

Ensuring First Responder Safety

With Emergency Responder Communications Enhancement Systems



**ERCES
Trainer Ltd**

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**For
State of Kentucky
Code Officials**

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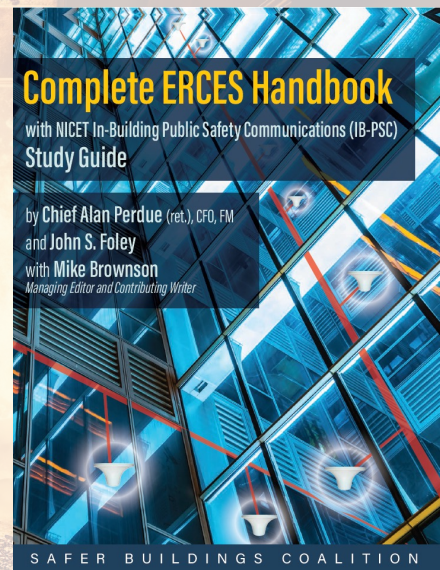
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Introduction

Managing Editor and one of the
Principal Authors of
The Complete ERCES Handbook

Contents of this presentation were
extracted from chapter 23 "The
Acceptance Test" plus other chapters of
this Handbook

www.ERCEShandbook.com



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Agenda

- Introduction to ERCES
- Codes and Standards
- Decibels and Noise
- System Acceptance Testing
- Documentation

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It's Not Easy

Radio Enhancement first included in IFC in 2009
vs Sprinkler code which has been around over 100 years

- Includes complexities such as understanding RF
- Radio networks
- BDA/Amplifier behaviors
- Applicable codes and standards include IFC510, NFPA 72, 1221, 1225, NFPA 70 (NEC)

And it is often one of the last systems tested

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It is a Critical Life Safety System

It MUST work when needed

AHJ acceptance testing is the last chance to verify operation before occupancy

NIOSH LODD reports include inadequate communications in their top 5 factors in firefighter deaths and injuries

Plus we must consider the public's health and safety

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Stakeholders



AHJ
Radio network FCC license holder
Systems Integrator
GC/building owner
The Public (and more)

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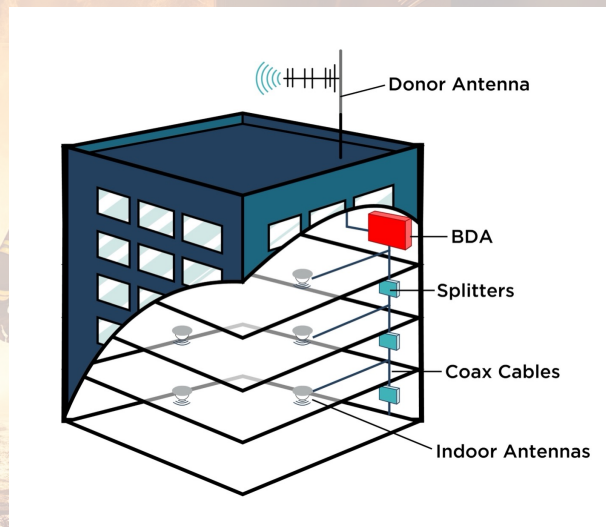
Introduction to ERCES

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ERCES System Example

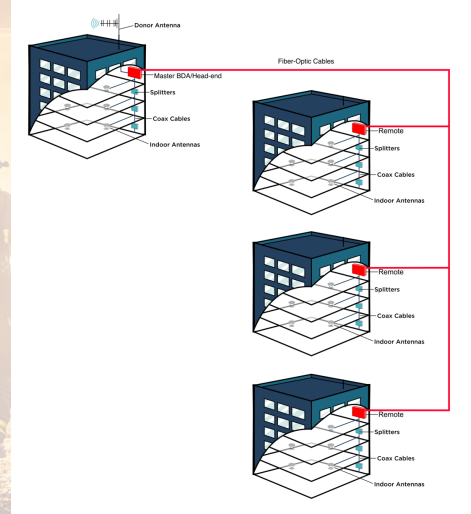
- Donor antenna picks up outdoor radio signals
- BDA amplifies the incoming signal
- DAS = A system of cables, splitters and antennas distributes the RF signal
- Operates in reverse path to amplify indoor signals toward the radio site



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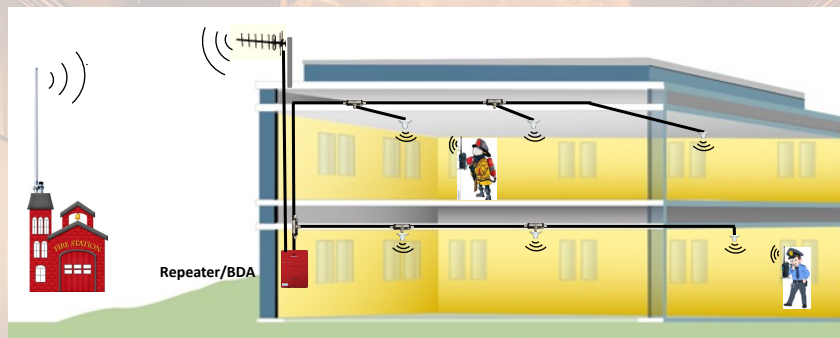
ERCES Active System Example

- Donor antenna picks up outdoor radio signals
- Master BDA amplifies the incoming signal and converts to fiber
- Remote amplifiers connected to master BDA via fiber
- Each remote serves separate buildings, or different areas of a large building



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ERCES in Action



Radio site transmits, signal is received by donor antenna and amplified throughout building by BDA

Signal received strong and clear by users indoors

Indoor radios transmit, signal received by indoor antennas, amplified by BDA and broadcast out donor antenna

Signal received loud and clear at radio site

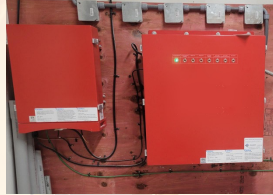
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Components of an ERCES

Donor Antenna



Donor Coaxial Cable



BDA/Amplifier

Battery Backup Unit

Indoor Coaxial Cable



Splitters, Tappers, and Couplers



Indoor Antennas



Handbook Chapter 12

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ERCES Codes and Standards

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ERCES Codes and Standards

- NFPA 72, 2010 edition
- NFPA 1221 editions 2013, 2016, and 2019
- NFPA 1225 edition 2022
- IFC 510 all editions since 2009
 - IFC510 2018 and later references NFPA
- NFPA 70 (NEC)



Chapter 5 of the Complete ERCES Handbook has an excellent review of each applicable code and standard written by Chief Alan Purdue (ret.) CFO, FM.

Codes for grounding and bonding of ERCES components are found in NFPA 70 (NEC), articles 250, 810, and 820.

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Radio Coverage is a Requirement

IFC and NFPA requires radio coverage to be tested in new buildings and if fail, an in-building communications enhancement systems installed. (Note exceptions)

IFC 510, 2021 Edition²⁷

510.1 Emergency responder communication coverage in *new buildings*.

Approved in-building, two-way emergency responder communication coverage for emergency responders shall be provided in all new buildings. In-building, two-way emergency responder communication coverage within the building shall be **based on the existing coverage levels** of the public safety communication systems utilized by the jurisdiction, measured at the exterior of the building. This section shall not require improvement of the existing public safety communication systems.

Exceptions:

1. Where api system in maintaine
2. Where it i needed.
3. In facilitie componer operation: automatic

NFPA 1, 2021 Edition 11.10.2 General.²⁸

In all *new and existing buildings*, minimum radio signal strength for emergency services department communications shall be maintained at a level determined by the AHJ.

11.10.3 In-building emergency responder communication enhancement systems shall comply with the design, installation, testing, inspection, and maintenance requirements in Section 9.6 of NFPA 1221 and 11.10.3.1 through 11.10.11 of this Code.

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Typical NFPA & IFC Code Requirements

- Establishes minimum radio signal level or a minimum voice quality included depending on version. Since 2016 specifies voice quality testing (DAQ of 3.0 or better).
- 90% (NFPA pre-2019) or 95% (IFC & NFPA post 2019) grid test areas must meet the minimum signal level or voice quality level required.
- 99% of critical areas must be covered such as stairwells, exit pathways, fire control room, standpipe locations and any area identified by the AHJ.
- BDAs must have FCC type acceptance
- BDA supervisory alarms shall be connected to fire alarm panel when one exists
- Battery backup of 12 hours must be included (IFC required 24 hours prior to 2016)
- Active equipment in NEMA 4 cabinets, batteries may be in NEMA 3R
- Coaxial cable pathways may have survivability requirement
 - Removed for many construction types in NFPA 1225 (non-high-rise sprinklered)
 - 2-hour backbone protection or fire rating matching building's structural fire rating

Typical NFPA & IFC Code Requirements (cont)

- Installer qualifications
- MUST get authorization to retransmit from FCC license holder
- Permit Required
- Listing of Equipment required (UL 2524 for the active equipment)
- Plenum Rated Coaxial cable required NFPA 1221, For NFPA 1225 follow NEC sections 7 and 8
- Lightning Protection Required in accordance with Article 820 of NEC (NFPA 1225)
- Technical Criteria to be provided by AHJ
- Must not cause noise at radio site (see later slides in Noise section)
- Minimum Isolation of Donor Antenna of 20dB greater than BDA gain
- BDA must have oscillation prevention mechanism (All UL2425 Listed units will comply)
- Dedicated annunciator required
- Compliance with FCC Part 90.219
- Other systems may not cause interference to public safety system

Code Comparison Worksheet at SBC Web Site

<https://www.saferbuildings.us/sbc-quick-code-reference-nfpa-2013-2022-and-ifc-2015-2024>

Return to Main Site

SBC Quick Code Reference - NFPA [2013 - 2022] and IFC [2015 - 2024]

- Click on Header Row to go to Codes Websites [Have you bought your code copies?]
- Updated July, 2022
- Members click here to download a customizable version
- Non Members click here for a copy of NFPA Codes or IFC Codes
- ©2009 Safer Buildings Coalition

TOPIC	IFC 2015	IFC 2018	IFC 2021	IFC 2024 DRAFT
Approved Emergency Services Department Communications Required	Sec. 510.1, 510.2	Sec. 510.1, 510.2	Sec. 510.1, 510.2	Sec. 510.1, 510.2 Note: Exception 4 One Story Buildings less than 12,000 Sq. Ft.
Field testing - Building Signal Coverage Assessment Required	510.6.3	510.6.4	510.6.4	510.6.4
Permit Required	Section 510.3	Section 510.3	Section 510.3	Section 510.3
Listing of Equipment	Not Specifically Addressed in Section 510	Not Specifically Addressed in Section 510	Sec. 510.4	Sec. 510.4
Limitation of External References	Not specifically addressed	Not specifically addressed	Not specifically addressed	Not specifically addressed
Signal Strength and Quality & Area Coverage Required	AS 48m Sec. 510.4.1 95% General - Sec. 510.4.1 99% Critical - Not Specifically Addressed in Sec. 510	DAQ 3.0 Sec. 510.4.1.1 95% General - Sec. 510.4.1 99% Critical - Sec. 510.4.2 Reference to NFPA 1221	DAQ 3.0 Sec. 510.4.1.1 95% General - Sec. 510.4.1 99% Critical - Sec. 510.4.2 Reference to NFPA 1221	DAQ 3.0 Sec. 510.4.1.1 95% General - Sec. 510.4.1 99% Critical - Sec. 510.4.2 Reference to NFPA 1221
IFC reference to NFPA 1221 or 1225 Standards	No	Sec. 510.4.2 Reference to NFPA 1221	Sec. 510.4.2 Reference to NFPA 1221	Sec. 510.4.2 Reference to NFPA 1225
Backbone / Riser Cable Defined	Not Defined	Not Defined	Refers to NFPA 1221	Refers to NFPA 1221
Distribution / Feeder Cable Defined	IFC 2015	IFC 2018	IFC 2021	IFC 2024 DRAFT
Pathway Survivability Fire Rating	Not Defined	Not Defined	Refers to NFPA 1221	Refers to NFPA 1221
Pathway Survivability Mechanical Protection	Not Specifically Addressed in Section 510 Referenced in 2013 NFPA 72 Section 24.3.6.8	Sec. 510.4.2 Reference to NFPA 1221	Sec. 510.4.2 Reference to NFPA 1221	Sec. 510.4.2 Reference to NFPA 1225
Plenum Rated Coaxial Cable Required	Not Specifically Addressed in Section 510 Referenced in 2013 NFPA 72 Section 24.3.6.8	Sec. 510.4.2 Reference to NFPA 1221	Sec. 510.4.2 Reference to NFPA 1221	Sec. 510.4.2 Reference to NFPA 1225

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Secondary Power Supply Requirements

- All code versions require a primary and secondary power source
- Typically a battery backup unit with either 12 or 24 hours of operation at 100%
- When connected to a compliant generator backup time reduced to 2 hours
- Primary power must be a dedicated AC circuit with lockout on the breaker
- Batteries may be housed in NEMA 4 or NEMA 3R enclosure
- AC power connections shall be hard-wired



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Cable Pathway Mechanical Protection

- Mechanical protection may be cable tray or conduit when cable is in exposed areas like parking structure.
- NFPA 1225 references NEC section 810 for mechanical protection standards
- Exposed donor cables on rooftops should be in conduit



Backbone Cable Pathway Fire Protection

- Backbone pathway enclosure may meet 2-hour, 1-hour or 0-hour based upon building's structural fire rating and sprinklers.

NFPA 1225, 2022 Edition³⁷

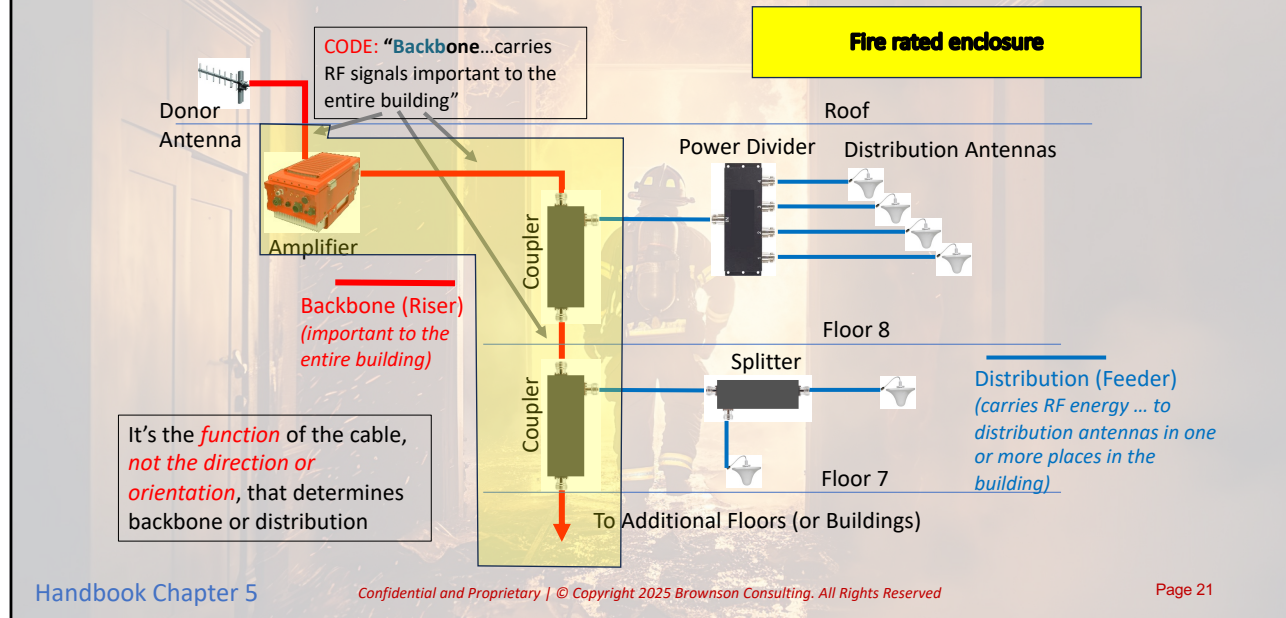
18.12.3.3 Backbone cables and backbone cable components installed in buildings that are fully protected by an automatic sprinkler system in accordance with NFPA 13 shall not be required to have a fire resistance rating.

- T n 18.12.3.4* Backbone cables and backbone cable components installed in nonsprinklered buildings, in buildings that are partially protected by a sprinkler system, or in high-rise buildings shall be protected from attack by fire in accordance with one of the following: 18.12.3.4(1) or 18.12.3.4(2)

NFPA 1221, 2019 Edition³²

3.3.10* Backbone. A communications cable in an in-building radio enhancement system that carries wideband signals important to the entire building, from the donor antenna, through the amplifiers, and to distribution antenna lines.

Backbone Protection



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IBC – Primary Structural Element Rating

Example: Type IA Construction – 10 story building

TABLE 601 FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV		TYPE V	
	A	B	A	B	A	B	HT		A	B
Primary structural frame ^f (see Section 202)	3 ^{a, b}	2 ^{a, b}	1 ^b	0	1 ^b	0	HT		1 ^b	0
Bearing walls	3	2	1	0	2	2	2		1	0
Exterior ^{e, f}	3 ^a	2 ^a	1	0	1	0	1/HT		1	0
Interior										
Nonbearing walls and partitions	See Table 602									
Exterior										
Nonbearing walls and partitions	See Table 602									
Interior ^d										
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT		1	0
Roof construction and associated secondary members (see Section 202)	1½ ^b	1 ^{b, c}	1 ^{b, c}	0 ^c	1 ^{b, c}	0	HT		1 ^{b, c}	0

For SI: 1 foot = 304.8 mm.

- a. Roof supports: Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.
- b. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members in roof construction shall not be required, including protection of primary structural frame members, roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.
- c. In all occupancies, heavy timber complying with Section 2304.11 shall be allowed where a 1-hour or less fire-resistance rating is required.
- d. Not less than the fire-resistance rating required by other sections of this code.
- e. Not less than the fire-resistance rating based on fire separation distance (see Table 602).
- f. Not less than the fire-resistance rating as referenced in Section 704.10.

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IBC – Primary Structural Element Rating

Example: Type IIIB Construction – 3 story wood frame

TABLE 601 FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A	B	A	B		A	B
Primary structural frame ^f (see Section 202)	3 ^{a, b}	2 ^{a, b}	1 ^b	0	1 ^b	0	HT	1 ^b	0
Bearing walls	3	2	1	0	2	2	2	1	0
Exterior ^{e, f}	3 ^a	2 ^a	1	0	1	0	1/HT	1	0
Interior									
Nonbearing walls and partitions	See Table 602								
Exterior									
Nonbearing walls and partitions	See Section 2304.11.2								
Interior ^d									
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	1 1/2 ^b	1 ^{b, c}	1 ^{b, c}	0 ^c	1 ^{b, c}	0	HT	1 ^{b, c}	0

For SI: 1 foot = 304.8 mm.

- a. Roof supports: Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.
- b. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members in roof construction shall not be required, including protection of primary structural frame members, roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.
- c. In all occupancies, heavy timber complying with Section 2304.11 shall be allowed where a 1-hour or less fire-resistance rating is required.
- d. Not less than the fire-resistance rating required by other sections of this code.
- e. Not less than the fire-resistance rating based on fire separation distance (see Table 602).
- f. Not less than the fire-resistance rating as referenced in Section 704.10.

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Code Equivalencies

NFPA 1225 has clarified many of the standards related to design and performance of an ERCES. Would highly recommend using 1225.

NFPA 1, 2018 Edition ²⁶

1.4 Equivalencies, Alternatives, and Modifications.

1.4.1 Equivalencies.

Nothing in this code is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety to those prescribed by this code, provided technical documentation is submitted to the AHJ to demonstrate equivalency and the system, method, or device is approved for the intended purpose.

1.4.1.1 * Compliance with Subsequent Editions of Referenced Publications.

The AHJ shall be authorized to accept subsequent editions of publications referenced in this code as evidence of compliance with the specified edition.

1.4.1.1.1 * Compliance with subsequent editions of reference publications shall be achieved by complying with the entire subsequent edition of the referenced publication.

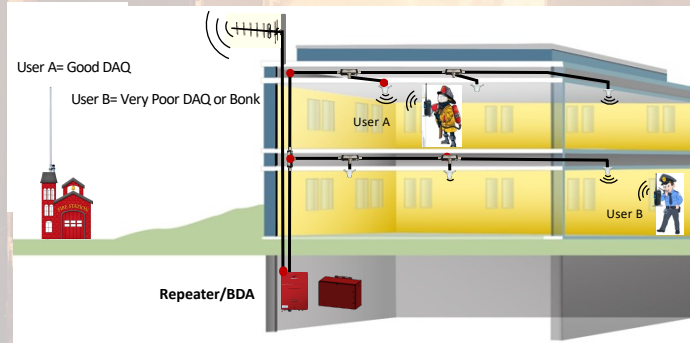
1.4.2 Alternatives.

1.4.3 Modifications.

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Antenna Density / Near-Far Performance

Too few indoor antennas creates problems when two radios transmit at the same time. The Far user may not be able to communicate. (IFC 510.4.2.8)



User A signal is received at BDA level

Adding more antennas improves coverage for User B and results in good audio quality

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Donor Antenna Mounting

The donor antenna shall be permanently affixed to the building unless approved by the AHJ. Movable sleds must have a sign as shown below.



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Limitation of External References

Beginning with NFPA 1225, 2022 edition it clarified that only sections specifically referenced in the standard shall apply. This helps eliminate confusion over the application of standards.

NFPA 1225, 2022 Edition³¹

18.1.2 The requirements of other chapters shall not apply to in-building emergency responder communications enhancement systems except where specifically referenced.

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System Testing, Initial and Annual

IFC and NFPA both require annual testing of the system to confirm performance. This consists primarily of validating coverage. Also includes verifying battery performance, alarm operation and BDA check.

I'll provide more best practices for acceptance testing later in this presentation.

IFC 2021⁶⁴

510.5.4 Acceptance test procedure.

1. Each floor of the building shall be divided into a grid of 20 approximately equal test areas. . . .
2. The test shall be conducted using a calibrated portable radio of the latest brand and model used by the agency talking through the agency's radio communications system or equipment approved by the fire code official.

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Minimum Qualifications of Personnel

IFC 510.5.3 has defined competency under the heading of “Minimum Qualifications of Personnel” as follows:

- A valid FCC-issued General Radiotelephone Operator’s License (GROL)
 - Note: This is being phased out since GROL provides no proof of qualifications to install ERCES
 - Suggest requiring NICET IB-PSC certification (In-Building Public Safety Communications)
- Certification of training by an approved school, organization, or manufacturer.
- Demonstration of adequate skills and experience satisfactory to the AHJ.



Technical Criteria to be Provided by AHJ

Must work with the radio system operator/administrator to determine some of these requirements

NFPA 1221, 2019 Edition⁴⁷

9.6.14 Technical Criteria.

N 9.6.14.1 The AHJ shall maintain a document of technical information specific to its requirements.

N 9.6.14.2 Technical information documents shall be kept in a secure place accessible to maintenance personnel but not accessible to the public.

N 9.6.14.3 Technical information documents shall contain, as a minimum, the following:

- (1) Frequencies required for the in-building enhancement system
- (2) Location and effective radiated power (ERP) of radio sites used by the public safety radio enhancement system
- (3) Maximum propagation delay — in microseconds
- (4) List of specifically approved system components
- (5) Other supporting technical information necessary to direct system design

Design Documents Required

IFC and NFPA clarify the requirements for design document submittals

IFC 510, 2018 Edition⁵⁹

510.4.2.7 Design documents. The fire code official shall have the authority to require “as-built” design documents and specifications for emergency responder communications coverage systems. The documents shall be in a format acceptable to the fire code official.

COMMENTARY: This information is readily available as documentation typically exists electronically where systems are designed and installed. Many jurisdictions utilize this type of information within their electronic records management systems and computer-aided dispatch systems. This section is consistent with other construction document requirements in Chapter 9 [of the IFC].



NFPA 1225, 2022 Edition⁵⁸

18.7 Approval and Permit.

18.7.1 Plans, including, but not limited to, specifications, link budget, and other information required by the AHJ and frequency license holder(s), shall be submitted for approval prior to installation.

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Monitoring by Fire Alarm

Not all buildings must have a fire alarm. Suggest remote annunciator in attended location

NFPA 1225, 2022 Edition⁵⁴

18.14.1 Fire Alarm System.

18.14.1.1 The system shall include automatic supervisory signals for malfunctions of the in-building emergency responder communications enhancement system that are annunciated by the fire alarm system in accordance with NFPA 72.

18.14.1.2 The system shall comply with all of the following:

- (1) Monitoring for integrity of the system shall comply with Chapter 10 of NFPA 72.
- (2) System supervisory signals shall include the following:
 - (a) Signal source malfunction
 - (b) Active RF-emitting device failure
 - (c) Low-battery capacity indication when 70 percent of the 12-hour operating capacity has been depleted
 - (d) Active system component failure
- (3) Power supply supervisory signals shall include the following for each RF-emitting device and active system components:
 - (a) Loss of normal ac power
 - (b) Failure of battery charger
- (4) The communications link between the fire alarm system and the in-building emergency responder communications enhancement system shall be monitored for integrity.
- (5) Where approved by the AHJ, a single supervisory input to the fire alarm system to monitor all system supervisory signals shall be permitted.

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Approval Prior to Installation

Prior to installation the AHJ and FCC license holder must approve the design and the equipment proposed.

IFC 510, 2021 Edition⁶⁰

510.5.2 Approval prior to installation.

Amplification systems capable of operating on frequencies licensed to any public safety agency by the FCC or other radio licensing authority shall not be installed without prior coordination and approval of the fire code official.

NFPA 1225, 2022 Edition⁶¹

18.2 Approval.

18.2.1* Where an in-building emergency responder communications enhancement system is used, the design of the system shall be approved by the AHJ and the frequency license holder(s).

18.2.2 The design of the system shall be performed by a RF system designer.

What Part Does the FCC Play?

They make the rules for anything that radiates RF. (47 CFR, Part 90.219)

- FCC License Holder must approve ALL retransmission of their signals in writing.
- Signal Boosters limited to no more than -43dBm of noise radiated (@ 10kHz bandwidth).
- Intermod products limited to no more than -30dBm (@ 10kHz bandwidth)
- No more than -13dBm spurious emissions (@ 100kHz bandwidth).
- Outside the intended band of operation, the noise radiated shall be no more than -70dBm (measured in 10kHz bandwidth).
- Max radiated power of 37dBm (ERP).
- May be used in weak signal areas only.
- Must register class B amplifiers on FCC web site.
- FCC License Holder must maintain a reasonable level of control over operation.
- Penalties of \$100,000 for each continuing instance of interference.

The Role of the FCC License Holder

Only the FCC license holder may allow a BDA to be turned on!

- Best practice is to engage the FCC license holder early and often
- They have the sole authority to allow rebroadcast of their licensed frequencies
- Noise caused by improperly installed BDAs can take down their radio sites!
- NFPA and IFC identify that BDAs shall not raise the noise floor (see Noise section)
- The license holder should issue provisional retransmit agreements for testing
- 5 year renewable retransmit authorization once system has been approved by AHJ
- The license holder is responsible for solving interference to their system
- The license holder must maintain reasonable level of control over retransmissions

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Decibels

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What is Decibels?

- It is both a measurement of RF power (dBm)
- And a ratio of the change in power (dB)
- It lets us express both very large and very small ratios
- It allows us to easily add gains and subtract losses in an RF path
- Decibels give us a common unit of measurements for gains, losses and power measurements

Why Decibels?

- Earlier versions of code used signal strength measurements for pass/fail threshold.
- IFC 510, 2015 used -95dBm as a minimum passing signal level
- Without test radios available, many installers still use signal level as a proxy for DAQ.
- NFPA 1225 Annex suggests -95dBm for analog radio systems and -100 dBm for P25 digital radio systems when DAQ testing is not available.
- If test equipment can provide SINR (Signal to Interference plus Noise Ratio) USE 20dB SINR as pass/fail threshold in addition to signal level.

Why Should You Understand Decibels?

- Every component, every BDA setting, every design, every link budget in RF is done using Decibels.
- While a high level of competency regarding Decibels is not expected, a basic understanding is necessary when acceptance testing ERCES.
- Example, a BDA with 90dB of gain is has an amplification factor of up to one billion times. This can cause issues with radio networks.
- One option many jurisdictions are going with, third party testing for the RF aspects of an inspection using local integrators with proven expertise in BDAs and RF testing.
- How to verify competency? Perhaps require NICET IB-PSC Level 2 or 3 or Design certification or companies with known competencies in RF and ERCES.

NICET In-Building Public Safety Certification

The National Institute for Engineering Technologists (NICET) recently established a certification program for ERCES (IB-PSC) installers and designers.



- Level 1 Technician – Performs rough installation, finish and trim-out activities.
- Level 2 Technician – Define project scope, evaluate RF signal strength and quality, perform commissioning, acceptance test and maintenance.
- Level 3 Engineering Technician – Define project scope, evaluate signal strength and quality, system design and layout.
- Design – Define scope, Evaluate RF signal strength and quality, designing the system.

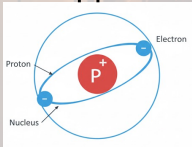
Imagine that 1 inch equals 0dBm of power



50 dBm equals the length of six of the world's largest container ships. (50 dBm = 100 Watts)



-100 dBm equals one tenth the diameter of a hydrogen atom



Handbook Chapter 7

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Noise

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No Noise!

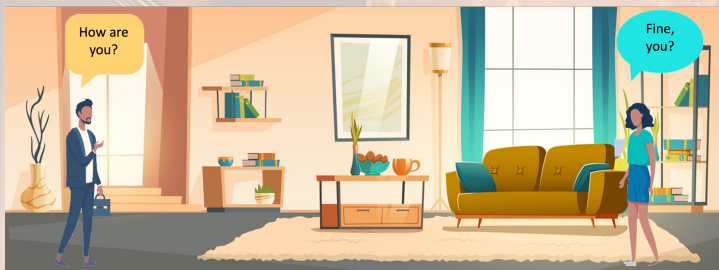


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Interference can impact radio systems

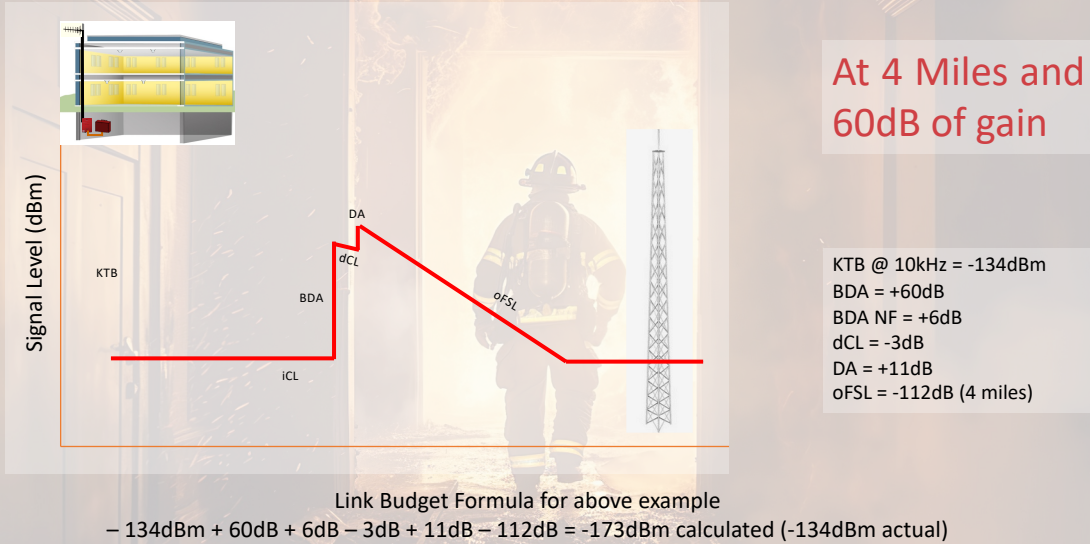


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System Uplink Noise Link Budget Example @4Miles

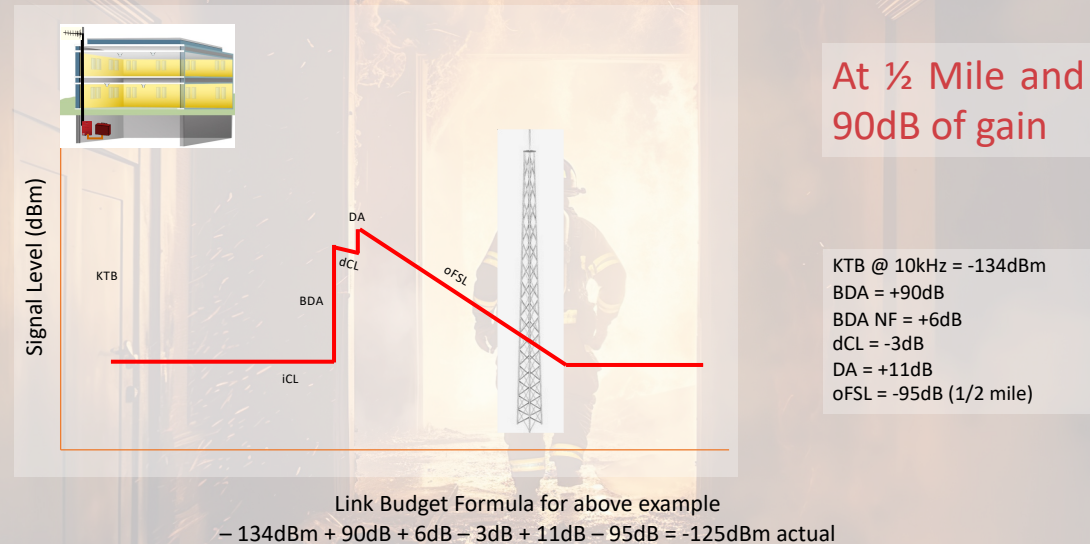


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System Uplink Noise Link Budget Example



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How to Test for Noise?

Have SI show you gain values in BDA
If gain at Max 80 or 90, fail them!

Require UL link budget submittals

For both signal and noise

Ask for calculated noise power

Must be below -144dBm @ 10kHz

Or as determined by radio network operator



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Test Equipment

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Installers Must be Competent With Test Equipment

Examples of necessary test equipment to verify RF coverage, install and test BDAs.

Spectrum Analyzer

Cable Analyzer

Signal Generator

Scanning Receiver / Grid Test



Handbook Chapters 14

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Building Assessment

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Buildings Must be Tested to Verify RF Coverage

Prior to building completion, it needs to be determined if it needs a BDA system.

Code requires 95% coverage on every floor.

Typical assessment includes either a 20-grid voice testing with loaner radios or testing RF signal levels or signal quality using SINR or BER.

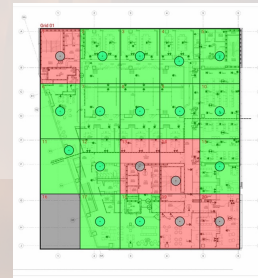
The building must be substantially closed in prior to testing.

This complicates the installation as it compresses the time available to install.

System Tester provides a pass/fail grid report to AHJ.

Only AHJ can determine if ERCES is needed.

If 95% of all floors and 100% of critical areas pass,
No ERCES is needed.

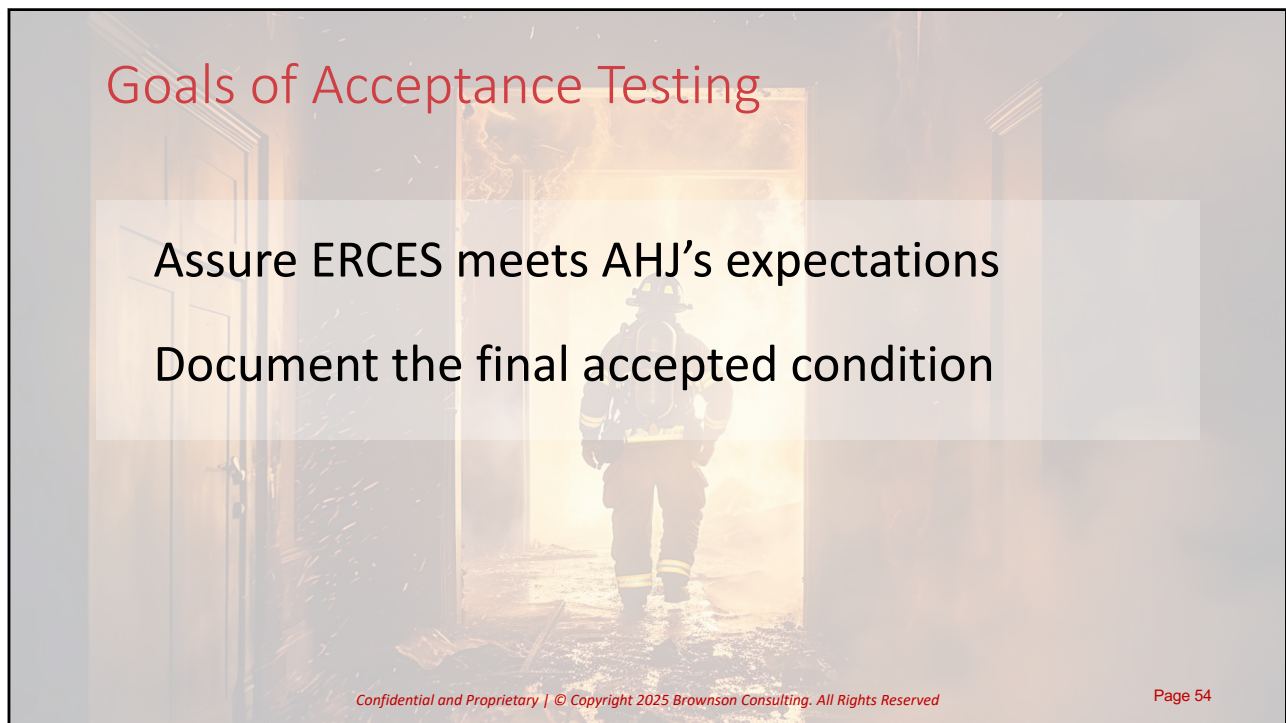


Building Assessment Testing Challenges

- If unsure, may need to pre-wire for ERCES and use only where needed.
- Code specifies DAQ testing, but loaner radios often not available.
- As alternate to DAQ many testers use RF signal level instead.
- But they can only test downlink signal.
- Most 700-800 MHz band systems should provide good DAQ at -100dBm .
- VHF-UHF band systems (150-174 & 450-512MHz) may need higher levels, eg. -90dBm.
- Testing SINR is better than just signal level (recommend 20dB SINR for pass/fail).
- If possible, work with integrators on building assessment testing. It is better to not install a ERCES if reliable radio coverage is available.
- Beware! Some system integrators just want to sell red boxes, even when not needed.



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Two Parts to Acceptance Testing

Physical



RF Performance

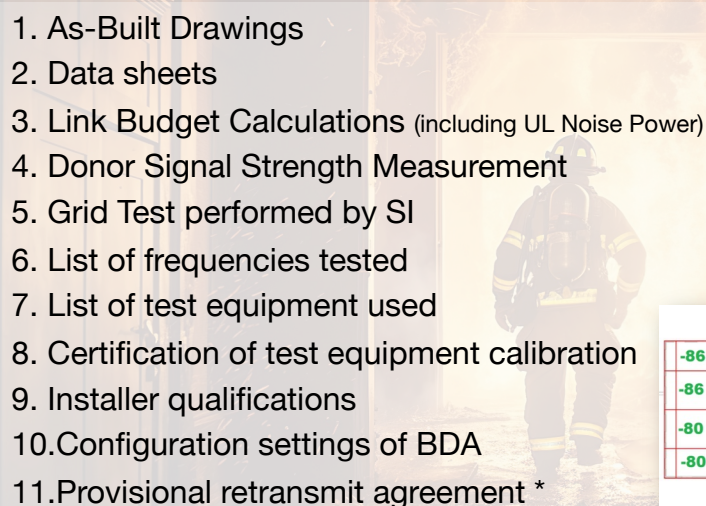


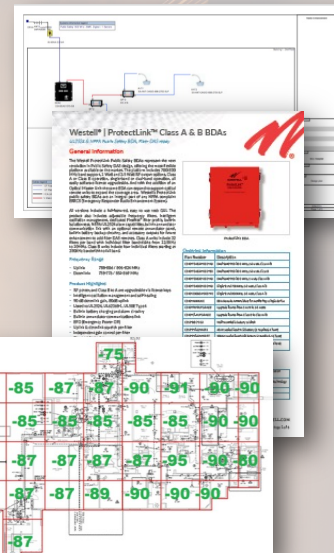
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Acceptance Test Submittals

- 
1. As-Built Drawings
 2. Data sheets
 3. Link Budget Calculations (including UL Noise Power)
 4. Donor Signal Strength Measurement
 5. Grid Test performed by SI
 6. List of frequencies tested
 7. List of test equipment used
 8. Certification of test equipment calibration
 9. Installer qualifications
 10. Configuration settings of BDA
 11. Provisional retransmit agreement *
- | |
|-----|
| -86 |
| -86 |
| -80 |
| -80 |



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Test Plan Requirements

Be clear about what is required

- What code version is currently enforced
 - Any local amendments or revisions
- Radio testing methods
 - Grid sizes, number, % passing grids (or other)
 - RSSI, DAQ or proxy such as BER or SINR
- Any other requirements
 - Conduit for cable pathways
 - Fire rated pathways and spaces
 - Critical areas identified



Critical Areas

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Best Practices for Verifying Compliance

- Inspect BDA/BBU placement and mounting, verify AC hard-wired with breaker lock-out
- Verify BDA UL gain is NOT at full gain, ideally 65dB or less
- Have system installer provide donor isolation results
- Disconnect AC power, let Battery Backup take over
- Measure DC voltage on battery
- Disconnect donor coax line at BDA temporarily
- Have SI disable UL power amplifier temporarily to verify RF Fail alarm
- Verify alarms at FACU for AC fail, Donor Disconnect and RF Emitter Fail
- Reconnect Donor coax line and re-enable UL power amplifier
- While running on battery do grid test validation as desired
- Suggest DAQ testing at several critical areas at minimum
- Verify cable pathways meet requirements
- Test DC battery voltage to verify minimal voltage drop, re-establish AC power.
- If acceptance testing passed sign off as completed

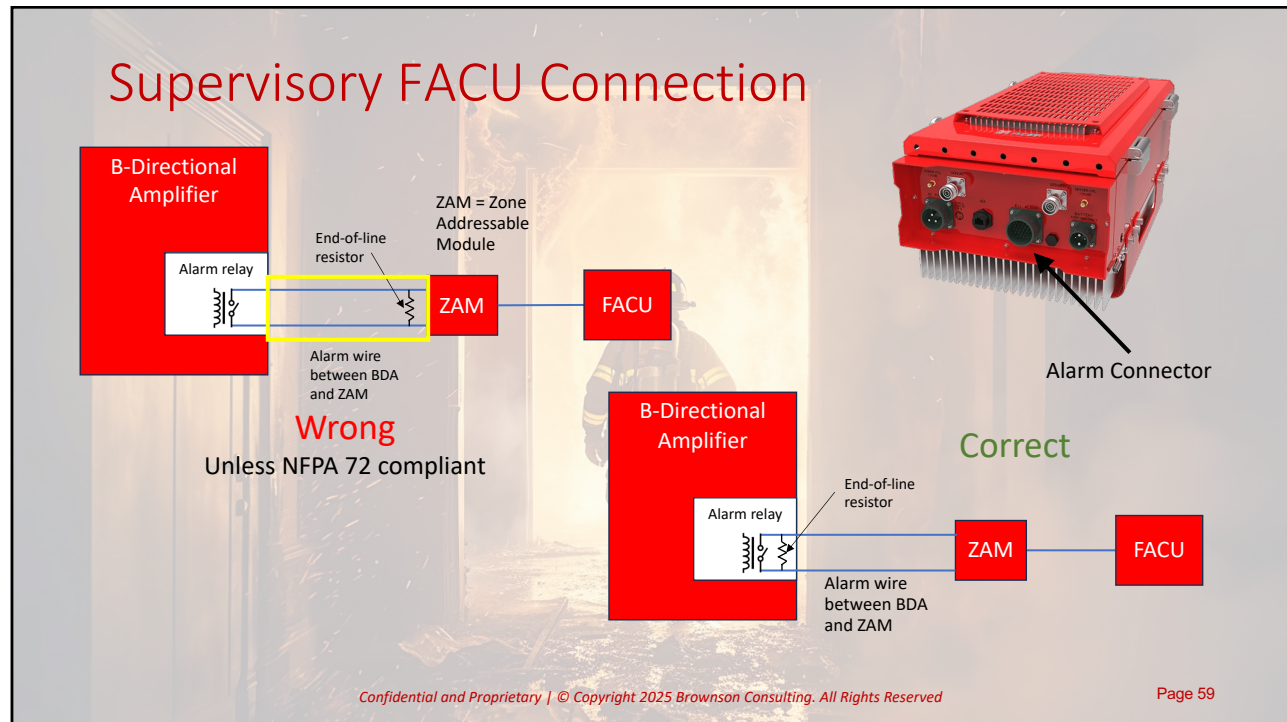


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Physical Inspection Checklist

Issue	What the AHJ is looking for	Issue	What the AHJ is looking for
Permit Required	Verify a permit was issued and the requirements of the permit were met	Cabinets for Equipment and Battery Backup Required	Verify proper NEMA enclosures were utilized for ERCES equipment and battery back up
Listing of Equipment	Verify active equipment meets UL 2524 (If AHJ has adopted NFPA 1225) and is installed in accordance with manufacturers requirements	Monitoring By Fire Alarm Required	Verify all supervisory signals report to the fire alarm control panel and that the signals are transmitted to the monitoring company for the fire alarm system
Pathway Survivability: Fire Rating	Verify pathway survivability (where required) is compliant including proper firestopping at all penetrations	Monitor Signal Source Malfunction Required	Verify that the signal source is monitored and that a supervisory signal is transmitted to the fire alarm control panel if signal source is lost
Pathway Survivability: Mechanical Protection	Verify mechanical protection has been provided where cables are subject to physical damage (ground level access, stairways, etc.)	Dedicated Annunciation Required	Verify a dedicated annunciator is provided in the fire command center and other areas when required. Verify that each of the supervisory signals required for the ERCES are transmitted to the annunciator
Plenum Rated Coaxial Cable Required	Verify coaxial cable is listed for plenum use	Design Documents	Verify as-built documents have been developed and are provided to the AHJ upon request
Lightning Protection Required	Verify proper grounding and bonding of system applicable components of the ERCES such as the antenna mast, cables, etc and a lightning protector has been installed on the donor line	Mounting of Donor Antenna	Verify the donor antenna is properly mounted and the fasteners are of the proper type for the application
Standby Power	Verify secondary standby power is provided for a minimum of 12 hours (or 24 hours if required by AHJ) at 100 percent system capacity	System Testing - Initial, Acceptance, Annual, 5-year	Documentation of the acceptance test findings shall be provided to the building owner and kept on file for reference on annual and 5-year tests

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RF Inspection Checklist

Issue	What the AHJ is looking for
Approved Emergency Services Department Communications Required	Does the ERCES and natural RF penetration provide coverage throughout the building
Signal Strength & Area Coverage Required	Verify test is properly performed and that test readings meet minimum requirements of the jurisdictions adopted codes and standards. 95% in General areas – 99% in Critical Areas
Noise Floor Requirement	Have the systems integrator work with the radio system personnel to determine that there was no rise in the noise floor at the donor site or any other site on the public safety communications system
Technical Criteria to be Provided by AHJ(s)	Ensure the ERCES meets all the technical criteria provided by the AHJ and the Frequency License Holder(s)
Isolation of Donor Antenna Required	Demonstrate a minimum of BDA Gain plus 20dB isolation between the donor antenna and distribution antennas
Frequency License Holder Approval Required	Verify there is a signed copy of the retransmission agreement for all frequencies and modulation technologies being enhanced by the ERCES

Issue	What the AHJ is looking for
Communication Antenna Density/Near Far	Verify test personnel perform near/far testing of the ERCES
Compliance with FCC Part 90.219	Confirm the installed equipment is FCC certified, gain is set at minimum levels to achieve required system performance, noise floor and spurious emissions do not exceed FCC limits and that the system is installed in weak signal areas only
Nonpublic safety system - non-interference	Verify that the ERCES and non-public safety systems are not causing interference with each other and if a cellular DAS is installed within the building that it is on and operational
Mounting of Donor Antenna	Verify donor antenna (where provided) is of the type listed in the submittal package, it is pointed in the proper direction, it has not been blocked by other trades equipment and it is permanently affixed to the structure, or if a movable sled was approved that proper signage has been attached
Minimum qualifications of personnel	Verify credentials of testing personnel prior to the acceptance test

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Close-Out Documentation

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Documentation Submittals

1. Installation documentation
2. Data sheets
3. As-Built drawings
4. System testing documentation
5. Secondary power calculations
6. List of assigned frequencies
7. System isolation measurement
8. Measured signal source levels
9. Configuration settings of BDA
Referred to for annual test to verify no changes
10. Above placed in document box near BDA



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Thank You

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