

INCREASING THE INTELLIGIBILITY OF INDUSTRIAL PUBLIC ADDRESS:

WIDE-AREA DISPERSION SPEAKERS AND THE BENEFITS OF A LINE ARRAY

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The Purpose of This White Paper

With an ever increasing emphasis placed on plant safety and protection among manufacturers and processors, there has been a heightening awareness of the issues surrounding the clarity of industrial public address systems. Demonstrating this building awareness and an interest in clearly defining desirable PA outputs, the National Fire and Protection Agency (NFPA) has in fact developed a guideline for intelligibility, and the creation of an intelligibility standard is currently under consideration by the agency.

The purpose of this paper is twofold: 1) To generate discussion about this important area and 2) To present a technical discussion of how Federal Signal addresses enhanced intelligibility through one of its product systems.

Three domains for discussion:

- I. Coverage – Effectiveness and Financial Return on Investment:
What to consider in terms of equipment and placement when balancing output and cost.
- II. Intelligibility – On Being Heard and Understood:
What acoustical factors to consider when deploying a PA system.
- III. System Optimization – Leveraging Location and Mounting:
How a well thought-out installation plan can make a difference.

I. Extensive Coverage Area and Reduced Installation Cost

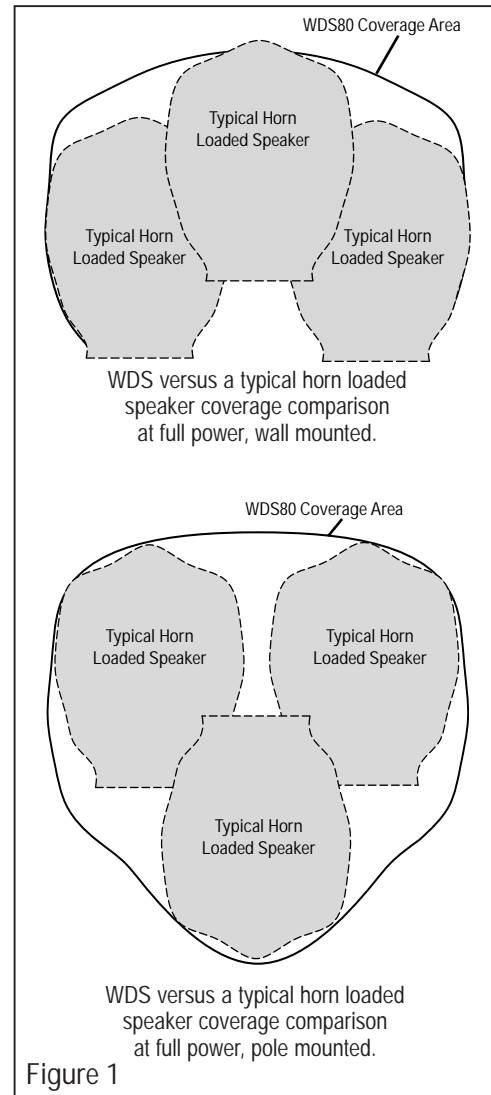
Federal Signal's Wide-Area Dispersion Speakers provide facilities engineers with a way to achieve extensive coverage with a smaller number of speakers than is required in most conventional installations. Consequently, the time and cost associated with installation and maintenance is drastically reduced. The factors that contribute to the system's impressive capability are as follows:

a. Wide Horizontal Beam Spread

The use of multiple transducers working in unison has the equivalent radiating surface area and performance capabilities of a 10" speaker. In addition, they afford the benefit of usable sound output that completely surrounds the speaker (360°) as shown in the horizontal pole mounted polar plot in Figure 1.

b. Consistent Sound Level

Mounting the transducers in a vertical line, technically referred to as "a line array," causes the sound to radiate in a cylindrical shape rather than the spherical shape generated by most other speakers. With this radiation pattern, the sound level decays at only a 3 dB per distance doubled rate instead of the 6 dB per distance doubled for a typical speaker.



Technical Concepts:

“Transducers” vs. “Speakers”

In this discussion, the term transducer refers to an electrical component that transforms electrical energy into acoustical energy. Multiple transducers can be housed in a single cabinet to form a single speaker.

Cylindrical vs. Spherical Sound Patterns

Sound can radiate from its source in a variety of patterns or shapes.

The sound pressure level over distance will vary depending on the shape of the transmission. The construction of acoustical equipment and its location will affect the sound radiation shape and intensity.

Horizontal and Vertical Beam Spread

Beam Spread is the angle formed between the center of the speaker and the two points on either side of the principal axis of a speaker

where the acoustical power drops to one-half (-3 dB) of the on-axis value. In essence, a speaker radiates most of its power over this angle.

Sound Reflectivity

Sound reflected off of floors, walls, ceilings and objects will reach its receiver later than the original sound that arrives directly. Consequently, this delay causes a negative effect on the clarity of the sound.

Distance On-Axis (feet)	WDS80 Speaker (dB)	A typical 103 dB @ 10' Speaker (dB)
10	103	103
20	100	97
40	97	91
80	91	85
160	85	79
320	79	73

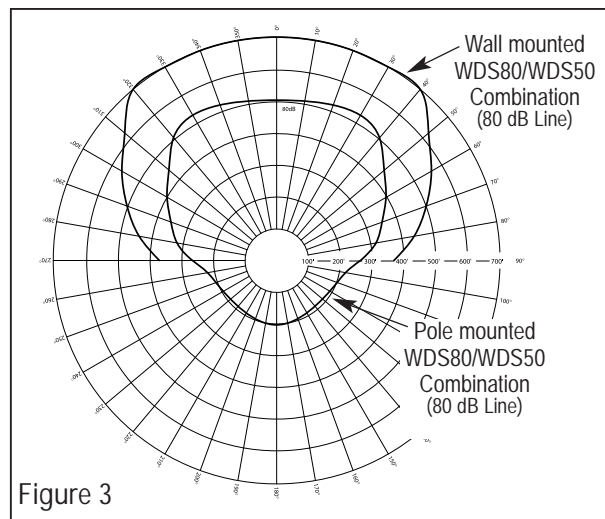
Figure 2

As can be seen in Figure 2, the sound level is much more consistent with respect to distance than is the case with typical speakers. This substantially reduces the undesirable situation where the level near the speaker must be annoyingly loud in order for individuals at a greater distance to hear the speaker clearly.

c. Increased Coverage Area

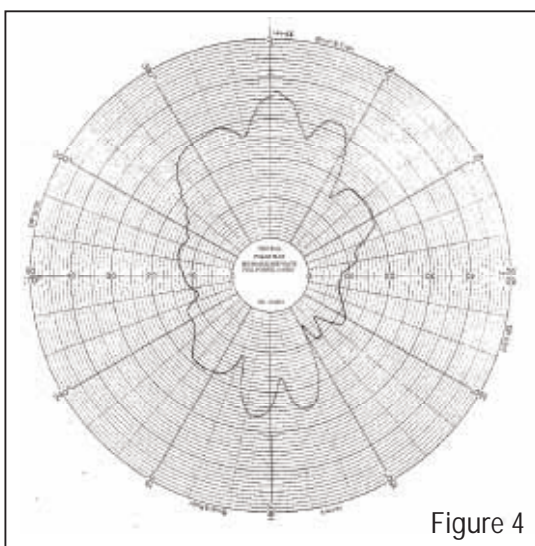
The Model WDS80 covers the same area as up to four typical industrial horn loaded speakers (Figure 1).

The Model WDS80 can be clearly heard for a distance of over 400 feet on the radiating axis of the speaker. Adding the Model WDS50 can increase the distance to 700 feet. (See Figure 3 for coverage information.)



II. Greatly Improved Intelligibility

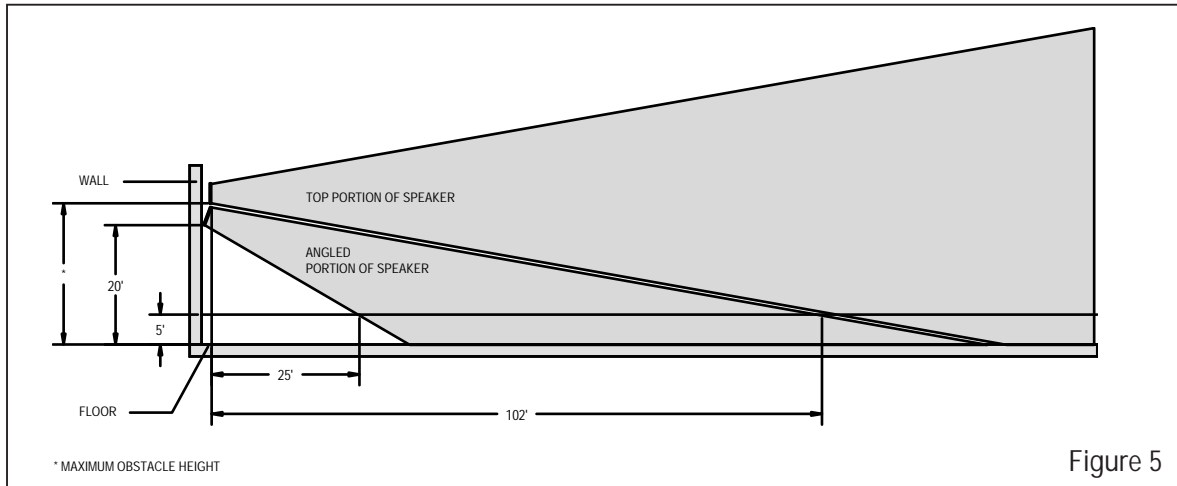
The unique design of the WDS80 Speaker Array produces a marked improvement in public address and voice message intelligibility. With a frequency response from 200 to 11,000Hz, the speaker array reproduces low and high ends of the voice spectrum, enabling it to overcome the poor acoustics commonly associated with warehouses, factories and large open facilities.



Another benefit to cylindrical sound radiation is the controlled vertical beam spread it achieves. As can be seen on the vertical polar plot in Figure 4, the beam spread is only 10°. This substantially improves intelligibility indoors because it prevents any significant sound level from reflecting off the floor or ceiling, thus arriving behind the original signal and making communication difficult to understand. In an outdoor environment, sound predominately radiates towards intended listeners without the normal loss of sound energy into the atmosphere.

III. Mounting Location and Speaker Angle

For optimum coverage, the bottom of the vertical



portion of the WDS80 must be above any obstacles in the coverage area. Although an elevated mounting such as this would normally create less coverage in close proximity to the speaker due to the tight vertical beam spread, the lower portion of the Federal Signal WDS80 can be angled towards these listeners, thereby eliminating the problem.

In the example below (Figure 5), the bottom of the speaker is mounted twenty feet above the floor. By angling the lower portion of the speaker twenty degrees, one need only be twenty-five feet from the speaker to be in its beam spread. In fact, a speaker incorporating the correct use of the angling feature can clearly be heard directly underneath the speaker. This occurs since the sound level loss due to being outside the beam spread is compensated for by the extremely close proximity of the listener to the speaker. Without the angling feature, the listener in this example would need to be over one hundred feet away to be in the beam spread and able to clearly hear the speaker.

The following chart (Figure 6) should be used to determine the optimum angle adjustment based on the distance between the speaker bottom and the floor.

Optimum Angle for Lower Speaker	Height: Bottom of Speaker to Floor
0°	5 to 10 feet
5°	> 10 to 12 feet
10°	> 12 to 15 feet
15°	> 15 to 18 feet
20°	Greater than 18 feet

Figure 6

Product mounting at a height of less than five feet is not recommended since intelligibility will be compromised by having the speaker too close to the reflective floor and coverage will be diminished due to the fact that people and objects in the coverage area will block and/or absorb sound.

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