between the panel and the microphone was flat tamped dirt with some grass. See photos in Annex 4-6.

4. Measurement setup

The measurements were carried out in accordance with IS-1693. One microphone was positioned at a height of 1.5 m 10 m down a line which was orthogonal to the panel. The wind direction was within 45 degrees of this line so that the microphone was downwind from the panel. A small microphone wind screen was used. See photos in Annexes 4-6.

The ball was kicked at the inside of the panel from a distance of 5 m (marked on the ground surface with duct tape) perpendicular to the panel. The ball was aimed for the centre of the panel – defined as the area between the posts. Hits outside of the desired area were not included in the analysis.

In series of 10-20 kicks the sound was recorded for offsite analysis. The recording was monitored and the impulse sound of both the kick to the ball and when the ball hit the panel were marked and elapsed time noted to be used for calculation of ball velocity.

Three identical balls of the type Select Brilliant Super TB with a weight of approx. 430 g were used. The pressure of the ball was (by Kompan A/S) measured to approx. 0.6 bar.

Kompan A/S was responsible for shooting the ball, where the aim was ball velocities between 30-110 km/h, as evenly distributed as possible. See Annexes 1-3. In total 92, 89 and 122 shots were included in the analysis for the Steel, HDPE and WPC panels respectively.

5. Meteorological conditions

5.1 For measurements on 27 November 2018 (HDPE & Steel)

Weather:	Clouded (~3/8)
Temperature:	0 °C
Wind velocity:	1-3 m/s

5.2 For measurements on 17 December 2018 (WPC)

Weather:	Clouded (~8/8)
Temperature:	2 °C
Wind velocity:	1-3 m/s

6. Instrumentation

See Annex 9.

7. Measurement results

For calculating the velocity of the ball the following equation was used (from IS-1693):

$$v = \frac{D \times 3.6}{T + \frac{D}{330}}$$

v = Velocity of the ball [km/h]

D = Distance from where the foot kicks the ball and to the panel [m]

T = Time difference between the foot kicks the ball and to the ball hits the panel [s]

Maximum A-weighted noise level, $L_{p,AFmax}$, for each shot on the different panel types are shown as scatterplots in Annex 1, Annex 2 and Annex 3 for Steel, HDPE and WPC panels, respectively. For all results included in the analysis there were more than 10 dB to the background noise. During the measurements made on 27 November 2018 carpenters were working on a nearby building using a nail gun which introduced peak levels at the level of and above the measured values. Shots affected by this have been removed in postprocessing by means of listening as well as plotting the recorded shots.

Applying linear regression (least square method) for the data a line (shown in red in the Annexes) can be drawn representing the maximum A-weighted noise level, $L_{p,AFmax}$ for different ball velocities.

The line can be described by the following equation:

y = a x+b

In the tables below the average 1/1-octave, A-weighted, spectrum corresponding to a ball velocity of 80 km/h are shown for the Steel, HDPE and WPC panel types.

7.1 Results with the Steel panel

At a ball velocity of 80 km/h the maximum A-weighted noise level, $L_{p,AFmax}$ at 10 m distance is 78.0 dB for the Steel panel. The octave data is calculated by means of linear regression in the individual bands. The sum of the octave data from regression is 77.6 dB, however, by first summing the octave data for the individual shots and then performing the regression a slightly higher value of 78.0 dB is found.

[Hz]	32	63	125	250	500	1000	2000	4000	8000	16000
[dB]	39.1	60.5	72.1	69.1	70.8	68.9	67.9	67.1	61.4	49.4

Table 1
Sound pressure level (SPL) from Steel panels at 80 km/h in 1/1-octave bands. The total level $L_{p,AFmax}$ is 78.0 dB.

7.2 Results with the HDPE panel

At a ball velocity of 80 km/h the maximum A-weighted noise level, $L_{p,AFmax}$ at 10 m distance is 74.8 dB for the HDPE panel. The octave data is calculated by means of linear regression in the individual bands. The sum of the octave data from regression is 74.6 dB, however, by first summing the octave data for the individual shots and then performing the regression a slightly higher value of 74.8 dB is found.

[Hz]	32	63	125	250	500	1000	2000	4000	8000	16000
[dB]	41.4	58.4	67.7	65.5	65.5	69.1	67.3	60.9	57.8	43.7

Table 2
Sound pressure level (SPL) from HDPE panel at 80 km/h in 1/1-octave bands. The total level $L_{p,AFmax}$ is 74.8 dB.

7.3 Results with the WPC panel

At a ball velocity of 80 km/h the maximum A-weighted noise level, $L_{p,AFmax}$ at 10 m distance is 78.4 dB for the WPC panel. The octave data is calculated by means of linear regression in the individual bands. The sum of the octave data from regression is 77.9 dB, however, by first summing the octave data for the individual shots and then performing the regression a slightly higher value of 78.4 dB is found.

[Hz]	32	63	125	250	500	1000	2000	4000	8000	16000
[dB]	33.5	54.8	70.3	69.8	67.7	67.9	73.3	68.1	61.2	49.8

Table 3
Sound pressure level (SPL) from WPC panel at 80 km/h in 1/1-octave bands. The total level $L_{p,AFmax}$ is 78.4 dB.

8. Propagation example

The noise propagation calculations have been made using SoundPLAN version 8.0, dated 05-03-2018. The General prediction method has been used with a “Reflection Loss” from facades of 1 dB, “Reflection Order” of 3 and a “Max Reflection Distance” of 400 m.

The levels measured at 10 metres distance for the three panel types have been converted to source strengths to be used in a propagation model in an example environment.

The environment consists of a MUGA with the dimensions 12x24 metres as well as four buildings situated around the MUGA. The terrain and MUGA are modelled as acoustically soft and with no elevation differences. The source is modelled as an area source mounted upright like the panels with a width of 0.5 m and a height of 1 m corresponding to an estimated radiating area from the measured panel. On the scale used in the noise maps in section 8.1 through 8.3 this results in the area source appearing more like a dot than an area.

The settings and source strength used when creating this noise maps can be found in Annex 8.

The propagation examples with the Steel panel, HDPE panel and WPC panel are shown in Figure 1 through Figure 3 all modelled with the reference ball velocity of 80 km/h.

8.1 Noise propagation with Steel panel for a ball velocity of 80 km/h

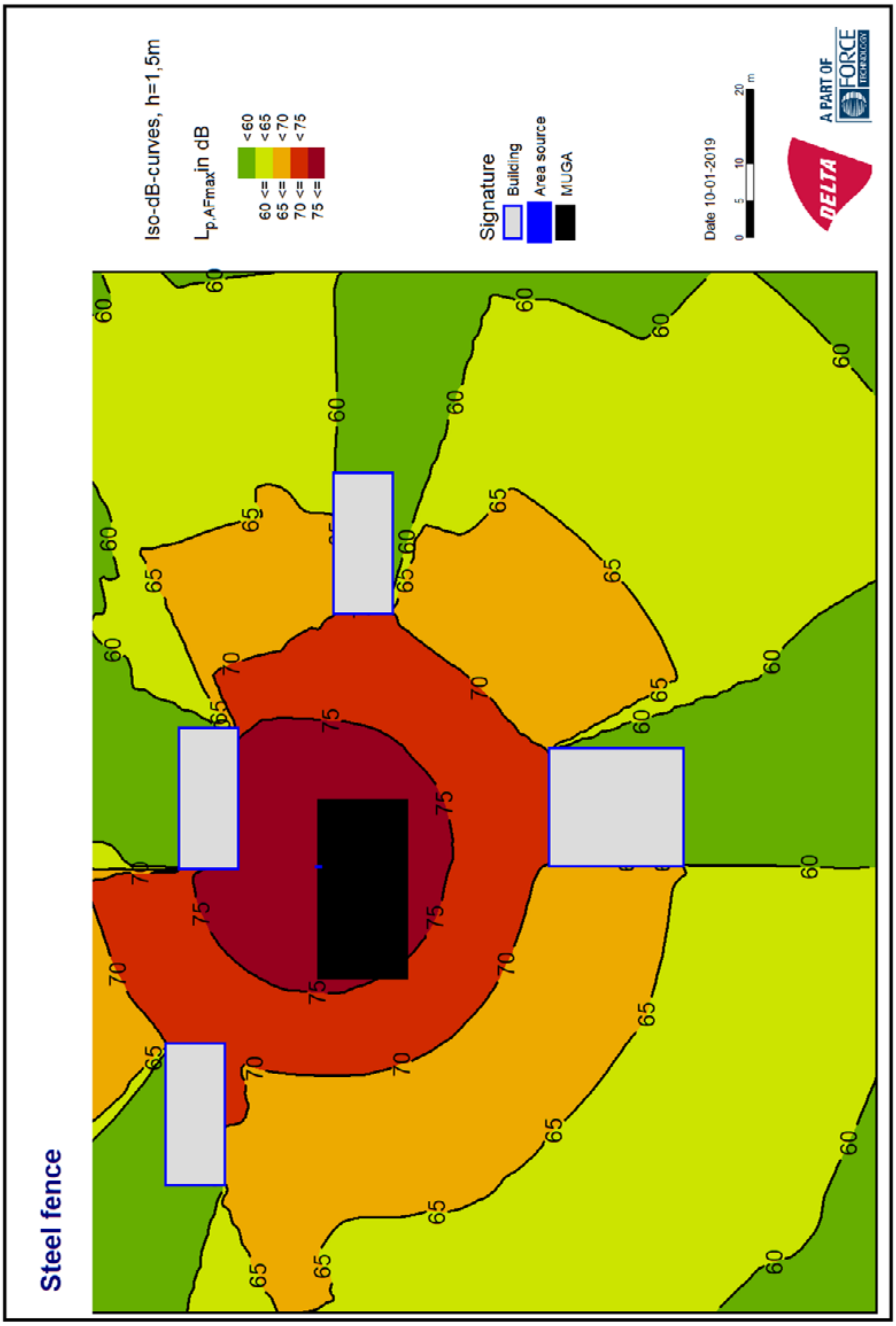

Figure 1
Noise contour (ISO dB-curves) from example MUGA with steel panels and the reference ball velocity of 80 km/h.

8.2 Noise propagation with HDPE panel for a ball velocity of 80 km/h

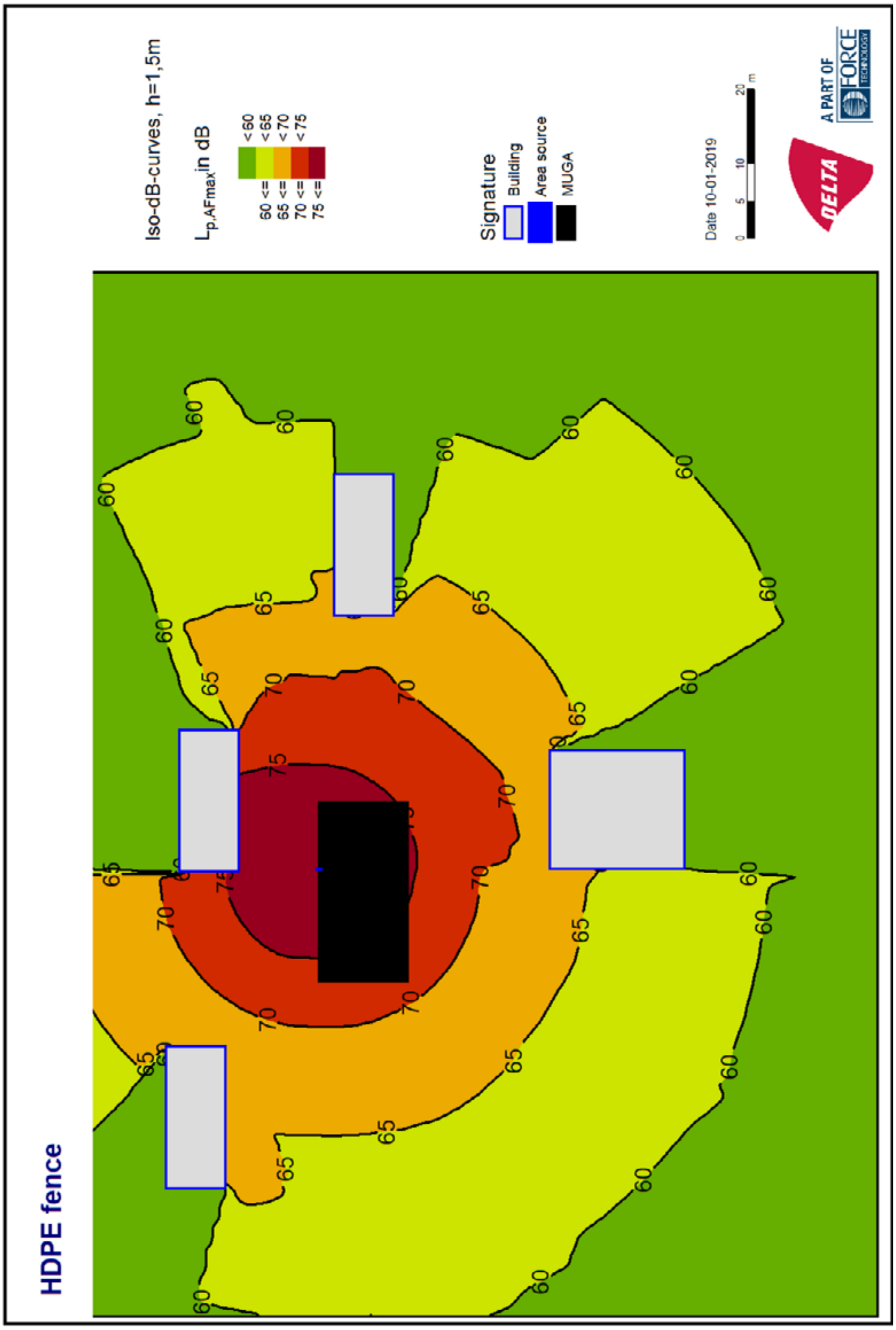

Figure 2
Noise contour (ISO dB-curves) from example MUGA with HDPE panels and the reference ball velocity of 80 km/h.

8.3 Noise propagation with WPC panel for a ball velocity of 80 km/h

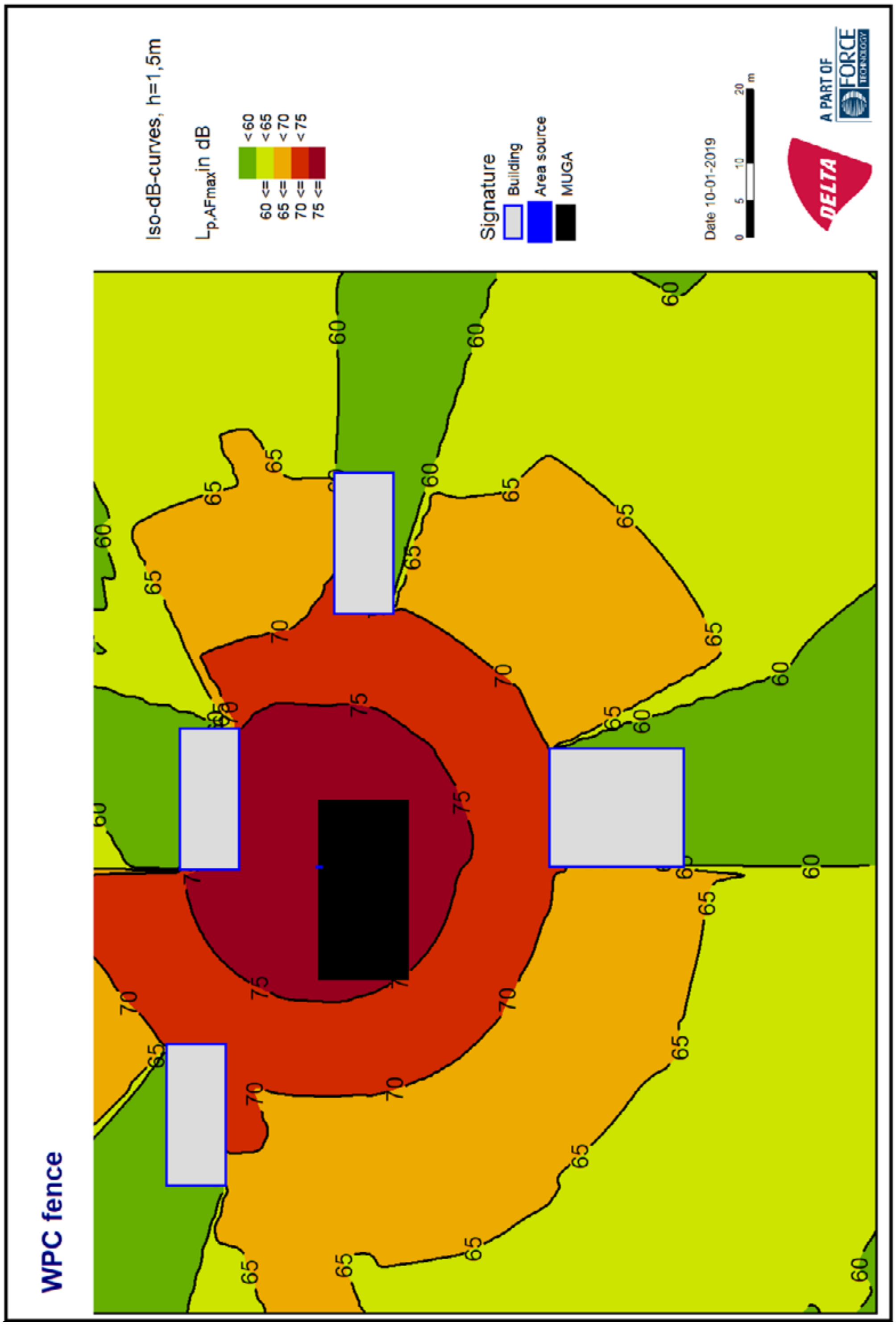

Figure 3
Noise contour (ISO dB-curves) from example MUGA with WPC panels and the reference ball velocity of 80 km/h.

Annex 1 – Measurement results for Steel panel

Date: 27 November 2018

Measuring period: 8.00 a.m. to 12.00 a.m.

Site: Starup Skole, Haderslev, Denmark

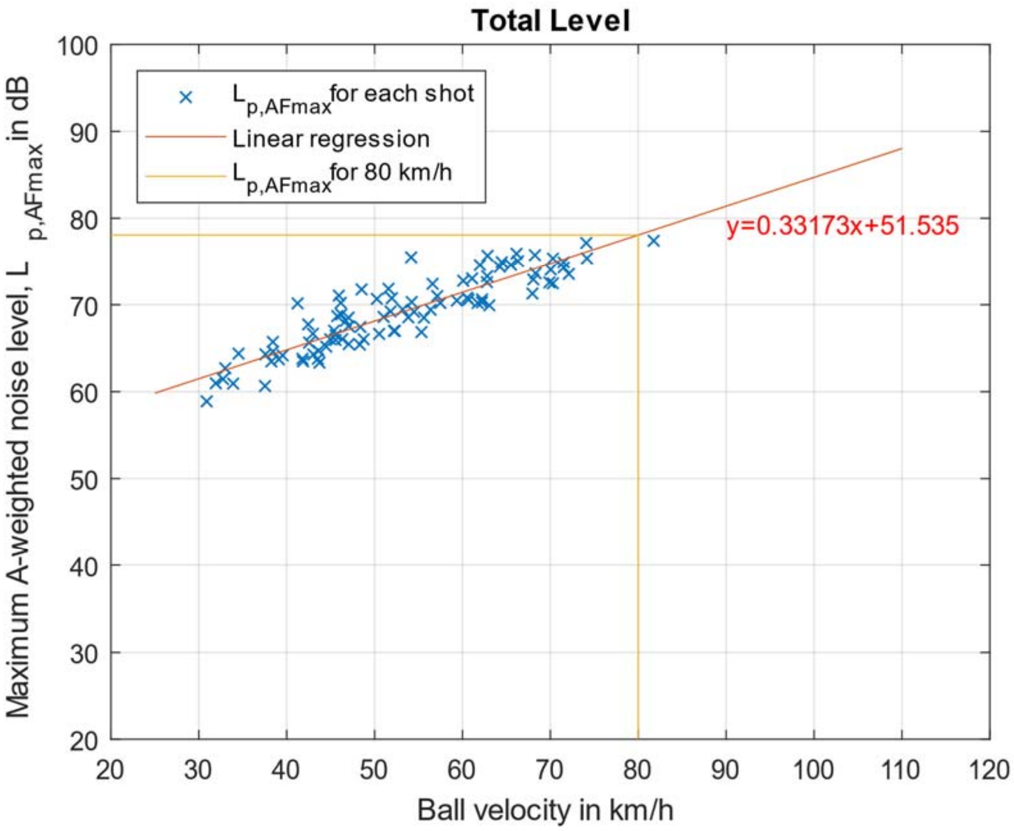

Figure 4

Maximum A-weighted noise level, $L_{p,AFmax}$, shown as a function of ball velocity.

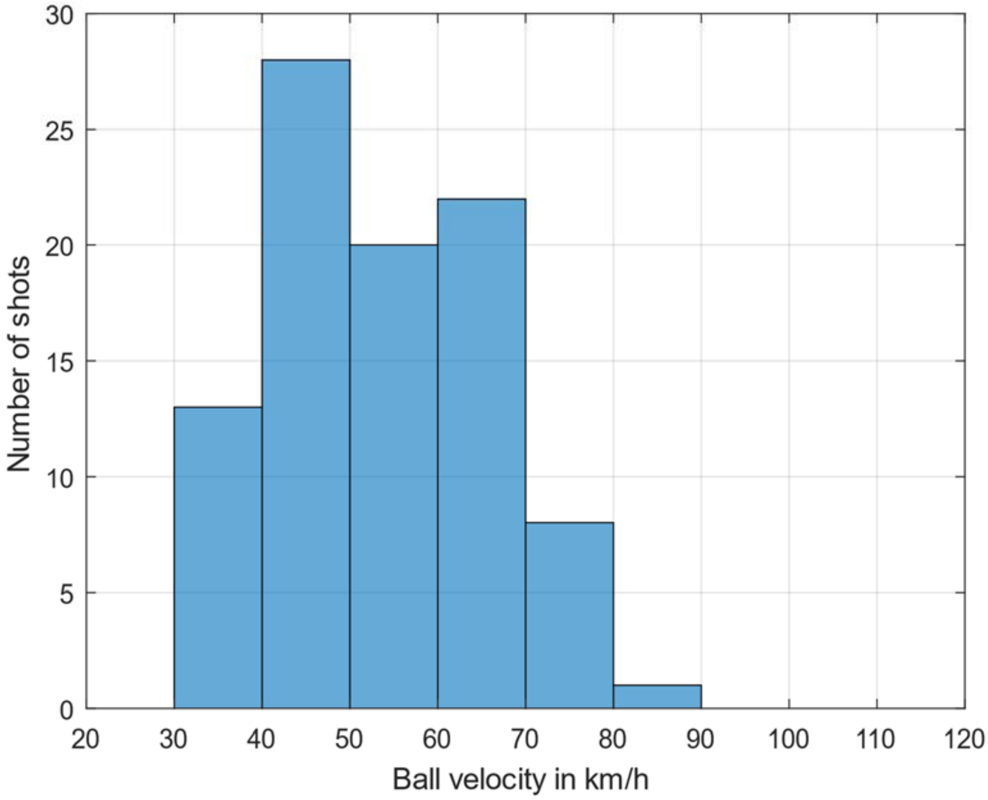

Figure 5
Number of shots per ball velocity (92 shots in total).

Annex 2 – Measurement results for HDPE panel

Date:	27 November 2018
Measuring period:	8.00 a.m. to 12.00 a.m.
Site:	Starup Skole, Haderslev, Denmark

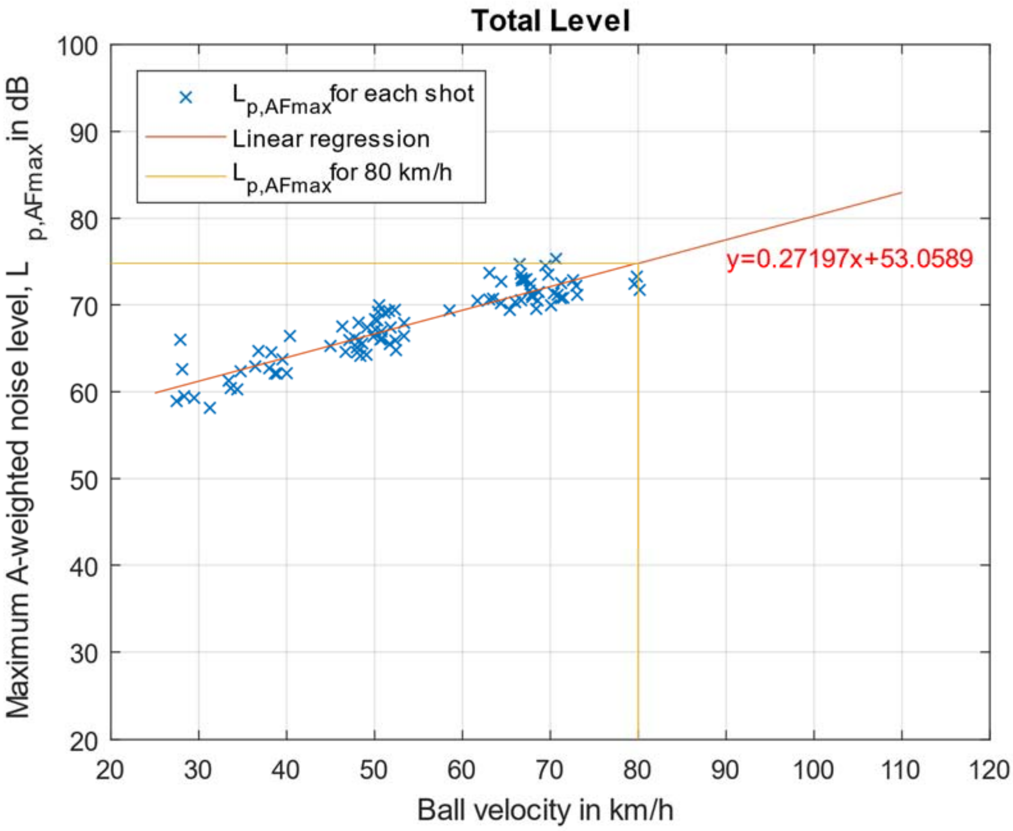

Figure 6
Maximum A-weighted noise level, $L_{p,AFmax}$, shown as a function of ball velocity.

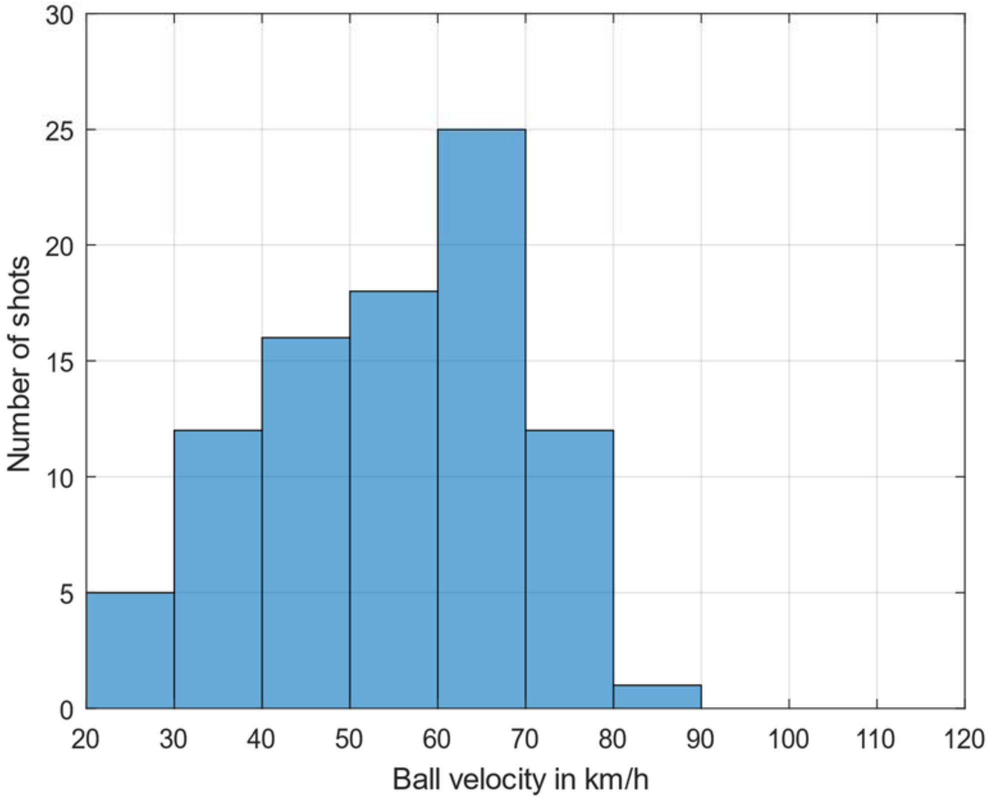

Figure 7
Number of shots per ball velocity (89 shots in total).

Annex 3 – Measurement results for WPC panel

Date:	17 December 2018
Measuring period:	09.00 a.m. to 10.30 a.m.
Site:	Starup Skole, Haderslev, Denmark

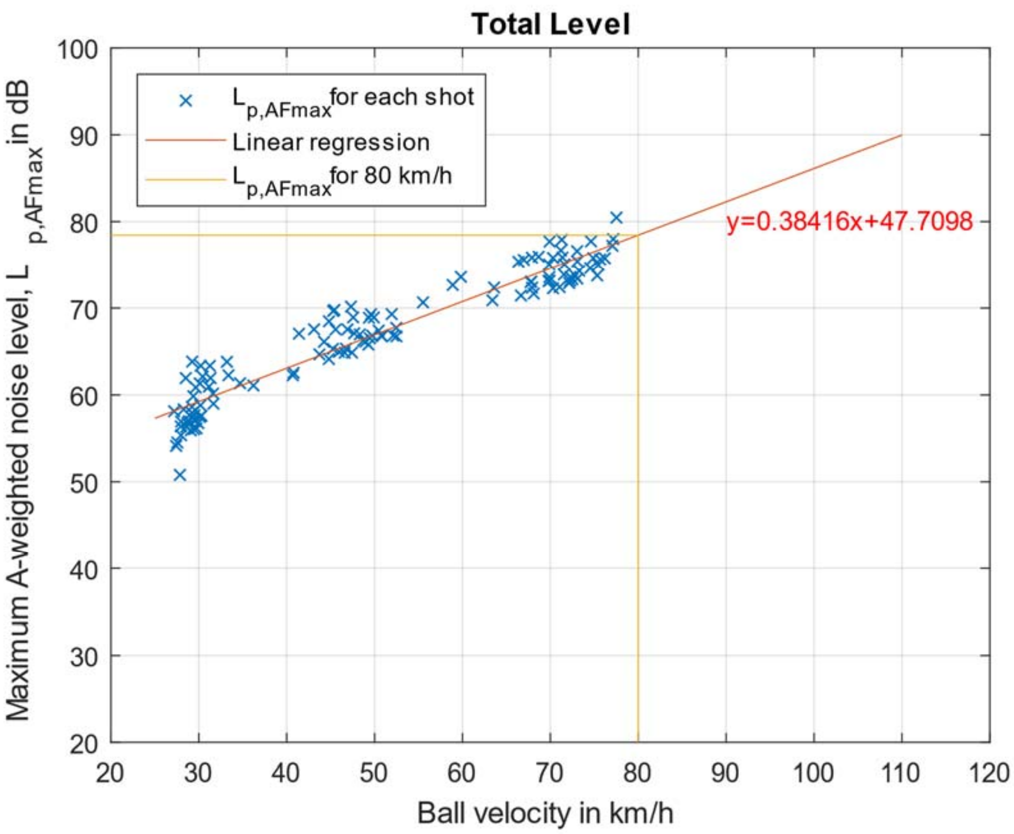

Figure 8
Maximum A-weighted noise level, $L_{p,AFmax}$, shown as a function of ball velocity.

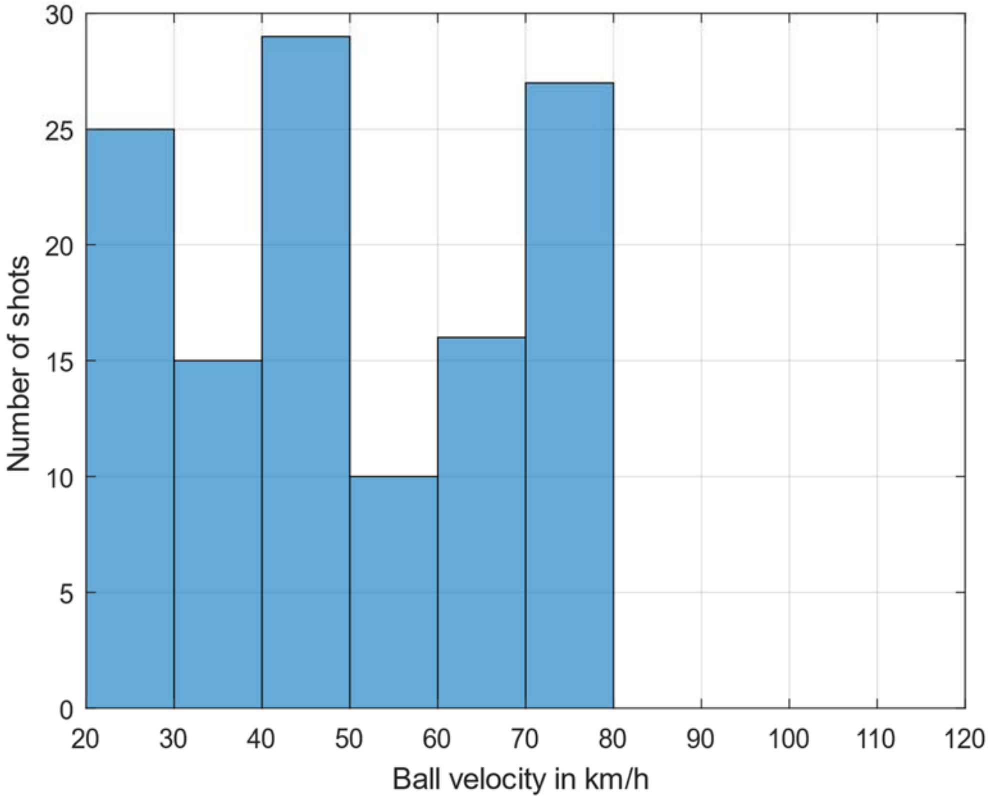

Figure 9

Number of shots per ball velocity (122 shots in total).

Annex 4 – Measurement environment and measurement object, Steel panel

Figure 10
Steel panel seen from inside the MUGA.

Figure 11
Steel panel seen from microphone.

Annex 5 – Measurement environment and measurement object, HDPE panel

Figure 12
HDPE panel seen from inside the MUGA.

Figure 13
HDPE panel seen from the microphone.

Annex 6 – Measurement environment and measurement object, WPC panel

Figure 14
WPC panel seen from inside the MUGA.

Figure 15
WPC panel seen from the microphone.

Annex 7 – The MUGA and footballs

Figure 16
Photo of the three identical footballs used during the test.

Figure 17
Photo of the MUGA used for the test.

Annex 8 – Source strengths

Name	Source type	l or A m,m²	Lw dB(A)	Day histogram	Emission spectrum	63Hz dB(A)	125Hz dB(A)	250Hz dB(A)	500Hz dB(A)	1kHz dB(A)	2kHz dB(A)	4kHz dB(A)	8kHz dB(A)	16kHz dB(A)
Steel	Area	0,5	**105,6**	100%/24h	1-1 oktav Steel	**88,5**	**100,1**	**97,1**	**98,8**	**96,9**	**95,9**	**95,1**	**89,4**	**77,4**
HDPC	Area	0,5	**102,6**	100%/24h	1-1 oktav HDPC	**86,4**	**95,7**	**93,5**	**93,5**	**97,1**	**95,3**	**88,9**	**85,8**	**71,7**
WPC	Area	0,5	**105,9**	100%/24h	1-1 oktav WPC	**82,8**	**98,3**	**97,8**	**95,7**	**95,9**	**101,3**	**96,1**	**89,2**	**77,8**

Annex 9 – Instrumentation

No.	Equipment	Make	Type	Calibration	
				Previous	Next
09L033	Preamplifier	G.R.A.S.	26CF	2016-12-05	2018-12-05
09L037	Preamplifier	G.R.A.S.	26CF	2017-06-28	2019-06-28
06L063	½" Microphone	G.R.A.S.	40AE	2018-01-02	2019-01-02
06L061	½" Microphone	G.R.A.S.	40AE	2018-06-07	2019-06-07
02L023	Calibrator	Brüel & Kjær	4231	2018-10-15	2019-04-15
02L019	Calibrator	Brüel & Kjær	4231	2018-10-15	2019-04-15
14L004	Data aq. Card	National Instruments	NI9233	2016-12-08	2018-12-08
14L014	Data aq. Card	National Instruments	NI9233	2017-06-27	2019-06-27

For recording and analysis, the program noiseLAB 4.0 and custom designed software from DELTA were used.

For the propagation analysis SoundPLAN ver. 8.0 was used.

All instruments and programs are calibrated regularly.

Annex 10 – A brief introduction to noise

Noise is generally defined as unwanted sound. The sound from a rock concert might be considered as music by the audience and as noise by neighbours at the same time. The World Health Organisation has through its "noise guidelines" shown that excessive exposure to noise is a hazard towards health both in terms of mental and physical health. The general guideline set forth by World Health Organisation is to strive to minimize noise as much as possible, especially in residential areas.

Quantification of noise

Any kind of sound is measured directly as fluctuations of the equilibrium pressure. The range of these fluctuations is extremely large and the quietest yet audible sounds at 1000 Hz are a result of such a fluctuation with a level of $20 \cdot 10^{-6}$ pascal. The upper limit is roughly 10^5 pascal. As it is unpractical to work in such a large range of numbers, a logarithmic scale is used instead. This allows for a definition of the smallest audible sound as 0 $dB_{ref20\mu Pa}$ and the loudest as 194 $dB_{ref20\mu Pa}$. The "dB" is called decibels and the reference to 20 micro pascal is often implicit.

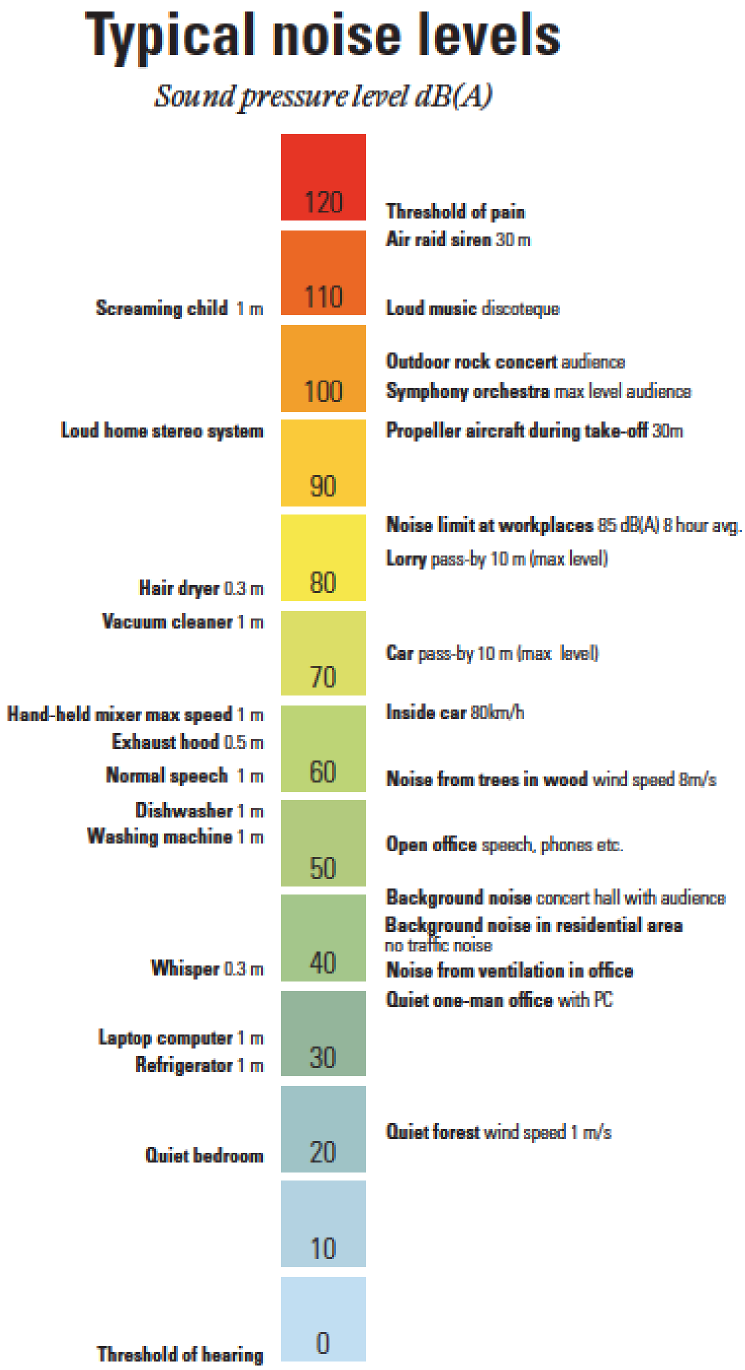

Figure 18
Examples of the levels of different sounds in dB(A). [From the DELTA “Støjbarometer” https://acoustics.madebydelta.com/viden.]

Perception of noise

The perception of noise is, among other things, influenced by the level, frequency characteristics and time variation. Where the level is described by the dB value, additional information can be included by also including a frequency and time weighting – some of the more common ones are listed below.

A-weighting (frequency)	The A-weighting is the most used frequency weighting. It is made to include the fact that humans are not equally perceptive towards sound of different frequencies. The use of A-weighted values makes it so that two sounds that are perceived as equally loud are also described by the same dB(A) value – unlike what would be the case using the dB values directly. For this reason, dB(A) values are normally used in legislation as well as product specifications.
Slow/fast/ impulse (time)	As sound is measured as fluctuations of pressure over time a time base has to be used in order to quantify it. This means that you cannot look at sound in an infinitely small time interval. The typical time bases are named slow, fast and impulse and denoted by a S, F or I respectively.
Equivalent level (time)	The equivalent level is a measure of the exposure of a listener over some period of time. This number is typically used when describing the sound which a person is exposed to during a work-day. A carpenter might spend half the day with a hammer in hand and the other half discussing with a customer. In order to calculate his daily exposure an average over the 8-hour workday is used, it is called L_{Aeq} and denoted by $dB_{A,8H}$. This value is not influenced by the choice of S, F or I time weighting.
Maximum (time)	This measure is used to show the maximum level a person has been exposed to during a period of time. For the carpenter example it would correspond to the one single hit with the hammer producing the loudest sound. The value is strongly dependant on the choice of S, F or I time weighting, where S-weighting will yield the smallest value and I-weighting the largest.

Table 4
Common weighting types for sound.