

# SYSTEM DESIGN AND THE IMPORTANCE OF A C O U S T I C S

- Will your communication or emergency notification system broadcast intelligible speech messages in addition to alarm tones?
- Will your system include multiple speaker towers or a combination of speaker tower(s) and single speakers?
- Do you want to be confident that employee alarms will be capable of being perceived above ambient noise by all employees?
- Do you want to save money on installation costs?
- Wouldn't it be reassuring to know that acoustical experts with over 60 years experience are available to perform an Acoustic Survey of your facility?

While designing a communication or emergency notification system, it is critical to consider the acoustic characteristics of your facility and define these factors as they relate to the requirements of the communication or alarm system. This brochure contains information explaining some of the important acoustic considerations. GAI-Tronics is pleased to provide this information to help you make an informed decision when choosing and designing communication systems.

A professional acoustic survey will ensure the intelligibility of voice alarm messages and increase recognition of tone signals for all personnel. After all, hearing the message is the whole reason for having a communication and notification system, isn't it?

Issues specific to industrial environments should be reviewed and addressed prior to the alarm system's design phase. By identifying acoustic obstructions and challenges during an Acoustic Survey, the system can be designed to eliminate or reduce these effects.

An Acoustic Survey will help define the type of system necessary to meet your communication needs. When designing a communication or emergency notification system, you must consider:

- Acoustical phenomena
- Facility features - internal and external
- Areas requiring coverage
- Regional environmental conditions

## Variables Affecting Acoustics

An Acoustic Survey will determine the most effective way to overcome noisy areas and provide communication to all employees, despite acoustic phenomena. All of the following characteristics, individually or combined, will affect the acoustical design.

### Multiple Speech Signal Arrival

A critical factor in designing distributed high power cluster systems is maintaining speech intelligibility when multiple speaker towers are installed. Sound travels at a specific speed whether the sound is a whisper or a shout. Sounds originating from two speaker towers at different distances from a given point will be heard at that point at different times.

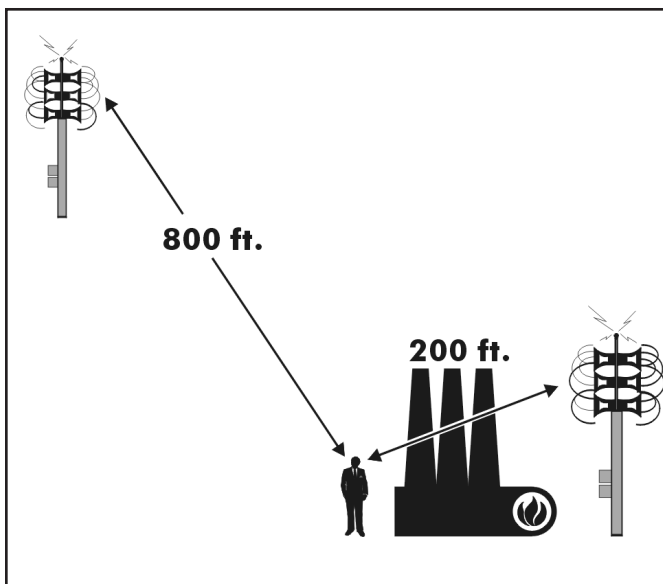
If a message arrives at a single point (from two different towers) over a half second apart and arrives at approximately the same volume (within 6 decibels), the speech message will be unintelligible.

The effects of multiple speech signal arrival can be greatly reduced by strategically locating speakers with precise dispersion angles to minimize overlapping of coverage areas. Pre-recorded voice messages which use a slower speech rate can also reduce the effects of multiple speech signal arrival.

### Acoustical Shadowing

Physical obstructions prevent suitable broadcast levels in the shadow of the obstruction. If an obstruction is present, the sound level reduction will be significant. The signal loss is caused by the obstruction's partial absorption of the sound.

Areas experiencing acoustical shadowing can be eliminated by repositioning loudspeakers of adjacent areas to compensate for the shadowing effect. In some instances, the best solution may be single loudspeakers strategically positioned to overcome acoustical shadows.



**Figure 1.** Often the combined effects of Multiple Speech Signal Arrival and Acoustical Shadowing make the task of speaker placement more difficult than dealing with these problems individually. It is typical to encounter both of these factors in industrial settings.

In Figure 1, the sound level originating from each tower is equal. The arrival times are over one half second apart due to the distance. The volume level is within six decibels due to acoustical shadowing from the building. The result is an unintelligible message.



**Figure 2.** Acceptable solution: Minimal obstructions exist and tower is located near the noise source.

## High Noise Areas

Process areas can produce extremely high decibel levels thus making communication difficult. Figure 2 represents an acceptable solution because the tower is in the worker's line-of-sight (no obstruction) and the tower is located near the noise source.

A speech or tone message should be six to ten decibels above the prevailing ambient noise. For high noise areas, similar to Figure 2, it is critical to place the loudspeaker as close as possible to the sound source. If a loudspeaker is not mounted close enough to the noise source, the speech will be too loud in the speaker's direct area and not loud enough near the noise source.

In some cases, it is possible that the sound levels created by operating machinery will surpass the ability of the speaker to broadcast an intelligible message as shown in Figure 3. The signal output level of the tower can be increased in order to compensate for the noise source; however, exceeding recommended output levels during alarm activation could cause hearing damage to personnel. In addition to the hearing damage, extremely loud broadcasts are also prone to distortion. Increasing the signal output level can be an acceptable solution provided the output level of the tower does not exceed the recommended decibel limit of 123dB.



**Figure 3.** Unacceptable solution: Obstructions and noise producing machinery restrict intelligibility of alarm messages.



**Figure 4.** Acceptable solution: Tower signaling system integrated with distributed loudspeaker and/or visual indicators enhance employee awareness.

If it is determined by the Acoustical Survey that a tower system is not a viable solution, a distributed loudspeaker system may be the best solution. A distributed loudspeaker system provides flexibility when placing the speakers by allowing the loudspeakers to be located near the noise source as well as in other areas requiring coverage. This solution is capable of covering all areas where personnel are working. For extremely high noise areas where personnel are required to wear hearing protection, strobes or other visual indicators may be necessary as shown in Figure 4. The Acoustic Survey will determine which of these solutions is right for your facility.

### **Reverberation**

The audibility of tone or speech message can be affected by echoes. Sound reflected from a surface impairs the listener's ability to comprehend the broadcast. Large open area, such as warehouses, can be prone to reverberation. One way to minimize the effects of reverberation is to select loudspeakers with the correct dispersion angles.

### **Weather Conditions**

Because weather conditions, such as wind speed and direction, can contribute to sound attenuation, it is unrealistic to design a system without considering their impact. For example, an additional six to eight decibel loss in sound pressure can occur over a distance of 300 feet with wind speeds of 15 to 20 miles per hour when the wind direction is from the listener towards the signal source.

Additional variations in sound signal levels due to temperature and humidity can range from three to 10 decibels per 1,000 feet based on the regional environmental extremes. We will also review any climate history documented by the facility. An average decibel loss will be calculated and taken into account when selecting speaker coverage to help compensate for environment conditions.

## **GAI-Tronics® Acoustic Services**

### **Why should GAI-Tronics perform the Acoustic Survey?**

With more 70 years of acoustic and speaker layout experience, GAI-Tronics is ideally suited to provide this service. You will feel confident in knowing that the Acoustic Survey is being completed by someone who knows communication equipment and is familiar with acoustical architectural layout.

State-of-the-art equipment will be used to identify sound signal levels throughout the facility. Problem areas will be identified and worst case scenarios will be simulated to ensure that the system will be effective under all anticipated ambient conditions.

The effectiveness of your system is dependent on the sound quality it produces – without intelligible signaling, the system is rendered useless. An Acoustic Survey will eliminate the guesswork and place the right speakers in the right locations for the right solution.

## **Acoustic Survey Benefits**

### **Reduced Installation Costs**

Realizing there is more than one way to install a system, GAI-Tronics will review all options before selecting the design that will reduce installation cost without sacrificing sound quality or coverage.

### **Employee Safety**

A system is valuable only if it is capable of being understood. Under emergency conditions this need is intensified: an Acoustic Survey will ensure that your employees hear and understand alarm messages.

### **Regulations**

Federal regulations state, “The employee alarm shall be capable of being perceived above ambient noise or light levels by all employees in the affected portions of the work place” (Occupational Safety and Health Administration, “Occupational Safety and Health Standards for General Industry, (29 CFR, Part 1910.165)”.

### **Defined System**

The Acoustic Survey will identify the type of system that best meets your communication needs by considering all variables affecting sound quality and coverage. This information will play a major role in determining the type and the positioning of equipment. Detailed documentation will be presented on customer provided drawings. A quotation will be supplied listing the equipment offered and any other pertinent information.

### **Optimum Performance**

GAI-Tronics provides a solution after considering all acoustical situations specific to your facility. Because industrial facilities have special acoustical considerations, factors including acoustical shadowing, reverberation, and multiple speech signal arrival will be evaluated during the Acoustical Survey to achieve intelligible speech broadcasts.

## Importance of Proper Speaker Tower Placement

An Acoustic Survey is especially critical when messages are broadcast over speaker towers. The Acoustic Survey will accurately position speaker towers for optimal usage. Because towers cannot easily be relocated, positioning needs to be right the first time.

Determination of effective audible coverage and prediction of sound signal levels is based on calculation of the distance from the speaker tower to the farthest area of desired coverage. The signal loss is calculated based on average environmental conditions, the directivity of the loudspeakers, and the power available to the loudspeakers.

The objective is to obtain a speech signal level of six decibels above the prevailing ambient noise at or near the zone boundary (if additional zones are present). Six decibels represents an established minimum speech-to-noise ratio for acceptable intelligibility. To achieve this ratio across large open areas, it is critical that the loudspeakers be placed in the area of the zone which exhibits the highest sound intensity. This placement ensures that a minimum six decibel signal-to-noise ratio will exist regardless of distance traveled toward the loudspeakers. Also, sound pressure levels will not exceed safe signaling levels in the proximity of the loudspeaker cluster.

GAI-Tronics is the leading supplier of durable communications for all types of industrial facilities. Since our founding in 1946, we have designed thousands of systems for industries including Chemical, Petrochemical, Power Generation, Pulp and Paper, and many more.

With the growing emphasis on employee safety, and ever-increasing federal regulations, we have expanded our expertise to the design and manufacture of systems specifically designed to provide Emergency Notification and Communication. Our extensive experience in industrial communications allow us to offer high quality systems adaptable to every facility's needs.



**USA** Toll Free 1 (800) 492-1212 Tel (610) 777-1374  
**UK** Tel +44 (0)1283 500500  
**Italy** Tel +39 02 48601460  
**Asia** Tel +(65) 6282 2242 (Press 4 for GAI-TRONICS)  
**Australia** Tel 011-61-28-851-5000

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