# “First Responder Radio Coverage Code Requirements, Test Procedures and Amplification System Requirements”

Steve Wheeler, RCDD – JDRM Engineering, Inc.

JDRM Engineering, Inc.

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BICSI

# When Did We Realize There Was a Problem?

The events of 9/11 brought the need for reliable radio coverage to the forefront of our nation's conscience.

# Current Code Requirements for New Buildings

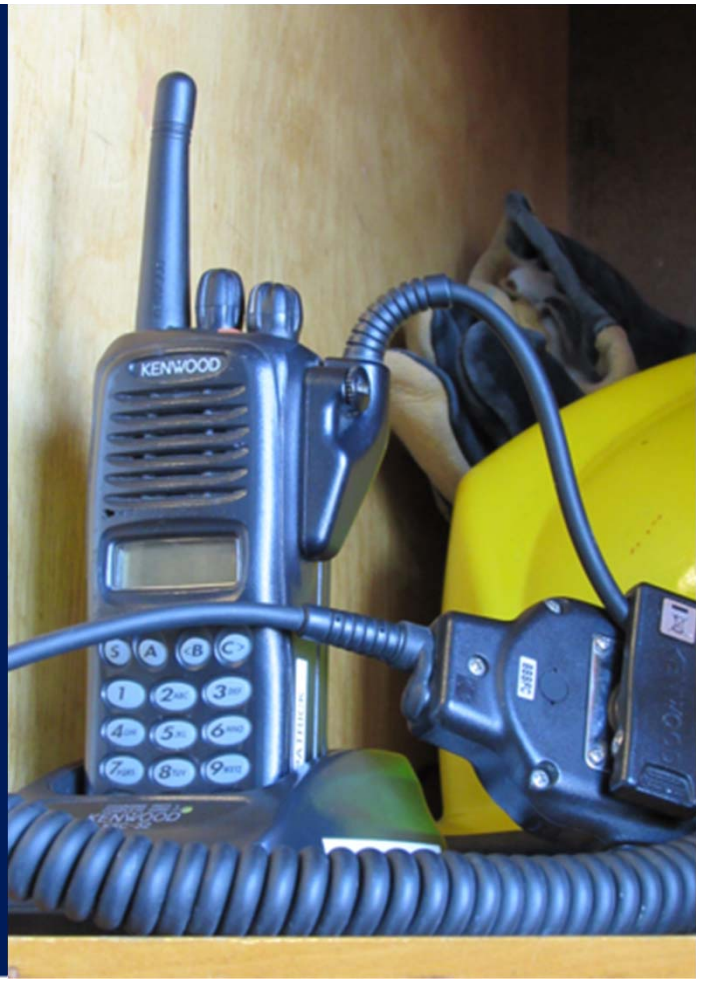
# International Building Code Section 915 (2012), 916 (2015), and 918 (2018)

***916.1 General.*** *Emergency responder radio coverage shall be provided in all new buildings in accordance with Section 510 of the international fire code.*

**Local jurisdictions and states may modify this.**

# Variations of Code in Other States

- 3 stories or more
- 5,000 square foot or more
- You impede your neighbor, you pay to fix their system
- Third party independent testing



# International Fire Code
# Section 510-2017

***510.1 Emergency responder radio coverage in new buildings.*** *All new buildings shall have approved radio coverage for emergency responders within the building based upon the existing coverage levels of the public safety communication systems of the jurisdiction at the exterior of the building. This paragraph shall not require improvement of the existing public safety communication systems*.

Also in NFPA 11.10.1

# IFC Section 510-2017

***Exceptions:***

*1. Where approved by the building official and the fire code official, a wired communication system in accordance with Paragraph (G)(2)(m)(ii) of Rule 1301:7-7-09 of the Administrative Code 907.2.13.2 shall be permitted to be installed or maintained in lieu of an approved radio coverage system.*

# IFC Section 510

***Exceptions:***

*2. Where it is determined by the fire code official that the radio coverage system is not needed.*

**Where, When, Why?**

# IFC Section 510

***Exceptions:***

*3. In facilities where emergency responder radio coverage is required and such systems, components or equipment required could have a negative impact on the normal operations of that facility, the fire code official shall have the authority to accept an automatically activated emergency responder radio coverage system.*

*NFPA 11.10.3*

# Current Code Requirements for Existing Buildings

# IFC Section 510

***510.2 Emergency responder radio coverage in existing buildings.*** *Existing buildings shall be provided with approved radio coverage for emergency responders as required in Rule 1301:7-7-11 of the Administrative Code.*

# Rule 1301:7-7-11 Administrative Code

**(1) 1101.1 Scope.** The provisions of this *rule* shall apply to existing buildings constructed prior to the adoption of this code *in accordance with paragraph* (B)(1)(c)(102.1) *of rule 1301:7-7-01 of the Administrative Code. The provisions of this rule shall not apply to existing buildings unless the conditions at the building constitute a distinct hazards to life or property in the opinion of the fire code official in accordance with paragraph (B)(1)(c)(102.1) of rule 1301:7-7-01 of the Administrative Code.*

# What else triggers a test?

When structural changes occur including additions or remodels that could materially change the original field performance.

(IFC 510.6.1 – Technically under maintenance)

# The Role of the Fire Code Official

*Ability to waive the requirement –*
*When and why would this be applicable?*

# IFC Section 510

***510.4.2.2 Technical Criteria**. The fire code official shall maintain a document providing the specific technical information and requirements for the emergency responder radio coverage system. This document shall contain, but not be limited to, the various frequencies required, the location of radio sites, effective radiated power of radio sites, and other supporting technical information.*

(Similar to NFPA 72 - 24.5.2.4.1 & NFPA 1221-9.6.14)

# Signal Strength and Coverage Requirements

# IFC Section 510

***(2) 510.4.1 Radio signal strength.*** *The building shall be considered to have acceptable emergency responder radio coverage when signal strength measurements in 95 percent of all areas on each floor of the building meet the signal strength requirements in Sections 510.4.1.1 and 510.4.1.2.*

# IFC Section 510

***(a) 510.4.1.1 Minimum signal strength into the building.*** *A minimum signal strength of -95 dBm shall be receivable within the building.*

# IFC Section 510

***(b) 510.4.1.2 Minimum signal strength out of the building.*** *A minimum signal strength of -95 dBm shall be received by the agency's radio system when transmitted from within the building.*

# What are the requirements for individuals performing the testing?

# *NONE.*

***In 2015 or 2017 International Fire Code***

***Check local codes and ordinances. Some use design criteria as testing criteria.***

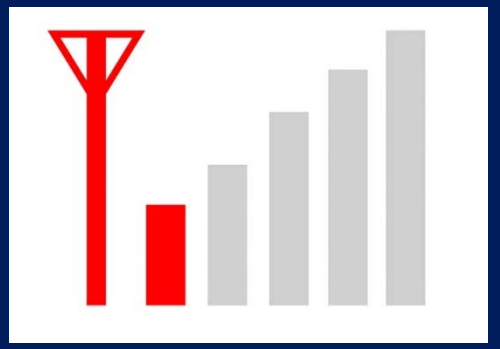
# What are the requirements for individuals designing the system?

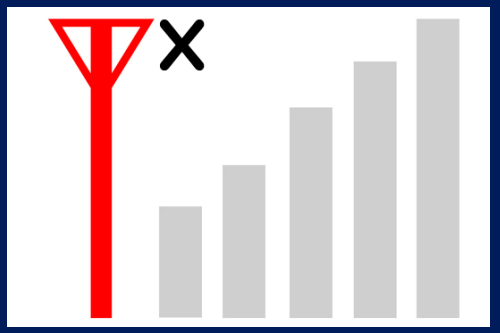
***510.5.2 Minimum qualifications of personnel.*** *The minimum qualifications of the system designer and lead installation personnel shall include both of the following:*

1. *A valid FCC-issued General Radio Operators License.*
2. *Certification of in-building system training issued by a nationally recognized organization or school OR Certificate issued by the manufacturer of the equipment being installed*

*These qualifications shall not be required where demonstration of adequate skills and experience satisfactory to the fire code official is provided.*

# What happens if the building does not pass the testing?





# IFC Section 510

***510.4.2.1 Amplification Systems Allowed.*** *Buildings and structures that cannot support the required level of radio coverage shall be equipped with a radiating cable system or a distributed antenna system (DAS) with FCC-certified signal boosters, or both, or with a system that is otherwise approved, in order to achieve the required adequate radio coverage.*

*(Also covered in NFPA 72 – 24.5.2.2.3 & NFPA 1221-9.6.7.6)*

# Who Pays for the Testing?

## The Building Owner – You!

# How Much Does Testing Cost?

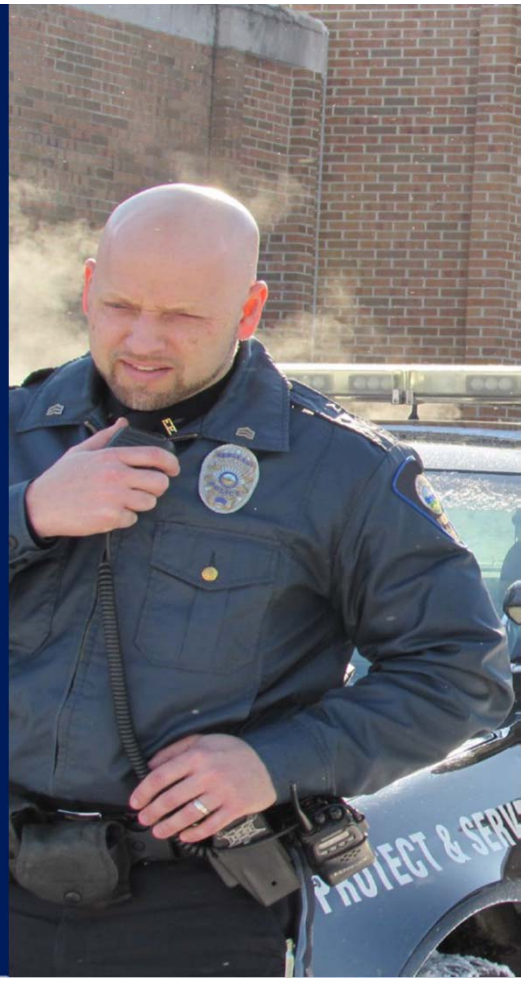
**The cost of testing is dependent on:**

- The number of buildings
- The number of floors for each building
- The number of frequencies in use by first responders
- Travel time to and from the site

# What about future changes or re-testing?

1. Retest when modifications to building to public agency's radio system changes.
2. Annual in-building test, signal booster test, battery test active components, and submit a report.

# FIRST RESPONDER SIGNAL SURVEY TEST PROCEDURE



# Pre-Enhancement

# vs.

# Post Enhancement

# Pre-Enhancement
# 95% Coverage All Areas on Each Floor IFC 510.41
# No Criteria for Test Pattern or Granularity

# Post Enhancement
# Division of Floor
# 90% Coverage All Areas on Each Floor NFPA 1221 9.6.7.5
# 99% Critical Areas
## (Depending on code year)

# WHAT ARE THE STANDARDS AND HOW IS THE TESTING PERFORMED?

-95dBm or stronger = **PASS**

Weaker than -95dBm = **FAIL**

IFC 510.4.1.1 & 510.4.1.2

Inbound & Outbound

Considerations:

Distance and location on antenna towers?

Repeaters/boosters, used in vehicles or trucks?

Tactical channels, mutual aid and Simplex.

**(c) 510.5.3 Acceptance test procedure.** Where an emergency responder radio coverage system is required and upon completion of installation, the building owner shall have the radio system tested to verify that two-way coverage on each floor of the building is not less than 90 *percent*. The test procedure shall be conducted as follows:

(i) Each floor of the building shall be divided into a grid of 20 approximately equal test areas.

(ii) 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.

(v) A test location approximately in the center of each test area shall be selected for the test, with the radio enabled to verify two-way communications to and from the outside of the building through the public agency's radio communications system. Once the test location has been selected, the location shall represent the entire test area. Failure in the selected test location shall be considered failure of that test area. Additional test locations shall not be permitted.

(vi) The gain values of all amplifiers shall be measured and the test measurement results shall be kept on file with the building owner so that the measurements can be verified during annual tests. In the event that the measurement results become lost, the building owner shall be required to rerun the acceptance test to re-establish the gain values.

(vii) As part of the installation a spectrum analyzer or other suitable test equipment shall be utilized to ensure spurious oscillations are not being generated by the subject signal booster. This test shall be conducted at the time of installation and subsequent annual inspections.

# Acceptance Test Procedure Enhanced System

IFC 510.5.3

(1) 90 percent coverage required

(2) Max 2 non adjacent shall not result in failure of test

(3) If 3 fail, can divide into 40

New in 2016

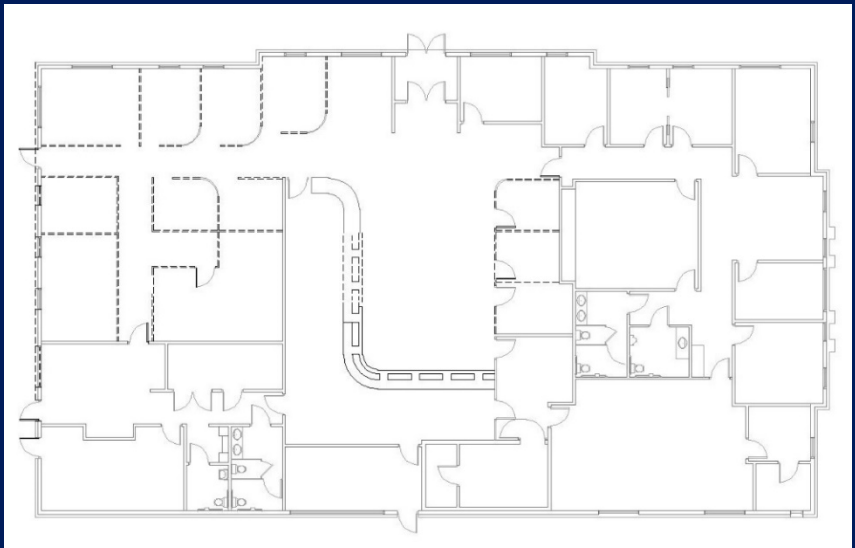
NFPA 1221 9.6.7.9 & 9.6.7.5

(1) 90 percent except critical areas 99 percent.

Critical areas defined as fire command centers, fire pump rooms, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations, and other areas deemed critical by AHJ.

# Step 1: Divide Each Floor into 20 Equal Spaces, as described in IFC 510.5.3

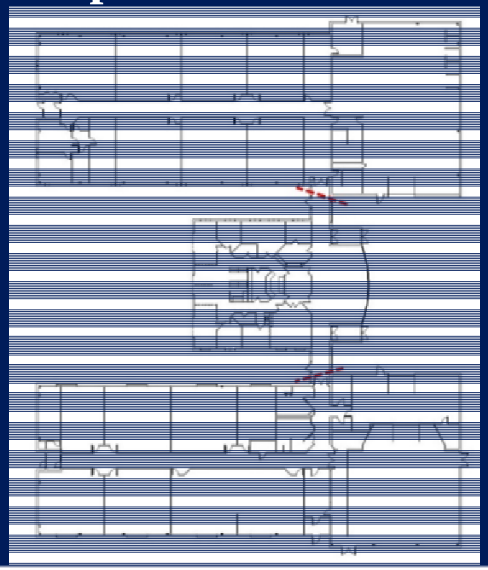
## Example #1

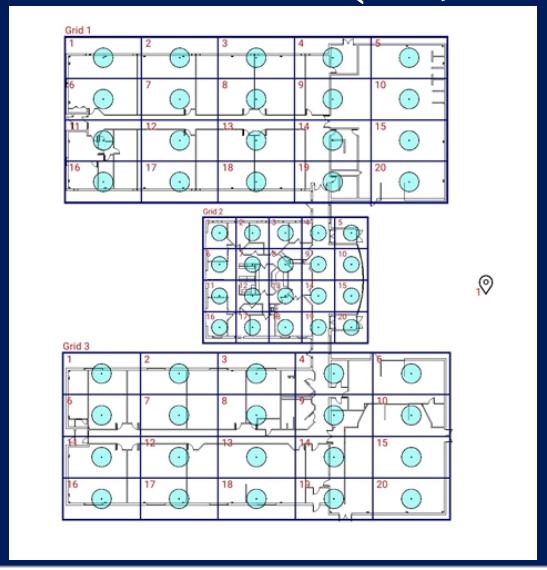


# Step 1: Divide Each Floor into 20 Equal Spaces, as described in IFC 510.5.3

**Example #2**

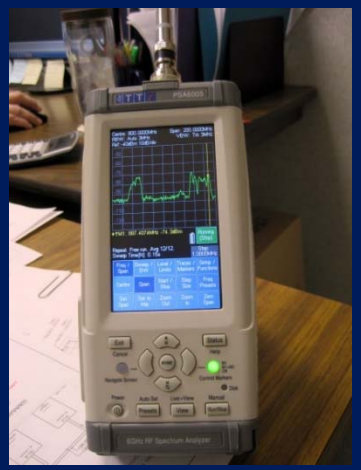
**2 hour Fire Separation walls or NFPA-72 Ch. 14-A14.4.10.3 (128,000 sq. ft.)**





# Step 2: Test Each Space

Step 2a: Measure signal levels with test equipment.

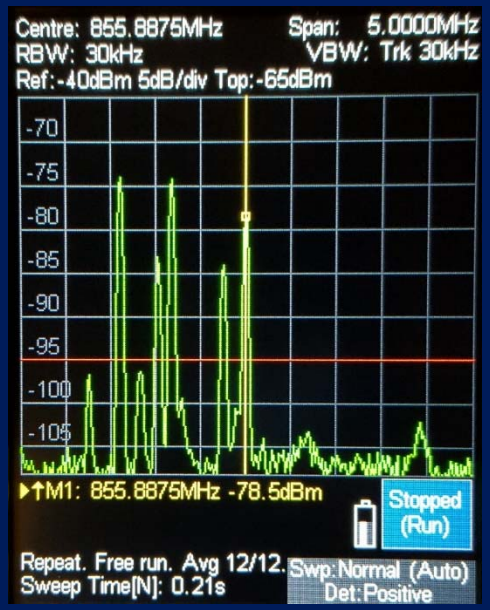


Spectrum Analyzer

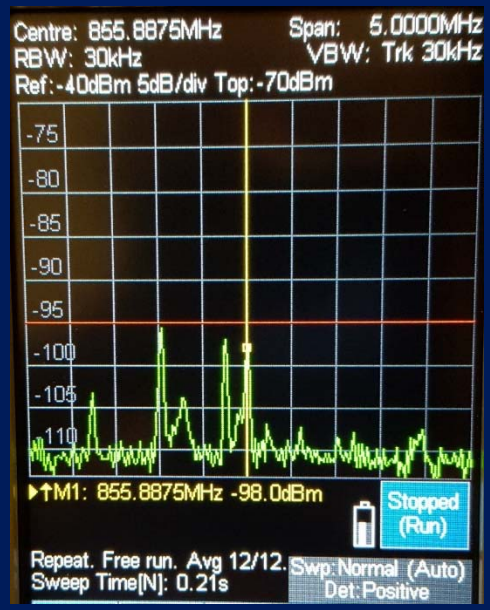
Scanning Receiver

Signal levels weaker than -95 dBM= FAIL

# Spectrum Analyzer Examples:




PASS




FAIL

# NFPA 1221 DAQ Allowed

**9.6.8.2 Outbound.**

A minimum outbound strength sufficient to provide usable voice communications, as specified by the AHJ, shall be provided throughout the coverage area. The outbound signal level shall be sufficient to provide a minimum of ***DAQ 3.0*** for either analog or digital signals.

# Step 2b: Measure DAQ voice Quality

VOICE QUALITY MEASURED USING THE DELIVERED AUDIO QUALITY (DAQ) STANDARD:

| | |
|---|---|
| **DAQ 1:** | **Unusable. Speech present, but not understandable.** |
| **DAQ 2:** | **Speech understandable with considerable effort. Requires frequent repetition due to noise or distortion.** |
| **DAQ 3:** | **Speech understandable with slight effort. Requires occasional repetition due to noise or distortion.** |
| **DAQ 3.4:** | **Speech understandable without repetition. Some noise or distortion present.** |
| **DAQ 4:** | **Speech easily understandable; little noise or distortion.** |
| **DAQ 4.5:** | **Speech easily understandable; rare noise or distortion.** |
| **DAQ 5:** | **Perfect; no distortion or noise discernible.** |

# Example Test Results:

**Floor: First Floor**

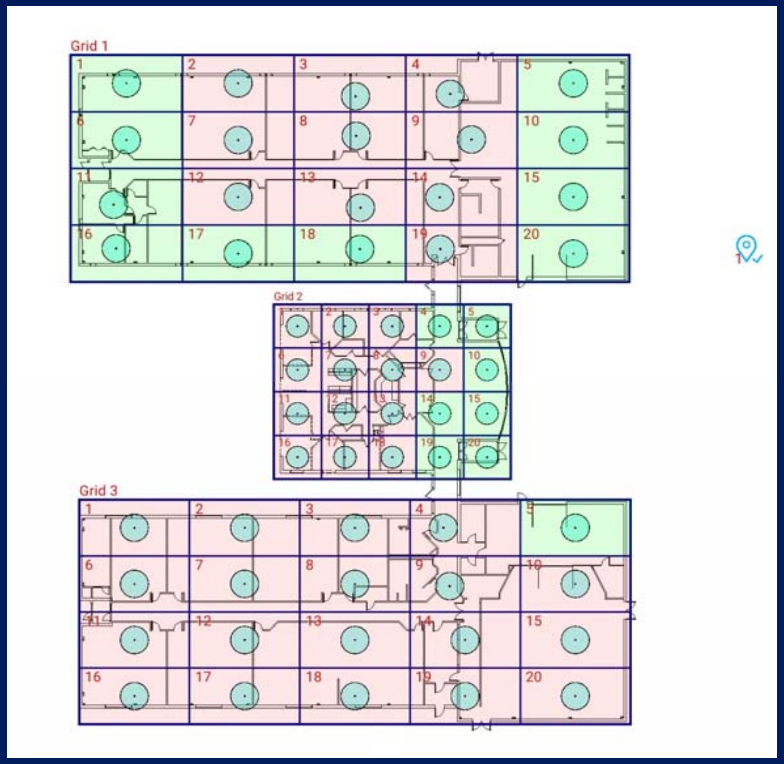
**Group: Countywide Communications System**

Reference Point Report

| Reference Point | Power (dBm) | UL DAQ | Comment |
|---|---|---|---|
| 1 | -81.65 | 5 | Control |

Area Report

| Grid | Area | DL Power (dBm) | UL DAQ | Result |
|---|---|---|---|---|
| 1 | 1 | -87.90 | 5.0 | Pass |
| 1 | 2 | -100.29 | 5.0 | Fail |
| 1 | 3 | -97.14 | 5.0 | Fail |
| 1 | 4 | -97.79 | 4.5 | Fail |
| 1 | 5 | -90.32 | 5.0 | Pass |
| 1 | 6 | -93.46 | 5.0 | Pass |
| 1 | 7 | -97.92 | 5.0 | Fail |
| 1 | 8 | -96.39 | 5.0 | Fail |
| 1 | 9 | -97.74 | 4.5 | Fail |
| 1 | 10 | -90.91 | 5.0 | Pass |
| 1 | 11 | -94.16 | 5.0 | Pass |
| 1 | 12 | -101.75 | 5.0 | Fail |
| 1 | 13 | -101.93 | 4.5 | Fail |
| 1 | 14 | -97.08 | 5.0 | Fail |
| 1 | 15 | -84.61 | 5.0 | Pass |
| 1 | 16 | -92.42 | 5.0 | Pass |
| 1 | 17 | -92.62 | 5.0 | Pass |
| 1 | 18 | -94.76 | 5.0 | Pass |
| 1 | 19 | -103.88 | 5.0 | Fail |
| 1 | 20 | -89.24 | 5.0 | Pass |



# 2018 IFC Section 510

**510.4.1.1 Minimum signal strength into the building.**

The minimum inbound signal strength shall be sufficient to provide usable voice communications throughout the coverage area as specified by the fire code official. The inbound signal level shall be sufficient to provide not less than a Delivered Audio Quality (DAQ) of 3.0 or an equivalent Signal-to-Interface-Plus-Noise Radio (SINR) applicable to the technology for either analog or digital signals.

# 2018 IFC Section 510

**510.4.1.2 Minimum signal strength out of the building.**

The minimum outbound signal strength shall be sufficient to provide usable voice communications throughout the coverage area as specified by the fire code official. The outbound signal level shall be sufficient to provide not less than a DAQ of 3.0 or an equivalent SINR applicable to the technology for either analog or digital signals.

# IN-BUILDING AMPLIFICATION SYSTEM DESIGN, INSTALLATION, AND WHAT THE CODE REQUIRES

Prior to 2016, requirements found in NFPA 72 Chapter 24.

Starting in 2016, Chapter 24 moved to NFPA 1221.

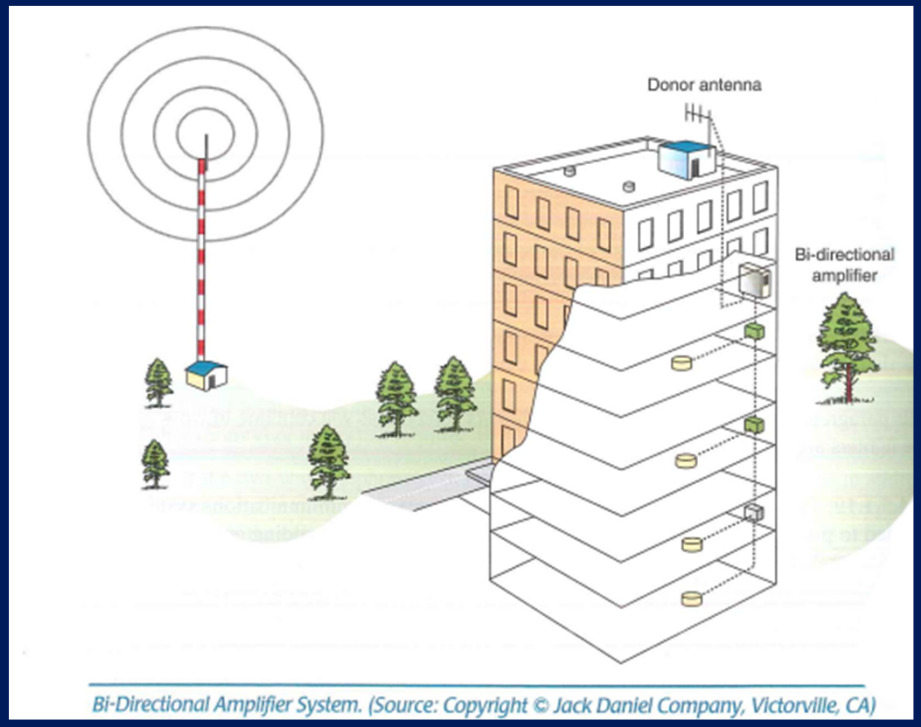
# Does your State code reference 1221?

# BI-DIRECTION AMPLIFIER (BDA) DESIGN

# NFPA 72 (2013)

***24.5.4 System Radio Frequencies.*** *The public safety radio enhancement system shall be capable of transmitting all public safety radio frequencies assigned to the jurisdiction and be capable of using any modulation technology.*

# Signal Booster Components




*Bi-Directional Amplifier System. (Source: Copyright © Jack Daniel Company, Victorville, CA)*

# NFPA 72 (2013)/NFPA 1221 (2017)

**24.5.2.5.2/9.6.11.2 Component Enclosures.** All repeater, transmitter, receiver, signal booster components, and battery system components shall be contained in NEMA 4- or 4X-type enclosure(s).

In 2018, IFC Battery will be reduced to NEMA 3R.

**24.5.2.5.4 Signal Booster Components/9.6.11.3 RF Emitting Devices.** If used, signal boosters shall meet the following requirements, as well as any other requirements determined by the authority having jurisdiction.

# NFPA 72 24.5.2.5.4/NFPA 1221 9.6.11.3 Signal Booster Components (cont.)

NFPA72

(1) Signal boosters shall have FCC certification prior to installation.

NFPA 1221 9.6.11.3

(1) RF Emitting devices shall have the certification of the radio licensing authority (FCC Part 47, CFR Part 90.219 per OFC 510.5.4) prior to installation.

# NFPA 72 24.5.2.5.4/NFPA 1221 9.6.11.3 Signal Booster Components (cont.)

NFPA 72 24.5.2.5.4

(2) All signal boosters shall be compatible with both analog and digital communications simultaneously at the same time of installation. *The authority having jurisdiction shall provide the maximum acceptable propagation delay standard.*

# 2018 IFC Section 510

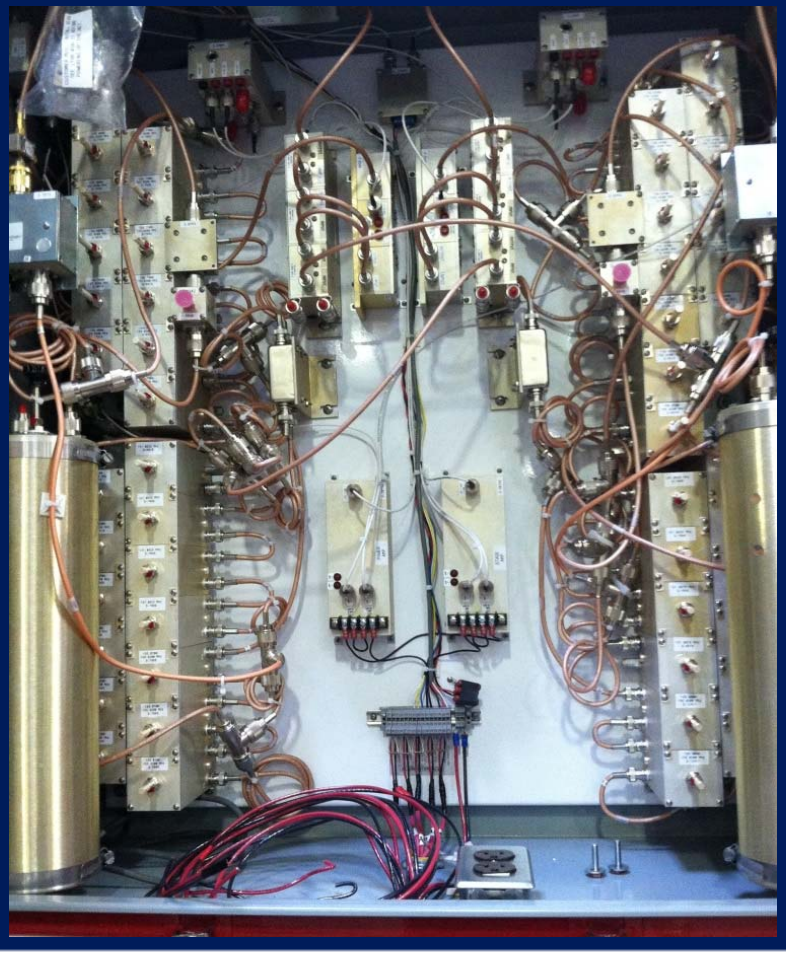
**510.4.2.4 Signal booster requirements.**

If used, signal boosters shall meet the following requirements:

1. All signal booster components shall be contained in a National Electrical Manufacturer's Association (NEMA) 4-type waterproof cabinet.
2. Battery systems used for the emergency power source shall be contained in a NEMA 3R or higher-rated cabinet.
3. Equipment shall have FCC or other radio licensing authority certification and be suitable for public safety use prior to installation.
4. Where a donor antenna and all inside antennas to not less than 20dB greater than the system gain under all operating conditions.
5. Bi-Directional Amplifiers (BDAs) used in emergency responder radio coverage systems shall have oscillation prevention circuitry.
6. The installation of amplification systems or systems that operate on or provide the means that cause interference on any emergency responder radio coverage networks shall be coordinated and approved by the *fire code official*.

# IFC Section 510

**(v)510.4.2.5 Additional frequencies and change of frequencies.** The emergency responder radio coverage system shall be capable of modification or expansion in the event frequency changes are required by the “FCC” or additional frequencies are made available by the “FCC”.



# NFPA 1221

**9.6.9 Isolation.**

If a donor antenna exists, isolation shall be maintained between the donor antenna and all inside antennas to a minimum of 20 dB under all operating conditions.

# IFC Section 510

**510.4.2.8 Radio communication antenna density.**

Systems shall be engineered to minimize the near-far effect. Radio enhancement system designs shall include sufficient antenna density to address reduced gain conditions.

**Exceptions:**

1. Class A narrowband signal booster devices with independent ACG/ALC circuits per channel.
2. Systems where all portable devices within the same band use active power control features.

# Power Requirements

# NFPA 72 (2013)/NFPA 1221

**24.5.2.5.5 Power Supplies.** At least two independent and reliable power supplies shall be provided for all *repeater*, *transmitter*, *receiver*, *and signal booster components*, one primary and one secondary.

**24.5.2.5.5.1 Primary Power Source.** The primary power source shall be supplied from a dedicated branch circuit and comply with NFPA 72 10.6.5.1.

*NFPA 1221 RF Emitting devices and any other components of the system.

# NFPA 72 (2013)/NFPA 1221

**24.5.2.5.5.2 Secondary Power Source.** The secondary power source shall consist of one of the following:

(I) A storage battery dedicated to the system with at least 12 hours of 100 percent system operation capacity and *arranged in accordance with 10.6.10*

**Not in NFPA 1221*

NFPA 72

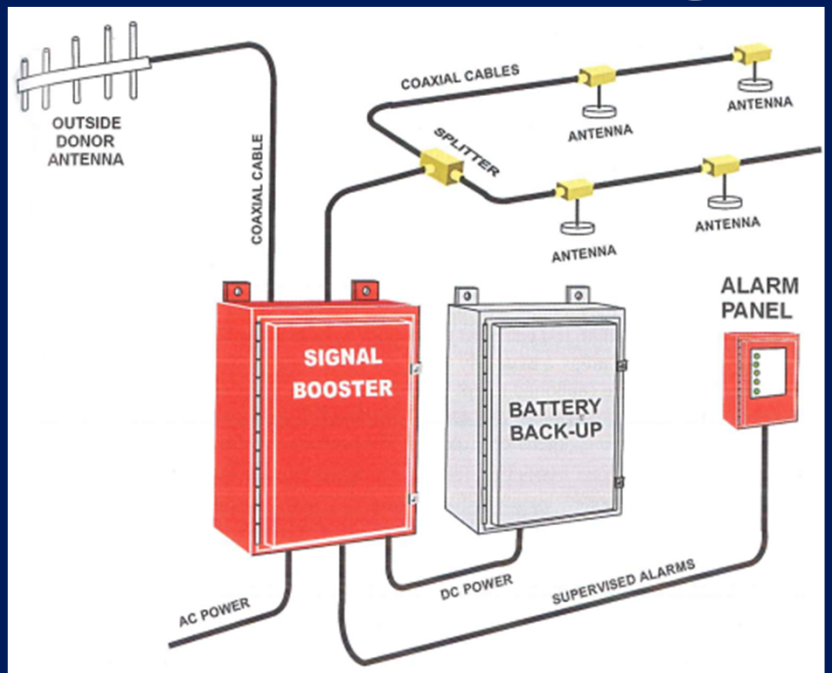
(2) An automatic-starting, engine-driven generator serving the dedicated branch circuit or the system with at least 12 hours of 100 percent system operation capacity and storage batteries dedicated to the system with at least 2 hours of 100 percent system operation capacity and arranged in accordance with 10.6.11.3

NFPA 1221

(2)An alternative power source of 12 hours at 100 percent system operation capacity as approved by the authority having jurisdiction.

# Monitoring Requirements

# Monitoring




*Bi-Directional Amplifier System Floor Layout. (Source: Copyright © Jack Daniel Company, Victorville, CA)*

# NFPA 72 (2013)/NFPA 1221

**24.5.2.6/9.6.12.13 Monitoring Integrity of Power Supplies.** Monitoring the integrity of power supplies shall be in accordance with 10.6.9/9.1.2.2

*i.e., the same requirements as for fire alarm systems.*

# Fire Alarm Connections

# NFPA 72 (2013)

**24.5.2.6.1 Fire Alarm System**. The public safety radio communications enhancement system shall include automatic supervisory and trouble signals for malfunctions of the signal booster(s) and power supply(ies) that are annunciated by the fire alarm system and comply with the following:

(1) The integrity of the circuit monitoring signal booster(s) and power supply(ies) shall comply with 10.6.9 and Section 12.6.

(2) System and signal booster supervisory signals shall include the following:
   (a) Antenna malfunction
   (b) Signal booster failure
   (c) Low-battery capacity indication when 70 percent of the 12-hour operating capacity has been depleted.

# NFPA 72 (2013)

**24.5.2.6.1 Fire Alarm System.** (continued)

(3) Power supply signals shall include the following for each signal booster:

(a) Loss of normal ac power
(b) Failure of battery charger

# NFPA 1221

9.6.13.1 Fire Alarm System. The system shall include automatic supervisory signals for malfunctions of the two-way radio communications enhancement systems that are annunciated by the fire alarm system in accordance with NFPA 72 and shall comply with the following:

(1) Monitoring for integrity of the system shall comply with NFPA 72, Chapter 10.
(2) System supervisory signals shall include the following:

(a) Donor antenna 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) System component failure

# NFPA 1221

## 9.6.13.11 Fire Alarm System. (continued)

(3) Power supply supervisory signals shall include the following for each RF emitting device and system component:

(a) Loss of normal ac power
(b) Failure of battery charger

(4) The communications link between the fire alarm system and the two-way radio communications enhancement system must be monitored for integrity.

# NFPA 72 (2013)

**24.5.2.6.2 Dedicated Panel.** A dedicated monitoring panel shall be provided within the fire command center to annunciate the status of all signal booster locations. The monitoring panel shall provide visual and labeled indication of the following for each signal booster:

(1) Normal ac power
(2) Signal booster trouble
(3) Loss of normal ac power
(4) Failure of battery charger
(5) Low-battery capacity

# NFPA 1221 (2016)

9.6.13.2 Dedicated Panel.

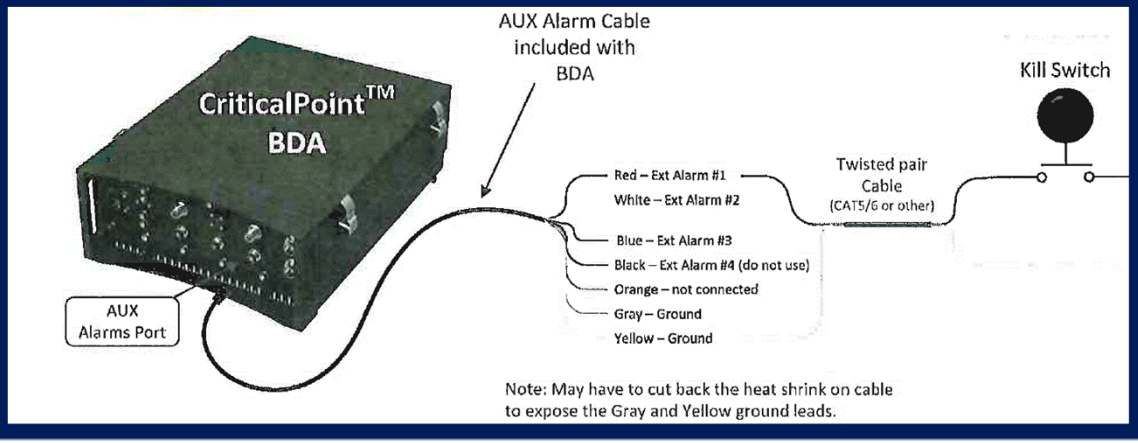
(1) A dedicated monitoring panel shall be provided within the fire command center to annunciate the status of all RF emitting devices and system component locations. The monitoring panel shall provide visual and labeled indications of the following for each system component and RF emitting device.

- (a) Normal ac power
- (b) Loss of normal ac power
- (c) Battery charger failure
- (d) Low battery capacity (to 70 percent depletion)
- (e) Donor antenna malfunction
- (f) Active RF Emitting device malfunction
- (g) System component malfunction

(2) The communications link between the dedicated monitoring panel and the two-way radio communications enhancement system must be monitored for integrity.

# EPO Switch 2018 IFC

**510.4.2.3.1** Emergency power off. The UPS system shall be equipped with an emergency power off (EPO) switch in a location approved by the fire code official. The EPO shall disconnect both the circuit breaker and secondary power supply simultaneously.



# “Kill Switch” Why?

Authorities Having Jurisdiction (AHJ) have requested the ability to remotely shutdown BDAs for various reasons.  One such reason would be as a quick verification step to ensure a specific BDA in the network is not causing interference to the Public Safety Donor site.

# Pathway Survivability

# NFPA 72 Ch.24 & NFPA 1221

**9.6.2.1.1(1221) 72:24.3.13.8.1**

Where a two-way radio communications enhancement system is used in lieu of a two-way in-building wired emergency communications system, it shall have a pathway survivability of level 1,2 or 3

*Exception: Where leaky feeder cable is utilized as the antenna, it shall not be installed in metal raceway.*

# NFPA 72 (2013)

**A.24.3.6.8.1** Extensive searches and discussions with cable manufacturers have not been able to identify a source of listed 2-hour-rated coaxial or fiber cables. Listed fire-rated 76 ohm coaxial cables for security cameras exist but are not adaptable to distributed antenna systems operating at much higher radio frequencies. Coaxial cable with characteristics similar to low loss 50 ohm, 1/2in. (13mm) diameter, coaxial cables are available in plenum and riser ratings. Past installations have used these plenum and riser rated coaxial cables prior to this Code.

The Fiber component of fiber-optic cables melts at temperatures well below the 1825° F (996° C) test specification for listed 2-hour cable.

Using 2-hour rated cable enclosures throughout each floor of most structures is impractical, especially when added to existing buildings.

# NFPA 72 & NFPA 1221

**24.3.13.8.1.1 or 9.6.2.1.1.1** The feeder and riser coaxial cables shall be rated as plenum cables.

**24.3.6.8.3 or 9.6.2.3** Riser coaxial cables shall be rated as riser cables and routed through a 2-hour-rated enclosure.

**24.3.13.8.4 or 9.6.2.1.4** the connection between the riser and feeder coaxial cables shall be made within the 2-hour-rated enclosure, and passage of the feeder cable in and out of the 2-hour-rated enclosure shall be firestopped to 2-hour ratings.

# Maintenance of System

# 2015 & 2018 IFC 510.6

510.6 Maintenance

The emergency responder radio coverage system shall be maintained operational at all times in accordance with Sections 510.6.1 through 510.6.4.

# What About Future Changes or Re-testing?

2015 IFC Requires:

1. Retest system when modifications to building or public agency's radio system changes.

2. Annual in-building coverage test, signal booster test, battery test, and submit a report.

# 2015 IFC 510.6

**510.6.1 Testing and proof of compliance.**
The emergency responder radio coverage system shall be inspected and tested annually or where structural changes occur including additions or remodels that could materially change the original field performance tests.

- 2018 Identifies responsibility to the owner or owners agent.

# 2015 & 2018 IFC 510.6

**510.6.1 Testing and proof of compliance.**
Testing shall consist of the following:

(1) In-building coverage test as described in Section 510.5.3.
(2) Signal boosters shall be tested to verify that the gain is the same as it was upon initial installation and acceptance or set to optimize the performance of the system.

# 2015 & 2018 IFC 510.6

**510.6.1 Testing and proof of compliance.**
Testing shall consist of the following:

(3) Backup batteries and power supplies shall be tested under load of a period of 1 hour to verify that they will properly operate during an actual power outage. If within the 1-hour test period the battery exhibits symptoms of failure, the test shall be extended for additional 1-hour periods until the integrity of the battery can be determined.
(4) Other active components shall be checked to verify operation with in the manufacturer's specifications .
(5) At the conclusion of the testing, a report, which shall verify compliance with Section 510.5.3, shall be submitted to the *fire code official*.

# Who Pays for the In-Building Amplication System?

The Building Owner – You!

# How Much Does It Cost To Design And Install An In-Building Amplification System?

Costs depend on how many frequencies require enhancement and how much of the building failed.

The range we have seen can be anywhere from $0.85 to $1.50 per square foot.

For budgetary purposes, we recommend around $1.25 per square foot.

# 2018 IFC Section 510

**510.6.4 Field testing.**

Agency personnel shall have the right to enter onto the property at any reasonable time to conduct field testing to verify the required level of radio coverage.

# 2018 IFC Section 510

**510.4.2.7 Design Documents.**

The *fire code official* shall have he 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.*

# What Does the Future Look Like?

# FirstNet
# First Responder Network Authority

FirstNet has been obligated by Congress to take all actions necessary to ensure the building, deployment and operation of the nationwide public safety broadband network.

# FirstNet Background

The Network will provide a single interoperable platform for emergency and daily public safety communications. We expect the Network to provide cutting-edge, prioritized, and preemptive wireless broadband communications to millions of public safety personnel that respond to emergencies at the local, state, tribal, and Federal levels.

JDRM Engineering, Inc.