

SECTION 13 49 20.00 10

RFI/EMI SHIELDING

10/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM B253/B253M	(2017) Standard Guide for Preparation of Aluminum Alloys for Electroplating
ASTM D2739	(2017) Standard Test Method for Volume Resistivity of Conductive Adhesives
ASTM D4935	(2018) Standard Test Method for Measuring the Electromagnetic Shielding Effectiveness of Planar Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book
IEEE 299	(2006; R 2012) Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 4 2023; ERTA 5 2023; ERTA 6 2023) National Electrical Code
NFPA 77	(2024) Recommended Practice on Static Electricity
NFPA 780	(2023) Standard for the Installation of Lightning Protection Systems

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-HDBK-419	(1987; Rev A) Grounding, Bonding, and Shielding for Electronic Equipments and Facilities Volumes 1 of 2 Basic Theory
MIL-STD-188-124	(1998; Rev B; Notice 2 1998; Notice 3 2000; Notice 4 2013) Grounding, Bonding and Shielding for Common Long

Haul/Tactical Communications Systems,
Including Ground Based Communications -
Electronics Facilities and Equipments

UNDERWRITERS LABORATORIES (UL)

UL 486A-486B (2018; Reprint Jul 2023) UL Standard for
Safety Wire Connectors

UL 1283 (2017) UL Standard for Safety
Electromagnetic Interference Filters

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation; G

Contract Drawings; G

SD-03 Product Data

RF Shielding System; G

Installation; G

Quality Control Plan; G

Qualifications; G

RF Shielded Door; G

Filter Assemblies; G

Penetrations; G

Approved Shielding Effectiveness (SE) Test Plan; G

SD-06 Test Reports

SE Field Testing with Witness

SD-07 Certificates

Qualification of Shielding Specialists, Installers, and (AM005)
Independent Testing Specialists

SD-10 Operation and Maintenance Data

Operating and Maintenance Manuals; G

1.3 QUALITY ASSURANCE

Work performed under this section must be supervised and inspected by the shielding specialist. Material and equipment shall be approved and verified by the shielding specialist before being submitted to the Contracting Officer for approval. The submittal must be date stamped and signed by the shielding specialist. The shielding specialist is responsible for coordinating the required shielding work with the work of all other trades that will interface or affect the shielding work in any way.

1.3.1 Qualification of Shielding Specialists, Installers, and (AM005) Independent Testing Specialists

Provide the name and background qualifications of individuals who will be responsible for installation, supervision, and testing of the shielding systems on this project. Include credentials such as a bachelor's degree in science or engineering and post-degree training and experience with RF shielding for shielding and testing specialists. (AM005) Preform all testing by an independent testing firm.

1.3.1.1 Testing Experience

The (AM005) independent testing specialist must have experience during the previous 5 years in using IEEE 299, and other methods of shielded enclosure testing.

1.3.1.2 Work Experience

Provide RF shielded system by an experienced firm or individual that has been regularly and successfully engaged in the installation, supervision, and/or testing of equivalent RF shielded systems for at least the previous 5 years. The principal work of this firm or individual must be the satisfactory installation and construction of RF shielded protection systems. Include experience such as achieving specified requirements for shielded system attenuation and maintainability of attenuation levels on work performed.

1.3.1.3 Project Experience

Furnish a project experience list on projects of similar scope which have been completed during the previous 5 years. Include project completion dates and the name and telephone number of the user and/or owner of each project. Indicate project experience for installers such as installation responsibilities, performance, materials, and methods used. Project experience for the shielding specialist must indicate the responsibilities performed. Project experience for the testing specialist must indicate the test methods performed.

1.3.2 Filter and Electrical Work Requirements

Perform filter and electrical work in compliance with NFPA 70, UL 486A-486B, and UL 1283. The label and listing of the Underwriters Laboratories or other nationally recognized testing laboratory will be acceptable evidence that the material or equipment conforms to the applicable standards of that agency. In lieu of the label or listing, a certificate may be furnished from an acceptable testing organization adequately equipped and competent to perform such services. State that the items have been tested and that they conform to the specified standard.

1.3.3 Qualifications of Shielding Effectiveness Electromagnetic (SE) Specialist Installer

Perform shielding installation of shielded products by experienced SE installers. Provide the names of the SE installers to be employed and proof of experience of RF shielding installation completed during the previous 5 years and as required by the Contracting Officer.

1.3.4 Pre-Installation Meeting

Hold a pre-installation meeting with the subcontractors and installers working in, on, or near the RF shield. Discuss coordination requirements and instructions to ensure the integrity of the RF shield.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and stored from excessive humidity and temperature variation, dirt, and other contaminants.

1.5 PROJECT/SITE CONDITIONS

Perform installation of RF shielding material and sheet panels at an ambient temperature of 50 degrees F minimum to 90 degrees F.

1.6 MAINTENANCE

1.6.1 Maintenance Supplies and Procedures

Provide one set of manufacturer recommended and Contracting Officer approved maintenance parts for RF shielded parts installed and provided in the RF shielded system sufficient for a 3 year period.

1.6.2 Extra Materials

1.6.2.1 Filters

(AM005) Furnish one extra RF power filter on the project as a spare. Spare power filter must be 225A 208VAC/60Hz rated power filter for all three phases and neutral. Filter insertion loss must be a minimum of 80 dB over a minimum frequency range of 14 KHz to 18 GHz.

1.6.2.2 RF Shielded Doors

Provide one set of manufacturer recommended and Contracting Officer approved spare parts for RF shielded doors of each style installed. Provide door maintenance supplies sufficient for a 3 year period or 50,000 open-close cycles, whichever is greater, for each RF shielded door. Prominently display maintenance instructions required to maintain the door through the cycle count nearby. Refer to 08 34 46 RADIO FREQUENCY SHIELDED DOOR ASSEMBLIES.

1.6.2.3 Tools

Furnish one full set of tools that are required to maintain the RF Shield parts and doors and are not typically available from tool vendors. Furnish environmentally safe lubricants, cleaning solvents, or coatings in sufficient quantities to last for 6 months from first day of full occupancy by the Government.

1.6.2.4 Special Tools

Provide one set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment as follows: IEEE 299 Test Set and as noted in the SE Test plan.

1.6.3 Operating and Maintenance Manuals

Submit manufacturer's written instructions for operation and maintenance of RF Shielding system. Address all components and aspects of the RF shielding and include, but not be limited to, the following:

- a. A complete set of assembly drawings to include penetration locations and installation details.
- b. The construction specification on RF shielding.
- c. Shield penetration schedule.
- d. Power filter schedule.
- e. Test plan.
- f. The prepared preventive maintenance instructions for periodic inspection, testing and servicing, lubrication, alignment, calibration, and adjustment events normally encountered. Extract complex preventive maintenance events from or refer to detailed vendor or manufacturer data. Derive this information from an evaluation of engineering data considering local environmental conditions, manufacturer's recommendations, estimated operating life for the specific application and use of the equipment, and types of job skills available at the operating site.
- g. Spare parts data approved and verified by the shielding specialist prior to submission. Include a complete list of recommended parts and supplies with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 SYSTEM REQUIREMENTS

2.1.1 General

Provide RF shielded facility that meets or exceeds minimum attenuation decibel (dB) levels specified. The RF shielding system includes, but is not limited to, the following (refer to contract drawings):

- a. Two layers of heavy duty solid 5 mil thick aluminum RF Foil for a 10 mil total aluminum thickness per IEEE 299 and ASTM D4935.
- b. Two layers of heavy duty perforated 5 mil thick aluminum RF Foil for a 10 mil total aluminum thickness per IEEE 299 and ASTM D4935.
- c. One layer of 26 gauge galvanized perforated sheet panel per IEEE 299 and ASTM D4935.
- d. Exterior RF shielded doors for access into the restricted secure areas.

- e. Interior RF shielded doors for access into the restricted secure areas.
- f. Electrical and electronic penetrations of the shield.
- g. RF Shielding tape: Per ASTM D2739.
- h. RF filter/surge arrester assemblies, including their RF enclosures.
- i. RF shielded pull boxes and junction boxes.
- j. RF shielded conduit runs.
- k. Structural penetrations.
- l. RF Mechanical and Utility Penetrations (such as air ducts, waste water, vent pipes, fire protection).
- m. Equipment door/access panels.
- n. Sufficient supervisory and/or quality control personnel onsite to supervise the installation crew and to conduct in-progress quality assurance tests.

2.1.2 SE Field Testing with Witness

Perform field tests as specified. The Contracting Officer reserves the right to witness the specified field tests. Notify the Contracting Officer at least 30 days before field tests are scheduled to be performed. Include a detailed description of the test instrumentation and equipment, including calibration dates, a detailed description of the test procedure, and the recorded test data.

2.2 MATERIALS AND EQUIPMENT

2.2.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Support equipment by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.2.2 Nameplates

For each major item of equipment, secure a plate with the manufacturer's name, address, type or style, model or serial number, and catalog number to the item of equipment.

2.2.3 Testability

Design and build equipment and materials of the RF shielding to facilitate testing and maintenance.

2.3 RF SHIELDING EFFECTIVENESS

Provide RF shielded system complete with all filters, doors, and/or waveguides with the following minimum RF shielding effectiveness attenuation:

RADIO FREQUENCY SHIELDING EFFECTIVENESS MINIMUM REQUIREMENTS (80 dB)		
FREQUENCY	FIELD TYPE	ATTENUATION
10 KHz	Magnetic Field	25 dB
100 KHz	Magnetic Field	45 dB
200 KHz	Magnetic Field	50 dB
200 KHz	Electrical Field	60 dB
1 MHz	Electrical Field	60 dB
10 MHz	Electrical Field	60 dB
400 MHz	Plane Wave	60 dB
1 GHz	Plane Wave	60 dB
10 GHz	Plane Wave	60 dB
18 GHz	Plane Wave	80 dB

2.4 RF SHIELDING SYSTEM REQUIREMENTS (ADHERED CONSTRUCTION)

2.4.1 Adhered Shielding System

The intent of this section and the contract drawings is to provide a complete six-sided metal continuous RF-shielded enclosure, including floor, walls, ceiling, doors, and penetrations. For HORIZONTAL applications, provide shielding sheets consisting of 26 gauge thick zinc-coated galvanized steel conforming to ASTM B253/B253M. Use steel plates, channels, or angles of a minimum of 1/4 inch thick to reinforce attachments of ducts, waveguides, conduits, pipes, and other penetrating items. For horizontal floor installation, adhere 26 gauge shielding sheets to the concrete floor slab. Before applying 26 gauge shielding sheets, all concrete surfaces must have waterproof sealer applied. Adhere 26 gauge shielding sheets to the concrete slab with neoprene adhesive; continuously welded seams, tape all welded seams with 5 mil (4) four-inch wide electrically conducted aluminum or copper tape. All surfaces must be free of oil, sharp edges, rust, and defects. For roof applications, use waterproof contact adhesive to adhere 26 gauge shielding sheets directly to the 5/8 inch glass mat gypsum thermal board above the metal deck. Continuously weld all seams of the sheets together, tape all welded seams with 5 mil (4) four-inch wide electrically conducted aluminum or copper tape. For VERTICAL applications, provide a double layer of 5 mil thick RF foil. For double-layer applications, stagger or offset the overlap of seams. Before applying shielding sheets to concrete surfaces, the concrete surfaces must have waterproof sealer applied. Adhere shielding foil to concrete wall with neoprene adhesive; overlap seams (2) two inches, tape all seams with 5 mil (4) four-inch wide electrically conducted aluminum or copper tape. Apply the second layer of RF foil with staggered joints over first layer of RF foil using contact adhesive.

Inspect for any holes, rips, or punctures that need to be covered or repaired with electrically conducted aluminum or copper tape. All surfaces must be free of oil, sharp edges, rust, and defects. For all exterior perimeter walls heavy-duty perforated RF foil must be installed, all other walls will have the option to use heavy-duty solid RF Foil.

2.4.2 Metal Members

Provide structural steel shapes, plates, and miscellaneous metal conforming to ASTM A36/A36M.

2.4.3 Fasteners

Self drilling black phosphorus flat head non-conductive screws, 12 inch o.c. perimeter and field. Cover all exposed fastener heads with (4) four-inch square non-conductive tape.

2.4.4 Miscellaneous Materials and Parts

Provide miscellaneous supports, braces, and connections necessary to complete the miscellaneous metal work. Thickness of metal and details of assembly and supports must provide ample strength and stiffness. The materials must be galvanically similar.

2.4.5 Penetrations

Seal penetrations of the shield, including bolts or fasteners, with 5 mil (4) four-inch wide electrically conducted aluminum or copper tape. Provide structural penetrations including beams, columns, and other metallic structural elements with continuously applied 5 mil (4) four-inch wide electrically conducted aluminum or copper tape between the penetrating element and the shield. Nonmetallic structural elements are not allowed to penetrate the electromagnetic barrier without wrapping RF Foil and electrically conducted aluminum or copper tape around penetration.

2.5 RF SHIELDED DOORS

Refer to Section 08 34 46 RADIO FREQUENCY SHIELDED DOORS ASSEMBLIES.

2.6 FILTER ASSEMBLIES

A filter must be provided for each power line penetrating the enclosure. Filters must be enclosed in metallic cases which shall protect the filter elements from moisture and mechanical damage. All external bonding or grounding surfaces must be free from insulating protective finishes. All exposed metallic surfaces must be suitably protected against corrosion by plating, lead-alloy coating, or other means. The finish must provide good electrical contact when used on a terminal or as a conductor, must have uniform texture and appearance, must be adherent, and must be free from blisters, pinholes and other defects. The filter assemblies must also meet the requirements of UL 1283. Insertion loss in the stop band between the load side of the filter and the power supply side must not be less than the RF shielding attenuation specified. Each filter unit must be capable of being mounted individually and must include one filter for each phase conductor of the power line and the neutral conductor.

2.6.1 Minimum Life

Design filter assemblies for a minimum service life of 15 years.

2.6.2 Power and Signal Line Factory Testing

Submit factory test report data for each filter configuration, voltage, and amperage which shows the ability of filters to meet the specified requirements. Base filter test reports on prior tests of the same filter assembly design and components. Submit test data reports in accordance with paragraph SUBMITTALS. Include the following in the test data:

- a. Voltage Drop Measurements.
- b. Insertion Loss Measurements.
- c. Dielectric Withstand Voltage.
- d. Insulation Resistance Test.
- e. Harmonic Distortion.
- f. Terminals.

2.7 WAVEGUIDE ASSEMBLIES

Provide waveguide-below-cutoff (WBC) protection for all ventilation penetrations of the electromagnetic barrier. Protect these WBC penetrations with cutoff frequencies and attenuation no less than the RF shielding effectiveness values listed. Ensure cutoff frequencies are no less than 1.5 times the highest frequency of the shielding effectiveness. Factory test waveguides of each assembly type in accordance with IEEE 299 and Table I of this specification.

2.7.1 Waveguide-Type Air Vents

Each ventilation WBC array must be a honeycomb-type air vent with a core fabricated of corrosion resistant steel as shown on the contract drawings. Include heavy frames to dissipate the heat of welding to the shield in waveguide construction. Do not exceed a static pressure drop through the vents of 0.1 inch of water at an air velocity of 1200 fpm. Provide waveguides for air vents (honeycomb) with access doors in duct work for maintenance. Include acceptance testing of all honeycomb panels with the final acceptance test. Do not pass conductors, such as wires and louver operating rods, through the waveguide openings.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

3.2.1 Coordination

The RF shielding installer must instruct other trades in the presence and with the direction of the Government representative, in advance of the RF shielding system installation, to ensure that all individuals are aware of the critical installation requirements. Submit manufacturer's data,

catalog cuts, and printed documentation regarding the work. Provide cleaners, solvents, coatings, finishes, physical barriers, and door threshold protectors as required to protect the shielding system from corrosion, damage, and degradation. Obtain approval of the shielding installation plan before construction begins.

3.2.2 Verification

Before, during, and after the RF shielding and penetration protection subsystem installation, the shielding specialist must verify and approve the installation for compliance with the specifications. Provide materials and methods, shop drawings, and other items for the shielding subsystem bearing an approval stamp of the shielding specialist. Provide compliance notification to the Contracting Officer before materials are installed or methods performed.

3.2.3 Inspection

During and after RF shielding and penetration protection subsystem installation, including RF filters and waveguides, a qualified shielding specialist must inspect the installation for compliance with the specifications. Complete the inspection before a finish or concrete topping coat is installed.

3.2.4 Manufacturer's Services

Provide the services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified. Supervise the installation, adjustment, and testing of the equipment.

3.3 ENCLOSURE INSTALLATION - ADHERED CONSTRUCTION

Install the RF shielded enclosure in accordance with this specification, the contract drawings, and the recommendations of the manufacturer and RF shielding specialist. Handle and install shielding without damage. Penetrations of the shield, other than those indicated on the contract drawings, will not be permitted, including fasteners and mounting bolts, without prior written authorization from the Contracting Officer.

3.3.1 Surface Preparation

Clean and buff contacting surfaces to ensure firm contact with shielding.

3.3.2 Placement of Floor Shield

Do not begin placement of the floor shield until at least 60 days after the pouring of the floor slab and Contracting Officer approval of all required submittals. Adhere 26 gauge shielding sheets to the concrete floor slab. Before applying 26 gauge shielding sheets, all concrete surfaces must have waterproof sealer applied. Adhere 26 gauge shielding sheets to the concrete slab with neoprene adhesive; Continuously weld all seams, tape all seams with 5 mil (4) four-inch wide electrically conducted aluminum or copper tape. All surfaces must be free of oil, sharp edges, rust, and defects. Start floor shield installation at the center of the space.

3.3.3 Placement of Overslab

Before placement of the overslab over any portion of the floor shield, the Contracting Officer's approval is required. Successfully complete both visual and IEEE 299 testing of the shielding within the area to be covered, repair and retest any defects, and supply full test results to the Contracting Officer prior to placement of the overslab.

3.3.4 Wall Shielding Attachment

Provide a double layer of 5 mil thick RF foil. For double-layer applications, stagger or offset the overlap of seams. Before applying shielding sheets to concrete surfaces, the concrete surfaces must have waterproof sealer applied. Adhere shielding foil to concrete wall with neoprene adhesive; butt jointed together, tape all seams with 5 mil (4) four-inch wide electrically conducted aluminum or copper tape. Apply the second layer of RF foil with staggered joints over first layer of RF foil using contact adhesive. Inspect for any holes, rips, or punctures that need to be covered or repaired with electrically conducted aluminum or copper tape. All surfaces must be free of oil, sharp edges, rust, and defects. For all exterior perimeter walls heavy-duty perforated RF foil must be installed, all other interior walls will have the option to use heavy-duty solid RF Foil.

3.3.5 RF Shielded Door Assemblies

Mount doors to perform as specified. Attach door framing continuously to the RF shield. The building structural system supporting the door frame must provide proper support for doors and frame. Refer to 08 34 46 RADIO FREQUENCY SHIELDED DOOR ASSEMBLIES.

3.4 WAVEGUIDE INSTALLATION

Treat penetrations of the RF shield with the appropriate waveguide method.

3.5 SHIELDING PENETRATION INSTALLATION

Install penetrations in accordance with requirements of the penetration schedule and coordinate with system installation.

3.6 FIELD QUALITY CONTROL

Develop a quality control plan to ensure compliance with contract requirements; maintain quality control records for construction operations required under this section; and submit the quality control plan to the Contracting Officer. Furnish a copy of testing records, as well as the records of corrective actions taken. Perform in-progress and final acceptance testing of RF shielding and penetration protection system work as specified. Correct deficiencies at no additional cost to the Government. Maintain legible copies of the daily inspection reports by the shielding specialist at the project site, and deliver copies of the Construction Quality Control Report to the Contracting Officer on the third workday following the date of the report. Include the type of work being performed during the report period and locations, type of testing, deficiencies, corrective actions, unsolved problems, and recommendations to assure adequate quality control in the daily inspections. Attach results of inspections and tests performed in accordance with this specification to the daily Construction Quality Control Report.

3.7 FIELD TRAINING

Provide a field training course for designated operating and maintenance staff members. Provide training for a total period of 8 hours of normal working time and start after the system is functionally complete but prior to the final acceptance test. Cover all the items contained in the Operating and Maintenance Manuals.

3.8 SHIELDING QUALITY CONTROL

Integrate the Contractor's organizational structure for shielding quality control into the job site management. Perform testing by an independent testing firm.

3.8.1 Test Reports

Include the method of testing, equipment used, personnel, location of tests, and test results. Submit daily reports of results of each test performed on each portion of the shielding system to the Contracting Officer within 3 working days of the test. Clearly identify location of the area tested. Identify leaks detected during testing with sufficient accuracy to permit relocation for testing in accordance with test procedures. Submit reports of testing to the Contracting Officer with required certification by the testing agency representative or consultant. Submit three reports (in-progress test report, initial test report, and final acceptance test report) in accordance with the format described below.

Cover Page:
A cover page is required.

Administrative Data:
Test personnel.
Contract number.
Date of test.

Authentication. Contractor personnel responsible for performance of the tests and witnessing organization or representatives.

Contents:
Shielded facility description.
Nomenclature of measurement equipment.

Serial numbers of measurement equipment. Date of last calibration of measurement equipment. Type of test performed. Measured level of reference measurements and ambient level at each frequency and test point. Measured level of attenuation in decibels at each frequency and test point. Dynamic range at each test frequency and test point. Test frequencies. Location on the shielded enclosure of each test point. Actual attenuation level at each test point.

Conclusions: Include results of the tests in brief narrative form in this section.

Number of Copies of the Report:
Three copies.

3.8.2 Approved Shielding Effectiveness (SE) Test Plan

Submit a performance test plan for Contracting Officer approval. Accomplish testing in three parts: (1) In-progress; (2) initial shielded enclosure effectiveness; and (3) final acceptance, shield enclosure effectiveness. Include in the test plan equipment listings (including calibration dates and antenna factors) and the proposed test report format. Also include specific test dates and durations during the overall construction period so that the Contracting Officer may be scheduled to observe the testing and so that repairs may be made to the shield and retests conducted. This separate testing schedule for the RF enclosure must show the points, during construction, when it begins and ends as well as a day-by-day test schedule. Indicate proposed dates and duration of lowest and highest frequency tests so that the Contracting Officer may be available for these final acceptance tests. Identify a test grid and provide plan for correlation of that grid to the structure.

3.8.3 Field Testing

Submit reports of certified test results and results of all field and factory tests as specified and as required by the Contracting Officer. Accomplish testing in the three parts described below.

3.8.3.1 Testing - Part 1

Perform Part 1 as in-progress testing including inspection, visual seam inspection, and seam testing of all RF shielding materials and installation. After successful completion of in-progress testing, including defect repairs and retest, and with prior approval of the Contracting Officer, placement of embedments covering may be made to complete the structural systems. Submit an in-progress test report.

3.8.3.2 Testing - Part 2

Part 2 initial testing consists of inspection, visual seam inspection, seam testing, and shielded enclosure effectiveness testing after shielding and shielding penetrations are completed, but before the installation of finish materials over the shielding. Access to penetrations is required. Test all seams, including shielding and penetrations not tested in part 1. Perform initial shielded enclosure effectiveness acceptance test consisting of an IEEE 299 test utilizing specified test frequencies for magnetic and plane wave. Conduct testing in accordance with the paragraph RF Shielding Effectiveness Testing. Perform these tests with the number of shield penetrations limited to those required to support the test. After successful completion of Part 2 initial testing, including defect repairs and retest, and with prior approval of the Contracting Officer, placement of any covering may be made except in areas where penetrations are located. Submit an initial test report.

3.8.3.3 Testing - Part 3

Perform Part 3 final acceptance testing consisting of a visual inspection and a shielded enclosure effectiveness test of the RF shielding materials and installation. Test all seams per IEEE 299, including shielding and penetrations not tested in parts 1 and 2. Perform part 3 testing upon completion of construction and when the building is ready for occupancy. Notify the Contracting Officer in writing 14 days prior to tests to permit adequate monitoring by authorized representatives. Accomplish corrective work immediately upon detection that any area has failed to meet the

requirements specified. Perform retesting to verify that remedial work done to meet the required attenuation has been properly installed. Submit a final acceptance test report.

3.8.4 RF Shielding Effectiveness Testing

Furnish services of an (AM005) independent RF shielding testing specialist, approved by the Contracting Officer, to test the shielded enclosure. Equip and staff the facility to perform field tests of RF shielded enclosures and perform these tests as a normal service. Use test equipment which has been calibrated within the last 12 months.

3.8.4.1 Test Procedure

Provide test procedure and equipment similar to that specified in IEEE 299. Test frequencies are specified herein. Test points are as indicated in Table I.

TABLE I - SHIELDING EFFECTIVENESS TEST POINTS	
Testing Location	Test Points Spacing
Joints between steel panels for roof, walls, and floors	Test every 10 feet (Note 1; minimum of one test point per side)
Corner seams for walls to floor, walls to roof, and wall to wall	Test every 10 feet (Note 1; minimum of one test point per corner seam)
Corners (intersection of three surfaces)	Test at all corners in Shield
Single doors	Test at each corner; at midpoint of each side longer than 5 feet; and at center
Double doors	Test each separately at same test point as single doors
WBC vents and panels	Test in center (on axis) for all sizes (including single); at all four corners if 12 by 12 inches or larger; and at the midpoint of each side longer than 5 feet
At treated penetrations of shield (and entry panel and backshield)	Test as close to "an-axis" as possible, or orient for maximum signal
All other shield joints, seams, or corners	Sweep all surfaces at one frequency in the range of 400 MHz to 1 GHz. Test every 10 feet max. plane wave
Doors	Door handles
RF filter enclosures	Test at each seam corner and midpoint of each side longer than 5 feet at center

TABLE I - SHIELDING EFFECTIVENESS TEST POINTS	
Testing Location	Test Points Spacing
RF cabinets and enclosures	Test at each seam corner and each side 5 feet on center
NOTE 1. Sweep each point in space 2 feet around the point.	

3.8.4.2 Test Points

Test points include the periphery of doors and covers, handles, latches, power filter penetrations, air vent filters, communications line filter penetrations, and points of penetration by pipes, tubes, and bolts.

3.8.4.3 Test Methodology

Orient antennas for maximum signal pickup. Probe each test point for area of maximum leakage, such as around door frames, accessible joints, filters, pipes, and air ducts. Determine magnitude and location of maximum signal levels emanating from the enclosure for each accessible wall at a minimum of two locations on each wall, around doors, and at penetrations and seams of the enclosure. Accomplish measurement of attenuation in accordance with Table I.

3.8.4.4 Test Frequencies

The detailed procedures are divided into three ranges, denoted as low frequency, resonance, and high frequency. Separate and distinct procedures and equipment are required for each of these ranges.

Table 1 - Standard Measurement Frequencies (IEEE Std 299)		
Standard frequency	Antenna type	Clause Procedure
Low range ^a		
9 kHz - 16 kHz	Small loop	5.6
140 kHz - 160 kHz	Small loop	5.6
14 MHz - 16 MHz	Small loop	5.6
Resonant range ^a		
20 MHz - 100 MHz		
100 MHz - 300 MHz		

Table 1 - Standard Measurement Frequencies (IEEE Std 299)		
High range ^a		
0.3 GHz - 0.6 GHz	Dipole	5.8
0.6 GHz - 1.0 GHz	Dipole	5.8
1.0 GHz - 2.0 GHz	Horn	5.8
2.0 GHz - 4.0 GHz	Horn	5.8
4.0 GHz - 8.0 GHz	Horn	5.8
8.0 GHz - 18 GHz	Horn	5.8
a. Actual test frequencies must be according to the approved test plan.		
b. While a single frequency in each band is recommended, the actual test frequencies must be according to the approved test plan.		
Pass/fail requirements - The owner must define minimum acceptable pass/fail requirements		
Data obtained by the measurement procedures are converted to Shielding Effectiveness (SE) by mathematical relationships. The magnitudes of the quantities E1, E2, H1, and H2 are the field values measured using the antennas placed in the prescribed configuration.		

3.9 GROUNDING

The contract drawings indicate the extent and general arrangement of the shielded enclosure grounding system. The grounding methods must be an equipotential grounding plane method in accordance with UL 1283, NFPA 70, NFPA 77, NFPA 780, IEEE 142, MIL-STD-188-124, and MIL-HDBK-419. For additional facility grounding requirements, see Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

-- End of Section --