Understanding ECS, Risk Analysis and Voice Intelligibility

Jack Poole, PE

Introduction

- Graduate from Univ. of Md., BS in FPE
- Poole Fire Protection – Est. in 1991
- Licensed PE in FPE (48 states)
- Member of NFPA, SFPE, ICC and ABPA
- Member of multiple NFPA Technical Committees, including NFPA 72, NAC
- NFPA Board of Directors, Aviation Section
- 26 Years of Fire Protection Experience

Topics to Be Covered

- Paradigm Shift and Industry Changes
- What is an Emergency Communication (Mass Notification) System?
- In-Building, Wide Area and Distributed Recipient Systems
- What is a “Risk Analysis”, and Why?
- Understanding of Intelligibility and How to Test Intelligibility
Unfortunate Historic Events

Weather Events
- Joplin Tornado
- Hurricane Katrina
- Japan Flood

Terroristic Attacks
- World Trade Center 93’ & ’01
- Yale University (Unabomber)
- Murrah Building

Nuclear & Chemical Attacks, Spills & Contamination
- Bhopal Gas Tragedy, India
- Three Mile Island

Base/Campus Shooters and Snipers
- Virginia Tech
- Fort Hood

Paradigm Shift
- September 11, 2001 was a major driver
- Forced Fire Departments to rethink the way they operate and respond to incidents
- Re-evaluation by Owners and Designers of how to make buildings safer
- Being prepared for the Emergency Event
- NFPA 1600, Standard on Disaster/Emergency Management & Business Continuity Programs
- Adequate Communication Capabilities
Industry Changes
NFPA 72 – 2010 Edition

- Significant NFPA 72 changes, now called...
  National Fire Alarm and Signaling Code

- Major Changes in format and addition of 3 new chapters (from 11 chapter to 29 chapters – 15 not used)
  - Circuits and Pathways
  - Emergency Control Functions & Interfaces
  - Emergency Communications Systems (ECS)

Industry Changes
NFPA 72 – 2010 Edition: Chapter 18 Notification Appliances

- Significant Chapter 18 changes (old Chapter 7)
- Intelligibility Designed and Measured in accordance with ISO 7240-19
- Established minimum indoor Intelligibility Values

<table>
<thead>
<tr>
<th>METHOD</th>
<th>Average Intelligibility</th>
<th>Single Point Minimum</th>
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<tbody>
<tr>
<td>10% of NSPR</td>
<td>0.30</td>
<td>0.10</td>
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<tr>
<td>25% of TSP</td>
<td>0.30</td>
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<td>50% of TSP</td>
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<tr>
<td>90% of TSP</td>
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- AHJ has authority to change minimum values

Industry Changes
NFPA 72 – 2010 Edition: Chapter 24 ECS

- Content from Chapter 6, Protected Premises Fire Alarm Systems
- Emergency Voice Alarm Communications
- One- and Two-Way Communication Service
- Chapter 24 is a complete set of requirements for emergency communications systems – including requirements from other chapters by reference
Industry Changes
UL 2572

- Standard for Safety for Mass Notification Systems
- Think of it as the UL 864 for Mass Notification System Control Units
- Equipment Standard

Industry Changes
UL 2572: Main Evaluation Points

- Construction
- Protection Against Injury to Persons
- Performance
  - General
  - Operation Tests
  - Common Requirements
  - Other tests
- Performance Tests – HPSA
- Manufacturing and Production
  - Line Tests
- Marking and Instructions

Industry Changes
UL 2572: Why is it needed?

- ECS is different than Fire Alarm
  - Different functions
  - Different purpose
  - Different equipment
Industry Changes
Clery Act: History

- The "Clery Act" is named in memory of 19 year old university freshman Jeanne Ann Clery who was raped and murdered while asleep in her residence hall room on April 5, 1986.
- Jeanne's parents, Connie and Howard, discovered students hadn't been told about 38 violent crimes on their daughter's campus in the three years before her murder.

Industry Changes
Clery Act: Connection to ECS

- 2008 Amendment - A statement of current campus policies regarding immediate emergency response and evacuation procedures, including the use of electronic and cellular communication:
  - Immediately notify the campus community upon the confirmation of a significant emergency or dangerous situation involving an immediate threat to the health or safety of students or staff occurring on the campus.
  - Publicize emergency response and evacuation procedures on an annual basis in a manner designed to reach students and staff.
  - Test emergency response and evacuation procedures on an annual basis.

Industry Changes
Clery Act: What does that mean?

- Notify campus community immediately:
  - College campuses turn to ECS to meet this requirement.
Questions

• If FA and MNS is integrated into a combined system, will the control unit have to comply with both UL 864 and UL 2572?
• Are they any questions at this point?

Emergency Communication System
What is it?

• Emergency Communication System (ECS), also known as Mass Notification (MNS), is a system designed to provide "real time" instructions and information to a large number of people spread out over a large complex, campus or multi-building facility in the event of an emergency
• May use voice communications, visible signals, text, graphics, tactile or other communications methods

Emergency Communication System
Purpose

• Provide communication capability in the event of any type of emergency
• Initiate evacuation, relocation, or to provide information on fire, weather, terrorist events, biological, chemical or nuclear emergencies to occupants
• Assist emergency responders to deal with real time conditions during an emergency
Emergency Communication System
Two Types of ECS

- One-Way System – recipient doesn’t have ability to provide information to sender (e.g., speakers that sound a tone, pre-recorded, or live voice message)
- Two-Way System – allows sender and recipient to communicate with each other (e.g., radios and telephones used by police & fire agencies)

Emergency Communication System
What Drives it?

- Owners
- NFPA 72 – Chapter 24 (2010)
- UFC 4-010-01
- UFC 4-021-01, includes intelligibility performance criteria
- Clery Act (kind of)

Emergency Communication System
Key Elements of ECS

- In-Building ECS
  - Audible and/or Visible
  - Integration with other systems
- Wide Area ECS
  - Also called Campus or City
  - High Power Speaker Arrays
- Distributed Recipient
  - Emails
  - PC Pop ups
  - Instant Messages
  - Pagers & Phones
  - SMS Messages (short message service)
In-Building ECS Components: Control Panel

- Often combined with FA system
- Sends digital voice messages to building occupants
- Send and receive digital messages and live page from the Campus or Base Wide System
- Has the ability to activate strobes and text displays

In-Building ECS Components: Local Operating Console

- Perform “live” paging to meet the specific emergencies
- Minimum of eight (8) switches for activating messages and a microphone
- Protected in a small wall mounted enclosure (non-lockable)
In-Building ECS
Components: Notification

- Provide a "clear" strobe for fire alarm events and an "amber" strobe for mass notification events

(Military Requirement for Army and Air Force only)

In-Building ECS
Components: Displays

- Service people with hearing disabilities by providing a method of sending the Emergency Communication Alert messages

Wide Area ECS
(also called Campus Wide ECS)

- Send Digital Voice Messages to any HPSA or In-Building ECS
- Receive emergency info (e.g. fire alarm data) from any In-Building ECS
- Have a Graphical Interface to display the campus and information for the operator
- Send live messages to any HPSA or In-Building ECS
- Print out all system events
HPSA Zones
(High Power Speaker Arrays)

- Inform people outside of buildings
  - Can send a voice message to individual HPSA’s or to all outdoor zones
- Strategically locate throughout campus or facility
- Each location should be at a height to be unobstructed by buildings and trees

Distributed Recipient ECS
Interface with other Systems/Functions

- Systems / Functions include:
  - PC Pop ups
  - Messages to Social Networks
  - Pager Interface
  - Email Server
  - Instant Messages
  - SMS Text Messaging to Cell Phones
  - VoIP Telephone Systems to Voice Mail

Emergency Communication System
Benefits of Combination Fire Alarm/ECS

- Built-in compatibility
  - Easier to program
  - Easier to interact properly
- Survivable
  - Paging systems are not built distributed messaging and survivability
- Expandable/灵活
  - Scalable
  - Ease of reconfigure
• Utilize multiple audio circuits to announce different messages simultaneously to multiple areas.

For example:
- Message A, “Evacuate the building using the South entrance”
- Message B, “Evacuate the building using the North entrance”
- Message C, “Do not evacuate the building, wait for further instruction”

Emergency Communication System
Multiple Channels Available

Types of ECS Technology

• Tier 1
  – Immediate & intrusive
  – Sirens, indoor/outdoor
  – Loudspeakers
  – Fire voice evacuation
  – Electronic signage
  – Code compliant

• Tier 2
  – Personal alerting
  – SMS Text (cell phones)
  – Computer pop-ups
  – Tone alert radios
  – Email broadcast (Internet)
  – Automated voice dialing & text messaging

• Tier 3
  – Public alerting
  – Sat/AM/FM radio broadcasts
  – Sat/off-air TV broadcasts
  – Location-specific
  – Text messages

• Tier 4
  – Locally relevant alerting
  – Handheld bullhorns
  – Radio cell phones
  – Two-way radios
Who needs it or is using it?

- College campuses
- Universities
- Military bases
- Corporate campuses
- Large manufacturing facilities

Owner Responsibilities

- Safety to life and property
- Per NFPA 72 (2010), hire a qualified System Designer who is...
  - Registered, licensed, or certified by a state/local authority
  - Certified by a nationally recognized certification organization acceptable to the AHJ
  - Factory trained and certified for fire alarm system design and ECS design of the specific type/brand of the system and who are acceptable to the AHJ

Military Projects

- UFC 4-021-01 Requirements for System Designers
  - ECS/MNS shall be designed under the supervision of a registered fire protection engineer (FPE), a registered fire protection engineer (FPE) having at least four years of current experience in the design of fire protection and detection systems, or by an engineering technologist qualified at NICET Level IV in fire alarm systems
Emergency Communication System

I think I need it, ... now what?

- Where do I start?
- What do I need?
- Who am I trying to protect?
- What is my objective?
  - Notify
  - Evacuate
  - Stay in place

Don't plan for the emergency situation (there are too many possibilities.) Plan for protecting the people in your charge.

- Where do I start?
- What do I need?
- Who am I trying to protect?
- What is my objective?

Risk Analysis

What is it?

- The design of the emergency communication/mass notification system shall be specific to the nature and anticipated risks of each facility for which it is designed
- The design of the mass notification system shall include the preparation of a design brief that is prepared utilizing recognized performance-based design practices
- The Risk Analysis process should include all applicable Stakeholders (team approach)

Emergency Communication System

Understanding An Emergency Event

- Understand and consider how:
  - An event may progress
  - An event may change
- Example: Sep. 11, 2011
  - Prepared for an emergency event in one building, not both
  - Fire Department directed occupants to remain in the South Tower
Understanding ECS, Risk Analysis and Voice Intelligibility

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Risk Analysis
Stakeholders

- Any individual, group, or organization that might affect, be affected by, or perceive itself to be affected by the risk, such as:
  - Authority Having Jurisdiction
  - Facility Owner / Users / Employees
  - Facility Maintenance Staff (I-T-M)
  - Emergency Responders
  - Insurance Company or Insurers
  - Fire Protection Design Professional (FPE)
  - Design & Construction Team

Risk Analysis
Stakeholders: Interests

- What are their interests?
- Combining/reconciling interests?
- Consensus among the group?

Risk Analysis
Process of Performing A Risk Analysis

1. Identify the range of hazards, threats, or perils:
   - Identify the hazards, threats, or perils that impact or might impact your organization, infrastructure and/or surrounding area

2. Determine the potential impact of each hazard, threat, or peril by:
   - Estimating the relative severity, frequency, and vulnerability of each hazard, threat, or peril
   - Estimate how vulnerable your people, operations, property and/or environment are to each hazard, threat, or peril
3. Categorize each hazard, threat, or peril according to how severe it is, how frequently it occurs, and how vulnerable you are.

4. Develop strategies to deal with the most significant hazards, threats, or perils
   - Develop strategies to prevent, mitigate, prepare, respond and recover hazards, threats, or perils that impact or might impact your organization and its people, operations, property, and environment.

Risk Analysis: Assessing the Risk

- To fully understand the risk(s) that you are attempting to be addressed, you should develop some questions to ask. The answers should then be evaluated by a licensed professional that is familiar with Risk Assessments. The following slides provide a list of questions that might help assess the level of risk and type of system desired.

Risk Analysis: Assessing the Risk: The Questions

- What is the type of emergency event?
- What is the urgency of the emergency event?
- What is the anticipated or expected severity of the emergency event?
- What is the certainty of the emergency event, is it happening now?
- What types of natural disasters, accidental hazards, or human-caused events could provide life threatening scenarios?
Risk Analysis
Assessing the Risk: The Questions

- What is the location of the event or from what direction is the event approaching?
- Based on the potential hazards or incident, which occupants and personnel should be notified?
- What zone or areas of the complex or building should receive the emergency message(s)?
- What instructions or message should we send to the personnel we are notifying?

Risk Analysis
Assessing the Risk: The Questions

- What is the expected performance or reliability of the system?
- Is a voice system the best to convey the message or desired actions? Intelligible?

Remember, when an emergency event occurs, the response must be immediate and deliberate, and there is no time for indecision. Therefore, keep it SIMPLE.

Risk Analysis
Sample Outline

1. General Context
   a. Purpose
   b. Scope
2. Project Description
   a. Summary
3. Risk Assessment
   a. Assessing the Risk
   b. Contingency Planning
   c. Risk Assessment Results
4. Number of Persons
5. Occupancy Characteristics
6. Anticipated Threats
7. Source of Information
8. Operational Goals and System Effectiveness
9. Staffing
10. Emergency Response Personnel
11. Risk Identification
   a. Use of Risk
   b. Risk Rating
   c. Risk Mitigation
   d. Mitigation Options
12. Cost and Effectiveness of Prevention(s)
13. Risk Reduction Recommendations
14. Summary/Next Steps
   a. Clear Environment
   b. Testing
Questions

- Of the stakeholders you discussed, who is best to lead the Risk Analysis?
- Any other questions at this point?

In-Building ECS Design
Things to Consider: Voice vs. Non-Voice

- Type of Occupants to Notify
  - Hearing Impaired
  - Multiple Languages
- Number of Occupants
  - Inhabited Building
- Building Size
  - High-rise Building
- Type of Building
  - Hard Surfaces
  - Large Open Areas

- Access to Control Equipment
  - Staff only
  - Staff and Visitors
  - Emergency Responders
- Capabilities of Control Equipment
  - Initiate Messages
  - Live voice announcements
- Location of Control Equipment
  - Security, Manager Office
  - Areas/rooms accessible to the Public
  - Secure rooms (located Electrical room)
In-Building ECS Design
Things to Consider: Notification

- **Types**
  - Audible
  - (Narrowband Signaling)
  - Visual
  - Textual

- **Locations**
  - Areas/rooms accessible to the Public
  - Staff/work rooms

- **Effectiveness**
  - Audibility
  - Intelligibility
  - Messages

- **Zoning**
  - Number of floors
  - Building Size

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In-Building ECS Design
Visual Notification

- **Strobes**
  - Used in high-noise environments, in areas occupied by hearing impaired individuals, or in areas where audible may not be desired (i.e. hospital operating rooms)

- **Selectable Candela Output (15, 15/75, 30, 75, 110)**

- **Clear verses Amber or other color**

- **Text Messages Signs or Boards**
  - Only used to supplement audible and visual

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In-Building ECS Design
Effectiveness: Audibility

- **Measured in decibels (dBA)**

- **Public Mode Audibility**
  - Sound level at least 15 dBA above the average ambient sound level or 5 dBA above the maximum sound level having a duration of 60 seconds

- **Private Mode Audibility**
  - Sound level at least 10 dBA above the average ambient sound level or 5 dBA above the maximum sound level having a duration of 60 seconds
In-Building ECS Design
Effectiveness: Intelligibility

- The capability of being understood or comprehended (distinguishable and understandable)
- Predicted according to “Standardized Transmission Index (STI) or “Common Intelligibility Score” (CIS)
- Better to use lower wattage settings and add additional speakers
- Higher wattage settings will create more reverberation and distortion

In-Building ECS Design
Effectiveness: Messages

- Evacuation message is required to be preceded and followed by three-pulse temporal pattern emergency evacuation signal
- The message shall be repeated at least three times
- Public Areas – Audible and Visual Notification
- Employee Areas - Staff rooms or office areas where non-accessible to the public are typically permitted to have audible notification appliances only

NFPA 72 Design Considerations
Intelligibility: History

- NFPA 72 – 1996, addressed Emergency Voice/Alarm Communication, no Intelligibility Requirements for these “voice” system
- NFPA 72 – 1999, addressed in Section 4-3.1.5
- Section 4-3.1.5 - Emergency voice/alarm communications systems shall be capable of the reproduction of prerecorded, synthesized, or live (for example, microphone, telephone handset, and radio) messages with voice intelligibility.
- NFPA 72 – 2002 and 2007
- Section 7.4.1.4. (Basically the Same at 1999, Section 4-3.1.5)
- Intelligibility is REQUIRED
NFPA 72 Design Considerations
Intelligibility: Technical Concepts

• Important building characteristics: occupancy type, ceiling height, surface features, etc.
• Factors related to talker/listener transmission path:

NFPA 72 Design Considerations
Intelligibility: Definitions and Annex Text

• Acoustically Distinguishable Space (ADS). An emergency communication system notification zone, or subdivision thereof, that might be an enclosed or otherwise physically defined space, or that may be distinguished from other spaces because of different acoustical, environmental or use characteristics such as reverberation time and ambient sound pressure level.

ADS is important new terminology to understand and apply when both designing and testing voice systems.

NFPA 72 Design Considerations
Intelligibility: Chapter 18

• 18.4.10 *Voice Intelligibility.
  - 18.4.10.1* Acoustically Distinguishable Spaces (ADS) shall be determined by the system designer during the planning and design of all emergency communications systems.
  - 18.4.10.2 Each ADS shall be identified as requiring or not requiring voice intelligibility.
  - 18.4.10.3* Where required by the authority having jurisdiction, ADS assignments shall be submitted for review and approval.
NFPA 72 Design Considerations

Audio Intelligibility

- When designing to meet intelligibility requirements, it is better to use lower wattage settings and add additional speakers. Higher wattage settings will create more reverberation and distortion.
- Army & Air Force – CIS = 0.8
- Navy & Marines – CIS = 0.7

ECS Testing

- Initial Acceptance Testing
  - All new systems are to be inspected and tested
  - The AHJ is to be notified prior to the initial acceptance test
- Reacceptance Testing
  - When an initiating device, notification appliance, or control relay is added, should be functionally tested
  - When an initiating device, notification appliance, or control relay is deleted, another device, appliance, or control relay on the circuit is to be operated.
  - Modifications or repairs to control equipment hardware warrant re-test of control equipment

Intelligibility Testing

Test Methods

- Two basic categories of intelligibility testing:
  - Subject (human) based testing; and
  - Instrument based test methods (used in this project)
- Well documented in literature
- Relationships established
Intelligibility Testing
Key Terminology

- STI – Speech Transmission Index – A rating of speech transmission quality with respect to intelligibility.
- STI-PA – Speech Transmission Index-Public Address – a “signal” used to be able to consistently measure STI or intelligibility.
- Audibility Test- Measurement of the sound pressure level of a tone signal in accordance with the requirements of NFPA 72.

Intelligibility Testing
Testing Equipment

- Audio Source Unit (ASU) or Talkbox
- STI-PA Audio Recording (CD)
- Field Test Meter (analyzer)

Intelligibility Testing
Acceptability Criteria

- 90% of the readings must pass
- Minimum of 0.45 STI (0.65 CIS)
- Average of 0.50 STI (0.70 CIS)
- Designed to Test the System
  Design/Components – not input signal
Intelligibility Testing
Challenges with Testing

• Areas of high ambient sound pressure levels ("noise") may be incapable of meeting the Acceptability Criteria.
• Impulse sounds made during measurements may impact measurement accuracy or cause instrument error. (Example: door or file drawer closing).
• Natural variation in ambient noise levels may affect the results.

Intelligibility Testing
Test Method - Occupied vs. Unoccupied

• Preferred method is to perform testing when furnished and occupied.
  – Perform Testing

  • It is possible to test when Unoccupied
    – Gather Ambient
    – Gather Ambient with STIPA
    – Gather Occupied
    – Obtain the "Corrected" STI Value*
      *Note – Computer Program Calculation

Intelligibility Testing
Test Equipment Calibration

• Insert the STI-PA Test Tone CD into the ASU
• Place the ASU microphone =1” from speaker
• Apply power to the ASU & activate the STI-PA signal
• Adjust the ASU volume so that the STI Analyzer’s reading is approximately 92 dBA
• Keeping the analyzer in approximately the same position, measure the STI
• The equipment is working properly if the reading is greater than 0.91 STI or 0.96 CIS. Perform 3 tests
Post-Construction

Owner Responsibilities

- Research shows that the message is one of the most important factors in determining the effectiveness of a warning system
- Develop effective emergency messages that provide the following content:
  - Information on the hazard and danger
  - Guidance on what people should do
  - Description of the location of the risk or hazard
  - An idea of when they need to act
  - The name of the source of the warning (who is giving it)
- Warning style is also crucial – specific, consistent, certain, clear, and accurate

Questions

- Does the code (NFPA 72) require the intelligibility of a voice system to be tested/measured with a meter?
- What companies manufacture Intelligibility Meters?
- Any other questions at this point?
Contact Information

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Thank You