TECHNOLOGY SPOTLIGHT

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The Voice of the Channel
SD&I SECURITY DEALER & INTEGRATOR

# Designing for Intelligibility

## *Key considerations when creating a mass notification system*

Recent high-profile emergencies, including natural and man-made disasters, have increased the demand for mass notification systems (MNS). Today's threats have reinforced the growing need to provide clear, concise and intelligible voice messages that communicate how people should respond in an emergency.

In order to properly plan, design and measure intelligibility, it is important for security dealers and integrators to first understand emerging codes and standards, space requirements and influential factors.

### Intelligibility Codes & Requirements

Intelligibility is the degree to which people understand what is being communicated. The National Fire Protection Association's (NFPA) latest national fire alarm and signaling code standards, NFPA 72 2013, defines intelligible as "capable of being understood; comprehensible; clear." If a voice message is not understood by occupants in a facility, then the MNS has failed and may have caused more harm than good.

According to Chapter 24 of the standard on emergency communications systems (ECS), the loudspeaker layout of an MNS must be designed to ensure both intelligibility and audibility. In the 2013 edition, updates were made to clarify intelligibility requirements. Previously, codes specified intelligibility must be verified via quantitative test methods or other methods acceptable to the Authority Having Jurisdiction (AHJ). The new codes state that voice communications must be verified as being distinguishable and understandable and a simple listen test, or a qualitative assessment, is permitted by code.

While the NFPA does not require quantitative testing measurements for intelligibility, it is permitted. In fact, Department of Defense facilities are required to test voice intelligibility using Common Intelligibility Scale (CIS) or Sound Transmission Index (STI). The U.S. Army and Air Force require a minimum CIS score of 0.80. The U.S. Navy and Marine Corps require a minimum CIS score of 0.7.

Introduced in the NFPA 72 2010 edition, Acoustically Distinguishable Space (ADS) is also an important term to understand when designing for intelligibility. Defined by NFPA, an ADS is an ECS zone, subdivision, physically defined space or section of a room that might be distinguished from other spaces due to different acoustical, environmental or use characteristics, such as ambient sound pressure level.

All parts of a building intended to have occupant notification are subdivided in an ADS. As determined by the system designer during the planning and design phase of the ECS, each ADS must be identified as either requiring intelligibility or not requiring intelligibility. Updates for 2013 include new sections that require system designers to not only identify, but also document which locations will have audible notification and which spaces will not.

### Factors That Affect Intelligibility

Designing an ADS for intelligible voice can be impacted by many variables, including background noise, frequency response, space configuration, acoustical properties of construction materials, distortion and bandwidth, and speaker characteristics. Here are some of the key factors that affect intelligibility:

***Signal-to-Noise Ratio*** compares the sound level output from the speaker to ambient noise in the room. It is the obscuring of voice due to background noise — the higher the ratio, the greater the intelligibility. In Chapter 18, NFPA recommends an average of 15 decibels (dB) over ambient noise. A level higher than 15 dB results in reduced returns in terms of improving intelligibility.

***Frequency Response:*** Most fire alarm system speakers produce frequency responses of 400 hertz (Hz) to 4 kilohertz (KHz). Commercial sound systems can usually distribute frequency responses of 125 Hz to 12.5 KHz, and professional sound systems can deliver frequency responses of 20 Hz to 20 KHz. Since humans can hear from approximately 50 Hz up to 22 kHz, the wider the frequency response of a speaker, the better it is at reproducing the frequencies in the original signal; thus, the chance is increased that the message will be understood.

Another key consideration is that most of the average energy is in vowels, which lie below 3 kHz; however, the most critical elements of speech are the consonants, which lie above it. The burst of high-frequency sound that distinguishes consonants occurs between 4 kHz and 14 kHz. For example, in an emergency, intelligibility reduces the chances of Stair B being misinterpreted as Stair D, Stair C or Stair E. If the loudspeaker reproducing that speech cannot han-

All photos courtesy Cooper Notification

**Top: Mass Notification systems are particularly useful in school and other campus situations, where a voice message must be quickly distributed among a large number of people.**

**Above: Many poor evacuation systems are the result of trying to compensate for an insufficient amount of speakers with too much volume.**

**Left: When designing an outdoor mass notification system, be sure to account for wind, temperature, humidity and changes resulting from time and season.**

dle certain frequencies, some of the information will be lost. According to the NFPA, an ADS that differs from another space because of frequency and level of ambient noise might require speakers and system components that have a wider frequency bandwidth.

***Physical Room Characteristics:*** Room reverberation depends on the physical characteristics of the space, such as room dimensions, construction materials, occupants and furnishings. NFPA states that the amount of reverberation in a room diminishes when the room includes construction features, people or furnishings that absorb sound. To reduce reverberation, designers should locate loudspeakers away from hard surfaces and point the speakers towards soft, absorbent surfaces.

Designing for intelligibility must include collaboration between the system designer, architect and interior designer. The ECS designer should have an understanding of the acoustics of the architectural design. According to the Fire Protection Research Foundation 2008 Report, *"Intelligibility of Fire Alarm and Emergency Communication Systems,"* designers will need to know all room dimensions, use, occupancy, finishes and treatments, as well as speaker polar plots. A design analysis could reveal that an intelligible system is not achievable unless some features of the architecture are changed.

## Design Trends

An intelligibility report developed by the National Electrical Manufacturers Association (NEMA), states that designers and engineers have the greatest effect on speech intelligibility by their choice of equipment; the number, distribution and placement of loudspeakers; and the power at which they are driven. According to NFPA, in order to achieve an intelligible voice message in certain situations, a distributed sound level with minimal sound intensity variations is required, which differs from past fire alarm design. It is not simply a matter of turning up the volume or increasing the speaker wattage. Many poor evacuation systems are the result of trying to compensate for an insufficient amount of speakers with too much volume.

The rule of thumb for enhanced intelligibility is increasing the number of speakers and using the lower tap settings instead of increasing the sound output — as increasing the wattage of a speaker can often distort the message. Optimizing intelligibility can equate to as much as eight times as many speakers used just to achieve audibility.

The deal point-source (speaker to listener) is 20 feet or less. Ceiling height should be speaker spacing. For example, if the ceiling is 12 feet high, space the speakers 12 feet apart for intelligibility, as opposed to 24 feet apart for audibility.

## Designing for Outdoor Areas

The same principles also pertain to designing intelligible systems for outdoor areas; however, there are additional parameters to consider such as wind, temperature and humidity, as well as the changing of the environment due to seasons, age and time.

For example, vegetation growth affects sound. Designing a wide-area MNS in the middle of winter when trees are bare without considering trees in full bloom, can greatly affect the intelligibility of the system.

Referring to NFPA 72 2013, consulting a sound professional and utilizing commercially available software tools are recommended when designing spaces and rooms for voice intelligibility. It is also important to note to include all stakeholders as part of the design process, such as the architect, interior designer and the AHJ. ▮

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