

Memo

To: MCC, LoR
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Date: 18 December 2023 (update 2 February 2024)

Project: Noise emission measurement Theatre and Warehouse element
Reference: MF-LAV-XX-XX-RP-YA-01-0051 (C03) – Issued for Construction (LA.170505.M35)

Introduction

This report presents results from noise emission tests from the Theatre and Warehouse element of Aviva Studios, taken on 4 July 2023 and 10 December 2023 respectively. The results are compared to the planning conditions and predicted noise emission which is described in “Noise emission calculation appendix 9.4 – update June 2021 (revision 2)”, reference MF-LAV-XX-XX-RP-YA-01-0039 (T01). All recommendations with regard to any acoustic treatment to the building including façade, external doors and lobbied door sets, glazing specification and acoustic rating, have all been complied with.

Criteria

The following criteria have therefore been set for amplified music in Factory in the previous stages of the project, by Arup and Sandy Brown consultants in conjunction with the MCC Environmental Protection Department (see Factory, Manchester – Environmental Statement Volume 1 – October 2016):

For residential apartment buildings and hotels, the maximally allowed sound levels inside due to amplified music in Factory are 47 dB for the 63 Hz octave band, 41 dB for the 125 Hz octave band.

An attenuation of 5dB through an open window at these low frequencies has been assumed by Arup. Which results in the following criteria on the facades:

The maximally allowed sound level on the façade of residential apartment buildings and hotels is:

- 52 dB Leq for the 63 Hz octave band
- 46 dB Leq for the 125 Hz octave band

The design of the building has been based on the sound level as shown in Table 1.

Table 1: Maximum sound levels (Leq) for Warehouse and Theatre

	Octave Band Centre Frequency [Hz]								Noise production level dB(A)
Spectrum	63	125	250	500	1000	2000	4000	8000	
Warehouse	110	105	104	104	101	97	93	90	106
Theatre	100	100	104	104	101	97	93	90	106

Method

Measurements have been performed in accordance with “BS 7445 – Description and measurement of environmental noise”. Because the sound production was controlled by loudspeakers, measurement times could be shorter than described by the standard. A special measurement noise was played through the loudspeakers.

Figure 1a shows the Theatre loudspeaker locations above (2 hanging clusters of 4 subwoofers on each side and 3 hanging clusters of mid-range loudspeakers) and on the sides of the stage (2 mid clusters and subwoofer on each side). The sound pressure level in the Theatre audience area was on average 110 dB at 63 Hz and 103 dB at 125 Hz. Because only the Warehouse-side proscenium door was closed the proscenium enclosure in the large cavity was exposed to sound in the theater (worst case scenario theater only).

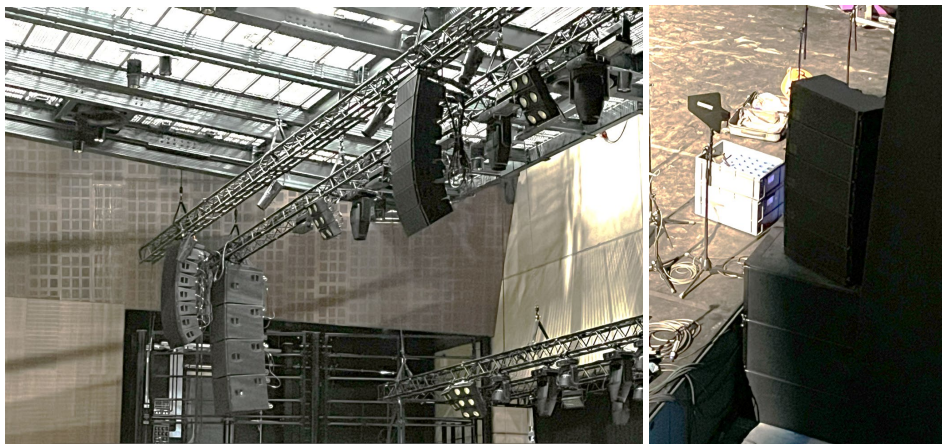


Figure 1a: Loudspeaker setup in the Theatre (4 July 2023)

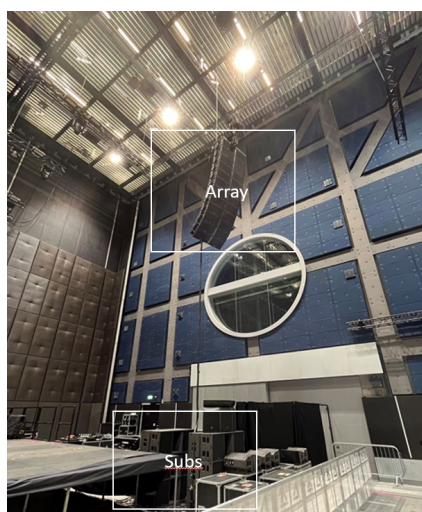


Figure 1a: Loudspeaker setup in the Warehouse (10 December 2023)

Figure 1b shows the Warehouse loudspeaker locations above (clusters of 6 subwoofers on each side and 2 hanging clusters of mid-range loudspeaker arrays). The sound pressure level in the Warehouse audience area was on average: 112 dB at 63 Hz and 106 dB at 125 Hz. This average value is equal to the value measured at the mixing desk (FOH). The sound level in front of the north façade behind the stage at standing height is 8 dB (at 63 Hz) and 7 dB (at 125 Hz) lower than in the audience area, caused the directivity of the loudspeaker system, which is beneficial for limiting noise egress. It should be noted that other stage/loudspeaker setups may result in higher exposure of the north façade and thus potentially more noise egress.

Only the Warehouse-side proscenium door was closed.

On 4 July, weather conditions were calm with low wind speeds and no rain. On 10 December, weather conditions were more with moderate wind speeds (4 Beaufort, SE direction) and no rain (with severe rainfall before midnight, wet streets).

The expectation was that the sound level of outside residual noise could be higher than the specific sound level received from the Theatre. This condition would limit a traditional measurement using random noise. Therefore, a stack of sine waves from 22 to 5656 Hz was used as noise source signal. At the receiving points the sound including the residual noise was recorded. The sine wave signal could be filtered out with special analysis software based on a correlation technique. As a result, higher noise reduction values can be determined even if the residual noise level is above the received noise level.

The "sine stack" has been recorded using a calibrated Rion NL-52 Class-1 Sound level meter for 180 up to 300 seconds. Besides, residual noise was measured for 30 seconds. Because the measurements took place in the middle of the night, the residual noise had little variation (except for the wind noise in December). Background noise levels at 63 and 125 Hz were similar in July and December (events without wind).

No correction was made for sound reflection of the façade (measurements were done without the façade installed or with window partly open) Sound reflection of the window behind the sound meter may have increased the sound level. Due to the weather conditions, it was not possible to measure 2 meters outside the window. All this leads to a pessimistic approach.

During the testing all internal doors were closed. One exception being a separate Warehouse test with 5 doors open in the east wall of the Warehouse (access doors to the lobby staircase), simulating a situation with visitors passing all doors at once or opened doors during a concert. See figure 2.



Figure 2: Doors in east wall Warehouse that were opened during one test (red)

Receptors

For the Theatre: the following receptor locations were selected as worst-case locations at the nearest residential towers:

- North-West Tower Level 5, outside (no façade installed)
- North-West Tower Level 9, outside (no façade installed, Theater roof visible)
- North Tower Level 16, inside (window open, microphone in window opening)

For the Warehouse: the following receptor locations were selected as worst-case locations at the nearest residential towers:

- North-West Tower Level 5, (window open, microphone in window opening)
- North-West Tower Level 15, outside (window open, microphone in window opening)
- North Tower Level 8, inside (window open, microphone in window opening)
- North Tower Level 16, inside (window open, microphone in window opening)

More information about the receptor locations are shown in figures 3a (Theatre) 3b (Warehouse) and 4.

Other receptor locations further away from Aviva Studios have not been measured due to time constraints.

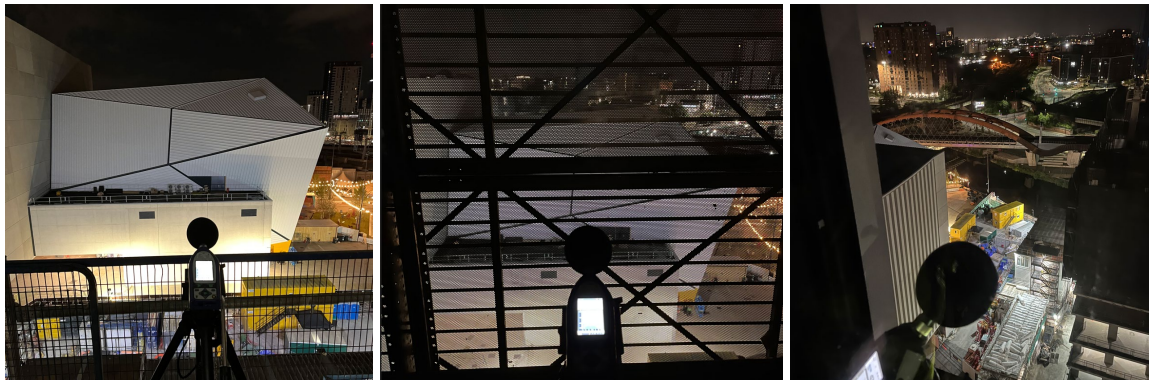


Figure 3a: Microphone at receptor locations Theatre, left to right: NW Tower L5, NW Tower L9, N Tower L16



Figure 3b: Microphone at highest receptor locations Warehouse, left to right: NW Tower L15, N Tower L16

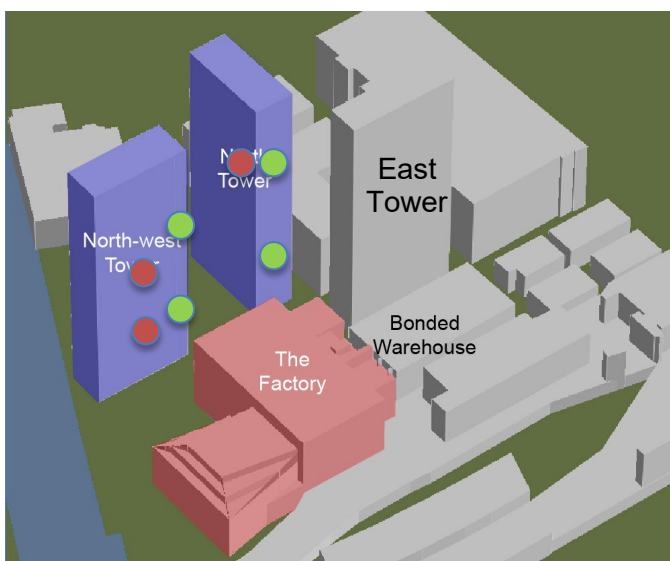


Figure 4: 3D model with receptor locations (red: Theatre receptors, green: Warehouse receptors)

Results

For the Theatre, the received sound level with measurement noise on and off (“ambient” and “residual”) was nearly identical for 63 Hz and 125 Hz with +/- 1-2 dB difference. This means that the correlation technique was indeed needed to determine the actual received specific sound level. Figure 4 shows the values for 63 Hz and 125 Hz for:

- **Measured correl.**
Measured received sound level at receptor location for 100 dB sound production in the Theatre, averaged over the audience area and FOH position.
- **Predicted**
Predicted received sound level at receptor location for 100 dB sound pressure in the Theatre on all internal surfaces, based on the acoustic 3D model, see reference MF-LAV-XX-XX-RP-YA-01-0039.
- **Planning**
Maximum allowed receiving sound level in accordance with the planning conditions.

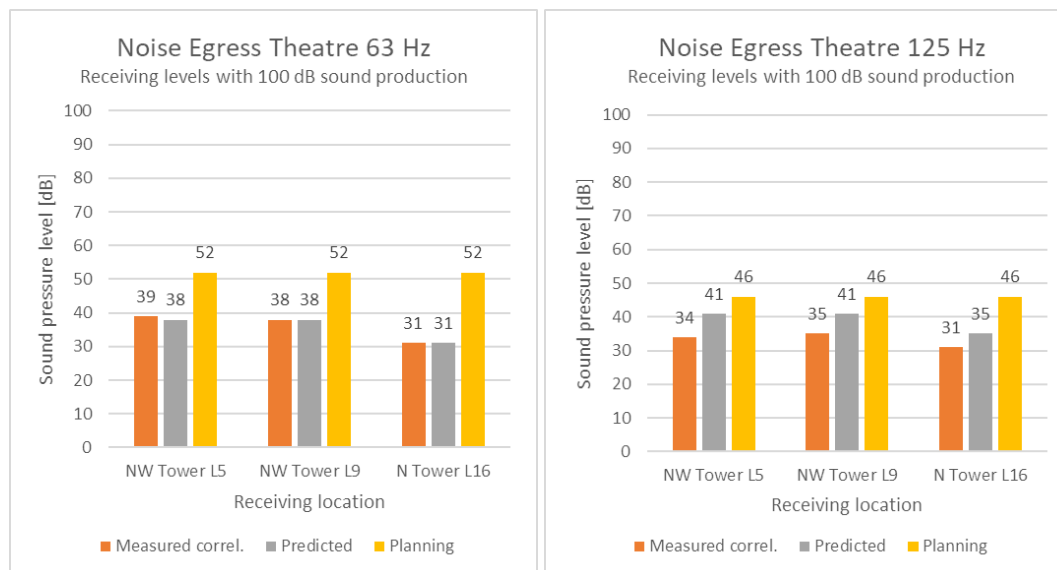


Figure 4: Noise egress Theatre for 63 Hz (left) and 125 Hz (right)

For the Warehouse The received sound level with measurement noise on ("ambient") for 63 Hz and 125 Hz was 3-4 dB higher than and off ("Residual") at the North Tower receptors. This means that the correlation technique was indeed needed to determine the actual received specific sound level. Figure 5 shows the values for 63 Hz and 125 Hz for:

- **Measured correl.**
Measured received sound level at receptor location for 110 dB and 105 dB sound production in the Warehouse averaged over the audience area and FOH position. The sound level in front of the north façade behind the stage at standing height is 8 dB (at 63 Hz) and 7 dB (at 125 Hz) lower than in the audience area, caused by the directivity of the loudspeaker system.
- **Predicted**
Predicted received sound level at receptor location for 110 dB and 105 dB sound pressure level in the Warehouse on all internal surfaces, based on the acoustic 3D model, see reference MF-LAV-XX-XX-RP-YA-01-0039.
- **Planning**
Maximum allowed receiving sound level in accordance with the planning conditions.

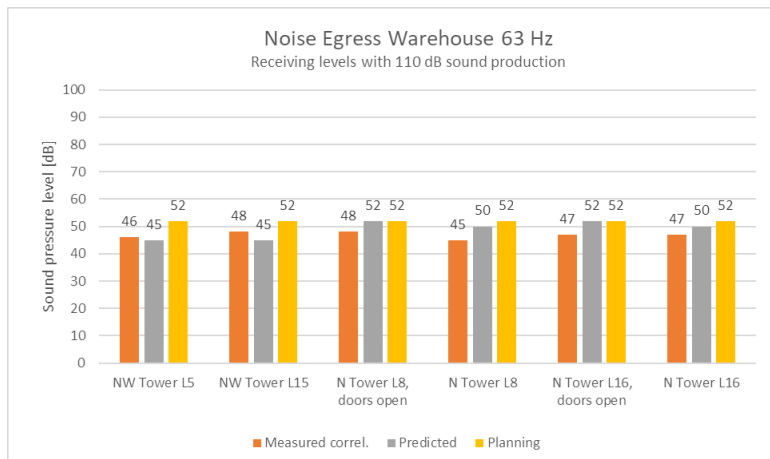


Figure 5a: Noise egress Warehouse @63 Hz

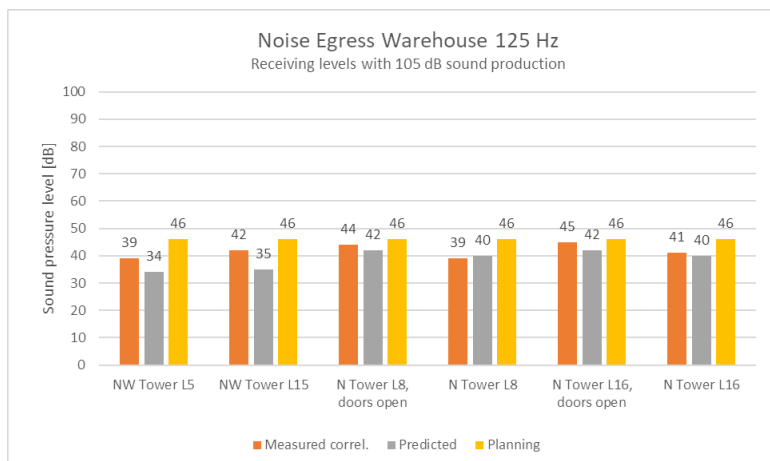


Figure 5b: Noise egress Warehouse @125 Hz

Results Theatre and Warehouse combined

The measured results for the Theatre and Warehouse element are shown separately and combined in table 1. It is shown that the noise egress from the Warehouse is determining the TH+WH combined noise egress. Only in the NW Tower, combined sound egress is increased by 1 dB in some cases. All green marked receiving levels meet the planning condition requirements.

Table 1: Noise egress Theatre, Warehouse separate and both combined

THEATRE (TH)	63 Hz	125 Hz
NW Tower L5	39	34
NW Tower L9	38	35
N Tower L16	31	31

WAREHOUSE (WH)	63 Hz	125 Hz
NW Tower L5	46	39
NW Tower L15	48	42
N Tower L8, doors open	48	44
N Tower L8	45	39
N Tower L16, doors open	47	45
N Tower L16	47	41

TH+WH combined	63 Hz	125 Hz
NW Tower L5 (TH+WH)	47	40
NW Tower L9 (TH) + L15 (WH)	48	43
N Tower L16 (TH+WH), doors open	47	45
N Tower L16 (TH+WH)	48	41

Planning condition requirement	52	46
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Conclusions

- The noise egress to the nearest noise sensitive receptors has been measured separately for the Theatre element with Warehouse door closed and the Warehouse element with Warehouse door closed. The stage in the Warehouse was set up in the north side of the building with the loudspeakers directed away from the north façade.
- It can be concluded that the TH+WH combined receiving sound levels derived from the measurements are lower than the planning conditions in all measured cases (the North-West and North residential tower as closest noise sensitive receptors). This includes a scenario when 5 doors are open in the Warehouse east internal wall on level 2.
- All recommendations with regard to any acoustic treatment to the building including façade, external doors and lobbied door sets, glazing specification and acoustic rating, have all been complied with. The measurement results confirm the predicted noise levels satisfactory.
- It is unlikely that planning conditions are not met for other receptors further away from Aviva Studios for these stage/loudspeaker setups. The validity of the results are discussed in the Annex.
- Therefore, the Theater and Warehouse element of Aviva Studios can operate whilst satisfying the requirements of the planning decision regarding noise egress of music.

ANNEX

Receptor locations

Level Acoustics & Vibration proposed to measure the following receptor locations prior to executing the Warehouse measurements (at that time the Theatre measurements were already executed months earlier).

- NW Tower
 - 10m (level 2)
 - **30m (level 8) TESTED APPROX.**
 - **50m (level 16) TESTED APPROX.**
 - 70m (level 23)
- N Tower
 - 10m (level 2)
 - **30m (level 8) TESTED APPROX.**
 - **50m (level 16) TESTED APPROX.**
 - 70m (level 23)
- Bonded Warehouse (Plant noise only)
 - 10m (level 2)
 - 20m (level 5)

EHO had set out the following requirements for additional receptors:

- *Marriot Hotel to be included as a receptor.*
- *Residential properties at Culvercliffe Walk off Byrom Street to be included as a receptor.*
- *Residential properties at the junction of Water Street and Liverpool road along with the residential at Stanley Street to be included as a receptor.*

Due to poor weather conditions on the night of measurements and limited access to the Towers (no lift available) it was decided to focus on the absolute worst-case receptors which are those halfway the towers (approx. 30 and 50 m height in green marked above). These are in closest proximity to the building's performance spaces. The other receptors are further away from the building and given the symmetry of the building it is highly unexpected that noise levels would be higher at these locations. Therefore, it was decided not to extend the measurement campaign to also test these locations on another night.

Other requirements

EHO had set out the following other requirements:

- *Day time measurement as well as night time measurement.*
- *Confirmation that all recommendations with regard to any acoustic treatment to the building including façade, external doors and lobbied door sets, glazing specification and acoustic rating, have all be complied with.*

Noise Egress of music has been tested for the planned maximum noise production level and spectrum. Outside levels during the day or night are not different. The reason why the measurements were executed during the night is because background noise levels are lower during the night making it possible to measure. It is not possible to measure the receiving level outside during the day.

The confirmation that all recommendations for acoustic solutions have been executed is stated in the report's introduction and conclusion. Regular site visits have been performed to check the building and relevant discrepancies have been reported and were solved.

General conclusion

The executed measurements have been performed under worst-case circumstances at the nearest sensitive receptors. Results show that at these receptor locations the planning conditions are met. It is highly unlikely and unexpected that results would be worse at locations further away from the building. Besides, background noise levels that are above noise receiving levels would have made measurements difficult or even impossible at further locations.

The results confirm that the applied solutions have been executed as planned. No critical deviations from the acoustic design have been detected. From a professional standpoint we conclude that further measurements regarding music noise egress are not needed to prove the building meets the planning conditions.

The measurement plan did include more receptor locations. These have not been measured because of stringent time constraints (a 3 hour time slot with dry weather conditions and an available sound system in the middle of the night). Measuring during the day would not provide new information because the receiving levels would be the same.

We recommend submitting the report the EHO for evaluation by the acoustics specialist in their team.