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INSTALLATION OF PUBLIC ADDRESS SYSTEMS AT PASSENGER STATIONS

1. Introduction

The object of the present leaflet is to formulate considerations of a general nature concerning the benefits which can be derived from public address systems at stations and, in addition, to establish general directives concerning the overall characteristics specified for such installations, with a view to achieving a basic qualitative standard valid for all countries.

Recommendations concerning the various component parts of these installations (microphones, amplifiers and loudspeakers) and the manner in which these are satisfactorily matched together, are only given insofar as they are necessary or desirable for the purposes of obtaining the overall characteristics mentioned above.

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2. Purpose of a public address installation

The primary purpose of a station loudspeaker system is as follows :

- to broadcast public announcements concerning the running of trains, or messages of a personal nature ;
- to convey service messages to staff.

The installation can also be used for other purposes, particularly for reproducing music.

3. Considerations of a general nature affecting public address installations

3.1 Nature of the problem which arises

The first concern is to ensure that announcements are reproduced by the system in a satisfactory and intelligible manner under the interior acoustic conditions obtaining at stations. Spoken announcements generally require to be diffused over areas where the reverberation time is rather lengthy (covered platforms, station concourses) and where the high noise level is subject to considerable variations (trains and passengers). Due allowance must also be made for reverberation and noise inside the announcer's cabin, since these factors can be introduced via the microphone and influence the quality of the sound transmitted. Since reverberation and noise both detract from speech intelligibility, they must be reduced as far as possible by applying suitable acoustic measures both inside the announcer's cabin and in the area covered by the loudspeakers. The public address equipment should be designed to be as insensitive as possible to these sources of interference.

3.2 Acoustic measures applicable to buildings

The noise on station platforms comes mostly from trains, railway service vehicles (luggage trolleys) and postal vehicles, and from crowds.

Train noise depends to a large extent on the nature and quality of the rolling stock. There are, for example, service regulations

against allowing steam or air to escape in stations, and routings are carefully considered with a view to fast trains bypassing the stations, thus contributing to an appreciable reduction in noise production.

By ensuring that the method of laying track at stations gives a shock-absorbing effect, and by fitting the walls of raised platforms with soundproof linings (porous concrete, for example), a definite reduction in the noise produced by wheels and brakes is obtained.

In order to reduce the noise of service vehicles, it is possible to deaden the motors, select carefully the kind of tyres, and finally, to give suitable instructions to driving staff.

It does not suffice merely to reduce the sources of noise, and construction should be carried out in such a way as to localise and deaden the noise produced ; this can be done by using soundproof materials. These measures should be aimed particularly at low frequency noises, which contain most of the energy and determine the sound intensity of the noise. The low tones are absorbed by slits arranged in the platform roofs, and by using slit-type absorption devices, perforated acoustic plates and resonance boards. It should be noted that these devices usually have a hard surface, and they can therefore be easily cleaned. In order to absorb higher frequency noises, the walls (if possible high enough to be out of reach) and ceilings are covered with porous acoustic materials, which lose only a small part of their absorbing power when covered with perforated plates. The aesthetic aspect hardly suffers therefore, and cleaning can be achieved without difficulty. The porous materials absorb a very large part of the low tones if they are some distance away from the hard wall ; it is therefore preferable to position them in this way. In addition, the noise absorption is helped with a reduction in the reverberation time if the awnings are made no higher than necessary.

What has been said above concerning platforms also applies to station concourses, waiting rooms, buffets, stairs and subways. Premises should not have ceilings which are too high, and it is particularly advisable for the ceiling to be of a noise-absorbing nature. A short reverberation time in stations limits not only the noise level of the trains, but also that emanating from the public. The psychological effect plays an important part, since experience

shews that in spaces where the reverberation time is long, people tend to speak louder, thus creating noisy conditions; when the reverberation time is short, on the other hand, conversation tends to be quieter. A reduction in reverberation time therefore has a twofold advantage on noise emanating from the public; not only does its level become less, as a direct result of absorption, but the noise production itself also decreases.

The acoustical comfort afforded to passengers as a result of these constructional measures itself produces a twofold improvement in the quality of loudspeaker announcements. Intelligibility is less affected by reverberation, also the transmission has a lower noise level to overcome and is thus of better quality, since the sound level required is less.

Noise and reverberation inside the announcer's cabin can adversely affect the intelligibility of the reproduction to a great extent. These parasitic noises are picked up by the microphone and reproduced by the loudspeakers. By virtue of the ability to orientate one's hearing, a person is able to concentrate on an announcement emanating from a given direction, by creating a kind of psychological screen against noises occurring around him or coming from other directions; conversely, a person is not able to isolate himself from parasitic noises transmitted by the loudspeaker itself and originating in the announcer's cabin: for this reason these noises are much more unpleasant to the ear of the listener than those originating around him.

In view of this it is necessary to place the announcer's microphone in a quiet place with good acoustic absorption; it is even recommended that an insulated cabin should be provided.

Failing this, if the announcements are to be made in a place occupied by several persons undertaking various types of work, it is necessary to install a protective screen against parasitic noise (telephonic screen). If the official responsible for announcements is obliged to move for other requirements, this measure is also impractical and the last resort is then to fit the loudspeaker equipment with a suitable device (see section II).

3.3 Overall frequency characteristic for spoken announcements

If the principal object is to transmit speech, a flat characteristic should be avoided, for the following reasons :

- the voice intensity is determined in most cases by low-pitched sounds of less than 1000Hz, while the intelligibility of the words is determined by high-pitched sounds of more than 1000Hz. It is this latter range which contains the characteristic harmonic groups of certain phonemes, such groups being known as "formants" ;

- in the announcing room, as in the loudspeaker area, the reverberation takes its sound level particularly from low frequency components. The reverberation, which degrades the transmission quality, will therefore be mainly due to the reproduction of low-pitched sounds ;

- in the announcing room, as in the loudspeaker area, the noise possesses a characteristic spectrum, the energy distribution of which generally decreases by at least 9dB per octave with increase of frequency. In addition, the noises extend their masking effect over a wide frequency band in the high frequency direction, but not in the direction of the low frequencies of their own frequency band.

For the announcements to be clearly understood, it is essential for the high frequency voice sounds to be more than 6 to 10 dB above the parasitic noise level in the same frequency band. However, in view of the low degree of intelligibility of low pitched voice sounds, there is no purpose in dominating the noise level in their frequency range, since this would lead to a needlessly loud and unpleasant transmission : further, low pitched voice sounds, reproduced strongly and strengthened further by reverberation, would run the risk of masking the high pitched sounds and of jeopardising the intelligibility of the announcement ;

the reproduction of the speech must generally be stronger than ordinary conversation. A flat frequency characteristic would result in a particularly intense physiological perception of low pitched sounds, and the voice reproduction would appear unnatural.

For all these reasons, it is therefore necessary to attenuate the low frequencies and to amplify the high frequencies to achieve the clearest reproduction possible. It goes without saying that the optimum form of the overall frequency characteristic depends on the reverberation, the noise level and the sound intensity of the transmission.

The frequency characteristic represented in figure 1 can serve as a model for the overall characteristics to be adopted so as to obtain a reproduction that is intelligible and sounds natural under the average acoustic conditions obtaining at stations.

This frequency characteristic gives a transmission band of 250 to 7000Hz, outside of which, it falls, while within it, it has a rising characteristic with increase of frequency. The object of this characteristic is especially to attenuate the frequency band between 250 and 630Hz which, while contributing only very little to intelligibility, contains a large part of the voice power and thus produces reverberation phenomena in the loudspeakers area.

This characteristic is the sum of the characteristics of the microphone, the amplifier and the loudspeakers.

In practice, it is difficult to measure this overall characteristic. It is nevertheless necessary to select the components of the installation (microphone, amplifier and loudspeakers) in such a way as to conform to the overall desired characteristic, and to obtain possibly, by adjustments made during operation, an optimum intelligibility.

3.4 Overall frequency characteristic for music

Generally speaking, only "background music" will be broadcast, particularly in waiting rooms and buffets, by retransmission of radio broadcasts or by use of magnetic tape recordings or records. The sound level will generally be quite low, and preference will be for a type of music of a non-dynamic nature. The overall frequency characteristic of music broadcasts will be preferably flat and will extend over a frequency field from 100 to 10 000Hz.

3.5. Installations for the speech and music

What has been said in the two preceding paragraphs implies that the overall frequency characteristics recommended for speech and for music differ appreciably; similarly the optimum sound level will not be the same for the two kinds of broadcast. If, in a given space, the loudspeakers (the terminal amplifiers and the loudspeakers respectively) broadcast both speech and music, it is necessary to give to these components a flat frequency characteristic within the band from 100 to 10 000Hz. With such an arrangement, speech enters by an input channel with the desired frequency characteristic, while the music enters by another channel with a volume control and sometimes even a tone control, so that the staff can regulate the music without affecting the speech channel.

3.6. Sound level of the reproduction

In order to obtain a satisfactory quality of announcements, it is necessary for the voice, in its own frequency range which is essential for intelligibility of speech, to have a sound level at least 6 dB higher than the noise level. This difference can be increased according to the type of noise existing in the places served by loudspeakers. In addition, announcements should not be broadcast with an unnecessarily high sound intensity, in view of the fact that too noisy a broadcast produces an unpleasant sensation and can even disturb the neighbourhood.

For intelligibility of the speech, it is also necessary for the sound level of the reproduction to be independent of the voice strength of the announcer and of his distance from the microphone. To this end, the amplifier should be fitted with a sound level stabilising device (see §5) ; in addition, the sounds broadcast by the announcer can be reproduced at his own ear (see §4).

In certain cases, it is possible to adapt the sound level to the needs of the moment by means of a programmed adjustment which increases the sound intensity at peak hours and reduces it during the night (and cuts out groups of loudspeakers which are unnecessary).

Instantaneous adjustment is obtained by enabling the announcer to choose between several sound levels (three for example), in accordance with an acoustic or visual indication of the noise level. In this way, it is possible to avoid broadcasting announcements when the noise level is extremely high, e.g. while a shunting locomotive is passing through.

This instantaneous adaptation of the sound level to the noise level can also be obtained by an automatic adjustment (see §5).

As regards the calculation of the amplifier power, a figure of 84dB can be taken as a standard for the maximum sound intensity of the reproduction where the public is situated.

4. Microphone

Arrangement and operation of the microphone in the announcing room

It is recommended that the microphone should be placed in an announcing room insulated from surrounding noise and with a reverberation time as low as 0.75 second, procured by means of walls lined with soundproofing materials. If the room is occupied by several persons, it is necessary to make use of an insulated cabin or to install a noise-resistant screen.

A speech microphone with unidirectional sensitivity, with a frequency characteristic at 0° possessing a transmission band of 250 to 7000Hz should be used; outside the characteristic could be less, while within it an ascending tendency of between 250 and 1600Hz approximately would be advantageous in the case of the application concerned. The directional characteristic would be a cardioid or a hypercardioid; in the frequency zone of the strongest spoken word and noise level (250 to 1000Hz) and for one or more directions within an angle of 180° $\pm$ 60°, the sensitivity is less by at least 12 dB than that found at 0°. The microphone would then compress the surrounding noises and echoes from 4 to 5 dB.

The microphone should be fixed to its support so that the mouth of the announcer is about 30cm distant when in his normal working position. When speaking normally, he should produce a sound level of 75 dB level in front of the microphone, which can even reach 84 dB for certain syllables; this is equivalent to an acoustic pressure of 1 and 3 microbars.

A microphone of normal sensitivity (0,2 mV/microbar for an impedance of 500 Ohm) will give an average output voltage of from 0,2 mV to 0,6 mV when the words are pronounced with a strong tonic accent, provided that at 0° the frequency characteristic is normally flat. The more suited for speech is the characteristic of the microphone (attenuating the voice in the frequency range where it possesses its maximum power, without however interfering with the intelligibility of the speech), the weaker the output voltage will become, decreasing to about a half.

If a high noise level is unavoidable in the announcing room, and if the microphone cannot be insulated, a special noise-cancelling microphone must be used.

A microphone of this type has a normal voice characteristic for speech emanating from the preferential direction and pronounced at a given point nearby. Its sensitivity is less for noise coming from a distance in a diffused manner, due to the directional effect; in the case of low sounds, the sensitivity is still weaker due to the correction factor acting on words spoken a short distance away.

The speech to noise ratio of the output voltage of the microphone is considerably improved as a result of the much higher sound level of sounds produced in the immediate vicinity of the microphone, but also, above all, due to the fact that low frequency noises, which contain the most energy, are particularly reduced.

The output voltage of the noise-cancelling microphone will be about 20 dB higher than that of an ordinary voice microphone where the announcer is 30cm away. Slight variations in this small distance will produce appreciable variations in the output voltage of the microphone. In addition, a speaker surrounded by noise will have a tendency to raise his voice in order to be able to hear himself; it follows that the voice level and the output voltage of the microphone will also vary in relation to the noise level in the announcing room.

In order to avoid unwanted variations of the transmission intensity, it is recommended that noise-cancelling microphones should be installed in a telephone handset which is connected to the output voltage of the installation and enables the announcer to hear himself also. This gives two advantages ; first, variations in the distance between the microphone and the mouth of the announcer are reduced;

further, the latter adjusts his voice according to the sound which is returned to him, and can therefore speak in a level voice, independent of the noise surrounding him.

To prevent accidental broadcasting, it is recommended that a push button should be provided which must be pressed to bring the equipment into operation for the whole broadcasting period. If it is possible to broadcast different types of messages (messages to the public, service messages, messages intended for a given platform and for the corresponding premises), a button may be provided for each of these cases. In order to create certain combinations not planned beforehand, it is necessary to arrange the switches on a preselection panel, a single spring button being provided to keep the circuit switched-in during the call. If a telephone handset is used, the button should preferably be on the latter itself.

In addition, the announcer should be provided with an indication as to the functional condition of the equipment (signal lighting up when switching on, hearing of his own speech by the user of a telephone receiver). A visual indication of the output level will make it possible to check whether the voice intensity is sufficient (ordinary voltage indicator, or small neon lamps connected to the output circuit and only lighting up when a certain level is reached).

This type of device can indicate simultaneously whether all the selected sections are functioning properly (small fluorescent tubes connected to the various outputs).

As the circuit connecting the microphone to the preamplifier may be very long, it is necessary to select low impedance microphones. The optimum value is between 50 Ohm and 500 Ohm; it should be noted in this connection that the standardised impedances in Europe are 50, 200 and 500 Ohm. If transistorised amplifiers are used, an impedance of 500 Ohm is preferable.

5. Amplifiers

5.1. General

Since the amplifying equipment is connected to the mains, it may involve risk of fire, and contact with it may be dangerous. Equipment should therefore conform to the international regulations contained in Publication No. 65 of the I.E.C., and, where applicable, with the national regulations concerned. The equipment should function reliably under varying climatic conditions. Care should be taken to see that it is not situated in the open air or exposed to intense direct radiation from the sun. The equipment should satisfy the following tests laid down in I.E.C. Publication No. 68 :

Test A : Cold severity VII (-10°C)

Test C : Long duration humid heat test.
Severity V (temperature 40 ± 2°C, relative humidity 90-95%, duration 21 days).

In order to make it rapidly repairable, the installation should consist of easily interchangeable parts, with testing being reduced to a strict minimum.

It is preferable to select a central position rather than split the equipment up into several groups.

Safety of operation

Safety of operation should be covered by guarantee. Normally, a year's guarantee against manufacturing defects should be given by the manufacturers.

Parts which normally wear more quickly should be mentioned as such in the guarantee conditions. Defects should be traceable quickly and not react adversely on the rest of the equipment.

5.2. Controls

The controls must be simple to operate. They should be arranged

clearly and bear an indication of their function. Manual control should only be possible in the case of controls necessary for current working of the equipment; these are, for example :

a) the selector switches for the various sound sources (microphones, recordings), which should consist preferably of a spring push-button clearly marked for each sound source; a pilot lamp indicates whether the switch has operated properly :

b) if it is necessary to provide an adjustment for the music channel it is preferable to use a sliding control.

Other regulating controls which are used solely for readjustment or maintenance, should not be easily thrown out of adjustment and it should not be possible to operate them except by means of instruments. Examples are the volume control for the microphone channels, the controls of amplifiers and acoustic filters.

5.3. Output

Non-linear distortion for the nominal output power need not satisfy strict requirements, since intelligibility of speech does not suffer from a low percentage of distortion.

- A maximum distortion of 5% between 250 and 5000Hz (for speech) or between 100 and 5000Hz (for music) is acceptable.

The internal resistance of the amplifier should be sufficiently low (a maximum of 25% of the load resistance measured at 1000Hz), for it to be considered as a constant voltage source. The loudspeakers can then be connected or disconnected at will, without the output level suffering any noticeable change. It will then be preferable to arrange a series of output voltages, rather than a series of compensating resistors. In order to determine the ratio between two consecutive voltages of this series it will be preferable to use an energy difference of 3dB, which is just audible, and corresponds to a factor 2 in power and $\sqrt{2}$ in voltage. Taking a maximum voltage of 100 volts, this series becomes :

100 V - 70 V - 50 V - 33 V - 25 V

In this series a value of 100V is recommended. Voltages less than 25V give rise to line losses of too great a magnitude.

5.4. Input

The input sensitivity (i.e. the input voltage necessary for the maximum output voltage) should correspond to the voltage supplied by the sound source. In accordance with the information given in Section 4 the sensitivity measured at 1000 Hz should be :

- 0.6 mV for an ordinary microphone
- 0.3 mV for a voice characteristic microphone
- 3 mV for a noise-cancelling microphone.

If the above values are exceeded, the distortion value given in 5.3 should be respected in any case.

The input sensitivity of recordings (intended, where applicable, for recorded announcements on tape or music) will have the usual value of 100 mV.

5.5. Frequency characteristics

The frequency characteristic for speech should be adapted to the microphone used. If the microphone itself possesses a voice characteristic, the frequency characteristic of the amplifiers should be flat (within ± 3dB) between 250 and 10 000 Hz. Where an ordinary microphone is used, the amplifier should have, between these two limiting frequencies, the voice characteristic indicated in Section 4, unless the loudspeakers already give it (see § 6.3.).

To ensure good musical reproduction, the recording channel should have a flat frequency characteristic (within ± 3dB) between 100 and 10 000 Hz. The frequency characteristic is measured at a voltage equivalent to 50% of the nominal output voltage, to avoid overloading the amplifiers.

5.6. Acoustic filters

If they are necessary for the microphone channel (see 5.5) these filters are adjusted once only when the equipment is installed.

In order to correct the characteristics of recording and of reproduction of the sound in the record channel, they should be continuously adjustable.

5.7. Noise level

While the background noise level of the amplifier (noise in the absence of speech or music) is less than the ambiant noise, it remains unnoticed. The sound level of the announcements will be about 85 dB, while the ambiant noise will never fall below 35 dB, even at quiet stations. The background noise level of the amplifier may therefore be stipulated as being at least 50 dB below the nominal power.

This level shall be measured according to the "weighting curve A" of I.E.C. Publication No. 123 (ear sensitivity curve with regard to low-frequency sounds).

5.8. Limitation of and precautions against overloading

The signals picked up by the microphone vary in intensity depending on the strength of the announcer's voice and his distance from the microphone. Conversely, the sound level of the loudspeakers on the platforms must be constant in order to ensure satisfactory intelligibility of the speech despite ambiant noise.

In order to satisfy this requirement, a limiting device can be installed in the amplifiers, which converts the large variations in input level into much lesser variations of the output level. The ratio between the two variations in level, when it becomes too considerable, gives rise to a heavy increase in noise around the microphone and in the input noise between announcements. Experience has shewn that good regulation is obtained if limitation commences when the input voltage reaches 30 to 50% of the nominal value and if it tolerates an increase in the input voltage of 26 to 30 dB (with this maximum input voltage, the nominal output voltage is attained).

The device should react quickly when an announcer begins to speak, and the adjustment time should be 10 msec. at the most.

In the reverse direction, the change should be much slower, in order to prevent amplification coming into effect during pauses for breath by the announcer and bringing about the unpleasant sound of breath intake. 2 seconds is an acceptable figure.

Normalisation time after an excessive overload should not exceed 0.5 second.

5.9. Adjustment of the level of the required sound in relation to the noise level

The output power of the installation should be such that the announcements remain intelligible even in very noisy conditions; as a result, under quiet conditions, the loudspeakers may have an unnecessarily high sound intensity. To avoid this, it is necessary to have recourse to some means of adjustment which adapts the sound level of the announcements to the surrounding noise and reduces it to a level which is tolerable during periods of quietness. A range of adjustment of 20 dB has proved adequate. Since the device should not react to bangs and sudden noises, and the reverberation time of the building can also influence the adjustment, a regulation time of 0.5 to 10 seconds can be laid down.

5.10. Supply

The installation must be suitable for supply at mains voltage and frequency. Variations in mains voltage up to 10% should not interfere with operation or affect the safety aspect of the equipment.

If an uninterrupted supply from the mains cannot be guaranteed, it is recommended that an emergency supply should be provided, in the form of a battery of accumulators, preferably with a nominal voltage of 24 V (in view of the increasing use of transistorised equipment).

6. Loudspeakers and their siting

6.1. Loudspeakers intended for announcements

The fundamental problem consists of finding a ratio between "direct sound" and "reverberated sound" which produces satisfactory intelligibility. "Direct sound" refers not only to sound reaching the listener by the shortest route from the nearest loudspeaker, but also sound from more distant loudspeakers and sounds reflected by the walls, if they reach the listener less than 1/20th of a second after the first sound received. Together, these sounds contribute in a practical manner to transmitted speech, as opposed to resonance and reflected noises arriving after 1/20th of a second. The sections of the walls near the listener, the floor, also low ceilings, while contributing usefully to the transmission of the sound, produce a simultaneous harmful effect,due to the fact that they produce diffused sound and therefore reverberation; high ceilings have an almost exclusively harmful effect because of sounds reflected from them with too much delay and reverberation.

While the noise level is of secondary importance with regard to the siting of the loudspeakers, it has an appreciable effect on the determination of the necessary acoustic power and the load per loudspeaker.

In principle, the desired objective can be attained either by placing a large number of small loudspeakers in the immediate proximity of the listeners, or by the use of a smaller number of loudspeakers beaming the sound towards the public.

In the case of numerous small loudspeakers of relatively low power, the desired sound reaches the listener from the nearest loudspeaker and from certain others situated nearby; conversely, the most distant loudspeakers transmit reverberating sounds accompanying the reverberation produced by all the loudspeakers at once. If this arrangement is adopted in a space with a short reverberation time, the desired objective is fully achieved. It lends itself particularly to premises with a low ceiling absorbing the noise: placing of the loudspeakers in this ceiling itself is usually a satisfactory architectural solution. It is ideal for waiting rooms, buffets, subways and platforms with an open awning, provided that the ceiling is not too high and that it absorbs the sound well. It gives a very even sound level throughout the premises.

In premises with a long reverberation time, the above arrangement would be unsatisfactory, since the distance between adjacent loudspeakers would be too small. It is recommended that directional loudspeakers (horn or column loudspeakers) directed towards the public should be used in this case.

Since the sound waves are concentrated into a beam, the latter contains quite a high sound intensity (direct sound), although the corresponding acoustic power is relatively weak. This total acoustic power is responsible for the reverberation which is created when the directed sound encounters an obstacle and is transformed into diffused reverberating sounds. The more the waves form a pronounced beam, the longer will be the distance over which the direct sounds exceed the reverberating sounds within the beam; a smaller number of loudspeakers will therefore suffice for a given distance.

In this connection, it is important to appreciate that in order to provide a loudspeaker system over a certain area, the angular aperture can be reduced (with a more concentrated beam and a weaker reverberation production) the more horizontal the direction of the beam becomes and the nearer it is to head level. In this case, the range of the direct sound will decrease, however, due to the absorption of the sound wave, during its propagation, by the deadening effect produced by the human body. The best compromise is to install the loudspeaker just above raised arm height (2.50 to 3.00m or high enough to leave a minimum of headroom), directing the beam slightly downwards so that its upper edge is at head height level with the next loudspeaker which serves the adjacent area. This arrangement also makes it possible to obtain an almost constant sound level throughout. When two loudspeakers are directed towards each other (loudspeakers fitted on both sides), the beams should cross at head height through the centre point.

In the case of a constant sound level, there will always be a transition zone where the action of two loudspeakers is almost equal, the sound from the furthest loudspeaker arriving with a certain delay in relation to that of the nearest loudspeaker. For this reason, it is necessary to limit the distance between loudspeakers, in order to avoid annoying echoes which occur when the delay exceeds 1/20th of a second. The maximum distance between two loudspeakers broadcasting in the same direction is 17m, and that between two loudspeakers facing each other is 26m, provided they are arranged as suitably as possible, in accordance with the information given above.

In placing the loudspeakers, it is particularly essential to take into account obstacles which are perpendicular to the direction of the beam. If any actual obstacle is encountered, the reflection may bring about unpleasant echoes between the loudspeaker and obstacle.

Beamed loudspeakers may either be in column form made up of a series of phase-operated cone loudspeakers, or be horn loudspeakers.

The vertical column type loudspeakers form a very narrow beam in the vertical plane but diffuse sound widely in the horizontal plane. In order to achieve a suitable beam effect at stations, it is necessary for the column to be at least 70 cm high, or higher if possible (1m). To obtain a larger range (on open platforms) or to avoid reflections from an obstacle, it will sometimes be necessary to concentrate the waves into beams, and, for this purpose, higher columns will be used, or several superimposed columns.

Loudspeaker horns with a circular opening produce a beam symmetrically radial round the axis, which is nevertheless appreciably more blurred than the vertically restricted beam which is diffused by a vertical column of loudspeakers.

The columns, as well as the horns, concentrate the power in beams, the opening angle of which decreases as the frequency increases, i.e. when the wavelength diminishes.

The angle φ (formed with the axis) for which the intensity falls at -6dB or at zero, is given by the following formulae for a wavelength λ :

	Column of length l	Horn of diameter d
- 6dB	$\sin \varphi = 0.6 \frac{\lambda}{l}$	$\sin \varphi = 0.72 \frac{\lambda}{d}$
0	$\sin \varphi = \frac{\lambda}{l}$	$\sin \varphi = 1.2 \frac{\lambda}{d}$

The horn is distinguished from the column (other than the difference in beams) by the fact that it possesses a definite limiting frequency for the reproduction of low-frequency sounds, as opposed to

the column where the curve falls gradually. The limiting frequency of the horn becomes lower as widening of the latter is more gradual. In order to have a sufficiently low frequency limit (250Hz), the horn would have to be excessively long and for this reason horns curving back two or three times are generally used ("re-entrant" type) with a loudspeaker fitted with a compression chamber. These are used to improve the output of the latter and to obtain concentration of the desired beams. For the purpose of loudspeaker systems on platforms and in large halls with heavy resonance, preference would be given to the use of columns of loudspeakers rather than horns, since they produce more concentrated beams, thus reducing, generally speaking, the reverberation phenomena and improving the sound quality. Conversely, horns will be installed when it is also necessary to have narrow beams, especially to transmit separate announcements on different parallel platforms. In this case, it is also possible to use columns of horizontal loudspeakers, with a beam limited horizontally which sweeps the platform.

Loudspeaker installations at very long and reverberating stations may often benefit from the provision of a delay device (see 6.6).

6.2. loudspeakers for music

Generally speaking, the reproduction of music is restricted to waiting rooms and buffets; its object is to create a musical background.

In most cases, the same loudspeakers will serve for the broadcasting of announcements.

When acoustic conditions allow, preference should be given to loudspeakers inserted in the ceiling; if this is not possible, vertical columns may be used.

In both cases, the closed volume situated behind the loudspeakers should be large enough to facilitate reproduction of low-frequency tones as low as 100Hz (see § 6.3).

6.3. Types of loudspeakers and cases

The acoustic output of cone loudspeakers varies between approximately 1% for those of three inches in diameter (7.5cm) with a simple magnetic system, and approximately 16% for those with a diameter of 12 inches (30 cm) with an improved magnetic system. The greater the diameter of the cone (provided the case is of suitable shape), the better will be the reproduction of low-frequency sounds and the greater the load capacity.

It should be remembered in this connection that to obtain the desired sound level, the amplification should be as great as the output of the loudspeaker is small.

In the case of loudspeakers intended for announcements, whether separate or grouped into columns, the best compromise between acoustic requirements and cost is obtained from equipment with a diameter of about 6 inches (15cm) functioning with improved magnetic system. Their respective efficiency is about 5%.

The size of the case is determined by the minimum volume of air per unit needed for the reproduction of low frequencies. A very small volume suffices for loudspeakers transmitting announcements only, since from below 250Hz the sound level can be reduced. For loudspeakers with a diameter of 6 inches, the volume ofair required in the body is about 2 dm^3.

For music broadcasts, equipment of about 7 or 8 inches in diameter and functioning according to the perfected magnetic system is preferable. The volume of the body will be sufficient to facilitate the reproduction of low-pitched tones up to 100 Hz. For equipment with a diameter of 7 or 8 inches, the volume of air required in the body is approximately 20 dm^3.

The efficiency of horn loudspeakers with a compression chamber system should be 10% at least. The use of this type of equipment should be limited to reproduction of the speech.

6.4. Matching of loudspeakers

In general, several loudspeakers of varying power will be connected to the same amplifier output.

Modern terminal amplifiers, with a low internal resistance, are intended to supply a given voltage to the output line, to which loads may be connected up to the nominal power of the amplifier (see § 5.3).

Loudspeakers for public address installations are generally provided with a transformer for a primary voltage in the "100V" series (see § 5.3) having on the secondary a number of tappings which enable the power to be regulated to a series of values the greatest of which is equal to the nominal power, each one decreasing in relation to the previous one in a ratio of 2 or $\sqrt{2}$. The power steps of 2 or $\sqrt{2}$ correspond to differences in sound level of 3 and 1.5 dB. Generally speaking, closer steps are not justified. If the line voltage exceeds 50V, the loudspeakers must comply, as regards construction, with the safety regulations of I.E.C. Publication No. 65.

6.5. Resistance of loudspeakers to mechanical stresses and bad weather conditions.

The equipment should be strong enough to satisfy service conditions. It should be fixed out of arm's reach and in such a way that it does not move under the effect of wind, which would swing the sound beam; the direction of the latter should, in fact, be kept stable. Loudspeakers situated in the open air or in moving air (under a marquee for example) should be resistant to humidity, since it has been found that a fall in temperature, especially during the night, can cause condensation in the closed volume of the case. Loudspeakers exposed to wind and rain (on open platforms for example) should be protected against their direct influence, either by means of a grill in front of the openings, or by a foil placed in front of the loudspeaker; this foil should not be stretched, since the quality of the sound produced would be affected; a thin loose foil does not affect the announcements.

"Re-entrant" horns are protected against direct atmospheric effects by their construction.

In order to prevent failures caused by the penetration of dust, it is recommended that dustproof construction should be adopted.

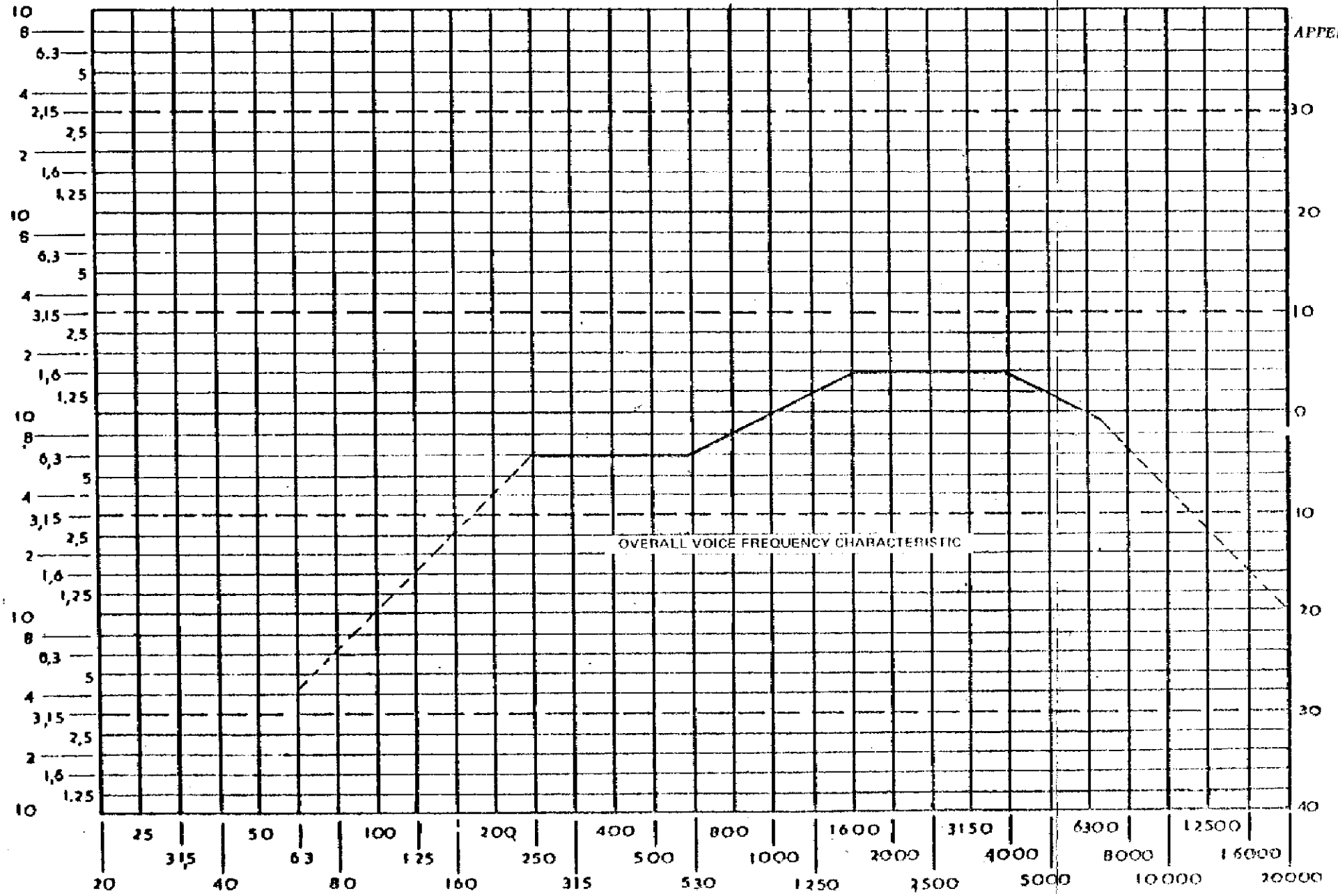
6.6. Delay systems

In accordance with § 6.1, the distances between loudspeakers may not exceed a certain maximum because of the echoes produced. This restriction may be disregarded if the installation incorporates a delay system, which may consist of a magnetic intermediate recording with multiple reading heads. This compensates for the difference in the distance covered by sounds emanating from a series of loudspeakers, and a continuous wave system is obtained. This measure facilitates full use of the range of the loudspeakers and a greater spacing between them, thus giving an economy in loudspeakers. The absence of difference in phasing between the sounds received improves the quality of retransmission. In addition, the continuous wave system produces less resonance.

For long covered platforms where the reverberation time is considerable, this system is the most beneficial. It should preferably be set up symmetrically, so that the continuous wave proceeds from the centre of the station towards the two open extremities.

7. Distribution circuit

7.1. In view of the high level of the signals transmitted between the amplifiers and loudspeakers, it is unnecessary for the distribution circuits to be specially balanced; nevertheless, in order not to influence other telecommunications installations, it is recommended that balanced circuits be used. For the same reason, it is not necessary to use screened cables for the circuits between the amplifiers and the loudspeakers.


OVERALL VOICE FREQUENCY CHARACTERISTIC
10
8
6.3
5
4
2,15
2,5
2
1,6
1,25
3,15
30
20
10
0
40
25
31,5
40
50
63
80
100
125
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200
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1250
1600
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2500
3150
4000
5000
6300
8000
10000
12500
16000
20000

APPLICATION

All Railways in the Union.

RECORD REFERENCES

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