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USACE / NAVFAC / AFCEC **UFGS-13 49 20.00 10 (October 2007)**

Preparing Activity: USACE **Nontechnical Title Revision (August 2015)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2025

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SECTION TABLE OF CONTENTS

DIVISION 13 - SPECIAL CONSTRUCTION

SECTION 13 49 20.00 10

RFI/EMI SHIELDING

10/07

-- End of Section Table of Contents --

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SECTION 13 49 20.00 10

RFI/EMI SHIELDING
10/07

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NOTE: This guide specification covers the requirements for electromagnetic shielded facilities.

Adhere to UFC 1-300-02 **Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.**

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR)**.**
****

PART 1 GENERAL

****
NOTE: The following information must be shown on the project drawings:

1. Assembly details.

2. Typical penetration details.

3. Method of mounting shielded enclosure within building.

4. Shield penetration plan containing wall elevations, floor and ceiling plans showing the locations of all penetrations (to include all mechanical, electrical, fire protection, etc.) to the HEMP shield.

5. Location of mechanical and electrical equipment within shielded enclosure.

6. Detail equipment mounted or suspended from the shielded ceiling.

7. Shield penetration schedule to include:
a. Location of the waveguide.
b. Size of waveguide (dimensions).
c. No. of penetrations in the waveguide.
d. Penetration designation of each penetration in the waveguide (if more than one).
e. Size of pipe for each penetration in the waveguide.
f. Type of pipe for each waveguide penetration.
g. Type of penetration.
h. The detail/sheet no. of the waveguide detail.
i. Any remarks pertaining to the waveguide.

8. Filter schedule to include:
a. Location of filter.
b. Type of filter (power or signal).
c. No. Of filters in the filter enclosure.
d. Electrical characteristics of the filter (, amperage, no. of poles, frequency).
e. Purpose of the filter.
f. The detail/sheet no. Of the typical filter detail.
g. Any remarks pertaining to the filter.

9. Typical filter details.

10. Hardness critical items (HCI) should be identified using the (HCI) symbol on project drawings.

Refer to MIL-HDBK 419 for special grounding and bonding requirements for EM shielded enclosures. Refer to the U.S. Air Force Handbook for the Design and Construction of HEMP/TEMPEST and Other Shields in Facilities (March 1993). This document can be obtained from HQ AFIC/LEEE, San Antonio, Texas 78243-5001. Also refer to AR 380-19. MIL-HDBK 423 should be used for projects requiring HEMP protection. The designer should consult these documents and other appropriate sources before applying this guide specification to large-scale EM shielded enclosures or to HEMP or TEMPEST projects. The requirement for thermal expansion joints inherent to large-scale enclosures is not addressed in this guide specification. The extent and location of the work to be accomplished and wiring, equipment, and accessories necessary for a complete installation should be indicated on the project drawings. The Air Force contracts with an independent testing laboratory to perform their acceptance testing. The test can consist of a SELDS or equivalent test and H-field and plane wave CW

tests per MIL-STD-188-125 and/or IEEE 299. See the U.S. Air Force Handbook for the Design and Construction of HEMP/TEMPEST and Other Shields in Facilities for more details. Methodology and procedures for setting up equipment are contained in MIL-HDBK-423. Full MIL-STD-188-125 acceptance testing (PCI tests as specified in appendix B) should be avoided. (Also see designer notes K and U). Although not addressed in this specification, fiber optic cable has gained acceptance as an effective method of transmitting data across the boundary of shielded enclosures without filtering. If fiber optic cable is used, describe the waveguide penetration of the shield in detail. Fiber optic cable is specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.
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1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
****

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.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2017) Steel Construction Manual

AMERICAN WELDING SOCIETY (AWS)

AWS A5.18/A5.18M	(2023) Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding
AWS BRH	(2007; 5th Ed) Brazing Handbook
AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel

AWS D1.3/D1.3M	(2018) Structural Welding Code - Sheet Steel
AWS D9.1/D9.1M	(2018) Sheet Metal Welding Code

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

APA L870	(2010) Voluntary Product Standard, PS 1-09, Structural Plywood

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A123/A123M	(2024) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A227/A227M	(2024) Standard Specification for Steel Wire, Cold-Drawn for Mechanical Springs
ASTM A568/A568M	(2019a) Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
ASTM A653/A653M	(2023) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B194	(2022) Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar
ASTM B545	(2022) Standard Specification for Electrodeposited Coatings of Tin
ASTM B633	(2023) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM E84	(2024) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E90	(2023) Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

COMPOSITE PANEL ASSOCIATION (CPA)

ANSI/CPA A135.4	(2012; R2020) Basic Hardboard

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
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE C62.33	(2016) Test Methods and Performance Values for Metal-Oxide Varistor Surge Protective Components
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2021) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 1 2024; TIA 24-1) National Electrical Code
NFPA 77	(2024; ERTA 1 2023) Recommended Practice on Static Electricity
NFPA 80	(2025) Standard for Fire Doors and Other Opening Protectives
NFPA 80A	(2022) Recommended Practice for Protection of Buildings from Exterior Fire Exposures
NFPA 101	(2024) Life Safety Code
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
MIL-STD-188-125-1	(1998; Rev A; Notice 1 2021) High-Altitude Electromagnetic Pulse (HEMP) Protection for Ground-Based Facilities Performing Critical, Time-Urgent Missions, Part I Fixed Facilities
MIL-STD-220	(2009; Rev C; Notice 2 2024) Method of Insertion Loss Measurement
UFC 3-301-01	(2023; with Change 3, 2025) Structural Engineering

UL SOLUTIONS (UL)

UL 486A-486B	(2025) UL Standard for Safety Wire Connectors
UL 1283	(2017; Reprint Feb 2024) UL Standard for Safety Electromagnetic Interference Filters
UL 1449	(2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices

1.2 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy and Air Force projects.

The "S" classification indicates submittals required

as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.
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Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. 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, [_____]

Approved Drawings; G, [_____]

SD-03 Product Data

EM Shielding System; G, [_____]

Installation; G, [_____]

Quality Control Plan; G, [_____]

Qualifications; G, [_____]

Qualifications of Welders; G, [_____]

EM Door; G, [_____]

Filter Assemblies; G, [_____]

Penetrations; G, [_____]

SD-06 Test Reports

Impulse Sparkover Voltage

ESA Extinguishing Test

ESA Extreme Duty Discharge Test

Field Testing

SD-07 Certificates

Qualifications of Welders

SD-10 Operation and Maintenance Data

Operating and Maintenance Manuals; G, [_____]

Service Organization; G, [_____]

1.3 QUALITY ASSURANCE

Work performed under this section must be supervised and inspected by the shielding specialist. Approve and verify materials and equipment before submitting 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 Shielding Specialists, Installers and 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 EM shielding for shielding and testing specialists.

1.3.1.1 Testing Experience

The testing specialist must have experience during the previous 5 years in shielded enclosure leak detection system (SELDS), IEEE 299, and other methods of shielded enclosure testing.

1.3.1.2 Work Experience

Provide EM shielded system by an experienced firm or individual that has been regularly and successfully engaged in the installation, supervision, and/or testing of equivalent EM 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 EM 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 Qualifications of Welders

Perform welding by certified welders. Provide the names of the welders to be employed and certification that each welder has passed qualification tests within the last 2 years in the processes specified in AWS D1.1/D1.1M, AWS D9.1/D9.1M, and as required by the Contracting Officer.

1.3.3 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.

1.3.4 Field Samples

****

NOTE: Requests for field samples and mock-ups usually add cost to the project. Samples should only be required for special applications and should be limited to scaled-down items. For example, the designer may ask for a welded floor/wall corner section. Do not normally ask for samples of filters and full-size waveguide vents.

****

Provide field samples for the following: [shielding sheet installation,] [shielding fastening,] [doors,] [[30] [100] [_____] ampere power filter,] [communication filter,] [waveguide,] [penetration,] and [_____].

1.3.5 Pre-Installation Meeting

Hold a pre-installation meeting with the subcontractors and installers working in, on, or near the EM shield. Discuss coordination requirements and instructions to ensure the integrity of the EM 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 welding of EM shielding material and sheet steel at an ambient temperature of 10 degrees C 50 degrees F minimum to 32 degrees C 90 degrees F. Do not install shielding until the building has been weather enclosed. Do not perform sheet steel welding in direct sunlight.

1.6 MAINTENANCE

1.6.1 Maintenance Supplies and Procedures

Provide maintenance supplies sufficient for a [3] [_____] year period or [50,000] [_____] open-close cycles, whichever is greater, for each EM shielded door. Prominently display maintenance instructions required to maintain the door through the cycle count nearby.

1.6.2 Extra Materials

1.6.2.1 Filters

Furnish [one extra EM power filter] [[_____] extra EM power filters] and [one extra communications filter] [[_____] extra communications filters] of each different type furnished on the project as a spare.

1.6.2.2 EM Shielded Doors

Furnish one set of finger stock and EM gaskets (if used) for each hinged

EM shielded door provided. In addition, provide one set of manufacturer recommended and Contracting Officer approved spare parts for EM shielded doors of each style installed.

1.6.2.3 Tools

Furnish one full set of tools that are required to maintain the 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.

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: [SELDS Test Set][_____]

1.6.3 Operating and Maintenance Manuals

Submit manufacturer's written instructions for operation and maintenance of EM Shielding system. Address all components and aspects of the EM 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 EM shielding.

c. Shield penetration schedule.

d. Power/signal 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.

h. Provide a list of hardness critical items (HCI) requiring periodic inspection to maintain EM shield integrity. Hardness critical items are those components and/or construction features which singularly and collectively provide specific levels of HEMP protection, such as the EM shield, surge arresters, EM shielded doors, shield welding, electrical filters, honeycomb waveguides, and waveguides-below-cutoff.

PART 2   PRODUCTS

2.1   SYSTEM REQUIREMENTS

****
NOTE: Projects involving military communications equipment must be designed to incorporate the applicable requirements of MIL-STD-188-124, which will be provided in the ELECTRICAL WORK, INTERIOR specification.
****

2.1.1   General

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

a. The [welded steel] [bolted] EM shield.

b. EM shielded doors for access into the facility.

c. Electrical and electronic penetrations of the shield.

d. EM filter/surge arrester assemblies, including their EM enclosures.

e. EM shielded pull boxes and junction boxes.

f. EM shielded conduit runs.

g. Special protective measures for mission-essential equipment outside the EM shield.

h. Structural penetrations.

i. Mechanical and utility penetrations (such as air ducts, gas, and water).

j. Instrumentation and control.

k. Equipment door/access panels.

l. Sufficient supervisory and/or quality control personnel onsite to supervise the installation crew and to conduct in-progress quality assurance tests.

2.1.2   Factory Tests

Perform factory tests as specified. The Contracting Officer reserves the right to witness the specified factory tests. Notify the Contracting Officer at least 30 days before factory 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 EM shielding to facilitate testing and maintenance.

2.3 EM SHIELDING EFFECTIVENESS

****

NOTE: The designer will consider the shield as early in the design as possible while the geometry of the shielded enclosure can be located to utilize components inherent in the structure. Failure to consider the shield configuration first in the design will increase design costs, cause problems in its incorporation into the structure, and lose installation simplicity. The EM shielded enclosure design should be coordinated by the structural, mechanical, and electrical engineers and architect. The structural and shielding systems should drive each other on large projects. Multi-story shielded enclosures require continuous connections of shielding steel interconnected to the structural steel. In these cases, the shielding wall layout should coincide with the structural steel beam layout. The shield within an exterior building concept must employ a design which allows for settling, seismic motion, and differential thermal expansion between the steel and concrete of the building and the steel of the EM shielding.

****

Provide EM shielded enclosure complete with all filters, doors, and/or waveguides with the following minimum EM shielding effectiveness attenuation. Use minimum magnetic field attenuation of [20 dB] [_____] at 14 kHz increasing linearly to [50 dB] [100 dB] at [200 kHz] [1 MHz] [_____]. Use minimum electric field and plane wave attenuation of [50 dB] [100 dB] [_____] from 14 kHz to [1 GHz] [10 GHz] [_____].

2.4 EM SHIELDING ENCLOSURE REQUIREMENTS (WELDED CONSTRUCTION)

****

NOTE: For the EM shielding enclosure, choose either

welded or bolted construction. The unused method should be deleted from the project specification. Welded construction will usually consist of continuous 1.897 mm 14 gauge thick steel plate and angles to form the enclosure. Thicker material may be used if it is more cost-effective or required for structural reasons. Welded construction is used when a shielded facility requires a long maintainable service life of high-level protection, 100 dB attenuation, or HEMP protection, 100 dB. Bolted construction is associated with a lower level (50 dB) of maintained shielding effectiveness. Bolted construction will usually consist of modular panels bolted together with metal strips or channels. Panels are commonly plywood with steel sheets laminated to one or both sides. Bolted construction is used when a shielded facility's service life is short, 10 years or less, or the system is required to be demountable for change of location. This system requires more maintenance than a welded system and requires access to the panels. The EM shield layout may restrict attenuation testing of the enclosure. It is desirable for large facilities to place the shield at least 1 meter 3.3 feet inside the exterior walls, although cost and construction restrict this consideration. The floor shielding can be tested by SELDS test but not by IEEE 299 if it is on grade. The facility layout must be carefully planned to allow for testing and shield maintenance.
****

2.4.1 Welded Shielding Enclosure

****
NOTE: Shielding steel thickness should not be based solely on the minimum thickness required for HEMP/TEMPEST attenuation. Thicker steel may be necessary because of structural factors and heat deformation or burn-through from seam welding.
****

The intent of this section and the drawings is to provide a complete metal enclosure including floor, walls, ceiling, doors, penetrations, welds, and the embedded structural members to form a continuous EM shielded enclosure. Provide shielding sheets and closures consisting of [3.416] [_____] mm [10] [_____] gauge thick hot-rolled steel conforming to ASTM A568/A568M. Use steel plates, channels, or angles of minimum 6 mm 1/4 inch thick to reinforce shield sheets for attachments of ducts, waveguides, conduit, pipes, and other penetrating items. Use furring channels to attach shielding sheets to walls or floors that are the minimum gauge of the shielding steel. The shielding sheet steel gauge may be thicker at the Contractor's option to reduce labor and welding effort only if structurally tolerable with the existing design. Use steel that is free of oil, dents, rust, and defects.

2.4.2 Metal Members

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

2.4.3 Steel and Welding Material

Provide welding materials complying with the applicable requirements of AWS D1.1/D1.1M and AWS D9.1/D9.1M. Provide steel and welding material conforming to AISC 325. Use welding electrodes conforming to AWS D1.1/D1.1M for metal inert gas (MIG) welding method. Use weld filler metal conforming to AWS A5.18/A5.18M.

2.4.4 Fasteners

Do not use self-tapping screws for attachment of shielding. Use zinc-coated steel, Type I, pin size No. 4 power-actuated drive pins to secure steel sheets to concrete surfaces and to light gauge furring channels. The drive pins must conform to ASTM A227/A227M Class 1 for materials and ASTM B633 for plating.

2.4.5 Miscellaneous Materials and Parts

Provide miscellaneous bolts and anchors, supports, braces, and connections necessary to complete the miscellaneous metal work. Provide the necessary lugs, rebars, and brackets to assemble work. Drill or punch holes for bolts and screws. Poor matching of holes will be cause for rejection. Thickness of metal and details of assembly and supports must provide ample strength and stiffness. The materials must be galvanically similar.

2.4.6 Penetrations

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NOTE: Configure the facility to minimize the number of metallic structural elements required to penetrate the barrier.

****

Seal penetrations of the shield, including bolts or fasteners, with puddle welds or full circumferential EM welds. Provide structural penetrations including beams, columns, and other metallic structural elements with continuously welded or brazed seams and joints between the penetrating element and the shield. Nonmetallic structural elements are not allowed to penetrate the electromagnetic barrier.

2.4.7 Penetration Plates (Welded Construction)

The penetration plate is the central location for treatment of penetrations. Construct panel of 6 mm 1/4 inch thick ASTM A36/A36M steel plate welded to the shield. Weld waveguide, conduit, and piping penetrations circumferentially at the point of penetration to the inner surface of the penetration plate. Extend penetration plates at least 150 mm 6 inch beyond all penetrations.

2.4.8 Floor Finish

****

NOTE: Indicate or specify whether other flooring is to be provided or higher floor loads are required. This is most critical when raised floors are specified. Allowances must be made for elevated door thresholds. Specify special requirements for

laboratory loads, provide seismic requirements, if a Government designer is the Engineer of Record, and show on the drawings. Delete the inappropriate bracketed phrase. Pertinent portions of UFC 3-310 04 and Sections 13 48 73 and 23 05 48.19 must be enclosed in the contract documents.

If concrete floor wearing slabs are specified, they should be thick enough to hold anchor bolts for equipment, supports, and interior partitions. Concrete wearing slabs may be provided in most applications with a minimum thickness of 100 mm 4 inches. The Air Force is opposed to placing concrete wearing slabs over shielding steel because of problems with testing and repair. Placing concrete over floor shielding requires a waiver from HQ AFCEC/ENE.

****

Cover floor EM shielding by a reinforced cast-in-place concrete slab [100] [_____] mm [4] [_____] inch thick. Conform to seismic requirements [in accordance with UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR NONSTRUCTURAL COMPONENTS and 23 05 48.19 SEISMIC BRACING FOR MECHANICAL SYSTEMS and [09 69 13 RIGID GRID ACCESS FLOORING][09 69 19 STRINGERLESS ACCESS FLOORING] (if needed)].

2.5 EM SHIELDING ENCLOSURE REQUIREMENTS (BOLTED CONSTRUCTION)

****

NOTE: For the EM shielding enclosure, choose either welded or bolted construction. The unused method should be deleted from the project specification. Welded construction will usually consist of continuous 1.897 mm 14 gauge thick steel plate and angles to form the enclosure. Thicker material may be used if it is more cost-effective or required for structural reasons. Welded construction is used when a shielded facility requires a long maintainable service life of high-level protection, 100 dB attenuation, or HEMP protection, 100 dB. Bolted construction is associated with a lower level (50 dB) of maintained shielding effectiveness. Bolted construction will usually consist of modular panels bolted together with metal strips or channels. Panels are commonly plywood with steel sheets laminated to one or both sides. Bolted construction is used when a shielded facility's service life is short, 10 years or less, or the system is required to be demountable for change of location. This system requires more maintenance than a welded system and requires access to the panels. The EM shield layout may restrict attenuation testing of the enclosure. It is desirable for large facilities to place the shield at least 1 meter 3.3 feet inside the exterior walls, although cost and construction restrict this consideration. The floor shielding can be tested by SELDS test but not by IEEE 299 if it is on grade. The facility layout must be carefully planned to

allow for testing and shield maintenance.
****

2.5.1 Panel Construction

Laminate flat steel sheets to each side of a 19 mm 3/4 inch thick structural core of either plywood or hardboard. Provide panels with a flame spread rating of less than 25 when tested according to ASTM E84. Provide flat steel conforming to ASTM A653/A653M with G-60 coating, minimum 0.5512 mm 26 gauge thick, zinc-coated phosphatized. Use plywood conforming to APA L870 for exterior, sound grade hardwood, Type I. Provide hardboard conforming to ANSI/CPA A135.4, Class 4, SIS, for standard type hardboard. Use waterproof type adhesive for laminating steel sheets to structural core which maintains a permanent bond for the lifetime of the enclosure.

2.5.2 Framing

Join and support panels by specially designed framing members that clamp the edges of the panels and provide continuous, uniform, and constant pressure for contact to connect the shielding elements of the panels. Provide walls that are self supporting from floor to ceiling with no bracing. Deflection of walls under a static load of 335 N 75 pounds applied normally to the wall surface at any point along the framing members must not exceed 1/250 of the span between supports. [Ceilings must be self-supporting from wall to wall.] [Support ceilings by adjustable, nonconducting, isolated hangers from the structural ceiling above.] Design ceilings to have a deflection under total weight, including ceiling finish, of no more than 1/270 of the span. Provide a one-piece factory pre-welded corner section or trihedral corner framed with a brass machine cast corner cap assembly consisting of inner and outer parts at all corner intersections of walls and floor or ceiling. Design the modular enclosure for ease of erection, disassembly, and reassembly.

2.5.3 Channel

The framing-joining system members must consist of 3 mm 1/8 inch thick zinc-plated steel channels having a minimum 16 mm 5/8 inch overlap along each side of the contacting surface. Space screw fasteners at 75 or 100 mm 3 or 4 inch intervals. Use screw fasteners that are either zinc or cadmium-plated steel, minimum size 6 mm 1/4 inch, with a pan or flat Phillips head. Heat-treat and harden fasteners with a minimum tensile strength of 931 MPa 135,000 psi.

2.5.4 Sound Transmission Class (STC)

Provide enclosure panels with an STC of [30] [_____] dB minimum when tested according to ASTM E90.

2.5.5 Penetration Plates (Bolted Construction)

Provide a minimum 3 mm 1/8 inch thick ASTM A36/A36M steel plate, sized [450] [_____] by [450] [_____] mm [18] [_____] by [18] [_____] inch with a 6 mm 1/4 inch thick extruded brass frame for mounting to the shielded enclosure wall panel. Extend penetration plates at least 150 mm inch beyond all penetrations.

2.6 EM SHIELDED DOORS

****
NOTE: Edit these paragraphs depending on type of door used on project.
****

2.6.1 General

Material in shielded doors and frames must be steel conforming to ASTM A36/A36M or ASTM A568/A568M and stretcher-leveled and installed free of mill scale. Use thicker metal where indicated or required for its use and purpose. Provide metal thresholds of the type for proper shielding at the floor. Provide fire rated shielded doors and assemblies meeting NFPA 80 and NFPA 80A requirements and bearing the identifying label of a nationally recognized testing agency qualified to perform certification programs. Provide EM shielded doors by a single supplier who has been regularly engaged in the manufacture of these items for at least the previous 5 years. Supply assemblies complete with a rigid structural frame, hinges, latches, and parts necessary for operation. Duplicate assemblies that have been in satisfactory use for at least 2 years. Provide door frame consisting of steel suitable for [welding] [bolting] to the surrounding structure and shield. Provide EM filters, EM waveguide penetrations for door systems, and miscellaneous material for a complete system. Provide nonsagging and nonwarping enclosure door. The EM shielded door must provide a shielding effectiveness of [10 dB] [20 dB] greater than the minimum EM shielding effectiveness requirements. Provide door with a clear opening [as shown on the drawings] [of [915] [_____] mm [36] [_____] inch wide and [2135] [_____] mm [84] [_____] inch] high. The door and frame assembly must have a sound rating of STC [30] [_____] minimum. Perform testing in accordance with ASTM E90.

2.6.1.1 Door Latch

The door latch must be lever controlled with roller cam action requiring no more than 67 N 15 pounds of operating force on the lever handle for both opening and closing. Equip door with a latching mechanism having a minimum of three latching points that provides proper compressive force for the EM seal. The mechanism must be operable from both sides of the door with permanently lubricated ball or thrust bearings as required at points of pivot and rotation.

2.6.1.2 Hinges

Equip doors with a minimum of three well-balanced adjustable ball-bearing or adjustable radial thrust bearing hinges suitable for equal weight distribution of the shielded doors. Hinges must allow adjustment in two directions. Do not exceed a force of 22 N 5 pounds to move the doors.

2.6.1.3 Threshold Protectors

Furnish threshold protectors for each EM shielded door. Provide protectors consisting of portable ramps that protect the threshold when equipment carts or other wheeled vehicles are used to move heavy items across the threshold. The ramps may be asymmetrical to account for different floor elevations on each side, but the slope of the ramp must not exceed 4:1 on either side. Design ramps to support a [227] [_____] kg [500] [_____] pound vertical force applied to a 75 by 13 mm 3 by 1/2 inch area for a personnel door, and a [907] [_____] kg [2,000] [_____] pound vertical force applied to a 75 by 13 mm 3 by 1/2 inch area for an equipment double leaf door. Apply force to the contact area between the threshold and the door. Provide mounting brackets, convenient to the entry, to store the ramp when not in use.

2.6.1.4 Frequency of Operation

With proper maintenance, door assemblies must function properly through 100,000 cycles and 15-year service life minimum without the shielding effectiveness decreasing below the overall shield required attenuation.

2.6.1.5 Electric Interlocking Devices

Provide electric interlocking devices for vestibules equipped with shielded doors at each end. Provide electric interlocking devices so that shielded doors at the ends of the vestibule cannot be opened at the same time during normal operation. Provide a manual override to allow emergency egress, and provide an audible alarm to indicate that doors at each end of the vestibule are open. The alarm will continue to sound while both doors are open. Provide a low- piezoelectric-type alarm, in a tamperproof enclosure, at a location shown on the project drawings or as directed by the Contracting Officer's representative. The sound intensity must be 45 dBA minimum at 3.05 m 10 feet. Provide lights on the side of each door outside the vestibule to indicate that the other door is open. Interlock systems may be integrated into a cypher lock system. Power the interlock system by an uninterruptible power source which is fail-safe in an unlocked condition in the event of a power failure.

2.6.1.6 Electric Connectivity

Install electric connectivity for sensors, alarms, and electric interlocking devices in accordance with the door manufacturer's instructions, the approved drawings, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Submit detail drawings showing location, number, and method of penetrating the shielding material. Fabrication details for penetrations of the shielding material and the complete EM shielded enclosure to include doors and filters. Show erection details and sequence of erection and clearly indicate the methods necessary to ensure shield integrity under all columns and other structural members.

2.6.1.7 Threshold Alarm

Apply a press-at-any-point ribbon switch to the threshold. The switch must enunciate an alarm whenever pressure is applied to the threshold of the EM shielded door.

2.6.1.8 Hold Open and Stop Device

Provide each EM shielded door leaf with a hold open and stop device permanently attached to the door leaf. Weld a fastener plate onto the door. The device must not interfere with the finger stock. Drilling or tapping of the shielded door will not be allowed.

2.6.1.9 Emergency Exit Hardware

Equip emergency exit EM shielded doors with single motion egress hardware. The force required to latch and unlatch emergency exit hardware on EM shielded doors must meet life safety code NFPA 101. Field alterations or modifications to panic hardware will not be allowed.

2.6.1.10   Finish

Factory prime paint EM shielded doors with zinc chromate primer. Doors may be factory finish painted or galvanized. Touch up any damaged finish.

2.6.1.11   Door Counter

Provide a door operation counter on the enclosure interior.

2.6.1.12   Additional Hardware

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NOTE: Alarms would normally be specified in Section 28 10 05 ELECTRONIC SECURITY SYSTEMS (ESS). Hardware will be specified in the hardware section.

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See door schedule on drawings and Section 08 71 00 DOOR HARDWARE, for additional hardware requirements. Provide fire rating and STC sound ratings as required by the door finish schedule on the drawings or in the specifications.

2.6.2   Latching Type Doors

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NOTE: Make the knife edge of stainless steel 430 series if it will be exposed to moist air containing salt (near the sea coast) or in an uncontrolled or corrosive environment.

****

Provide [steel] [laminated] type doors. [Provide steel doors that are a minimum of 3.416 mm 10 gauge thick steel sheet electrically and mechanically joined by welded steel frames overlapping joints with continuous EM welds.] [Laminated type must be the same construction as enclosure panels, except electrically and mechanically join the steel faces by channels or overlapping seams, both of which are continuously seam welded or soldered along all joined surfaces.] The closure seal must utilize an extruded brass channel containing a recess into which [two] [_____] sets of [beryllium copper condition HT in accordance with ASTM B194] [stainless steel 430 (magnetic type) series] contact fingers and a closed cell foam rubber air seal are fitted and can be easily removed and replaced without the use of special tools and without the application of solders. Mate the door to the frame in a manner that allows the insertion of a brass knife edge between the two rows of the radio frequency finger stock, to obtain optimum conductivity and electromagnetic shielding. Use high-temperature silver solder to attach the brass knife edge components to the door panels and the frame. Protect the fingers that form a contact between the door and its frame from damage due to physical contact and conceal within the door and frame assembly.

2.6.3   Pneumatic Sealing Doors

Pneumatic sealing mechanisms must achieve EM shielding by using pressure to force the door panel against the frame surface. Contact areas of door and frame must be a peripheral strip no less than 75 mm 3 inch wide completely around the door with a tinned or highly conductive noncorrosive surface. After the door is in a closed position, the pneumatic sealing mechanism must exert pressure in no more than 10 seconds. Actuate sealing mechanism release in no more than 5 seconds. Manual [override] [operation] must not exceed a maximum of [155] [_____] N [35] [_____] pounds. When the door is sealed, the attenuation around the edges must meet the EM shielding effectiveness requirements of this specification. Provide swinging doors with a threshold of zinc-plated steel, no less than 9.5 mm 3/8 inch thick. Provide door with a pneumatic system that maintains a nominal sealing pressure of [240] [_____] kPa [35] [_____] psi. Attach a label to pneumatic doors warning against painting of the mating surfaces.

2.6.3.1 Door and Enclosure Design

Design doors for long life and reliability without the use of EM gaskets, EM finger stock, or other sealing devices other than the direct metal-to-metal contact specified. Provide EM sealing device that is fail-safe upon loss of air pressure and readily allows manual opening of the door. For either normal or fail-safe operation, the maximum time to reach the open position must be no more than 7 seconds. Include provision for removing the door for routine maintenance without disturbing its alignment and EM sealing properties.

2.6.3.2 Control Panel

Provide a control panel including the necessary opening and closing pneumatic valves on the inside and outside of the shielded enclosure. The outside control panel must also have a pressure regulator and filter. Ensure door air supply is capable of quick opening from inside the enclosure to allow escape when opening pneumatic valves fail or malfunction.

2.6.3.3 Air System for Pneumatic Sealing

Provide complete air system including compressor, filter alarm, tank, lines, air filter, dryer, air control valves, and controls. Size air tank capacity so that the air volume and pressure are sufficient to operate the door through ten complete cycles after the loss of normal power.

2.6.4 Magnetic Sealed Door Type

Form an EM seal by a solid metal-to-metal contact around the periphery of the door frame. Provide materials at the contact area which are compatible and corrosion resistant. Provide contact force for the door EM seal by electromagnets. When the electromagnet is energized, pull the door leaf in to ensure a solid and continuous contact with the door frame. When the electromagnet is de-energized, the door leaf must be free to swing. The EM shielded doors may use electromagnets or a combination of permanent magnets and electromagnets.

2.6.5 Sliding Type Door

Provide a sliding shielded door of the size and operating direction indicated. Clear openings indicated on the drawings must not require dismantling of any part of the door. Manually operate door from either side, inside or outside, with a maximum pull (force) of 155 N 35 pounds to set the shielded door in motion. Construct shielded door face panels and frames of reinforced steel suitable for achieving the specified attenuation. Construct frames of steel shapes welded together to form a true rectangular opening. In the sealed position, the shielded doors must provide the minimum shielding effectiveness specified without any derating. Design doors for long life and reliability and do not use EM gaskets, EM finger stocks, or other sealing devices other than the specified direct metal-to-metal contact. Attach a label to sliding doors warning against painting of the mating surfaces.

2.6.6 Power Operators

Provide [pneumatic] [electric] type power operators conforming to NFPA 80 and the requirements specified. Provide readily adjustable limit switches to automatically stop the door in its full open or closed position. Ensure all operating devices are suitable for the hazardous class, division, and group defined in NFPA 70.

2.6.6.1 Pneumatic Operators

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NOTE: Designer will coordinate with the drawings to ensure compressed air is available at door locations.

****

Provide heavy-duty industrial type pneumatic operators designed to operate the door at no less than 0.2 m/s 2/3 fps or more than 0.3 m/s 1 fps with air pressure of [_____] kPa psi. Provide a pressure regulator if the operator is not compatible with available air pressure. Provide dryer, filter, and filter alarm Provide pneumatic piping up to the connection with building compressed air, but no more than 6 m 20 feet from door jambs. Make provisions for immediate emergency manual operation of the door in case of failure. The operator must open, close, start, and stop the door smoothly. Control must be [electrical, conforming to NEMA ICS 2 and NEMA ICS 6; enclosures must be Type 12 (industrial use), Type 7 or 9 in hazardous locations, or as otherwise indicated] [pneumatic] [with] [pushbutton wall switches] [ceiling pull switches] [rollover floor treadle] [as indicated].

2.6.6.2 Electric Operators

Provide heavy-duty industrial type electrical operators designed to operate the door at no less than 0.2 m/s 2/3 fps or more than 0.3 m/s 1 fps. Provide electrical controls that are [pushbutton wall switches] [ceiling pull switches] [rollover floor treadle] [as indicated]. Provide electric power operators complete with an electric motor, brackets, controls, limit switches, magnetic reversing starter, and other accessories necessary. Design the operator so that the motor may be removed without disturbing the limit switch timing and without affecting the emergency operator. Provide power operator with a slipping clutch coupling to prevent stalling of the motor. Make provisions for immediate emergency manual operation of the door in case of electrical failure. Where controls differ from motor voltage, provide a control voltage transformer inside as part of the starter. Use control voltage of 120 volts or less.

2.6.6.2.1 Motors

Provide drive motors conforming to NEMA MG 1 that are the high-starting torque reversible type and of sufficient output to move the door in either direction from any position at the required speed without exceeding the rated capacity. Provide motors that are suitable for operation on [[120] [208] [277] [480] volts, 60 Hz] [[220] [240] [380] volts, 50 Hz], [single] [three] phase and suitable for across-the-line starting. Design motors to operate at full capacity over a supply variation of plus or minus 10 percent of the motor voltage rating.

2.6.6.2.2 Controls

Provide an enclosed reversing across-the-line type magnetic starter with thermal overload protection, limit switches, and remote control switches for each door motor. Provide control equipment conforming to NEMA ICS 2; provide enclosures conforming to NEMA ICS 6, which are Type 12 (industrial use), Type 7 or 9 in hazardous locations, or as otherwise indicated. Each wall control station must be of the three-button type, with the controls marked and color coded: OPEN - white; CLOSE - green; and STOP - red. When the door is in motion and the stop control is pressed, the door must stop instantly and remain in the stop position. From the stop position, operate the door in either direction by the open or close controls. Use full-guarded type controls to prevent accidental operation.

2.6.6.3 Leading Edge Safety Shutdown

Provide a safety shutdown switch strip the entire length of the leading edge of the door with operators. The safety strip must be press-at-any-point ribbon switches. Activate the strip to shut down the operator and release the door with reset required to continue door operation.

2.6.7 EM Shielded Door Factory Test

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NOTE: When specifying nonlatching doors, delete door static load and sag tests and cycle test for door latches. Retain cycle test for door hinges.

****

Provide test data on at least one shielded door of each type provided for the facility to verify that the EM shielded doors of the design supplied have been factory tested for compliance with this specification. Do not furnish test doors on the project. Submit test data reports in accordance with paragraph SUBMITTALS.

2.6.7.1 Swinging Door Static Load Test

Mount and latch the door to its frame, then set down in a horizontal position such that it will open downward with only the frame rigidly and continuously supported from the bottom. Apply a load of 195 kg/psm 40 lb/psf uniformly over the entire surface of the door for at least 10 minutes. The door will not be acceptable if this load causes breakage, failure, or permanent deformation which causes the clearance between door leaf and stops to vary more than 1.6 mm 1/16 inch from the original dimension.

2.6.7.2 Swinging Door Sag Test

Install the door and its frame normally and open 90 degrees. Suspend two 45 kg 100 pound weights, one on each side of the door, from the door within 130 mm 5 inch of the outer edge for at least 10 minutes. The door will not be acceptable if this test causes breakage, failure, or permanent deformation which causes the clearance between the door leaf and door frame to vary more than 1.6 mm 1/16 inch from the original dimension.

2.6.7.3   Door Closure Test

Operate each door design 100,000 complete open-close cycles. The door will not be acceptable if the closure test causes any breakage, failure, or permanent deformation which causes the clearance between the door and door frame to vary more than 1.6 mm 1/16 inch from the original dimension.

2.6.7.4   Handle-Pull Test

Mount and latch the door to its frame. Provide handle with a force of 1100 N 250 pounds applied outward (normal to the surface of the door) at a point within 50 mm 2 inch of the end of the handle. The door will not be acceptable if this test causes any breakage, failure, or permanent deformation exceeding 3 mm 1/8 inch.

2.6.7.5   Door Electromagnetic Shielding Test

Factory test EM shielded door in accordance with the requirements of this specification both before and after the mechanical tests described above.

2.7   ELECTROMAGNETIC FILTERS

****

NOTE: All EM filters for power and signal lines should be scheduled on the drawings.

This guide specification covers electromagnetic filters for 50, 60, and 400 Hz power lines and signal lines for General Use Only. This specification is NOT applicable for filters to be used with a specific individual item of electronic equipment. Filters for use with specific individual items of equipment must be scheduled on the drawings showing voltage, current, insertion loss, passband, frequency, baud rate, and cutoff frequency.

****

Provide a filter for each power, data, and signal line penetrating the enclosure. These lines include, but are not limited to, power lines, lines to dummy loads, alarm circuits, lighting circuits, and signal lines such as telephone lines, antenna lines, HVAC control, and fire alarm. Enclose filters [and ESAs] in metallic cases which protect the filter elements from moisture and mechanical damage. Ensure all external bonding or grounding surfaces are free from insulating protective finishes. Protect all exposed metallic surfaces 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, have uniform texture and appearance, be adherent, and free from blisters, pinholes and other defects. The filter [and ESA] 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 be no less than the EM shielding attenuation specified. Provide filter used for 400 Hz with power factor correcting coil to limit the reactive current to 10 percent maximum of the full load current rating. Each filter unit must be capable of being mounted individually and include one filter for each phase conductor of the power line and the neutral conductor. Include one filter for each conductor.

2.7.1 Enclosure

****
NOTE: The intent of this paragraph is to preserve the integrity of the filter and to shield the input and output circuits from each other. Usually, this is accomplished by mounting the filters in an EM-modified NEMA Type 1 enclosure with separate compartments for the input and the output terminals. If a weatherproof or hazardous area type enclosure is needed, it must be specified.
****

Mount filter units in an EM modified NEMA Type [1] [_____] enclosure in accordance with NEMA ICS 6 and meet the requirements of UL 1283. Make enclosures of corrosion resistant steel of 1.9837 mm 14 gauge minimum thickness with welded seams and galvanized bulkhead cover plates. Finish enclosure nonconductive surfaces with a corrosion-inhibiting primer and two coats of baked or finish enamel. The input compartment must house the individual line filters and the input terminals of the filters and mounting for the surge arrestor. Space live parts in accordance with NFPA 70. Use copper filter leads. Test filter enclosures for shielding effectiveness in accordance with IEEE 299 and Table I of this specification. [Provide test leads and coaxial connectors through the enclosure for HEMP testing.] [Use the imbedded configuration for filter enclosures as required by MIL-STD-188-125-1.]

2.7.1.1 Filter Unit Mounting

Mount each filter unit individually in an enclosure containing one filter for each penetrating conductor. Attach one end of the individual filter case to the rf barrier plate between the two compartments to provide a rf tight seal between the rf barrier plate and the filter case. The terminals of the filters must project through openings in the rf barrier plate into the inner terminal compartment. Attach the case of each filter to both the enclosure and to the barrier plate to prevent undue stress being applied to the rf seal between the filter case and the rf barrier plate. Individual filters must be removable from the enclosure. Like filters must be interchangeable.

2.7.1.2 Conduit Connections to Enclosures

Provide load terminal and input compartments without knockouts, and provide each compartment with weldable threaded conduit hubs. EM weld hubs circumferentially in place and size and locate as required for the conduits indicated.

2.7.1.3 Access Openings and Cover Plates

Provide enclosures with separate clear front access cover plates on terminal and power input compartments. Provide access cover plates which are hinged with EM gaskets and 75 mm 3 inch maximum bolt spacing. Include thick cover plates and folded enclosure edges to prevent enclosure deformation, bolt spacers to prevent uneven gasket compression, and gasket mounting to facilitate replacement. All gasket contact areas must be tin-plated using the electrodeposited type I method in accordance with ASTM B545. Permanently fasten nuts and bolts to the enclosure by welding or captive attachments.

2.7.1.4 Operating Temperature

Provide filter and ESA assembly which is rated for continuous operation, with filters at rated voltage and full-load currents, in ambient temperatures from minus 55 to plus 65 degrees C (measured outside the EM filter enclosure). Useilter components that are suitable for continuous full load operation at a temperature from minus 55 to plus 85 degrees C.

2.7.1.5 Short Circuit Withstand

Label and build filters to have standard short circuit withstand ratings in accordance with UL 1283. The minimum ratings are as follows:

FILTER RATED CURRENT, RMS AMPERE	SHORT CIRCUIT FULL LOAD AMPERES SYMMETRICAL
0-100	10,000
101-400	14,000

2.7.1.6 Filter Connections

Provide individual filters with prewired standoffs and solderless lugs. Provide hexagonal head bolt or screw type lugs conforming to UL 486A-486B. Space live parts in accordance with NFPA 70.

2.7.2 Internal Encapsulated Filters (Filter Units)

****

NOTE: There are two kinds of power filters, commonly known as "W" and "X" series. The "W" series filters are designed to achieve rated insertion loss under load when tested in accordance with MIL-STD-220, which only requires testing under load conditions from 100 kHz to 20 MHz. The "X" series device data sheets will contain the phrase "tested using extended range buffer networks" and will satisfy the stated performance under full load at frequencies below 100 kHz. The "X" series filters will also be tested in accordance with MIL-STD-220. The "X" series filters can also be differentiated from "W" devices by the fact that they are usually two to three times greater in weight.

Fire alarm, signal, energy monitoring and control system, telephone, and control lines require filters that pass a specific frequency, voltage, and number of conductors. Fire alarm circuits with ground fault indicators will show a ground fault when connected through a filter and should be avoided. A fiber optic connection through the shield is recommended. Keepconductors penetrating the shield perimeter to a minimum. Systems penetrating the shield will have special requirements in their specifications for compatibility between system signal and control circuits and the EM filters.

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2.7.2.1 Filter Construction

Individual filters must be heavy-duty type sealed in a steel case. After the filter is filled with an impregnating or encapsulating compound, weld the seams. When a solid potting compound is used to fill the filter, the filters may be mechanically secured and sealed with solder. Use hermetically sealed impregnated capacitors, or vacuum impregnate the complete filter assembly. Faricate individual filter cases of no less than 2 mm 14 gauge thick steel and finish with a corrosion-resistant plating,or one coat of corrosion-resistant primer and two coats of finish enamel. Fill the filter with an impregnating or potting compound that is chemically inactive with respect to the filter unit and case. The compound, either in the state of original application or as a result of having aged, must have no adverse effect on the performance of the filter. Use the same material for impregnating as is used for filling. Use copper filter terminals that can withstand the pull requirements specified and measured in accordance with paragraph ELECTROMAGNETIC FILTERS.

2.7.2.2 Ratings

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NOTE: Indicate maximum current, voltage, and pass band frequency ratings on the drawings. If no drawings are furnished with the specifications, specify the ratings here.

****

[Provide filters in the current, voltage, and frequency ratings indicated on the drawings.] [Filter current must be [_____].] [Filter voltage must be [[120] [208] [277] [480] volts, 60 Hz] [[230] [250] [400] volts, 50 Hz].] [The pass band frequencies [_____] Hz to [_____] Hz must be suitable for use with the [50] [60] [_____] [and] [400] [_____] Hz power source and signal line filters as indicated.]

2.7.2.3 Voltage Drop

Voltage drop through the filter at operation frequency must not exceed 2 percent of the rated line voltage when the filter is fully loaded with a resistive load (unity power factor). Measure voltage drop in accordance with paragraph Voltage Drop Measurements.

2.7.2.4 Input Elements

Provide filters with inductive inputs. If inductive input is used an ESA is required to protect the filter. The inductor must ensure firing potential for the preceding ESA and limit the current through the filter capacitor. Design the input inductor to withstand at least a 10,000-volt transient.

2.7.2.5 Drainage of Stored Charge

Provide filters with bleeder resistors to drain the stored charge from the capacitors when power is shut off. Drain stored charge in accordance with NFPA 70.

2.7.2.6 Insertion Loss

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NOTE: Use 100 dB insertion loss at 14 kHz to 10 GHz for applications such as secure communications installations. For other applications, insert appropriate insertion loss and frequency range for the specific product. Consult filter manufacturer for detailed requirements. Also consult the manufacturer when leakage current is important, such as in life safety areas. There is a tradeoff between leakage current and insertion loss when insertion loss is measured according to MIL-STD-220 because of the test connection and the line-to-ground capacitance. Harmonic loading of EM filters will require alterations to the electrical system design to protect the filters from damage. Large individual loads, such as adjustable speed drive and uninterruptible power supplies, should have shielded isolation transformers on their input line side. Multiple small individual loads, such as computers, should have EM filters derated or shielded isolation transformers between filter output and the harmonic generating loads. EM filters should be derated by 50 percent when serving loads with substantial harmonic components. If a facility is formally required to fully comply with MIL-STD-188-125, filter and ESA characteristics should meet the standard's requirements as applied to the facility. The facility's electrical system should be designed to meet the requirements of MIL-STD-188-125 with commercially available filters and ESA. The commercial electrical power feeder should be arranged in a manner that will meet MIL-STD-188-125 requirements. Voice and data lines should be converted to fiber optics prior to penetration of the EM shield. The requirements of MIL-STD-188-125 should be applied by a shielding specialist experienced in the standard's requirements and applications.

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Insertion loss must meet or exceed the levels complying with EM shielding effectiveness attenuation requirements herein when measured in accordance with MIL-STD-220. Perform insertion loss measurements in accordance with MIL-STD-220 and the paragraph ELECTROMAGNETIC FILTERS.

2.7.2.7 Operating Temperature Range

Mount individual filters in the filter enclosure operating at full load amperage and rated voltage that do not exceed plus 85 degrees C 185 degrees F based on an ambient temperature of 65 degrees C 150 degrees F outside the filter enclosure. Demonstrate continuous operation from minus 55 to plus 85 degrees C minus 67 to plus 185 degrees F according to paragraph "Filter Life Test (at Elevated Ambient Temperature)". Filters must also withstand temperature cycling as specified in paragraph ELECTROMAGNETIC FILTERS. Maintain the filter at rated voltage and full-load current until temperature equilibrium is reached or 24 hours, whichever is greater.

2.7.2.8 Current Overload Capability

Provide filters that are capable of operating at 140 percent of rated current for 15 minutes, 200 percent of rated current for 1 minute, and 500 percent of rated current for 1 second when tested in accordance with paragraph Overload Test.

2.7.2.9 Reactive Shunt Current

The reactive shunt current drawn by the filter operating at rated voltage must not exceed 30 percent of the rated full-load current when measured in accordance with paragraph Reactive Shunt Current Measurements.

2.7.2.10 Dielectric Withstand Voltage

Provide filters which conform to the minimum values of dielectric withstanding voltage. Perform filter dielectric withstand voltage test in accordance with paragraph "Dielectric Withstand Voltage Test". Provide HEMP filters that are capable of operating continuously at full-rated voltage and of withstanding an overvoltage test of 2.8 times the rated voltage for 1 minute. In addition, ensure each filter is capable of withstanding a 20-kV or 4-kA peak transient pulse of approximately 20 ns pulse width at full operating voltage, without damage.

2.7.2.11 Insulation Resistance

The insulation resistance between each filter terminal and ground must be greater than 1 megohm when tested in accordance with paragraph Insulation Resistance Test.

2.7.2.12 Parallel Filters (Current Sharing)

Where two or more individual filters are electrically tied in parallel to form a larger filter, they must equally share the current. Equally sharing is defined to be within 5 percent of the average current. Perform tests in accordance with paragraph ELECTROMAGNETIC FILTERS.

2.7.2.13 Harmonic Distortion

Harmonics generated by the insertion of a filter must not increase line voltage distortion more than 2.5 percent when measured with a unity power factor in accordance with the paragraph ELECTROMAGNETIC FILTERS.

2.7.3 Marking of Filter Units

Mark each filter case with HCI tags and with the rated current, rated voltage, manufacturer s name, type of impregnating or potting compound, operating frequency, and model number. In addition, provide individual filter cases, the filter enclosures, and supply and load panelboards of filtered circuits marked by the manufacturer with the following: "WARNING: Before working on filters, terminals must be temporarily grounded to ensure discharge of capacitors. Attach nameplates and warning labels securely.

2.7.4 Minimum Life

Design filter assemblies for a minimum service life of 15 years. Submit filter schedule including voltage, amperage, enclosure type (low, high, band pass), location, cut-off frequency, band pass frequencies, and electrical surge arresters (ESA). Submit data and/or calculations for design of EM door including schedule of EM penetrations.

2.7.5 Power and Signal Line Factory Testing

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NOTE: In most cases, test results for equal filters are sufficient to determine compliance with specification requirements. Factory tests on individual filters may be required for higher than average temperature applications, special filter configurations, and other special project requirements.

Filters with nonstandard configuration or ratings may require testing by an independent testing organization. These ratings would be for filters above 1,000 amperes.

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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. Filter Life Test.

d. Thermal Shock Test.

e. Overload Test.

f. Reactive Shunt Current Measurements.

g. Dielectric Withstand Voltage.

h. Insulation Resistance Test.

i. Current Sharing.

j. Harmonic Distortion.

k. Terminals.

2.7.5.1 Voltage Drop Measurements

Perform voltage drop measurements on both ac and dc filters with the components mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method that will be used for mounting in the enclosure. For ac rated filters, make measurements by using expanded scale-type meters. For dc rated filters, make measurements by using a dc meter when the filter is carrying rated current and rated voltage.

2.7.5.2 Insertion Loss Measurements

Insertion loss measurements for power filters must have the following modifications. Install filters in the filter/ESA assembly enclosure. Operate load current power supply at the rated voltage of the filters and provide any current from no-load through rated full-load current. The rf signal generator must be a swept continuous wave (cw) source. Modify buffer networks to permit valid measurements over the entire frequency band on which insertion loss requirements are specified (14 kHz-1 Ghz). Provide receiver or network analyzer capable of operating over the entire frequency band on which insertion loss requirements are specified (14 kHz-1 Ghz). Use adequate sensitivity to provide a measurement dynamic range at least 10 dB greater than the insertion loss requirement. Use resistive load impedance which is capable of dissipating the rated full-load filter current. Make insertion loss measurements at 20 percent, 50 percent, and 100 percent of the filter full-load operating current. Perform insertion loss measurements for communication/signal line filters the same as for power filters except that the insertion loss measurements are required at a load impedance equal to the image impedance of the filter. Do not perform load insertion loss measurements over the frequencies defined in the EM shielding effectiveness attenuation requirements for both power and communication filters. [Perfom load to source testing for TEMPEST.] [Perform source to load testing for HEMP.]

2.7.5.3 Filter Life at High Ambient Temperature

This test is conducted for the purpose of determining the effects on electrical and mechanical characteristics of a filter, resulting from exposure of the filter to a high ambient temperature for a specified length of time, while the filter is performing its operational function. Surge current, total resistance, dielectric strength, insulation resistance, and capacitance are types of measurements that would show the deleterious effects due to exposure to elevated ambient temperatures. Use a suitable test chamber which will maintain the temperature at the required test temperature and tolerance. Make temperature measurements within a specified number of unobstructed mm inches from any one filter or group of like filters under test. Make this test in still air. Mount specimens by their normal mounting means. When groups of filters are to be tested simultaneously, specify the mounting distance between filters for the individual groups otherwise use sufficient mounting distance to minimize the temperature on one filter affecting the temperature of another. Do not test filters fabricated of different materials simultaneously. Use a test temperature of 85 + 2 degrees C 184 + 34 degrees F. Perform test for a length of 5,000 hours. Make specified measurements prior to, during, or after exposure.

2.7.5.4 Thermal Shock Test

This test is conducted for the purpose of determining the resistance of a filter to exposures at extremes of high and low temperatures, and to the shock of alternate exposures to these extremes. Use suitable temperature controlled systems to meet the temperature requirements and test conditions. Use environmental chambers to meet test requirements and to reach specified temperature conditions. Place filters so that there is no obstruction to the flow of air across and around the filter. Subject filter to the specified test condition. Run the first five cycles continuously. After five cycles, the test may be interrupted after the completion of any full cycle, and the filter allowed to return to room ambient temperature before testing is resumed. One cycle consists of steps 1 through 4 of the applicable test condition for dual environmental test chambers (one low temperature and one high temperature test chamber) and steps 1 and 3 for single compartment test chambers where both high and low temperatures are achieved without moving the filter. The test conditions are as follows:

1. -55 deg C. 0 deg and -3 deg
2. 25 deg C. +10 deg and -5 deg
3. 85 deg C. + 3 deg and -0 deg
4. 25 deg C. +10 deg and -5 deg

Do not exceed an effective total transfer time from the specified low temperature to the specified high temperature of 5 minutes. The exposure time in air at the extreme temperatures is a function of the weight of the filter. Use minimum exposure time per the weight of the filter as follows:

1 oz. and below	15 minutes
Above 1 oz. to 4.8 oz.	30 minutes
Above 4.8 oz. to 3 lb.	1 hour
Above 3 lb. to 30 lb.	2 hours
Above 30 lb. to 300 lb.	4 hours
Above 300 lb.	8 hours

Make specified measurements prior to the first cycle and upon completion of the final cycle, except base failures on measurements made after the specimen has stabilized at room temperature following the final cycle.

2.7.5.5 Overload Test

Mount filters in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method that will be used for mounting in the enclosure. Apply a specified current for a specified period of time. After the filter has returned to room temperature, measure the insulation resistance and voltage drop. Measure the insulation resistance using the method in paragraph ELECTROMAGNETIC FILTERS. Make AC voltage drop measurements by using expanded scale-type meters which will enable voltage differences of less than 1 volt to be read. Make DC voltage drop measurements by using a dc reading meter when the filter is carrying rated current and rated voltage. The insulation resistance and the voltage drop will be measured after each separate overload test. Filters will also be visually examined for evidence of physical damage after each test.

2.7.5.6 Reactive Shunt Current Measurements

Perform reactive shunt current measurements with the filters mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method that will be used for mounting in the enclosure. Terminate filter in the inner compartment in an open circuit. Apply rated ac voltage between the filter outer compartment terminal and the enclosure or metal plate. Monitor the ac current into the outer compartment terminal. The measured current is equal to the filter reactive shunt current.

2.7.5.7 Dielectric Withstand Voltage Test

The dielectric withstanding voltage test (also called high-potential, over potential, .voltage breakdown, or dielectric-strength test) consists of the application of a voltage higher than rated voltage for a specific time between mutually insulated portions of a filter or between insulated portions and ground. Repeated application of the test voltage on the same filter is not recommended as even an overpotential less than the breakdown voltage may injure the insulation. When subsequent application of the test potential is specified in the test routine, make succeeding tests at reduced potential. When an alternating potential (ac) is used, the test voltage must be 60 Hz. and approximate a true sine wave in form. Express all ac potentials as root-mean-square values. The KVA rating and impedance of the source must permit operation at all testing loads without serious distortion of the waveform and without serious change in voltage for any setting. When a direct potential (dc) is used, the ripple content must not exceed 5 percent rms of the test potential. Use a voltmeter to measure the applied voltage to an accuracy of 5 percent. When a transformer is used as a high-voltage source of ac, connecta voltmeter across the primary side or across a tertiary winding provided that the actual voltage across the filter will be within the allowable tolerance under any normal load condition. Unless otherwise specified, use the dc test voltage as follows:

DC rated only	2.5 times rated voltage
For filters with ac and dc ratings	2.5 times rated dc voltage
AC rated only	4.2 times rated rms voltage

The duration of the dc test voltages must be 5 seconds minimum, 1 minute maximum, after the filter has reached thermal stability at maximum operating temperature produced by passage of rated current. Apply the test voltage between the case (ground) and connect all live (not grounded) terminals of the same circuit together. Raise test voltage from zero to the specified value as uniformly as possible, at a rate of approximately 500 volts (rms or dc) per second. Upon completion of the test, reduce the test voltage gradually to avoid voltage surges. The changing current is 50 mA maximum. During the dielectric withstanding voltage test, monitor the fault indicator for evidence of disruptive discharge and leakage current. Use sufficient sensitivity of the breakdown test equipment to indicate breakdown when at least 0.5 mA of leakage current flows through the filter under test. Perform test with the components mounted in the filter/ESA assembly enclosure. Test filters for ac circuits with an ac source. Test filters for dc circuits with a dc source. After the test, examine the filter and perform measurements to include insulation resistance measurements to determine the effect of the dielectric withstanding voltage test on specific operating characteristics.

2.7.5.8 Insulation Resistance Test

This is a test to measure the resistance offered by the insulating members of a filter to an impressed direct voltage tending to produce a leakage current through or on the surface of these filters. Make insulation-resistance measurements on an apparatus suitable for the characteristics of the filter to be measured such as a megohm bridge, megohm-meter, insulation-resistance test set, or other suitable apparatus. Perform test with the components mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method that will be used for mounting in the enclosure. Disconnect the bleeder resistor. Apply direct potential to the specimen which is the largest test condition voltage (100, 500, or 1,000 volts +10 percent) that does not exceed the rated peak ac voltage or the rated dc voltage. A separate dc power supply may be used to charge the filters to the test voltage. Do not exceed a measurement error of 10 percent at the insulation-resistance value required. Use proper guarding techniques to prevent erroneous readings due to leakage along undesired paths. Make insulation-resistance measurements between the mutually insulated points or between insulated points and ground. Read the insulation resistance value with a megohmmeter and record after the reading has stabilized. When more than one measurement is specified, make subsequent measurements of insulation resistance using the same polarity as the initial measurements.

2.7.5.9   Current Sharing

Perform testing with the filters mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method that will be used for mounting in the enclosure. Load filter inner compartment terminals with a resistor equal in value to the rated operating voltage divided by the sum of the current ratings of the devices in parallel. Use resistor capable of dissipating the total current. Apply rated operating voltage at the filter outer compartment terminals. Monitor the current into each filter outer compartment terminal.

2.7.5.10   Harmonic Distortion Test

Make harmonic distortion measurements using a spectrum analyzer having a dynamic range of [70 dB] [_____] and a frequency range from [10 kHz to 1.7 GHz] [_____]. Measure total harmonic distortion at the input and output terminals of the filter when operating at 25, 50, and 100 percent of rated full-load current.

2.7.5.11   Terminals Pull Test

The purpose of this test is to determine whether the design of the filter terminals can withstand the mechanical stresses to which they will be subjected during installation or disassembly in equipment. Perform testing with the components mounted in the filter/ESA assembly enclosure or mounted on a plate by the same holding method that will be used for mounting in the enclosure. Apply a force of 89 N 20 pounds to the terminal. The point of application of the force and the force applied must be in the direction of the axes of the terminations. Apply force gradually to the terminal and maintain for a period of 5 to 10 seconds. Check the terminals before and after the pull test for poor workmanship, faulty designs, inadequate methods of attaching of the terminals to the body of the part, broken seals, cracking of the materials surrounding the terminals, and the changes in electrical characteristics such as shorted or interrupted circuits. Measurements are to be made before and after the test.

2.8   ELECTRICAL SURGE ARRESTERS (ESA)

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NOTE: ESA application guidance is found in MIL-HDBK 423.

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2.8.1 Power and Signal Line ESA

2.8.1.1 ESA General

Provide ESAs consisting of metal oxide varistors (MOVs) or spark gaps. When a spark gap is specified, enclose the ESA within a metal case. Contain discharges within the case; no external corona or arcing will be permitted. Provide factory installed ESAs with minimum lead lengths within the outer compartment. For all power filter/ESA assemblies, install the ESAs a minimum of 75 mm 3 inch apart, with terminals at least 75 mm3 inch from a grounded surface. For telephone filter/ESA assemblies, install the ESAs with a minimum clearance spacing of 25 mm 1 inch, and place terminals at least 75 mm 3 inch from a grounded surface. Connect each phase, neutral and telephone circuit conductor through an ESA to the ground bus. Install the ESA [in the power input compartment of the filter] [in a separate EM shielded enclosure]. Provide ESA units within the filter/ESA assembly that are individually replaceable. Like ESAs must be interchangeable. ESA terminals mus withstand the 89 N 20 lb pull test. Space live parts in accordance with NFPA 70. Use copper ESA leads. Mark individual ESAs with HCI tags containing the manufacturer's name or trademark and part number. Provide ESA meeting the requirements of IEEE C62.11, IEEE C62.41.1, IEEE C62.41.2, and UL 1449.

2.8.1.2 Wiring

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NOTE: Some designers prefer coiling the wire between the ESA and the filter, because it creates enough inductance to develop the ESA firing potential during transients for HEMP applications. Short leads, as recommended herein, improve the voltage-limiting effectiveness of the ESA. Fusing of the ESA is not recommended because protection may be lost without the operator's knowledge. If fusing is necessary, a light to indicate a blown fuse will be provided on the ESA enclosures.

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Locate ESAa so that leads of minimum length connect the ESA ground terminal to the enclosure. The total lead length connecting the ESA to the filter and the ESA ground terminal to the enclosure must be less than 300 mm 12 inch. Power line ESA wiring must be No. 4 AWG minimum. Provide communication/signal line ESA wiring of the same or heavier gauge than the communication/signal line conductor.

2.8.1.3 Voltage Characteristics

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NOTE: Clamping voltage requirement is intended to ensure that the ESA does not have excessive series resistance. The specific value should be chosen after reviewing manufacturer's data.

Specified dc breakdown voltage (or MOV voltage at 1 milliampere dc current) for dc and single phase ac power should be in the range of 150 to 200 percent of the peak (not rms) operating voltage. Use 200 to

250 percent on three-phase circuits, so that a short-circuit fault in one phase will not fire ESA on the other two phases.

The spark gap dc breakdown voltage requirement is intended to ensure that the spark gap is a low-inductance, fast device. The precise values are not critical and should be chosen after reviewing ESA catalog information.

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Make measurements of (MOV) voltage at 1 mA dc current and spark gap dc breakdown voltage in accordance with the following procedure. Perform testing with the ESAs mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure. Connect a variable dc power supply between the ESA terminal and the enclosure (or plate). Increase the applied dc voltage at a rate not to exceed 10 percent of the rated firing voltage per second. The (MOV) voltage at 1 mA dc current is the power supply output voltage, when the output current is 1 milliampere. The spark gap dc breakdown voltage is the applied voltage just prior to breakdown (indicated by a rapid decrease in the voltage across the device). De-energize the power supply immediately after the value has been recorded. MOV direct current breakdown voltage at 1 milliampere dc current must be at least [340] [500] [1,000] [_____] volts and less than [425] [1,500] [_____] volts. Perform MOV testing in accordance with IEEE C62.33. Spark gap direct current breakdown (sparkover) voltage must be at least [500] [1,000] [_____] volts and less than [1,500] [3,000] [_____] volts. Spark gap impulse sparkover voltage of the ESA must be less than 4,000 volts. This voltage must be on surges of either polarity having a rate of rise of 1,000 volts/nanosecond. Perform testing of the ESA impulse sparkover voltage with the spark gaps mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure. Connect the pulse generator between the spark gap terminal and the enclosure (or plate) with a minimum inductance connection. Use pulse generator capable of providing a ramp voltage of 1 kV/ns to a peak voltage which is at least twice the open circuit impulse sparkover voltage. Monitor voltage across the spark gap on an oscilloscope or transient digitizing recorder, capable of at least 1 ns resolution. The peak transient voltage during the pulse is the impulse sparkover voltage. Response time must be less than 4 nanoseconds. Clamping voltage of the ESA must be less than [900] [_____] volts at a current pulse of 10 kA. Perform ESA clamping voltage measurements with the ESAs mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure. Connect the pulse generator between the ESA terminal and the enclosure (or plate) with a minimum inductance connection. Use pulse generator capable of providing a 10 kA current pulse, on an 8- by 20-microsecond waveshape into the ESA. Monitor current through the ESA and monitor voltage across the ESA on oscilloscopes or transient digitizing recorders. The asymptotic voltage during the 10 kA portion of the pulse is the clamping voltage.

2.8.1.4 ESA Extinguishing Characteristics

The ESA must extinguish and be self-restoring to the normal nonconductive state within one-half cycle at the operating frequency. Perform ESA extinguishing test with the ESA mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure. Use an ac power source connected between the ESA terminal and ground at the rated voltage and frequency capable of providing at least 25 amperes into a short-circuit load. Also connect a pulse generator capable of providing a short pulse which will fire the ESA across the ESA. Monitor voltage across the ESA on an oscilloscope or transient digitizing recorder. Inject a series of ten pulses. Performance of the ESA is satisfactory if the arc extinguishes (indicated by re-occurrence of the sinusoidal waveform) within 8.5 milliseconds after the start of each pulse.

2.8.1.5 ESA Extreme Duty Discharge Current

Provide ESA which is rated to survive the extreme duty discharge current of a single 8- x 20-microsecond pulse with a 10 to 90 percent rise time of 8 microseconds and fall time to a value of 36.8 percent of peak in 20 microseconds. Use ESA for high voltage power lines (above 600 volts) with an extreme duty discharge capability equal to or greater than 70 kA. The ESA for low voltage power lines (below 600 volts) to such things as building interiors, area lighting, and external HVAC equipment with an extreme duty discharge capability equal to or greater than 50 kA. Provide ESAs for control circuits such as interior alarms, indicator lights, door access controllers, HVAC controls, and telephones, with an extreme duty discharge capability equal to or greater than 10 kA. Perform ESA extreme duty discharge test with the ESA mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure. Connect a pulse generator between the ESA terminal and the enclosure (or plate) with a minimum inductance connection. Use pulse generator capable of supplying an 8- x 20-microsecond waveshape and a only single pulse is required. Monitor current through the ESA and monitor voltage across the ESA on oscilloscopes or transient digitizing recorders. Monitor the ESA visually during the test and after the pulse inspected for charring, cracks, or other signs of degradation or damage. Test must be on a prototype only. Repeat the dc breakdown voltage test.

2.8.1.6 Minimum Operating Life

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NOTE: Surge life test will be performed only when required by the user. Coordinate current amplitude with manufacturer.
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Perform ESA operating life tests with the ESA mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure. Connect a pulse generator between the ESA terminal and the enclosure (or plate) with a minimum inductance connection. Use pulse generator capable of supplying repetitive 4 kA current pulses, with a 50 ns x 500 ns waveshape, to the ESA. A series of ten pulses is required. Monitor current through the ESA and voltage across the ESA on oscilloscopes or transient digitizing recorders. Monitor the ESA visually during the series of pulses for indications of external breakdown. The ESA must be able to conduct 2,000 pulses at a peak current of 4 kA and 50 nanoseconds x 500 nanoseconds waveform. Post-test includes inspection for charring, cracks, or signs of degradation. Repeat the dc breakdown voltage test.

2.8.1.7 Operating Temperature

The ESA must be rated for continuous operation in ambient temperatures from minus 25 to plus 125 degrees C minus 12 to plus 255 degrees F.

2.8.2 ESA Testing

Submit ESA factory test data which shows the ability to meet the requirements herein, based on prior tests of the same ESA assembly components and design. Perform testing with the ESA mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure. Connect the pulse generator between the ESA terminal and the enclosure (or plate) with a minimum inductance connection. Monitor current through the ESA and voltage across the ESA on oscilloscopes or transient digitizing recorders. Include the following in the test data:

a. Breakdown Voltage.

b. Impulse Sparkover Voltage.

c. Clamping Voltage.

d. Extinguishing.

e. Extreme Duty Discharge.

f. Surge Life.

2.9 WAVEGUIDE ASSEMBLIES

Provide waveguide-below-cutoff (WBC) protection for all piping, ventilation, fiber optic cable penetrations and microwave communications barrier penetrations of the HEMP electromagnetic barrier. Protect these WBC penetrations with cutoff frequencies and attenuation no less than the EM shielding effectiveness values listed herein. Ensure cutoff frequencies are no less than 1.5 times the highest frequency of the shielding effectiveness. For 1 GHz, the maximum rectangular linear diagonal dimension must be 100 mm 4 inch and the maximum circular diameter must be 100 mm 4 inch. The length-to-cell cross-section dimension ratio of the waveguide must be a minimum of [5:1 to attain 100 dB] [3:1 to attain 50 dB]. Arrange penetration locations to facilitate installation and testing by minimizing the number of locations. Factory test waveguides of each assembly type in accordance with IEEE 299 and Table I of this specification.

2.9.1 Waveguide-Type Air Vents

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NOTE: Occurrence of dissimilar metals will use corrosion resistant design.

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Each ventilation WBC array must be a honeycomb-type air vent with a core fabricated of corrosion resistant steel as shown on the drawings. Include heavy frames to dissipate the heat of welding to the shield in waveguide construction. Construct a welded WBC array from sheet metal or square tubes. Form array cells by welding the sheets at intersections or welding adjacent tubes along the entire length of the WBC section. Use a maximum cell size of 100 mm 4 inch on a diagonal. Use a WBC section length of at least five times the diagonal dimension of the cells. Provide air vents with a shielding effectiveness equal to that of the total enclosure as a permanent part of the shielded enclosure. Do not exceed a static pressure drop through the vents of 3.4 gpscm 0.01 inch of water at an air velocity of 305 m/s 1000 fpm. Provide waveguides for air vents (honeycomb) with access doors in duct work for maintenance. [Weld] [Bolt] the frame of the honeycomb panel into the penetration plate [with continuous circumferential EM welds.] [with bolts 75 mm 3 inch on center.] Welds for fabrication and installation of honeycomb waveguide panels are primary shield welds and inspect as indicated. 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.

2.9.2   Piping Penetrations

Make all piping penetrations of the HEMP barrier to include utility piping, fire mains, vent pipes, and generator and boiler exhausts with piping WBC sections. Provide steel WBC material with a composition suitable for welding to the HEMP shield. Provide a minimum wall thickness of 3.2 mm 0.125 inch. Provide a maximum inside diameter of 100 mm 4 inch or install a metallic honeycomb insert with a maximum cell dimension of 100 mm 4 inch. Provide WBC section with an unbroken length of at least five diameters to form a minimum cutoff frequency of 1.5 times the highest frequency of the shield effectiveness. Weld or braze the piping WBC section circumferentially to the HEMP shield, pipe sleeve or a penetration plate as shown on the drawings. Construct generator and boiler exhausts as shown in the drawings and configure as a WBC or WBC array. The circumferential penetration welds are primary shield welds and inspect and test as indicated.

2.9.3   Waveguide Penetrations

Implement waveguide penetrations for dielectric fibers or hoses in the same manner as piping penetrations. Convert dielectric hoses or pipes to metal waveguide piping before penetrating the shield. Do not pass conductors, such as wires and fiber cable strength members, through the waveguide opening.

2.9.4   GROUNDING STUD

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NOTE: Grounding stud will be provided only for small (under 100 square meters 1,000 square feet of floor area) bolted and welded enclosures.

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Provide enclosure with 13 mm 1/2 inch diameter stud circumferentially welded to each side of the shielding penetration plate.

2.10   PENETRATION PLATES

Provide penetration plates that are minimum 6 mm 1/4 inch thick and sized as shown on the drawings. The penetration plate must overlap the shield penetration cutout dimension by a minimum of 150 mm 6 inch on each side. [Weld] [Bolt] the penetration plate to the HEMP shield [with continuous circumferential EM welds.] [with bolts 75 mm 3 inch on center.]

2.11 GALVANIZING

Galvanizing, when practical and not otherwise indicated, must be hot-dipped processed after fabrication. Galvanizing must be in accordance with ASTM A123/A123M, or ASTM A653/A653M, as applicable. Exposed fastenings must be galvanically compatible material. Avoid electrolytic couples and dissimilar metals that tend to seize or gall.

2.12 EM SHIELDED CABINETS AND PULL BOXES

Provide cabinets and pull boxes which are modified NEMA [1] [_____] in accordance with NEMA ICS 6 made of corrosion resistant steel of no less than 2 mm 14 gauge thick with welded seams and galvanized bulkhead cover plates. Provide hinged access cover plates with EM gaskets and 75 mm 3 inch maximum bolt spacing. Include thick cover plates, folded enclosure edges, and bolt spacers to prevent uneven gasket compression and enclosure deformation in the design. Gasket must be easy to replace. Gasket contact areas must be tin-plated using the electrodeposited type I method in accordance with ASTM B545. EM weld conduit hub circumferentially to the enclosure. Finish cabinets with a corrosion-inhibiting primer and two coats of baked or finish enamel. Provide cabinets with mounting brackets for wall mounting or legs for floor mounting. Factory test cabinets and boxes of each type in accordance with IEEE 299 and Table I of this specification.

2.13 QUALITATIVE MONITORING SYSTEM

Provide a built-in shield monitoring system for SELDS testing. Provide system consisting of either multiple injection points or a surface loop system. Bring driving conductors to a single lockable EM shielded connection box, located outside the shield in a controlled space.

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 EM shielding installer must instruct other trades in the presence and with the direction of the Government representative, in advance of the EM 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. Obatin approval of the shielding installation plan before construction begins.

3.2.2 Verification

Before, during, and after the EM 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 EM shielding and penetration protection subsystem installation, including EM 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.

3.2.5 Posting Framed Instructions

Post framed instructions containing wiring and control diagrams under glass or in laminated plastic. Frame condensed operating instructions, prepared in typed form, as specified above and post beside the diagrams before acceptance testing of the system.

3.3 ENCLOSURE INSTALLATION - WELDED STEEL CONSTRUCTION

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NOTE: Either the welded or bolted construction will be used for the EM shielding enclosure. Choose the appropriate construction and delete the non-applicable paragraphs.

Welded construction will usually consist of continuous 1.897 mm 14 gauge thick steel plate and angles to form the enclosure. Thicker material may be used if it is more cost-effective or required for structural reasons. Welded construction is used when a shielded facility requires a long maintainable service life of high-level protection, 100 dB attenuation, or HEMP protection, 100 dB. For bolted construction see the NOTE and paragraphs below under the title ENCLOSURE INSTALLATION - BOLTED CONSTRUCTION

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Install the EM shielded enclosure in accordance with this specification, the drawings, and the recommendations of the manufacturer and EM shielding specialist. Handle and install shielding steel without damage. Penetrations of the shield, other than those indicated on the 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 steel.

3.3.2 Control of Warping

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NOTE: Steel plates exposed to sunlight and changing environmental conditions increase warpage and buckling.
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Keep warping of steel shielding plates during installation and welding within 1 mm in 1 meter 1/8 inch in 10 feet. use embeds, drive pins, and/or anchor bolts or ties to hold plates in place during welding. Also use other techniques such as skip welding to reduce warpage. The system chosen must be fully coordinated and approved by the Contracting Officer. Seal fasteners, drive pins, and other shield penetrations with full penetration circumferential EM welds.

3.3.3 Placement of Floor Shield

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NOTE: The shingle overlap method is one successful method of floor shield placement. Designers have the option to select other methods.
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Do not begin placement of the floor shield until at least 14 days after the pouring of the floor slab and Contracting Officer approval of all required submittals. [The placement of the floor shield must utilize [the shingle overlap method] [_____].] [Attach individual floor sheet on the top and one side only with air-pressure drive tools to the floor. Oerlap floor shielding sheets 50 mm 2 inch at joints, Bend and lay flat on the concrete floor without voids or gaps, and seal with continuous EM welds at all seams and joints.] Start floor shield installation at the center of the space.

3.3.4 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 SELDS 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. Place a vapor barrier over the floor shield.

3.3.5 Welding

Provide shielding work in accordance with the performance criteria specified. Shielding steel structurally welded to the steel frame must be welded in accordance with AWS D1.1/D1.1M and AWS D1.3/D1.3M. Seal EM shielding seams EM-tight by the MIG method, using electrodes structurally and electrically compatible with the adjacent steel sheets. [Weld sheet steel to support steel by plug or tack welding at 300 mm 12 inch on center, and then EM weld sheet seams continuously to seal the enclosure] [_____]. Slag inclusions, gas pockets, voids, or incomplete fusion will not be allowed anywhere along welded seams. Correct weld failures by grinding out such welds and replacing with new welds. A qualified welder must perform welding, both structural and EM sealing. Weldments critical to shielding effectiveness are shown on the drawings and perform in the manner shown on the drawings. Where both structural integrity and shielding quality are required for a given weldment, meet both criteria simultaneously. Perform brazing conforming to the documents discussed above, where practical, and also conform to requirement of AWS BRH. Seal structural, mechanical, or electrical systems penetrations by providing a continuous solid perimeter weld, or braze to the shield as specified. Provide all shield joints and seams with a minimum 50 mm 2 inch overlap and seal with a continuous solid weld. After testing, the Contracting Officer will inspect and approve the installation prior to covering by other trades.

3.3.6 Wall Shielding Attachment

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NOTE: The wall attachment method outlined in this paragraph is one successful example. Site-specific methods must be edited at this point in this specification. Note that all attachment penetrations must be welded closed. Metal wall studs or furring strips should be of equal or greater thickness (gauge) than the shield steel when shield steel is welded to supporting metal.

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Secure continuous [1.613] [_____] mm [16] [_____] gauge thick furring channels spaced no more than 600 mm 24 inch on center to steel wall studs by using self-tapping sheet metal screws. Tack weld steel sheets to the furring strips every 400 mm 16 inch on center horizontally and 600 mm 24 inch on center vertically. Make a continuous full penetration EM weld to join the sheets and form the shield. Welds must not form dimples or depressions causing fish mouths at the edge of the sheet.

3.3.7 Formed Closures

Install formed closures where indicated and/or necessary to completely close all joints, openings, enclosures of pipe chases, and structural penetrations, columns, and beams.

3.3.8 Sequence of Installation

Sequence erection of the steel to prevent steel sheet warpage. Install shielding components that have passed initial testing (part 1) before construction of any features that would limit access for repairs to the shield.

3.3.9 Door Assemblies

Mount doors to perform as specified. Weld door framing continuously to the EM shield. The structural system supporting the door frame must provide proper support for doors and frame.

3.4 ENCLOSURE INSTALLATION - BOLTED CONSTRUCTION

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NOTE: Either welded or bolted construction will be used for the EM shielding enclosure. For welded construction see the NOTE and paragraphs above.

Bolted construction is associated with a lower level (50 dB) of maintained shielding effectiveness.

Bolted construction will usually consist of modular panels bolted together with metal strips or channels. Panels are commonly plywood with steel sheets laminated to one or both sides. Bolted construction is used when a shielded facility's service life is short, 10 years or less, or the system is required to be demountable for change of location. This system requires more maintenance than a welded system and requires access to the panels. The EM shield layout may restrict attenuation testing of the enclosure. It is desirable for large facilities to place the shield at least 1 meter 3.3 feet inside the exterior walls, although cost and construction restrict this consideration. The floor shielding can be tested by SELDS test but not by IEEE 299 if it is on grade. The facility layout must be carefully planned to allow for testing and shield maintenance.
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3.4.1 Enclosure Panel Installation

Install panels, without damage to the shielding steel, in accordance with the shielding manufacturer's recommendations. Clean exposed surfaces of dirt, finger marks, and foreign matter resulting from manufacturing processes, handling, and installation. Install electrical conduits as close to the EM shield as possible. Do not use framing-joining system bolts to mount material and equipment. Seam weld or solder material and equipment which penetrate the shielded enclosure to both shielding surfaces.

3.4.2 Surface Preparation

Clean and buff surfaces to ensure good electrical contact with shielding surface. Remove paint or other coverings on mating surfaces of special boxes such as for fire alarm systems, buzzers, and signal lights, including areas between box and cover, box and wall, and box and conduit. Remove insulating material to maintain a low-resistance ground system and to ensure firm mating of metal surfaces.

3.4.3 Floor Panel Setting

Place a polyethylene film 0.15 mm 6 mil thick vapor barrier over the structural floor of the parent room before any other work is set thereon. Provide a 3 mm 1/8 inch thick layer of hardboard over this film with joints loosely butted. Over this layer, provide an additional layer of similar filler material of equal thickness as the projection of the framing-joining member from the bottom surface of the floor panel leaving no more than 6 mm 1/4 inch of space between the hardboard and the framing-joining member.

3.4.4 Framing-Joining System

Tighten screws with a calibrated adjustable torque wrench with equal torque set for each screw. Use proper torque values in accordance with the manufacturer's requirements.

3.4.5 Door Assemblies

Mount the door to perform as specified. The door must be through-bolted to the EM shield.

3.4.6 Filter Installation

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NOTE: When the filter unit must be installed inside the shielded enclosure, the input terminal compartment will be EM-tight instead of the load terminal compartment, and the filters will be located in the load terminal compartment. This arrangement is necessary to prevent radiated EM energy within the shielded enclosure from inducing EM energy in the power conductors between the filters and the point where the conductors pass through the shielded enclosure wall. To provide for this arrangement, change the wording as necessary; i.e., change the word "load" to read "input" and change the words "input" to read "output" or "load," as appropriate.

****

Support filters independently of the wall shielding. Conduct inspections on filters provided under this specification, to verify compliance with the specified requirements. Ship filters after successful testing and examine prior to installation to determine if damage occurred during shipment. Damage, no matter how slight, will be reason for rejection of the filter.

3.5 WAVEGUIDE INSTALLATION

Treat penetrations of the EM shield with the appropriate waveguide method. Provide waveguides suitable for piping and for fluids or gases contained within, in accordance with specified requirements.

3.6 SHIELDING PENETRATION INSTALLATION

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

3.7 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 EM 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.

3.8 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.

3.9 SHIELDING QUALITY CONTROL

Integrate the Contractor's organizational structure for shielding quality control into the jobsite management. Perform testing by [an independent testing firm] [the shielding installer].

3.9.1 HEMP Hardness Critical Item Schedule

Identify hardness critical items during the detail drawing submittal period. These items are those components and/or construction features which singularly and collectively provide specified levels of HEMP protection, such as the EM shield, surge arresters, EM shielded doors, shield welding, electrical filters, honeycomb waveguides, and waveguides-below-cutoff.

3.9.1.1 Performance 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 EM 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.

3.9.1.2 Test Reports

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NOTE: Specifications and/or quality assurance test results of this paragraph may be classified for some projects. Provide appropriate instructions when this occurs.

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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.

3.9.2 Field Testing

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NOTE: If a facility is required to fully comply with MIL-STD-188-125 by the Joint Chiefs of Staff, a military department headquarters, or a major command, coordinate with the using organization to establish test requirements. Quality assurance and the testing required by appendix A of that standard should be performed. However, the using organization may insist on full testing in accordance with appendix B as well. In that case, advise the user that, based on limited testing to date, no existing EM filter/ESA devices have survived the E-2 and E-3 waveforms. Include appropriate cost and scheduling considerations if appendix B testing is required. If MIL-STD-188-125 is not a requirement, avoid its reference.

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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.

3.9.2.1 Testing - Part 1

Perform Part 1 as in-progress testing including inspection, visual seam inspection, and seam testing of all EM shielding materials and installation. [In-progress testing of welded shielding must include testing the structural welds to be embedded prior to concrete placement by dye penetrant and magnetic particle testing and 100 percent testing of wall, ceiling, and floor shielding welds by the SELDS tests.] [In-progress testing of bolted construction must include 100 percent testing of floor, wall, and ceiling shielding seams by the SELDS testing.] 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.

3.9.2.2 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. SELDS test all [seams] [welds], including shielding and penetrations not tested in part 1. Prform initial shielded enclosure effectiveness acceptance test consisting of a MIL-STD-188-125-1 test utilizing specified test frequencies for magnetic and plane wave. Conduct testing in accordance with the paragraph EM 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.

3.9.2.3 Testing - Part 3

Perform Part 3 final acceptance testing consisting of a visual inspection and a shielded enclosure effectiveness test of the EM shielding materials and installation. SELDS test all [seams] [welds], 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. Test facilities requiring HEMP protection for shielding effectiveness in accordance with acceptance test procedures in MIL-STD-188-125-1. 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.

3.9.3 Weld Inspection

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NOTE: Additional welding tests may be specified, such as ultrasonic or radiographic tests, but these tests are costly.

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Inspect weld seams visually by a qualified welder during the welding operation and after welding is completed. Inspect completed welds after the welds have been thoroughly cleaned by hand or power wire-brush. Inspect welds with magnifiers under bright light for surface cracking, porosity, slag inclusion, excessive roughness, unfilled craters, gas pockets, undercuts, overlaps, size, and insufficient throat and concavity. Grind out defective welds and replace with sound welds.

3.9.4 Shielded Enclosure Leak Detection System (SELDS) Testing

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NOTE: SELDS testing the welds in the floor shielding is usually performed on the interior only because it is not possible to "sniff" on both sides (assuming the shield is on the ground level). Dye penetrant may also be used to test the welds where SELDS testing is not possible. The SELDS can be obtained commercially from the following: 1. Carnel Labs Corporation 21434 Osborne Street Canoga Park, CA 91304 Telephone: (818) 882-3977 2. Rayproof Shielding Systems Corporation 50 Keeler Avenue Norwalk, CT 06854 Telephone: (203) 838-4555 3. Retlif Corporation 795 Marconi Avenue Ronkonkoma, NY 11779 Telephone: (516) 737-1500

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The leak detection system must use a 95- to 105-kHz oscillator and a battery operated hand-held receiver. Provide receiver or "sniffer" with a ferrite loop probe capable of sensing leaks within 6 mm 1/4 inch of the probe location with a dynamic range of 140 dB. Conduct testing in accordance with test equipment manufacturer's instructions. Place test loops or leads under the shield floor or into inaccessible locations prior to installation to assist in the detection of seam leaks in the floor, ceiling and walls. Place the loop or lead wires between the vapor barrier and the structural slab for the floor shield with the leads brought to an accessible location. Provide test leads that are insulated stranded copper conductors 2 to 2.5 mm 5/64 to 3/32 inch diameter and bond to the shield only at the end. Place test leads in plastic conduit for protection and do not exceed 45 m 150 ft in length. The surface area of the shield will determine the number of test leads (drive points) that are required. Install drive points on the shielding exterior and attach to two sets of diagonally opposing corners during construction. The distance between test lead connections on a shield surface must not be more than 20 m 66 ft. The maximum testing area must be 400 sm 4300 sf. If the shield area exceeds this requirement, provide additional drive points. Bonding of the test leads to the shield is accomplished by brazing or high-temperature soldering. Run test leads from the drive points to a lockable test cabinet for connection to the SELDS oscillator. If more than one test cabinet is required for a given area or building, duplicate test leads that would be common to different surface areas at each test cabinet to ensure that test point parings are maintained. Record the location of the permanent test leads and provide this information to the Contracting Officer for permanent reference. Welds and seams must be 100 percent tested. Probe seams continuously with the test receiver set to detect abrupt changes of shielding level greater than 10 dB on the shielding unit scale. Mark points having a change greater than 10 dB clearly and have the weld repaired to meet the specified requirement. Retest each repaired point until there are no points on seams which fail the test.

3.9.5 EM Shielding Effectiveness Testing

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

3.9.5.1 Test Procedure

Provide test procedure and equipment similar to that specified in MIL-STD-188-125-1. Test frequencies are specified herein. Test points are as indicated in Table I. Corner points of the grid must occur at the intersection of three planes (two-wall surfaces and ceiling or two wall surfaces and floor). Record measurement data at all test points, and provide a grid map for each surface tested. For any test point where required attenuation is not provided, correct the discrepancy and retest. Provide the results of the test failure as well as the successful results. Perform enclosure effectiveness test for magnetic attenuation with the antennas located directly opposite each other and separated by a distance of 600 mm 2 ft plus the wall thickness. Perform plane wave attenuation tests with the antennas located directly opposite each other and with the transmitting antenna placed 300 mm 1 ft away from the enclosure wall and with the receiving antenna set 300 mm 1 ft from the wall for stationary measurements and 50 to 600 mm 2 inch to 2 ft from the wall for swept measurements. Perform the magnetic field test and the plane wave test using the following sequence. Perform calibrations at the beginning of each test day. Then set up the test area for the 100 to 400 MHz stationary measurement in on to the two required polarizations. With the transmitter off check the receiver sensitivity. Energize the transmitter, and record the fixed measurement data. Remove the receiving antenna from the test stand and perform the swept measurement at the same frequency and transmitting antenna polarization. Rotate the transmitting antenna, and perform the second 100 to 400 MHz stationary measurement. Perform the swept measurement for the second transmitting antenna polarization. Reconfigure the equipment for the 900 to 1000 MHz test frequency, and repeat the series of four measurements. To perform the swept measurement, remove the receiving antenna from the test stand and hold with a dielectric rod at least 300 mm 12 inch in length. Attach a dielectric spacer to the sweeping antenna to assist in maintaining the 50 mm 2 inch distance from the shield. Make a rapid sweep to locate hot spots by rotating the polarization and waving the antenna through the specified volume. The final activity of each test day is to repeat the calibrations and verify the consistency with the previous calibration results. Include a definition of all test points including but not limited to walls, door frames, accessible joints, and around filters and penetrations in the test procedures. Test each EM door at the locations 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 3 m 10 feet (Note 1; minimum of one test point per side)

TABLE I - SHIELDING EFFECTIVENESS TEST POINTS	
Testing Location	Test Points Spacing
Corner seams for walls to floor, walls to roof, and wall to wall	Test every 3 m 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 1.5 m 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 300 by 300 mm 12 by 12 inches or larger; and at the midpoint of each side longer than 1.5 m 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 3 m 10 feet max. plane wave
Doors	Door handles
EM filter enclosures	Test at each seam corner and midpoint of each side longer than 1.5 m 5 feet at center
EM cabinets and enclosures	Test at each seam corner and each side 1.5 m 5 feet on center
NOTE 1. Sweep each point in space 600 mm 2 feet around the point.	

3.9.5.2 Test Points

Measure additional test points in accordance with MIL-STD-188-125-1 for facilities requiring HEMP protection. 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.

3.9.5.3 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.

3.9.5.4 Test Frequencies

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NOTE: Test frequencies will be in accordance with MIL-STD-188-125 when applicable.
****

Testing frequencies for shielded enclosures are as follows:

Magnetic field	[14 kHz,] [400 kHz,] and [10.1 MHz] [_____]
Electric field	[200 kHz] and [16 MHz] [_____]
Plane wave	[100 MHz], [415 MHz], and [1.29] [18] [_____] [GHz]
MIL-STD-188-125-1 frequencies are as follows:	
Magnetic	[_____]
Plane wave	[_____]

3.9.6 Weld Testing

Test structural welds to be embedded in accordance with AWS D1.1/D1.1M using magnetic particle inspection or dye penetrant inspection and 100 percent of the shielding seams by the SELDS testing prior to embedment.

3.10 GROUNDING

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NOTE: Grounding method will be in accordance with MIL-STD-188-124. An equipotential ground plane is recommended for shielded facilities.
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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 --