Piotr Z. KOZŁOWSKI[1]

8. INFLUENCE OF THE ARCHITECTURAL FINISH OF ROOMS ON THE SPEECH INTELLIGIBILITY OF VERBAL MESSAGES BROADCASTED BY THE VOICE ALARM SYSTEM

8.1. Introduction

This work has been inspired by experience in consulting situations where the STIPA speech intelligibility indicator value for verbal messages broadcast by a voice alarm system installed in a room did not meet the requirements of the regulations. In most situations, STIPA values are required to be no less than 0.5.

Participants in the discussion to find a corrective solution present different opinions on the reasons for this. The most common reasons for unsatisfactory speech intelligibility are found in poor design of the voice alarm system. In fact, relatively often too low STIPA speech intelligibility values are primarily due to inadequate room acoustics.

Even if the ongoing discussion identifies the inadequate room acoustics as the cause of the problem, the problem arises as to how much reverberation time should be reduced to achieve satisfactory STIPA values. Changing the interior finish is, on the one hand, costly and, on the other hand, not always possible due to functional or visual aspects. This raises the key question of which areas of the room should be acoustically adapted first. This question can also be asked in a different way: which surfaces will be the most effective, i.e. which areas will be adapted as much as possible, that is the reverberation time will be reduced as much as possible and this will lead to the greatest increase in the STIPA intelligibility value.

To answer these types of questions, it was decided to first examine four model rooms whose shapes and dimensions were taken directly from one of the objects for which the author was asked to propose a solution to improve the speech intelligibility of messages emitted by the voice alarm system. The following studies were carried out to verify the effectiveness of the acoustic adaptation modifications to the reverberation time change and thus the value of the

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STIPA speech intelligibility indicator by means of geometric computer modelling using EASE software (version 4.4.61.16) with the Aura Module 4.0.

The analyses presented in this paper are one of the stages in a larger series of studies that will also use objective and subjective tests of speech intelligibility obtained with real-life sound systems.

8.2. Models of tested rooms

8.2.1. Lobby

The first room used in the research presented in the text is a lobby with a cuboid shape. The following room dimensions have been adopted: width 10 m, length 25 m, height 5 m. Longer walls were given odd symbols F3 and F5, shorter even symbols F4 and F6. The ceiling has the symbol F2 and the floor F1.Fig. 1. Lobby – axonometric view and top view presenting ceiling speakers placement

Rys. 1. Lobby – widok aksonometryczny i widok z góry przedst. rozmieszcz. głośników sufitowych

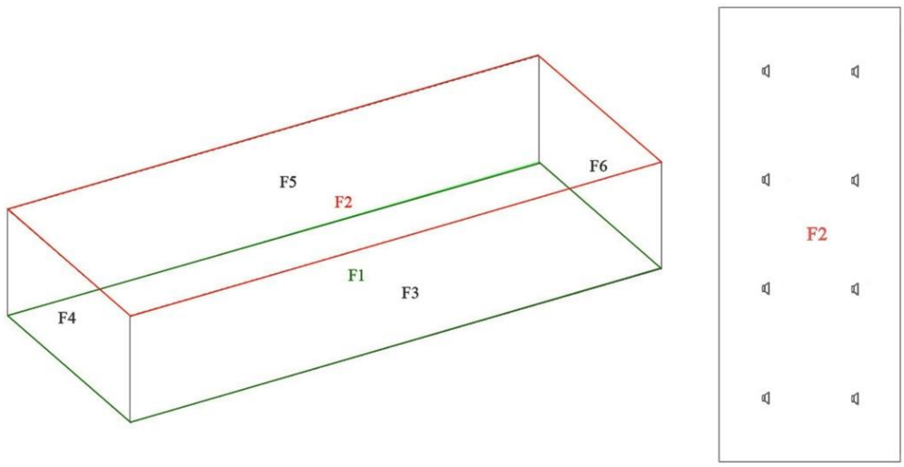


Fig. 1. Lobby – axonometric view and top view presenting ceiling speakers placement
Rys. 1. Lobby – widok aksonometryczny i widok z góry przedst. rozmieszcz. głośników sufitowych

The voice alarm system uses 8 ceiling loudspeakers. The shape of the room and speaker placement are shown in the Fig. 1.

8.2.2. Corridor

The second room used in the research presented in the text is a corridor consisting of two perpendicular parts. The following room dimensions are assumed: width 2 m, length of both parts measured along the "outer" wall 15 m and length measured along the "inner" wall 13 m. Longer "outer" walls are given odd symbols F3 and F7, shorter "inner" walls are given symbols F5 and F6. The end face walls have F4 and F8 symbols. The ceiling has the symbol F2 and the floor F1. The voice alarm system uses 8 ceiling loudspeakers. The shape of the room and speaker placement are shown in the Fig. 2.

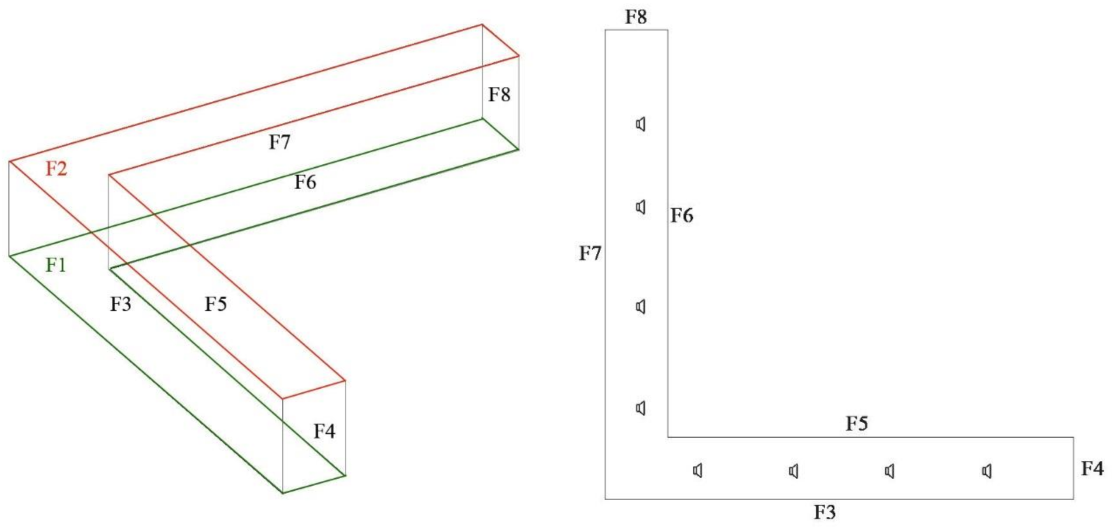


Fig. 2. Corridor – axonometric view and top view presenting ceiling speakers placement
Rys. 2. Korytarz – widok aksonometryczny i widok z góry przedstawiający rozmieszczenie głośników sufitowych

8.2.3. Room with a smooth ceiling

The third interior used in the research presented in the text is an exhibition room of rectangular shape. The following room dimensions have been adopted: width 20 m, length 30 m, height 8 m. Longer walls were given even symbols F4 and F6, shorter odd symbols F3 and F5. The smooth ceiling has the symbol F2 and the floor F1. The Voice Alarm System uses 12 projector loudspeakers. The shape of the room and speaker placement are shown in the Fig. 3.

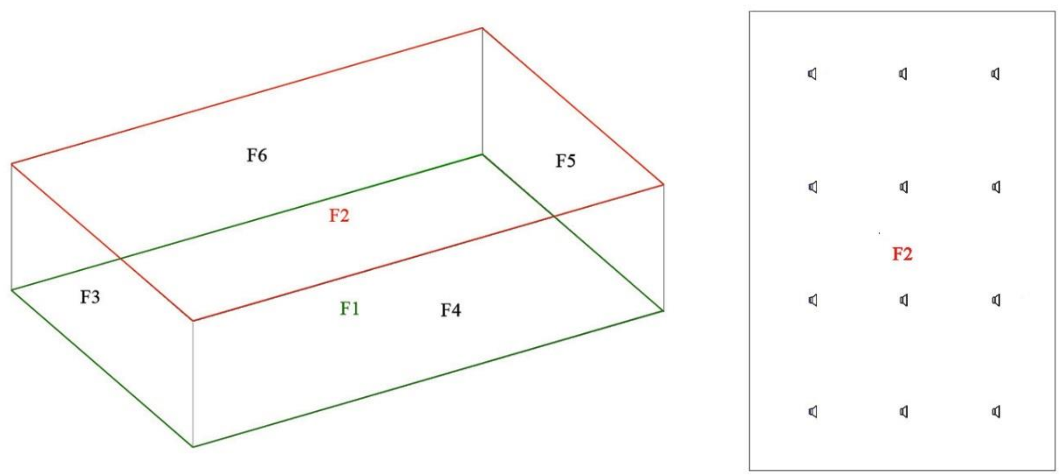


Fig. 3 Room with a smooth ceiling – axonometric view and top view presenting ceiling speakers placement
Rys. 3. Pomieszczenie z gładkim sufitem – widok aksonometryczny i widok z góry przedstawiający rozmieszczenie głośników sufitowych

8.2.4. Room with exposed bars on the ceiling

The fourth interior used in the research presented in the text is an exhibition room with a cuboid shape and exposed structural beams on the ceiling. The following room dimensions have been adopted: width 20 m, length 31 m, total height 10 m. Longer walls were given symbols F2 and F3, shorter symbols F4 and F32. The Voice Alarm System uses 12 projector loudspeakers. In this room, the ceiling acoustical treatment means that all horizontal and vertical ceiling surfaces will be covered by an acoustically absorbent material. The shape of the room and speaker placement are shown in the Fig. 4.

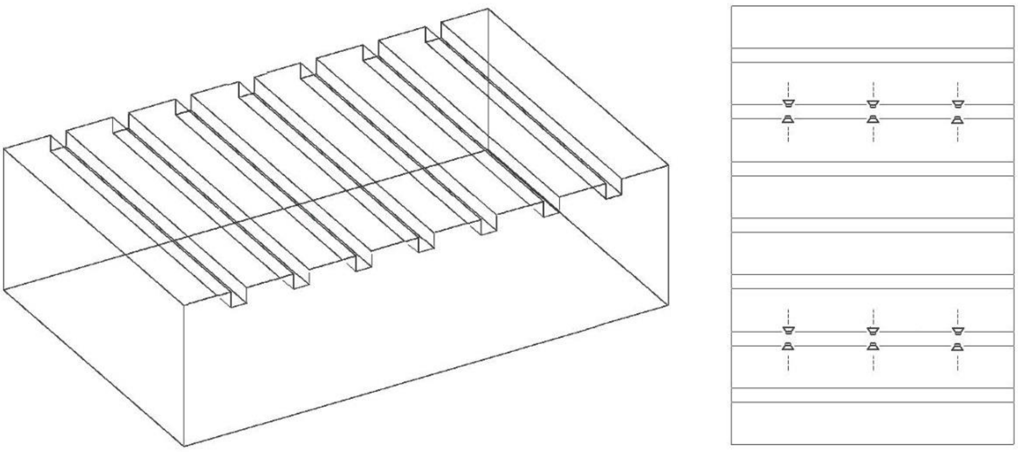


Fig. 4. Room with exposed bars on the ceiling – axonometric view and top view presenting ceiling speakers placement
Rys. 4. Pomieszczenie z odsłoniętymi podciągami na suficie – widok aksonometryczny oraz widok z góry prezentujący rozmieszczenie głośników sufitowych

8.3. Research assumptions

Classic statistic methods of calculating reverberation time are based on the well-known Sabine's equation (1).

$$\mathrm{RT} = \frac{0.161 \cdot V}{A} = \frac{0.161 \cdot V}{S_1 \cdot \alpha_1 + S_2 \cdot \alpha_2 + \cdots + S_n \cdot \alpha_n} \tag{1}$$

The reverberation time *RT* is directly proportional to the cubic volume of the room *V* and inversely proportional to the acoustic absorption *A* of the entire room. The acoustic absorption *A* of each of *n* surfaces/elements in the room is the product of the surface area *S* and the acoustic absorption coefficient *α* of a given element. We can, therefore, directly influence the reverberation of the room by changing acoustic absorption coefficient α of surfaces existing inside the room.

The reverberation time *RT* values discussed in this paper were not calculated using statistic calculations. All the calculations were done using geometric computer modelling using EASE software (version 4.4.61.16) with the Aura Module 4.0. Detailed analyses during design are performed using reverberation time values for individual octave bands in the range 125 Hz – 8 kHz. To simplify the description and analysis of the results, as in many publications on interior acoustics, the value of the reverberation time will be expressed using the T_m indicator, which is the arithmetic mean of the reverberation time in the 500 Hz and 1 kHz octave bands.

It is well known that the intelligibility of rooms increases with the decrease of the reverberation time. A similar relationship exists for the speech intelligibility of messages emitted by public address systems. It is essential to determine which reverberation time limits allow the required value of STIPA $\geq$ 0.5.

The technical specification CEN/TS 54-32 for alarm systems [1] for upper limit of acoustically simple ADA (Acoustically Different Area) takes reverberation time values up to 1.3 s and ambient noise L_{Aeq} < 65 dB. This means that in areas where the reverberation time is less than 1.3 s and the level of noise does not exceed 65 dB, it is relatively easy to obtain the STIPA $\geq$ 0.5 with a standard public address system. In the literature, a reverberation time of 1.7 s is taken as the upper limit of conditions for good intelligibility in large spaces such as shopping centres [2]. This shows that in areas where we cannot afford more sophisticated solutions such as room geometry or cladding, it is necessary to reduce the reverberation time and background noise levels accordingly.

The model tests presented in this paper were carried out according to the scheme described below. The values of the absorption coefficient α were changed in the following steps: 0.02, 0.10, 0.30, 0.50, 0.70, 0.99. This means that the effect of the sound absorption of each plane was tested in 6 independent simulations for the subsequent values α given above. The first series of modelling was carried out for situations where α was changed between 0.02 and 0.99 for the planes given in the case name, for instance:

- ceiling,
- one wall,
- two parallel walls,
- ….,

and the value α for all other planes was 0.02.

During the second series of modelling, for each simulation performed, the α value for the ceiling was always $\alpha = 0.7$, while for the planes given in the case name, the α value was changed from 0.02 to 0.99:

- one wall + ceiling,
- two parallel walls + ceiling,
- ….,

and the value α for all other planes was 0.02. Simulations were performed for 6 α values for:

- lobby - 9 cases,
- corridor - 13 cases,
- room with a smooth ceiling - 9 cases,
- room with exposed bars on the ceiling - 9 cases,

which gave a total of 240 simulations. In each of the simulations, the distribution of the STIPA speech intelligibility index values for the messages emitted by the public address sound system was determined on the basis of measurement methods [3] and the frequency characteristics of the reverberation time determined in a manner analogous to the measurement standards applicable in interior acoustics [4].

Table 1

Computer modelling settings EASE Aura

Parameter	Lobby	Corridor	R. smooth ceiling	R. exposed bars
Particles	Intermediate Resolution			
Length	Long			
Noise level [dB]	0			
Resolution:				
Patch Size	1.00	0.50	2.00	2.00
Isoline Step [dB]	1.00	1.00	1.00	1.00
Scale [m]	0.10	0.10	0.10	0.10

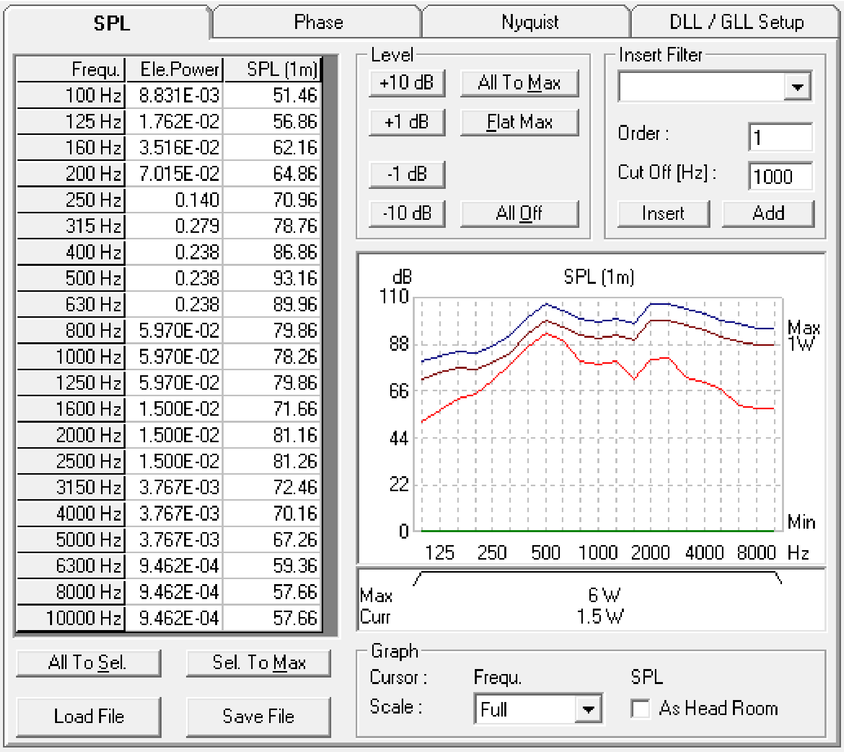


Fig. 5. Settings for ceiling loudspeaker Partner DEL-F 165/6 PP [6 W] used at lobby
Rys. 5. Ustawienia dla głośnika sufitowego Partner DEL-F 165/6 PP [6 W] używanego w holu

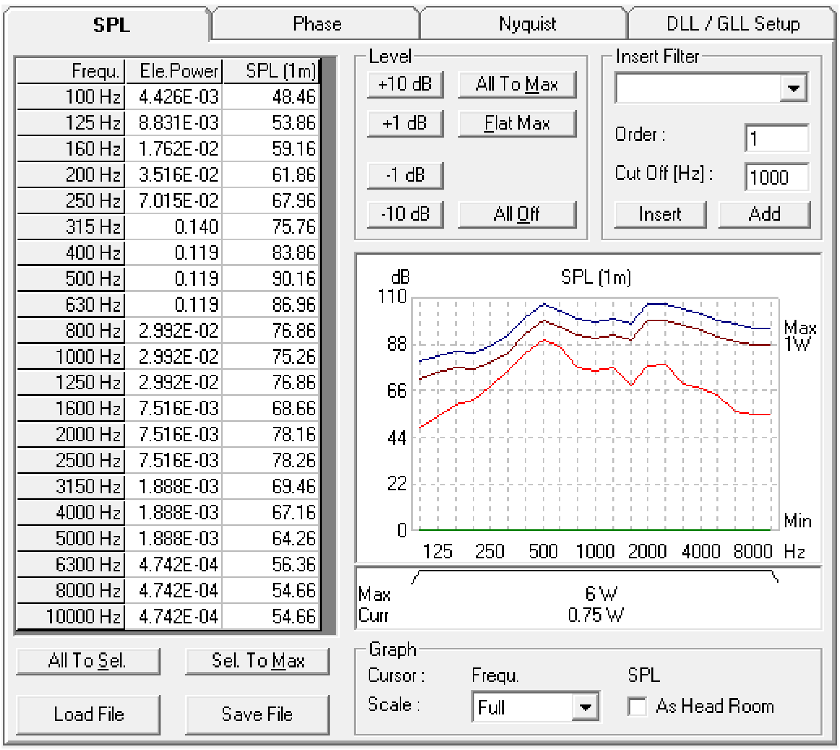


Fig. 6. Settings for ceiling loudspeaker Partner DEL-F 165/6 PP [3 W] used at corridor
Rys. 6. Ustawienia dla głośnika sufitowego Partner DEL-F 165/6 PP [3 W] używanego w korytarzu

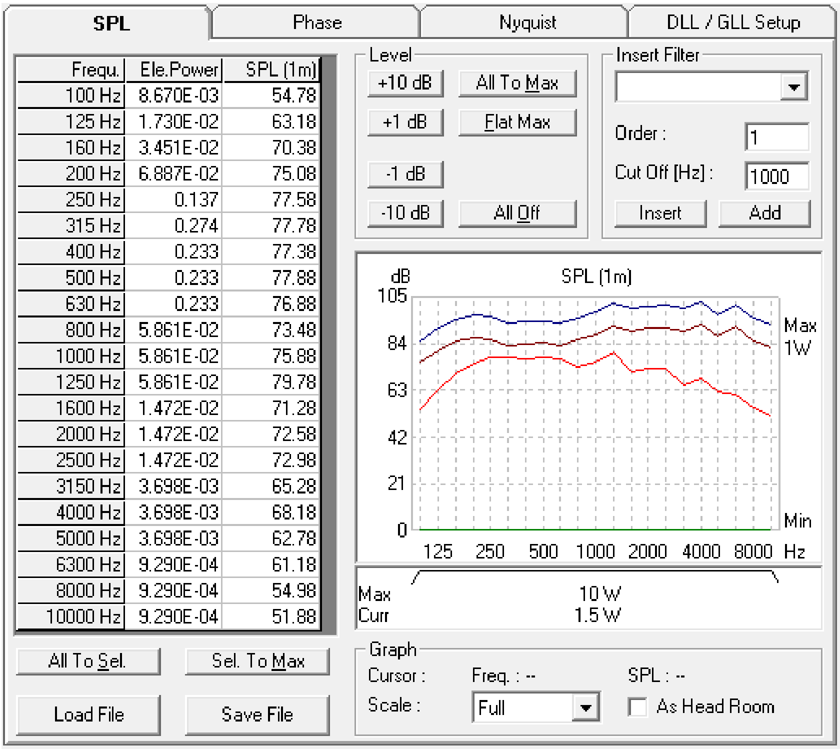


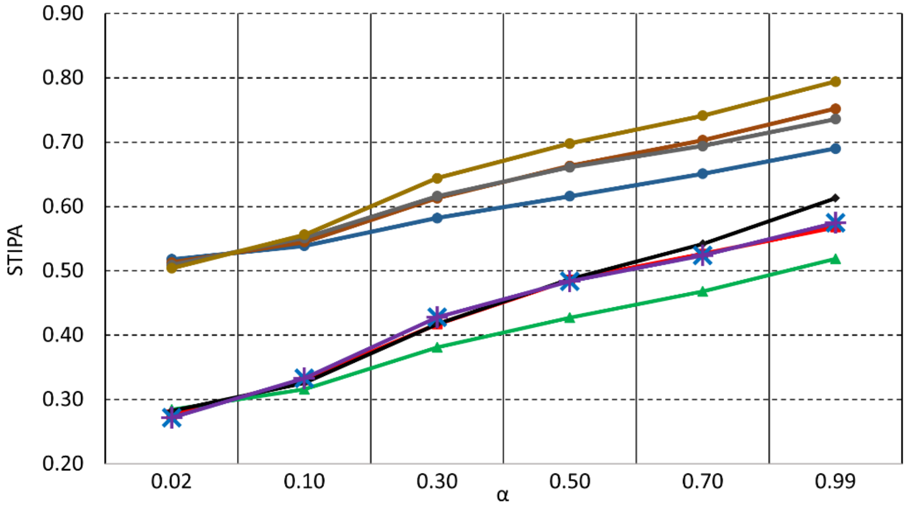
Fig. 7. Settings for projector loudspeaker Partner DAW 130/10 PP [6 W] used at room with a smooth ceiling and room with exposed bars on the ceiling

Rys. 7. Ustawienia dla głośnika projekcyjnego Partner DAW 130/10 PP [6 W] stosowanego w pomieszczeniu z gładkim sufitem oraz w pomieszczeniu z odsłoniętymi podciągami na suficie

8.4. Results of computer modelling

8.4.1. Lobby

Acoustic adaptation of only one wall in the case of the lobby is not able to provide the required STIPA speech intelligibility value. If only the ceiling surface is adapted, the required STIPA value is achieved by using materials $\alpha \geq 0.7$. Adaptation that does not use the ceiling surface requires at least two walls to be covered with a material of $\alpha \geq 0.7$. If adaptation is carried out on two walls, better results are achieved if the adapted walls are perpendicular to each other than if parallel walls are adapted. This is due to the effect of eliminating the fluttering echo between two parallel planes reflecting the acoustic wave. When a ceiling is adapted using a material with an absorption coefficient of $\alpha = 0.7$, adding a finish with an absorption coefficient of $\alpha \geq 0.1$ to any wall guarantees the required STIPA ≥ 0.5.

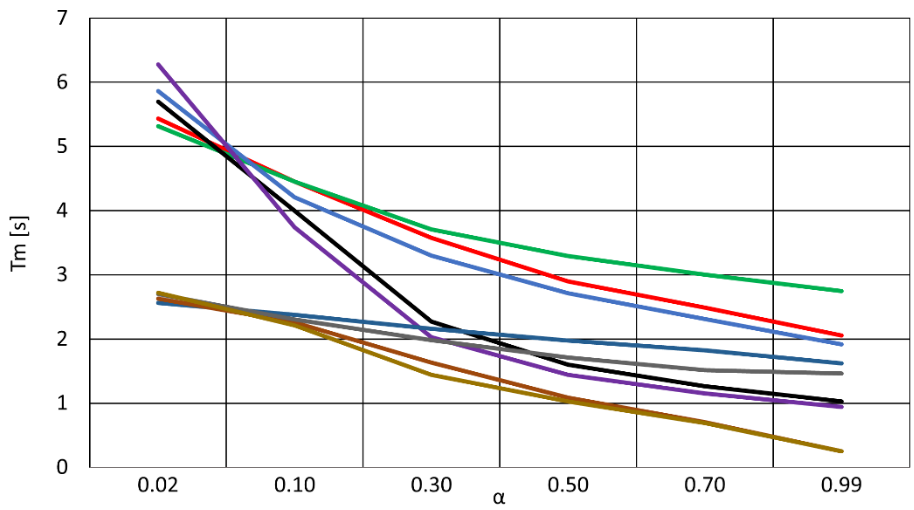


STIPA ceiling	0.276	0.330	0.417	0.486	0.526	0.568
STIPA one wall	0.284	0.316	0.381	0.427	0.468	0.519
STIPA two orthogonal walls	0.282	0.326	0.417	0.487	0.542	0.613
STIPA two parallel walls	0.272	0.333	0.428	0.484	0.524	0.575
STIPA three walls	0.272	0.333	0.428	0.484	0.524	0.575
STIPA one wall + ceiling	0.518	0.539	0.582	0.616	0.651	0.690
STIPA two ortho walls + ceiling	0.513	0.545	0.613	0.663	0.703	0.752
STIPA two parallel walls + ceiling	0.509	0.551	0.616	0.661	0.694	0.736
STIPA three walls + ceiling	0.504	0.556	0.644	0.698	0.741	0.794

Fig. 8. Speech intelligibility STIPA values in α function – lobby
Rys. 8. Wskaźnik transmisji mowy STIPA w funkcji α – lobby

According to the PN-B-02151-4:2015-06 so-called "reverberation standard" 5 in force, the value of reverberation time in a lobby 5 m height should meet the criterion $T_m \leq 1.5$ s. By analysing the results for not only the required speech intelligibility but basic acoustic comfort as defined in the "reverberation standard" [5], it is necessary to adapt at least two perpendicular walls with a material of $\alpha \geq 0.5$ in addition to adapting the ceiling or two parallel walls with a $\alpha \geq 0.99$ or three walls with a $\alpha \geq 0.3$. It is also possible to meet the reverberation criterion if the acoustic ceiling is not adapted but two perpendicular walls are covered with a $\alpha \geq 0.70$ or three walls are finished with a $\alpha \geq 0.5$.

There is no possibility to fulfill requirements by adopting only ceiling or only one wall or two parallel walls.



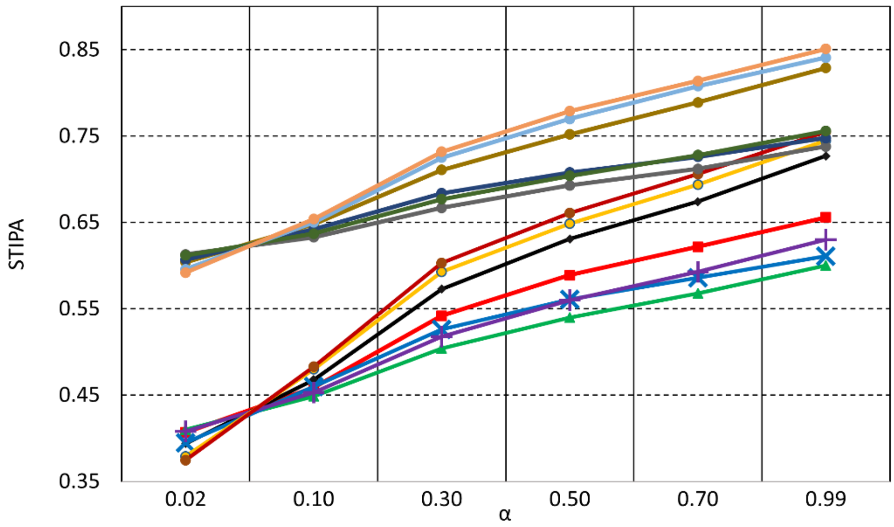
	0.02	0.10	0.30	0.50	0.70	0.99
Tm ceiling	5.44	4.46	3.58	2.90	2.49	2.06
Tm one wall	5.32	4.45	3.71	3.30	3.01	2.75
Tm two orthogonal walls	5.70	4.00	2.27	1.60	1.27	1.03
Tm two parallel walls	5.87	4.21	3.30	2.72	2.31	1.92
Tm three walls	6.28	3.74	2.03	1.44	1.16	0.95
Tm one wall + ceiling	2.57	2.38	2.16	1.98	1.83	1.62
Tm two ortho walls + ceiling	2.63	2.26	1.64	1.09	0.71	0.25
Tm two parallel walls + ceiling	2.70	2.31	1.98	1.71	1.52	1.46
Tm three walls + ceiling	2.72	2.21	1.44	1.03	0.69	0.25

Fig. 9. Reverberation time T_m values in α function – lobby
Rys. 9. Czas pogłosu T_m w funkcji α – lobby

8.4.2. Corridor

In the case of a corridor, it is possible to achieve the required STIPA ≥ 0.5 value if the following surfaces are adapted with materials with the given absorption coefficient α:

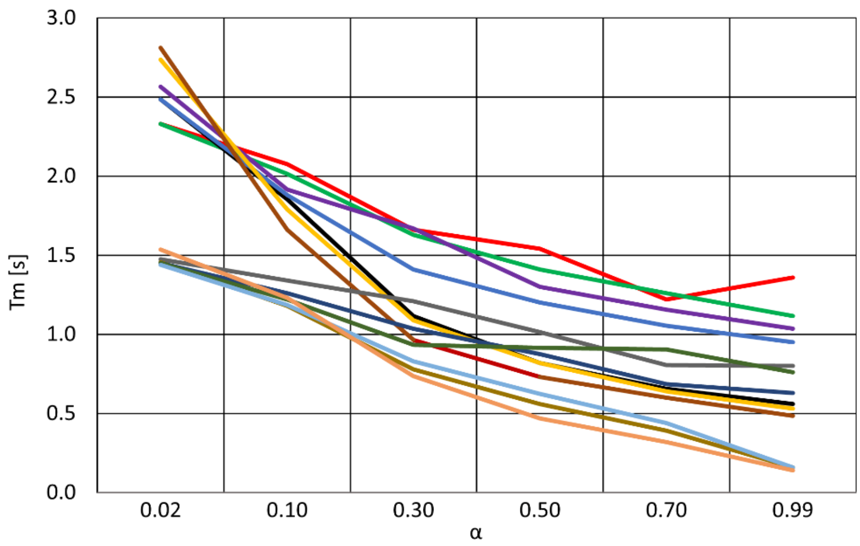
- ceiling – $\alpha \geq 0.3$,
- one wall – $\alpha \geq 0.5$,
- any combination of two walls – $\alpha \geq 0.3$,
- three or four walls – $\alpha \geq 0.3$,
- if ceiling $\alpha = 0.7$ there is no need to adopt walls.



STIPA ceiling	0.407	0.459	0.542	0.589	0.622	0.656
STIPA one wall	0.410	0.449	0.504	0.540	0.568	0.600
STIPA two ortho walls F3, F7	0.394	0.468	0.573	0.631	0.674	0.727
STIPA two parallel walls F3, F5	0.395	0.460	0.526	0.561	0.586	0.611
STIPA two parallel walls F3, F8	0.408	0.453	0.518	0.560	0.593	0.630
STIPA three walls F3, F5, F7	0.379	0.480	0.593	0.649	0.694	0.745
STIPA four walls F3, F5, F7, F8	0.375	0.483	0.603	0.661	0.706	0.755
STIPA one wall + ceiling	0.613	0.633	0.667	0.693	0.712	0.738
STIPA 2 ortho walls F3, F7 + ceiling	0.604	0.648	0.711	0.752	0.789	0.829
STIPA 2 par. walls F3, F5 +ceiling	0.607	0.642	0.684	0.708	0.726	0.748
STIPA 2 par. walls F3, F8 + ceiling	0.612	0.637	0.677	0.704	0.728	0.756
STIPA 3 walls F3, F5, F7 + ceiling	0.596	0.650	0.725	0.770	0.808	0.841
STIPA 4 walls F3, F5, F7, F8 + ceiling	0.592	0.654	0.732	0.779	0.814	0.851

Fig. 10. Speech intelligibility STIPA values in α function – corridor
Rys. 10. Wskaźnik transmisji mowy STIPA w funkcji α – korytarz

An analysis of meeting the requirements set out in the PN-B-02151-4:2015-06 “reverberation standard” [5] for corridors indicates that it is actually sufficient to adapt the ceiling with a material of $\alpha \geq 0.85$ for the requirement defined as $A \geq 0.8 \cdot S$ (where A - sound absorption (in m), S - total floor area of the corridor (in m^2)) to be met. However, when looking at the acoustic comfort criteria for e.g. conducting a conversation in such a corridor, it should be considered that limiting the reverberation time to $T_m \leq 1$ s requires at least one wall to be adapted with a material of $\alpha \geq 0.5$ additionally to the ceiling adopted with the material $\alpha = 0.7$.



	0.02	0.10	0.30	0.50	0.70	0.99
Tm ceiling	2.33	2.08	1.66	1.54	1.22	1.36
Tm one wall	2.33	2.02	1.63	1.41	1.26	1.12
Tm two orthogonal walls F3, F7	2.49	1.86	1.12	0.82	0.66	0.56
Tm two parallel walls F3, F5	2.49	1.88	1.41	1.20	1.06	0.95
Tm two parallel walls F3, F8	2.57	1.92	1.67	1.30	1.16	1.04
Tm three walls F3, F5, F7	2.74	1.79	1.09	0.82	0.64	0.53
Tm four walls F3, F5, F7, F8	2.81	1.66	0.97	0.73	0.60	0.49
Tm one wall + ceiling	1.48	1.34	1.21	1.02	0.81	0.80
Tm two ortho walls F3, F7 + ceiling	1.46	1.18	0.78	0.56	0.39	0.16
Tm two parallel walls F3, F5 + ceiling	1.45	1.26	1.04	0.88	0.69	0.63
Tm two parallel walls F3, F8 + ceiling	1.45	1.22	0.94	0.92	0.91	0.76
Tm three walls F3, F5, F7 + ceiling	1.44	1.19	0.83	0.63	0.44	0.16
Tm four walls F3, F5, F7, F8 + ceiling	1.54	1.23	0.74	0.47	0.32	0.14

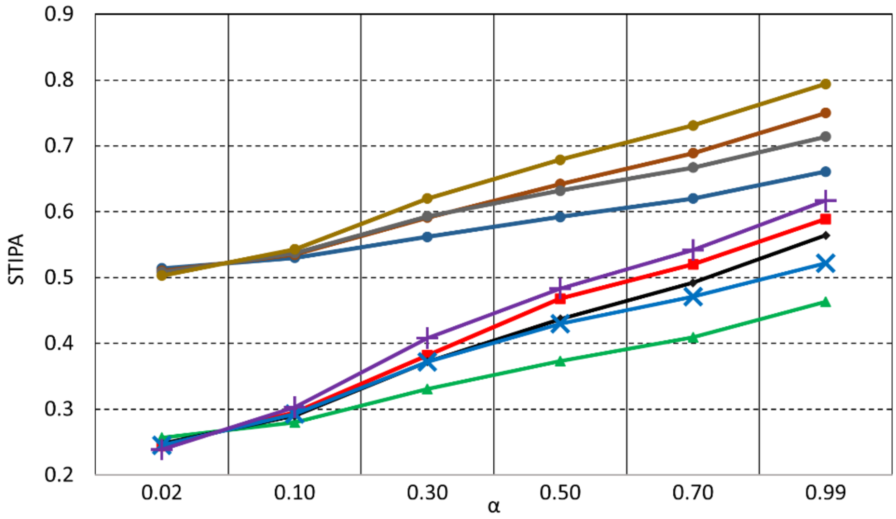
Fig. 11. Reverberation time T_m values in α function – corridor
Rys. 11. Czas pogłosu T_m w funkcji α – korytarz

8.4.3. Room with a smooth ceiling

In the case of a room with a smooth ceiling, it is possible to achieve the required STIPA ≥ 0.5 value if the following surfaces are adapted with materials with the given absorption coefficient α:

- ceiling – $\alpha \geq 0.7$,
- any combination of two walls – $\alpha \geq 0.99$,
- three walls – $\alpha \geq 0.7$,
- if ceiling $\alpha = 0.7$ theoretically there is no need to adopt walls, but practically it is worth to adapt at least one wall using material $\alpha \geq 0.10$.

There is no possibility to achieve required STIPA value if just one wall is adapted.



	0.02	0.10	0.30	0.50	0.70	0.99
STIPA ceiling	0.244	0.295	0.382	0.468	0.520	0.589
STIPA one wall	0.257	0.280	0.331	0.373	0.409	0.463
STIPA two orthogonal walls	0.248	0.290	0.372	0.437	0.492	0.564
STIPA two parallel walls	0.245	0.293	0.372	0.430	0.471	0.522
STIPA three walls	0.239	0.303	0.408	0.483	0.542	0.617
STIPA one wall + ceiling	0.514	0.530	0.562	0.592	0.620	0.661
STIPA two ortho walls + ceiling	0.510	0.535	0.591	0.642	0.689	0.750
STIPA two parallel walls + ceiling	0.508	0.537	0.593	0.632	0.667	0.714
STIPA three walls + ceiling	0.503	0.543	0.620	0.679	0.731	0.794

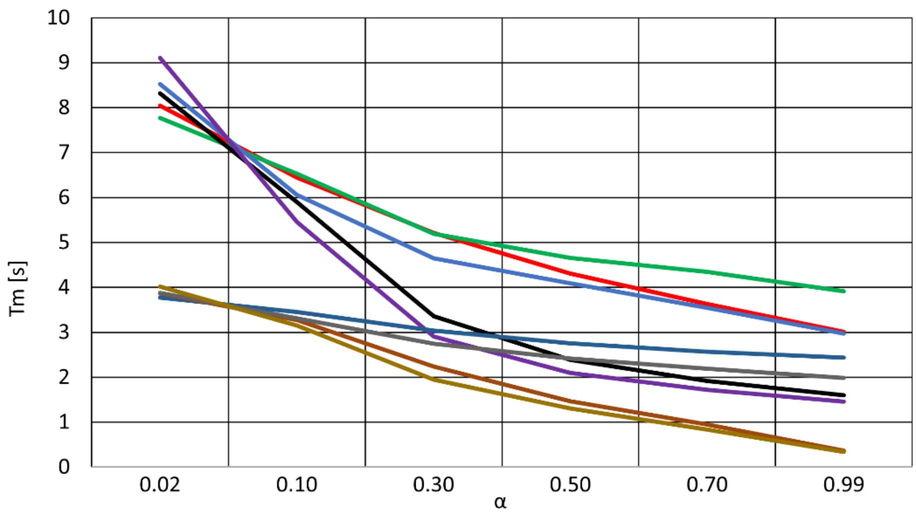
Fig. 12 Speech intelligibility STIPA values in α function - room with a smooth ceiling
Rys. 12. Wskaźnik transmisji mowy STIPA w funkcji α - pomieszczenie z gładkim sufitem

To fulfill criteria $T_m \leq 2.0$ s for exposition galleries 8 m height presented at the “reverberation standard” [5], it is necessary to use one of adaptation combination:

- two orthogonal walls – $\alpha \geq 0.7$,
- three walls – $\alpha \geq 0.7$,
- ceiling $\alpha = 0.7$ + two orthogonal walls – $\alpha \geq 0.5$,
- ceiling $\alpha = 0.7$ + three walls – $\alpha \geq 0.3$,

It shall not be possible to comply with the requirement $T_m \leq 2.0$ s if:

- only the ceiling is adapted,
- only one wall is adapted,
- two parallel walls are adapted,
- the ceiling and one wall are adapted,
- the ceiling and two parallel walls are adapted.



	0.02	0.10	0.30	0.50	0.70	0.99
Tm ceiling	8.04	6.45	5.22	4.31	3.63	3.01
Tm one wall	7.77	6.53	5.19	4.66	4.35	3.92
Tm two orthogonal walls	8.32	5.90	3.36	2.39	1.92	1.60
Tm two parallel walls	8.53	6.06	4.65	4.10	3.55	2.98
Tm three walls	9.11	5.46	2.91	2.10	1.72	1.46
Tm one wall + ceiling	3.78	3.45	3.04	2.76	2.57	2.44
Tm two orth. walls + ceiling	3.87	3.28	2.24	1.47	0.95	0.37
Tm two parallel walls + ceiling	3.88	3.32	2.75	2.42	2.19	1.99
Tm three walls + ceiling	4.02	3.15	1.95	1.31	0.84	0.34

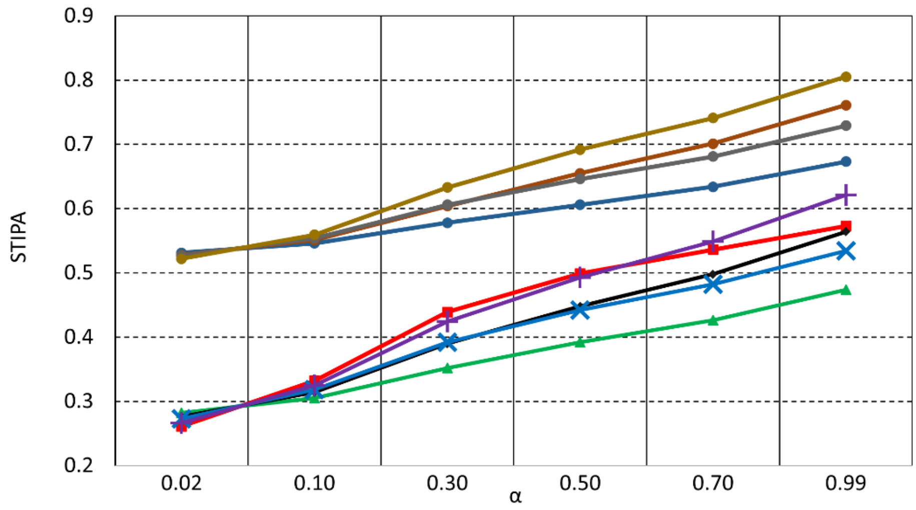
Fig. 13. Reverberation time T_m values in α function - room with a smooth ceiling
Rys. 13. Czas pogłosu T_m w funkcji α - pomieszczenie z gładkim sufitem

8.4.4. Room with exposed bars on the ceiling

In the case of a room with exposed bars on the ceiling, it is possible to achieve the required STIPA ≥ 0.5 value if the following surfaces are adapted with materials with the given absorption coefficient α:

- ceiling – $\alpha \geq 0.7$,
- any combination of two walls – $\alpha \geq 0.99$,
- three walls – $\alpha \geq 0.7$,
- if ceiling $\alpha = 0.7$ there is no need to adopt walls.

There is no possibility to achieve required STIPA value if just one wall is adapted.



STIPA ceiling	0.261	0.332	0.439	0.499	0.536	0.573
STIPA one wall	0.282	0.305	0.352	0.392	0.426	0.474
STIPA two orthogonal walls	0.276	0.314	0.390	0.448	0.498	0.564
STIPA two parallel walls	0.273	0.318	0.392	0.442	0.482	0.534
STIPA three walls	0.266	0.325	0.424	0.493	0.549	0.621
STIPA one wall + ceiling	0.531	0.546	0.578	0.606	0.634	0.673
STIPA two ortho walls + ceiling	0.528	0.551	0.604	0.655	0.701	0.761
STIPA two parallel walls + ceiling	0.527	0.554	0.606	0.646	0.681	0.729
STIPA three walls + ceiling	0.522	0.559	0.633	0.692	0.741	0.805

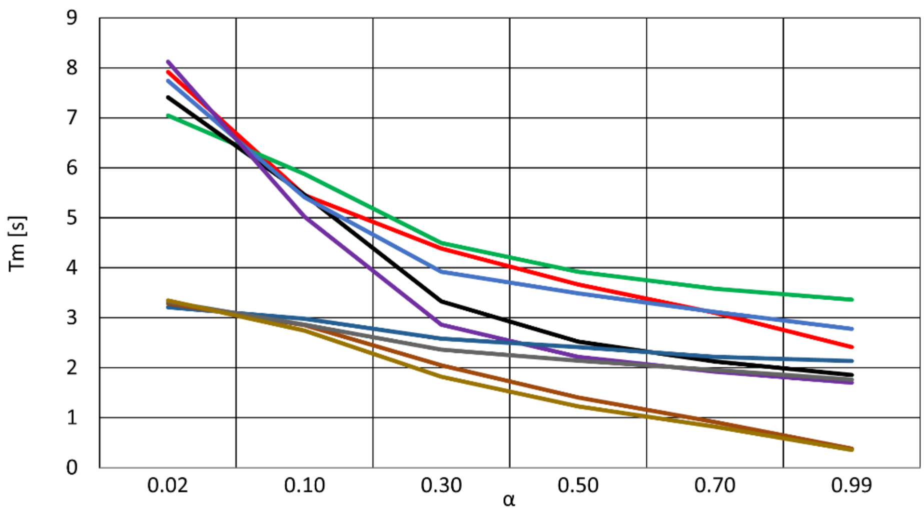
Fig. 14. Speech intelligibility STIPA values in α function - room with exposed bars on the ceiling
Rys. 14. Wskaźnik transmisji mowy STIPA w funkcji α - pomieszczenie z odsłoniętymi podciągami na suficie

To fulfill criteria $T_m \leq 2.0$ s for exposition galleries 10 m height presented at the "reverberation standard" [5], it is necessary to use one of adaptation combination:

- two orthogonal walls – $\alpha \geq 0.99$,
- three walls – $\alpha \geq 0.7$,
- ceiling $\alpha = 0.7$ + two orthogonal walls – $\alpha \geq 0.5$,
- ceiling $\alpha = 0.7$ + two parallel walls – $\alpha \geq 0.7$,
- ceiling $\alpha = 0.7$ + three walls – $\alpha \geq 0.3$.

It shall not be possible to comply with the requirement $T_m \leq 2.0$ s if:

- only the ceiling is adapted,
- only one wall is adapted,
- two parallel walls are adapted,
- the ceiling and one wall are adapted.



Tm ceiling	7.92	5.45	4.39	3.67	3.10	2.42
Tm one wall	7.05	5.88	4.50	3.92	3.59	3.36
Tm two orthogonal walls	7.41	5.46	3.33	2.52	2.13	1.86
Tm two parallel walls	7.74	5.42	3.93	3.49	3.12	2.78
Tm three walls	8.12	5.03	2.87	2.22	1.93	1.70
Tm one wall + ceiling	3.21	2.98	2.59	2.41	2.22	2.14
Tm two ortho walls + ceiling	3.29	2.85	2.05	1.41	0.92	0.38
Tm two parallel walls + ceiling	3.32	2.86	2.37	2.14	1.96	1.76
Tm three walls + ceiling	3.35	2.74	1.82	1.23	0.82	0.36

Fig. 15. Reverberation time T_m values in α function - room with exposed bars on the ceiling
Rys. 15. Czas pogłosu T_m w funkcji α - pomieszczenie z odsłoniętymi podciągami na suficie

8.5. Conclusion

This paper presents the influence of the acoustic adaptation of individual room planes on the obtained values of the STIPA speech intelligibility index and the single number reverberation time T_m. It has been shown that the total lack of absorption in the room prevents the minimum value STIPA $\geq$ 0.5 from meeting the requirements as well as the reverberation time below the limits specified in the PN-B-02151-4:2015-06 so-called "reverberation standard" [5].

The results confirm the well-known principle that in the case of broadcast announcements from a public address system which loudspeakers are located on the ceiling it is necessary to adapt the ceiling acoustically. However, it has been noted that in some situations adaptation of the ceiling itself is not sufficient for both STIPA values and reverberation times.

The analysis of the results also shows that speech intelligibility is clearly more effective by adapting two perpendicular walls to the acoustic performance of two parallel walls. It was also found to be more effective in adapting a ceiling with visible structural beams compared to adapting a flat ceiling, assuming that all ceiling surfaces (vertical and horizontal) are adapted.

The research presented in this article is an introduction to the planned series of publications on speech intelligibility and its examination using objective and subjective methods.

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