Acoust. Sci. & Tech. **26**, 2 (2005)

ACOUSTICAL LETTER

The acoustical effect of audio equipment and furniture in a mixing room

Atsuro Ikeda[1,*], Masataka Nakahara[1,2], Chizuru Kai[1] and Akira Omoto[3]

[1]*SONA Corporation,*
2–19–9 Yayoi-cho, Nakano-ku, Tokyo, 164–0013 Japan
[2]*Kyushu Institute of Design,*
Shiobaru 4–9–1, Minami-ku, Fukuoka, 815–8540 Japan
[3]*Faculty of Design, Kyushu University,*
Shiobaru 4–9–1, Minami-ku, Fukuoka, 815–8540 Japan

(*Received 21 September 2004, Accepted for publication 20 November 2004*)

Keywords: Mixing room, Loudspeaker response, Absorption coefficient
PACS number: 43.55.Fw, 43.55.Gx [DOI: 10.1250/ast.26.233]

1. Introduction

A mixing room is the room where the mixing engineer sits at the listening position and operates the various audio equipment with listening to the playback sound reproduced by the loudspeaker. These equipment and furniture, which are usually of large dimensions, have to be installed into the mixing room after the architectural construction is done. However, the acoustical effect of them is rarely discussed. On the other hand, in respect to the acoustic design for auditoriums, the acoustical effect of chairs and the audience are often considered in order to estimate the acoustical properties under the actual environment. In recent research, the acoustical effect of equipment in a mixing room is reported [1]. Focusing on this point, the authors conducted acoustical measurement in the existing mixing room with and without equipment and furniture. This letter shows the measurement results and reports the acoustical effect of equipment and furniture on a mixing room.

2. Measurement

Impulse responses were measured in the mixing room shown in Fig. 1. The mixing room is a medium sized post-production studio in Tokyo [2] whose floor area and room volume are 35 sq meters and 83 cu meters, respectively. The eleven loudspeakers, nine full-range loudspeakers and two subwoofers, are installed in order to work for the multichannel programs. Therefore, 11-kinds of impulse responses are able to be measured at one receiver position in the room.

The impulse responses were measured under three conditions as follows.

(1) 'empty': There is nothing in the room (Fig. 1).
(2) 'console in the room': Only the mixing console is located in the room (Fig. 2).
(3) 'all equipment in the room': All equipment such as the mixing console, audio equipment (racks) and furniture (tables, sofas, chairs) are located in the room (Fig. 3).

The loudspeakers, amplifiers, measurement tools and receiver positions were consistent though all conditions. The positions of loudspeakers, sources, are shown in Figs. 1 to 3, where the L, C, R, LS1, LS2, LS3, RS1, RS2 and RS3 indicate the full-range loudspeakers, and SUBL and SUBR indicate subwoofers which reproduce only the low frequency sound. The loudspeaker responses, namely the transfer functions from the loudspeakers to the mixer's position including the loudspeaker characteristics, were measured.

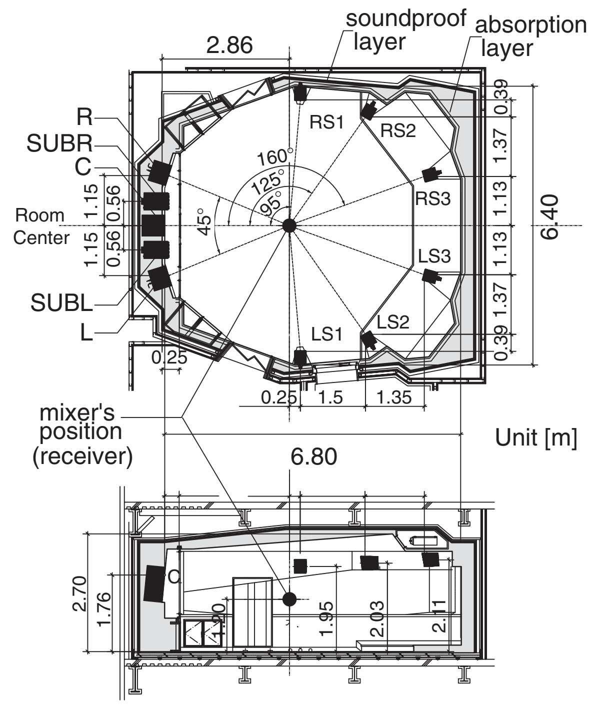

Fig. 1 Examined mixing room with the condition 'empty'; there is nothing in the room. Loudspeakers; full-ranges, L/C/R/LS1/LS2/LS3/RS1/RS2/RS3, and subwoofers, SUBL/SUBR.

3. Measurement results

3.1. Loudspeaker responses

One of the most important things for the acoustical property of the mixing room is the frequency characteristics of a loudspeaker response at the mixer's position. This section shows the differences of the responses from C, RS1 and RS3 loudspeakers due to the presence of a mixing console and

---

*e-mail: ikeda@sona.co.jp

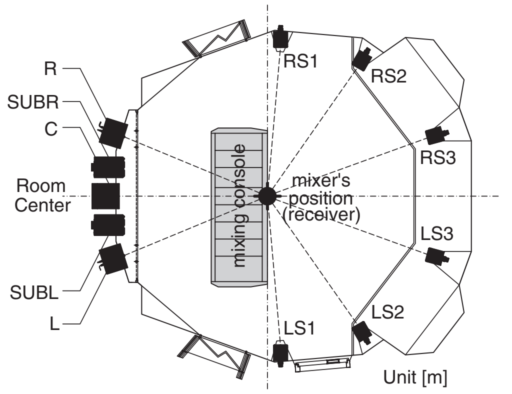

Fig. 2 Plan view of the mixing room. 'console in the room'; only the mixing console as the grayed object is in the room.

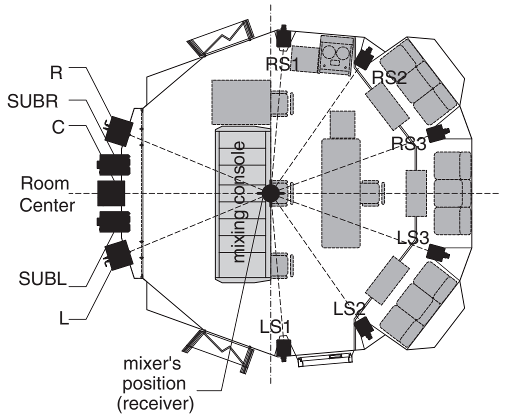

Fig. 3 Plan view of the mixing room. 'all equipment in the room'; equipment and furniture shown as the grayed objects are in the room.

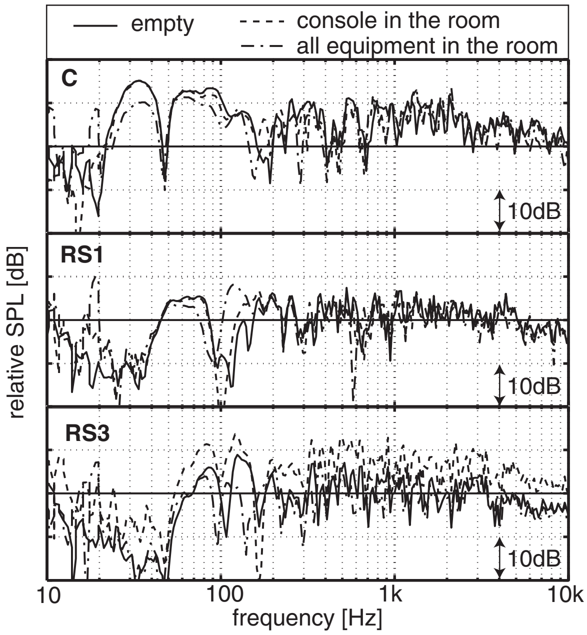

Fig. 4 The variation of the loudspeaker responses at the mixer's position due to the presence of equipment and furniture. From the top, the responses from C, RS1, and RS3 loudspeakers. The solid lines, the dashed lined and the dash-dotted lines indicate the responses of 'empty,' 'console in the room' and 'all equipment in the room,' respectively. Results are averaged at 1/24 octave intervals.

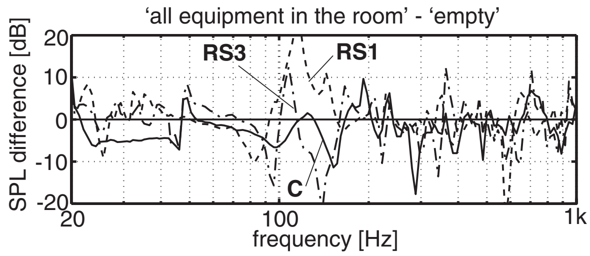

Fig. 5 Differences between the loudspeaker responses with equipment and furniture and ones without them; 'all equipment in the room' — 'empty.' The solid lines, the dashed lined and the dash-dotted lines indicate the responses from C, RS1 and RS3 loudspeakers, respectively.

other equipment shown in Figs. 1, 2 and 3.

Figure 4 shows the frequency characteristics from three kinds of the loudspeaker to the mixer's position under three room conditions, 'empty,' 'console in the room' and 'all equipment in the room.' Because of the horizontally symmetrical shape of the room, the responses from the loudspeakers on the right hand are shown. Figure 5 shows the effects of the equipment and furniture, namely the differences between the responses of 'all equipment in the room' and 'empty.' Because of the little difference at higher than 1 kHz, the results in the range from 10 Hz to 1 kHz are shown. In Figs. 4 and 5, results are averaged at 1/24 octave intervals. According to the results shown in Figs. 4 and 5, we ascertain that the equipment and furniture affects the loudspeaker response at low frequency range.

3.2. Reverberation times

The reverberation time is not usually considered on the acoustic design of a mixing room, because a mixing room is usually surrounded by the highly sound absorbing materials, and is no longer the diffuse sound field. On the other hand, the absorption characteristics is one of the most important subjects for the acoustic design of a mixing room, and the reverberation time is often reported as the measurement result of a mixing room.

Therefore, the apprehension for the variation of the absorption characteristics due to the presence of equipment and furniture may be useful for the acoustic design of a mixing room. Figure 7 and Table 1 show the reverberation times under three conditions, 'empty' (solid line), 'console in the room' (dashed line) and 'all equipment in the room' (dash-dotted line). The gray solid line indicates the measurable minimum reverberation time due to the limit of the measurement system, e.g., the duration of the band pass filters *et al.* Reverberation times were averaged by the values at five

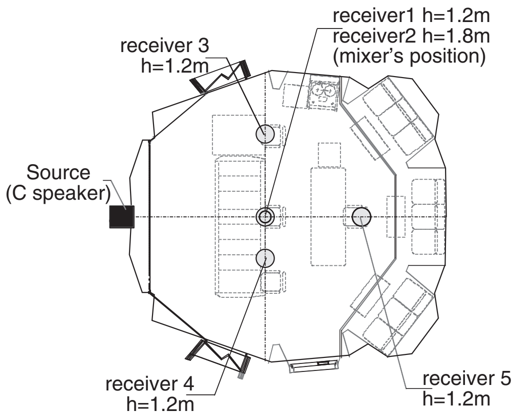

Fig. 6 The source (C loudspeaker) position and the five receiver positions for the measurement of the reverberation time.

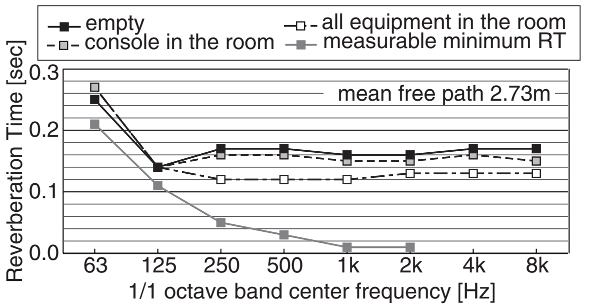

Fig. 7 Variation of the reverberation times due to three room conditions; 'empty' (solid line), 'console in the room' (dashed line), 'all equipment in the room' (dash-dotted line). The gray solid line indicates the measurable minimum reverberation time due to the limit of the measurement system.

Table 1 The reverberation times of the mixing room under three room conditions; 'empty,' 'console in the room' and 'all equipment in the room.'

mean free path : 2.73 [m]

1/1 octave band fc [Hz]		63	125	250	500	1k	2k	4k	8k
RT [sec]	empty	0.25	0.14	0.17	0.18	0.16	0.16	0.17	0.17
	empty + console	0.27	0.14	0.16	0.16	0.15	0.15	0.16	0.15
	empty + all equipment	0.27	0.14	0.12	0.12	0.12	0.13	0.13	0.13
measurable minimum RT		0.21	0.11	0.05	0.03	0.01	0.01	-	-

receiver positions shown in Fig. 6, and the C loudspeaker was used as the source. According to the Fig. 7 and Table 1, the results at 63 Hz and 125 Hz seem to be less confidence due to the duration of a system response.

4. Discussion

According to the results shown in Chap. 3, we ascertain the variations of the loudspeaker responses and the reverberation times occur when the equipment is installed into the mixing room (Figs. 4 and 7, Table 1). In respect to the reverberation time, more the equipment and furniture are installed, shorter the reverberation time becomes (Fig. 7, Table 1). This suggests that the equipment and furniture have a certain sound absorption power which cannot be omitted for the acoustic properties of a mixing room.

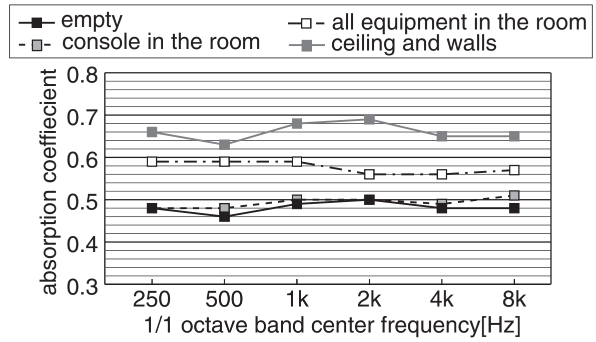

Fig. 8 Variation of the average sound absorption coefficients under three room conditions; 'empty' (solid line), 'console in the room' (dashed line), 'all equipment in the room' (dash-dotted line). The gray solid line indicates the average sound absorption coefficients of walls and the ceiling of the 'empty' condition.

Table 2 The average absorption coefficients of the mixing room under three room conditions.

1/1 octave band fc [Hz]		250	500	1k	2k	4k	8k
$\overline{\alpha}$	empty	0.48	0.46	0.49	0.50	0.48	0.48
	empty + console	0.48	0.48	0.50	0.50	0.49	0.51
	empty + all equipment	0.59	0.59	0.59	0.56	0.56	0.57

Because of the high sound absorption and the small volume of the room, the acoustical properties of a mixing room cannot be expressed by the statistical theories based on the diffuse sound field. However, in reality, these theories such as a reverberation formula are often used for the acoustic design and the representative values of the measurement data of a mixing room. Focusing on this point, the authors examine how the acoustical effect of equipment and furniture reflects the values of the absorption coefficient and the equivalent sound absorption area.

Figure 8 and Table 2 show the average sound absorption coefficients which are calculated by the Eyring's reverberation formula using the reverberation times shown in Table 1. The black solid line, the black dashed line and the black dash-dotted line indicate the absorption coefficient under the condition of 'empty,' 'console in the room' and 'all equipment in the room,' respectively. The results at 63 Hz and 125 Hz are omitted due to the less confidence.

The gray solid line in Fig. 8 shows the average sound absorption coefficients of the ceiling and walls only, that are calculated using the absorption coefficient of 'empty' condition shown in Table 2, and the absorption coefficient of the floor shown in Table 3 which is adopted from [3]. This gray solid line shows typical absorption coefficients of the sound absorption finishing of a mixing room.

Figure 8 suggests that the difference of the sound absorption coefficient between 'console in the room' and 'empty' is slight. On the other hand, the difference between 'all equipment in the room' and 'empty' is large at higher than

Table 3 The average sound absorption coefficients of walls and the ceiling of the 'empty' condition, and the assumed coefficients of the floor [3].

1/1 octave band fc [Hz]		250	500	1k	2k	4k	8k
$\overline{\alpha}$	ceiling and walls	0.66	0.63	0.68	0.69	0.65	0.65
	floor (assumed)	0.04	0.07	0.06	0.06	0.07	0.06

Table 4 The equivalent sound absorption area of the mixing console, the equipment excluding the mixing console (other equipment) and all equipment.

room volume $V = 83\,m^3$, floor area $S = 35\,m^2$, mean free path $d = 4V/S_{all} = 2.73\,m$

1/1 octave band fc [Hz]		250	500	1k	2k	4k	8k	ave.
A [m^2]	console	0.0	2.6	1.3	0.2	1.7	4.0	1.6
	other equipment	14.2	13.1	10.8	7.1	8.8	8.3	10.4
	all equipment	14.2	15.7	12.1	7.3	10.5	12.3	12.0

250 Hz. This suggests that the equivalent sound absorption area of the equipment and furniture excluding the mixing console is quite larger than the one of the mixing console.

Table 4 shows the equivalent sound absorption area of a mixing console, the one of other equipment and furniture and the one of all equipment and furniture. The results are calculated from the sound absorption coefficients shown in Table 2.

According to Table 4, we ascertain that the equipment and furniture has too large equivalent sound absorption area to be ignored for the acoustical properties of a mixing room. The equivalent sound absorption area of all equipment and furniture is around 12 sq meters in this case.

5. Conclusion

According to the measurements of the mixing room under three different room conditions, 'empty,' 'console in the room' and 'all equipment in the room,' the following matters are obtained.

(1) The equipment and furniture which are installed into the mixing room after architectural construction is finished, affect the acoustical properties of the mixing room.

(2) The loudspeaker response is changed due to the presence of equipment and furniture.

(3) The equipment and furniture shows the fairly large equivalent sound absorption area which cannot be ignored. It reached 12 sq meters in the measured room, whose total surface area is 128 sq meters.

The results suggest the importance of the consideration for the acoustical effect of equipment and furniture when we make the acoustic design for a mixing room.

The authors are continuing to measure the impulse responses in other mixing rooms to grasp the variations of the physical measures such as the reverberation time and the equivalent sound absorption area.

References

[1] M. Nakahara, A. Omoto and K. Fujiwara, "Scattering effect of a mixing console in a production studio," *Proc. Int. Symp. Room Acoustics: Design and Science* (*RADS*), 050 (2004).

[2] C. Kai, A. Ikeda, S. Ueoka, M. Nakahara and A. Omoto "Acoustic design of a multichannel production studio: Example of a small/medium post-production studio in Tokyo," *Proc. Int. Symp. Room Acoustics: Design and Science* (*RADS*), 055 (2004).

[3] Z. Maekawa and P. Lord, *Environmental and Architectural Acoustics* (E & FN Spon, London, 1994), p. 359.