

tures, wiring, equipment and accessories are red or are identified by red or red/white markings. The manner of identification is subject to the approval of the fire code official.

**509.1.1 Utility identification.** Where required by the *fire code official*, gas shutoff valves, electric meters, service switches and other utility equipment shall be clearly and legibly marked to identify the unit or space that it serves. Identification shall be made in an *approved* manner, readily visible and shall be maintained.

❖ This section provides the fire code official with the authority to require utility identification for services serving multiple-unit or multiple-building properties, including facilities, campuses, strip malls, business parks, residential properties and similar locations where identification of utilities is considered essential to emergency responders. Note that this section does not prescribe any particular design requirements for utility identification markings. It should be recognized that the markings are intended to provide an easily understood and consistent tool to emergency responders who must secure utilities during emergency operations. Jurisdictions should develop a policy to ensure that utility identification markings are prepared in a standard, consistent format to avoid confusing the responders, and yet provide the minimum information required so they can correctly and efficiently utilize them. Note that the photovoltaic requirements in Section 1204.5 address signage to identify the rapid shut-down switches for these systems.

**509.2 Equipment access.** *Approved* access shall be provided and maintained for all fire protection equipment to permit immediate safe operation and maintenance of such equipment. Storage, trash and other materials or objects shall not be placed or kept in such a manner that would prevent such equipment from being readily accessible.

❖ This section requires immediate access to and working space around all fire suppression, protection, and detection system devices and control elements necessary for fire department use. It further prohibits obstruction of such equipment by materials or objects that may prevent such equipment from being immediately accessed by emergency responders.

## SECTION 510

### EMERGENCY RESPONDER RADIO COVERAGE

**510.1 Emergency responder radio coverage in new buildings.** New buildings shall have *approved* radio coverage for emergency responders within the building 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 *approved* by the building official and the *fire code official*, a wired communication system in accordance with Section 907.2.12.2 shall be permitted

to be installed or maintained instead of an *approved* radio coverage system.

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

❖ The provisions of Section 510 are concerned with the reliability of portable radios used by emergency responders inside buildings. This is in keeping with the philosophy inherent in the I-Codes that, when a facility grows too large or complex for effective fire response, fire protection features must be provided within the building. While modeling and other techniques may provide a good prediction as to whether a building will interfere with radio communications, the reality is that it is unknown if a building will need to install any type of radio system enhancements until after the building is constructed. Determining factors may include construction type, shadows of other buildings, size of the structure, and use of building products such as low-emission glass. Though this section does not offer specific types of buildings that should be targeted, discussions with public safety radio professionals found that, based on current radio technologies, these requirements should be applied in any building with one or more basements or below-grade building levels, underground buildings or buildings more than five stories in height.

Emergency responders use portable radios to communicate with other emergency responders, the incident commander and the public safety communications center. Building construction features and materials can absorb or block the radio frequency energy used to carry the signals inside or outside the building. Blockage or absorption of the radio frequency signal can prevent a critical message from an emergency responder from being received and acknowledged. Depending on the incident, this loss of information can place other emergency responders in greater danger, or may prevent an injured or disoriented emergency responder from communicating for assistance. The requirements apply to analog or digital radio systems and are applicable to all buildings.

This section requires that all buildings have approved radio coverage for emergency responders within the building. Approved radio coverage is based on the ability of the existing public safety communications system to transmit a signal inside and outside the building.

Where testing using the existing public safety communications system finds that the signal strengths are not satisfactory, Exception 1 allows for the alternative installation of a wired communication system in accordance with Section 907.2.12.2, which

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requires that such a system be designed in accordance with NFPA 72. When applying this exception, the concurrent approval of fire and building code officials is required.

Where testing using the existing public safety communications system finds that the signal strengths are satisfactory, Exception 2 allows the fire code official to waive the requirements when it is determined that emergency responder radio coverage is not needed. This exception does not give any criteria as to buildings that can be exempted. However, discussions with public safety radio professionals found that, based on current radio technologies, most wood frame or mixed construction Group R-1 and R-2 occupancies, single-family dwellings, townhomes and buildings with an area less than 50,000 square feet (4645 m<sup>2</sup>) without basements, should engender little concern for loss of radio signal strength inside the building or an inability to transmit to an outdoor receiver.

Exception 3 provides a means for the fire code official to allow the installation of a manual or automatic switch that turns on the emergency responder radio coverage system (ERRCS) when it is needed. These systems allow emergency responders to operate their radios inside telephone central offices (COs) or similar occupancies without disrupting telephone network operations, including calls for service to a jurisdiction's public safety answering point via 9-1-1. Exception 3 also recognizes that operating public safety radio systems in certain buildings with electronic equipment sensitive to radio frequency (RF) energy can cause damage to the equipment, or worse, impact the operations of a local or regional computer network. One such occupancy is a telephone CO, which is where landline and cellular telephone signals are received and dispatched to the recipient caller. It is not uncommon for a telephone CO to be capable of receiving and processing more than 250,000 telephone calls within a 1-minute period. Telephone COs serve an important public safety function because they process emergency or information calls routed via 9-1-1 to a jurisdiction's public safety answering point.

Exception 3 was written to address testing sponsored by the major telecommunications companies and performed at UL. The purpose of the tests was to determine the impact of operating hand-held radios within a telephone CO. Telephone COs contain an array of digital and analog equipment that receives and routes telephone calls. Some of the equipment, such as digital switches that receive and route calls over landline and cellular circuits, is sensitive to the RF energy generated by hand-held radios. Testing by UL confirmed that portable radios programmed to operate in many of the public safety frequency ranges can cause severe service interruptions to equipment in telephone COs. The level of impact to the telephone CO equipment is dependent on the radio's wattage and its sphere of radiation at the antenna.

Conversely, the impact of the telephone CO equipment and radio operation inside the building is also dependent on whether the equipment is electrically shielded or unshielded from stray RF energy.

**510.2 Emergency responder radio coverage in existing buildings.** Existing buildings shall be provided with *approved* radio coverage for emergency responders as required in Chapter 11.

❖ See the commentary to Section 1103.2.

**510.3 Permit required.** A construction permit for the installation of or modification to emergency responder radio coverage systems and related equipment is required as specified in Section 105.7.6. Maintenance performed in accordance with this code is not considered a modification and does not require a permit.

❖ A construction permit must be obtained in accordance with Section 105.7.6 prior to the installation of the ERRCS and for any modification or alteration to the system to ensure that the work is done correctly and any parts replacement will be compatible with the existing system components. Note that normal maintenance required for the system would not require a permit.

**510.4 Technical requirements.** Systems, components and equipment required to provide the emergency responder radio coverage system shall comply with Sections 510.4.1 through 510.4.2.8.

❖ This section simply introduces Sections 510.4.1 through 510.4.2.8, which are the technical requirements for the ERRCS.

**510.4.1 Emergency responder communication enhancement system signal strength.** The building shall be considered to have acceptable emergency responder communications enhancement system 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 through 510.4.1.3.

❖ This section introduces the minimum acceptable signal criteria that must be achieved and maintained throughout 95 percent of all areas on each floor of a building, as indicated in Sections 510.4.1.1 and 510.4.1.3.

**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-Interference-Plus-Noise Ratio (SINR) applicable to the technology for either analog or digital signals.

❖ The focus of this section is the signal received within the building. Section 510.4.1.2 addresses the minimum signal to a radio on the outside of the building. The language provided for minimum signal strength into and out of the building in this section and Section 510.4.1.2 is performance based in that it simply

requires that the signal strength be sufficient to provide usable voice communication. A criteria is provided in the form of a minimum delivered audio quality of 3.0, or an equivalent signal to interference plus noise ratio (SINR). This approach aligns national standards with industry practices in delivering communications quality to the users of emergency responder systems. Utilizing a quality measure in dBm, as previous editions of this code have, only addresses signal strength, not interference of noise, and thus is an incomplete assessment of usable signal. Delivered Audio Quality (DAQ) refers to a range of usable voice parameters and is useful regardless of the modulation or system technology utilized. This allows a measure of how the signal will sound to the end user, which is critical to emergency operations. Again, this is the same criteria provided for minimum outbound signal.

#### 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.

❖ The criteria for outbound signal is the same as the inbound signal. See commentary for Section 510.4.1.1.

**510.4.1.3 System performance.** Signal strength shall be sufficient to meet the requirements of the applications being utilized by public safety for emergency operations through the coverage area as specified by the *fire code official* in Section 510.4.2.2.

❖ This section addresses data network performance for other emergency responder signals such as Long Term Evolution (LTE), which is part of the nationwide public safety responder network commonly known as FirstNet.

**510.4.2 System design.** The emergency responder radio coverage system shall be designed in accordance with Sections 510.4.2.1 through 510.4.2.8 and NFPA 1221.

❖ This section simply introduces Sections 510.4.2.1 through 510.4.2.8 as the system design criteria for the ERRCS. NFPA 1221 is the standard that addresses installation, maintenance and use of emergency services communication systems.

**510.4.2.1 Amplification systems and components.** Buildings and structures that cannot support the required level of radio coverage shall be equipped with systems and components to enhance the public safety radio signals and achieve the required level of radio coverage specified in Sections 510.4.1 through 510.4.1.3. Public safety communications enhancement systems utilizing radio-frequency-emitting devices and cabling shall be approved by the *fire code official*. Prior to installation, all RF-emitting devices shall have

the certification of the radio licensing authority and be suitable for public safety use.

❖ In many cases, buildings cannot provide the necessary inbound and outbound performance levels without providing amplification within the building. This section stresses that additional amplification must be provided to achieve the necessary performance. There are several methods to provide the amplification needed by fire departments in structures identified as needing ERRCS. These enhancements need to be both approved by the fire code official and also through certification through the radio licensing authority. In the case of the US this would be the Federal Communications Commission (FCC). The wording is more performance based than previous editions to state more clearly that a variety of different methods can be used.

**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 communications coverage system. This document shall contain, but not be limited to, the various frequencies required, the location of radio sites, the effective radiated power of radio sites, the maximum propagation delay in microseconds, the applications being used and other supporting technical information necessary for system design.

❖ In order to effectively install such systems, the fire code official must provide basic information such as the frequency range to be supported and maximum propagation delay. For example, a fire department may provide a requirement such as "The frequency ranges that must be supported shall be 806 MHz to 824 MHz and 851 MHz to 869 MHz." The fire code official will likely need to provide a reference to the local communications center or provide details on radio sites in the jurisdiction.

**510.4.2.3 Standby power.** Emergency responder radio coverage systems shall be provided with dedicated standby batteries or provided with 2-hour standby batteries and connected to the facility generator power system in accordance with Section 1203. The standby power supply shall be capable of operating the emergency responder radio coverage system at 100-percent system capacity for a duration of not less than 12 hours.

❖ This section requires secondary power to operate the equipment in cases where the primary building power must be shut down or is lost. There are two options provided: dedicated standby batteries or through a traditional generator-type source with 2-hour standby batteries. The standby power supply, regardless of how it is provided, must be capable of operating the in-building radio amplification system for a minimum 12-hour duration. The 12-hour value was selected to ensure the reliability of the signal boosters during long-term emergency operations such as response to natural disasters where utility-supplied electrical

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power is disabled. See Section 1203 for secondary power system specifics and standards. The 12-hour duration is consistent with NFPA 72 Section 24.5.2.5.5.2.

**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 exists, isolation shall be maintained between the 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 to cause interference on any emergency responder radio coverage networks shall be coordinated and approved by the *fire code official*.
- ❖ If a building is equipped with a signal booster, this section requires that the components of the signal booster be located in a National Electrical Manufacturers Association (NEMA) Type 4 cabinet. A NEMA Type 4 cabinet is designed to protect personnel having incidental contact with the equipment and to protect the equipment from falling dirt, rain, snow, windblown dust, and both splashing and hose-directed water. The standby power source is to be located in a NEMA Type 3R cabinet, which provides similar protection but with the ventilation necessary for most batteries. Type 3R does not require protection from splashing water and hose-directed water but is felt to provide an appropriate level of protection. The system is also required to be certified by the Federal Communications Commission (FCC) or other radio licensing authority. This document may be used outside the United States where the FCC is not applicable. Items 4, 5 and 6 provide requirements that limit the opportunity for interference and/or noise created by inadequate system components and their location and placement.

**510.4.2.5 System monitoring.** The emergency responder radio enhancement system shall be monitored by a listed *fire alarm control unit*, or where approved by the *fire code official*, shall sound an audible signal at a constantly attended on-site location. Automatic supervisory signals shall include the following:

1. Loss of normal AC power supply.

2. System battery charger(s) failure.
3. Malfunction of the donor antenna(s).
4. Failure of active RF-emitting device(s).
5. Low-battery capacity at 70-percent reduction of operating capacity.
6. Failure of critical system components.
7. The communications link between the *fire alarm system* and the emergency responder radio enhancement system.

❖ The system monitoring requirements were previously wrapped into the signal booster requirements. This location clarifies and provides detail as to what is required to be monitored. These requirements are those necessary to maintain integrity of the emergency responder communications enhancement system.

**510.4.2.6 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 other radio licensing authority, or additional frequencies are made available by the FCC or other radio licensing authority.

❖ Because of potential changes in public safety radio frequency bands, the code requires the capability for changing the frequency in the future. Note that since this code can be applied outside the United States, reference is made to the FCC or other radio licensing authority.

**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*.

❖ 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.

**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 narrow band signal booster devices with independent AGC/ALC circuits per channel.
  2. Systems where all portable devices within the same band use active power control features.
- ❖ The near-far effect occurs when too few indoor antennas are used to enhance coverage inside the building, creating an excessively wide dynamic range of operation. A portable device in close proximity to an indoor antenna, when keyed, can cause the talk-out

amplifier's AGC/ALC circuit to reduce the gain, leaving other portables farther away at risk of not hitting the repeater site due to insufficient gain. If the near-far effect occurs, some public safety communications equipment will not function as required by the code and will leave responders at risk.

**510.5 Installation requirements.** The installation of the public safety radio coverage system shall be in accordance with NFPA 1221 and Sections 510.5.1 through 510.5.4.

❖ This section simply introduces the installation requirements for such systems. In addition, it also notes that such systems must also comply with NFPA 1221. NFPA 1221 is the standard that addresses installation, maintenance and use of emergency services communication systems.

**510.5.1 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*.

❖ The installation of ERRCS in a building is similar to other building features where review of the plans and installation is required and covered under a permit. Part of the approval process for amplification systems operating on frequencies licensed to a public safety agency requires approval of the local fire code official.

**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 an approved organization or approved school, or a 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.

❖ This section is to ensure that a qualified person designs and installs the ERRCS in the building. The qualification may be from a school program in communications or a manufacturer's training program. This section also allows the jurisdiction to accept a person or business upon adequate demonstration of skills and experience to the fire code official.

**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 95 percent. The test procedure shall be conducted as follows:

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.
  3. Failure of more than one test area shall result in failure of the test.
  4. In the event that two of the test areas fail the test, in order to be more statistically accurate, the floor shall be permitted to be divided into 40 equal test areas. Failure of not more than two nonadjacent test areas shall not result in failure of the test. If the system fails the 40-area test, the system shall be altered to meet the 95-percent coverage requirement.
  5. 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, that location shall represent the entire test area. Failure in the selected test location shall be considered to be a failure of that test area. Additional test locations shall not be permitted.
  6. 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 reestablish the gain values.
  7. 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 at subsequent annual inspections.
  8. Systems incorporating Class B signal-booster devices or Class B broadband fiber remote devices shall be tested using two portable radios simultaneously conducting subjective voice quality checks. One portable radio shall be positioned not greater than 10 feet (3048 mm) from the indoor antenna. The second portable radio shall be positioned at a distance that represents the farthest distance from any indoor antenna. With both portable radios simultaneously keyed up on different frequencies within the same band, subjective audio testing shall be conducted and comply with DAQ levels as specified in Sections 510.4.1.1 and 510.4.1.2.
- ❖ This section provides a testing procedure to be followed upon completion of system installation and prior to acceptance of the system by the jurisdiction. The 95-percent coverage required is consistent with that required in Section 510.4.1. The building owner or agent is responsible for ensuring that the ERRCS is functioning properly prior to the building being occupied. Note that if there are problems as a result of the testing, the test area is to be altered to provide more specific data on the strength of the signal-

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boosting capability of the system. Testing results are to be kept on file by the building owner for annual testing verification. If the testing results are lost, a retest of the building shall be required to determine compliance levels. The testing identified in Item 8 will ensure that there is consistent, objective data for the fire code official to use to ensure quality and conformance and to maintain consistency with the DAQ requirements in Section 510.4.

**510.5.4 FCC compliance.** The emergency responder radio coverage system installation and components shall comply with all applicable federal regulations including, but not limited to, FCC 47 CFR Part 90.219.

❖ As with all radio systems, the ERRCS and its components must comply with all applicable FCC regulations.

**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.

❖ This section simply introduces the maintenance requirements for the ERRCS for continued successful operation of the system.

**510.6.1 Testing and proof of compliance.** The owner of the building or owner's authorized agent shall have 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. 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.
  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 within 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*.
- ❖ Signal boosters are tested to verify that the gain is equal to that produced during the initial acceptance. Testing must also include functional tests of the secondary power supply and an inspection of any other components connected to the in-building amplification system. The inspection report must be submitted to the fire code official and requires documentation

that the amplification system complies with the requirements in Section 510.5.3. This section authorizes the fire code official to require additional tests when structural changes or modifications occur that could materially change the performance of the signal boosting system. This section also emphasizes that the responsibility to undertake this testing is that of the owner.

**510.6.2 Additional frequencies.** The building *owner* shall modify or expand the emergency responder radio coverage system at his or her expense in the event frequency changes are required by the FCC or other radio licensing authority, or additional frequencies are made available by the FCC or other radio licensing authority. Prior approval of a public safety radio coverage system on previous frequencies does not exempt this section.

❖ Where additional frequencies are needed to change or expand the coverage of the ERRCS, the building owner is the responsible person to ensure that the work is performed. Previous approvals of the system do not apply when changes are needed. Changes to the system are not exempt because of prior approval. If the change is needed, the work must be done.

**510.6.3 Nonpublic safety system.** Where other nonpublic safety amplification systems installed in buildings reduce the performance or cause interference with the emergency responder communications coverage system, the nonpublic safety amplification system shall be corrected or removed.

❖ With the public's reliance on cellular devices as a primary method of communications, many buildings are being equipped with cellular enhancement systems that provide improved coverage. If not properly designed, installed and maintained these nonpublic safety systems may cause interference and performance issues on the public safety radio enhancement system. This section provides the necessary tool for the fire code official to address interference of a required public safety system. Requiring correction or removal of the nonpublic safety system where it is causing interference or performance issues is vital to the public safety responders in the event of an incident.

**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.

❖ Like all systems, ERRCS need to be tested to verify their continued sufficiency. Whether the test is an annual review of the system or an in-service familiarization test by an engine, truck or squad company, this section provides the ability of the personnel to enter the building at reasonable hours to test and operate the system. As with any inspection, the right of entry for testing the system is limited by constitutional constraints. See the commentary to Section 104.3 for further discussion on the right of entry.