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USACE / NAVFAC / AFCEC **UFGS-13 49 30 (May 2026)**

Preparing Activity: NAVFAC **Superseding**
UFGS-13 49 20.00 10 (October 2007)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2026
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DIVISION 13 - SPECIAL CONSTRUCTION

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HIGH-ALTITUDE ELECTROMAGNETIC PULSE (HEMP) SHIELDING

05/26

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SECTION 13 49 30

HIGH-ALTITUDE ELECTROMAGNETIC PULSE (HEMP) SHIELDING
05/26

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This guide specification covers the requirements for spaces using the High Altitude Electromagnetic Pulse (HEMP) with the Electromagnetic Interference (EMI) Protection Subsystem.

This specification section was originally created for HEMP shield systems; also used for facilities for EMI eternally/externally radiated where TEMPEST RF shielding techniques are not sufficient. This is not a universal specification for all scenarios.

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)**.**
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NOTE: For larger enclosures and for High Altitude Electromagnetic Pulse (HEMP) protected enclosures, contact NAVFAC Engineering Innovation and Criteria Office (Code EICO) before beginning design. The electrical designer should refer to MIL-HDBK-419 Volumes I and II for special grounding and bonding requirements for EMC enclosures. Although not

addressed in this specification, it is recognized that 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 penetration of the shield in detail. For a discussion of the advantages and disadvantages of fiber optic systems see NAVFAC DM-12.02. Designer should consult these documents and other appropriate sources before applying this guide specification to large scale EMI enclosures to HEMP and to TEMPEST Projects. The potential requirement for thermal expansion joints inherent to large scale enclosures is not addressed in this guide specification.
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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.
h. Filter performance specifications.

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. This document can be obtained from HQ AFIC/LEEE, San Antonio, Texas 78243-5001. Also refer to AR 25-12. 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] MIL-HDBK-423. 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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PART 1 GENERAL

This section includes standards and construction specifications for spaces using the High Altitude Electromagnetic Pulse (HEMP) with the Electromagnetic Interference (EMI) Protection Subsystem.

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.

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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	(2025) Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding
AWS BRH	(2007; 5th Ed) Brazing Handbook
AWS D1.1/D1.1M	(2025) Structural Welding Code - Steel
AWS D1.3/D1.3M	(2025) Structural Welding Code - Sheet Steel
AWS D9.1/D9.1M	(2018) Sheet Metal Welding Code

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	(2025a) Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
ASTM A653/A653M	(2025a) 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 E90	(2023) Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
ASTM E1289	(2008; R 2022) Standard Specification for Reference Specimen for Sound Transmission Loss

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

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	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code
NFPA 77	(2024) 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	(2026) Standard for the Installation of Lightning Protection Systems

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-HDBK-419	(1987; Rev A, Notice 1 2014) Grounding, Bonding, and Shielding for Electronic Equipments and Facilities Volumes 1 of 2 Basic Theory
MIL-HDBK-423	(1993; Notice 1 2019) High-Altitude Electromagnetic Pulse (HEMP) Protection for Fixed and Transportable Ground-Based C4I Facilities
MIL-PRF-15733	(2020; Rev J) Filters and Capacitors, Radio Frequency Interference, General Specification for
MIL-PRF-26915	(1997; Rev D) Performance Specification: Primer Coating, for Steel Surfaces
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

UL SOLUTIONS (UL)

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

1.2 SYSTEM DESCRIPTION

This section covers components, fabrication, fabrication mock-ups and installation, and testing for the HEMP protection subsystem. The HEMP protection subsystem must include, but not be limited to, the following:

a. The welded steel HEMP shields.

b. Electrical filter/ESA assemblies for HEMP protection at hardwired electrical penetrations through the facility HEMP shields.

c. Waveguides below cutoff and waveguide-below-cutoff arrays for HEMP protection at all piping and HVAC penetrations through the facility HEMP shields.

d. Waveguides below cutoff for HEMP protection at all fiber optic cable penetrations through the facility HEMP shields.

e. Special protective measures, as required, for HEMP protection of mission-critical equipment (MCr) outside the facility HEMP shields. MCr outside the HEMP shields include HVAC condensers, and mission-critical fiber optic cables of the site communications distribution system.

f. Shielded conduits and shielded pullboxes as needed to be used for future equipment that will be installed by others.

The HEMP protection subsystem must comply with the requirements of MIL-STD-188-125-1 and must be in general accordance with the guidelines of MIL-HDBK-423 unless otherwise shown in the drawings or explicitly stated in this specification. In the event of conflict between this specification and MIL-STD-188-125-1 or other specifications sections, the Contractor must notify the Contracting Officer in writing. Pending resolution by the Contracting Officer, this specification section must govern.

1.3 GENERAL REQUIREMENTS

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NOTE: Insert additional details describing the specific project for which this specification is being used. Projects involving military communications equipment must be designed to incorporate the applicable requirements of MIL-STD-188-124, "Grounding, Bonding, and Shielding for Common Long Haul/Tactical Communication Systems." A/An 2400 by 2400 by 2400 mm 8 by 8 by 8 feet test module has proven beneficial on complex, extra large, or extra critical construction projects. The module simulates the Contractor's welding techniques, penetration techniques, and testing techniques prior to trying them out in the actual building shield. The test module fabrication and testing plan should also detail the SELDS and other testing as described in MIL-STD-188-125 and MIL-HDBK-423 to be performed including test dates so that an expert government witness may be present for the tests. The results of all module testing must be included in a final test module reports. Be

aware that standard manufactured shielded doors are not designed for exposure to weather.

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Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to this section, with the additions and modifications specified herein. Provide enclosure complete with[RF air vents,][penetrations for compressed air lines, water lines, and [_____],][[_____],][coaxial-cables,][lighting fixtures,][workbenches with convenience outlets,] and door assembly. Provide each item with fittings and hardware necessary for a complete and operable HEMP shielded enclosure. Where two or more units of the same type, class, and size of equipment are required, units must be products of a single manufacturer. Completely isolate the enclosure electrically from the building in which the enclosure is to be installed.

1.3.1 Related Work

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NOTE: Modify or delete these paragraphs as required for each project. Additional items such as raised computer floors may be specified in the same manner.

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NOTE: Insert appropriate Section number and title in blank below using format per UFS 1-300-02, "Unified Facilities Guide Specifications (UFGS) Format Standard".

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Provide complete shielded enclosure[s] including work specified in other Divisions and as shown on the drawings including the following additional instructions:

a. Section [_____]

b. Section [_____]

c. Section [_____]

1.3.1.1 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.

1.4 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.

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-01 Preconstruction Submittals

Quality Control Plan

Performance Test Plan

ESA Factory Test Plan; G, [_____]

HVAC WBC Array Assembly Factory Test Plan; G, [_____]

WBC Piping Array Factory Test Plan; G, [_____]

Shielding Effectiveness Acceptance Test Plan; G, [_____]

SD-02 Shop Drawings

HEMP Shielded Enclosure Shop Drawings; G, [_____]

HVAC WBC Array Shop Drawings; G, [_____]

Piping WBC Arrays Orifice Plate Shop Drawings; G, [_____]

Drain System Shop Drawings; G, [_____]

SD-03 Product Data

HEMP Shielding Systems; G, [_____]

Shielded Filter Assemblies; G, [_____]

Waveguide-Type Air Vents

SD-04 Samples

Any Fabrication Mock-Ups; G

SD-06 Test Reports

Impulse Sparkover Voltage

ESA Extinguishing Test

ESA Extreme Duty Discharge Test

Field Testing

HEMP Quality Control Plan; G, [_____]

Daily HEMP QC Reports; G, [_____]

ESA Factory Test Report; G, [_____]

HVAC WBC Array Assembly Factory Test Report; G, [_____]

WBC Piping Array Assembly Factory Test Report; G, [_____]

Shielding Effectiveness Acceptance Test Report; G, [_____]

Filter/ESA Assembly Transient Analysis Report; G, [_____]

SD-07 Certificates

Industrial Standards Compliance Certificate

Qualifications of the Shielding Specialist; G, [_____]

Qualifications of the Shielding Enclosure Testing Agency

Welder Qualification; G

SD-08 Manufacturer's Instructions

HEMP Shielded Enclosure

HEMP Filters

SD-10 Operation and Maintenance Data

HEMP Shielded Enclosure, Data Package 2; G, [_____]

HEMP Protection Subsystem Operation and Maintenance Manual; G

SD-11 Closeout Submittals

Operating and Maintenance Manuals; G

HEMP Protection Subsystem As-Built Assembly Drawings; G

As-Built Shield Penetration Schedule; G

Filter/ESA Assembly As-Built Schedule; G

1.5 PRE-INSTALLATION MEETING

Hold a pre-installation meeting including all relevant subcontractors, designer of record, and shielding specialists at the onset of the construction planning process. Issue coordination requirements and written instructions to ensure integrity of shielding, penetration protection devices, and other protective measures.

1.6 RELIABILITY

Maintaining high shielding effectiveness for long term usage with minimum maintenance must be stressed throughout construction, and erection of the specified shielded enclosure. Ensure corrosion and the installation of electrical service, power line filters, ventilation and connector panels do not derate the required shielding effectiveness. The enclosures will be subject to varying moveable live floor loads and continuous use of the ventilation system and ac power line filters.

1.7 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.

1.8 DELIVERY AND STORAGE

Protect equipment delivered and stored from excessive humidity and temperature variation, dirt, and other contaminants. Deliver protection subsystem materials, components, and equipment to the job site in a clean, corrosion-free, and undamaged condition. Materials, components, and equipment, along with the accompanying element identifications and certifications, must be inspected upon receipt on site to ensure that they are the proper items and that their condition is satisfactory. Reject and replace at no cost to the government, improper, defective, or damaged materials, components, and equipment.

Store HEMP protection subsystem elements during storage and after installation. Materials, components, and equipment until ready for use under cover in a well-ventilated enclosure with proper drainage to prevent exposure to extreme temperature, humidity and moisture, dirt, and other contaminants that could cause damage.

1.9 QUALITY ASSURANCE

1.9.1 Qualifications

1.9.1.1 Shop Drawings General Requirements

Include penetration details and bulkhead entry plates. Shop drawings must identify shield construction technique, material properties, attenuation levels of shield system/materials, anodic index/corrosion problems, and filters. The shop drawings for the shielded enclosures must be prepared by a shielding manufacturer/fabricator experienced in the installation of metal welded[Electromagnetic Pulse (EMP),] EMI shielded enclosures and has supervised the installation of[two] such enclosures which have operated satisfactorily. Prior to commencing work, and as a condition of continuing work, forward to the Contacting Officer[and Site Security Manager] information demonstrating such experience.[Drawings must be approved by and bear the seal of a registered, professional structural engineer.]

1.9.1.2 Responsibilities of the Shielding Specialist

Provide materials, products, and services necessary for a complete, tested, and operational protection system. Supervise and inspect all work performed under this section prior to submitting to the Contracting Officer for approval. HEMP protection subsystem submittals must be date stamped and signed by the shielding specialist. Coordinate HEMP protection subsystem work with the work of all other trades that will interface with or affect the performance of the HEMP shields and penetration protection devices.

Provide sufficient and qualified supervisory and quality control personnel on site to supervise the installation crew and to conduct in-progress quality assurance inspections and tests. Provide the services of a qualified and independent shield testing specialist to perform the acceptance testing.

1.9.1.3 Shielding Specialist

The HEMP protection subsystem must be provided by a HEMP protection subsystem (shielding) specialist, approved by the Contracting Officer. The shielding specialist must be an experienced firm that has been regularly and successfully engaged in the manufacturing, installation, and supervision of equivalent electromagnetic shielded systems.

1.9.1.3.1 Qualifications of the Shielding Specialist

The name and background qualifications of the firm that will be the shielding specialist on this project must be provided to the Contracting Officer for approval. The principal work of this firm must be the satisfactory installation and construction of EM shielded protection systems. The firm must be experienced in the successful installation, supervision, and testing of equivalent HEMP shielding systems for at least 5 years. The shielding specialist must have experience achieving specified requirements of shielded systems attenuation and maintainability of attenuation levels on work performed. Furnish a project experience list of projects that are similar in scope and have been completed during the previous 5 years. A brief description of the shielding system and the name and telephone number of the user [and][or] owner of each project must be included. The Contracting Officer may reject any proposed shielding specialist who cannot show documented evidence of qualifying satisfactory experience. Further, the key personnel (e.g., project manager/engineer and testing specialist) credentials must include a bachelor's degree in science or engineering and post-degree training and experience with EM shielding.

1.9.1.4 Welder Qualification

Welding on the HEMP protection subsystem must be performed only by qualified and certified welders. Welder qualification Certificates, Disqualification Notices, and Requalification Notices must be submitted to the Contracting Officer for each qualified welder before that individual is permitted to perform work on the project. 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. Whenever the results of welder monitoring creates a reasonable doubt of a welder's proficiency, that individual must be removed from the job and retrained/recertified or discharged. Welder disqualification notices and recertifications must be provided to the Contracting Officer within 24 hours of the event.

1.9.2 HEMP Quality Control Plan

The Contractor and shielding subcontractor must establish a quality control (QC) program to ensure that the HEMP protection subsystem is fabricated and assembled in accordance with the project drawings and these specifications. The QC program must be documented in a HEMP Quality Control Plan, which must be submitted to the Contracting Officer for approval within 30 days after notice to proceed. The plan must include, but not be limited to, the following:

a. A description of the HEMP QC organization and its integration into job site management.

b. Names, qualifications, and assignments and responsibilities of leading QC personnel.

c. QC program methods for source quality control, including specified in-factory testing; receiving inspections for purchased materials and components, including review of accompanying data; on-site inspections and testing, including in-progress weld inspections and testing; acceptance testing; and QC reporting.

Detailed test plans, procedures, and equipment list must be provided as appendices to the QC plan or as separate documents.

1.9.3 Daily HEMP QC Reports

Submit daily RF QC reports to the contracting officer within 24 hours of the date of the report during the period when the RF subsystem is assembled and other periods when associated work is taking place.

1.9.4 Notification of Tests

The Government reserves the right to witness all specified in-factory and on-site tests of the HEMP protection components and subsystem. Notify the Contracting Officer must be notified at least 30 days before in-factory tests are scheduled to be performed and at-least 14 days before on-site tests are scheduled to be performed.

1.9.5 Workmanship

All work required under this section must be performed in a professional manner and must be in accordance with accepted industry standards. All materials, components, equipment, and assemblies must be of good quality, uniform in appearance, and free of defects that affect life, performance, or serviceability.

1.9.6 Certifications

1.9.6.1 Performance Test Plan

Submit a performance test plan for SELDS and applicable testing of the facility. The test plan must include tester qualifications, equipment listings (including calibration dates and antenna factors), and proposed test report format. The plan must also address specific dates and durations that testing will be conducted during the overall construction period so that the expert Government witness may be scheduled to observe the testing and so that repairs may be made to the shield and retests conducted before the building finish materials are installed. Finally the test plan must indicate the proposed dates and duration of the lowest and highest frequency tests following installation of the building finish materials[so that an expert Government witness may be available for these final acceptance tests]. The results of EMI testing must be submitted to the Contracting Officer on a daily basis and test results incorporated into an EMI Shielding Test Final Report.

1.9.6.2 Qualifications of the Shielding Enclosure Testing Agency

Submit the experience and qualifications of an independent testing agency for review and approval. The testing agency must have recent experience in Shielded Enclosure Leak Detection System (SELDS) and MIL-STD-188-125-1 and MIL-HDBK-423 shielded enclosure testing and must list where and when the experience was obtained. Certify that laboratory is equipped and staffed to perform field tests of RF shielded enclosures and performs the tests as a normal service. Certify that test equipment has been calibrated within the last 12 months.

1.9.6.3 Field Samples

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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.

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Provide field samples for the following: [shielding sheet installation,][shielding fastening,][doors,][power filter,][communication filter,][waveguide,][penetration,][structural steel support through shield steel plate,] and [_____].

1.10 FIELD MEASUREMENTS

The Contractor and shielding specialist must be familiar with requirements and details of the HEMP protection subsystem work. Verify dimensions in the field and must advise the Contracting Officer of any discrepancies before performing the work.

1.11 MAINTENANCE

1.11.1 HEMP Shielded Enclosure, Data Package 2

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Indicate allowable loads on top of room and on shelves mounted on walls and floor, including permissible weights of equipment that can be mounted on walls. Include prescribed method of welding panels, cleaning of seams and contact fingers, bonding jumpers, installing metallic items penetrating the shielding material without decreasing the attenuation characteristics.

1.11.2 Operation And Maintenance Manual

Provide Operation and maintenance manuals must be provided in accordance with the requirements in Section 01 78 23 OPERATION AND MAINTENANCE DATA, except as required for this section. A HEMP Protection Subsystem Operation and Maintenance Manual must be provided for each HEMP-protected building at least 3 months prior to Building Occupancy Date (BOD). The manuals must address all aspects of the shielding, shield penetration protection devices, and special protective measures. The contents must include, but not be limited to, the following:

a. This construction specification section for the HEMP protection subsystems, including all approved change orders.

b. A complete set of HEMP protection subsystem as-built assembly drawings, including shield penetration locations and installation details.

c. The as-built shield penetration schedule.

d. Manufacturers' data for all shielded filter/electrical surge arrester assemblies, and other purchased items used in the HEMP protection subsystem.

e. Preventive maintenance instructions for periodic inspection, testing and servicing, lubrication, alignment, calibration, adjustment, and other routine maintenance actions. The maintenance instructions must be extracted from vendor or manufacturer data or, in the case of complex instructions, may refer to the manufacturers' data. This information must be derived from an engineering data considering local environmental conditions, manufacturers' recommendations, estimated operating life for the specific application and use of the equipment, and types of job skills available at the operating site.

f. The shielding specialist's Individual designers recommendations for spare and repair parts, maintenance supplies, and special tools and test equipment.

1.11.3 Maintenance Supplies and Procedures

Electronic Security Enclosure Intrusion Detection System maintains count of door openings/closings. Furnish [1][5][10][_____] sets of the supplies below.

1.11.4 Extra Materials

1.11.4.1 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.

1.11.4.2 EM Shielded Doors

Furnish [one][_____] set[s] 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.

1.11.4.3 Tools

Furnish [one][_____] full set[s] 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.

1.11.4.4 Special Tools

Provide [one][_____] set[s] of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment as follows: [SELDS Test Set][_____]

1.11.5 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, electrical 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 EM shield.

b. EM shielded doors and entry vestibules 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.

m. Bulkhead plates for penetrations.

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 New and Standard Products

All materials, components and equipment must be new and must be 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 for the equipment must be by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.2.2 Reliability, Maintainability, Testability, and Safety

Materials, component, and equipment must be designed and built to be rugged and reliable and to facilitate maintenance and testing. They must be engineered for safety of personnel during operation, routine maintenance and testing, and repairs.

2.2.3 Standards Compliance

When material, components, and equipment are specified to conform to requirements of standards published by industrial organizations, such as ASTM or ANSI, proof of such conformance must be provided to the Contracting Officer. The label and listing of the specified organization will be acceptable evidence. In lieu of the label and listing, a written Industrial Standards Compliance Certificate, when required, stating that the item has been tested and conforms to the specified standard from a testing organization equipped and competent to perform such testing must be submitted.

2.2.4 Factory Test Plans

Prepare detailed test plans/procedures for all required factory tests. Submit test plan to the COR for approval. The test plan contents must include an introduction that states the purpose of the testing, a list of tests to be conducted, and the testing location and schedule; a list of applicable references; a general description of each test method and the associated test equipment requirements; detailed procedures including test equipment calibration, test configurations, measurement locations, data requirements, and pass/fail criteria; examples of all test data sheets, and the format and outline of the test report to be provided.

With the approval of the Contracting Officer, previous documented tests of components that are identical to those to be provided will be allowed to substitute for in-factory type tests. For example, a variance to performing the factory for filters could be requested if the same filter type by the same manufacturer was tested and provided as part of previous projects.

The request for variance must include results of the previous tests and a letter from the manufacturer indicating that the type previously tested is the same, with no modifications, as that being provided now.

2.2.5 Factory Test Reports

Prepare detailed test reports for all required factory tests. Submit test plan to the COR for approval. The format must be in the format described in the approved factory test plan. The contents must include copies of measured and processed test data; identification and rationale for any deviations from the test plan, and pass/fail conclusions.

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 will increase design costs, cause problems in its incorporation into the structure, and lose installation simplicity.

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 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 [100 dB] at [1 MHz][_____]. Use minimum electric field and plane wave attenuation of [100 dB][_____] from 14 kHz to [1 GHz][_____].

2.4 EM SHIELDING ENCLOSURE REQUIREMENTS (WELDED CONSTRUCTION)

****

NOTE: Welded construction will usually consist of continuous 4.76 mm 3/16 inch 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. It is desirable for large facilities to place the shield at least 1 meter 6 feet inside the exterior walls, although cost and construction restrict this consideration. The floor shielding can be tested by SELDS test 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 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. 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.

2.5 EM SHIELDED DOORS

****

NOTE: Edit these paragraphs depending on type of

door used on project.
****

2.5.1 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 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 outlined in MIL-STD-188-125-1. Provide door with a clear opening[as shown on the drawings][of [915][_____] mm [36][_____] inch wide and [2135][_____] mm [84][_____] inch] high.

2.5.1.1 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.

2.5.1.2 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.

2.5.1.3 Electric Connectivity

Install electric connectivity for sensors, alarms, and electric interlocking devices in accordance with the door manufacturer's instructions, the HEMP Shielded Enclosure Shop 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.

2.5.1.4 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.

2.5.1.5 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.

2.5.1.6 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.

2.5.1.7 Finish

Factory prime paint EM shielded doors with zinc chromate primer per MIL-PRF-26915. Doors may be factory finish painted or galvanized. Touch up any damaged finish.

2.5.1.8 Additional Hardware

****

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

****

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

2.5.2 Swing Type Doors

****

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[carbon steel][galvanized][403SS][304SS][laminated][hollow metal with cold rolled SS Skin] 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.]

2.5.2.1 Door Characteristics

Provide sound retardant door assemblies of the thickness, width, and height indicated, complete with perimeter seals, seal housings, gasketing,[automatic door bottoms,] thresholds, door frames, and astragals as required to conform to[STC-50][STC-55] per ASTM E90 and ASTM E1289.

Submit fabrication drawings for[Metal Sound Retardant Doors,][Veneered Metal Sound Retardant Doors,] Metal Door Frames and Door Frame Sound Infill. Submit certificates showing conformance with the referenced standards in this section, and manufacturer's catalog data including STC ratings and UL fire rating, where applicable. Provide assemblies that are complete with metal frame, door(s), sealing system, and Cam-lift hinges (when required).

2.5.2.1.1 Door Edge

The closure seal must use 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.

2.5.2.2 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.

2.5.2.3 Lockset

Provide doors with an eletromechanical cypher lock to meet MIL-HDBK-423 requirements.

2.5.2.4 Threshold and Ramps

****
NOTE: Knife edge doors do not meet accessibility requirements at threshold and cannot be used unless door is located on a military installation that is designated and constructed exclusively for able bodied military personnel.
****

Provide thresholds designed for[zero clearance access[flat][recessed]][ramp for heavy equipment access][saddle for acoustic sealing].

2.5.2.5 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 67 N 15 pounds to move the doors.

2.5.2.6 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.

2.5.2.6.1 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.

2.5.2.6.2 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.

2.5.3 Pneumatic Sliding Doors

Provide[low carbon steel with thermally bonded tin coated skin][galvanized][403SS][304SS][hollow metal with cold rolled SS Skin] 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.]

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. Manual[override][operation] must not exceed a maximum of [133][_____] N [30][_____] pounds. When the door is sealed, the attenuation around the edges must meet the EM shielding effectiveness requirements of this specification. Provide door with a pneumatic system that maintains a nominal sealing pressure of [250][_____] kPa [35][_____] psi. Attach a label to pneumatic doors warning against painting of the mating surfaces.

2.5.3.1 Door Characteristics

2.5.3.2 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 15 seconds. Include provision for removing the door for routine maintenance without disturbing its alignment and EM sealing properties.

2.5.3.3 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.

2.5.3.4 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. Including rubber composite bladder gasketing.

2.5.3.5 Pneumatic Operators

****
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].

2.5.4 EM Shielded Door Factory Test

****
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.

2.5.4.1 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 is not 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.

2.5.4.2 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 is not 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.

2.5.4.3 Door Closure Test

Provide Manufacturer's testing data showing each door design has been tested operationally for 100,000 complete open-close cycles. The door is not 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.

2.5.4.4 Handle-Pull Test

Mount and latch the door to its frame. Provide handle with a force of 1000 N 225 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 is not acceptable if this test causes any breakage, failure, or permanent deformation exceeding 3 mm 1/8 inch.

2.5.4.5 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.

2.6 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, 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. Filters must be certified UL 1283 compliant. Submit data and shope drawings for Shielded Filter Assemblies to the Contracting Officer for apporval prior to procurement.

2.6.1 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 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.]

2.6.1.1 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.

Provide and install RF gasket making the connection according to the requirements of MIL-HDBK-423. An RFI gasket or a combination RFI and environmental gasket provides electrical continuity between the cover and box of a shielded compartment. An environmental gasket only is generally used for an unshielded compartment.

2.6.1.2 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.

2.6.1.3 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.

2.6.1.4 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 minus 67 to plus 150 degrees F (measured outside the EM filter enclosure). Use filter components that are suitable for continuous full load operation at a temperature from minus 55 to plus 85 degrees C minus 67 to plus 185 degrees F.

2.6.1.5 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
1200	42,000

2.6.1.6 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.

2.6.2 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. Keep conductors 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.

****

2.6.2.1 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. Fabricate 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.

2.6.2.2 Ratings

****

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.

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[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.]

2.6.2.3 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.

2.6.2.4 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.

2.6.2.5   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.

2.6.2.6   Insertion Loss

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NOTE: Unless otherwise specified, the required insertion loss is 100 dB at 14 kHz to 1 GHz. Consult filter manufacturer for detailed requirements. Also consult the manufacturer when leakage current is important, such as in life safety areas.

There is a trade-off 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 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.

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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.

2.6.2.6.1   Telephone and Signal Line Filters

Provide filters that comply with MIL-PRF-15733 with an insertion loss of 100 decibels in the frequency range of 14 kHz to 10 GHz measured according to MIL-STD-220, full load condition. Filters must have a pass band of [_____] kHz to [_____] kHz with a characteristic impedance of [_____] ohms.

2.6.2.7 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. 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.

2.6.2.8 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.

2.6.2.9 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.

2.6.2.10 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.

2.6.2.11 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.

2.6.2.12 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.

2.6.2.13 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.

2.6.3 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.

2.6.4 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.

2.6.5 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.

2.6.5.1   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.

2.6.5.2   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.[Perform source to load testing for HEMP.]

2.6.5.3   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 to 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. Perform test according to UL 1283 for 1000 hours at temperature 90 C 194 F. Make specified measurements prior to, during, or after exposure.

2.6.5.4   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) minus 55 deg C minus 67 deg F. 0 deg and minus 3 deg

(2) 25 deg C 77 deg F. plus 10 deg and minus 5 deg

(3) 85 deg C 185 deg F. plus 3 deg and minus 0 deg

(4) 25 deg C 77 deg F. plus 10 deg and minus 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.

2.6.5.5 Overload Test

Mount filters in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method that is 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 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 must be measured after each separate overload test. Filters must also be visually examined for evidence of physical damage after each test.

2.6.5.6 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 is 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.

2.6.5.7 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, connect a voltmeter across the primary side or across a tertiary winding provided that the actual voltage across the filter is 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.

2.6.5.8   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 is 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 plus 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.

2.6.5.9   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 is 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.

2.6.5.10   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.

2.6.5.11   Terminals Pull Test

The purpose of this test is to determine whether the design of the filter terminals can withstand any mechanical stresses during installation or disassembly of equipment. Perform testing with the components mounted in the filter/ESA assembly enclosure or mounted on a plate by the same holding method that is 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.

2.7 ELECTRICAL SURGE ARRESTERS (ESA)

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NOTE: ESA application guidance is found in MIL-HDBK 423.
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2.7.1 Power and Signal Line ESA

2.7.1.1 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 must 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.

2.7.1.2 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.

2.7.1.3 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 is 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 is 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 is 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.

2.7.1.4 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 is 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 to 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.

2.7.1.5 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 is 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.

2.7.1.6 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 is 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.

2.7.1.7 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.

2.7.2 ESA Testing

Provide ESA Factory Test Plan and upon completion of the testing, the ESA Factory Test Report. The Filter/ESA Assembly As-Built Schedule must include voltage, amperage, filter type (low, high, band pass), system, location, cut-off frequency, band pass frequencies, and electrical surge arresters. Include the Filter/ESA Assembly Transient Analysis Report with the submittal. Filter/ESA schedule must include voltage, amperage, filter type (low, high, band pass), system, location, cut-off frequency, band pass frequencies, and electrical surge arresters (ESA).

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 is 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.

2.8 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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Enclosure must have a permanently installed, solid brass or bronze grounding stud complete with hardware and jamb nuts located in the entrance plate[unless otherwise specified or indicated]. The stud must be 13 mm 1/2 inch diameter double-threaded bolt and circumferentially welded to each side of the shielding penetration plate.

2.9 WAVEGUIDE ASSEMBLIES

Waveguide-below-cutoff (WBC) protection must be provided for all HVAC, piping, plumbing and fiber optic cable penetrations of the facility HEMP shields as shown in the project drawings. No conductors (electrical wiring, louver operating rods, fiber optic cable metallic strength members or shields, pipes or hoses, etc.) must be permitted to pass through the WBCs. Waveguides containing fluid or dielectric material must be designed specifically for shielding performance.

2.9.1 General Requirements

2.9.1.1 Shielding Effectiveness Performance

For 1 GHz, the maximum rectangular linear diagonal dimension must be 101.6 mm 4 inch and the maximum circular diameter must be 101.6 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.

The WBC penetration protection devices for all piping penetrations for piping systems that are closed metal piping systems within the HEMP shielded volume must have transverse dimensions such that the waveguide cutoff frequency is at least 1.5 GHz. The lengths of the WBCs must be at least five times the cross-sectional diameter for circular waveguides and at least five time the diagonal cross-sectional cell dimension for rectangular waveguides. These WBC assemblies, in combination with their associated closed metal piping systems, must provide at least the minimum shielding effectiveness required for the overall HEMP protection subsystem.

2.9.2 Waveguide-Type Air Vents

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NOTE: Occurrence of dissimilar metals will use corrosion resistant design.
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Honeycomb WBC arrays and welded WBC arrays are both acceptable for ventilation, and must be constructed out of corrosion resistant material as indicated in 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. Unless otherwise specified in the drawings, the pressure drop across the WBC array with all attachments in place must not exceed 3.4 g/cm2 0.1 inch of water) at an air velocity of 305 m/min 1000 ft/min. Provide waveguides for air vents (honeycomb) with access doors in duct work for maintenance. Weld the frame of the honeycomb panel into the penetration plate with continuous circumferential EM welds. 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.

2.9.3 HVAC WBC Array Assemblies

2.9.3.1 HVAC WBC Array Shop Drawings

Shop drawings for honeycomb HVAC WBC array assemblies must be prepared by the Contractor and shielding specialist and submitted to the Contracting Officer for approval as part of the shop drawings for the facility HEMP shields (see paragraph SHOP DRAWINGS GENERAL REQUIREMENTS). The drawings must provide a complete list of materials and parts, sizes, arrangements, and methods and sequence of assembly. RF jointing methods and details must be provided. Methods of attachment to the HEMP shield, ducts, louvers, or other attachments must also be detailed. Hardness critical items and hardness critical processes must be identified on the drawings with HCI and HCP symbols, respectively.

2.9.3.2 WBC Array Construction

HVAC WBC arrays and piping WBC arrays must be new and must be standard products of a manufacturer regularly engaged in the manufacture of such products for at least the previous 5 years. The WBC array devices must essentially duplicate items that have been in satisfactory use for a period of at least 2 years prior to bid opening. WBC array vendor identification and experience data, drawing and catalog cuts for the devices to be supplied, manufacturer's recommended installation and maintenance procedures, and other documentation must be submitted to the Contracting Officer at least 60 days before shield assembly and installation is scheduled to commence. All honeycomb HVAC WBC arrays with the same size and functional requirements must be provided by the same manufacturer and must be of the same model number.

a. Materials: Waveguide to be constructed of[steel][brass][aluminum][stainless steel].[Provide[tin][tin lead][EN coating] on waveguide.]

b. Dimensions: Provide waveguide with [3.17][4.76][6.35] mm [1/8][3/16][1/4] inch cells and [12.7][19.0][25.4] mm[1/2][3/4][1] inch thickness.

c. Attenuation: [Insert attenuation range requirements]

d. Gasketing: Compatible gasketing to be[EMI][Monel][Tin coated][Aluminum mesh].

2.9.3.3 HVAC WBC Assembly Factory Testing

At least one honeycomb HVAC WBC array assembly from each vendor must be factory tested to demonstrate satisfactory compliance with requirements of the electromagnetic shielding test. An HVAC WBC Array Assembly Factory Test Plan for the WBC assembly factory testing must be prepared by the Contractor and shielding specialist and must be submitted to the Contracting Officer for approval. The Contractor must notify the Contracting Officer at least 30 days before the scheduled performance of the factory tests, and the Government reserves the right to witness all required testing. Factory test results must be documented in an HVAC WBC Array Assembly Factory Test Report and submitted to the Contracting Officer. The test WBC assembly must be furnished on the project. The electromagnetic shielding of the honeycomb HVAC WBC assembly must be measured in accordance with test procedures in Appendix A of MIL-STD-188-125-1 at frequencies up to 1 GHz.

2.9.4 WBC Piping Array Penetrations

At least one WBC Piping Array Assembly from each vendor must be factory tested to demonstrate satisfactory compliance with requirements of the electromagnetic shielding test. An WBC Piping Array Factory Test Plan for the WBC assembly factory testing must be prepared by the Contractor and shielding specialist and must be submitted to the Contracting Officer for approval. Factory test results must be documented in an WBC Piping Array Assembly Factory Test Report and submitted to the Contracting Officer.

Piping WBC Arrays Orifice Plate Shop Drawings must be prepared by the Contractor and shielding specialist and submitted to the Contracting Officer for approval as part of the shop drawings for the facility HEMP shields (see paragraph SHOP DRAWINGS GENERAL REQUIREMENTS). The drawings must provide a complete list of materials and parts, sizes, arrangements, and methods and sequence of assembly. RF jointing methods and details must be provided. Methods of attachment to the HEMP shield, ducts, louvers, or other attachments must also be detailed. Hardness critical items and hardness critical processes must be identified on the drawings with HCI and HCP symbols, respectively.

Make all piping penetrations of the HEMP barrier to include but not limited to, 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. For compressed air 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. For water the opening must be less than 1.34 cm 0.53 inch in diameter for a cutoff frequency greater than 1.5 GHz. This reduction in the maximum transverse dimension of the waveguide is required. 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. Waveguide must be constructed of[copper][brass][steel].

2.9.4.1 Floor Cleanout and Drain System Shop Drawings

Shop drawings for the Floor Cleanouts and Drain System, including all shield penetrations and penetration protection treatments, must be prepared by the Contractor and shielding specialist and submitted to the Contracting Officer for approval before assembly and installation is commenced. The shop drawings must meet the requirements and be of comparable construction to Floor Cleanouts and Drain System shown in the detail drawings. The drawings must provide a complete list of materials and parts, sizes, arrangements, and the methods and sequence of assembly. Layouts of the floor cleanout and drain system components, details for welding the seams and joints, and all attachments to the sewer system must be detailed. The number and locations of penetrations and the method of HEMP protection at each penetration must be shown. Hardness critical items and hardness critical processes must be identified on the drawings with HCI and HCP symbols, respectively.

2.9.5 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.

2.10 COAXIAL CABLE PENETRATIONS

For each coaxial cable entering the shielded enclosure, provide RF waveguide threaded insert with cap and chain on shielded room side of enclosure.

2.11 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 the penetration plate to the HEMP shield with continuous circumferential EM welds.

2.12 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.

2.13 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 Table I of this specification.

2.14 TRANSFORMERS

Provide transformers that meet requirements identified in MIL-STD-188-125-1 for Transformer requirements.

2.15 AUTOMATIC TRANSFER SWITCHES

Provide Automatic Transfer Switches that meet requirements identified in MIL-STD-188-125-1. ATS must be provided within the HEMP shield in order to provide suitable protection.

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. Examine materials for evidence of corrosion, contamination, or damage.

3.2 GENERAL INSTALLATION REQUIREMENTS

3.2.1 Coordination

The HEMP protection subsystem (shielding) specialist must supervise and inspect all fabrication and installation work performed under this section. The shielding specialist individual design specialists must be responsible for coordinating the HEMP protection subsystem work with the work of all other trades. The shielding specialist individual designers must instruct the other trades, in the presence of and with the direction of the Government representative, to ensure that all individual workers are aware of the hardness critical installation requirements. The HEMP shielded enclosure shop drawings and sequence of assembly must have been approved before shield construction begins.

3.2.2 Sequence of Assembly

The HEMP protection subsystem must be fabricated and installed in accordance with the approved sequence of assembly, which was submitted with the shop drawings. Erection of the welded steel shield must be sequenced to minimize sheet warpage. Penetration protective devices and other components must have successfully completed factory testing and initial testing required by other sections of the specifications before installation. Preliminary shielding effectiveness testing must have been successfully completed before installation of equipment that would limit access for repairs to the shield. Changes to the sequence of assembly, if required, must be submitted to the Contracting Officer for approval before implementation.

3.2.3 Verification

Before, during, and after the HEMP shielding and penetration protection subsystem installation, the shielding specialist must verify and approve the installation for compliance with the specifications. Materials and methods, shop drawings, and other items for the shielding subsystem must have been approved by the shielding specialist and by the Contracting Officer, if required.

3.2.4 Inspection

During and after HEMP shielding and penetration protection subsystem installation, including HEMP filter/ESA assemblies and waveguides, a qualified quality control inspector must inspect the installation for compliance with the specifications.

3.2.5 Protection of Installed Components

The shielding specialist individual designers must provide cleaners, solvents, coatings, finishes, physical barriers, door threshold protectors, and other measures required to protect installed HEMP protection subsystem materials, components, and equipment from corrosion, damage, or degradation during the fabrication and installation phase.

3.2.6 Manufacturer's Services

As required, services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified must be provided. The representative must supervise the installation, adjustment, and testing of the equipment.

3.2.7 Posting Framed Instructions

Framed instructions containing wiring and control diagrams under glass or in laminated plastic must be posted for the shielded doors. Condensed operating instructions, prepared in typed form, must be framed as specified above and posted beside the diagrams before acceptance testing of the system.

3.2.8 Miscellaneous Shielding Penetration Installation

HEMP shield penetrations, other than those listed in the penetration schedule on the approved shop drawings, must not be made without the prior written approval of the Contracting Officer.

3.3 ENCLOSURE INSTALLATION - WELDED STEEL CONSTRUCTION

****

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 paragraph ENCLOSURE INSTALLATION - BOLTED CONSTRUCTION

****

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, are not 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

****
NOTE: Steel plates exposed to sunlight and changing environmental conditions increase warpage and buckling.
****

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, drive pins, embeds or anchor bolts must not penetrate the steel plate used to make the shield.. 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 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 is not 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 or butt-joint with a continuous solid weld. After testing, the Contracting Officer will inspect and approve the installation prior to covering by other trades. Refer to AISC 325 for further information regarding structural support of HEMP Shield.

3.3.4 Wall Shielding Attachment

****
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.
****

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.

3.3.5 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.

3.3.6 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. Welding of door framing must not deform or warp door frame or degrade electromagnetic shielding properties of RF seal.

3.4 LINE FILTERS

Provide filters for incoming electrical power lines[, including neutrals,] and for incoming telephone and signal lines. Support filters independently of the shielding.

3.5 CONDUCTOR INSTALLATION

Provide filtered conductors in conduit, except for coaxial cables, from filter to shielding and penetrate the enclosure through threaded rigid steel conduits.[Twist conductors leading from the filters and conductors inside the shielded enclosure approximately 10 turns per foot in the conduit.]

3.6 GROUNDING

****

NOTE: If not specified in Division 26, "Electrical," the following sentence must be added: "Wires inside the enclosure and for a distance of at least 15 meters 50 feet outside of the enclosure shall be enclosed in a grounded, threaded rigid steel conduit system."

****

Extend the grounding stud through and[bolt][weld] it to the electrical power panel with a minimum No. 4 AWG insulated stranded copper conductor to effectively serve as a single grounding point for the completely assembled shielded enclosure, both internally and externally.

3.7 WAVEGUIDE-TYPE AIR VENTS

[Provide each inlet and return air duct with the number and size of waveguide-type air vents at each location where the ducts enter the shielded enclosure.][As a minimum, provide each enclosure with one 300 mm 12 inch square and one 300 mm 12 inch square return waveguide-type air vent.]

3.8 WAVEGUIDE INSTALLATION

Penetrations of the HEMP shield must be treated with the appropriate waveguide method. Waveguides must be suitable for piping and for fluids or gases contained within, in accordance with specified requirements.

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.

3.9 SHIELDING PENETRATION INSTALLATION

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

3.10 INSTALLATION OF HEMP SHIELD TEST PENETRATION PANELS

3.10.1 Test Penetration Panel Quality Control

The quality control program for installation of shield test panels must include in-progress primary shield weld inspections and tests of connector-to-penetration plate, WBC-to-penetration plate, and penetration plate-to-HEMP shield closures. It must also include preliminary shielding effectiveness testing and shielding effectiveness acceptance testing.

Results of the quality control inspections and tests on the installations of shield test panels must be reported to the Contracting Officer in the Daily HEMP QC Reports.

3.11 GROUNDING

****

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

****

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, MIL-STD-188-124, and MIL-HDBK-419. For additional facility grounding requirements, see Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.12 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.

3.13 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].

3.13.1 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.

3.13.1.1 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.

3.13.1.2 Test Reports

****

NOTE: Specifications [and][or] quality assurance test results of this paragraph may be classified for some projects. Provide appropriate instructions when this occurs. SE and CWI testing will require authorization from either the FCC or the military spectrum management office. Testing should not begin before proper authorization is obtained. Contractors can apply to the FCC for authorization and must also coordinate with the military spectrum management office after receipt of the FCC authorization. Authorization through military spectrum management is completed through the NTIA and can take a very long time to acquire.

****

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 (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.

Provide copies of the raw acquired data directly from the recording instrument as well as the processed data in engineering units to show compliance.

Describe any processing of the data so that it is understandable by others at a later date.

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

Number of Copies of the Report:

[Three][_____] copies.

3.13.2 Field Testing

****

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.
****

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.

3.13.2.1 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.

3.13.2.2 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. Perform 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.

3.13.2.3 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.

3.13.3 Weld Inspection

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

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.

3.13.4 Shielded Enclosure Leak Detection System (SELDS) Testing

****
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 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 feet in length. The surface area of the shield determines 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 feet. 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.

3.13.5 EM Shielding Effectiveness Testing

Provide a Shielding Effectiveness Acceptance Test Plan to the Contracting Officer prior to starting lprocurement. Factory test results must be documented in an Shielding Effectiveness Acceptance Test Report and submitted to the Contracting Officer. The test WBC assembly must be furnished on the project. 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.

3.13.5.1 Test Procedure

Provide test procedure and equipment according 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 feet 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 foot away from the enclosure wall and with the receiving antenna set 300 mm 1 foot from the wall for stationary measurements and 50 to 600 mm 2 inch to 2 feet 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 each of 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)
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.	

3.13.5.2 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.

3.13.5.3 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.

3.13.5.4 Test Frequencies

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

Testing frequencies for shielded enclosures are as follows:

MIL-STD-188-125-1 frequencies are as follows:	
Magnetic	[_____]
Plane wave	[_____]

3.13.6 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.

3.14 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.

-- End of Section --