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Acoustics of a Sitzprobe rehearsal

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ABSTRACT

A Sitzprobe rehearsal is normally the first-time singers and orchestra play together. It requires the fire curtain to be lowered pushing the vocalist to the very edge of the stage. A series of acoustics tests were undertaken on behalf of The Royal Opera House to establish this change in the environment as far as the musicians were concerned. Measurements were taken at two key positions, 2nd violins and the conductor location whilst a single sound source was positioned centre stage, the control condition, front of stage and around the auditorium. In addition, sound control solutions were tested and proposes to reduce sound exposure are presented.

1. INTRODUCTION

Sound exposure in orchestra pits has long been an issue for musicians [1-4] and a difficult problem to solve acoustically [5]. Of particular concern are the issues raised by Sitzprobe rehearsals. A Sitzprobe rehearsal is the first time the opera singers perform with the orchestra in the main auditorium. The fire curtain is lowered so that the staging can be set for the evening performance whilst the rehearsal continues. This means that the vocalists, typically 2-10 people, must move forward of the fire curtain to the very edge of the stage. This movement forward can result in increased sound levels in the orchestra pit as the opera singers tend to face the conductor and the distances between vocalists and musicians is significantly reduced.

2. AUDITORIUM REVERBERATION TIME

Reverberation time (RT) is the most common acoustic test. The parameter determines the sound decay of the room which is primarily dominated by the volume of the space. As the fire curtain is down for the Sitzprobe rehearsal, there should be a significant reduction in the reverberation time, T30, of the auditorium, 12500m^3. The Royal Opera House provided an acoustics report on the original auditorium [6], a recent measurement of the current auditorium [7] for comparison with the room acoustic of the fire curtain condition. For reasons of expediency the measurement was not compliant with ISO 3382-2 due to the use of a directional loudspeaker, Yahama HS50m using ARTA computer based measurement system, in all other respects the procedure was in accordance with the standard. All acoustics measurements had to be taken between 7-9am on 5th May 2022.

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Figure 1 shows the average of the 12 1/3 octave band RT measurements in terms of T_{20} and T_{30} with their respective standard deviations in unoccupied conditions for the Sitzprobe configuration, see Figure 1.

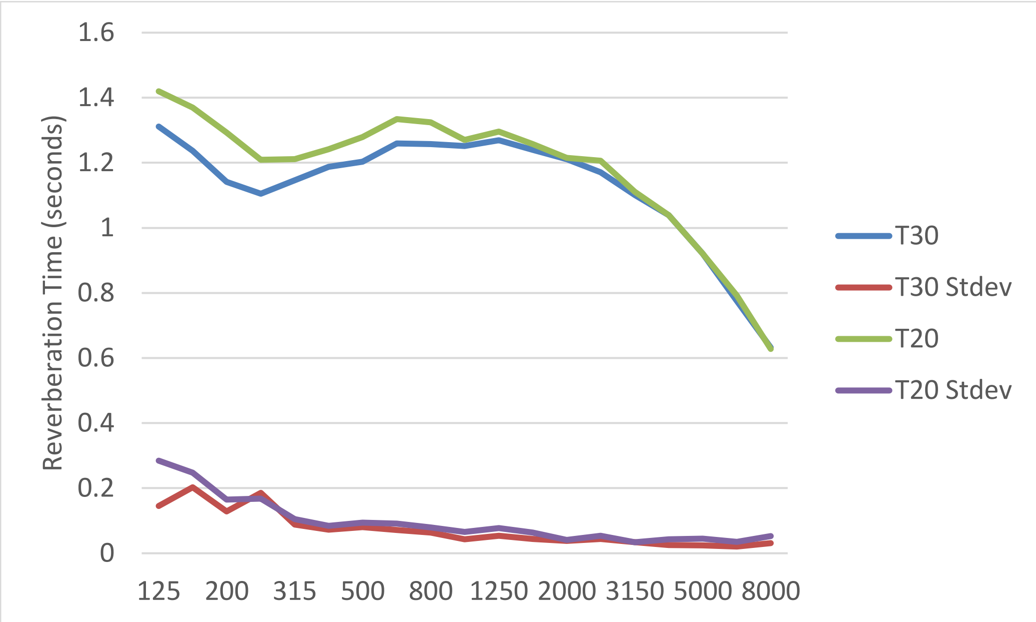

Figure 1. Reverberation time in the auditorium of the Royal Opera House in Sitzprobe condition.

By way of comparison figure 2 gives the octave band T_{30} results for the Royal Opera House as measured in 1995, 2017 and 2022 (Sitzprobe condition). The Sitzprobe condition is rarely tested as it is never seen by the general public unlike dress rehearsals or performances.

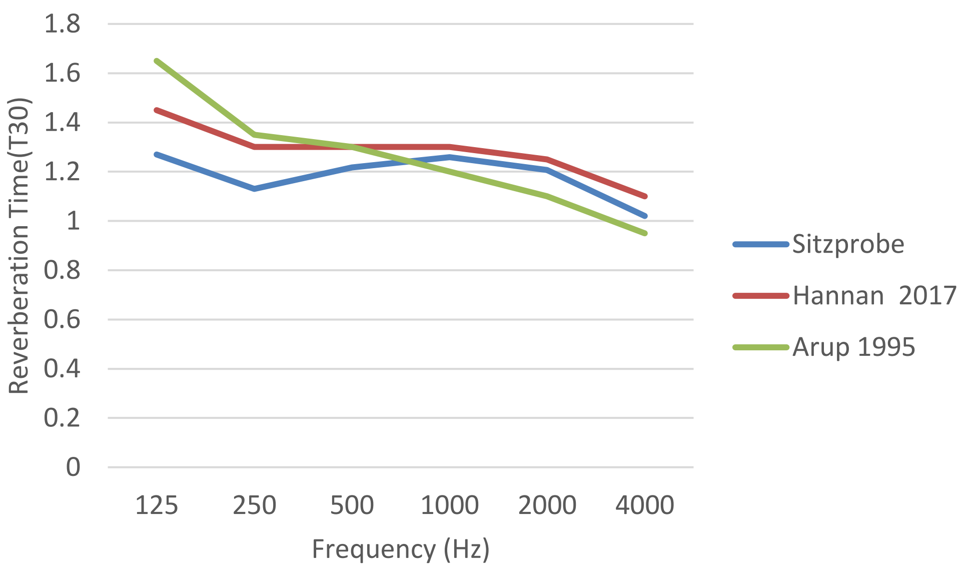

Figure 2. Reverberation time in the Royal Opera House auditorium over time.

From figure 2 it can be seen that the old Royal Opera House auditorium had a unbalance sound with the low frequency overly warm which would have decrease speech intelligibility. This is best described the acoustic parameter, Bass Ratio, which compares $T_{125+250Hz}$ to $T_{500+T1000\ Hz}$, a Bass Ratio of 1.2, the upper end of the recommend range. The refurbishment corrected the balance with a broad even acoustic with some low frequency boost to increase the warmth of the room, a Bass Ratio of 1.07. However, under Sitzprobe conditions the Bass Ratio dropped to 0.97, below the desired range, of 1.0 to 1.2.

3. ORCHESTRA PIT SOUND LEVEL TESTS

In total 12 measurements were undertaken, Norsonic Nor140 Class 1 sound level meter, positioned in two locations in the orchestra pit: at the conductor and 2nd violin positions. An NTi Minirator Pro generated a pink noise sound signal through a Yahama HS50M loudspeaker on a 1.4m and a 2.4m tripod. The configurations represent a traditional rehearsal, a Sitzprobe rehearsal, and possible mitigation measures on stage and in the auditorium. Table 1 summarises the configurations tested.

Table 1: Test Configurations

Test	Source Position	Fire Curtain	Type of Test
0	Background Noise	Open	Empty Condition
1	Source at Front Stage 1.4m source height	Open	Control Condition
2	Source Mid Stage 1.4m source height	Open	Traditional Rehearsal
3	Source Front Stage 1.4m source height	Closed	Sitzprobe Rehearsal
4	Source Front Stage 2.4m source height	Closed	Mitigation
5	Source Front Stage Carpet 1.4m source height	Closed	Mitigation
6	Source at Stalls Seat C24 1.4m Facing Out	Closed	Mitigation
7	Source at Stall Seat E27 1.4m Facing Conductor	Closed	Mitigation
8	Source at Stall Seat G23 1.4m Facing Conductor	Closed	Mitigation
9	Source at Stall Seat A23 1.4m Facing Out	Closed	Mitigation
10	Source at Stall Seat A23 1.4m Facing Conductor	Closed	Mitigation
11	Source in Royal Box 1.4m Facing Conductor	Closed	Mitigation

4. TEST RESULTS

Measurements of constant Pink Noise were simultaneously taken at two locations in the pit over a period of 10 seconds, see Figure 1 and 2 for example of Test Number 1 and 3.

Figures 1 and 2: On Stage Rehearsal and Sitzprobe Acoustic Measurements

Measurement parameters included average level (LAeq and LZeq), as well as the sound spectrum in 1/3 octave bands. For simplicity only averaged sound level, LAeq (dBA), will be presented representing perceived sound levels. Table 2 presents the change in sound level from traditional rehearsal to a Sitzprobe rehearsal at two positions.

Table 2: Measured change in sound level based on a simulated Traditional Rehearsal in dBA

Compare	Test Configuration	Fire Curtain	Change in Sound Level 2nd Violin (dBA)	Change in Sound Level Conductor (dBA)
2 -> 1	Source Mid Stage->Front Stage	Open	5.7	7.0
1 -> 3	Source Front of Stage	Open->Closed	0.6	0.8
2 -> 3	Source Mid Stage->Sitzprobe	Open->Closed	6.3	7.8

Table 3 presents potential mitigation measures in terms of reduction in sound level based on the simulated Sitzprobe rehearsal configuration at two positions. Potential solutions included: raising the sound source, adding carpet to the front of stage, and moving the source into the auditorium.

Table 3: Measured reduction in sound level based on a simulated Sitzprobe Rehearsal in dBA

Compare	Test Configuration	Reduction in Sound Level 2nd Violin (dBA)	Reduction in Sound Level Conductor (dBA)
3 -> 4	Source Added Height 2.4m	-1.2	-0.6
3 -> 5	Added Carpet	0.1	0.0
3 -> 6	Source at Stalls Seat C24 1.4m Facing Out	6.7	8.4
3 -> 8	Source at Stalls Seat G23 facing Conductor	5.2	6.7
3 -> 9	Source at Stalls Seat A23 Facing Out	3.7	6.4
3 -> 10	Source at Stalls Seat A23 facing Conductor	-0.5	3.1
3 - >11	Source in Royal Box facing Conductor	4.3	4.4

5. DISCUSSION

The results of the tests showed that sound levels from the simulated Sitzprobe rehearsal were significantly higher, 6-7 dBA, than for traditional rehearsals. This increase would be clearly perceptible to those in the orchestra pit. As to the potential mitigation measures the results showed that no on stage configuration reduced the sound level by any significant amount. For the auditorium positioned source, Seat C24, there was a reduction of 7-8 dBA, when facing out towards the rear of the house. A CCTV monitor would be used to show the conductor. When the source faced towards the conductor, G23, the greatest reduction was seen 5-7 dBA. This would bring the sound levels in the pit to a similar level as those found in a traditional rehearsal. However, this results in only a partial view of the conductor, at a side on angle.
As such these aren’t acceptable solutions. A key point is the turnaround time between rehearsals is less than 1 hour hence any solution must be implementable in short order. One possible solution is to implement a horizontal barrier between the standing singers and the sunken musicans in the pit, see figure 3.

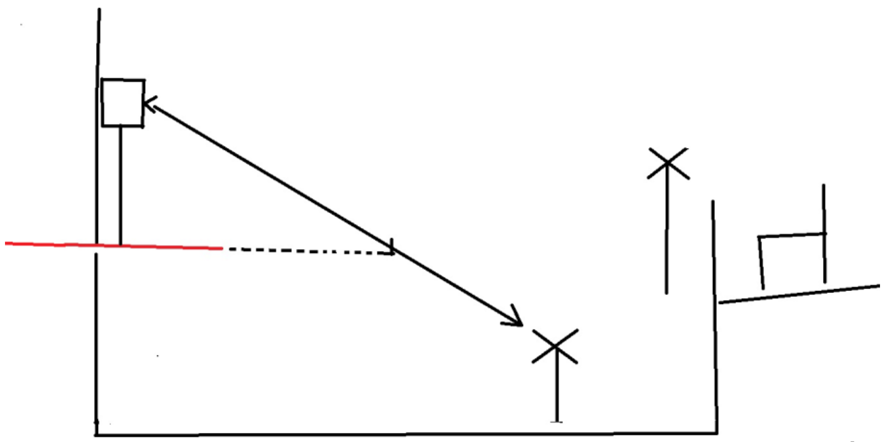

Figure 3. Sound path from sound source at the front of stage to 2nd violinist position

Currently, the stage has a slight decline angle to the front of stage, 1.4m, with a 1.2 meshed overhang to prevent a performer accidental falling into the pit. If the meshed area was covered by a rollable solid temporary floor, then a horizontal barrier would be formed. This barrier insertion loss was predicted using Maekawa [8] to reduce the sound level to the strings by a predicted 5 dBA [9] based on a reflective wall directly behind the source and directly behind the receiver. In addition, the horizontal barrier would increase the sound level at the conductor position by a predicted 2 dBA. The rollable flooring would need to be 12m long and 1.2m wide and be made of a dense vinyl-type material, a mass (M) of approximately 3 kg/m^2, or 43 kg, to prevent direct transmission of sound, a 20 dB transmission loss (TL) based on 750 Hz dominant frequency (f) of soprano singers [10]. Transmission loss being based on $TL= 20 \log (Mf)-47$. A room acoustic model would be required to predict the level of reduction possible more accurately [11].

6. CONCLUSIONS

The orchestral musicians had complained about their environment specifically when rehearsal with the fire curtain lowered, a Sitzprobe rehearsal. After a series of acoustic measurements, it was found that during a Sitzprobe rehearsal perceived levels would be significantly higher for the musicians in the pit, approximately 6-7 dBA. It was found that the fire curtain only marginally changed the sound level, indicating that it was position of the vocalists that created the issue. Experiments were undertaken to mitigate this increase without success, that is neither additional height, or a carpet laid at the front of stage assisted. Another set of experiments were undertaken where the source was position in the auditorium facing the conductor. This significantly reduced the sound levels in the pit by 5-7 dBA. If the source faced into the main auditorium a further reduction of 1.5 dBA was possible. However, line of sight with the conductor was significantly reduced.

To acceptably mitigate the sound level in the pit it would be necessary to implement a temporary horizontal barrier specifically for Sitzprobe rehearsals. This was found through web based simulations to reduce sound levels by 5 dBA at the violin positions. In the future a 12m of dense vinyl material would be purchased and tested to establish acceptability of the proposed solution.

The room acoustic of the Sitzprobe condition differed significantly from the dress rehearsal or performance condition. This is a direct result of the stage and fly tower being blocked off by the fire curtain significantly reducing the volume of the auditoria. Consequently, the measured reverberation times were significantly reduced, particularly in the lower frequencies, resulting in the Bass Ratio moving to unfavourable.

7. REFERENCES

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