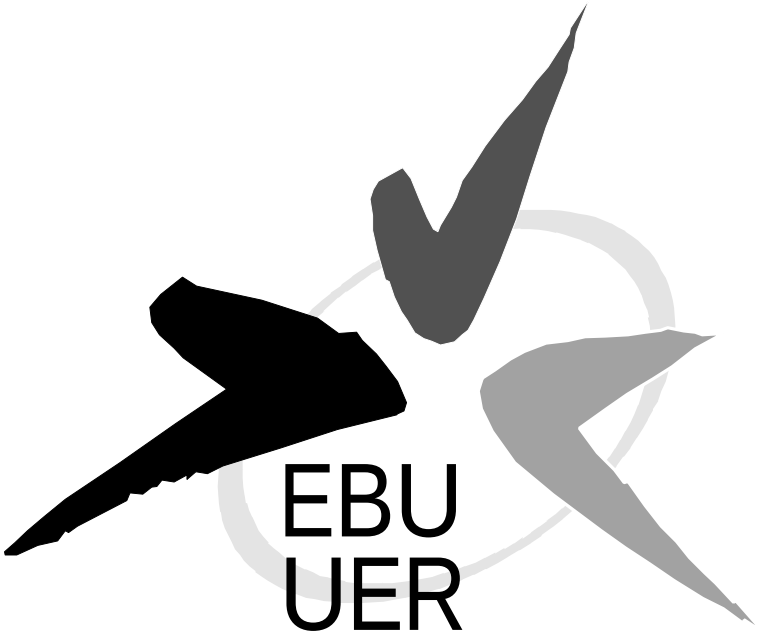
EBU Tech 3276-E

Listening conditions for the assessment of sound programme material

Supplement 1

Revised May 2004

Multichannel sound



european broadcasting union

Geneva

Listening conditions for the assessment of sound programme material: multichannel sound

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Scope

The main part of Technical Document 3276, “Listening conditions for the assessment of sound programme material: monophonic and two-channel stereophonic” [1] does not include any recommendations for sound systems or programme material using more than two channels. The purpose of this supplement is to add requirements which relate specifically to the use of additional channels. In this context, ‘multichannel’ means more reproduction channels than the two used by the well-established, two-channel stereophonic system.

The scope of this supplement is limited to the multichannel sound system described in ITU-R Recommendation BS.775-1 [2] which uses five, full-bandwidth main loudspeakers usually arranged on the perimeter of a circle centred on the main listening position (5.0), with an optional ‘low frequency extension’ channel (5.1). In order to align this document with established Cinema Practice, this “0.1” channel will be described in this document as the Low Frequency Effects (LFE) Channel, which more clearly describes the established function of this channel. In BS.775-1, the code “3/2” (three front channels / two surround channels) is used for this loudspeaker arrangement. In addition, the listening levels in this document are essentially aligned with those in the SMPTE Recommended Practice RP200 [9].

For ease of cross-referencing, this supplement is arranged with the same layout and section headings as the main document, even though in many cases there are no additional or altered requirements.

The recommendations given in this supplement should be taken as additional or alternative to those in the main part of Tech. 3276. For clarity, and in order to make this supplement more readable without a great deal of cross-referencing, some parts of the text of the main part of Technical Document 3276 have been repeated or summarised.

Sound field parameters for listening rooms

1. General considerations

1.1. Loudspeaker listening

The quality of the listening conditions in a listening room is defined by the properties of the sound field produced by the monitor loudspeaker(s) in the listening area (see *Appendix 1*) at the height of the listener(s) ears (about 1.2 m above the floor level).

The main components of the sound field are the direct sound, the early reflections and the later reflections which form the reverberant field. All these components are time and frequency dependent.

Multichannel sound systems are frequently employed in conjunction with presentations of accompanying pictures [2,3,4]. In many cases, it is difficult to reconcile the requirements of the listening and viewing arrangements. Appendix 5 gives some guidance on the potentially conflicting requirements.

1.2. Low-frequency effects channel (LFE)

Many parameters do not apply to the LFE channel, see Appendix 1, Section 3 and Appendix 3, Section 2.8.

2. Acoustic parameters

2.1. Direct sound

No additional or altered requirements.

2.2. Early reflections

No additional or altered requirements.

2.3. Reverberation field

No additional or altered requirements.

2.4. Operational room response curve

The 5.0 multichannel system is based on the use of five identical, full-range, discrete channels. Each of the five channels should satisfy the same response tolerances as for monophonic or two-channel stereophonic listening as specified in the main part of EBU Tech. 3276.

Usually, the same equipment would be used for all five main channels. However, systems using main loudspeakers with reduced bass output may be used in conjunction with one or more separate bass loudspeakers. The effective response of each of the five main loudspeakers should meet the operational room response curve specification. In those cases where the number of separate bass loudspeakers is not the same as the number of main loudspeakers, the matrixing of the low-frequency drive signals must be such as to ensure that appropriate proportions of each main channel signal are taken.

With multiple (i.e. >2) loudspeakers, it is not usually possible to use the same electronic equalisation curve for all channels. The front left and right loudspeakers should be adjusted according to the main part of Tech. Doc. 3276 (as for two-channel stereophony). The equalisation used for centre loudspeaker should be as nearly as possible the same. The equalisation curves used for the two rear loudspeakers should be the same as each other. It is advisable to make the corrections in the low-frequency range ($f < 300$ Hz) only.

It is important that the responses of the three front loudspeakers are closely matched.

2.5. Listening level

The level produced by each of the five main channels separately should be adjusted such that:

$$L_{LISTref} = 96 \text{ dB SPL, referenced to digital FSD signal level.}$$

To achieve this, a signal consisting of noise of equal energy per octave and covering the frequency range from 500 Hz to 2kHz, should be employed. Measurements should actually be made at a mean signal level equal to the alignment level, which is defined here as 18 dB below digital FSD. Under these conditions, the loudspeaker gains should be adjusted to achieve a reference listening level of 96 – 18 = 78 dB Sound Pressure Level (SPL) per loudspeaker. The measurements should be made at the reference listening position (see figure 1 in Appendix 1) using a C weighted slow response sound level meter (SLM) complying with IEC651.

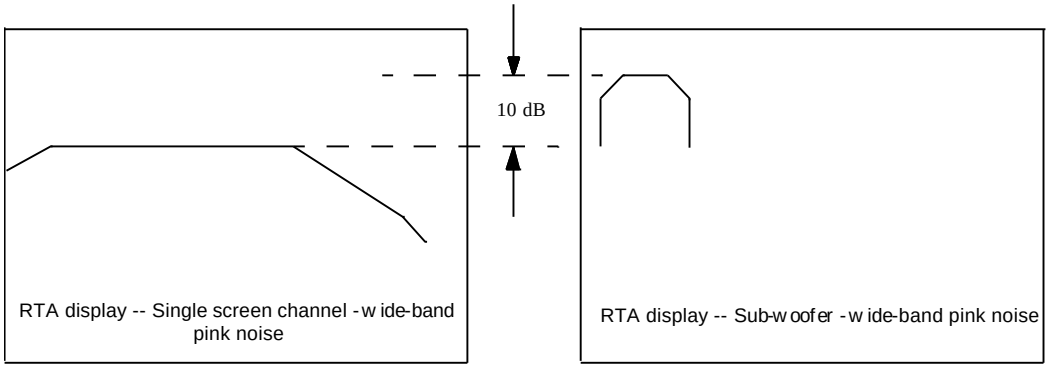
Note 1: This procedure produces a similar reproduction level referenced to alignment level as that defined in the main part of Tech Doc. 3276 for 2.0 reproduction systems.

The difference between the levels of any two channels should not exceed 1 dB.

For multichannel listening, close matching of the three front loudspeakers is especially important. They should be adjusted so that the difference between any two of them is less than 0.5 dB.

2.6 LFE Channel Alignment

The LFE channel should demonstrate 10 dB of reproduced gain when compared to the main reproduction channels. The correct listening level for this channel may be established by using a signal consisting of noise of equal energy per octave and covering the frequency range 20 Hz to 100 Hz, and displaying the resultant sound pressure level on a Real-Time Spectrum Analyser (RTA). A correct alignment is shown diagrammatically in the Figures below:-



The LFE channel may also be aligned to a reproduction level of 106 dB SPL referenced to digital FSD, by using a C weighted SPL meter with a slow response and by using a signal consisting of pink noise covering the frequency range from 50 to 100 Hz.

A problem may arise with the calibration of the LFE channel, if room modes (standing waves) are significant within the listening room. This, to some extent, is mitigated by the use of band limited noise, rather than tones, but in serious cases it may be necessary to obtain an estimate of the average SPL as the sound level meter is moved around in the vicinity of the reference listening position. The amount of movement relative to the reference listening position is dependent on the size of the listening area, but for a loudspeaker baseline of 4m a variation of +/- 0.5 m movement of the SLM should be sufficient.

2.7. Background noise

No additional or altered requirements.

Appendix 1

Multichannel loudspeaker listening: positioning of sound sources and listeners.

1. General

The general requirements for the layout of the listening arrangement, for loudspeaker height, for inclination and locations relative to room boundaries, for the location of the listening positions relative to room boundaries and for inter-channel time delays are the same as for monophonic and two-channel stereophonic sound, as defined in the main part of Tech. Doc. 3276.

For multichannel listening, the requirements for height and maximum inclination angle apply to all five main loudspeakers.

2. Multichannel listening arrangement

For multichannel listening, the five loudspeakers should be arranged according to the layout given in Fig. 1. (See ITU-R Recommendation BS:775-1 [2].)

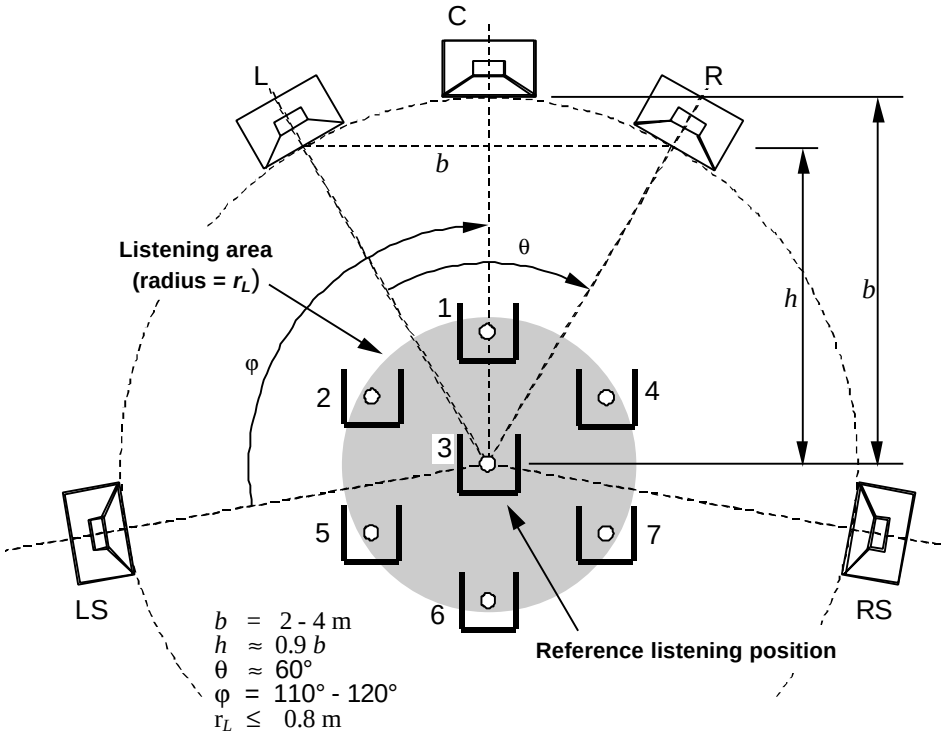


Fig. 1 Typical layout of five channel listening arrangement

The main loudspeakers should be located symmetrically with respect to the line from reference listening position to centre front loudspeaker.

For multichannel listening, front-back balance is more important and left-right balance less important because the centre front loudspeaker tends to stabilise frontal images. A multichannel seating arrangement would therefore tend to be wider (left-right) and shallower (front-back) than a similar one for two-channel stereophony.

If the loudspeakers cannot be located on the reference circle, for example the centre-front because of a viewing screen, electronic delays should be used to compensate for the different acoustic path lengths.

Note 1 - The same physical loudspeaker layout can also be used for 3/1 (mono surround signal split between rear speakers), 3/0, 2/0 (conventional two-channel stereophonic) and 1/0 (monophonic) listening.

3. Separate bass loudspeakers

Where there is no LFE channel or where the loudspeakers for the LFE and main channels are separate, the general requirements for the separate bass loudspeakers are the same as for monophonic and two-channel stereophonic sound, as defined in the main part of Tech. Doc. 3276. Additional requirements for multichannel listening are given in Section 2.4 of the main part of this supplement.

The performance requirements for the subwoofer and separate bass loudspeakers differ. Separate bass loudspeakers must extend the (restricted) main channel loudspeaker responses in order to provide correct responses over the full spectrum. They must match the main loudspeakers in sound quality and sound level capability. They must have a complementary frequency response, low distortion and a relatively steep transition from pass to stop bands, using high-order filters. The crossover frequency may be in the range 80 - 160 Hz, depending on the physical location of the separate bass loudspeakers.

In contrast, the subwoofer may have a frequency response range from 20 to 120 Hz and a maximum output level capability +10 dB higher than the main loudspeakers. They need not necessarily produce such low output distortion nor have especially steep crossover responses.

Where an LFE channel and the bass frequencies of the main channels are combined for reproduction into one set of loudspeakers[1], those loudspeakers must satisfy both sets of requirements simultaneously. These two sets of requirements may be in conflict. For example, a single subwoofer, with a combined frequency range up to 120 Hz, could not be located very far from the main loudspeakers before being perceived as a spatially disconnected source. That might be acceptable for the LFE signal but would not be acceptable for a main channel. Fig. 2 shows the derivation of the loudspeaker input signal [5].

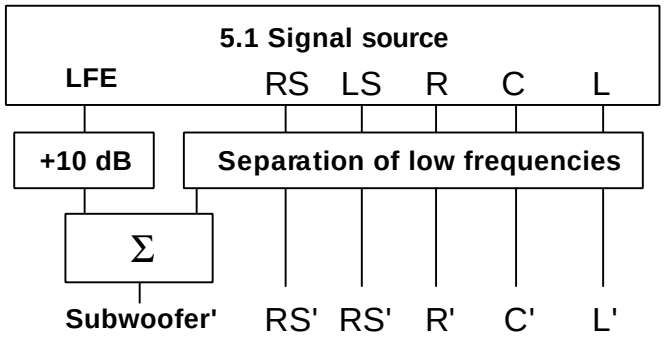


Fig. 2. Derivation of combined subwoofer and LFE signal.

In those cases where a subwoofer is not used, it is recommended that the LFE channel signal is **not** added to the main channels unless it is known that the main loudspeakers can accommodate the additional, potentially large low-frequency excursions without compromising the sound quality of the main channels.

[1] This process is commonly referred to as “bass management”

Appendix 2

Design of listening rooms and sound control rooms

1. General

No additional or altered requirements.

2. Listening room dimensions

No additional or altered requirements.

3. Other design considerations

No additional or altered requirements.

Appendix 3

Reference monitor loudspeakers

1. Terms and definitions

No additional or altered requirements.

2. Technical requirements

2.1. General

No additional or altered requirements.

2.2. Frequency response

No additional or altered requirements.

2.3. Directional characteristics

2.3.1. Polar patterns

No additional or altered requirements.

2.3.2. Directivity index

No additional or altered requirements.

2.4. Distortion

No additional or altered requirements.

2.5. Decay time

No additional or altered requirements.

2.6. Time delay

No additional or altered requirements.

2.7. Dynamic range

2.7.1. Maximum operational sound pressure level

No additional or altered requirements.

2.7.2. Self-generated noise level

No additional or altered requirements.

2.8. Separate low-frequency loudspeakers.

There may be conflicting requirements when the low-frequency loudspeakers are used both as separate bass components of the main loudspeakers and for the Low Frequency Effects Channel. See Appendix 1, Section 3.

Appendix 4

Listening arrangements with accompanying pictures

The addition of controlled viewing requirements to a listening arrangement may cause conflicts between the two sets of requirements. If nothing else, it will severely limit the range of acceptable screen sizes. The viewing screen may also be located either directly on the line between the left and right loudspeakers or somewhat behind. Only rarely, in broadcasting, will it be acceptable to locate the viewing screen nearer to the listening area than the line between the loudspeakers or much further away than the edge of the circle of loudspeakers[2].

The presence of the viewing screen also causes difficulties for the location of the centre loudspeaker. The height of the screen almost always makes it impossible to meet the height and inclination requirements for the loudspeaker. Screens which are 'acoustically transparent' would allow the loudspeaker to be placed in the correct location behind the screen. However, such screens generally cause some alteration of the sound quality, both by attenuation of the direct sound and by causing reflections and standing waves in the space between the rear face of the screen and the front face of the loudspeaker. Sometimes two centre loudspeakers are used, driven in-phase, with one above and one below the screen. This arrangement can cause severe response irregularities for listening positions that are not on the horizontal axis of symmetry.

The actual size of the viewing screen is a function of several factors involved – the base width of the listening arrangement, the size of the screen, the aspect ratio of the picture and the recommended viewing distances for the picture. Some of the possibilities are shown in Table 1, for the reference listening/viewing position. For other possible listening/viewing positions, the requirements would be modified by the different distances, making it more difficult to find acceptable locations for several listeners/viewers.

Table 1. Relationship between some viewing and listening arrangement parameters

	Viewing distance = b*					**Viewing distance = h***				
Screen aspect ratio [6,7,8]	**16:9 (Widescreen or HDTV)**			**4:3**		**16:9 (Widescreen or HDTV)**			**4:3**	
Viewing distance as a multiple of screen height	3**	4	6	4	6	3**	4	6	4	6
Screen width as fraction of base width, b	0.59	0.44	0.30	0.33	0.22	0.51	0.38	0.26	0.29	0.19
Screen width, metres* **	1.19	0.89	0.59	0.67	0.44	1.03	0.77	0.51	0.58	0.38
Screen diagonal, inches* **	54	40	27	33	22	46	35	23	28	19

* *b* and *h* refer to Fig. 3.
** Recommended for HDTV in ITU-R Recommendation BT.710-3 [6]
*** based on a listening circle of 2 m radius.

[2] In film production, the screen may be very large and distant, but the loudspeaker arrangement will also be large and, in general, not meet the other requirements for a reference listening room. For additional information see ITU-R Recommendation BS.1286 [4].

All of these examples can be accommodated in the space available, though many of the screen sizes required are large and can only be satisfied (with the present state of display technology) by projection systems. Some of the possibilities are illustrated in Fig. 3.

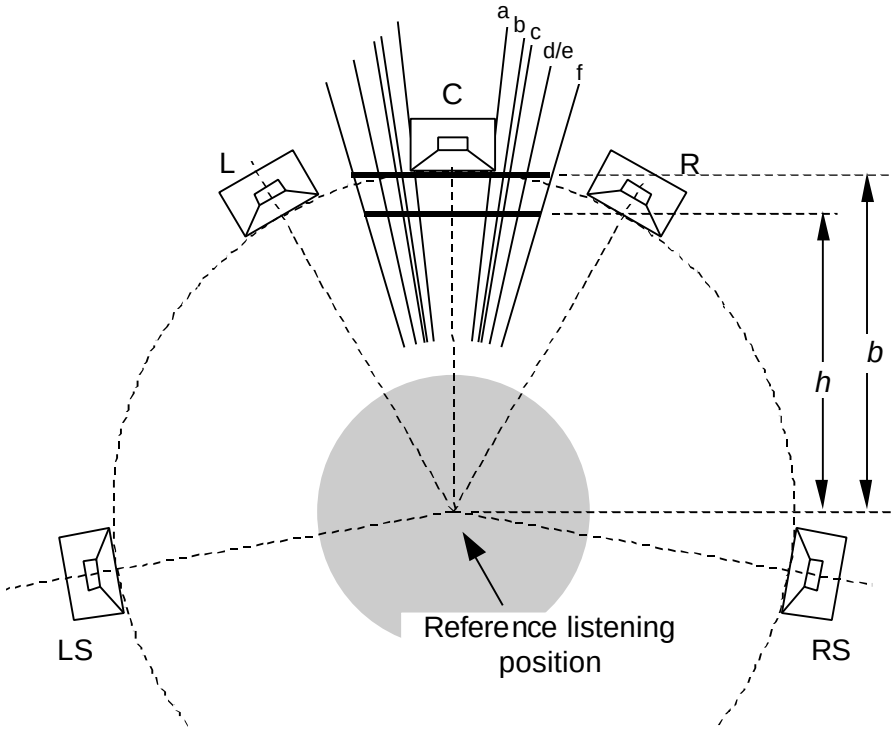


Fig. 3. Viewing angles for different television systems.

Key to angle notation of Fig. 3.

Code	Television standard	Television aspect ratio	Viewing distance	Viewing angle
a	SDTV	4:3	6H	13
b	SD widescreen	16:9	6H	17
c	SDTV	4:3	4H	19
d	SD widescreen	16:9	4H	25
e	HDTV	16:9	4H	25
f	HDTV	16:9	3H	33

Bibliography

[1] **EBU Tech 3276 (2nd Edition) :** *Listening conditions for the assessment of sound programme material : monophonic and two-channel stereophonic*

[2] **ITU-R Recommendation BS.775-1:** *Multichannel sound systems with and without accompanying picture.*

[3] **ITU-R Recommendation BS.1116-1:** *Methods for the subjective assessment of small impairments in audio systems including multichannel systems*

[4] **ITU-R Recommendation BS.1286:** *Methods for the subjective assessment of audio systems with accompanying picture*

[5] **Empfehlung für die Praxis SSF-01: Surround Sound Forum (VDT) 10/98** *Hörbedingungen und Wiedergabeanordnungen für Mehrkanal-Stereofonie.*

[6] **ITU-R Recommendation BT.710-3:** *Subjective assessment for image quality in high-definition television*

[7] **ITU-R Recommendation BT.811-1:** *Subjective assessment of enhanced PAL and SECAM systems*

[8] **ITU-R Recommendation BT.1128-2:** *Subjective assessment of conventional television systems*

[9] **SMPTE, RP 200:** *Relative and Absolute Sound Pressure Levels for Motion-Picture Multichannel Sound Systems.*