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Performance-Based Engineering Options for Audible Occupant Notification

by Robert P. Schifiliti, P.E., FSFPE

Occupant notification is not just about being able to hear or see a signal. It's all about trying to change the behavior of the target audience in the most efficient and effective way possible. It's also about trying to balance costs versus mission. Prescriptive code-based methods work for most situations, but not for challenging environments. This presentation is focused on audible notification but also emphasizes the importance of integrating other forms of notification.

This presentation shows how analysis and engineered solutions can meet goals and reduce system costs. How can a system for tone and voice be optimized for high noise environments? Effective occupant notification in challenging environments is really quite easy and cost effective. But, it requires you to actually do some analysis and engineering – more than just applying simple prescriptive code requirements and industry rules-of-thumb. The proposed design must work with Emergency Operation Plans. And, you have to show the authority having jurisdiction how the proposed design will work with the E-Plan and why it will be effective.

Attendees will learn performance-based options that optimize tone signals for a given audible noise spectrum. The presentation will show how to design an effective acoustic signal. You will also learn how to designate Acoustically Distinguishable Spaces to develop a strategy that can be approved by an AHJ and that will meet the system's mission goals.

Bio:
Mr. Schifiliti is a licensed Fire Protection Engineer and holds a Master of Science degree in Fire Protection Engineering from Worcester Polytechnic Institute (WPI). He has over thirty-eight years' experience in fire protection and prevention work. For much of that time he has developed expertise and focused his engineering practice on the design, analysis and forensic investigation of fire detection, alarm and signaling systems. Mr. Schifiliti is the past chair (2006 – 2016) of the NFPA Signaling Systems for the Protection of Life and Property Correlating Committee, which is responsible for the development of NFPA 72, National Fire Alarm and Signaling Code and NFPA 720, Standard for the Installation of Carbon Monoxide (CO) Detection and Warning Equipment. He is a member of the Notification Appliances technical committee for NFPA 72, which he chaired from 1993 to 2003 and is a member of the Commissioning and Integrated Testing technical committee (NFPA 3 and NFPA 4). Mr. Schifiliti is the author of the "Notification Appliances," chapter in the NFPA Fire Protection Handbook and the principal author of the "Design of Detection Systems" chapter in the SFPE Handbook of Fire Protection Engineering. In addition, under a grant from the NFPA Fire Protection Research Association, he studied and developed engineering strategies for visible signaling in big box stores.

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Presented at the
2018 Annual Fire Protection & Life Safety Seminar
of the New England Chapter of the SFPE

by: Robert P. Schifiliti, P.E., FSFPE
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SFPE New England

Agenda

- Introduction
- Goals
- Conventional Audible Signaling
- Audible Signaling
  - Noise analysis
  - Signal design
- Speech Intelligibility

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Housekeeping

- Format
- Questions
- Cell phones and pagers
- Background / Introduction

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Risk Analysis			
Emergency Plans			
Emergency Preparedness Plan		**Emergency Response Plan**	
Communications Needs		**Communications Needs**	
Target Audience	**Channels**	**Target Audience**	**Channels**
10 – 100 Targets	**2 – 10 Channels**	**5 – 20 Targets**	**5 – 10 Channels**

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Occupant and Staff Signaling Goals
Alerting, Notification, Information & Instructions

- Goal: Effect Peoples' Behavior
- Occupants
  - Evacuate
  - Relocate
  - Do as we say
- Staff
  - Provide information to trigger established Emergency Operation Plans

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Conventional Audible Signaling

- Make noise
  - 15 dB above average noise during OCCUPIED period (10 dB for private mode)
    OR
  - 5 dB above peak noise that lasts at least 60 seconds
- Any sound, any frequency

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Operating Modes

- Public operating mode
- Private operating mode

Private Mode Signaling
The Real World

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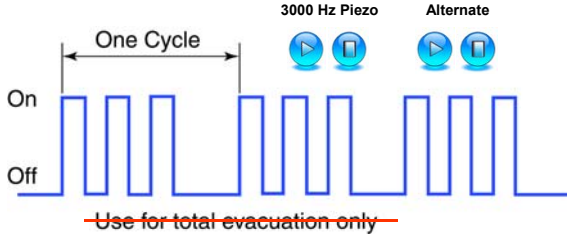
Conventional Audible Signaling

2013

- T3 now permitted for relocation & partial evacuation



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Conventional Audible Signaling
Low Frequency Audible In Sleeping Areas

2010

- 520 Hz Square Wave
  - Systems – effective 2014
  - Household – effective on adoption

520 Hz Sq. Wave 3000 Hz

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Audible Notification
Psychoacoustics

"The Mosquito and the Picket Fence – A Modern Day Fire Alarm Fable About Broad-band versus Narrow-band Signaling", NEMA Supplement in Fire Protection Engineering, Society of Fire Protection Engineers, Bethesda, MD 20814, three parts Winter, Spring and Summer 2005 issues by Robert P. Schifiliti, P.E., FSFPE.

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Signaling in Challenging Environments
Narrow Band Signaling

- Where possible, stop noise sources automatically
- Measure ambient noise spectrum throughout
- Analyze/merge data to create worst-case frequency profile
- Design signal frequency content
- Document required loudness
- Engineer the system

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Audible Notification
Narrow Band Signaling

- +10 dB over masked threshold in at least one octave band

or

- +13 dB over masked threshold in at least one one-third octave band

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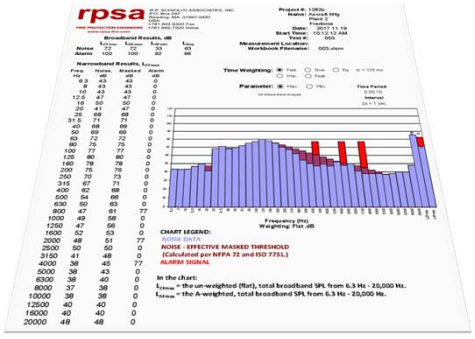
Audible Notification
Narrow Band Signaling



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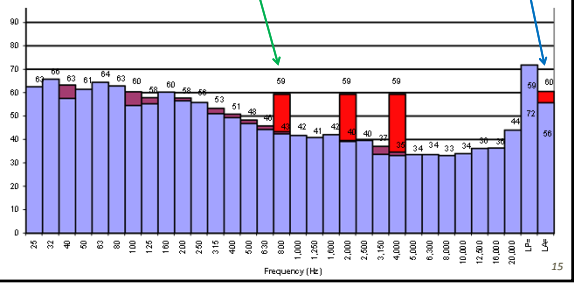
Narrow-Band Signaling
Example: Manufacturing Plant Noise

Noise (masked) at 800 Hz = 43 dB
Required alarm = 43 + 13 = 56 dB
+3 dB F.O.S. = 59 dB

Total noise = 56 dBA.
Total Alarm signal = 60 dBA.
S/N = 4 dB
(Would fail dBA code req.)



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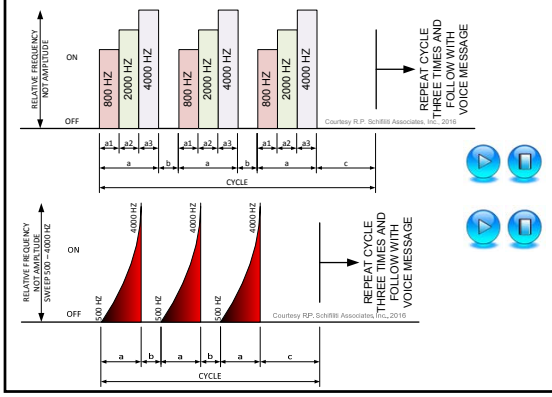
Modified T-3



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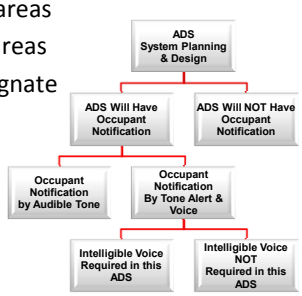
Signaling in Challenging Environments
Voice Intelligibility

- Required by Ch. 24, ECS
- Not required in all areas
- Not possible in all areas
- Designer must designate Acoustically Distinguishable Spaces (ADSs)



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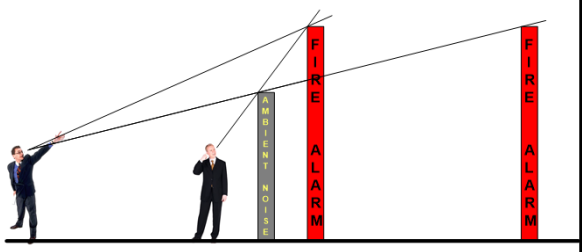
Acoustically Distinguishable Spaces (ADSs)



Use the concept of ADSs for a TOTAL Notification Plan: Tone, Voice, Visual Alerting, Visual Information, etc.

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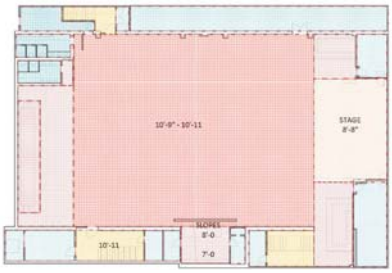
Audible Notification Voice Intelligibility

Sample ADS plan for a nightclub.



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Factors in the Communications Path That Affect Speech Intelligibility

- Speech source
- Microphone properties
- Booth noise
- Electrical noise
- Loudspeaker properties
- Room acoustics
- Noise in the room
- Corrected Components

Simulation courtesy of Arup Acoustics, NY, NY

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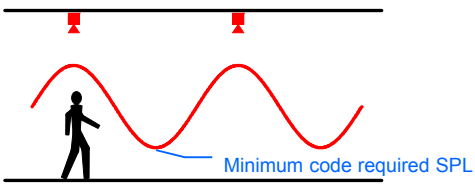
The Quantity and Spacing of Speakers



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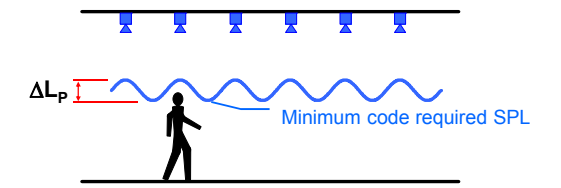
The Quantity and Spacing of Speakers



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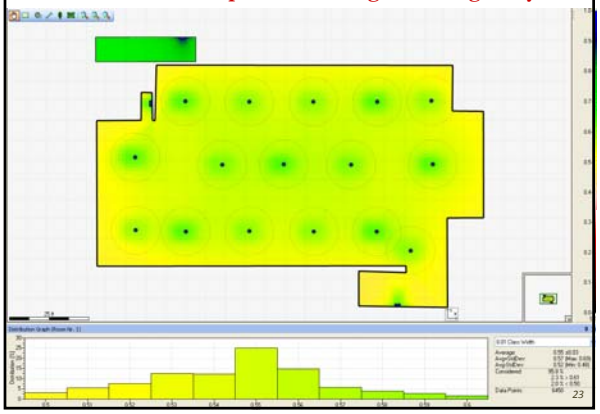
EASE Evac Computer Modeling of Intelligibility



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Conclusions

- Prescriptive code requirements work most of the time.
- Challenging situations require new ideas
  - A sudden, dramatic change in the environment
  - Information and instructions delivered with clarity, simplicity and authority
  - You must have several layers of communications channels (modalities)

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Conclusions

- Designers and authorities must think more about results and be less concerned with methods.
- The designer must document goals, plan strategies, anticipate & address concerns and communicate the plan to owners and AHJs.

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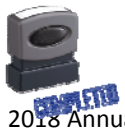

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