# Pinellas County and Local Municipalities Authority Having Jurisdiction (AHJ)

# Compliant Public Safety In-Building Two-Way Radio Communications Enhancement System Requirements

June 13, 2019

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# Introduction

Pinellas County (County) has adopted NFPA 72, National Fire Alarm and Signaling Code, 2013 Edition (NFPA72-2013) as its Fire Alarm Code. NFPA72-2013 Chapter 24 includes requirements for "Emergency Communications Systems" provides Two-Way, In-Building Emergency Communications Systems Coverage requirements.

Modern building design and construction techniques, especially those required to satisfy requirements for LEED-certified building designs, make it difficult or impossible for the County or local municipality's Authority Having Jurisdiction (AHJ) to provide reliable two-way radio coverage for first responders operating inside of buildings. Two-way radio communications enhancement systems help ensure the safety of building occupants and first responders by extending the coverage of a public safety communications system to the interior areas of the building using special bi-directional amplifiers (BDAs) and a network of indoor antennas strategically located to provide reliable public safety radio system coverage throughout the interior of a building. The BDA and network of antennas is known collectively as a Distributed Antenna System (DAS).

DAS systems must be designed, installed, maintained, and repaired by qualified personnel to ensure that they meet the coverage reliability requirements of NFPA72-2013 and do not cause unintended harmful interference to the radio systems or other users of the RF spectrum licensed by the Federal Communications Commission (FCC).

The FCC requires that DAS systems be either operated by the licensee of the public safety radio system, or explicitly authorized by the licensee. Additionally, the BDA/DAS system owners must enter the DAS into a nationwide registry maintained by the FCC, so the appropriate parties can be contacted should the DAS cause interference to radio systems operated by other licensees.

Pinellas County owns and operates the Intergovernmental 800 MHz digital simulcast radio system and a 700 MHz digital simulcast overlay for first responder communications. The City of Clearwater owns and operates a separate 800 MHz digital simulcast radio system. The County and Clearwater radio shops have responsibility for the day-to-day operation, maintenance, and management of the system.

This document is intended to provide guidance to building owners and developers who are contemplating projects in the County and local municipalities that are required to meet the requirements of NFPA72-2013, and to DAS firms installing NFPA72-2013 compliant systems to meet the County's and local AHJ Fire Alarm Code requirements.

# Summary of Requirements for Owners

NFPA 1, 2015 Edition Fire Code, as adopted by the County, requires reliable in-building public safety radio system coverage, and where necessary, two-way radio communications enhancement systems:

All commercial, multi-unit residential, governmental, and educational occupancies must have reliable in-building public safety radio communications coverage that meets the requirements of NFPA72-2013. Refer to Florida State Statute Chapter 633, Section 202.

## Occupancies meeting coverage reliability requirements without radio communications enhancement systems:

In some occupancies, such as those with smaller footprints or those located near one of the radio transmission sites, it may be possible to achieve reliable public safety radio communications coverage throughout the occupancy and meet code requirements without the use of a radio communications enhancement system. Public safety radio coverage in these occupancies must meet the same reliability requirements as those occupancies that require a radio communications enhancement system.

- The County and local AHJ require building owners and developers engage the services of a qualified firm having the knowledge of Radio Frequency (RF) installation with training and experience with two-way radio communication enhanced radio systems in the engineering and design of two-way radio communications enhancement systems to assist with this determination. The system designer (a licensed Professional Engineer, "P.E."), lead installation personnel (factory trained) and personnel conducting radio system tests shall be qualified to perform the work. Design documents and all tests shall be documented and signed by a person in possession of a current FCC General Radio Telephone Operator License and a certificate or certification issued by the:
    - 1. Associated Public Safety Communications Officials International (APCO), or
    - 2. National Association of Business and Education Radio (NABER) or
    - 3. Personal Communications Industry Association (PCIA), or
    - 4. Manufacturer of the equipment being installed.
- Building owners/developers must submit all test documentation and a Certificate of Radio Coverage Compliance ("CORCC"), signed and sealed by the Florida licensed engineer (P.E.) of record, stating that the public safety radio system coverage reliability within the occupancy meets the requirements set forth in NFPA72-2013 24.5.2.2, 24.5.2.3, and was tested in

accordance with the provisions set forth in NFPA72-2013 14.4.10 (1-6) and A14.4.10 (3-6).

- The Certificate of Radio Coverage Compliance shall be posted at the fire alarm control panel or at the main electrical panel if no fire alarm control panel is present. An additional copy can be placed in the building manager's office. For buildings not equipped with two-way radio communications enhancement systems, testing for coverage reliability compliance and certification must be performed when all construction and interior finishing work is complete. If predictive software is used to model coverage, an actual test still needs to be performed when work is complete.

- In cases where a radio communications enhancement system is not provided, the indoor public safety radio communications coverage must be certified, signed, and sealed by the Florida licensed engineer (P.E.) of record, as meeting the requirements set forth in the following NFPA72-2013 sections, incorporated herein by reference and submit a CORCC stamped by a Florida licensed P.E. with representative screen shots of readings taken in the lowest level of the stairwells:

    - 24.5.2.2 Radio Coverage
    - 24.5.2.3 Signal Strength
    - 14.4.10 (1-6) In-building Emergency Radio Communications Systems (testing)
    - A14.4.10 (3-6) In-building emergency radio communications systems testing annex

## Occupancies requiring radio communications enhancement systems to meet coverage reliability requirements:

In occupancies where two-way radio communications enhancement systems are required to meet code requirements, two-way radio communications enhancement systems and related equipment must meet all NFPA72-2013 requirements and additional requirements described in this document. More specifically, the requirements of the following NFPA72-2013 sections are incorporated herein by reference:

- 24.5.2 Two Way Radio Communications Enhancement Systems
- 10.5.1 System Designer
- 10.5.2 System Installer
- 10.5.3 Inspection, Testing, and Maintenance Personnel
- 10.6.6/10.6.6.3.1 Secondary Power Supply
- 14.4.10 In-building Emergency Radio Communications Systems (testing)

- A.14.4.10 In-building emergency radio communications systems testing annex

- Building owners/developers must submit plans for the design of proposed two-way radio communications enhancement systems to Pinellas County Radio & Technology Department (PCR&T) or City of Clearwater (City) staff for review and approval of the selected donor site(s).

- Building owners/developers must apply for and obtain a Provisional Retransmission Authorization from County or City prior to commissioning the two-way radio communications enhancement system. The Retransmission Authorization is required by the FCC, and is the system operator's proof that the County/City has granted permission to operate equipment that uses radio frequencies licensed to the County/City[1]. Provisional Retransmission Authorizations are issued for initial system activation, optimization and testing. Final Retransmission Authorizations are issued upon successful commissioning of the system, and are valid for a period of five years from date of issuance.

- Equipment used by the two-way radio communications enhancement system must be type accepted by the FCC.

- The two-way radio communications enhancement system must be operated in accordance with FCC rules and regulations.

- The two-way radio communications enhancement system shall not cause interference to the County/City radio systems or equipment, or to systems or equipment operated by any other FCC licensee.

- Building owners/developers must submit as-built documentation, including the CORCC, in soft copy format (e.g., PDF) to PCR&T/City after testing is completed.

## Initial Determination

- In all new buildings and existing buildings that are modified, minimum radio signal strength must be provided. An applicant submits building plans to Pinellas County Building Services and/or local AHJ for review. See below for appropriate AHJ.

| Municipality | Address | Phone Number |
|---|---|---|
| Belleair | 901 Ponce de Leon Bl | (727) 588-3769 x215 |
| Belleair Beach | Pinellas County Building Services, 440 Court St | (727) 464-3888 |
| Belleair Bluffs | City Pre-Permit needed before contacting County @ 2747 Sunset Bl | (727) 584-2151 |
| Belleair Shore | Pinellas County Building Services, 440 Court St, 3rd floor | (727) 464-3888 |
| Clearwater | Planning Dept, 100 S Myrtle Av, 2nd floor | (727) 562-4580 |
| Dunedin | Planning & Development, 737 Loudon Av, 2nd Floor | (727) 298-3210 |
| Gulfport | Building Dept, 5330 23 Ave S | (727) 893-1024 |
| Indian Rocks Beach | Building Dept, 1507 Bay Palm Bl | (727) 517-0404 |

[1] See 47CFR90.219(b)(1)(i)

| | | |
|---|---|---|
| Indian Shores | Building Dept, 19305 Gulf Bl | (727) 517-3940 |
| Kenneth City | Building Dept, 6000 54 Av N | (727) 498-8948 |
| Largo | Building Services, 201 N Highland Av, Largo | (727) 586-7488 |
| Madeira Beach | Building Dept, 300 Municipal Dr | (727) 391-1131 |
| N. Redington Beach | Florida Municipal Services, 18001 Gulf Bl | (727) 202-6825 |
| Oldsmar | Building Division, 100 State St W | (813) 749-1124 |
| Pinellas Park | Building Development, 6051 78 Av N | (727) 369-5647 |
| Redington Beach | FL Municipal Services, 18001 Gulf Bl | (727) 202-6825 |
| Redington Shores | Building Dept, 17425 Gulf Bl | (727) 397-5538 |
| Safety Harbor | Building Division, 750 Main St | (727) 724-1515 |
| St. Pete Beach | Building Services, 155 Corey Ave, 1st floor | (727) 363-9214 |
| St. Petersburg | Building & Permitting, One 4th St N | (727) 893-7231 |
| Seminole | Building & Permitting, 9199 113th St | (727) 391-1966 |
| South Pasadena | Community Improvement, 6490 Hibiscus Av S | (727) 343-4192 |
| Tarpon Springs | Building Dept, 324 E Pine St | (727) 942-5617 |
| Treasure Island | Community Improvement, 120 108th Av | (727) 547-4575 x230 |
| Unincorporated | Pinellas County Building Services, 440 Court St, 3rd floor | (727) 464-3888 |

- Plan review staff includes a plan comment as part of the building permit review stating that compliant public safety radio coverage is required for the occupancy, including the installation of a two-way radio communication enhancement system if necessary to meet code requirements.

- The applicant is directed to Pinellas County Radio & Technology for additional information. This Compliant Public Safety In-Building Two-Way Radio Communications Enhancement System Requirements document is provided upon request, and is available for download from the Pinellas County Building Department's web site.

- The applicant proceeds with the **Radio Communications Enhancement System Implementation Process** described below.

- The applicant engages the services of a qualified firm having the knowledge of County and local AHJ requirements, RF installations with training and experience with two-way radio communication enhanced radio system integrations and installations to assess available radio coverage for the public safety communication systems at the location of the occupancy and determine if public safety radio coverage reliability in the occupancy will meet code requirements after it is fully constructed and finished, without the use of a two-way radio communications enhancement system.

- Once construction is complete, and prior to occupancy, owners/developers must submit all test documentation and a Certificate of Radio Coverage Compliance, signed and sealed by the engineer of record to the Authority Having Jurisdiction, stating that the public safety radio system coverage reliability within the occupancy was tested in accordance with the provisions set forth in NFPA72-2013 14.4.10 (1-6) and A14.4.1 (3-6), and meets the requirements set forth in NFPA72-2013 24.5.2.2, 24.5.2.3.

- The Certificate of Radio Coverage Compliance shall be posted at the fire alarm control panel or at the main electrical panel if no fire alarm control panel is present. An additional copy to be placed in the building manager's office.

- **If testing determines that public safety coverage reliability does not meet code requirements for the public safety communication systems, a compliant radio communications enhancement system must be installed and tested prior to issuance of the certificate of occupancy.**

# PINELLAS COUNTY and Local AHJ, FLORIDA

## CERTIFICATE OF RADIO COVERAGE COMPLIANCE

PROJECT NAME: _____

PROJECT ADDRESS: _____

DESIGN PROFESSIONAL ENGINEER OF RECORD: _____

TEST DATE AND TIME: _____

(Testing for compliance and certification shall be performed after construction and interior finishing work is complete)

I have responsible charge and I certify that the occupancy identified above was tested for the Pinellas County 800 MHz Intergovernmental Public Safety Radio System and/or the City of Clearwater Public Safety Radio System RF coverage levels and meets the requirements set forth in NFPA72-2013 24.5.2.2, and NFPA72-2013 24.5.2.3 without the use of a Two-Way Radio Communications Enhancement System. I further certify that the building was tested in accordance with the provisions set forth in NFPA72-2013 14.4.10 (1-6) and A14.4.10 (3-6). To the best of my knowledge, information and belief, the RF coverage levels for this occupancy meet or exceed those required by NFPA72-2013.

Professional Certification: I hereby certify that these documents were prepared or approved by me, and I am a duly licensed Professional Engineer under the laws of the State of Florida,

License Number _____, Expiration Date: _____.

Respectfully submitted,

_____

Signature and Seal of Design Professional Engineer of Record Date

# Radio Communications Enhancement System Implementation Process

The County and local AHJ has defined the following process for owners or developers planning new occupancies or modifications to existing occupancies that require a radio communications enhancement system to ensure operation of the public safety communication systems inside buildings.

## 1. Conduct System Planning and Design

The applicant includes an NFPA72-2013 compliant two-way radio communication enhancement system in the design requirements for the project. A qualified integrator or installation firm is hired to design, install, test, and activate the two-way radio communications enhancement system as a part of the building project. PCR&T and/or the City of Clearwater Radio Shop aids the integrator/installer in directing the selection of the donor sites for the proposed two-way radio communications enhancement system.

The applicant must obtain a separate low-voltage permit at Building Services or the local AHJ to cover the installation of the two-way radio communication enhancement system. Note: The fire alarm contractor is responsible for the fire alarm permit application, and integration of the radio communications enhancement system into the fire alarm supervisory notification/alarm panel.

## 2. Submit Retransmission Application

Integrator/installer completes a Retransmission Application for each BDA headend in the system design. Retransmission Applications must include the Low Voltage Permit Number assigned for the work. Owner submits Retransmission Application(s) and proposed design documentation (system design diagrams, bill of materials (including specification sheets) and floor plan diagrams) to County/City for review.

## 3. Entry in FCC Signal Booster Database

Federal Communications Commission (FCC) Registration Requirement
BDA/DAS system owners are required by the FCC to register their BDA/DAS system (which the FCC identifies as 'signal boosters') with the FCC. This applies to those systems already placed in operation, in permitting or under construction. The FCC Rule requiring registration is CFR 47, FCC Part 90.219(d) (5). Additional information may be found at: https://signalboosters.fcc.gov/signal-boosters/

A copy of this registration shall be submitted to the PCR&T and/or City.

## 4. Obtain Pinellas County and/or Clearwater Provisional Retransmission Authorization

Conducts a technical review of the proposed design. Upon approval of the design, the AHJ will notify PCR&T and/or City to issue signed Provisional Retransmission Authorization to applicant, which authorizes operation of the system for the purposes of installation, testing, and optimization. The Provisional Retransmission Authorization is valid for a period of one year from date of issuance.

## 5. Perform System Installation

The integrator/installer proceeds with installation of the approved system(s) in accordance with the project's plan and schedule. Substantial design changes from those specified in the initial design must be approved (e.g., selection of a different donor site, selection of different model BDA, selection of a different donor antenna, additions or changes to number of line amplifiers in the design, and changes to equipment room location in building).

Updated review and approval is not required for minor changes that do not impact the number of active amplification devices used by the system or impact the donor site (e.g., changes to the number or location of indoor coverage antennas in the design).

The two-way radio communication enhancement system should not be activated for optimization and testing without prior PCR&T and/or City approval. Staff may, at their sole discretion, require that an initial de-sense test be conducted prior to initial activation to ensure that no harmful interference occurs to the radio systems.

Integration with supervisory notification/alarm panel(s) must be compliant with the requirements of NFPA72-2013 and must be completed prior to fire alarm and two-way radio communication enhancement system testing.

## 6. Perform Pre-Commissioning Activation and Optimization

DAS Integrator/installer posts the Provisional Retransmission Authorization at the headend location(s). The integrator/installer notifies PCR&T and/or City staff when ready to activate the system for the first time.

If required by staff, an initial de-sense test is coordinated for the first activation of the system. The integrator/installer conducts system activation and optimization.

## 7. Perform Fire Alarm/Two-way Radio Communications Enhancement System Testing

The DAS integrator/installer coordinates scheduling of system testing with the fire alarm contractor at the site. Testing shall include integrator/installer staff, fire alarm contractor staff, and the AHJ.

The test participants conduct NFPA72-2013 compliant coverage testing and supervisory notification/alarm panel testing on the scheduled date.

PCR&T/City and/or AHJ reviews test documentation and provides comments and signoff to the Fire Marshal.

Vendor can arrange to use loaner radios provided by PCR&T. Vendor will be responsible any lost or damaged equipment.

## 8. Submit As-Built Documentation

The DAS integrator/installer provides test results and full system as-built documentation to in soft copy (e.g., PDF) format. AHJ will notify PCR&T to issue a Final Retransmission Authorization valid for a period of five years from date of issuance. The Final Retransmission Authorization must be posted at all headend location(s).

## 9. Issue Certificate of Occupancy

After all requirements for occupancy are met, including successful testing of the two-way communications enhancement system, supervisory notification/alarm panel interface and donor site de-sense, receipt of required documentation, and posting of Final Retransmission Authorization(s) at the system headend(s), the Fire Marshal/AHJ issues a Certificate of Occupancy. An additional copy to be placed in the building manager's office.

## 10. Annual Testing/Maintenance/Retransmission Agreement Renewal

The building owner retains services of a qualified firm having the knowledge of RF installation with training and experience with two-way radio communication enhanced radio systems to insure the original installed system is still in compliance, to conduct annual preventive maintenance and assist with annual testing.

The building owner coordinates annual testing of the two-way radio communications enhancement system with annual testing of other fire alarm and fire safety systems. Annual testing of two-way radio communications enhancement systems shall be performed in accordance with the requirements of NFPA72-2013.

Retransmission Authorizations are valid for five years from date of issuance and must be retested annually. To renew, submit current (within 30 days) annual test documentation and application for Retransmission Authorization renewal to PCR&T and/or City electronically at ratsupport@pinellascounty.org and/or Charles.Wilson@myclearwater.com. County and/or City will issue a new Retransmission Authorization valid for a period of five years from date of issuance after all the required documents have been submitted and reviewed.

## Contractor Qualifications

The Contractor shall be able to demonstrate previous experience in deployments of in-building RF radio coverage solutions for Public Safety systems, specifically in the following frequency bands: 700 MHz and 800 MHz.

To ensure personnel safety, all construction tasks shall be conducted in accordance with OSHA safety and/or local safety regulations (whichever is more stringent). Contractors must comply with applicable Federal, State and Local Codes and requirements, including the Florida Building Code. All site development and equipment installation work shall comply with all applicable codes in use by the County and/or AHJ. Government and local codes shall take precedence over the requirements of this document provided they offer added safety.

Contractor must be knowledgeable and adhere to the latest versions and amendments of the following industry standards and codes:

- NFPA 1,2015 National Fire Protection Association Fire Code
- NFPA 70, 2014 National Fire Protection Code or "National Electrical Code"
- NFPA 72, 2013 National Fire Alarm and Signaling Code
- NFPA 780, 2014 "Standard for the Installation of Lightning Protection Systems"
- NFPA 1221, 2016 "Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems"
- Harris, "Site Grounding and Lightning Protection Guidelines"
- Motorola R-56, "Standards and Guidelines for Communication Sites"
- TIA Bulletin TSB-88.1-C, Wireless Communications Systems Performance in Noise-Limited Situations, Part 1: Recommended Methods for Technology-Independent Performance Modeling
- Florida Building Code
- ANSI/TIA-222-G, Structural Standard for Antenna Supporting Structures and Antennas
- IEEE STD 142 "Green Book", "Recommended Practice for Grounding of Industrial and Commercial Power Systems"
- ANSI/TIA/EIA-568-B, "Commercial Building Telecommunications Cabling Standard

- ANSI/TIA/EIA-569-B, “Commercial Building Standards for Telecommunications Pathways and Spaces”

- ANSI/TIA/EIA-606, “The Administration Standard for the Telecommunications Infrastructure of Commercial Building”

- ANSI/TIA/EIA-607, “Commercial Building Grounding and Bonding Requirements for Telecommunications”

- All other applicable Federal, State and Local Building Codes and Requirements

## General Scope of Work

The DAS Integrator Designer/Installer shall provide a “turn-key” solution for the design, installation and testing of an in-building RF coverage system capable of meeting the requirements detailed in this document.

Should the contractor of record fail to have radio RF communications installation and repair experience with Distributed Antenna Systems, the contractor of record shall sub-contract the installation or repair of non-fire alarm function to a qualified company, having knowledge of Radio RF communications installation and repair.

For the downlink signal, a minimum signal strength of negative (-) 95 dBm throughout the entire facility with a Delivered Audio Quality (DAQ) of 3.4 or better, is required 100 % of the time.

For General Structure Areas, the in-building RF solution shall provide the above-specified coverage in 90% of the floor area as directed in this document and NFPA72-2013. General Structure Areas are defined as living areas, basements, parking garages, administrative offices, and conference rooms.

For Critical Areas, the in-building RF solution shall provide the above-specified coverage in 99% of the floor area. Critical Areas are defined as mechanical and utility rooms, public bathrooms, “Employee Only” access areas, stairwells, exit stairs, exit passageways, Police holding areas, elevator lobbies, fire pump rooms, sprinkler sectional valve locations, and other areas considered by the AHJ. The Designer/Installer shall contact the AHJ to confirm critical areas in the new construction.

The system shall provide the required coverage in the frequency bands or channels specified by the County and/or City.

The in-building RF Public Safety radio coverage system and other radio systems operating within (or in the vicinity of) the facility shall not interfere with each other.

Signal boosters shall be a Class B; FCC-type accepted and must operate in accordance with FCC rules.

The signal booster shall be installed in a fire engine-red NEMA 4 (or 4X) enclosure with locking mechanism with 2" high contrasting letters. Include the following information:

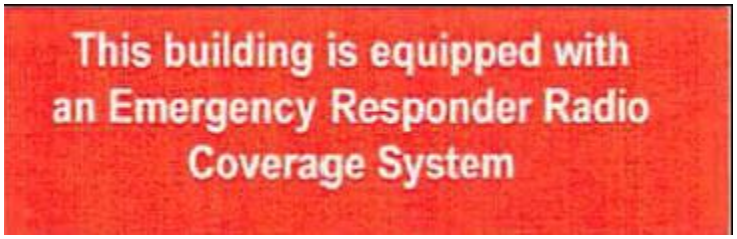
a) Fire Department Signal Booster

b) Permit Number: _____

c) Serviced by: Vendor name and telephone

Maximum VSWR measured in any RF branch of the DAS shall not exceed 1.5:1 (14 dB Return Loss).

Buildings equipped with an Emergency Responder Radio Coverage system shall be identified by a sign located on or near the Fire Alarm Control Panel stating: "This building is equipped with an Emergency Responder Radio Coverage System." As a rule, fire protection and related equipment are identified by a red sign with minimum one-inch white letters as shown below.
Example:




**Electrical power requirements**

All active components of the DAS shall be powered from an emergency power source via dedicated ("home run"). In addition, twelve-hour battery backup for the in-building system operating at 100% capacity is required.

NEMA twist-lock electrical plug and receptacle set shall be utilized to connect the active components of the DAS to the AC power.

Surge protection device(s) shall be used to protect active components of the DAS from electrical transients.

## Alarm and Monitoring System

An automatic monitoring system is required with a dedicated panel in the administrative office of the building (or other location to be agreed) so the system can be constantly monitored.

The system must monitor and produce an alarm in the event of antenna system malfunction or signal booster failure. Additionally, in case that an in-building solution based on RF/Fiber Optics converters is selected, the system shall also be capable of alarming in the event of malfunction of the main and the expansion hubs.

A separate alarm for oscillating amplifiers is also required. The selected signal booster shall be capable of "AGC Overdrive" and "Oscillation Control" features. This includes, but is not limited to, an alarm and automatic shutdown for oscillating amplifiers. These features are intended to minimize interference due to oscillation of the signal booster(s).

Power supplies must, at a minimum, alarm at loss of ac power, failure of the battery charger, and low battery charge (defined as 70% of capacity).

## Propagation Delay

The maximum radio signal propagation delay introduced by the in-building coverage solution shall not exceed 8 μs. If a delay greater than 8 μs is expected by design, then further analysis should be conducted in conjunction with the County and/or City to evaluate potential signal degradation in areas where the direct signal coming from a radio site coincides with the DAS output signal.

## Exterior Antenna System

The orientation of the donor antenna shall be determined in coordination with PCR&T and/or City.

If required by FAA regulations, obstruction lighting and/or marking shall be installed.

All exterior antennas are to be narrowband, high-gain, vertically polarized and designed for the specified frequency band. Yagi or corner reflector-type antennas are recommended.

All exterior mount antennas must be rated for 160 MPH wind gusts or higher.

The antenna installation, including the shield of the coaxial cable shall be suitably connected to the building's electrical ground system at the base of the antenna mast and at a coaxial lightning protector as per Motorola R56 and Harris Site Grounding and Lightning Protection Guidelines.

A weatherized coaxial lightning protector designed for the proper frequency band shall be installed in the coaxial cable feed outside the facility.

Typical requirements for coaxial lightning protectors are the following:

- Impedance: 50 Ω
- Frequency range: as needed to the respective bands
- VSWR: 1.1:1 or better
- Insertion Loss: 0.1 dB or better
- Impulse Discharge Current: 10KA or better
- Turn-on voltage: 600 V
- Turn-on Time: 2.5 nS for 2kV/nS
- Energy Throughput Rating: 5 nJoule for 3 kA (8/20μS waveform)
- Continuous handling RF power: 100 W or better at the respective frequency bands
- Rated for 160 MPH wind gusts or higher

A rooftop donor antenna installation shall meet the wind loading requirements of the Florida Building Code and ANSI/TIA-222-G.

## In-Building Antennas

The in-building antenna system shall consist of enough antennas, distributed in a wise manner within the building to meet the coverage criteria previously specified and not excessively penetrate outside of the building.

## Test procedures and measurement parameters

### 1. System isolation

Once the DAS is deployed, and before turning up the active components of the DAS, the very first test the Contractor shall perform is to verify that the isolation between the donor and the in-door antenna systems is at least 15 dB greater than the gain of the DAS.

### 2. Downlink Signal Strength Measurements

Downlink signal levels shall be measured to ensure the system meets the requirements of a minimum RF signal level of -95 dBm and 3.4 DAQ or better,

throughout the entire facility and attached structures under the conditions described in this document, 100% of the time.

With the purpose of (to some degree) accounting for the signal fading, two (2) readings of signal strength per tile should be taken within intervals of 20 seconds each.

The first 20-second reading shall be performed to determine the maximum peak hold of the test channel. The second reading shall be performed to determine the minimum peak hold of the test channel. The average of both readings per tile should then be calculated.

If the signal readings are conducted using a unity-gain antenna attached to a professional spectrum analyzer, and considering the signal attenuation due to "body effect", the average pick levels previously obtained is an indication reasonably good of the received channel power under fading conditions in each tile. Received channel power is precisely what should be determined during the baseline study to verify the need for a DAS in the facility under study.

For the benchmarking of the facility, the Contractor shall reflect in appropriate floor plan(s) the maximum and minimum pick hold readings obtained at each test point. For the final report or As-built documentation, the Vendor should develop floor plans showing "before" and "after" measurements of the maximum and minimum pick hold readings.

### 3. Uplink

Testing the uplink signal of a DAS is a difficult task for the Contractor since it would imply conducting measurements directly in the infrastructure of the Public Safety radio system.

Calculations of the link budget may be used to estimate the necessary gain in the uplink to produce a signal strength of -95 dBm at the donor site. However, as a rule of thumb it is advisable to set up the uplink gain of the DAS at values ranging between 10-20 dB less than the downlink gain, depending on the distance to the donor site.

It is advisable that the test procedures be conducted considering the following:

- Size of the building

- Classification of the area under test (General Structure or Critical Area)

## Designer/Contractor Responsibilities

- Survey the facility to demonstrate the necessity of an in-building RF solution and submit benchmarking results, testing shall follow the grid test specified in NFPA72-2013 14.4.10 (1-6) and A14.4.1 (3-6) and corresponding Scope of Work to the County/City and AHJ

- Design, commissioning and testing of an in-building RF coverage solution that guarantees a minimum RF signal level of -95 dBm and 3.4 DAQ throughout the entire facility and attached structures under the conditions described in this document

- Sealed floor plans showing radio coverage for critical and general areas using industry standard radio frequency computer generated propagation modeling

- Notation that the system is upgradable for frequency band coverage changes including at a minimum both 700/800 MHz

- Obtain the necessary building permits

- Record all appropriate signal levels after the system implementation as previously detailed. Prepare and submit to the AHJ the "Before and After" floor plans showing signal levels

- Address any in-building RF coverage issue discovered during the Acceptance Test

- Address any reported RF interference issue related to the new DAS installation

- Provide the Building Owner with project documentation including but not limited to "As-built" documentation, in soft copy format (e.g., PDF), system documents, technical manuals, Return Loss or VSWR readings of the RF lines, diagrams showing equipment placement and routing for antennas, coaxial cables, fiber optics interconnections and AC power

## Building Owner Responsibilities

- Keep record of the project documentation including but not limited to a signed CORCC and "As-built" documentation, in soft copy format (e.g., PDF), system documents, technical manuals, Return Loss or VSWR readings of the RF lines, diagrams showing equipment placement and routing for antennas, coaxial cables, fiber optics interconnections and AC power

- Have in place a service contract with a qualified RF Vendor for technical maintenance, repair (including all components of the system), operation and

troubleshooting in the event of radio RF interference involving the in-building RF radio coverage solution

- The Building Owner shall provide the contact information of the System Maintenance Vendor to PCR&T/City, so this entity can work directly with the Vendor in case of troubleshooting due to an interference event

- Provide the County and/or AHJ with continuous access to the facility for purposes of testing of the public safety radio signal

# Sample Retransmission Authorization

## PINELLAS COUNTY, FLORIDA

## 700/800 MHz RETRANSMISSION AUTHORIZATION

Pinellas County, Florida (Pinellas) hereby grants authorization to:

_____

[*name of system operator*] (Operator) to operate a Two-Way Radio Communications Enhancement System (System) on 700/800 MHz frequencies licensed to Pinellas by the Federal Communications Commission (FCC) under call signs WPJR 956, WPWX247, WPVM761, KNJU723, and KNJH386 at the following location:

Site Name: _____

Site Address: _____

Latitude: _____ Longitude: _____

FCC Booster ID: _____

Site Contact: _____

Phone #: _____ Email: _____

This Authorization is subject to the following conditions:

1. The Retransmission Authorization is valid for five years from date of issuance, and will be renewed upon request, when an application for renewal and proof of successful NFPA72-2013 compliant annual testing are provided. Renewal forms and instructions can be obtained by emailing ratsupport@pinellascounty.org or calling (727) 464-3879.
2. The System shall be operated, maintained and tested annually in accordance with manufacturer's instructions, FCC rules and regulations, and the requirements of NFPA 72, National Fire Alarm and Signaling Code, 2013 Edition.
3. The System shall not cause interference to radio systems or equipment operated by Pinellas, or any other FCC licensee.
4. Operator shall promptly resolve any interference that occurs to radio systems or equipment operated by Pinellas, or any other FCC licensee, up to and including deactivation of the System, if necessary, until such time that the interference is corrected.
5. In the event of an outage of the System, Operator shall notify the AHJ in accordance with the regulations, policies and procedures for reporting any fire alarm/fire safety system outage.
6. Operator shall provide access to the System for inspection upon request by Pinellas or the FCC.
7. A separate Retransmission Authorization shall be obtained for each headend location used in the system design and posted conspicuously with the headend equipment.
8. Pinellas, as FCC licensee for its frequencies, reserves the right to terminate this Authorization at its sole discretion.

_____ Date: 21

Pinellas County Radio & Technology

# Sample Retransmission Application

Radio Communication Enhancement System
Retransmission Application

Pinellas County, Florida

| | | |
|---|---|---|
| COMPLETE SEPARATE APPLICATIONS FOR EACH HEADEND IN SYSTEM DESIGN. SEE INSTRUCTIONS AND CHECKLIST ON SECOND PAGE. | | |
| **1. SITE INFORMATION** | | |
| Site Name: | | |
| Site Address: | | |
| Low Voltage Permit Number: | | |
| Site Description (include type of construction, number of floors, total interior square footage): | | |
| Site Latitude and Longitude: | | |
| BDA Manufacturer and Model: | | Class: |
| BDA Headend Location (room number, etc.): | | |
| Number of Line Amplifiers: | Line Amplifier Manufacturer and Model: | |
| Type of System: Single carrier, Pinellas County700/ 800 MHz only | Multiple carrier, neutral host | Other (describe below) |
| **2. OWNER CONTACT INFORMATION** | | |
| Owner: | | |
| Owner Address: | | |
| Point of Contact: | Email: | |
| Work Phone: | Mobile Phone: | |
| **3. SITE ACCESS OR TECHNICAL CONTACT INFORMATION** | | |
| Name: | Email: | |
| Company: | | |
| Address: | | |
| Work Phone: | Mobile Phone: | |
| **3. SYSTEM RF INTEGRATOR/INSTALLER/MAINTAINER** | | |
| Name: | Email: | |
| Company: | | |
| Address: | | |
| Work Phone: | Mobile Phone: | |
| **5. PREPARER SIGNATURE AND DATE** | | |
| Signature: | Date: | |
| Print name and title: | | |



Revised March 5,2019

# System Technical Data

Pinellas County operates the Intergovernmental 800 MHz digital simulcast radio system. The City of Clearwater operates a separate 800 MHz digital simulcast radio system. To assist two-way radio communications enhancement system designers, the **frequency range which must be supported is 769 MHz to 861 MHz**. This requirement encompasses the needs of both entities to support all public safety personnel.

### Table 1 – County Tower Locations

| Site Name | Address |
|---|---|
| Ridgecrest | 12490 Ulmerton Rd. Largo |
| PSC | 10750 Ulmerton Rd. Largo |
| Courthouse | 315 S. Fort Harrison, Clearwater |
| Tarpon site | 4100 Dunn Dr, Palm Harbor |
| Eldridge Wilde | 3563 Old Keystone Rd, Tarpon Springs |
| Safety Harbor | 3290 SR 580, Safety Harbor |
| Highway | 22211 US Hwy 19 N, Clearwater |
| Toy Town | 10540 16th St. North, St Pete |
| St Petersburg | 1430 – 2nd Ave. North, St Pete |
| Ft Desoto | 3500 Anderson Blvd, St Pete |
| The Fountains | 1255 South Pasadena Ave. St. Pete |

### Table 2 – City Tower Locations

| Site Name | Address |
|---|---|
| Missouri | 1417 S. Missouri Av, Clearwater |
| 580 | 3290 SR 580, Clearwater |

# Appendix A – 47CFR90.219, FCC rules governing use of Signal Boosters

### §90.219 Use of signal boosters.

This section contains technical and operational rules allowing the use of signal boosters in the Private Land Mobile Radio Services (PLMRS). Rules for signal booster operation in the Commercial Mobile Radio Services under part 90 are found in §20.21 of this chapter.

(a) *Definitions.* The definitions in this paragraph apply only to the rules in this section.

*Class A signal booster.* A signal booster designed to retransmit signals on one or more specific channels. A signal booster is deemed to be a Class A signal booster if none of its passbands exceed 75 kHz.

*Class B signal booster.* A signal booster designed to retransmit any signals within a wide frequency band. A signal booster is deemed to be a Class B signal booster if it has a passband that exceeds 75 kHz.

*Coverage area of a PLMRS station.* All locations within the normal reliable operating range (service contour) of a PLMRS station.

*Deploy a signal booster.* Install and/or initially adjust a signal booster.

*Distributed Antenna System (DAS).* A network of spatially separated antenna nodes connected to a common source via a transport medium that provides wireless service within a geographic area or structure.

*Operate a signal booster.* Maintain operational control over, and responsibility for the proper functioning of, a signal booster.

*Signal booster.* A device or system that automatically receives, amplifies, and retransmits signals from wireless stations into and out of building interiors, tunnels, shielded outdoor areas and other locations where these signals would otherwise be too weak for reliable communications. Signal booster systems may contain both Class A and Class B signal boosters as components.

(b) *Authority to operate.* PLMRS licensees for stations operating on assigned channels higher than 150 MHz may operate signal boosters, limited to the service band for which they are authorized, as needed anywhere within the PLMRS stations' service contour, but may not extend the stations' service contour.

(1) PLMRS licensees may also consent to operation of signal boosters by non-licensees (such as a building owner or a signal booster installation contractor) within their service contour and across their applicable frequencies, but must maintain a reasonable level of control over these operations in order to resolve interference problems.

(i) Non-licensees seeking to operate signal boosters must obtain the express consent of the licensee(s) of the frequencies for which the device or system is intended to amplify. The consent must be maintained in a recordable format that can be presented to an FCC representative or other relevant licensee investigating interference.

(ii) Consent is not required from third party (unintended) licensees whose signals are incidentally retransmitted. However, signal booster operation is on a non-interference basis and operations may be required to cease or alter the operating parameters due to a request from an FCC representative or a licensee's request to resolve interference.

(2) [Reserved]

(c) *Licensee responsibility; interference.* PLMRS licensees that operate signal boosters are responsible for their proper operation, and are responsible for correcting any harmful interference that signal booster operation may cause to other licensed communications services. Normal co-channel transmissions are not considered to be harmful interference. Licensees are required to resolve interference problems pursuant to §90.173(b). Licensees shall act in good faith regarding the operation of signal boosters and in the resolution of interference due to signal booster operation. Licensees who are unable to determine the location or cause of signal booster interference may seek assistance from the FCC to resolve such problems.

(d) *Deployment rules.* Deployment of signal boosters must be carried out in accordance with the rules in this paragraph.

(1) Signal boosters may be used to improve coverage in weak signal areas only.

(2) Signal boosters must not be used to extend PLMRS stations' normal operating range.

(3) Signal boosters must be deployed such that the radiated power of each retransmitted channel, on the forward link and on the reverse link, does not exceed 5 Watts effective radiated power (ERP).

(4) Class B signal boosters may be deployed only at fixed locations; mobile operation of Class B signal boosters is prohibited after November 1, 2014.

(5) Class B signal booster installations must be registered in the FCC signal booster database that can be accessed at the following URL: https://signalboosters.fcc.gov/signal-boosters/

(6) Good engineering practice must be used in regard to the radiation of intermodulation products and noise, such that interference to licensed communications systems is avoided. In the event of harmful interference caused by any given deployment, the FCC may require additional attenuation or filtering of the emissions and/or noise from signal boosters or signal booster systems, as necessary to eliminate the interference.

(i) In general, the ERP of intermodulation products should not exceed −30 dBm in 10 kHz measurement bandwidth.

(ii) In general, the ERP of noise within the passband should not exceed −43 dBm in 10 kHz measurement bandwidth.

(iii) In general, the ERP of noise on spectrum more than 1 MHz outside of the passband should not exceed −70 dBm in a 10 kHz measurement bandwidth.

(7) Signal booster passbands are limited to the service band or bands for which the operator is authorized. In general, signal boosters should utilize the

minimum passband that is sufficient to accomplish the purpose. Except for distributed antenna systems (DAS) installed in buildings, the passband of a Class B booster should not encompass both commercial services (such as ESMR and Cellular Radiotelephone) and part 90 Land Mobile and Public Safety Services.

(e) *Device Specifications.* In addition to the general rules for equipment certification in §90.203(a) (2) and part 2, subpart J of this chapter, a signal booster must also meet the rules in this paragraph.

(1) The output power capability of a signal booster must be designed for deployments providing a radiated power not exceeding 5 Watts ERP for each retransmitted channel.

(2) The noise figure of a signal booster must not exceed 9 dB in either direction.

(3) Spurious emissions from a signal booster must not exceed −13 dBm within any 100kHz measurement bandwidth.

(4) A signal booster must be designed such that all signals that it retransmits meet the following requirements:

(i) The signals are retransmitted on the same channels as received. Minor departures from the exact provider or reference frequencies of the input signals are allowed, *provided that* the retransmitted signals meet the requirements of §90.213.

(ii) There is no change in the occupied bandwidth of the retransmitted signals.

(iii)The retransmitted signals continue to meet the unwanted emissions limits of §90.210 applicable to the corresponding received signals (assuming that these received signals meet the applicable unwanted emissions limits by a reasonable margin).

(5) On or after March 1, 2014, a signal booster must be labeled to indicate whether it is a Class A or Class B device, and the label must include the following advisory

(1) In on-line point-of-sale marketing materials,

(2) In any print or on-line owner's manual and installation instructions,

(3) On the outside packaging of the device, and

(4) On a label affixed to the device:

"WARNING. This is NOT a CONSUMER device. It is designed for installation by FCC LICENSEES and QUALIFIED INSTALLERS. You MUST have an FCC LICENSE or express consent of an FCC Licensee to operate this device. You MUST register Class

B signal boosters (as defined in 47 CFR 90.219) online at *www.fcc.gov/signal-boosters/registration*. Unauthorized use may result in significant forfeiture penalties, including penalties in excess of $100,000 for each continuing violation."

[78 FR 21564, Apr. 12, 2013]

## Appendix B - Article 800 • Communications Circuits 800.179
**(National Electrical Code Handbook 2014)**

| | |
|---|---|
| TABLE 800.179 | Cable Markings |
| Cable Marking | Type |
| CMP | Communications plenum cable |
| CMR | Communications riser cable |
| CMG | Communications general-purpose cable |
| CM | Communications general-purpose cable |
| CMX | Communications cable, limited use |
| CMUC | Undercarpet communications wire and cable |

Informational Note: Cable types are listed in descending order of fire resistance rating.

Informational Note: One method of defining a cable that is low-smoke producing cable and fire-resistant cable is that the cable exhibits a maximum peak optical density of 0.50 or less, an average optical density of O. 15 or less, and a maximum flame spread distance of I .52 m (5 ft) or less when tested in accordance with NFPA 262-2011, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

See the commentary following the informational note to 725.179(A).

(B) Type CMR. Type CMR communications riser cables shall be listed as being suitable for use in a vertical run in a shaft or from floor to floor and shall also be listed as having fire-resistant characteristics capable of preventing the carrying of fire from floor to floor.

Informational Note: One method of defining fire-resistant characteristics capable of preventing the carrying of fire from floor to floor is that the cables pass the requirements of ANSI/UL 1666-2011, Standard Test for Flame Propagation Height of Electrical and Optical Fiber Cable Installed Vertically in Shafts.

See the commentary following the informational note to 725.179(B).

(C) Type CMG. Type CMG general-purpose communications cables shall be listed as being suitable for general-purpose communications use, with the exception of risers and plenums, and shall also be listed as being resistant to the spread of fire.

Informational Note: One method of defining resistant to the spread of fire is for the damage (char length) not to exceed 1.5 m (4 ft 11in.) when performing the CSA "Vertical Flame Test — Cables in Cable Trays," as described in CSA C22.2 No. 0.3-M-2001, Test Methods for Electrical Wires and Cables.

See the commentary following the informational note to 725.179(C).

(D) Type CM. Type CM communications cables shall be listed as being suitable for general-purpose communications use, with the exception of risers and plenums, and shall also be listed as being resistant to the spread of fire.

Informational Note: One method of defining resistant to the spread of fire is that the cables do not spread fire to the top of the tray in the 'SUL Flame Exposure, Vertical Flame Tray Test" in ANSI/UL 1685-2011, Standard for Safety for Vertical-Tray Fire Propagation and Smoke-Release Test for Electrical and Optical Fiber Cables. The smoke measurements in the test method are not applicable.

Another method of defining resistant to the spread of fire is for the damage (char length) not to exceed 1.5 m (4 ft 11 in.) when performing the CSA "Vertical Flame Test— Cables in Cable Trays," as described in CSA C22.2 No. 0.3-M-2001, Test Methods for Electrical Wires and Cables.

See the commentary following the informational note to 725.1790.

(E) Type CMX. Type CMX limited-use communications cables shall be listed as being suitable for use in dwellings and for use in raceway and shall also be listed as being resistant to flame spread.

Informational Note: One method of determining that cable is resistant to flame spread is by testing the cable to the VW-I (vertical-wire) flame test in ANSI/UL 1581-2011, Reference Standard for Electrical Wires, Cables and Flexible Cords.

(F) Type CMUC Undercarpet Wires and Cables. Type CMUC undercarpet communications wires and cables shall be listed as being suitable for undercarpet use and shall also be listed as being resistant to flame spread.

Informational Note: One method of determining that cable is resistant to flame spread is by testing the cable to the VW-I (vertical-wire) flame test in ANSI/UL 1581-201 1, Reference Standard for Electrical Wires, Cables and Flexible Cords.

(G) Circuit Integrity (CI) Cable or Electrical Circuit Protective System. Cables that are used for survivability of critical circuits under fire conditions shall be listed and meet either or (2) as follows:

Informational Note: The listing organization provides information for circuit integrity (CI) cable and electrical circuit protective systems, including installation requirements required to maintain the fire rating.

(1) Circuit Integrity (CI) Cables. Circuit integrity (CI) cables specified in 800.179(A) through (E), and used for survivability of critical circuits, shall have an additional classification using the suffix "CI." In order to maintain its listed fire rating, circuit integrity (CI) cable shall only be installed in free air.

Informational Note: One method of defining circuit integrity (CD cable is by establishing a minimum 2-hour fire resistance rating for the cable when tested in accordance with ANSI/UL 2 196-2006, Standard for Tests of Fire-Resistive Cable.

(2) Fire-Resistive Cables. Cables specified in 800.179(A) through (E) and 800.179(G)(1), that are part of an electrical circuit protective system, shall be fire-resistive cable identified with the protective system number on the product, or on the smallest unit container in which the product is packaged, and shall be installed in accordance with the listing of the protective system.

Informational Note No. I: One method of defining an electrical circuit protective system is by establishing a minimum 2-hour fire resistance rating for the system when tested in accordance with UL Subject 1724, Outline of Investigation for Fire Tests for Electrical Circuit Protective Systems.

Informational Note No. 2: The listing organization provides information for electrical circuit protective systems (FHIT), including installation requirements for maintaining the fire rating.

(H) Communications Wires. Communications wires, such as distributing frame wire and jumper wire, shall be listed as being resistant to the spread of fire.

Informational Note: One method of defining resistant to the spread of fire is that the cables do not spread fire to the top of the tray in the "UL Flame Exposure, Vertical Flame Tray Test" in ANSI/XUL 1685-2010, Standard for Safety for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables. The smoke measurements in the test method are not applicable.

Another method of defining resistant to the spread of fire is for the damage (char length) not to exceed 1.5 m (4 ft 11 in.) when performing the CSA "Vertical Flame Test— Cables in Cable Trays," as described in CSA C22.2 No. 0.3-M-2001, Test Methods for Electrical Wires and Cables.

(I) Hybrid Power and Communications Cables. Listed hybrid power and communications cables shall be permitted where the power cable is a listed Type NM or NM-B, conforming to the provisions of Part Ill of Article 334, and the

communications cable is a listed Type CM, the jackets on the listed NM or NM-B, and listed CM cables are rated for 600 volts minimum, and the hybrid cable is listed as being resistant to the spread of fire.

Informational Note: One method of defining resistant to the spread of fire is that the cables do not spread fire to the top of the tray in the "UL Flame Exposure, Vertical Flame Tray Test" in ANSI/UL 1685-2010, Standard for Safety for Vertical-Tray Fire Propagation and Smoke-Release Test for Electrical and Optical Fiber Cables. The smoke measurements in the test method are not applicable.

Another method of defining resistant to the spread of fire is for the damage (char length) not to exceed 1.5 m (4 ft 11 in.) when performing the CSA "Vertical Flame Test — Cables in Cable Trays," as described in CSA 02.2 No. 0.3-M-2001, Test Methods for Electrical Wires and Cables.

800.180 Grounding Devices

Where bonding or grounding is required, devices used to connect a shield, a sheath, or non—current-carrying metallic members of a cable to a bonding conductor or grounding electrode conductor shall be listed or be part of listed equipment.

800.182 Communications Raceways and Cable Routing Assemblies
Communications raceways and cable routing assemblies shall be listed in accordance with 800.182(A) through (C).

Informational Note: For information on listing requirements for both communications raceways and cable routing assemblies, see ANSI/UL 2024-4-2011, Signaling, Optical Fiber and Communications Raceways and Cable Routing Assemblies.

(A) Plenum Communications Raceways and Plenum Ca Routing Assemblies. Plenum communications raceways and plenum cable routing assemblies shall be listed as having adequate fire-resistant and low-smoke producing characteristics.

(B) Riser Communications Raceways and Riser Cable Routing Assemblies. Riser communications raceways and routing assemblies shall be listed as having adequate fire-resistant characteristics capable of preventing the carrying of fire from floor to floor.

(C) General-Purpose Communications Raceways and General-Purpose Cable Routing Assemblies. General-purpose communications raceways and general-purpose cable routing assemblies shall be listed as being resistant to the spread of fire.

The application of communications raceway and cable routing assemblies are summarized in Tables 800.154(b) and (c). The installation location will dictate the type of cable permitted within the raceway or assembly as summarized in Table 800.154(a).

A raceway marked "plenum" is suitable for use in ducts, plenums, or other spaces used for environmental air in accordance with 800.154. These are identified by a marking on its surface or on a marker tape indicating "plenum." A "plenum" raceway assembly is also suitable for installation in risers, for general purpose use, and for dwellings.

A raceway or routing assembly marked “riser" is suitable for installation in risers in accordance with 800.154. These are identified by a marking on its surface or on a marker tape indicating "riser." A "riser” raceway or routing assembly is also suitable for general-purpose use and for dwellings.

A raceway or routing assembly marked "general purpose” is suitable for installation in general-purpose areas in accordance with 800.154 and for dwellings.

Pliable raceway is raceway that can be bent by hand without the use of tools. The smallest radius of the curve of the inner edge of any bend to which the raceway can be bent without cracking either on the outer surface or internally is not less 2 ½ times the outside diameter of the raceway.

Informational Note: The general term grounding conductor as previously used in this article is replaced by either the term bonding conductor or the term grounding electrode conductor (GEC) where applicable, to more accurately reflect the function of the conductor.