

**DIVISION 28  
ELECTRICAL**

**SECTION 28 31 13**

**EMERGENCY RESPONDER RADIO ANTENNA/REPEATER SYSTEM**

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish, install, and test a complete and operating Emergency Responder Radio Antenna/Repeater System. The system will support only City and County of Denver Department of Safety radio system and Denver Public School Department of Safety. Provisions for supporting other; cell phone carriers; private security and/or maintenance personnel radio systems, etc. – now or in the future – shall not be included.
- B. This Section includes the requirements for an Emergency Responder Radio Antenna/Repeater System for the purposes of amplifying Emergency Responder radio signals to achieve minimum signal strength in 95% of all areas on each floor of the building or as required for Denver Fire Department.
- C. Final acceptance and approval is required from the Denver Fire Department in writing prior to contract closeout.
- D. Section Includes
  - 1. Bi-directional amplifiers (BDA's)
  - 2. Distributed Antenna System
  - 3. Coaxial cables
  - 4. Splitters and direction couplers
  - 5. UPS
  - 6. All other equipment and components necessary for a complete and functioning Emergency Responder Radio Antenna/Repeater System.

1.02 REGULATIONS

- A. Codes, regulations and standards referenced in the Section are:
  - 1. ICC International Fire Code, Code and Commentary
  - 2. Denver Building and Fire Code Amendments
  - 3. Federal Communication Commission (FCC)
  - 4. NFPA Codes and Standards

1.03 DEFINITIONS

- A. Definitions:
  - 1. Bi-Directional Amplifier BDA: Device used to amplify band-selective or multi-band RF signals in the uplink, to the base station for enhanced signals and improved coverage.
  - 2. Emergency Responder Radio Coverage System: Two-way radio communication system installed to assure the effective operation of radio communications systems for fire, emergency medical services or law enforcement agencies within a building or structure. A system used by firefighters, police, and other emergency services personnel.

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## 1.04 SUBMITTALS

- A. Submit product data for each type of proposed system component specified, including dimensioned drawings showing minimum clearances and installed features.
- B. Layout Drawings
  - 1. Component specification sheets shall be 8.5 inch x 11 inch or greater, scaled or dimensioned, with dimensions or scale clearly noted.
  - 2. Floor plan drawings shall be 24 inch x 36 inch minimum with drawings scaled to legible size.
  - 3. Floor plan drawings may include elevation detail names for each elevation view. Sheet title shall include site name, address, sheet number, floor plan number and north arrow. Include site plan view of the subject buildings and surrounding property to clearly indicate the location and orientation of roof mounted outdoor antennas associated with the proposed system.
  - 4. Include a minimum of (1) building elevation depicting the location of any outdoor antennas associated with the proposed system. Include height of antenna centerline above building, orientation, and location of all external grounding connections.
  - 5. Include a detail plan view of all Telecommunications Spaces housing head-end and/or other consolidated equipment, showing the location of the rack(s) and/or enclosure(s) of the Emergency Responder Radio Antenna/Repeater System equipment.
  - 6. Include a separate plan view of each interior floor where indoor antenna systems are proposed. Include antenna numbers, coaxial cable routes, and the locations of any other system components including splitters, couplers, filters, amplifiers, etc. All components shall be named or labeled for reference in power budget calculations tables. Overlay approximated coverage radii indicating -95 dBm downlink (base to mobile) signal strength around each proposed indoor coverage antenna. Include results of any previous coverage testing per grid, if available.
  - 7. Include a minimum of one (1) detail elevation view(s) of all rack(s) and/or enclosure(s) housing the Emergency Responder Radio Antenna/Repeater system equipment. Identify each piece of equipment by brand, model number and equipment type.
  - 8. Specify antenna grounding and surge protection in accordance with NEC Article 810.
  - 9. Specify the backup power source and include calculations to ensure the backup power requirements as specified in this standard are met.
- C. Equipment Specification Sheets
  - 1. Provide copies of manufacture specification sheets of all system components, including:
    - a. Amplifiers
    - b. Antennas
    - c. Coaxial cable, couplers, splitters, combiners, or other passive components
  - 2. Operation and maintenance data
  - 3. Pass band curves in for the uplink and downlink portions of the NPSPAC band for any amplifiers, if not included in #1. Amplifiers may NOT amplify portions of other licensed services.
  - 4. Backup battery and charging system.
- D. Submit wiring diagrams from manufacturer differentiating clearly between factory and field-installed wiring. Include diagrams for each component of the system with all terminals and interconnections identified. Make all diagrams specific to this Project.
- E. Submit product certificates signed by the manufacturer of radio system components certifying that their products comply with specified requirements.
- G. Maintenance data for radio system shall be included in the operation and maintenance manual. Include data for each type of product, including all features and operating sequences, both automatic and manual. Provide the names, addresses, and telephone numbers of service organizations that carry stock of repair parts for the system to be furnished.

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- H. Record of field tests of the radio system shall be included in the operation and maintenance manuals.
- I. Design Approval: Plans shall be submitted and approved prior to installation. The following information shall be provided to Denver Fire Department unit representative by the system designer/Contractor:
  - 1. A minimum of three (3) copies of detailed drawings showing the location of the amplification equipment and associated antenna systems which includes a view showing building access to the equipment; and
  - 2. A minimum of three (3) copies of schematic drawings of the electrical system, backup power, antenna system and any other associated equipment relative to the amplification equipment including panel locations and labeling.
  - 3. A minimum of one (1) copy of the Manufacturer's data sheets on all equipment to be installed.

#### 1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced factory-authorized installer to perform work of this Section. No contractor shall install, modify, repair, alter or replace an RES without a valid Denver Fire Department license. All field installers shall be individually certified by the manufacturer for the equipment being installed. Each certified installer shall be permitted to supervise one apprentice/helper
- B. Single-Source Responsibility: Obtain radio system components from a single source who assumes responsibility for compatibility of system components.
- C. All equipment shall be UL listed and labeled, and in accordance with applicable NEMA and ANSI Standards. Where copper cabling is routed to an area, either in another building, or with a separate electrical service, the Technology Contractor shall provide primary protective equipment.
- D. All racks and enclosures shall be either welded or assembled with paint piercing ground washers, grounding strip and bonding jumper as indicated on the Drawings.

#### 1.06 MANUFACTURERS

- A. Subject to compliance with requirements and offering products that may be incorporated into the project include, but are not limited to, the following:
  - 1. CommScope/Andrew
  - 2. Times Microwave
  - 3. Tessco
  - 4. CCI (Communication Components Inc.)
  - 5. Solid Technologies
  - 6. Potter Electric

## PART 2 PRODUCTS

### 2.01 GENERAL PERFORMANCE REQUIREMENTS

- A. **Compatibility:** The equipment, including but not limited to repeaters, transmitters, receivers, signal boosters, cabling, fiber distributed antenna system, etc., shall not interfere with the existing communication systems utilized by the Public Safety and First Responder agencies.
- B. **Power Supplies:** At least two (2) independent and reliable power supplies shall be provided, one primary and one secondary. The primary power source shall be supplied from a dedicated 20 ampere branch circuit and comply with of NFPA 70 and 72. The secondary power source shall be a dedicated battery, capable of operating the in-building radio system for at least 12 hours of 100% system operation. The battery system shall automatically charge in the presence of external power input. The battery system shall be contained in one NEMA 4 or 4X type enclosures. Monitoring the integrity of power supplies shall be in accordance with of NFPA 72. The UPS input circuit shall be a dedicated circuit and any cord and plug connection(s) shall be secured in an approved cabinet to prevent inadvertent disconnection. The circuit shall also be connected to the emergency generator where one is provided. The circuit shall be provided with a “lock-on” device. The RES system shall be maintained in an operative condition at all times.
- C. **Survivability**
  - 1. Cabling and optic fiber shall be installed in Electrical Metallic Tubing (EMT) throughout unless noted otherwise. EMT/ Conduit is NOT required in concealed areas, including but not limited to above ceilings, attics, etc.
  - 2. Cabling not in EMT conduit shall meet requirements NEC for securing and supporting.
  - 3. Riser cable and amplifiers for distributed antenna systems shall be located in stacked electrical rooms, telephone rooms or shaft enclosure separated from the remainder of the floor by not less than a one-hour fire-resistance rated fire barrier constructed in accordance with Section 707 or 713 of the International Building Code. Wiring runs from an RES unit amplifier to a riser shall be separated from the remainder of the building by a minimum 1-hour fire-resistance rated fire barrier constructed in accordance with Section 707 of the International Building Code or a one hour fire-resistance rated horizontal assembly constructed in accordance with Section 711 of the International Building Code, or both.
  - 4. Cabinet. The signal booster and all associated RF filters shall be housed in a single, NEMA 4 certified, painted steel weather tight box. The cabinet shall be large enough to dissipate internal heat without venting the inside of the cabinet to the outside atmosphere. Operating temperatures: -22 degrees F to +120 degrees F (-30 degrees C to +50 degrees C) minimum temperature range, including microprocessors. Equipment installed on the roof of structures shall be rated for the expected extreme temperatures associated with rooftop installations.

### 2.02 SYSTEM COMPONENTS A.

#### Signal Strength

- 1. Downlink: A minimum signal strength of -95 dBm shall be provided throughout the coverage area or as required by Denver Fire.
  - 2. Uplink: Minimum signal strength of -95 dBm received at the Denver Fire Radio System from the coverage area.
  - 3. A donor antenna must maintain isolation from the distributed antenna system. The donor antenna signal level shall be a minimum of 15 dB above the distributed antenna system under all operating conditions.
- B. **Permissible Systems**
    - 1. Buildings and structures shall be equipped with an FCC Certified Class B Bi-Directional UHF Amplifier(s) as needed.

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- 2. The distributed antenna system may utilize a radiating cable, fixed antennas or a combination of both.
- C. Supported Frequencies: The radio system shall support frequencies in the Radio communications systems shall only operate on the frequency range of 806-816MHz and 851-861MHz.MHz public safety bands as utilized by the Denver Department of Safety.
- D. Band Migration Capability: The signal booster shall include re-tunable or replaceable filters to accommodate rapid and economic passband changes in the event of mandatory FCC changes within the NPSPEC band. The use of non-adjustable and non-replaceable RF input and output filters is prohibited.
- E. Output Level Control: An automatic output leveling circuit shall be included for both passbands with a minimum dynamic range of 60 dB, less any gain reduction setting, to maintain FCC out of band and spurious emission compliance.
- F. Degraded Performance in Emergencies: The system shall be designed to allow degraded performance in adverse conditions, such as abnormally high temperatures resulting from nearby fires, extreme voltage fluctuations or other abnormal conditions that may occur during an emergency. Circuits that intentionally disable the signal booster in such situations (i.e. under/over voltage, over/under current, over/under temperature, etc.) will not be implemented as the standard mode for public safety applications.
- G. Mode of Operation: The system shall be normally powered on and shall continuously provide passing of frequencies within the Public Safety and First Responder bands.
- H. All in-building radio systems shall be compatible with both analog and digital communications simultaneously at the time of installation.

## 2.03 SYSTEM MONITORING

- A. The distributed antenna system shall include a connection to the fire alarm system to monitor the integrity of the circuit of the signal booster(s) and power supplies and annunciate this malfunction on the fire alarm system shall comply with NFPA 72.
- B. A sign shall be located at the fire alarm panel with the name and telephone number of the Denver Fire Department indicating that they shall be notified of any failures that extend past the 2 hour time limit.

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. Distribution System Signal Wires and Cables
  1. Wires and cables shall enter each equipment enclosure, console, cabinet or rack in such a manner that all doors or access panels can be opened and closed without removal or disruption of the cables.
  2. Routing and Interconnection
    - a. Wires or cables routed between consoles, cabinets, racks, and other equipment shall be installed in an approved conduit or cable tray that is secured to building structure or other approved methods.
    - b. Completely test all of the cables after installation and replace any that are found to be defective.
  3. Install cables without damaging conductors, shield, or jacket.
  4. Do not bend cables, while handling or installing, to radii smaller than as recommended by manufacturer.
  5. Pull cables without exceeding cable manufacturer's recommended pulling tensions.

- B. Product Delivery, Storage, and Handling
  - 1. Delivery: Deliver materials to the job site in OEM's original unopened containers, clearly labeled with the OEM's name and equipment model and serial identification numbers.
  - 2. Store and protect equipment in a conditioned space until installation.
- C. System Installation
  - 1. Coaxial antenna cabling shall not be installed in the same conduit, raceway, or cable trays used for other systems.
  - 2. All equipment shall be connected according to the OEM's specifications to insure correct installation and system performance.
  - 3. Coordinate all roof penetrations with Owner and/or roofing contractor.

### 3.02 LICENSING

- A. All fees associated with the licensing shall be paid by the Owner. B. All testing must be done on frequencies authorized by the FCC.

### 3.03 GROUNDING

- A. Ground cable shields and equipment per Manufacturer's requirements.
- B. Antenna mast shall be grounded per NFPA 70 NEC requirements, "Grounding and Bonding for Communications Systems" and antenna manufacturer's requirements. Provide grounding blocks and surge protection for outside coaxial cabling. Bond the antenna mast to the existing lightning protection system.

### 3.04 APPROVAL TESTING

- A. The Denver Fire Department will review plans and specifications. Upon acceptance, plans will be stamped to indicate approval. Stamped plans are required to be present at the acceptance test. Any field changes that occur during construction shall be incorporated into new As-Built plans, including any manufacturer's data sheets for any equipment changes not submitted in the original submittal. As-Built plans, if required due to system changes, shall be submitted to the Denver Fire Department for approval.
- B. Tests shall be made using frequencies close to the frequencies used by the Fire Department and appropriate emergency services. If testing is done on the actual frequencies, then this testing must be coordinated with the Denver Fire Department. All testing must be done on frequencies authorized by the FCC. A valid FCC license will be required if testing is done on frequencies different from the police, fire or emergency medical frequencies.
- C. Testing Procedures
  - 1. Minimum Signal Strength: For testing system signal strength and quality, the testing shall be based on the delivered audio quality (DAQ) system. A DAQ level below 3.0 shall be considered a failed test for a given grid cell.
  - 2. Measurements shall be made with the antenna held in a vertical position at 3 to 4 feet above the floor to simulate a typical portable radio worn on the belt or turnout coat pocket.
- D. Final Acceptance Testing
  - 1. All acceptance testing shall be done in the presence of a Denver Fire Department representative or by the Denver Fire Department unit at no expense to the DPS.
  - 2. Small scale drawings (11 inch x 17 inch maximum) of the structure shall be provided by the Contractor to the Owner. The plans shall show each floor divided into the grids as described above, and the results of the pre-testing. Each grid shall be labeled to indicate the DAQ result from the final

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- acceptance testing.
- 3. The Contractor shall provide the latest approved plans for the system, including any manufacture's data sheets for any equipment changes not submitted in the original submittal to the Owner.
- 4. Include testing results of the repeater (output wattage, gain level, etc) and connection to the fire alarm.

### 3.05 MAINTENANCE AND ANNUAL TESTING

- A. Annual tests will be conducted by the Denver Fire Department unit or authorized company.
  - 1. The re-testing will be done at no expense to the DPS or the appropriate emergency services departments as required in the original testing procedures.
- B. Maintenance Contract
  - 1. Maintenance contract with a Radio Service Provider in place with name of authorized company, who will provide a 24 hour by 7 day emergency response within two (2) hours after notification. The system shall be maintained in accordance with FCC requirements. The contract shall be for 5 years.
  - 2. All tests shall be conducted, documented, and signed by a person in possession of a current FCC General Radio telephone Operator License, or a technician certification issued by the Association of Public-Safety Communications Officials International (APCO) or equivalent as determined by the Denver Fire Department.
  - 3. Maintain a list of contact personnel with phone numbers at the radio repeater system cabinet. The contact personnel shall have knowledge of the building and the repeater system and be available to respond to the building in the case of an emergency.
  - 4. Radio Service Provider maintenance contract shall include but not limited to:
    - a. Annual Test
      - 1) All active components of the distributed antenna system, including but not limited to amplifier, power supplies, and back-up batteries, shall be tested a minimum of once every 12 months.
      - 2) Amplifiers shall be tested to insure that the gain is the same as it was upon initial installation and acceptance. The original gain shall be noted and any change in gain shall be documented.
      - 3) Back-up batteries and power supplies shall be tested under load for a period of 1 hour to verify that they will operate during an actual power outage.
      - 4) Active components shall be checked to determine that they are operating within the manufacturer's specifications for their intended purpose.
      - 5) Documentation of the test shall be maintained on site and a copy forwarded to DPS and Denver Fire Department Radio Supervisor upon completion of the test.

END OF SECTION