Acoustic Considerations

Acoustic considerations report considering LDA speakers

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1. INTRODUCTION

The purpose of this document is to provide basic guidance on system acoustic considerations and to optimise the layout, orientation and positioning of loudspeakers in an enclosure in order to obtain the best possible performance from the public address and voice evacuation system.

The following concepts are described:

- Sound Pressure Level (SPL).
    - SPL increase.
    - SPL attenuation.
- Speaker connection.
    - High impedance speaker line.
    - Digital speaker line.

Then, these concepts will be applied in LDA speakers:

- CH-42TN ceiling speaker (6W).
- DS-60TN surface speaker (6W).
- SC-95TN ceiling speaker (24W).
- PCM-20TN unidirectional projector speaker(20W).
- PS-30TN horn speaker (15W).
- CI-225TN column speaker (20W).
- CI-825TN column speaker(40W).

2. ACOUSTIC RELATED CONCEPTS

2.1. Sound Pressure Level (SPL).

Sound Pressure Level (SPL) or sound level is a logarithmic measure of the effective sound pressure of a sound relative to a reference value. It is measured in decibels (dB) above a standard reference level. The standard reference sound pressure in air or other environments is 20 µPa, which is generally considered to be the threshold for human hearing (at 1 kHz)

$$SPL(dB) = 20\log\frac{P}{Pref}$$

Where Pref is the reference sound pressure and P is the sound pressure being measured. That is, when the power is doubled, the sound pressure level increases by 3 dB.

SPL increase.

An SPL increase is the logarithmic ratio (expressed in dB) between the input power supplied to a given loudspeaker and a reference power.

$$SPL = 10 \log (P_2 / P_1)$$

Where "P1" is the reference power (in the case of speakers, generally 1 W) and "P2" is the supplied power.

SPL attenuation.

When a sound is emitted from a speaker, it is distributed through space in the shape of a sphere, so the sound pressure level is inversely proportional to the square of the distance. That is, each time the distance doubles, the sound pressure level is attenuated by 6dB.

$$SPL = 20 \log (r_2 / r_1)$$

Where "r1" is the reference distance (in the case of speakers, generally 1m) and "r2" is the distance where we are calculating the attenuation.

In the particular case of linear sources, in which propagation is cilindric (for example, speaker columns) the sound pressure level is attenuated 3 dB when the distance from the source is doubled.

2.2. Reflection and absorption of sound

Any element in the path of a sound wave will always produce two opposite effects; it will absorb some of the energy of the sound wave and reflect the rest. As a general rule, objects that are smooth, heavy and rigid are reflective while those that are rough, porous or can vibrate easily are absorptive.

This property of sound must be taken into account in order to avoid directing the loudspeakers, depending on the desired effect, towards a panel that is too absorbent or reflective.

2.3. Acoustic wave difraction

A basic rule must be met for sound to reflect off an object; its size must be equal to or greater than the wavelength of the sound in question. If a sound of a certain wavelength (bass sound has a longer wavelength) reaches a smaller object, the sound wave instead of reflecting off the object surrounds it and continues to propagate behind it.

When placing loudspeakers, the arrangement of obstacles must be taken into account in order to avoid shadow zones that do not allow the sound to propagate.

2.4. Reverberation in an enclosure

This parameter is the consequence of the reflection of sound against various objects, walls, floors, etc. Reverberation is like a prolongation of the hearing of a sound, caused by reflections that reach our ear moments after the original sound.

Reverberation can be beneficial or detrimental to hearing, depending on its intensity and the nature of the sound. Thus, a high level of reverberation will lead to a lower rate of intelligibility.

2.5. Angle of coverage and directivity of a loudspeaker

The coverage angle of a loudspeaker is the angle at which the sound pressure level (SPL) is reduced by 6 dB relative to that provided on its axis. Directivity indicates the variation of the frequency response depending on the direction of the sound source. In other words, it shows how the sensitivity varies with respect to the direction of the sound source. Directivity is represented by polar diagrams.

This parameter is very important when placing the loudspeakers because it will allow us to create a direct sound beam more focused on the receiver or an homogeneous acoustic environment.

2.6. Acoustic wave phase

The phase of an acoustic wave is a characteristic parameter of an acoustic wave that indicates the instantaneous situation in the cycle, i.e. it is a magnitude that varies cyclically.

A phase cancellation can occur when two sound waves from different emitting sources with the same magnitude and cycle meet, i.e. face each other.

2.7. Signal attenuation

As a signal passes through a transmission medium, a loss of power occurs, which we call attenuation.

It is important to control the losses of the acoustic signal both through the air (from the transmitter to the receiver) and through the transmission cable, the cross-section of which must be optimised.

3. HIGH IMPEDANCE SPEAKER LINE

High impedance speaker line is also called 70/100 V speaker line and is often used in public places. The following table gives the maximum cable length in metres for different impedances and cable cross-section.

The type of cable used is twisted pair copper. The values shown may be used as a guide, but it is the responsibility of the installer to make the final calculations appropriate to each case. The table shows the power output of typical amplifier channels, using 100 V rms lines.

Power (W)	0,82 mm²	1,04 mm²	1,65 mm²	2,08 mm²	2,63 mm²	3,65 mm²	4,15 mm²	5,27 mm²	6,62 mm²	8,35 mm²
60 W	200	255	405	510	645	810	1020	1300	1625	2050
120 W	100	130	200	255	320	405	510	645	810	1025
240 W	50	65	100	130	160	200	255	320	405	510
480 W	25	35	50	65	80	100	130	160	200	255

4. ACOUSTIC CONSIDERATIONS FOR THE PROPOSED LOUDSPEAKERS

4.1. CH-42TN ceiling loudspeakers

The EN 54-24 5" ceiling loudspeaker for 70/100V lines provides the necessary protection so that in the event of a fire, damage to the loudspeaker will not cause failure of the loudspeaker circuit to which it is connected. This maintains the integrity of the system by ensuring that the loudspeakers are still connected to the same circuit so that warning messages can continue to be broadcast.

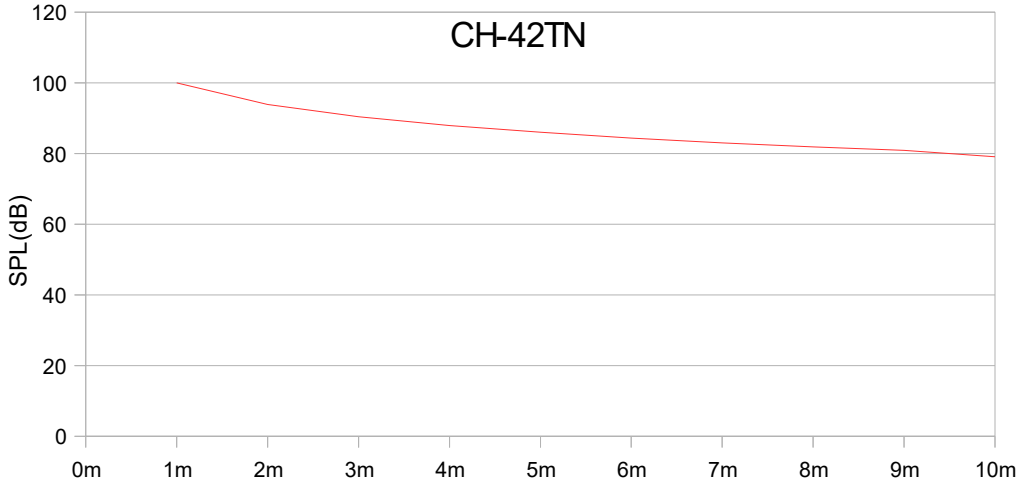
CH-42TN characteristics:

- Voice Alarm speakers.
- Meets EN 54-24 norm.
- High protection against fires.
- Suitable for sound distribution
- Built-in spring mount

The following table contains the SPL values as defined in the previous sections:

SPL (1W,1m)	SPL (6W,1m)	SPL (6W,3m)	SPL (6W,5m)	SPL (6W,10m)
92 dB	100 dB	91dB	86 dB	79 dB

This figure shows the dB decrease denpending on the distance:



4.2. DS-60TN Surface Speaker

DS60-TN EN 54-24 certified vandal-proof loudspeaker. Its white design allows it to blend in with most spaces and it is an ideal loudspeaker for sound distribution in various types of installations such as shopping centres, hotels, conference rooms, cinemas, factories, exhibition halls, etc.

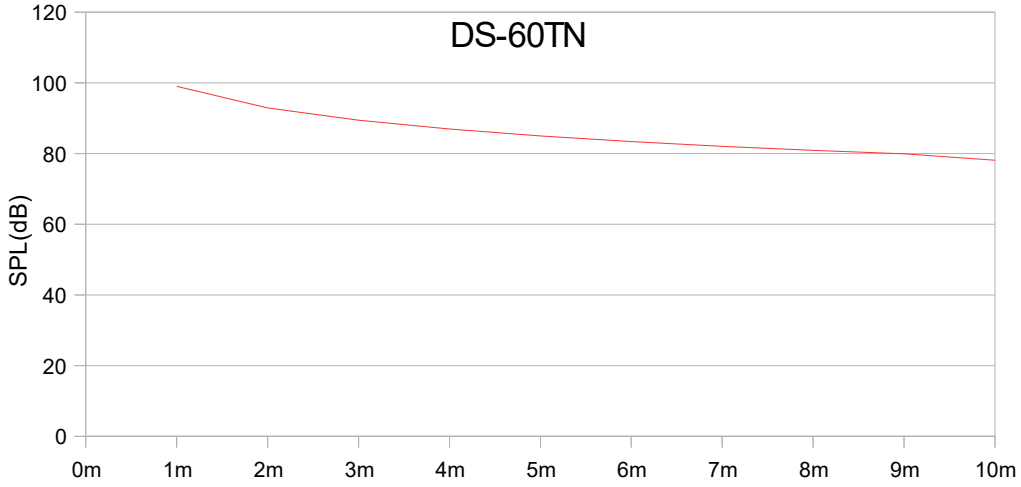
DS-60TN characteristics:

- Voice inteligibility and quality sound reproduction
- Robust metal case
- Integrates with interior decoration
- Simple power setup
- Easy configuration
- Meets EN 54-24 norm

The following table contains the SPL values defined in the previous sections:

SPL (1W,1m)	SPL (6W,1m)	SPL (6W,3m)	SPL (6W,5m)	SPL (6W,10m)
91 dB	99 dB	90 dB	85 dB	78 dB

This figure shows the dB decrease depending on the distance:



4.3. SC-95TN ceiling speaker

SC-95TN is a high-performance 24W coaxial ceiling loudspeaker. Its wide frequency range, low distortion and high sound pressure level provide excellent sound and speech intelligibility. Its modern low profile and red and white design make it blend easily into most installations, such as hotels, shopping malls, conference rooms or exhibition centres. This loudspeaker complies with the EN54-24 voice alarm norm which ensures that, in the event of fire, damage to the loudspeaker does not cause failure of the circuit to which it is connected.

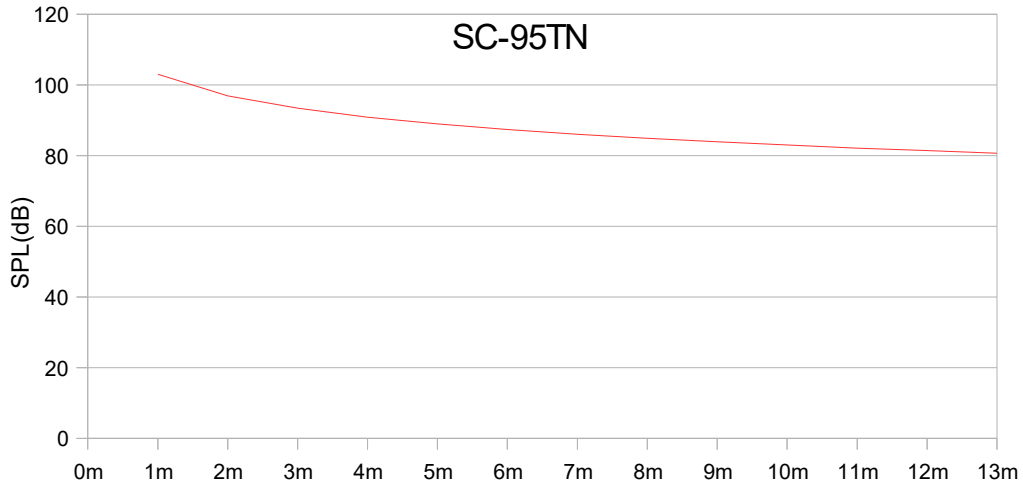
SC-95TN characteristics:

- EN54-24 norm certified
- Voice inteligibility and excellent sound reproduction
- Easy to blend in with interior decorations
- Robust metal housing with fireproof dome
- Easy configuration and wiring

The following table contains the value of SPL defined in the previous sections:

SPL (1W,1m)	SPL (24W,1m)	SPL (24W,3m)	SPL (24W,5m)	SPL (24W,13m)
91 dB	103 dB	93 dB	89 dB	81 dB

This figure shows the dB decrease depending on the distance:



4.4. PS-30TN horn speaker

PS-30TN is a high-performance exponential loudspeaker (horn) that complies with EN54-24 for voice evacuation. Its wide frequency range, low distortion and high sound pressure level (SPL) ensure clear voice reproduction and high sound quality. It is constructed of ABS and includes a ceramic terminal and a thermal fuse for extra fire protection. The built-in power selector allows power selection in a range of 15 W / 10 W / 5 W at 100V or 8 Ohms.

It is perfect for using it in extreme outdoor applications. The elegant and discreet light grey design allows for easy integration into most applications such as train stations, harbours, factories, car parks, universities or stadiums.

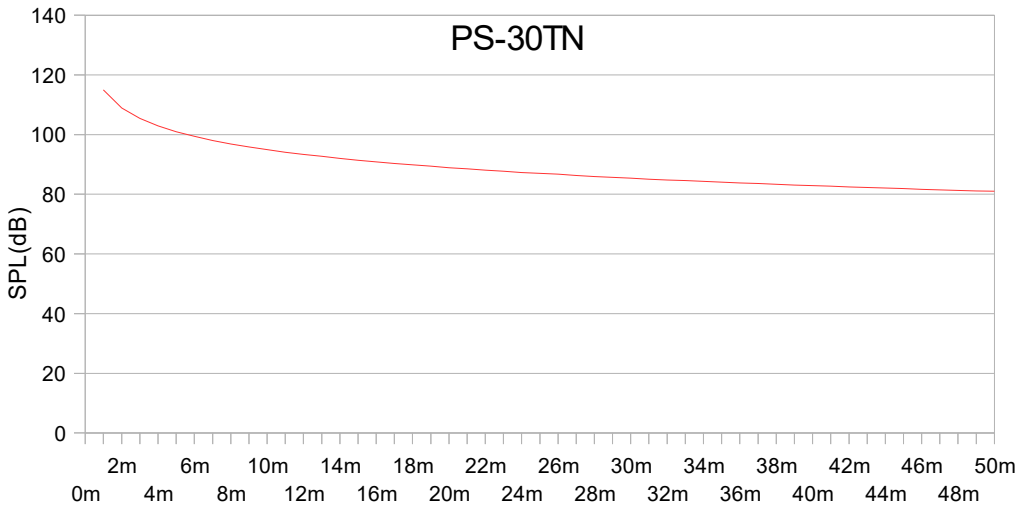
PS-30TN speaker characteristics:

- EN54-24 certificate: 0359-CPR-00456
- Clear, intelligible voice and superior sound quality
- Sleek and discreet design that integrates easily into any application
- Made of highly resistant ABS with UV protection (UL94V0)
- Simple installation on walls or columns with U-bracket.
- High sensibility: 105dB (1W, 1m)

The following table contains the SPL values defined in the previous sections:

SPL (1W,1m)	SPL (15W,1m)	SPL (15W,15m)	SPL (15W,20m)	SPL (15W,50m)
105 dB	115 dB	93 dB	89 dB	81 dB

This figure shows the dB decrease depending on the distance:



4.5. PCM-20TN projector speaker

PCM-20TN loudspeaker is a high-performance 20W vandal-resistant one-way acoustic projector that complies with the EN54-24 voice alarm standard. It provides high sound quality and intelligible voice evacuation messages thanks to its high sound pressure, low distortion and wide frequency response.

Its high IP protection rating ensures reliable operation over a wide temperature and humidity range, making it suitable for both indoor and outdoor applications.

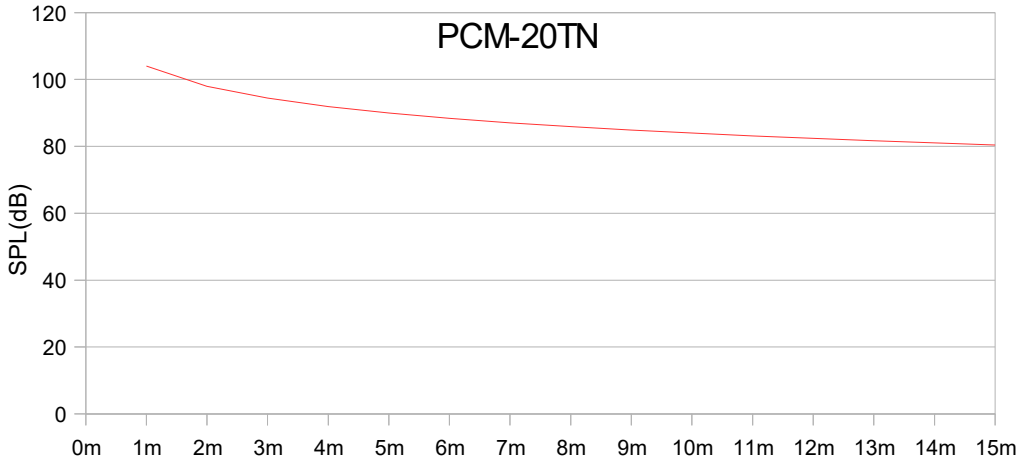
PCM-20TN characteristics are:

- Meets EN 54-24 norm
- Excellent sound reproduction
- Voice messages intelligibility

The following table contains the SPL values defined in the previous sections:

SPL (1W,1m)	SPL (20W,1m)	SPL (20W,8m)	SPL (20W,15m)
91 dB	104 dB	86 dB	81 dB

This figure shows the dB decrease depending on the distance:



4.6. CI-225TN column speaker

CI-225TN is a 20W acoustic column certified EN 54-24. It offers a wide frequency response, low distortion and high sound pressure suitable for intelligible evacuation messages as well as music.

It is suitable for both indoor and outdoor use thanks to its IP 66 protection, making it suitable for all types of environments.

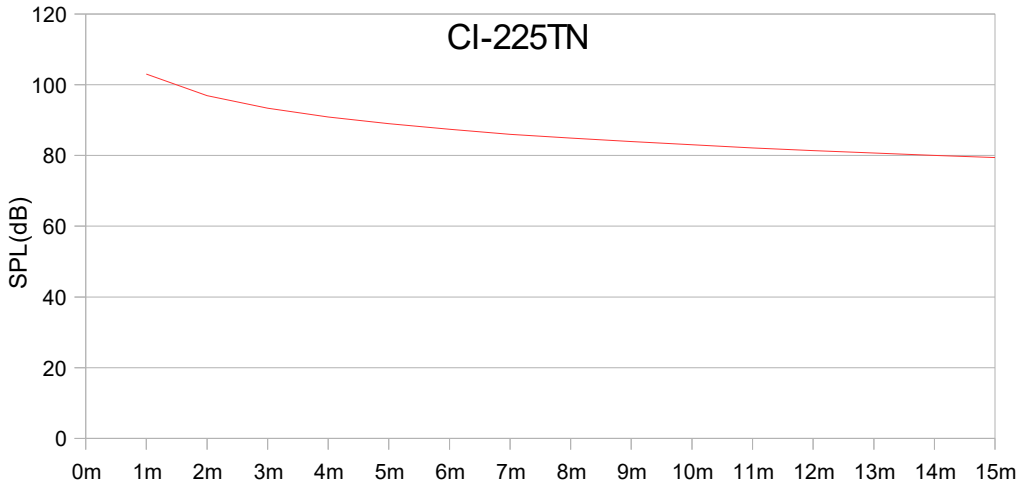
Features of the CI-225TN loudspeaker

- Meets EN 54-24 norm
- Voice intelligibility and excellent sound reproduction
- Made in resistent alluminium
- Including angle-adjustable support bracket
- 70V / 100 V transformer
- Adapts to extreme environments
- IP66 protection

The following table contains the SPL values defined in the previous sections:

SPL (1W,1m)	SPL (20W,1m)	SPL (20W,8m)	SPL (20W,15m)
92 dB	103 dB	85 dB	79 dB

This figure shows the dB decrease depending on the distance:



4.7. CI-825TN column speaker

LDA CI-825TN is a 40 W EN 54-24. certified acoustic column. It offers a wide frequency response, low distortion and high sound pressure suitable for intelligible evacuation messages as well as music..

It is suitable for both indoors and outdoors thanks to its IP 66 protection, making it suitable for all types of environments.

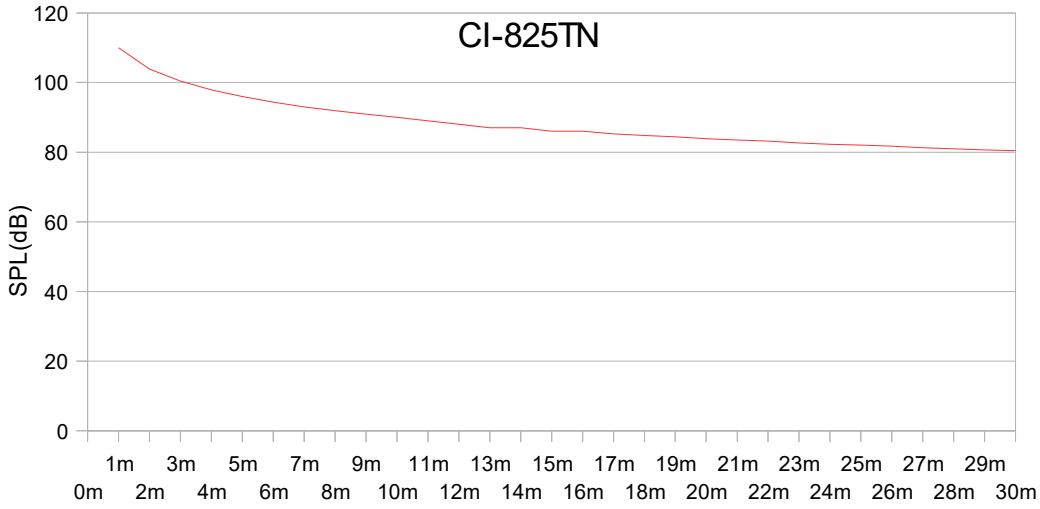
CI-825TN speaker characteristics:

- Meets EN 54-24 norm
- Voice intelligibility and excellent music reproduction
- Made in resistent aluminium
- Including angle-adjustable support bracket
- 70V / 100 V transformer
- Adapts to extreme environments
- IP66 protection

The following table contains the SPL values defined in the previous sections:

SPL (1W,1m)	SPL (40W,1m)	SPL (40W,15m)	SPL (40W,20m)	SPL (40W,30m)
94 dB	110 dB	87 dB	84 dB	81 dB

This figure shows the dB decrease depending on the distance:

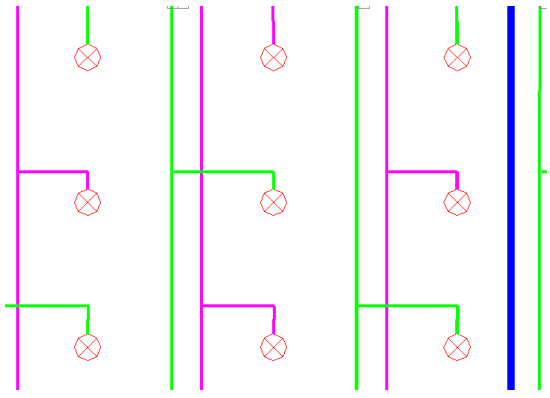


5. DISTRIBUTION PATTERNS; TARGETING AND POSITIONING

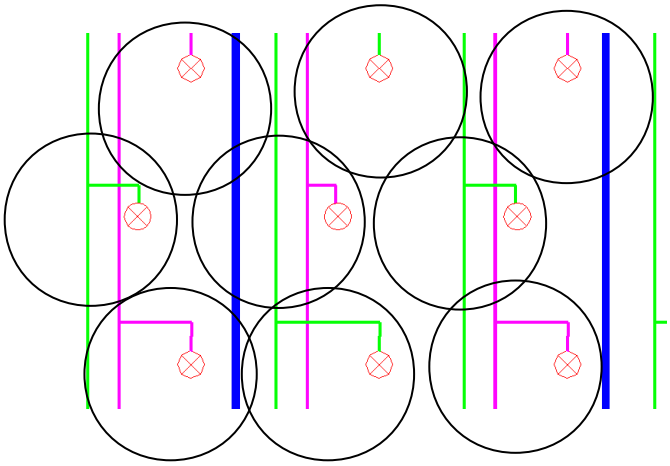
5.1. Ceiling speaker distribution

In ceiling loudspeakers it is a common mistake to follow a grid layout.

A hexagonal layout is proposed in order to optimise the coverage angle and directivity of the loudspeaker, as shown in the following figures:



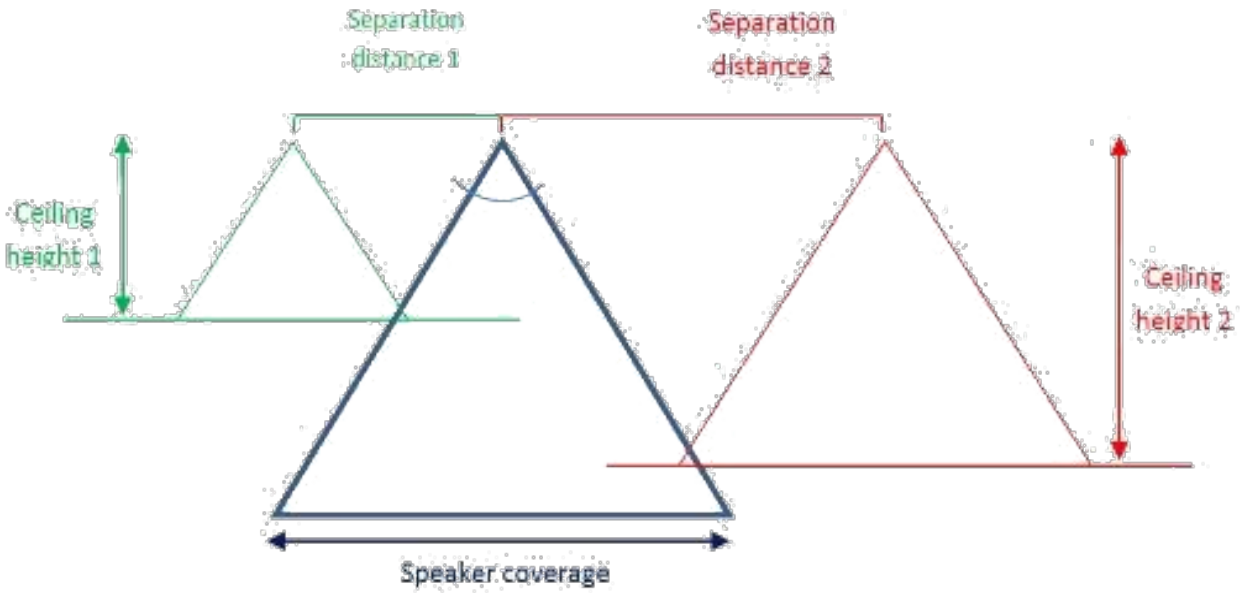
Grid layout in ceiling speakers



5.2. Speaker spacing

Speaker spacing tends to be evenly spaced, so we may have the same distance between speakers at points where the ceiling height varies.

It is proposed to increase or decrease their separation depending on the height, since the lower the height, the lower the degree of dispersion and vice versa, as shown in the following figures:



5.3. Number of speakers per line

The number of speakers per line is usually high, many speakers with low power.

It might be better to limit the number of speakers per line so that loss of signal or electrical problems on the line will result in a greater loss of coverage.

5.4. Projector speaker distribution

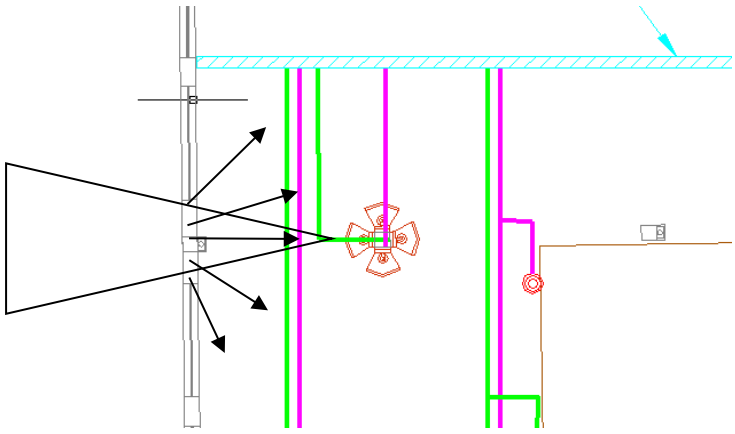
Projector loudspeakers tend to be distributed in right angle, not taking into account the dispersion and directivity of the loudspeaker..

It is proposed to avoid a clash between two beams of two acoustic projectors if their separation distance is less than 40 metres, as the range of the projectors is estimated to be 20 metres, because the acoustic signal will have sufficient gain level to produce unwanted phase cancellation effects at a shorter distance. The following figures show how to reorient these projectors to avoid this effect.

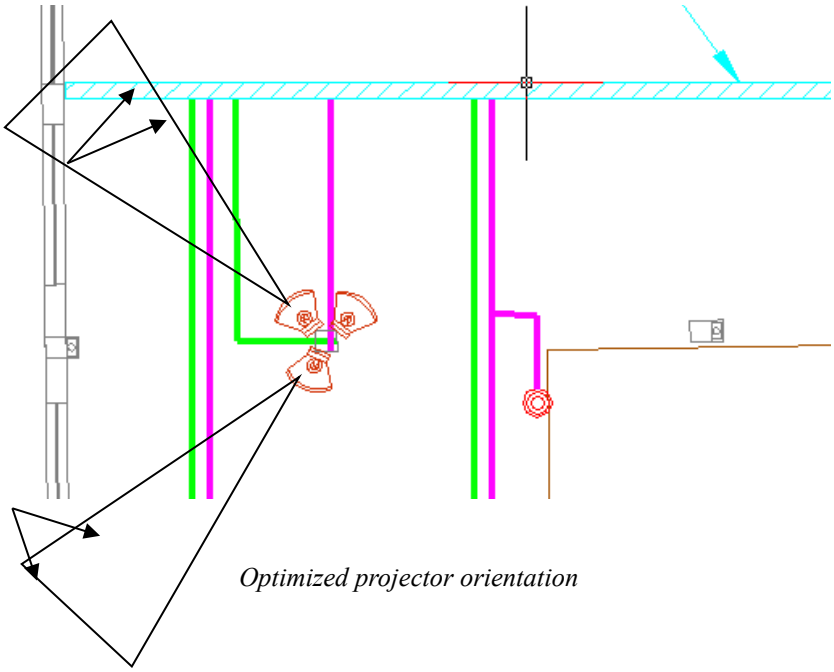
5.5. Projector speaker orientation

In certain parts of the room, the loudspeakers may be positioned in front of acoustic obstacles, not taking into account the reflection and therefore reverberation effects that these may produce.

It is proposed to reorient the loudspeakers at these points by avoiding the acoustic obstacles and trying to ensure that the sound beam is not reflected perpendicular to any object, as shown in the following figures:



Projector speakers oriented to objects (not optimized).



Optimized projector orientation

6. CONCLUSIONS

We carried out this study with EN54 certified loudspeakers, that loudspeakers must meet with respect to their acoustic and constructional characteristics.

This distance calculation according to the characteristics of the loudspeakers in a theoretical system according to the formula used. Always carry out an acoustic study that is the most accurate and can obtain more information such as the STI (Speech Transmission Intelligibility Index).

For more information, please contact your company or the support department.