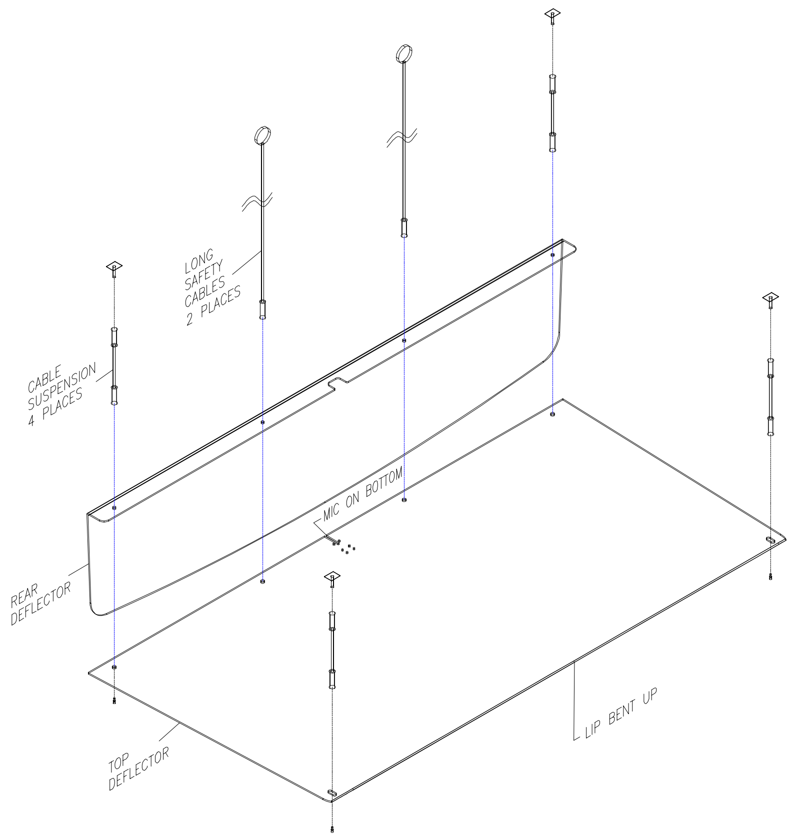
TANDBERG AudioScience



Theory and Operation

TANDBERG AudioScience Theory and Operation:

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The ***TANDBERG AudioScience*** microphone is a ceiling microphone designed specifically for use in Videoteleconferencing and Distance Learning environments. It consists of a Crown PZM® microphone attached to a boundary specifically shaped to optimize the Frequency response, Polar response, and reach of the microphone assembly. Also, the combination of those parameters enhances the performance of some echo cancellers, and results in some "natural" automatic gain control functions.

Theory of Operation:

Simplicity:

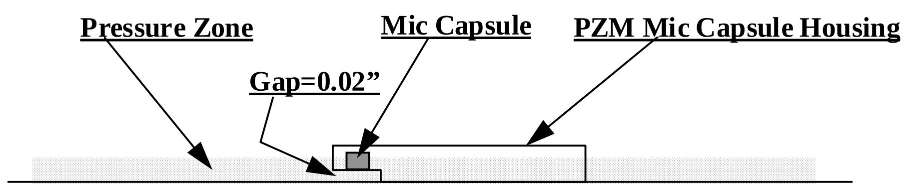
All of the principles discussed below are simple acoustical principles. PZM® mics and proper boundaries achieve all these effects simply through the natural action of air movement. No software, no algorithms, no sophisticated control devices, etc. are used. In fact, the only electrical parts involved are those minimal electronics that make up the microphone cartridge itself.

The Pressure Zone:

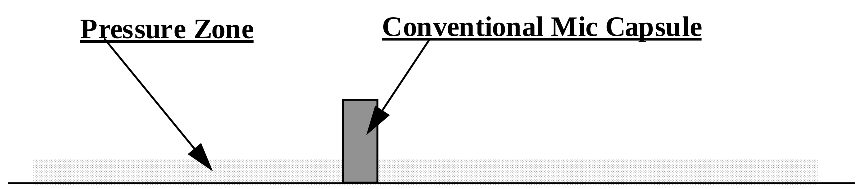
The Crown PZM^R microphone operates under the principles of the *Pressure Recording Process*™. A more detailed description of this process can be found in *The Crown Boundary Microphone Application Guide* but effectively, the *Pressure Recording Process*™ works essentially like this:

When sound encounters a hard unyielding surface, that sound is reflected away from the surface. As a result, a doubling of sound pressure occurs in a zone right next to that surface. If a microphone is placed within this "Pressure Zone", there will be a doubling of acoustic pressure at the diaphragm of the microphone, which results in a higher output of the microphone. This effectively means that the microphone then has a higher sensitivity.

The "thickness" of this "Pressure Zone" depends upon frequency as it is directly related to the wavelength of the sound signals striking the surface. At a distance of ½ a wavelength away from the surface, the direct and reflective waves will completely cancel each other so, at that distance, there is not only no doubling, but there is actually a complete cancellation of the signal. A distance of ½ wavelength is therefore well out of the pressure zone. At a distance of 1/13 of a wavelength however, the doubling phenomenon just starts to drop off, so this distance is just barely starting to be out of the pressure zone. Human speech is specified to exist in the frequency band of 150Hz to 7500Hz although virtually all of the important speech sounds exist in the 250Hz to 4000Hz band. The wavelength of sound at 7500Hz is about 1.8" (1 – 13/16") The pressure zone at 7500Hz is therefore .139" tall, or slightly more than 1/8 inch. The pressure zone at 4000Hz is about ¼." Therefore, in order for a microphone to be totally within the pressure zone, it has to either be very small in diameter, or be oriented parallel to the reflective surface.



If a large diameter microphone (more that ¼" in diameter!) is placed perpendicular to the reflective surface, there will be a gradual reduction in high frequency response due to high frequency waves of varying phase hitting at different places on the microphone's diaphragm simultaneously, and canceling, or partially canceling each other.



Boundary Effects:

The doubling effect of the pressure zone will happen equally across the frequency spectrum as long as the reflective surface or "Boundary" is infinitely long and infinitely wide. Unfortunately, infinite surfaces are difficult to manipulate so, because we have to use finite surfaces, the effects of finite surfaces need to be taken into account. Low frequency sound waves have quite large wavelengths. The wavelength of a 150Hz tone is about 7.5 feet; a 250Hz tone is about 4.5 feet. When sound strikes a finite object that is about the same size as the wavelength of the sound, in addition to reflecting off the surface, the sound tends to bend around the object. As a result the directionality of a Pressure Zone Microphone (redundantly referred to as a "PZM^{R} mic.") on a boundary is a function of the dimensions of the boundary. The larger the boundary is, the more directional the mic is at lower frequencies or the more it rejects low frequencies emanating from outside the boundaries' desired pickup area.

Off axis Frequency response:

Because the PZM^{R} mic is an omni-directional microphone, it has the same frequency response for sound arriving from in "front" of the microphone as it does for sound arriving from the sides, as long as that sound is not blocked by the boundary. As a result, the microphone-boundary assembly has nearly the same frequency response for all angles within its pickup area. People standing to the side of the microphone will therefore sound the same as people in front of the microphone. In contrast, most unidirectional microphones have different frequency responses from the side as from the front. A microphone with a traditional "cardiod" polar pattern tends to be nearly omni-directional at low frequencies, and quite directional at high frequencies. As a result, people speaking to the side of a cardioid microphone will sound muffled or distant. Also, due their low-frequency omni-directional characteristics, unidirectional microphones tend to pick up more low frequency reverberation than PZM^{R} and boundary assemblies. The pickup of reverberation by PZM^{R} microphones tends to be more uniform across the frequency spectrum which makes the reverberation sound more "live" then "hollow." This makes distant sound sources sound closer.

Direct to Reverb ratio:

When a second boundary is added perpendicular to the first boundary, another 6dB doubling of acoustic pressure is achieved within the pressure zone. However, this doubling refers only to sound travelling directly from the source to the microphone. Reverberant sound (sound which bounces off one or more surfaces before reaching the microphone assembly) only increases by 3dB. As a result, for each boundary added at right angles to the existing boundaries, the direct to reverb ratio increases by 3dB. The ***TANDBERG AudioScience*** microphone has two boundaries so it has a 3dB increase in direct to reverb ratio when compared to a non-boundary microphone.

Critical Distance:

When using microphones placed at a distance from the sound source, the principle of critical distance comes into play. Critical Distance is defined classically as the distance at which the level of the direct sound reaching the microphone is equal to the level of the reverberation reaching the microphone. Subjectively, critical distance can be thought of as the distance at which the person you are trying to hear sounds "far away." Unfortunately, the classic definition of critical distance applies only to "conventional" non-PZM^R microphones. As a result of the increase of direct to reverb ratio, and the uniform off-axis-response, subjective critical distances of PZM^R mics are considerably longer than their conventional unidirectional counterparts. Therefore the term "reach" which refers to the "subjective critical distance" is more applicable to PZM^R mics and boundaries.

Performance Characteristics of the TANDBERG AudioScience microphone:

Frequency response:

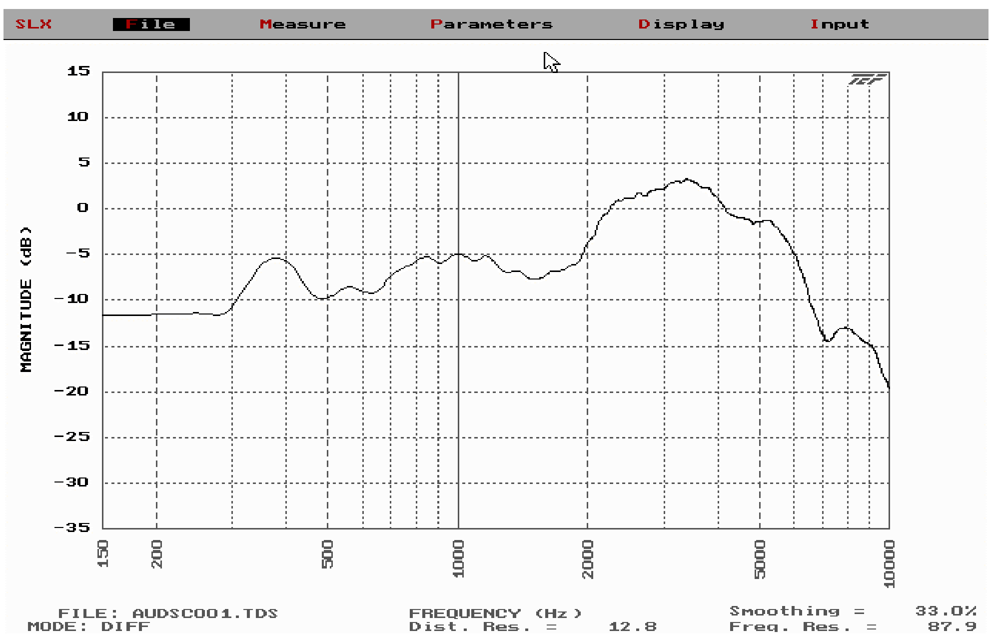


Fig. 1: The frequency response of a ***TANDBERG AudioScience*** microphone when mounted in a typical application.

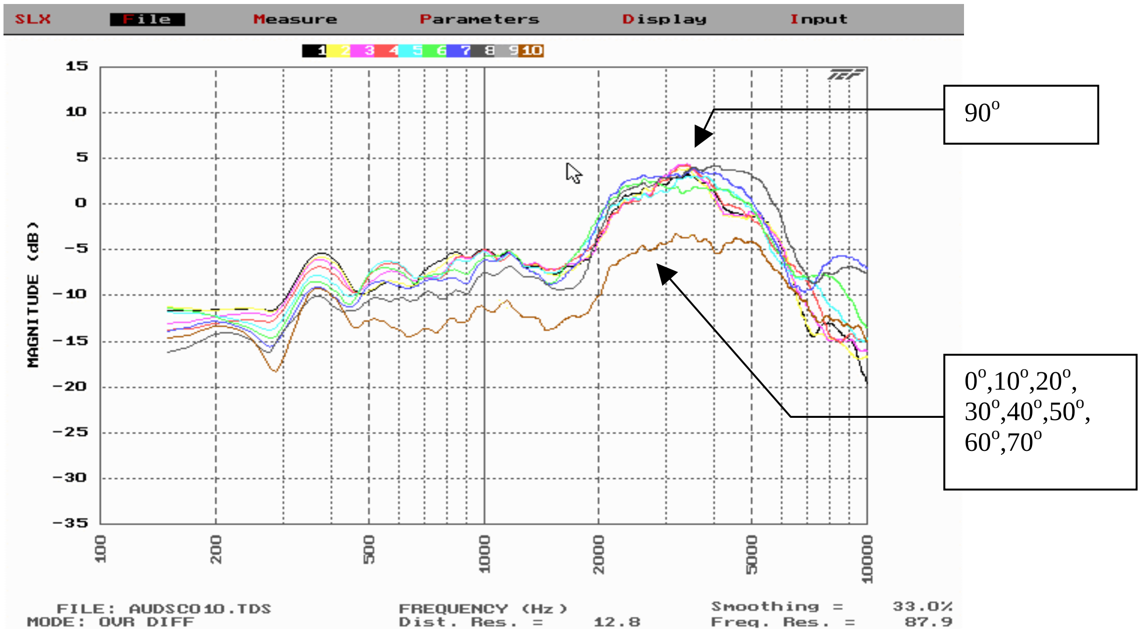


Fig 2: The Frequency response of sound of various "Angles of incidence" reaching the ***TANDBERG AudioScience*** microphone. Note: 90°angle of incidence is sound originating from the side of the microphone assembly.

Horizontal Polar response:

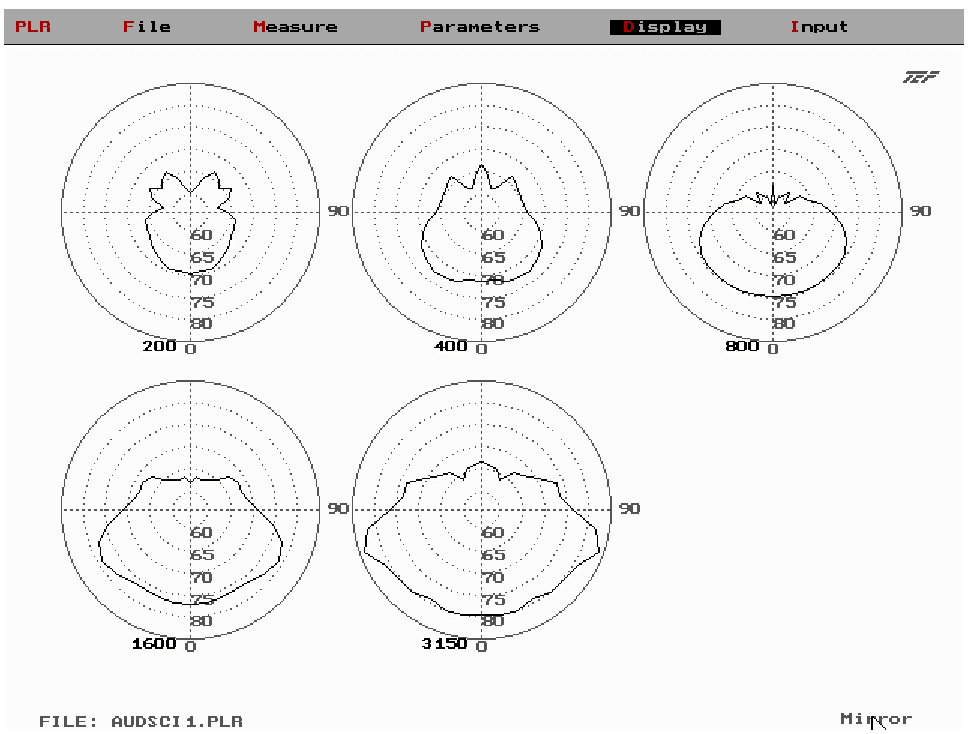


Fig 3. Polar response of ***TANDBERG AudioScience*** microphone in typical room at frequency bands of 200Hz, 400Hz, 800Hz, 1600Hz, and 3150Hz

Critical Distance/Reach:

Subjective tests with the ***TANDBERG AudioScience*** mic have shown that its usable reach is about 14 feet in most rooms. Therefore all seating positions should be within 14 feet of the microphone, and be within the pickup area defined by its two boundaries. (i.e. A quartersphere whose flat edges coincide with the two boundaries of the ***TANDBERG AudioScience*** microphone.) As a result of this "reach," One ***TANDBERG AudioScience*** microphone can typically pick up the same seating area as 6 or more conventional uni-directional mics.

"Natural" AGC (Automatic Gain Control):

In a typical application, the ***TANDBERG AudioScience*** microphone will be mounted on a 8-9 foot ceiling, and be about 6 feet from the closest person, and about 14 feet from the farthest person. As a result, the difference in level between the closest and farthest is about 7dB. In contrast, on a typical "long-table" setup with a typical cardioid table-mic, the closest person may be as little as 2 feet away, and the farthest may be as much as 7 feet away. The difference in level between these two people is then about 10dB. Therefore, within the pickup area of the ***TANDBERG AudioScience*** microphone, there is typically not as extreme a level difference between the various participants as there is with a table-mic system.

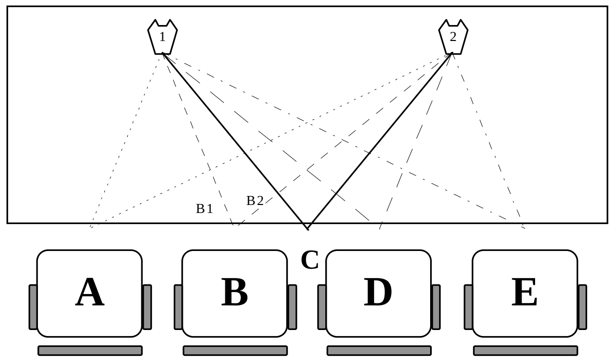
Echo Canceller Enhancement:

In Videoteleconferencing where compressed video is used, there is a short processing delay in encoding and decoding the audio and video. In addition, as in any speaker-microphone arrangement, some of the sound from the speaker gets into the microphone(s) and will be transmitted back to the far end. If this is allowed to happen, the far end will hear echo of themselves, and have a difficult time speaking. As a result of this condition, virtually every compressed videoteleconferencing system uses some form of echo control. This echo control is typically some combination of Echo Cancellation and Echo Suppression. From a performance point of view, most of today's Echo control systems perform better with small quantities of "acoustically large" unmoving microphones, than with larger quantities of "acoustically small" moving microphones, to pick up the same area. The ***TANDBERG AudioScience*** microphone is an example of an "acoustically large" unmoving microphone.

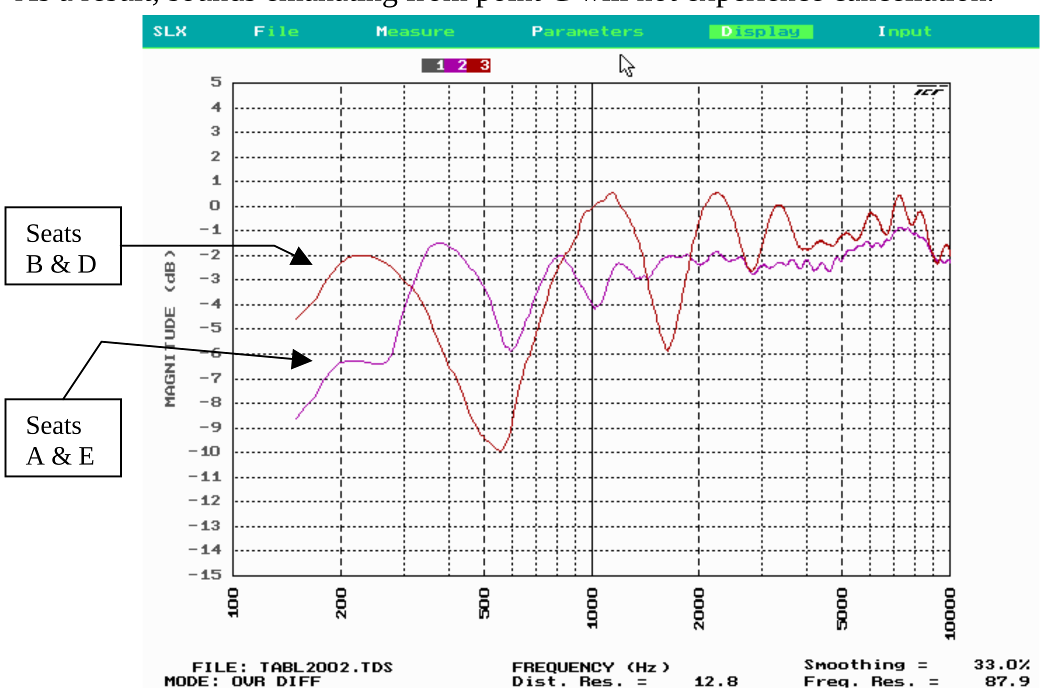
Antinodes, the 3 to 1 rule:

If a sound source is picked up unequally by two microphones, that sound source will be partially cancelled due to interference between the differences in distances between the two microphones. If these cancellation points, or "anti-nodes" occur where no one is seated, then it is not a problem. If they occur where someone is seated, then it will be difficult to hear that person unless they move out of the anti-node. Typically, that person only has to move about 6 inches in any direction to be heard again. In most videoconferencing situations however, usually the person speaking has no knowledge as to how well they are being received from the far end unless someone at the far end tells them. Usually, people just accept the fact that they can't hear the person well, and politely struggle to listen. When more than two mics are used, the number of anti-nodes increases as well. A commonly accepted practice when using more than one microphone is to make sure that if a sound source is picked up by more than one microphone, then the distance between the sound source and the second microphone is 3 or more times greater than the distance between the sound source and the first microphone.

For Example, assume a conference table is set up as follows:



Seats B and D are in a partial antinode. The ratio of the path length of seat B to mic 1 (marked B1) and Seat B to mic 2 (marked B2) is about 2:1 therefore, Seat B will encounter some cancellation. Likewise, Seat D will have a nearly identical cancellation pattern. Seats A and E have path lengths of nearly 3:1. As a result, the sound arriving at mic 2 from Seat A is about 9.5dB less than that at mic 1 due simply to the effects of distance. As a result, the signal reaching mic 2 is too weak to cancel the signal at mic 1 by much. The Position marked "C" is a spot that is equidistant from both microphones. As a result, sounds emanating from point C will not experience cancellation.



The graph above represents the frequency responses of the seat locations relative to the response from position C. The graph shows that Seats B & D experience a large antinode at a frequency of 554Hz, and successively smaller antinodes at 1623Hz, 2798Hz, and others. Seats A and E also experience a few antinodes but while they are audible, they are not as significant as those for seats B and D. The Audible result of these antinodes or cancellations is that people sitting in seats B and D will be harder to hear than people in seats A and E.

The large pickup area of the ***TANDBERG AudioScience*** mic means that often only one microphone is needed per room. This eliminates the dual-microphone anti-nodes completely. In larger rooms, typically less than 4 are required, and they can be arranged to reduce the quantity and significance of the antinodes. By comparison, if a room requires 4 ***TANDBERG AudioScience*** mics, that room can have a seating area as large as about 56' x 28', and comfortably seat about 144 people. With corridors, the room would be about 68 x 32 feet – a very large room. The same room would require 48 – 72 table microphones to pick up the same amount of people.

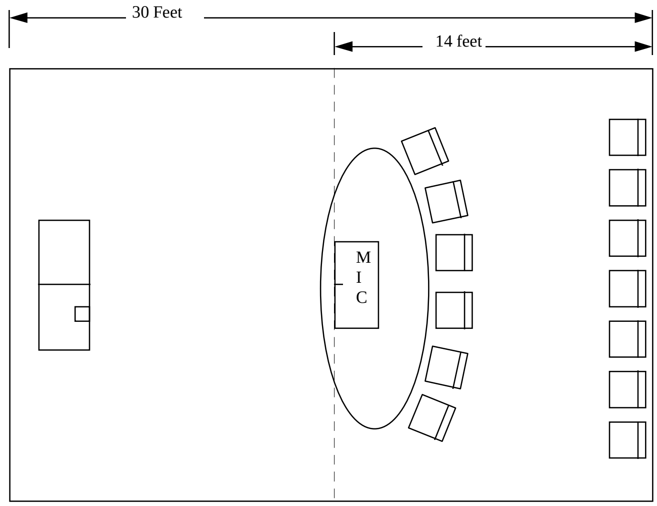
Use of the TANDBERG AudioScience Microphone:

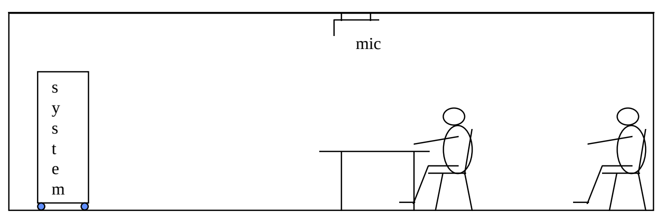
Selecting a mounting location:

The mounting location of the ***TANDBERG AudioScience*** microphone can be determined through the application of 3 principles:

1. All desirable seating positions should be within 14 feet of the microphone capsule, with an unobstructed line-of-sight of the microphone cartridge.
2. All undesirable noise sources should be blocked from reaching the microphone capsule by one or both boundaries of the microphone.
3. The mounting holes of the microphone must be directly under a ceiling track to allow for mounting hardware. Additionally, to allow for easier changing of lighting tubes or bulbs, the microphone should not be mounted where the microphone blocks these items. If, due to acoustic concerns, a light fixture has to be "blocked" then string the microphone cable in such a way as to allow for removal of the microphone when light bulbs or tubes need to be changed.

A drawing of the microphone mounted in a typical medium-sized conference room is shown below:





Selection of Echo cancellers:

The ***TANDBERG AudioScience*** microphone should work well with most modern Echo Cancellers. Specifically, as of July, 2001, it has been tested to work well with the following echo cancellers/codecs:

ASPI EF-400
ASPI EF-600
Rane ECS systems
Sound Control AVT-44^{TM}
TANDBERG 7000$_{TM}$
TANDBERG 6000^{TM}
TANDBERG 2500^{TM}
TANDBERG 800^{TM}
TANDBERG VISION 5000
TANDBERG VISION 2500
TANDBERG VISION 800
Picturetel 4000/4500/Concorde codecs & systems

It is not recommended for use with the following echo cancellers/codecs as it may contribute to less than acceptable audio:

Biamp/Coherent Voicecrafter 2000
Biamp/Coherent Voicecrafter 3000
Gentner GT-series echo cancellers
Gentner AP-800/AP-400
CLI codecs using internal echo cancellers
VTEL codecs using internal echo cancellers
Polycom codecs using internal echo cancellers
GPT/BT codecs using internal echo cancellers

When not to use the ***TANDBERG AudioScience***:

The ***TANDBERG AudioScience*** microphone is an entirely passive device. It depends simply upon its physical shape to block out unwanted noise. In this, it works exceptionally well. However, it is not magic. If it is mounted next to a noisy air vent, it will pick up that noise. How much noise is picked up will depend upon the location of the vent relative to the microphone, and the frequency characteristics of the noise itself. The TANDBERG 6000 codec has active noise reduction algorithms built in to compensate for this, or the use of a 250Hz High Pass Filter (such as Radio Design Labs ST-HP1 unit) with a mic mixer will often reduce the amount of noise that may be picked up. Care should be taken to either not use the ***TANDBERG AudioScience*** mic, or select a different room to videoconference in if the noise is excessive.

As described before, the ***TANDBERG AudioScience*** microphone is an "acoustically large" unmoving microphone. As a result, it does couple with the speakers in the room, and will create echo if no echo control devices are used. As a result of this acoustical coupling, the ***TANDBERG AudioScience*** microphone should not be used for sound-reinforcement applications. Unless special care is taken to eliminate or negate feedback, while still allowing the echo canceller to work, ringing or feedback will usually occur when the ***TANDBERG AudioScience*** microphone is used for sound-reinforcement. In summary, the ***TANDBERG AudioScience*** microphone works great for recording, and for transmission to the far end, but it should not be used to amplify signals within the same room as it is in.

Further information:

1. The Crown Boundary Microphone Application Guide. Crown International, PO box 1000, Elkhart, Indiana 46515-1000

™ The Pressure Recording Process™ is the basis for the PZMicrophones originally manufactured by Wahrenbrock Sound Associates, LTD. Crown PZMicrophones are now manufactured under license from E.M. Long Associates and their agent, Synergetic Audio Concepts.

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