Directional Sound Performance Findings

Scott Lang
R&D Manager
scott.lang@systemsensor.com

Mike Dybas
Engineer
mike.dybas@systemsensor.com

System Sensor
3825 Ohio Avenue
St. Charles, IL 60174
(630) 377-6674

Introduction

After a fire has been detected in a building and its occupants notified, those individuals need to quickly find their way to an exit or area of refuge. Typically, fire safety professionals rely on visible exit markings and pre-planning to identify egress paths. As buildings and occupancies have grown in size and complexity, achieving an egress design goal has become a complex and expensive undertaking.

Even in relatively small occupancies, lives have been lost in fires as occupants all move toward the same exit – typically, the way they entered. In addition, changing fuel loads have reduced the amount of egress time available.

While codes require that emergency exits be visually marked, oftentimes in an emergency, occupants bypass or miss the closest safe exit due to the lack of visibility (smoke), confusion and lack of clear direction, or the tendency to seek out the exit by which they entered the building.

Directional sound is one method that has been shown to enhance the ability of building occupants to find the closest safe exit during an emergency. Adding sound to the visible indicators that are already required helps to overcome the limitations of relying only on one exit marking method.

Codes and Standards

In 2007, the NFPA 72® (National Fire Alarm and Signaling Code) technical committee for notification appliances recognized the need to create a new category of notification appliance called “Exit Marking Audible Notification Appliances.” These devices are defined as notification appliances that mark building exits and areas of refuge by the sense of hearing for the purpose of evacuation or relocation (see NFPA 72: 3.3.160.1.1). Beyond the definition, requirements were also added to Chapter 18 (Notification Appliances) to detail minimum device sound pressure level requirements and how directional sounders must be installed. NFPA 72 does not require the use of directional sounders.

Despite recognition of the technology in NFPA 72, there is currently no industry standard that can be used to measure the effectiveness of audible notification appliances in creating a sound that will direct building occupants to an exit. However, there is a “publicly available

specification" developed by BSI (British Standards Institute) known as PAS 41:2003. PAS 41 was developed by BSI committee FSH/12/5 (Alarm devices, voice alarm evacuation sub-systems and emergency voice communications). This document describes the construction and performance requirements for directional sounders. It also proposes a method to quantify the ability of a person to locate the sound source using subject-based testing similar to that used to measure intelligibility.

PAS 41 describes a localization test in which a subject is seated in a fixed position encircled by 36 identical notification appliances. The sounders are mounted about 1.2 meters from the ground and 3 meters away from the subject. The subject must sit facing the front unit and not move his head while the testing is conducted. A random unit is then activated and the subject, while using a record diagram as a guide (see Figure 1), must visualize which sounder is on and record the test number on the sheet.

This test is repeated 18 times for each subject. A group of ten subjects must correctly identify which sounder activated at least 75 percent of the time for the sounder to be considered "directional."

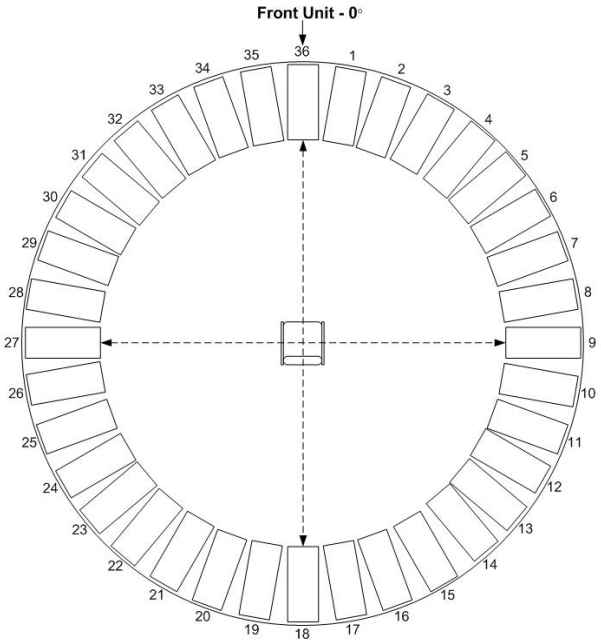

Figure 1: Record Diagram

Testing

In order to get a better understanding of the requirements of PAS 41and assess its applicability as a quantitative measurement of directionality, System Sensor conducted a number of experiments with dozens of volunteers with self-reported normal hearing to perform the localizing tests. A number of test modifications were also evaluated with the goal of improving the test method and gauging the overall viability of the document. Both directional and standard audible notification appliances (including temporal 3 and whoop tones) were used in the tests and System Sensor was able to rank the directionality of the sound from each of the devices.

In phase 1, the testing was performed exactly as it was described in PAS 41. The following System Sensor notification appliances were used in the testing: ExitPoint® directional sounder, chime set to whoop tone, standard 2-4 kHz temporal 3 sounder, and 3 kHz pure tone mini horn. Table 1 shows the percentage of correct location identifications made by the group as a whole as well as the minimum and maximum percentage of correct identifications by any one subject. The results show that none of the notification appliances would pass the 75% threshold to be considered "directional" according to PAS 41.

Product	% Correct	Min. %	Max. %
ExitPoint	36	6	61
Chime (Whoop)	18	0	44
Standard Sounder in T-3	19	6	39
Mini horn in T-3	7	0	22

Table 1: Percentage of correct identifications of sound during localization test

After analyzing the results from phase 1 and discussing the test methodology with the test subjects, it was determined that many of them had difficulty visualizing the correct number (location) of the sounder that was being activated during the tests. The tests from phase 1 were repeated with the subject seated in a chair that could swivel. While each sound was played, the subject could rotate the chair to locate the sounder. The sounders were also numbered during this round of tests. Table 2 compares the results of the original test to the modified test method. The results show that the subjects' ability to locate the correct sounder improve greatly if they are allowed to rotate to face the sound.

Product	Percent Correct Phase 1	Percent Correct Phase 2
ExitPoint	36	90
Chime (Whoop)	18	55
Standard Sounder in T-3	19	69
Mini horn in T-3	7	27

Table 2: Percentage of correct identifications in original and modified test method

One concern that is often raised in discussing the use of exit marking notification appliances is the effect of competing sounds on the ability of people to localize the sound. In phase 3 of the testing, we repeated the test as it was conducted in phase two for ExitPoint and the whoop tone, but added three competing sounds: a standard sounder, a 520 Hz sounder, and a mini horn. The additional sounder was wall mounted approximately 3.1 meters to the right of the test subject (near sounder number nine in Figure 1). It was continuously activated at about 87 dBA during the localization test. Table 3 shows that competing sounds do diminish the subjects' ability to localize the sound.

Product	Competing Sound	Percent Correct
ExitPoint	Standard sounder	87
ExitPoint	520 Hz	77
ExitPoint	Mini horn	78
ExitPoint	None (Phase 2)	90
Whoop	Standard sounder	45
Whoop	520 Hz	44
Whoop	Mini horn	29
Whoop	None (Phase 2)	55

Table 3: Results for ExitPoint and whoop tone with and without competing sounds.

Conclusions and Recommendations

The results of this testing show that different types of sounders vary widely in their ability to create directional sound. The sound created by the ExitPoint directional sounder enabled people to correctly locate the device more often than other sounders. This result occurred even when competing sounds were played during the localization test. The testing also showed that PAS 41 could be used for listing directional sounders if certain changes are made. The primary change required would be to allow subjects to rotate in their chair in order to face the sound.

In terms of further testing in this area, an assessment as to the repeatability and reproducibility of the test method needs to be conducted. Additional sounds could also be tested to assess their localization potential.

Based on these tests, PAS 41 should be moved forward on the path to become a full standard with the changes that have been described. PAS 41 should also be considered for inclusion into EN 54 Part 3 and UL 464.