Audio Engineering Society

Conference Paper 4

Presented at the AES 4th International Conference on Audio and Music Induced Hearing Disorders
2024 May 29-31, Aalborg, Denmark

This conference paper was selected based on a submitted abstract and 750-word precis that have been peer reviewed by at least two qualified anonymous reviewers. The complete manuscript was not peer reviewed. This conference paper has been reproduced from the author's advance manuscript without editing, corrections, or consideration by the Review Board. The AES takes no responsibility for the contents. This paper is available in the AES E-Library (http://www.aes.org/e-lib), all rights reserved. Reproduction of this paper, or any portion thereof, is not permitted without direct permission from the Journal of the Audio Engineering Society.

Extensive sound level measurements at festivals

Marcel Kok[1]

[1] dBcontrol, Netherlands

Correspondence should be addressed to Marcel Kok (info@dbcontrol.nl)

ABSTRACT

For a combined study between consultancy firm dBcontrol (Netherlands) and Ghent University (Belgium) several sound level measurements were organized in 2022 at music festivals. The festivals of investigation were in the Netherlands and Belgium. The sound level measurements were done at fixed positions: the barrier up front of the audience area and at the FOH (front-of-house) position, which is most of the times in the centre of the audience area. Also detailed measurements were done before the show to obtain a sound level contour map for the audience area. The parameters of interest were dB(A), dB(C) and specially LCpeak. From Ghent University [1] several students were walking around during the festival day with a dosimeter. Those results are presented at this conference in a separate presentation and publication.

1 Introduction

In the Netherlands there is a covenant about sound level restrictions at Front of House, the place of the mixing console, most of the time in the centre of the audience area. The covenant working group is conducted by the Ministry of Public Health, Welfare and Sports. This working group came up with a research question about high bass levels at the audience area and wanted to have more knowledge about that. The covenant [2] in the Netherlands describes the highest value of LAeq = 103 dB at FOH averaged over 15 minutes. In Belgium (Flanders region) there's a law called Vlarem [3] which states the highest level of LAeq = 102 dB averaged over 15 minutes.

Some countries in Western Europe use a restriction [4] for LCpeak, this may vary from LCpeak = 130 to 140 dB. This parameter is rarely found in measurement reports.

2 Measurement layout

A) Barrier measurements

During the events a continuous measurement was done at the front row of the audience area, behind the stage barrier (fig.1). The measurement microphone, as part of a class-1 sound level meter, was at several meters in front of the ground stacked sub array. This measurement resembles what the audience experiences at first row.

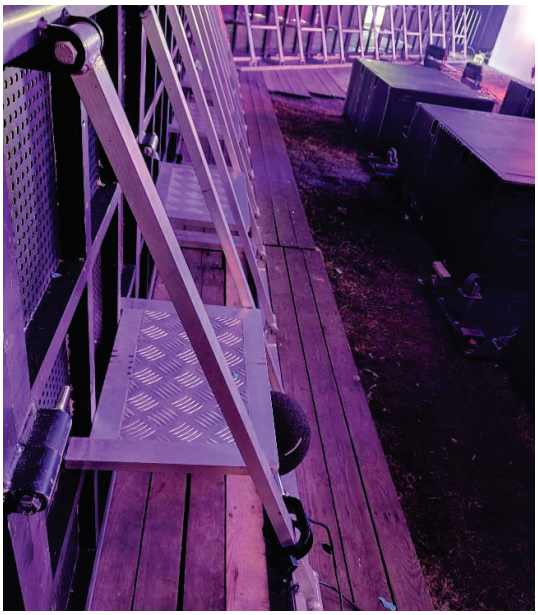


Figure 1, Microphone at barrier

B) FOH measurements
At these festivals, a measurement computer (fig.2) was installed at the FOH (front-of-house) position, usually in the center of the audience area. The purpose of the FOH computer is to log the results and to give the sound engineer detailed insight in the decibels during the event. This is most of the time part of the regulations for a music festival.



Figure 2, FOH measurement computer

C) Decibel contour mapping

For the events there's also a special measurement, which results in the contour mapping. This is done by drawing a matrix of points in the audience area, for larger area's this is at least a grid of 5 x 5 meters, in the back of the audience area 10 x 10 meter. The points are marked on the floor. The sound engineer plays a test file with brown noise, which spectrum corresponds to the modern dance music styles. The levels for playback of this test file are approximately 100 dB(A) and 115 dB(C) at FOH. For speeding up the measurements (which take 30 minutes, done before opening) the half of the audience area is measured. The assumption is that the radiation pattern of the PA sound system is symmetric to the center line from front to back.

After the event, the data is processed with a noise contour mapping program called Noise at Work [5]. This software generates a color contour plot. The results fort he contour mapping are presented in appendix A.

3 Measurement results.

A) Barrier measurements

In figures 3 to 5 the results of the barrier measurements are shown.

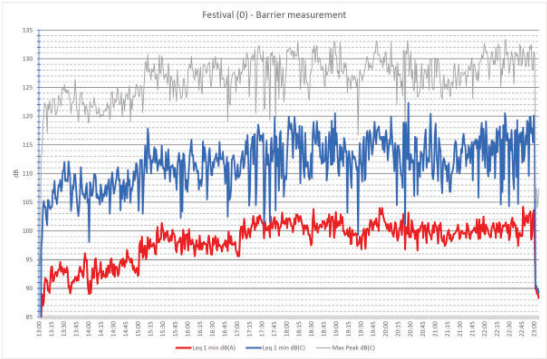


Figure 3, barrier measurement, festival 0

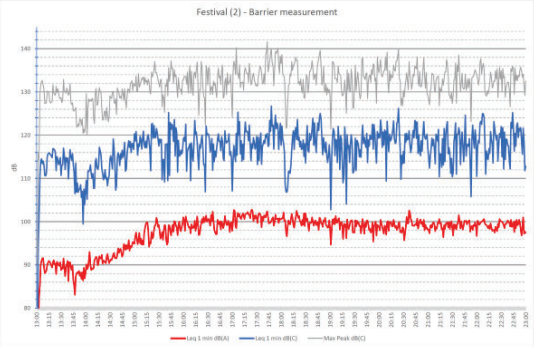


Figure 4, barrier measurement, festival 2

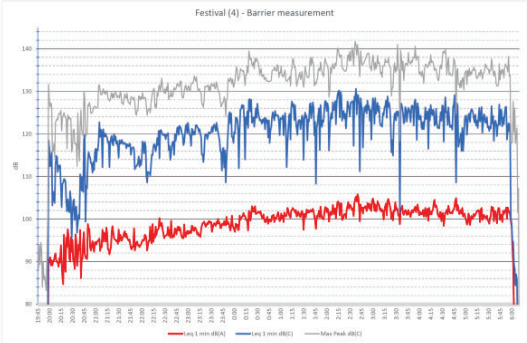


Figure 5, barrier measurement festival 2

B) FOH measurements

In figures 6 to 11 the results of the FOH measurements are displayed, including a histogram of the LAeq and LCeq levels.

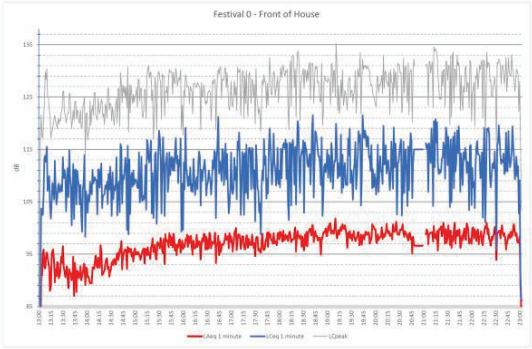


Figure 6, FOH measurement festival 0

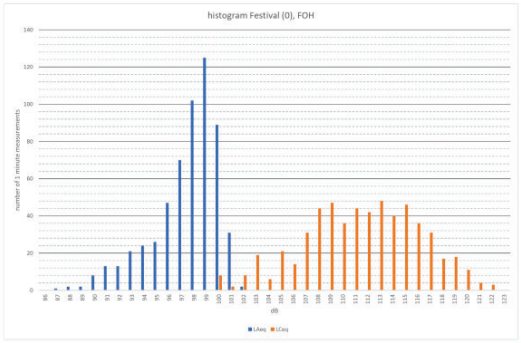


Figure 7, histogram FOH festival 0

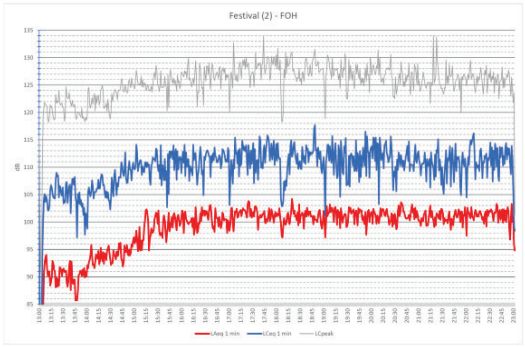


Figure 8, FOH measurement festival 2

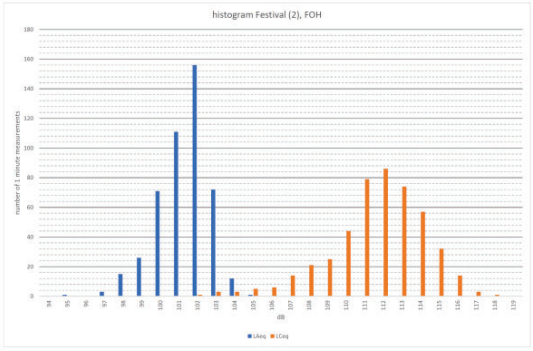


Figure 9, histogram FOH festival 2

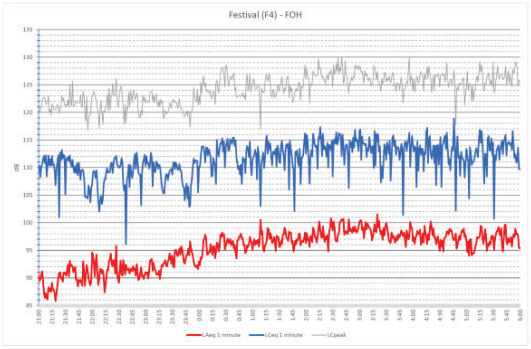


Figure 10, FOH measurement festival 4

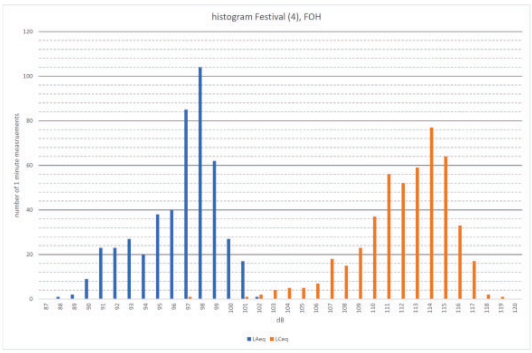


Figure 11, histogram FOH festival 4

C) decibel contour mapping

The measured contours are presented in Appendix A, figures 12 to 17.

4 Discussion of results

A) Barrier measurements
At festival 0 the levels LAeq vary between 86 and 104 dB, most of the time between 96 and 104 dB. The LCeq varies between 105 and 122 dB. The parameter LCpeak is not higher than 133 dB.

At festival 2 the levels for LAeq vary between around 90 at start to 102 dB later at the day. The LCeq varies between around 110 and 122 dB. The parameter LCpeak reaches a very high level, several times at 140 dB and all time high at 142 dB.

At festival 4 the levels for LAeq vary between around 90 at start to 106 dB later at night. The LCeq varies between around 110 and 130 dB. The parameter LCpeak reaches high levels, several times at 140 dB and all time high at 142 dB.

A possible solution to prevent those high values of LCpeak is to maintain more distance between bass cabinets (ground stacked sub) and the first row of audience. This is a challenge for the sound designer of the bass array in combination with production people for placing the barriers. Putting the FOH some closer to the barrier (for instance 5 meters) is not a solution. This raises the level at the ears of the sound engineer with maybe 1 dB.

An alternative is to avoid the ground stacked sub option and replace this with “flown subs”, a line array with bass cabinets. Some cities in the Netherlands (Amsterdam, Rotterdam) will not allow this solution at outdoor events, to prevent complaints from the neighbors.

The parameter LCpeak is sometimes mentioned in regulations in Western European countries. However, measurements and control are rare. And never at the barrier row

B) FOH measurements
At festival 0 the levels LAeq vary between 91 at start and 101 dB, most of the time between 95 and 101 dB. The LCeq varies between 105 and 119 dB. The parameter LCpeak is not higher than 135 dB. The histogram shows 99 dB(A) as the most measured value, the dB(C) graph in the histogram has no specific level more than other levels.

At festival 2 the levels for LAeq vary between around 90 at start to 104 dB later at the day. The LCeq varies between around 105 and 117 dB. The parameter LCpeak reaches the highest level of 134 dB.
It’s most of the times not higher than 131 dB.
The histogram shows 102 dB(A) as the most measured value, the dB(C) graph shows that 112 dB(C) is slightly more measured than other levels.

At festival 4 the levels for LAeq vary between around 90 dB at start to 101 dB later at night. The LCeq varies between around 110 and 119 dB. The parameter LCpeak reaches a level of 130 dB, not higher. The histogram shows 98 dB(A) and 114 dB(C) as the most measured values.

Those levels at FOH are in line with a previous report 9 years ago [6] at the Music Induced Hearing disorder conference.

The tentative conclusion is that LCpeak levels *at FOH* will not reach the limit of 140 dB.

C) decibel contour mapping

At festival 0 there is a level difference between frontstage and end of the audience area of 6 dB(A) and 7 dB(C). The situation is a tent with dimensions for the audience area of 50 (depth) x 35 meter (width). It appears that the level distribution in the majority of the audience area is rather stable.

At festival 2 there is almost no level difference in dB(A) between frontstage and end of the audience area. This is due to the use of delay arrays. The level for the dB(C) drops with 7 dB(C) from front to back in the audience area. It appears that the level distribution in the majority of the audience area is rather stable.

At festival 4 there is a level difference between frontstage and end of the audience area of 5 dB(A) and 10 dB(C). The situation is a very large hall with dimensions for the audience area of 95 (depth) x 53 meter (width).

Those decibel level contour maps are seldom in literature. Most of the time "PA-shoots" are shown with software modelling of the contours in the audience area.

5 Conclusions

A more detailed knowledge of the variation in sound levels is obtained by extensive measurements, both in level versus time at barrier and FOH and level versus x, y coordinate in the audience area.

The outcome of the LCpeak measurements shows that a LCpeak > 140 dB is measured, although not very often and only at the barrier position, which is similar to the first audience row. Maintaining a larger distance between the audience and the ground stacked subs is a solution. Flown subs in the form of an array is also an option, although neighbors might not like that because of bass annoyance [7]. The outcome of the dB(A) and dB(C) measurements at the FOH shows levels versus time as expected, this is mainly due to the local or national regulations about decibels and limits. As an extra for this conference, histograms are shown for the various dB(A) and dB(C) measurements. The histograms show a different curve for the A-weighted and C-weighted levels, which is due to the dance music character. For the level contour mapping the results show the level decrease versus distance from the barrier at first row to the end of the audience area. Some events show a high level of dB(C) at the first rows, other show some more gradual decrease in level versus distance to the barrier. Level contour mapping is not seen very much in literature, instead of computational modelling of the SPL at the audience area. With the measured level versus time data, level versus x, y coordinates data and statistical analysis, these 3 ways of measuring and analyzing data give a comprehensive overview of what's happening with the decibels at dance music events.

In some situations, levels were measured at front row (barrier) just at or slightly above 140 dB $L_{Cpeak.}$ It's recommended to measure this parameter more often at first row. It should be a challenge for sound designers to avoid peak levels around 140 dBC.

At the barrier the levels for LCeq sometimes were up to 130 dB(C). The higher dB(A) levels varied between 100 and 104 dB(A).

The sound level in the audience area differs per festival situation. A conclusion is that at the central axis in the audience area there is a difference between first and last row of around 7 dB(A) and 7 to 10 dB(C). To the sides of the audience area there's always less bass level.

References

[1] "Characteristics of personal sound and noise exposure at music festivals and events". Van Ransbeek et al, 14th ICBEN Congress on Noise as a Public Health Problem, 2023.

[2] "Vierde convenant preventie gehoorschade versterkte muziek", Staatscourant van het Koninkrijk der Nederlanden, version 06-12-2023. https://zoek.officielebekendmakingen.nl/stcrt-2024-3787.html

[3] "Geluidsnormen voor muziekactiviteiten", Flemish Government, departement omgeving, https://omgeving.vlaanderen.be/nl/geluidsnormen-voor-muziekactiviteiten-vlarem-rubriek-321-en-322-hoofdstuk-5322-en-hoofdstuk-67

[4] "Understanding and managing sound exposure and noise pollution at outdoor events", Hill et al, Technical Document AESTD1007.1.20-05, page 14, May 2020.

[5] "Noise at work" software, https://dgmrsoftware.com/products/noiseatwork/

[6] "Sound level measurements & control at large dance events", Kok M., Proceedings of the 58th AES international conference Aalborg, Denmark on Music Induced Hearing Disorder, 2015

[7] "On the comparison of flown and ground-stacked subwoofer configuration regarding noise pollution", Mouterde T., Corteel E., AES 151st Convention Paper, Las Vegas, 2021.

Appendix

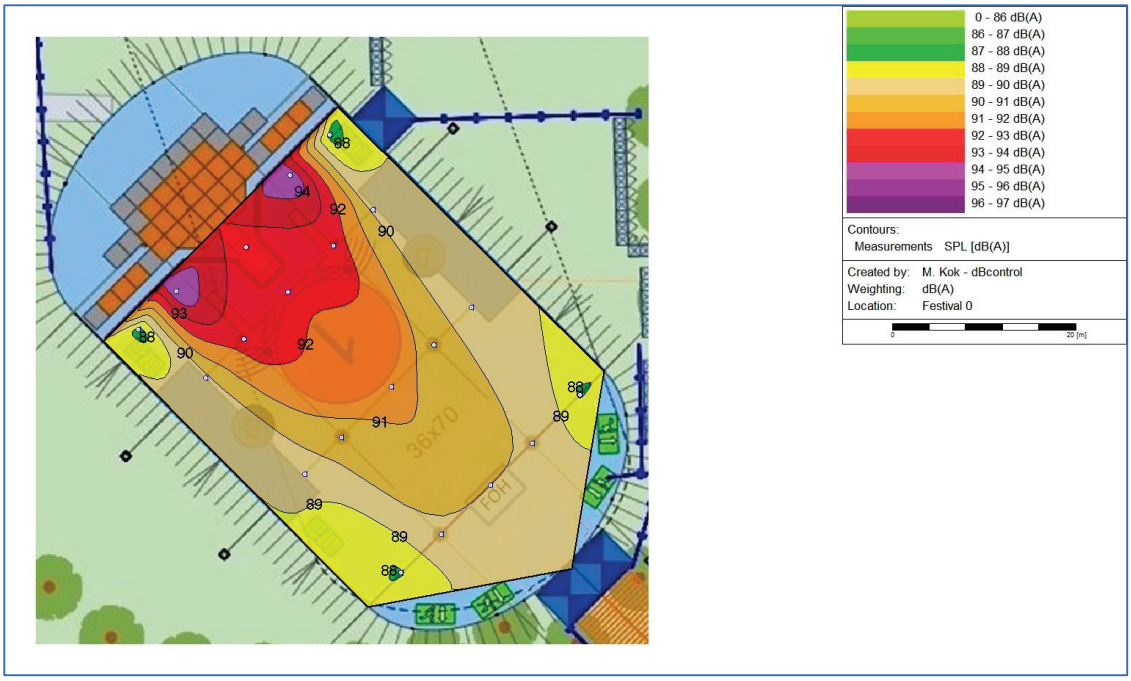


Figure 12, contour map, festival 0, dB(A)

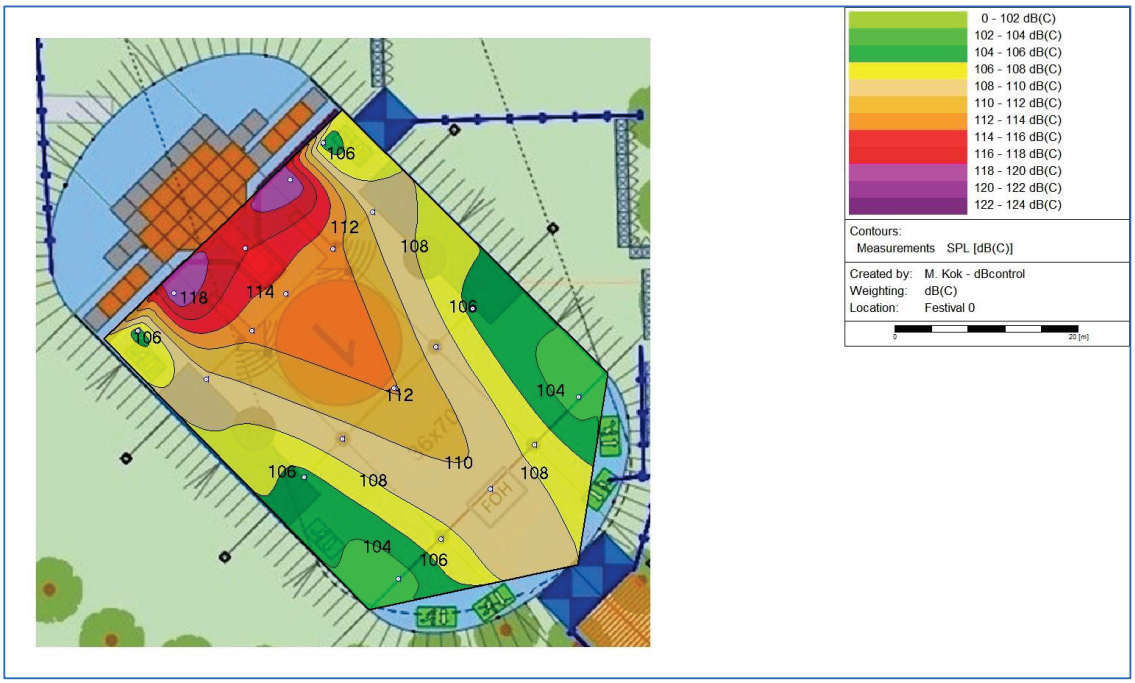


Figure 13, contour map, festival 0, dB(C)

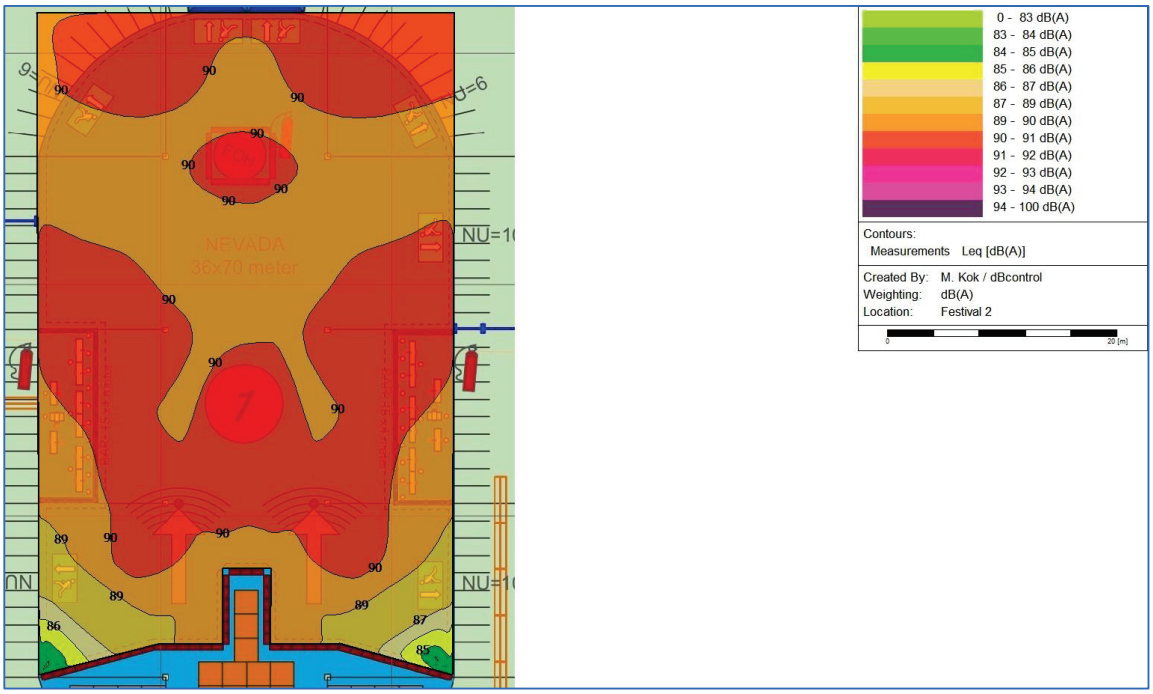


Figure 14, contour map, festival 2, dB(A)

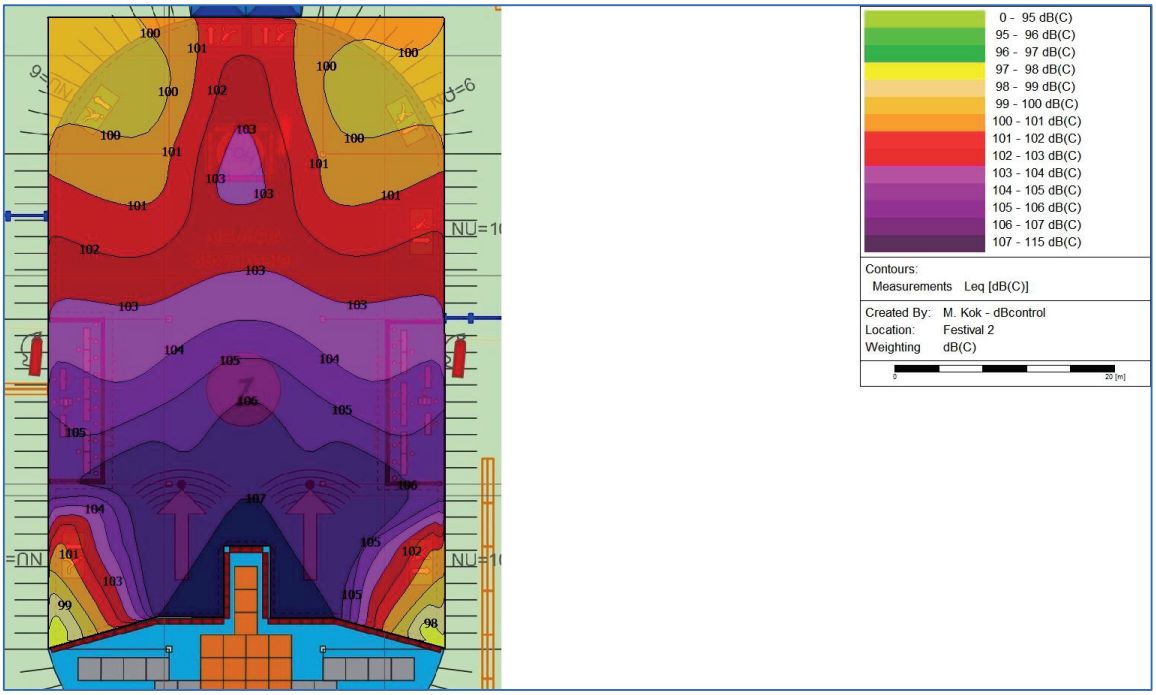


Figure 15, contour map, festival 2, dB(C)

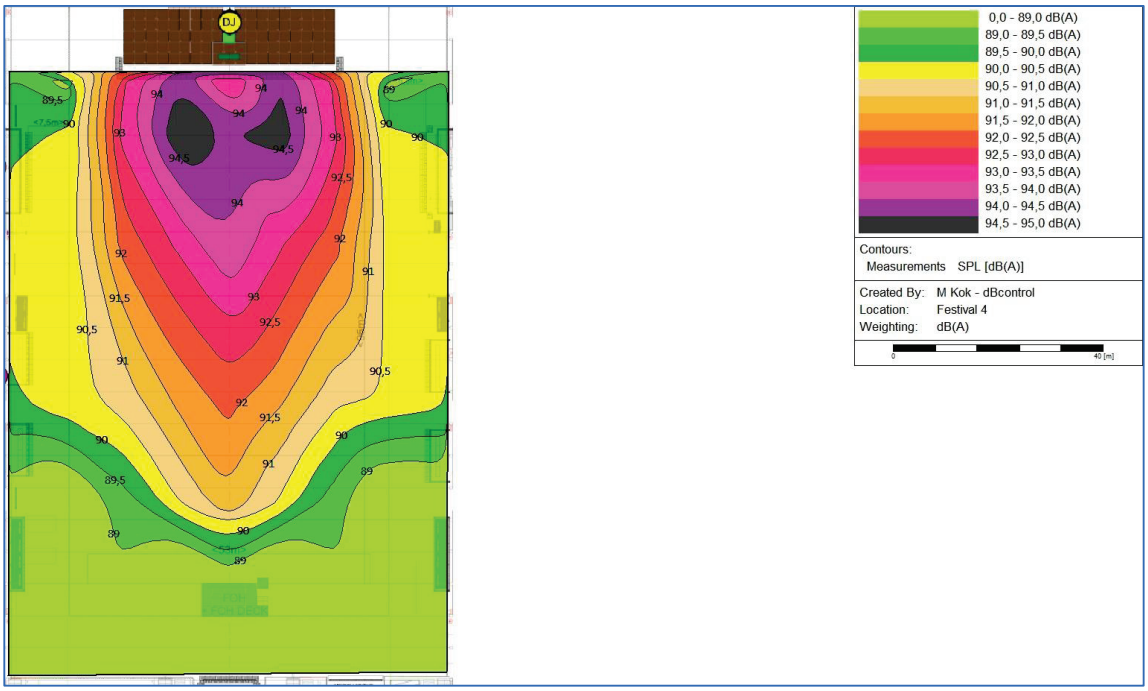


Figure 16, contour map, festival 4, dB(A)

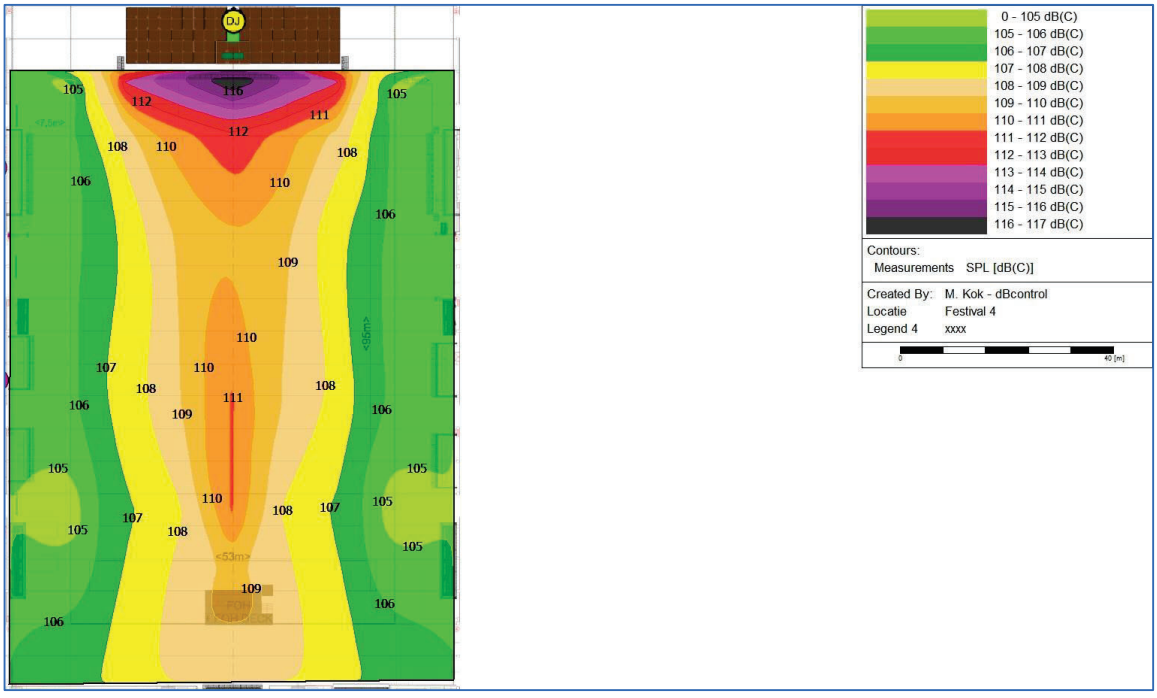


Figure 17, contour map, festival 4, dB(C)