SAMPLE RF-SHIELD DOOR SPECIFICATION

FOREWORD TO THE GUIDE SPECIFICATION PACKAGE

This report presents guide specifications for HEMP/TEMPEST protection of three large classes of penetrations:

- Shield doors and frames
- Filter/electrical surge arrester (ESA) assemblies
- Other shield penetrations, including waveguides and piping

Each sample specification is an independent document. For convenience, these specifications are collected under one cover. The guide specifications have been generated for Headquarters, Electronic Security Command/LEEEC, Kelly Air Force Base, San Antonio, Texas, under contract F41621-86-D-7003.

SAMPLE ELECTRICAL FILTER/ESA ASSEMBLY SPECIFICATION

SAMPLE POWER, SIGNAL, FIBER OPTIC, VENTILATION DUCTS, AND PIPING PENETRATION PROTECTION SPECIFICATION

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS ELECTRONIC SECURITY COMMAND
SAN ANTONIO TX 78243-5000

REPLY TO ATTN OF: LEEEC (MR EDWARDS)

1 Jul 88

SUBJECT: Guide Specifications for HEMP/TEMPEST Shield Doors, Electrical Filter/ESA Assemblies, and Other Shield Penetrations

TO: See Distribution List

1. These guide specifications were prepared in response to suggestions and requests for more detailed information by Air Force design engineers. Prior to this we had been releasing much of this information piecemeal, mostly by telephone. The information in this booklet is intended to complement that which is contained in the USAF Handbook for the Design and Construction of HEMP/TEMPEST Shielded Facilities (Jul 88).

2. Several manufacturers of the equipment covered in these specifications were consulted to ascertain that the specified quality and durability of these materials is readily obtainable. This type of information was included along with other experience factors and HEMP/TEMPEST engineering data to produce this guide specification. We do not expect this guide to be all inclusive or to be used in its entirety, but if it contains a small portion which may be useful to you, we have succeeded in this effort.

3. Again, we invite your comments and assistance in updating our thinking and this guide specification for the benefit of others.

John I. Cardenas

JOHN I. CARDENAS
Chief, Advanced Systems Branch
Dir, Engineering and Services
DCS/Logistics and Engineering

AFB
MR. EDWARDS

2 Atch
1. Distribution List
2. Guide Specifications

"Freedom Through Vigilance"

DISTRIBUTION LIST
June 1988

Number of copies	Addressee
1	1842 EEG/EEISG Scott AFB, IL 62225-6348 Attn: Mr. John Zych Lt. Steve Smith
3	HQ AAC/DEME Elmendorf AFB, AK 99506 Attn: Mr. Lee Slick
1	HQ AFCC/DEO Scott AFB, IL 62225-5001 Attn: Mr. Paul Cardinal
1	AFCC/AITI Scott AFB, IL 62225-5001 Attn: Mr. McKinnon
1	AFCSC/SRV San Antonio, TX 78243-5000 Attn: Mr. R. C. Salas
1	HQ AFESC/DEM Tyndall AFB, FL 32403-6001 Attn: Mr. Dave Conkling
1	AFIT/DET Wright-Patterson AFB, OH 45433-5001 Attn: Capt. Jorge Monserrate
2	HQ AFLC/DEE/DEM/SIQ Wright-Patterson AFB, OH 45433-5001 Attn: Mr. Richard A. Winters Mr. Stan Blum Mr. Joseph Colarusso
1	AFRCE-BMS/DEES Norton AFB, CA 92409 Attn: Mr. Robert Smith
1	AFRCE-SAC Offutt AFB, NE 68113-5000 Attn: Mr. Dale Ogden
2	HQ AFRES/DEE/DEM Robins AFB, GA 31098 Attn: Mr. Dennis C. Radunzel Mr. Hugh Maddox
1	AFWL/NTCA Kirtland AFB, NM 87117-6008 Attn: Mr. John Frisbie
1	ANGSC/DEE Andrews AFB, DC 20331 Attn: Mr. Fred MacDonald
2	ASD/DED Wright-Patterson AFB, OH 45433 Attn: Mr. Joseph Haines Mr. Robert Randall
2	HQ ATC/DEM/DEE Randolph AFB, TX 78150 Attn: Mr. Jim Magee Mr. A. G. Pinson
1	HQ AU/DEED Maxwell AFB, AL 36112 Attn: Mr. Michael Allen
*(X)	HQ ESC/LEEEC San Antonio, TX 78243-5000 Attn: Mr. John Cardenas Mr. Tom Klein
1	ESD/DEE Hanscom AFB, MA 01731 Attn: Mr. Charles Wire
2	AF/LEECC Washington, DC 20330-5130 Attn: Mr. Fred Esposito
*(X)	AF/LEEEU/LEEES Bolling AFB, DC 20331-5000 Attn: Mr. R. S. Fernandez
1	AF/LEEPR Washington, DC 20330-5130 Attn: Capt. Larry Brittenham
2	HQ AFSC/DEE Andrews AFB, MD 20334 Attn: Mr. Jerry Lohsl
1	AFSC/XTW Andrews AFB, MD 20334 Attn: Col. Torgler
2	HQ AFSPACECOM/DEPR/DEES Peterson AFB, CO 80914-5001 Attn: Mr. Phil Montoya Mr. George Morkovin
2	HQ USAF/RDQM, Pentagon Washington, DC 20332-5040 Attn: Lt. Col. Bill Beekman

*(X) Extra copies

DISTRIBUTION LIST
June 1988

Number of copies	Addressee
2	DIRNSA (Y344) 9800 Savage Road Ft. Mead, MD 20755 Attn: Mr. Jack A. Mehok
2	HQ SAC/DEMU Offutt AFB, NE 68113 Attn: Mr. Robert Jay
1	SD/DEE P.O. Box 92960 Worldway Postal Center Los Angeles, CA 90009 Attn: Mr. Pete Campbell
1	USAF/SCTT Washington, DC 20330-5190 Attn: Maj. Ed Broestl
2	USAF RGN CIVIL ENGR/CR 1114 Commerce Street, Room 207 Dallas, TX 75242 Attn: Mr. Cleo Walton
1	USAF RGN CIVIL ENGR/ER 526 Title Building 30 Pryor Street, SW. Atlanta, GA 30303 Attn: Mr. Gary Lowe
1	U. S. Army Harry Diamond Laboratories SLCHD-NW-EC 2800 Powder Mill Road Adelphi, MD 20783-1197 Attn: Mr. R. J. Reyzer
2	HQ MAC/DEE/DEM Scott AFB, IL 62225-5001 Attn: Mr. Sam Sivewright
1	HQ PACAF/DEE Hickam AFB, HI 96853 Attn: Mr. Raymond Ching
1	AF/INSC, Pentagon BD951 Washington DC 20330-5110 Attn: Mr. Steven D. Fager
2	AF/LEEES Bolling AFB, DC 20332-5000 Attn: Mr. Satish Abrol
2	DNA/RAEE 6801 Telegraph Road Alexandria, VA 22310-3398 Attn: Maj. Mel Hoke

Number of copies	Addressee
2	NAVAL FACILITIES ENGINEER COMMAND 200 Stovall Street Hof II Room 12N51, Code 04T5 Alexandria, VA 22332 Attn: Mr. G. Anthony Brown
2	HQ TAC/DEE/DEM Langley AFB, VA 23665-5001 Attn: Mr. Steven Coleman-White Mr. Cal Poole
2	USAF RGN CIVIL ENGR/WR 630 Sansome Street, Room 1316 San Francisco, CA 94111 Attn: Mr. Nick DiMario
2	U. S. Army Engineering Division USAEDH-ED-FD P. O. Box 1600 Huntsville, AL 35807 Attn: Mr. Rich Sevigny
1	HQ USAFE/DEE APO New York 09012 Attn: Mr. Romel Madlangbayan
1	HQ USAFE/DER APO New York 09241 Attn: Mr. Donald L. Castamore
2	NESSEC - DIV 220 3801 Nebraska Avenue, NW. Washington, DC 20390 Attn: Mr. Earl Jamison Ms. Ann Rideout
1	HQ USA ISC DCS Plans, AS-PLN-SE Fort Huachuca, AZ 85613-5000 Attn: Mr. Pat Connell
1	DAEN-ECE-E Pulaski Building 20 Mass Ave, NW. Washington, DC 20314-1000 Attn: Mr. Les Horvath
1	Construction Engineering Research Laboratory (CERL) P. O. Box 4005 Champaign, IL 61820 Attn: Mr. Ray McCormack
1	AEDC/DEE Arnold AFB, TN 37389 Attn: Capt. Dennis Greer

DISTRIBUTION LIST
June 1988

Number of copies	Addressee
1	SAF/AQQS Pentagon Building, Room 5D543 Washington, DC 20330-5040 Attn: Lt. Col. Kee
1	Defense Communications Agency Washington, DC 20305-2000 Attn: Mr. Wheeler Hatch (Code B220)
1	Naval Civil Engineering Lab (Code L72) Port Hueneme, CA 93043 Attn: Mr. James Brooks
1	FESA-PREP Building 358 Ft. Belvoir, VA 22060-5516 Attn: Dr. Harold D. Hollis
1	Defense Communications Engineering Center (DCEC) 1860 Wiehle Avenue Reston, VA 22090 Attn: Mr. Mike Hanz (Code R620)
1	USAF Academy/DEE, Building 8120 Colorado Springs, CO 80804 Attn: Mr. Ken Walters
1	AFFTC/DEEE Edwards AFB, CA 93523 Attn: Mr. Ron Smoldt

DISTRIBUTION LIST
(Other Government Offices)
June 1988

Number of copies	Addressee
1	U. S. Army Corps of Engineers P. O. Box 1580 Albuquerque, NM 87103 Attn: Ms. Gene McGinn
1	U. S. Army Corps of Engineers Louisville District/ORLED-M 600 Federal Place, Room 667 Louisville, KY 40201 Attn: Mr. Whittle
2	U. S. Army Corps of Engineers Omaha District/MROED-ST 215N 17th Street Omaha, NE 68102 Attn: Mr. Tom Smith
1	Navy Space Command Code N40 Dahlgren, VA 22448 Attn: Lt. Cmdr. Elsbernd
1	1606 CES/DEE Kirtland AFB, NM 87117 Attn:
1	31 CSG/DEEE Homestead AFB, FL 33039 Attn: Mr. Diac
2	HQ ESD/SCC-6 Pave Paws Program Office Hanscom AFB, MA 01731-5000 Attn: Mr. Tom Pucci
1	HQ EID/EISS Tinker AFB, OK 73145-6343 Attn: Mr. Olivas
1	HQ AFSC/DLWW Andrews AFB, MD 20334-5000 Attn: Maj. Clark
1	U. S. Army Corps of Engineers Sacramento District/SPKED-M 650 Capitol Mall Sacramento, CA 95814 Attn: Mr. Jim Nightingale
1	U. S. Army Corps of Engineers 803 Front Street Norfolk, VA 23510-1096 Attn: Mr. Ross Underwood or Mr. Mike Richardson

Number of copies	Addressee
1	U. S. Army Corps of Engineers Seattle District P. O. Box C-3755 Seattle, WA 98124 Attn: Mr. Bob Daniel
1	Naval Facilities Engineering Western Division P. O. Box 727 San Bruno, CA 94066
1	832 CSG/DEEVM Luke AFB, AZ 85309-5045 Attn: Mr. Mousel
1	HQ USAF/SCMO P. O. Box 46024 Pentagon Washington, DC 20330 Attn: Mr. White
1	485th EIG EPG AFCC GLCM PMO Griffiss AFB, NY 13441 Attn: Mr. Tom Maher
1	U. S. Army Corps of Engineers 20 Massachusetts Avenue, NW. Washington, DC 20314-1000 Attn: DAEN-ECR
1	2750 ABW/DEEE Wright-Patterson AFB, OH 45433 Attn: Mr. Kolovrat

DISTRIBUT ON LIST
(Contractors)
June 988

Number of copies	Addressee
1	William Tao & Assoc. 2357 59th Street St. Louis, MO 63110 Attn: Mr. Schroer
1	Northwest Architectural Company West 1203 Riverside Avenue Spokane, WA 99201 Attn: Mr. Bruce Blackmer
1	TRW, Suite 200 2340 Alamo, SE. Albuquerque, NM 87106 Attn: Mr. Rob Zeitler
1	Horizon Technology, Inc. Hartwell Avenue Lexington, MA 02173-3127 Attn: Mr. James Lee
1	Science and Engineering Assoc. P. O. Box 3722 Albuquerque, NM 87190 Attn: Mr. Bill Brummer
1	Electro Magnetic Applications, Inc. 1025 Hermosa Drive, SE. Albuquerque, NM 87108 Attn: Dr. Dave Merewether
1	Lectro Magnetics, Inc. 6056 West Jefferson Blvd. Los Angeles, CA 90016 Attn: Mr. Fred Nichols
1	Gordan-Prill 1485 Bay Shore Blvd. San Francisco, CA 94124 Attn: Mr. Satre

Number of copies	Addressee
1	Fil-Coil Company, Inc. 800 Axinn Avenue Garden City, NY 11530 Attn: Mr. Fergason
1	TRW Defense Support Division 5203 Leesburg Pike Falls Church, VA 22041 Attn: Mr. D. DeLoziner
1	Stottler Stagg & Assoc. 5200-A Philadelphia Way Washington Business Park Lanham, MD 20706 Attn: Mr. Kazmierczak
1	Kaman Sciences Corp. South Bay Center Suite 410, 1515W 190th Street Gardena, CA 90248 Attn: Mr. Lowell
1	Harris Corp. Govt. Comm. Sys. Div. 301 Washington Street Bellevue, NE 68005 Attn: Mr. Jack Lamb
1	Keene Corp. Ray Proof Division 50 Keeler Avenue Norwalk, CT 06856-5060 Attn:
1	Axel Electronics, Inc. 134-20 Jamaica Avenue Jamaica, NY 11418 Attn: Mr. Joe Alaimo

November 1987
Revision 1, June 1988

GUIDE SPECIFICATIONS FOR HEMP/TEMPEST SHIELD DOORS, ELECTRICAL FILTER/ESA ASSEMBLIES, AND OTHER SHIELD PENETRATIONS

L. David Wellems
Richard H. St. John
Paul R. Trybus

Prepared for:
Department of the Air Force
HQ, Electronic Security Command/LEEEC
Building 2000
San Antonio, TX 78243-5000

Contract F41621-86-D-7003
Task Order ESC/DE-87-002

Prepared by:
Mission Research Corporation
1720 Randolph Road, SE.
Albquerque, NM 87106-4252

SAMPLE RF-SHIELD DOOR SPECIFICATION

FOREWORD TO THE GUIDE SPECIFICATION PACKAGE

This report presents guide specifications for HEMP/TEMPEST protection of three large classes of penetrations:

- Shield doors and frames
- Filter/electrical surge arrester (ESA) assemblies
- Other shield penetrations, including waveguides and piping

Each sample specification is an independent document. For convenience, these specifications are collected under one cover. The guide specifications have been generated for Headquarters, Electronic Security Command/LEEEC, Kelly Air Force Base, San Antonio, Texas, under contract F41621-86-D-7003.

SAMPLE RF-SHIELD DOOR SPECIFICATION

CONTENTS

FOREWORD

This sample specification addresses the performance and quality assurance requirements for doors used in RF shield rooms. It examines principally the 100 dB (nominal) requirements for high-altitude electromagnetic pulse (HEMP)/TEMPEST shielding of the room and door; these are addressed since they are more stringent than others and are commonly required in many installations. The following comments and specification can be applied, however, to any shielding requirement.

It has been seen in practice that the shielding effectiveness of all doors declines with use and age, regardless of type of door and manufacturer. This decay can be reversed only with a program of effective maintenance. Here, a problem with maintenance and the writing of specifications arises: one cannot require maintenance in the specification since maintenance is really in the domain of the user, not the manufacturer. Thus, it is probably not possible to write a specification for a door that will last for several years only on the basis of manufacturing requirements. It is, however, possible to specify construction techniques and procedures which will enhance the longevity of the door regardless of the maintenance provided after installation.

The leakage associated with unflawed shielding is related to the skin depth or diffusion of the electromagnetic energy into the shielding material. For the thickness of steel or copper commonly used in shield rooms, the diffusion leakage is far less than any current specification. Thus, the electromagnetic leakage of a "perfect" door is much less than that obtained with a real door. This results from the impedance across a seam of a real door being much larger than that across an unseamed section of door or shield room material. This localized flaw in the shield allows a voltage differential to form across the seam when currents flow on the exterior or interior surfaces. This voltage differential then radiates electromagnetic energy to both the interior and exterior of the room allowing energy or information to pass through the shield room barrier.

The doors used for RF shielding attempt to minimize this by creating a low-impedance path across the door aperture when closed. This is accomplished by effectively connecting the periphery of the door material to the opening of the shield room in a fashion such that little voltage differential is created when a current flows over the seam. The creation and maintenance of the mechanical and electrical properties of the low-impedance seam is crucial to the satisfactory operation of the door.

The seams in doors require close mechanical tolerances for proper operation. Misalignment above several hundredths of a centimeter will change contact points and pressures and result in a change in the impedance. This forces mechanical requirements on doors to reduce flexure and wear to values below those seriously affecting the seam impedances.

The requirements on the electrical nature of the contact points between the door and the shelter walls are also stringent: with use of the door, the contact resistance between the door and shield room materials must not increase above values of a few milliohm-meters. This value must be maintained over time and in corrosive environments.

The approaches taken by manufacturers to build doors with the required elements are varied, but fall into two general categories: knife-edge type and flat-surface type.

Most manufacturers make the knife-edge type door (Fig. 1). On this door, a moving knife edge is forced between two rows of contact fingers to create a low-impedance path for the surface currents. Variations on this type are minor and are limited to the number of knife edges, the manner in which the contact fingers are fastened, the type of material on the mating surfaces, and trading the knife-edge and contact-finger locations between the door and the shield-room surfaces.

The flat-surface type of door employs pressure to force two conducting surfaces against each other to create the low-impedance connection. It

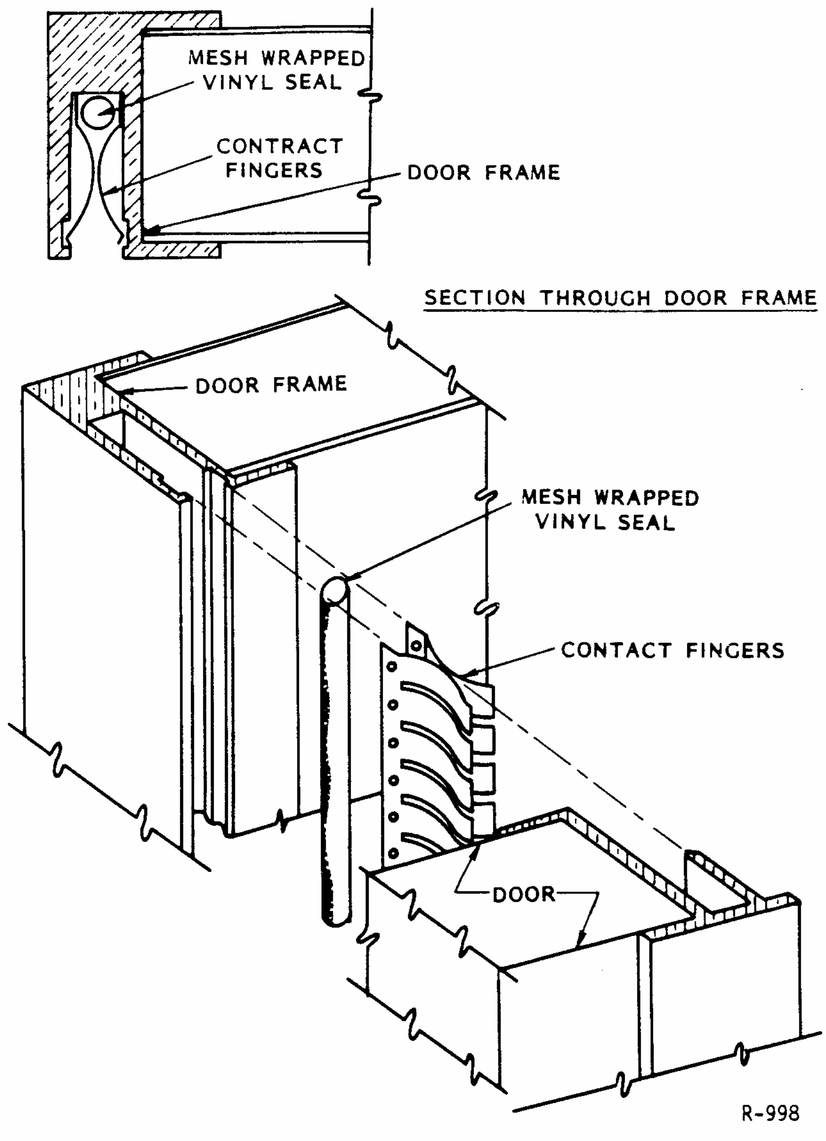


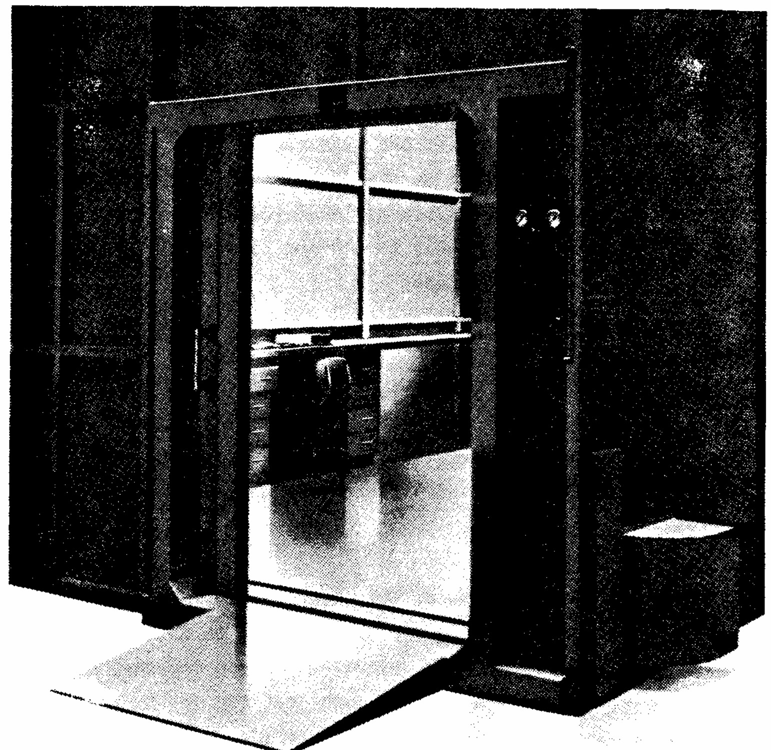
Figure 1. Typical knife-edge mechanism (Keene Corp., RayProof Division).

can be seen that one or both of the surfaces must be flexible to allow electrical continuity over the entire surface. The variations on this type of door (Fig. 2) are in the manner in which the surfaces flex: one type (hinge) uses the same type of flexible material as that used in the contact fingers of knife-edge type doors as one of the surfaces; the other type (sliding) uses a thick (10-12 mils), malleable coating on two rigid surfaces which allows the two surfaces to conform to each other and the low-impedance connection to be made.

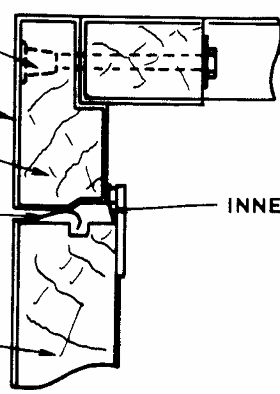
The first example of a flat-surface door rotates on hinges and, while closing, forces the contact fingers against the flat surface of the frame. The second example of this door type is a sliding door containing a bladder. After the door is moved into the closed position, the bladder is expanded using compressed air which forces the door panels against the door frame.

Immediately after manufacture, most doors perform reasonably well. After use, however, most doors do not work as well as when they were first installed. This is due to a deterioration and increase of the seam impedances. It cannot be stressed too much that the key to the longevity of the shielding ability of the door is maintenance. Because of the critical nature of the electrical contact requirements, the mating surfaces must remain in a state close to that present during the manufacture of the door. Both the material of the mating surfaces and their alignment must be maintained.

In knife-edge doors, the mechanical alignment can generally be maintained through proper manufacture and a lack of trauma to the door after it has been installed; no maintenance to the mechanical alignment is necessary unless the door is damaged. Proper manufacture of the door as far as alignment is concerned is the use of sealed, high-quality bearings at all points possible and the use of door and jam materials that will not sag, warp, or change dimensions appreciably.



(a) Sliding (Lectromagnetics, Inc.).



(b) Hinge (Lindgren RF Enclosures).

R-998

Figure 2. Flat-surface type doors.

The electrical contact of the surfaces is a different matter: regular cleaning and contact-finger (if present) replacement are required. The contact fingers should be replaced if any sections are missing or broken and should be replaced periodically regardless of apparent condition. The knife edge or flat surfaces should also be cleaned periodically and the door or knife edge replaced if the knife edge or flat surface is damaged (generally, the knife edge is not easily replaced or repaired).

Furthermore, replacing the contact fingers is necessary to maintain the low-impedance seal formed by the door and frame. There is a tradeoff between ease of replacement and having the fingers pull loose with regular use. A cross-section of the door and contact fingers should show some sort of positive locking action to hold the contact fingers in place; the use of friction is generally not sufficient to prevent the contact fingers from being pulled loose inadvertently.

All manufacturers recommend preventive maintenance for their doors. However, the types of cleaning materials and procedures recommended by them vary. The use of acetone or other solvent for grease and debris buildup, an abrasive pad for polishing, and finishing with a spray lubricant is common. More exotic cleaning materials such as antioxidation compounds and metal preservatives are also recommended by some manufacturers to enhance the conductivity between the mating surfaces. It seems reasonable that these compounds would be helpful in maintaining the contact surfaces, but an unbiased study has not been done. The recommended use of a spray lubricant after cleaning also varies between manufacturers: some recommend no spray, some a nonconducting spray lubricant, while others suggest one that is conducting.

The installation procedure used for the door also affects its electromagnetic performance. Because the mechanical alignment is so critical, the door must be treated gently during installation. Improper bolting or welding technique for the installation of the door frame to the walls may warp the frame and lead to misalignment with the door contacts.

Shield doors are generally delivered to the construction site fastened to the door frame. This preconstruction is necessary because of the close tolerances required between the contact surfaces. If the construction of the building requires the removal of the door from its frame for any reason, the shielding capability of the door may be permanently compromised due to the difficulty of realigning the door properly with the frame during the reinstallation.

During construction of the site, the exposure of the door to dust, debris, and shock must be minimized. The presence of these materials on the contact surfaces increases the seam impedance and lowers the shielding performance of the door. Shock resulting from opening or closing the door too firmly or collision with construction equipment will also degrade the door performance.

The requirement to verify the electromagnetic performance of the door and the shield room before the interior and exterior are finished is related to this problem. The room and door are completed and tested and then exposed to further construction activity which frequently leads to a deterioration of the shielding ability of the door.

The environment of the door after installation also affects both its electromagnetic performance and the optimal maintenance schedule. Because the manufacturer generally has no knowledge of the door's environment after installation, the recommended maintenance schedule will not be optimal. Any door exposed to a corrosive atmosphere will not function properly for long due to an increase in the contact impedances; this should be avoided if at all possible.

A general rule is that a door which is exposed to outside weather will not maintain its shielding ability as long as one which is protected in an interior room. Thus, for any external door, either the maintenance schedule must be accelerated or the door must be protected by a vestibule and an external, weather-proof door; the vestibule area should have a temperature- and humidity-controlled environment for maximum effectiveness. The second approach is preferable since it is a one-time expense and will considerably enhance the longevity of the shield-room door, even in the absence of proper maintenance.

The air flow between the interior and exterior of the building which occurs through the door should be minimized to avoid the buildup of dust on the contact fingers and flat surfaces. The problem may be minimized by requiring air-tight gaskets on the door surfaces or the presence of honeycomb vents near or in the doors to carry the bulk of the air. Between these choices, the gaskets would probably be more effective since, in the second case, some air would still tend to flow through the door spacing.

The key to the longevity of the electromagnetic shielding ability of the door is proper construction and maintenance. The construction of the door can be specified; the maintenance, however, cannot. Thus, any maintenance-related items which can be specified, should be. These include maintenance kits with cleaning procedures, materials, and inducements. The procedures should be explicit and easy to understand and, as an inducement for maintenance, be positioned near the door where it may be seen each time the door is used. The specified cleaning materials should be practical to use and effective. Any further specified inducements for maintenance, such as cycle counters, timers, etc., would be useful because of the importance of maintenance. Since maintenance is voluntary on the part of the user, however, any scheme must appeal to human nature in order to be effective.

SAMPLE RF-SHIELD DOOR SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
1.0 GENERAL	
1.1 Purpose--This section specifies the design, construction, installation, testing, and quality assurance related to the electromagnetic performance of RF-shield doors to meet the HEMP/TEMPEST requirements. Other criteria related to the submittals and components specified herein appear in other sections of this document, as follows:	Delete HEMP or TEMPEST if only one of these requirements apply.
• Section ____: General Requirements for Contractor Submittals • Section ____: Shielding and Penetration Protection Subsystem • Section ____: General Mechanical Requirements • Section ____: General Electrical Requirements	The other sections listed are for illustrative purposes only. Appropriate entries should be made for each project.
1.2 Scope--This specification defines requirements for the design, construction, performance, inspection, test, and acceptance of RF-shield doors.	
1.3 Shield Door Specialists--All work under this section shall be performed by a "shield door specialist". A shield door specialist shall have successfully completed at least five (5) similar shield door projects of comparable size in the last ten (10) years. A "shielding quality assurance specialist," to perform or observe the required testing, shall have performed the quality assurance program for at least five (5) similar programs over the last ten (10) years. The government reserves the right to approve the specialist, based upon information and references provided under paragraph 3.1.	This paragraph might be construed as a limitation on competition and should be used with discretion. Many companies may make good products and not be competitive under these limitations. This permits the government to be selective of contractors and to disallow those with past unsatisfactory performance.

2.0 APPLICABLE DOCUMENTS

The publications listed below form a part of this specification to the extent specified. In the event of a conflict between a referenced document and this specification, the specification shall take precedence.

Other ASTM and AWS standards for the specified construction materials and processes should be added as required. If specifications and/or QC test data are classified, the classification guide should also be referenced.

2.1 Federal Specification (Fed. Spec.)

QQ-C-533B	Copper-Beryllium Alloy Strip
QQ-S-571	Solder
QQ-S-775A	Steel, Sheets Carbon, Zinc Coated

Materials specifications should only be required on materials needed, e.g., solder is not used on some flat-type doors.

2.2 Military Specification (Mil. Spec.)

MIL-T-10727	Tin Plating, General Specifications for

2.3 Military Standards (Mil. Std.)

MIL-STD-285	Attenuation Measurements for Enclosures, Electromagnetic Shielding, for Electronic Test Purposes, Measurement of
MIL-STD-248B	Qualification Test for Welders

2.4 National Security Agency

(Applicable TEMPEST documents)

2.5 American Society for Testing and Materials (ASTM) Standards

A36-84a	Structural Steel
A366-72 (R 1979)	Steel, Carbon, Cold-Rolled Sheet, Commercial Quality
A569-72	Steel, Carbon (0.15 Maximum Percent), Hot-Rolled Sheet and Strip, Commercial Quality

2.6 American Welding Society (AWS) Standards

A5.18-79	Carbon Steel Filler Metals for Gas Shielded Air Welding, Specificaton For
B1.0-77	Nondestructive Inspection of Welds, Guide For
B2.1-84	Welding Procedures and Performance Qualification
D1.1-84	Structural Welding Code, Steel

2.7 USAF Handbook for the Design and Construction of HEMP/TEMPEST Shielded Facilities (Revised, July 1988)

3.0 SUBMITTALS

The contractor shall submit data identified in paragraphs 3.1 through 3.8.

3.1 Shield Door or Shielding Quality Assurance Specialist's Credentials--The contractor shall submit identification and credentials of the shield door specialist and shielding quality assurance specialist, establishing evidence of the experience required by paragraph 1.3. The contracting agency, contract number, and contracting officer shall be identified on those projects submitted in fulfillment of the experience requirement.

3.2 Materials Certification--Certificates attesting that the materials used in the RF-shield door fabrication meet the specified requirements of paragraph 4.3 shall be submitted to the Contracting Officer. If requested, samples of the material shall also be provided.

3.3 Shop Drawings--Shop and as-built drawings shall be submitted for approval to the Contracting Officer as required by paragraph 4.4. All deviations from the project drawings shall be explicitly identified. The drawings shall provide a complete list of materials. They shall identify arrangements, thicknesses, sizes of parts, construction fastenings, clearances, assembly, and erection details. Shop drawings shall include connection to work of other trades and provide a catalog for all manufactured items: hinges, bearings, gaskets, seals, etc. Approved shop drawings are required before fabrication can begin.

3.4 Welder Qualification Plan and Qualification Certificates--Detailed procedures used for qualification of welders, as required by paragraph 4.6, and qualification certificates of personnel approved to perform welding of the door frame to the shield-room walls shall be submitted to the Contracting Officer.

Welding or other fastening of the door frame to the structure should be done in accordance with the manufacturer's instructions.

3.5 Quality Assurance Plans--The contractor's plan for in-progress testing of welds and RF-shield door performance and the final acceptance testing shall be submitted to the Contracting Officer for approval before the start of door installation.

To minimize schedule delays, the procuring agency may explicitly authorize some detailed test procedures (those not immediately needed)

The plan shall establish the general framework of the quality assurance program and shall contain the detailed test procedures as appendices. The detailed procedures shall identify the system configuration for testing, the instrumentation to be used, the data requirements, test-point locations, and measurement and calibration procedures.

Note: to be submitted at a later date.

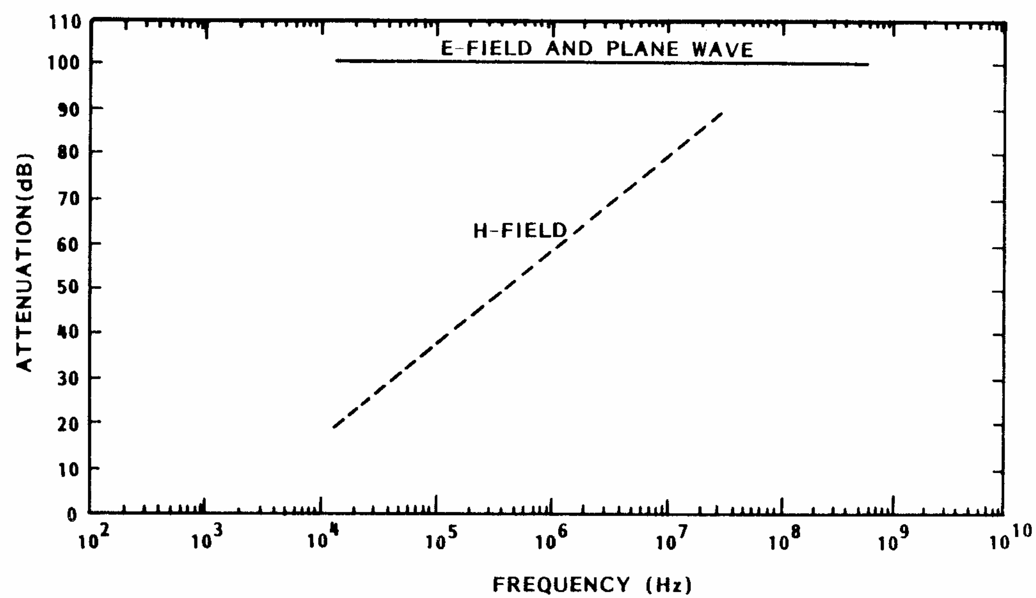
3.6 Test Reports--Test reports, certified by a licensed engineer, and copies of all original data, shall be submitted to the Contracting Officer. Any deviations from the test procedures submitted in paragraph 3.5 shall be discussed. Success or failure of the component to satisfy the criteria shall be clearly stated and proposed resolutions of unacceptable performance shall be presented. It is emphasized that test data, where required, shall be for the RF-shield door actually installed. Test results on model prototypes or standard products will not be acceptable.

Note: Specifications and/or QC test results may be classified for some projects. Provide appropriate instructions when this occurs.

3.7 Maintenance Procedures--Procedures to preserve the performance of the RF-shield door and to maintain the manufacturer's warranty shall be submitted to the Contracting Officer along with the shop drawings required under paragraph 3.3. Revisions of the maintenance plan, if required by as-built conditions, shall be submitted prior to the performance of the final shield acceptance test.

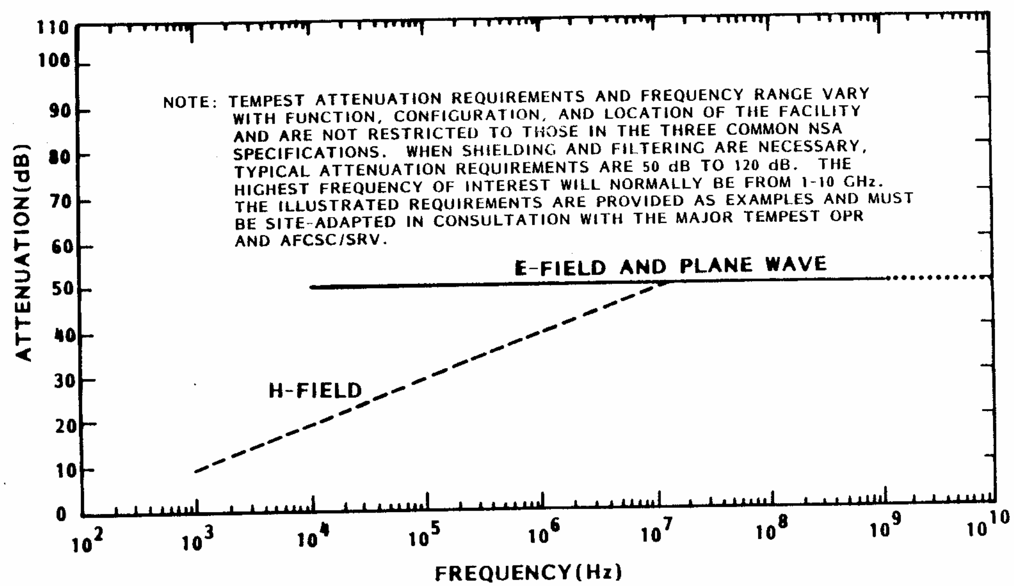
3.8 Installation Procedures--Procedures to install and protect the RF-shield door in a manner to maintain the shielding capabilities measured by the vendor at the place of manufacture and to maintain the manufacturer's warranty shall be submitted to the Contracting Officer along with the shop drawings required under paragraph 3.3. The installation and protection instructions shall cover the expected conditions in transit and from crate arrival at the site to the final installation of equipment within the facility.

SAMPLE RF-SHIELD DOOR SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
4.0 GENERAL REQUIREMENTS All RF-shield doors are to be provided by a single supplier regularly engaged in the manufacture of these items. The assemblies shall be supplied complete with a rigid structural frame, hinges, latches, and all spare parts necessary for operation and maintenance as detailed in paragraph 5.7. The products shall duplicate assemblies that have been in satisfactory use for at least two (2) years. The exhibition of satisfactory use by previously installed assemblies shall be demonstrated by an independent testing agency.	
4.1 Electromagnetic Requirements--The RF-shield door shall provide a minimum shielding effectiveness of 10 dB greater than the requirements of Figure 3, where compliance shall be shown as in paragraph 7.1.5 for in-plant quality control. The RF-shield door shall provide a minimum shielding effectiveness of the requirements of Figure 3, where compliance shall be shown as in paragraph 5.8 for in-place acceptance testing.	The 10 dB excess is used to allow for degradation and compliance with this initial requirement must be shown in factory testing. Figure 3a illustrates the in-place requirements for high-confidence HEMP protection, while Figure 3b shows a possible TEMPEST-only specification. Figure 3c illustrates the combining of shielding effectiveness requirements for HEMP/TEMPEST applications. The in-place performance of the door is limited by shielding effectiveness of the remainder of the room.
4.2 Usage Requirements--The RF-shield door will be subject to continuous use. The door and its components shall be built to function properly through 50,000 cycles of usage.	The number of cycles over which the door is to perform should be chosen to match the expected lifetime of the installation and usage. 50,000 cycles is minimum for a permanent facility.



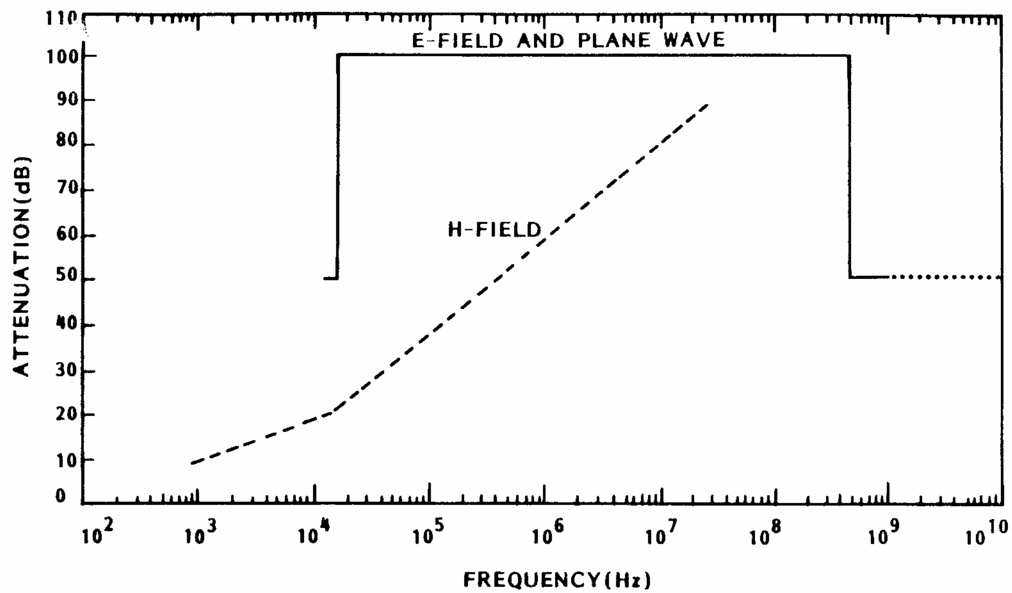
a. HEMP-only installations.

Figure 3. Shielding effectiveness requirements (use MIL-STD-285 test methods).



b. TEMPEST-only installations.

Figure 3. Shielding effectiveness requirements (use MIL-STD-285 test methods) (continued).



c. HEMP/TEMPEST installations.

Figure 3. Shielding effectiveness requirements (use MIL-STD-285 test methods) (concluded).

4.3 Materials--Steel elements used in the construction of the door shall comply with ASTM, AWS, and other standards as specified in the shop drawings. The contractor shall certify to the Contracting Officer that the materials meet these requirements. If requested by the Contracting Officer, samples of the materials shall be provided by the contractor.

4.4 Shop Drawings--Shop drawings of the RF-shield door with all details, materials, and erection data shall be submitted for approval to the Contracting Officer. The drawings shall indicate the materials, arrangements, thicknesses, sizes of parts, construction fastenings, clearances, assembly and erection details, welding procedures, and necessary interfaces to the work of other trades.

The contractor is permitted to make minor deviations from the drawings to improve performance or decrease cost. Such deviations shall be explicitly identified in the shop drawings and are subject to approval by the Contract Officer. Such approval, however, does not relieve the contractor of his obligation to conform to all performance specifications.

Upon completion of the project, all shop drawings shall be modified to show the "as-built" configuration and shall be resubmitted.

4.5 Welding--The door frame shall be fastened to the walls of the shield room by an RF-tight method. The metal-electrode, inert-gas (MIG) process or other government-approved method shall be used.

In modular rooms, the door frame will be fastened to the walls in the same fashion as the wall panels are connected to create the room. When welding is used to fasten the frame to the walls, extreme caution must be exercised to avoid warping or altering the frame

4.6 Welder Qualification--Personnel performing welding on the door frame shall be qualified in the specific procedures to be used in accordance with MIL-STD-2488, Qualification Test for Welders.

4.7 Delivery and Storage--RF-shield doors shall be packaged such that no physical or moisture damage shall occur during shipping. If special protection is required after installation, but before building completion, protection materials and instructions shall be provided by the door manufacturer.

dimensions. Any occurrence of this will seriously degrade the performance of the door. In the event that welding is required, the manufacturer's method should be followed.

Protection of the RF-shield door, frame, and contact surfaces is extremely important in maintaining the shielding performance through the post-installation construction phase. Any protection materials and plan submitted by the manufacturer should be scrutinized for practicality and effectiveness.

The list of manufacturers is not exhaustive. Manufacturers not on the list may make equal or superior products. All manufacturers on the list have made doors that perform well and all have made doors that do not perform well. The lack of performance can be traced to improper maintenance in some cases.

SAMPLE RF-SHIELD DOOR SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
5.0 DETAILED REQUIREMENTS	
5.1 Configuration--The RF-shield doors shall have a minimum clear opening of the size indicated on the drawings and listed in Table 1.	Here, Table 1 is an example for a typical installation. A table similar to this should be included with the specification. It should be altered to show the doors and geometry actually required.
5.1.1 The door frame shall be made of steel and shall be structurally rigid and suitable for welding to the surrounding structure and shield.	The frame should be made of materials similar to the remainder of the shield-room walls: if the construction is welded steel, the frame should withstand welding to the wall; if the construction is modular,

TABLE 1. RF-SHIELD DOOR SCHEDULE

Door Desig-nation	Clear Opening Size	Hardware	Hinge Side*	Additional Information
D-1 (door and equipment panel)	3 × 7 ft single leaf	Panic push bar exit device. No outside handle. Door open alarm.	Left	To be mounted in a 4 × 8 ft framed opening.
D-2	3 × 7 ft single leaf	Lever handle on both sides of door. Cypher lock. Interlock with door D-3.	Left	To be mounted in a 4 × 8 ft framed opening.
D-3	3 × 7 ft single leaf	Lever handle on both sides of door. Inter-lock with door D-2.	Left	To be mounted in a 4 × 8 ft framed opening.
D-7	3 × 7 ft single leaf	Lever handle on both sides. Pad lock with alarm if open.	Right	To be mounted in a 4 × 8 ft framed opening.
D-1 ICF	3 × 7 ft single leaf	Lever handle on both sides. Cypher lock. Interlock with D-2 ICF with alarm system.	Right	To be mounted in a 4 × 8 ft framed opening.
D-2 ICF	3 × 7 ft single leaf	Lever handle on both sides of door. Inter-lock with D-1 ICF.	Left	To be mounted in a 4 × 8 ft framed opening.

*As viewed from the "pull-open" side.

SAMPLE RF-SHIELD DOOR SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
	the frame should be fastened to the wall in a fashion similar to that used for connecting the wall panels together.
5.2 RF Seal--The RF-shield doors shall be supplied with a double row of RF contact fingers conforming to QQ-C-533, installed around the periphery of the door or frame. The closure seal shall utilize an extruded brass channel containing a recess into which two sets of beryllium copper contact fingers are fitted without the use of solder. The door shall mate to the frame in such a manner to insert a brass knife edge between the two rows of RF contact fingers so as to obtain the minimum impedance between the knife edge and contact fingers.	This example is written for the more-or-less standard knife-edge door; most manufacturers use the materials shown in the sample specification. If it is felt that a door with RF gaskets or other type is more appropriate, then it should be specified. One danger in specifying the door construction is a reduction in the development of innovative procedures by the manufacturer. To avoid this, the RF shield can be specified to meet only the RF-shielding specification and to be approved by the Contracting Officer. Obviously, with this requirement, the Contracting Officer's technical representative must be highly qualified to judge any new shielding approaches. Other door types which may be specified are the flat-surface types: one would specify either (1) two rows of alloy 510 grade A spring temper bronze contact finger strips in accordance with ASTM B103 (hinge) or

(2) 10-12 mil thick tin coating (MIL-T-10727) on rigid surfaces forced together with sufficient pressure to form a low-impedance seal (sliding).

The fastening of the contact fingers to the door or frame must be done in such a fashion that they can be replaced. A locking-catch method, bolting, and riveting are all acceptable if done so that the contact fingers do not fall out with normal use and can be replaced without an excessive effort.

5.3 Air Seal--The door shall be supplied with a gasket on the periphery of the door or frame which will limit the flow of air through the electromagnetically sensitive contact area to a small amount. The air flow shall be small enough so that the maintenance procedures of paragraph 5.7 shall enable the requirements of paragraph 4.1 to be met.

5.4 Latching and Hinging Mechanisms--The RF-shield doors shall be provided with a suitable three-point latching mechanism that shall provide proper compressive force for the contact-finger and knife-edge mating. The operating handle shall not mechanically interfere with the door frame when the door is either open or closed. The latching mechanism shall work with equal ease when operated from either side of the door. At no point in the operation should the required force to move the door handle exceed twenty (20) pounds.

This is also written for a knife-edge type or the flat-surface door with fingers. The sliding, flat-surface door containing an expandable bladder should be specified to ride on bearings which allow a close enough placement of the door in the closed position such that the inflation of the bladder will result in a proper

The door shall be equipped with three, well balanced, adjustable ball bearing or adjustable radial thrust bearing hinges suitable for equal weight distribution of the door. The hinges shall allow for adjustment in two perpendicular directions in the plane of the door.

5.5 Locks and Interlocks--Cypher locks shall be supplied by the manufacturer to assure compatibility with the door actuating mechanism. Emergency exit/equipment doors shall be configured to actuate an alarm when open. Double doors (those on two ends of a vestibule) shall be configured to actuate an alarm when both doors are simultaneously open. Battery backup power shall be supplied for all alarms.

5.6 Threshold Protectors--Threshold protectors shall be furnished for each RF-shield door. They shall consist of portable ramps that protect the threshold area when wheeled vehicles are used to move articles across the threshold.

5.7 Maintenance Supplies and Procedures--Maintenance supplies sufficient for a three (3) year period or 50,000 open-close operations, whichever is greater, will be delivered with the door. The supplies shall include instructions, cleaning materials, lubricants, and a sufficient length of contact fingers to replace those required on one door. A log book for warranty certification showing the required maintenance activity and an entry location for certifying that the maintenance was undertaken shall be included. A counting device to show the number of door cycles shall be included. The maintenance instructions required to maintain the door through the cycle count shall be prominently displayed nearby. The maintenance procedures shall be such that the RF-shielding capability of the door meets or exceeds the requirements of paragraph 4.1 at all times. All maintenance instructions

seal. For this type of door, the positioning before inflation of the bladder is not as important as the positioning of the knife-edge type doors.

Cypher locks and alarms are optional, depending upon the user's design criteria for the building.

Some door frame thresholds extend 3/4 in to 3 in above the floor finish. Protectors are necessary in order to prevent damage and keep them RF-tight.

Maintenance is the single most important requirement for maintaining the RF-shielding ability of the door. Any device to entice the user into maintaining the door should be required from the manufacturer. The cycle counter in the example will show the number of times the door has been opened; nearby, a list of instructions will indicate, for example, that from 5000 to 10,000 cycles the contact fingers should be replaced and the knife-edge and contact fingers shall be approved by the Contracting Officer before start of installation of the door.

5.8 <u>Acceptance Testing</u>--The RF-shield door shall be tested in conjunction with the acceptance testing of the remainder of the facility. The door will not be acceptable if it does not deliver the shielding requirements of paragraph 4.1 for in-place testing.

6.0 INSTALLATION

The installation of the door shall be the responsibility of the contractor. The manufacturer shall be required to provide detailed installation instructions or to supervise the installation. The contractor

should be cleaned and lubricated each 1000 cycles.

Typical maintenance might be:

<u>Weekly</u> (0-500 cycles)--Examine door for signs of loose or missing contact fingers or other physical damage, correct any damage.

<u>Monthly</u> (500-2000 cycles)--Clean knife edge with solvent and fine abrasive, clean contact fingers with solvent, check door and latch hardware for loose bolts, and lubricate knife-edge.

<u>Annually</u> (2000-25000 cycles)--Replace all contact fingers and air-seal gaskets and maintain door handle (remove and clean shaft, replace gasket and grease, and reassemble)

The Government may wish to hire an independent firm for verification testing and periodic spot checks.

The door should be protected from adverse environments at all times. The effect of and manufacturer shall ensure that the door is installed with the correct alignment and without warpage of the frame or door that would compromise the shielding integrity of the unit.

The contractor shall require the manufacturer to supervise or submit a detailed set of instructions in fulfillment of paragraph 4.7 for the installation of all protective measures in place during the remainder of construction of the facility. The protective measures shall maintain the RF-shielding integrity of the door during the remainder of the construction.

7.0 QUALITY CONTROL

Quality control shall be maintained in the manufacturing process for the doors and on the construction site.

7.1 <u>In-Plant Quality Control</u>--Procedures for quality control shall be maintained within the manufacturing plant to assure that the RF-shield doors will provide the required electromagnetic shielding effectiveness. These procedures shall maintain the required dimensional measurements on all doors and frames.

The following tests shall be undertaken on one of each type of RF-shield door delivered:

7.1.1 <u>Static-Load Test</u>--The swinging leaf door shall be mounted and latched to its frame and placed in a horizontal position such that the door opens downward and that only the periphery of the frame is supported. A load of forty (40) pounds per square foot (psf) shall be uniformly applied over the surface of the door for at least ten (10) minutes. The door shall not deform in any way to cause any permanent departure from its previous dimensions of more than 1/16-inch. The door shall not change its dimensions

outdoor weather is generally sufficient to degrade the shielding capability on a time scale of months or less. For maximum longevity of the door, it should be protected from outside weather by a vestibule with a conditioned environment for the permanent installation and by a method affording similar security during the construction phase.

The in-plant tests are appropriate for swinging doors, either knife-edge or flat-surface types. For the sliding door with an expandable bladder, in-plant tests should examine the flatness of the mating surfaces and the bulging of the door frame when the bladder is filled. The surface flatness of the door and frame when the bladder is unfilled should be sufficiently small to allow a good RF seal when the bladder is inflated. The change in any dimension of the door or frame after inflation of the bladder should be less than 1/8-inch.

between the leaf and frame by more than 1/16-inch. If any dimension is changed by more than 1/16-inch, the door is unacceptable.

7.1.2 Sag Test--The door and its frame shall be installed in a normal fashion in a structure similar to the one for which the door is intended. The door shall be opened 90 degrees and two weights, each equal to half the weight of the door, shall be suspended, one on each side of the door, from a point not less than five (5) inches from the outer edge of the door. The test shall last for a minimum of ten (10) minutes. Any breakage, failure, or permanent deformation of the door which causes the clearance between the door and frame to vary by more than 1/16-inch will indicate that the door is unacceptable.

7.1.3 Handle-Pull Test--The door shall be mounted and latched to its frame. A force of 250 pounds shall be applied outward (normal to the surface of the door) at a point within two inches of the end of the handle. The door will not be acceptable if this test causes any breakage, failure, or permanent deformation exceeding 1/8-inch.

7.1.4 Closure Test--The door shall be operated 10,000 complete open-close cycles with application of the recommended maintenance procedures. The door will not be acceptable if this test causes any breakage, failure, or permanent deformation that causes the clearance between the door and the frame to change by more than 1/16-inch.

The closure test of 10,000 cycles may be excessive if only one door per type is needed. Manufacturers perform this test manually and, as such, it may add as much as one person-month to the cost of the door. If one door per type is needed, a certification that this test has been done for a similar door may be sufficient.

7.1.5 Electromagnetic Shielding Test--The RF-shield door shall be tested by MIL-STD-285 procedures before and after the

Minimally, the test plan should call for MIL-STD-285-type testing mechanical tests of paragraphs 7.1.1 through 7.1.4. The testing shall be done in accordance with a contractor-prepared, government-approved test plan to demonstrate compliance with the in-plant testing of paragraph 4.1. All test results shall be made available to the Contracting Officer.

During the closure test of paragraph 7.1.4, the door shall be tested for RF shielding every 2000 cycles with a 400 MHz plane wave and a 100 Khz magnetic test as indicated in MIL-STD-285. The door will not be acceptable if a decrease in attenuation (compared to the pre-mechanical-test results of paragraph 7.1.5) of more than 15 dB or if performance below minimum shielding effectiveness requirements for the facility occurs at any point on the periphery of the door or at the handle. All test results shall be provided to the Contracting Officer.

7.2 Site Quality Control--The quality control required on site shall be the responsibility of the contractor and RF-shield door manufacturer. The manufacturer may provide detailed instructions for installation and subsequent protection or may supervise all procedures needed to maintain the RF-shielding characteristics as obtained in the manufacturer's plant. The contractor and manufacturer shall assure that the door is installed with the correct alignment and without warpage of the frame or door that would compromise the shielding integrity of the unit.

7.3 Remedial Action--If the RF-shield door or any component of the door fails to meet the specified performance requirements, the contractor shall replace the defective door or components at no additional charge to the government.

7.4 Warranty--The RF-shield door shall be warranted, under proper maintenance, to provide the required attenuation of paragraph 4.1 for a period of three (3) years. The

at locations on the periphery of the door at frequencies across the specified performance band (see Fig. 3). The separation between test points should be less than two feet apart. The door handle, vents, and any other penetrations in the door should also be tested. The contractor-prepared test plan should require measurements at the same frequencies used in testing the remainder of the shield room. Minimally, the measurements should be made at 14 kHz (magnetic), 100 kHz (magnetic), 1 MHz (magnetic), 20 MHz (magnetic), 100 MHz (plane-wave), 500 MHz (plane-wave), and 1-10 GHz (plane-wave). If desired, the electric tests of MIL-STD-285 may be added; in the past, these tests have not shown any leakage that the other tests do not already indicate.

The warranty period can be changed to reflect requirements, but it must also be shown in

SAMPLE RF-SHIELD DOOR SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
manufacturer shall require from the government a certified record, paragraph 5.7, of all maintenance done on the door for any action done under the warranty.	paragraph 5.7. The log book for maintenance on the door should show any procedures required by the manufacturer, thus allowing the government compensation if the door fails in spite of following the manufacturer's maintenance instructions.

SAMPLE ELECTRICAL FILTER/ESA ASSEMBLY SPECIFICATION

CONTENTS

FOREWORD

Power and communication/signal line filters reduce unwanted conducted emissions, transients, and electrical noise on power and communication/signal circuits entering or leaving secure and other radio frequency (RF)-controlled areas. Electrical surge arresters (ESAs) protect filters, associated electronics, and insulation against damage by limiting the duration and/or amplitude of high-altitude electromagnetic pulse (HEMP)-induced or lightning-induced pulses and switching/fault transients.

This guide specification addresses performance and quality assurance requirements for filter/ESA assemblies used in HEMP/TEMPEST shielded facilities. The electromagnetic performance parameters are applicable for reasonable worst-case HEMP coupling and communications security situations which can be satisfactorily countered with National Security Agency (NSA) Specification 73-2A prescribed measures. Provisions for protection from strong lightning excitation (but not all direct strikes) to power lines are incorporated; weaker lightning coupling to communication and signal conductors has been assumed. The sample specification must be amended to reflect site-specific requirements, when they differ from these baselined conditions.

Not every feature of the filter/ESA assembly can be fixed by reference to existing military standards and specifications. Operating voltage, current, and frequency, for example, are determined from the particular requirements for the facility. Also, constraints on the allowable leakage current through the filter capacitance to ground may exist because of limitations of the power source which feeds the line. Numerical requirements for such requirements are omitted from the body of the guide specification, to be completed by the electrical designer.

Standardization documents do not address the RF isolaion characteristics of the inner and outer compartments of the assembly enclosure; these are determined by the installation configuration.

NOTE: Ambiguity exists in the terms "input" and "output," because they can be interchanged depending upon the application. Unwanted HEMP signals originate outside the shielded volume and must be attenuated as the conductors penetrate into the protected region. TEMPEST signals, however, are emitted from equipments within the shield and must not be allowed to escape. The terminology to be used in this document will be as follows:

- "Outer" compartment--the compartment which is topologically external to the shield barrier and whose terminals connect to wiring which is outside the shield.

- "Inner" compartment--the compartment which is topologically within the shield and whose terminals connect to the interior wiring.

The three possible installation configurations will be illustrated in the guide specification and applicable RF compartmentation requirements will be identified.

Furthermore, some standardized test procedures are either not universally realizable or are not relatable to the required performance of the devices in an operating environment. Examples include:

- MIL-F-15733G temperature rise test procedures require a filter to be suspended by its terminals in still air. This is clearly inappropriate for some large filters, which can weigh hundreds of pounds. Furthermore, the test geometry does not represent the typical installation configuration, where several filters are in close proximity within a sealed enclosure.

- The largest MIL-STD-202E terminal strength test force is 20 pounds. Actual installation stresses for some filters can exceed this value by many times.

- MIL-STD-220A "full load" insertion loss tests are only performed at frequencies above 100 kHz. Nonsaturation of inductors is best demonstrated at lower frequencies, where measurements are taken only when extended range buffer networks are specified.

NOTE: Most filter vendors supply two types of filters rated at 100 dB from 10 kHz to 10 GHz. The "X" series are tested with the extended range networks and are two to three times heavier than the "W" series devices. (The "W" series units are full load tested only at the higher frequencies.) This illustrates that designs may be driven by the quality assurance test procedure, rather than by the performance requirement.

It is important that standardized tests, when specified, be critically reviewed for practicality and applicability and that they be appropriately tailored.

Finally, this guide specification should not be used for filters operating at voltages in excess of 600 V d.c. or 600 V a.c. Experience with high-voltage devices indicates that detailed specifications are required for the individual components, as well as at the assembly level, in such cases. For similar reasons, dedicated specifications with requirements not addressed in this document must be written for special-purpose devices with operating signals in the radio frequency band.

Our goal here is to define reasonable performance requirements for power and communication/signal line filter/ESA assemblies and testing necessary to demonstrate compliance with the specifications. The quality assurance provisions do include tests which are not described in current standards and specifications. Some procedures require special equipment and experienced engineers to perform them and are, therefore, costly. Tradeoffs between the cost of conducting a test and the risk of not performing it are principally left to the designer. Factors such as criticality of the mission, number of units to be procured, and past experience with the specific manufacturer, and type of device should be considered in this evaluation.

SAMPLE ELECTRICAL FILTER/ ESA ASSEMBLY SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
1.0 GENERAL This specification defines requirements for the configuration and electrical performance design, construction, installation, and quality assurance testing for filter/electrical surge arrester (ESA) assemblies used to protect power (up to 600 V) and communication/signal lines in HEMP/TEMPEST shielded ground-based facilities. The filter/ESA assemblies also provide lightning protection. Other criteria related to the submittals and components specified herein appear in other sections of this document, as follows: • Section _____: General Requirements for Contractor Submittals • Section _____: Shielding and Penetration Protection Subsystem Requirements • Section _____: General Electrical Requirements	Delete HEMP or TEMPEST if only one of these requirements apply. The other sections listed are for illustrative purposes only. Appropriate entries should be made for each project.
2.0 APPLICABLE DOCUMENTS The publications listed below form a part of this specification to the extent specified. In the event of a conflict between a referenced document and this specification, the specification shall take precedence. 2.1 <u>Government Documents</u> 2.1.1 <u>Military Standards</u> MIL-STD-130 Identification Marking of U.S. Military Property	

MIL-STD-202E	Test Methods for Electronic and Electrical Component Parts
MIL-STD-220A	Methods of Insertion Loss Measurements
MIL-STD-285	Attenuation Measurements for Enclosures, Electromagnetic Shielding, for Electronic Test Purposes, Measurement of

2.1.2 Military Specifications

MIL-F-15733G	Filters, Radio Frequency Interference, General Specifications for
MIL-T-10727	Tin Plating; Electro-Deposited or Hot-Dipped; for Ferrous and Non-Ferrous Metals

2.1.3 Military Handbooks

MIL-HDBK-419	Grounding, Bonding and Shielding for Electronic Equipment and Facilities

2.1.4 Other Government Documents

Catalog of Vendors for TEMPEST Countermeasures, Filters and Optical Isolators (Jun 1986)

USAF Handbook for the Design and Construction of HEMP/TEMPEST Shielded Facilities (Revised, July 1988)

(Applicable TEMPEST documents)

3.0 SUBMITTALS

The contractor shall submit data identified in paragraphs 3.1 through 3.5.

3.1 Manufacturer's Data--The contractor shall submit copies of specifications and manufacturer's data sheets for all purchased components in the filter/ESA assembly to the Contracting Officer for approval.

3.2 Shop Drawings--The contractor shall submit shop drawings of all contractor-fabricated components in the filter/ESA assembly to the Contractor Officer for approval, prior to installation. The drawings shall provide a complete list of materials. They shall identify arrangements, thicknesses, sizes of parts, clearances, assembly, and installation details. The shop drawings shall identify required coordination with work of other trades. Shop drawings shall be updated to show as-built configurations and shall be resubmitted before facility acceptance.

3.3 Test Plans--The contractor's quality assurance test plan for all testing required by Section 7.0 of this specification shall be submitted to the Contracting Officer for approval, prior to the start of testing. The plan shall identify configurations for testing, instrumentation to be used, data requirements, test point locations, and measurement and calibration procedures.

Many of the tests recommended in this guide specification are not standardized procedures. Manufacturers may not be familiar with the conduct and may not have the necessary test equipment in their inventory. Testing may be a significant fraction of the total cost and its value can only be assured through careful planning.

3.4 Test Reports--Test reports, certified by a licensed engineer, and copies of all original data shall be submitted to the Contracting Officer. Any deviations from the test procedures submitted under paragraph 3.3 shall be described. Success or failure of

Most manufacturers routinely sample test units from their production line and, based upon these results, provide the component to satisfy the criteria shall be clearly stated and proposed resolutions of unacceptable performance shall be presented. It is emphasized that test data shall be for the actual components to be delivered and installed. Test results on random samples from the line of standard products or prototype units will not be acceptable.

3.5 Maintenance Procedures--Procedures to preserve the performance of the filter/ESA assembly and to maintain the contractor's warranty in effect shall be submitted to the Contracting Officer, along with the manufacturer's data and shop drawings required under paragraphs 3.1 and 3.2. Revisions to the maintenance plan, when required by as-built conditions, shall be submitted prior to facility acceptance.

4.0 GENERAL REQUIREMENTS

All electrical conductors entering the HEMP/TEMPEST shielded volume shall be protected by filter/ESA assemblies. All circuits entering a double-door shielded vestibule from outside or inside the shielded volume shall also be protected with filter/ESA assemblies. These lines include, but are not limited to, power lines, dummy load, signal lines, HVAC control, fire alarm, door, and lighting circuits. The complete filter/ESA assembly shall meet all requirements defined herein.

4.1 Delivery and Storage--All filters/ESA assemblies shall be delivered to the job site in an undamaged condition. They shall be protected against physical damage and dampness. Storage shall be the responsibility of the contractor. Instructions for proper storage shall be provided by the manufacturer.

certifications of compliance. They will not test the particular units to be installed or supply the actual test data except where explicitly required by these specifications.

Other manufacturers are listed in the "Catalog

The following manufacturers supply ESAs of the general types and ratings specified herein.

General Electric Company
Power Electronics Semiconductor Dept.
W. Genesee Street
Auburn, NY 13021
Telephone: (315) 253-7321

Joslym Electronic Systems
6868 Cortona Drive
Santa Barbara Research Park
Post Office Box 817
Goleta, CA 93116
Telephone: (805) 968-3551

of Vendors for TEMPEST Countermeasures, Filters, and Optical Isolators," dated June 1986. This document is available from the major command TEMPEST officer or Air Force Cryptologic Support Center/SRVT, San Antonio, TX 78243-5020.

The lists of manufacturers are not exhaustive. Other suppliers, not on the lists, may make equal or superior products.

SAMPLE ELECTRICAL FILTER/ ESA ASSEMBLY SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
General Semiconductor 2001 West Tenth Place Tempe, AZ 85281 Telephone: (602) 968-3101	
5.0 DETAILED REQUIREMENTS	
5.1 Configuration	
5.1.1 Filter/ESA Assembly Enclosure	
5.1.1.1 Installation Configuration--The filter/ESA assembly enclosure shall be installed into the HEMP/TEMPEST shield in the ___________ configuration, as shown in the drawings and Figure __.	Specify the inside (Fig. 1), imbedded (Figs. 2 and 3), or outside (Fig. 4) installation configuration. The "inside," "imbedded," or "outside" terminology refers to the physical location of the enclosure with respect to the HEMP/TEMPEST shield. The inside installation configuration prevents access to signals on the interior wiring from outside the shield and is recommended for TEMPEST-only facilities. The outside configuration is recommended for HEMP-protected facilities, because the compartment containing the ESAs does not require RF shielding (see note for paragraph 5.1.1.3). The imbedded configuration is recommended for TEMPEST-only, HEMP-only, and HEMP/TEMPEST facilities.

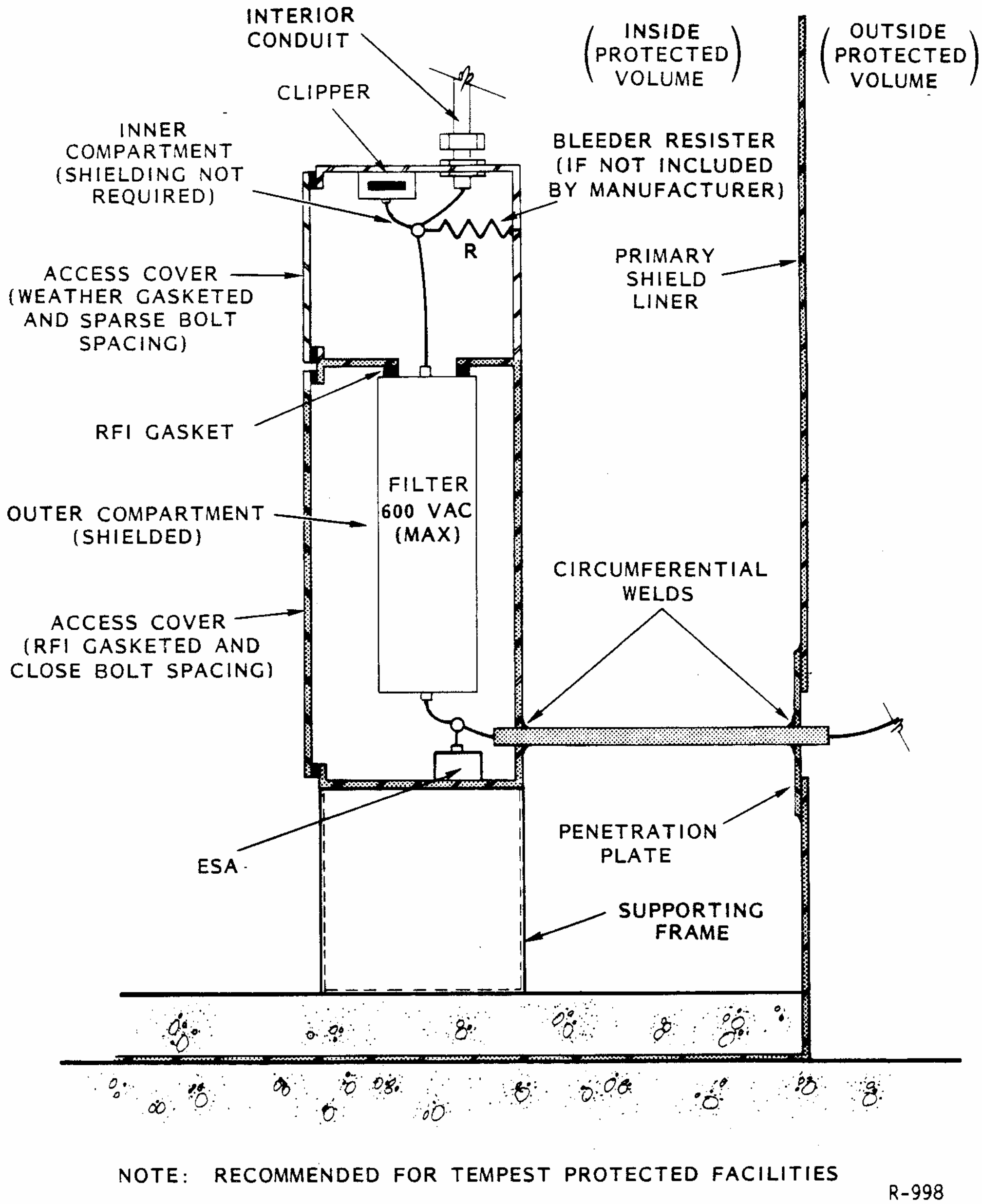
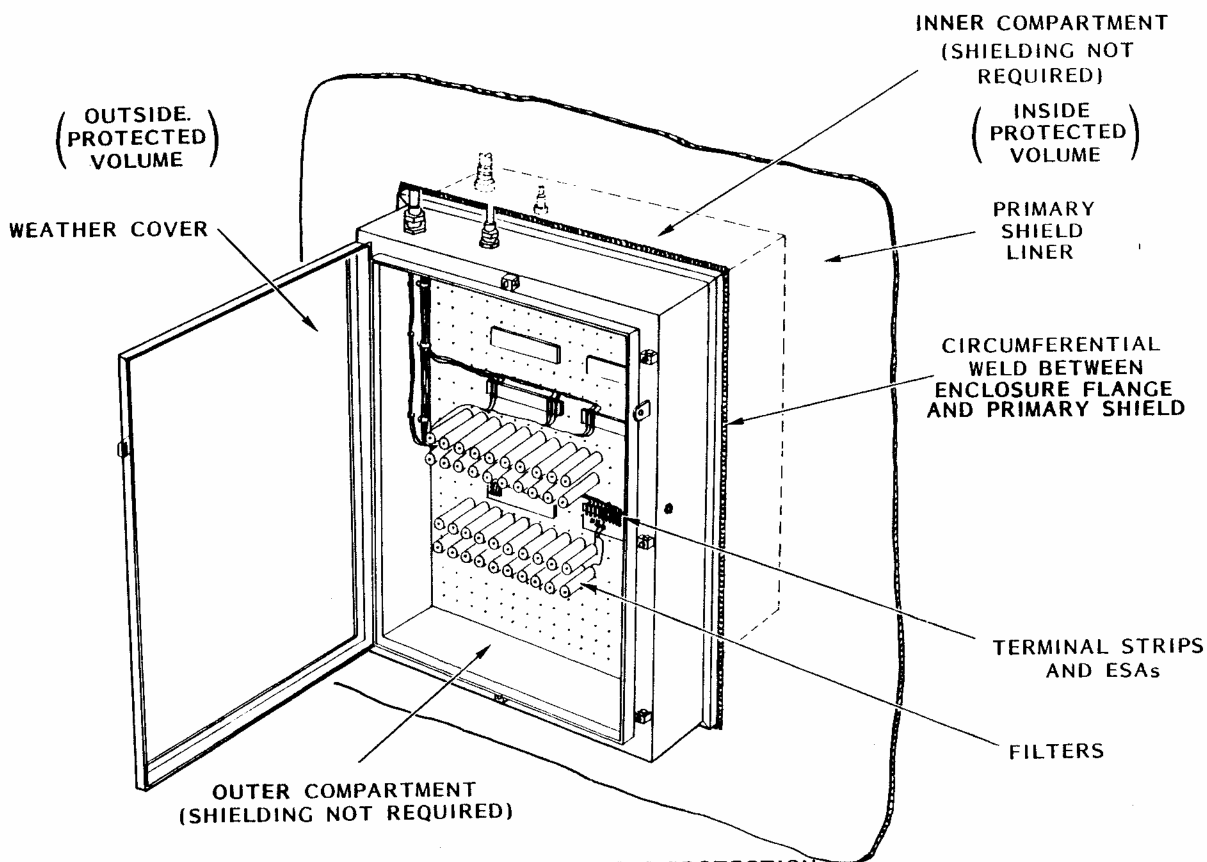


Figure 1. Inside configuration.



NOTE: 1. RECOMMENDED FOR TEMPEST AND/OR HEMP PROTECTION
2. FOR TEMPEST, A "CONTROLLED" AREA IN ACCORDANCE WITH NACSIM 5203 IS REQUIRED IF THE FILTERS ARE INSTALLED IN THE OUTER COMPARTMENT

R-998

Figure 2. Imbedded configuration, isometric view.

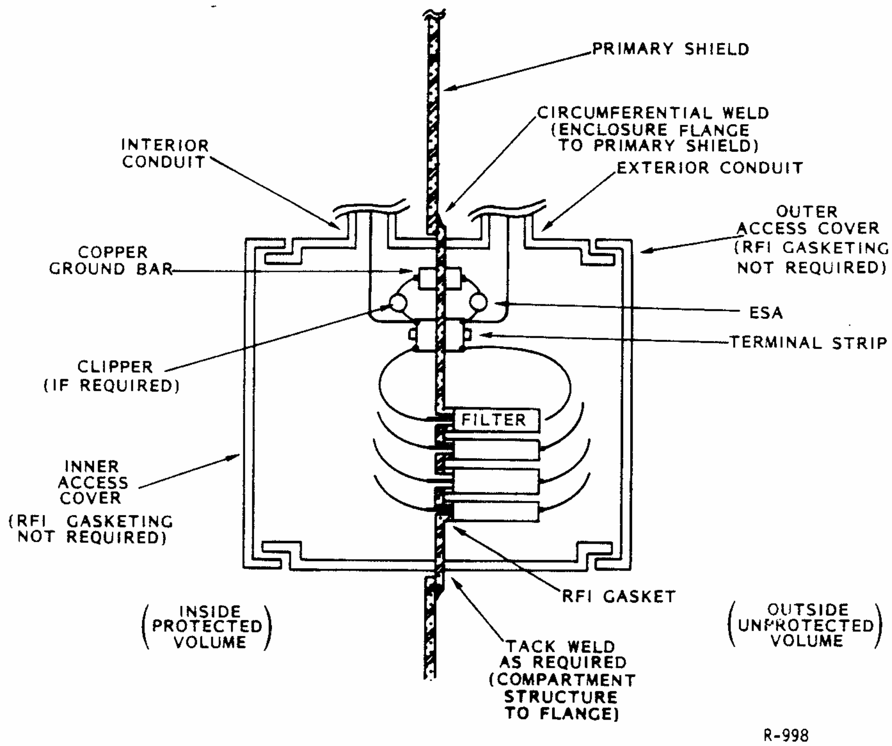


Figure 3. Imbedded configuration, cross-section.

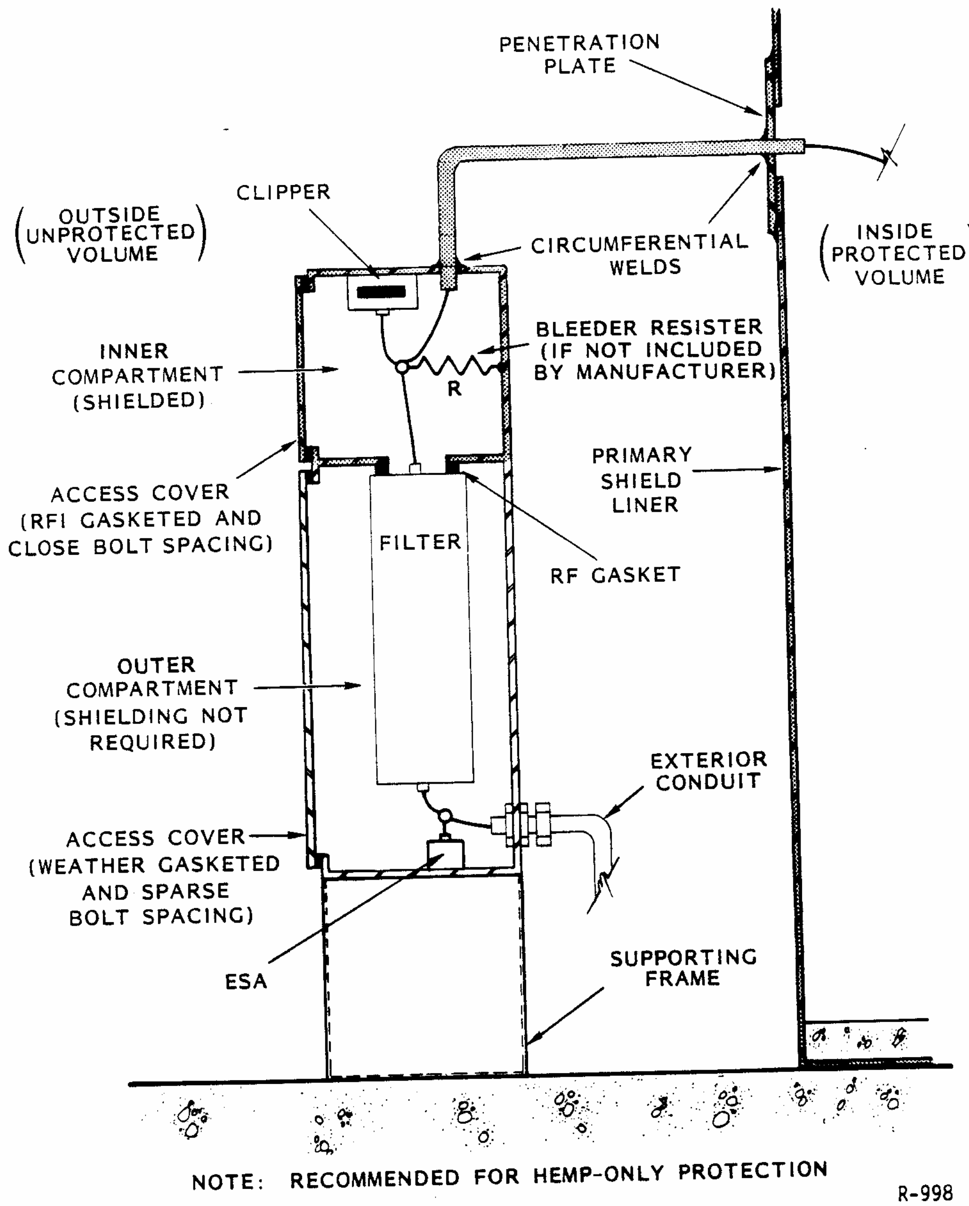


Figure 4. Outside configuration.

5.1.1.2 Construction--The filter/ESA assembly enclosure shall be a two-compartment enclosure and shall be of welded steel construction. Access covers, which protect the components from dirt, moisture, and mechanical damage, shall be provided into the two compartments.

5.1.1.3 RF Compartment--The ______ compartment shall be an RF-tight compartment. The access cover shall be RF-gasketed and mating contact surfaces shall be tin-plated in accordance with MIL-T-10727. The cover shall be bolted in place; the bolt spacing shall not be greater than 7.5 cm (3 inches). The bolts (or nuts) shall be securely and permanently attached to the enclosure.

Specify inner or outer compartment. Minimum bolt spacing will vary with the degree of isolation required and thickness and construction of the cover.

The two compartments are termed as the "inner" and "outer" compartments. By definition, the inner compartment is always topologically inside the HEMP/TEMPEST shield. The inner compartment does not require RF shielding in the inside or imbedded installation configurations, because it is also physically inside the shield. RF shielding of the inner compartment is required for the outside installation configuration. Similarly, the outer compartment is always outside the shield in the topological sense and requires RF shielding only in the inside installation configuration.

5.1.1.4 Unshielded Compartment--The ______ compartment(s) shall be an unshielded compartment. The access cover into the unshielded compartment shall be weather-gasketed and shall be a hinged door.

Specify inner, outer, or both compartments.

Commercially available products with either a

SAMPLE ELECTRICAL FILTER/ ESA ASSEMBLY SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
	hinged door or a bolted access cover can be obtained. The hinged door is preferred for ease of maintenance, but is less common and may be more expensive.
5.1.1.5 Size/Weight--[Specify special dimensional or weight (including filters and ESAs) constraints, when applicable.]	Assemblies can be quite large and heavy and normally require special mounting support.
5.1.1.6 Finish--(Specify.)	This article may refer to another section of the specifications that covers painting.
5.1.1.7 Marking--The filter/ESA assembly enclosure shall be marked in accordance with MIL-STD-130 with the manufacturer's name or trademark and part number.	
5.1.2 Filters	
5.1.2.1 Filter Case--The filter components shall be enclosed in a metal case for protection from dust, moisture, and mechanical damage. The case shall be cold-rolled steel and shall be hermetically sealed. The finish shall be hot-dipped tin-plating per MIL-T-10727 and shall not be painted on areas where electrical continuity of RF seals is required.	
5.1.2.2 Filter Terminals--Filter terminals shall be ceramic-insulated and shall be of the standoff-type, with threaded studs. The terminals shall withstand a 50-pound pull without degradation or damage, when tested in accordance with procedures of paragraph 7.2 of this specification.	The terminal strength requirement should be tailored to the maximum likely stress during installation/operations. It is not necessary to restrict the specified force to 20 pounds (the largest value listed in MIL-STD-202).

SAMPLE ELECTRICAL FILTER/ ESA ASSEMBLY SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
5.1.2.3 Installation and Clearance--Filters shall be installed in the outer compartment of the enclosure, with an RF-tight seal to the barrier between the two compartments. Minimum clearances shall be as specified in paragraph 3.5 of MIL-F-15733.	In TEMPEST-only facilities, filters may be installed in either the inner or outer compartment. When installed on the outer side of a TEMPEST shielded room, (security) access to the unfiltered side of the conductors must be controlled.
5.1.2.4 Replaceability--Individual filter units within the filter/ESA assembly enclosure shall be individually replaceable.	
5.1.2.5 Marking--Individual filters shall be marked in accordance with MIL-STD-130 with the manufacturer's name or trademark and part number.	
5.1.3 Electrical Surge Arresters	
5.1.3.1 ESA Case--The ESA shall be enclosed within a metal case. Discharges shall be totally contained within the case; no external corona or arcing is permitted.	
5.1.3.2 ESA Terminals--ESA terminals shall be ceramic-insulated and shall be of the standoff-type, with threaded studs. They shall withstand a 50-pound pull without degradation or damage, when tested in accordance with procedures of paragraph 7.2 of this specification.	The terminal strength requirement should be tailored to the particular application.
5.1.3.3 Installation and Clearance--ESAs shall be installed in the outer compartment of the enclosure with minimum clearances as specified in paragraph 3.5 of MIL-F-15733.	Desired protection is from surges originating outside the shielded volume.
5.1.3.4 Replaceability--Individual ESAs within the filter/ESA assembly enclosure shall be individually replaceable.	

5.1.3.5 Marking--Individual ESAs shall be marked in accordance with MIL-STD-130 with the manufacturer's name or trademark and part number.

5.1.3.6 Wiring--The ESAs shall be located so that leads of minimum length connect the ESA to the filter and the ESA ground terminal to the enclosure. Power line ESA wiring shall be NO. 4 AWG (minimum). Communication/signal line ESA wiring shall be of the same or heavier gauge than the communication/signal line conductor. In all cases, total ESA lead length shall be less than 0.3 m (12 inches).

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. Short leads, as recommended here, improve the voltage-limiting effectiveness of the ESA.

5.2 Performance Characteristics

5.2.1 Power Filters

5.2.1.1 General--Power filters shall satisfy the requirements of MIL-F-15733. In the event of a conflict between MIL-F-15733 and this specification, this specification shall take precedence.

5.2.1.2 Interface Elements--The first filter element, looking into the inner compartment terminal shall be an inductor. The first element, looking into the outer compartment terminal, shall be an inductor.

Power filters can be designed with either capacitive or inductive interface elements. Except in unusual circumstances, there is no clear and unanimous preference, so the types of interface elements are seldom specified. When used in combination with an ESA, an initial capacitor reduces the rate of voltage increase and results in a lower sparkover voltage, but draws larger transient currents and may even prevent firing of a spark gap. An initial inductive element allows a higher voltage to be developed at the filter terminal, but this produces earlier ESA activation. Inductive interface elements also limit the capacitor discharge current in the event of a short-circuit fault in the external circuit.

5.2.1.3 Operating Voltage--The filters shall be rated for continuous operation at ________, as shown in the drawings.

For a.c. filters, specify the operating a.c. voltage (rms) across the filter and the operating frequency. For d.c. filters, specify the d.c. operating voltage.

Some designers specify that filters in the three phase wye-connected power circuits be rated at the phase-to-phase voltage (because phase-to-ground voltage can approach this value when a short circuit occurs on another phase). Other designers allow the dielectric withstanding voltage specification to provide capability to withstand this circumstance.

Filters for applications at voltages greater than 600-V a.c. or 600-V d.c. are subject to failures from internal discharges in the components. The performance characteristics needed to avoid internal discharges are not addressed in this sample specification. Therefore, it should not be used for high-voltage assemblies.

5.2.1.4 Operating Current--The filters shall be rated for continuous operation at _______, as shown in the drawings.

Specify the maximum operating current.

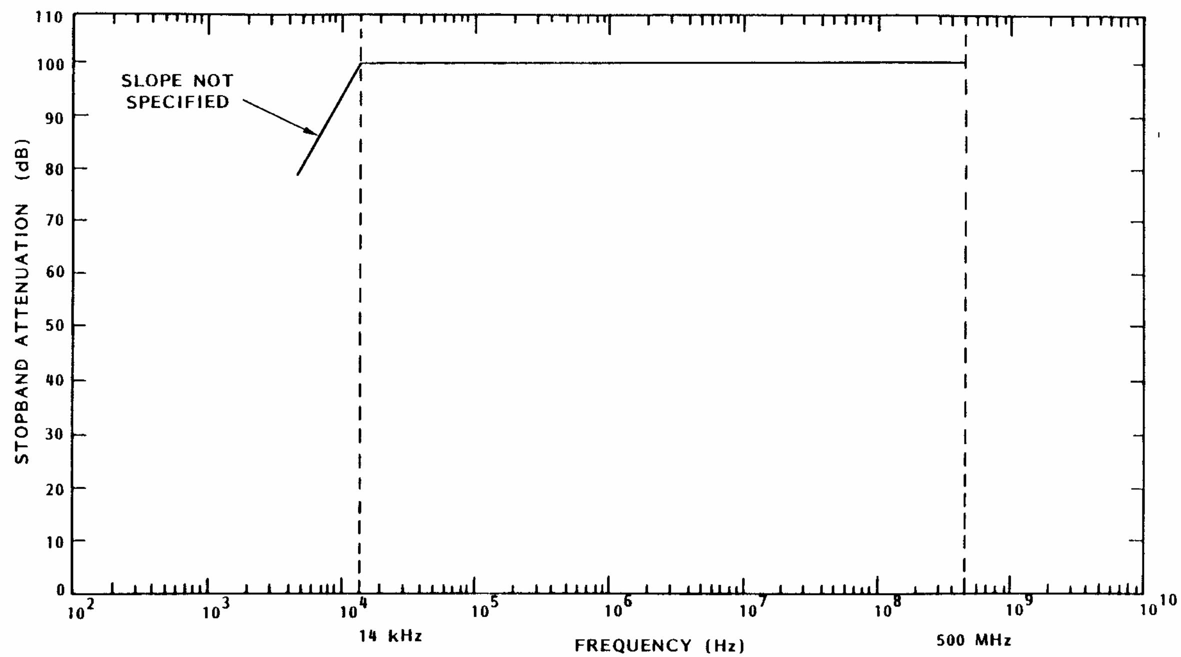
No filters rated in excess of 400 A are known to be commercially available. If larger current ratings are required, they may be achieved by paralleling two or more filters.

5.2.1.5 Stopband Attenuation--The filters shall provide at least the minimum stopband attenuation requirements shown in Figure 5, when tested in accordance with procedures of paragraph 7.3 of this specification. These stopband attenuation requirements apply at any current from no-load through full-load current.

The term "stopband attenuation," rather than insertion loss, has been used to avoid confusion with a MIL-STD-220 specification.

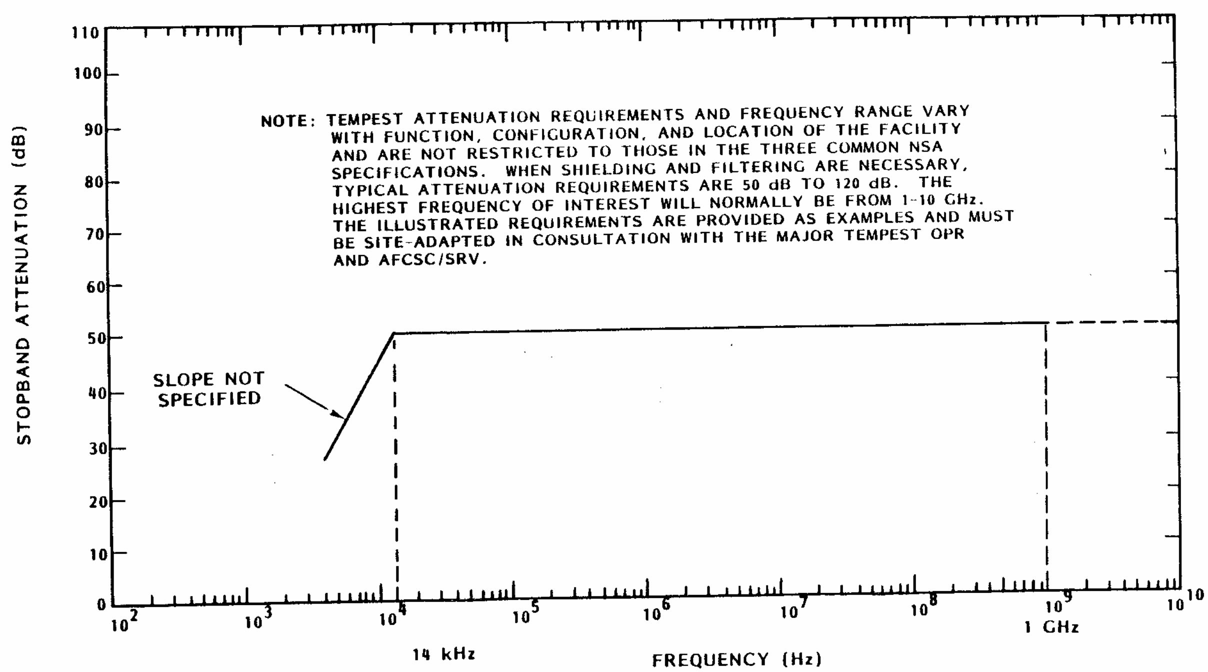
Figure 5a illustrates the attenuation requirement for high-confidence HEMP protection, while Figure 5b shows a possible TEMPEST-only specification. Figure 5c illustrates the combining of attenuation requirements for HEMP/TEMPEST applications.

Because filter inductor characteristics can change as a function of the load current, attenuation should be measured at several different load currents.



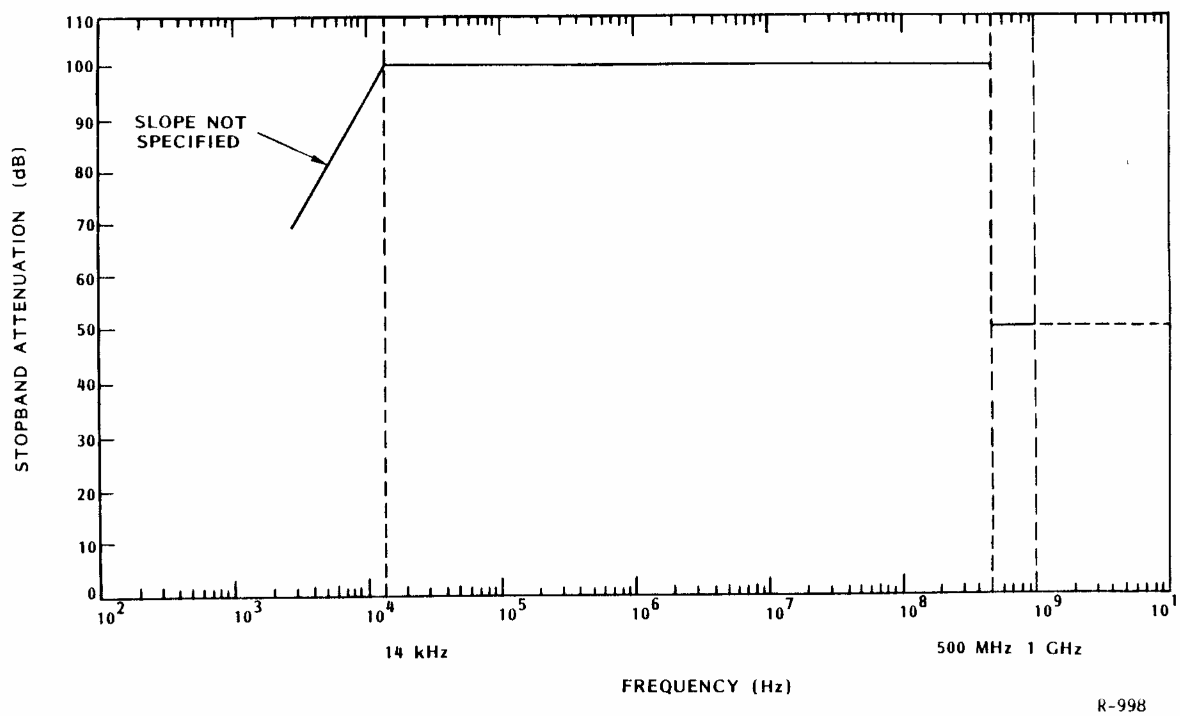
a. HEMP-only installations.

Figure 5. Minimum stopband attenuation requirements (use test procedures of paragraph 7.3).



b. TEMPEST-only installations.

Figure 5. Minimum stopband attenuation requirements (use test procedures of paragraph 7.3) (continued).



c. HEMP/TEMPEST installations.

Figure 5. Minimum stopband attenuation requirements (use test procedures of paragraph 7.3) (concluded).

SAMPLE ELECTRICAL FILTER/ ESA ASSEMBLY SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
5.2.1.6 <u>Dielectric Withstanding Voltage</u>--The filters shall withstand twice the rated operating voltage for a period of one minute without degradation or damage, when tested in accordance with procedures of paragraph 7.4 of this specification.	The sample specification language is for a.c. filters. For d.c. filters, the requirement is 2.5 times rated voltage for 1 minute.
5.2.1.7 <u>Pulsed Withstanding Voltage</u>--The filters shall withstand a 40-kV, 10-ns × 100-ns pulse applied at the filter outer compartment terminals without degradation or damage.	The waveshape of a transient impulse is defined by two time numbers, such as t1 x t2 (see Fig. 6). The first number is the rise time from zero to the crest value. The second number gives the time interval from zero to a point on the wave tail at which the magnitude has decayed to one-half of the crest value. This performance is necessary, but is usually not explicitly specified. The prescribed pulse is the reasonable worst case HEMP-coupled transient, after surge suppression with a spark gap ESA. (Amplitude and pulse width are primarily determined from inductance in the ESA leads.) Although standard commercial filters have not been built to this type of requirement, few have failed in actual testing. A test procedure has not been specified, but Figure 7 shows the test configuration which would be used.

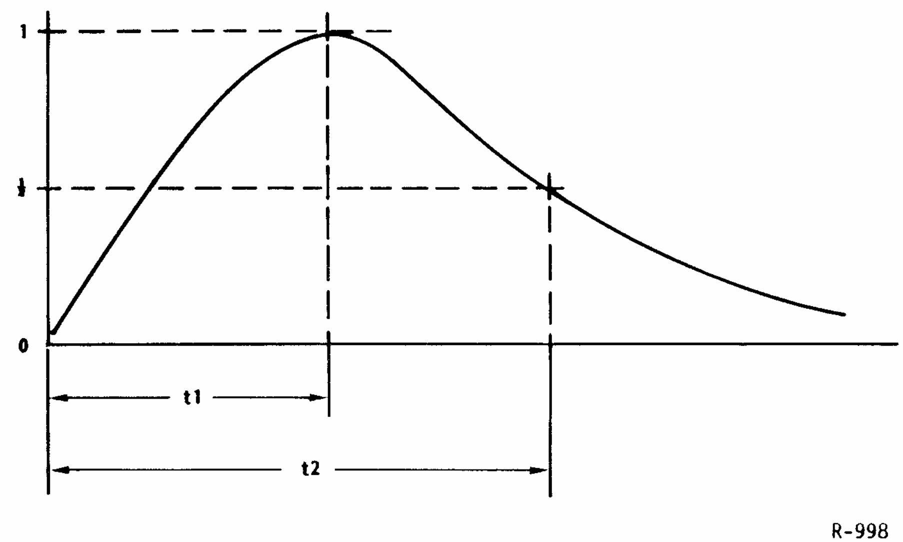


Figure 6. t1 × t2 wave shape.

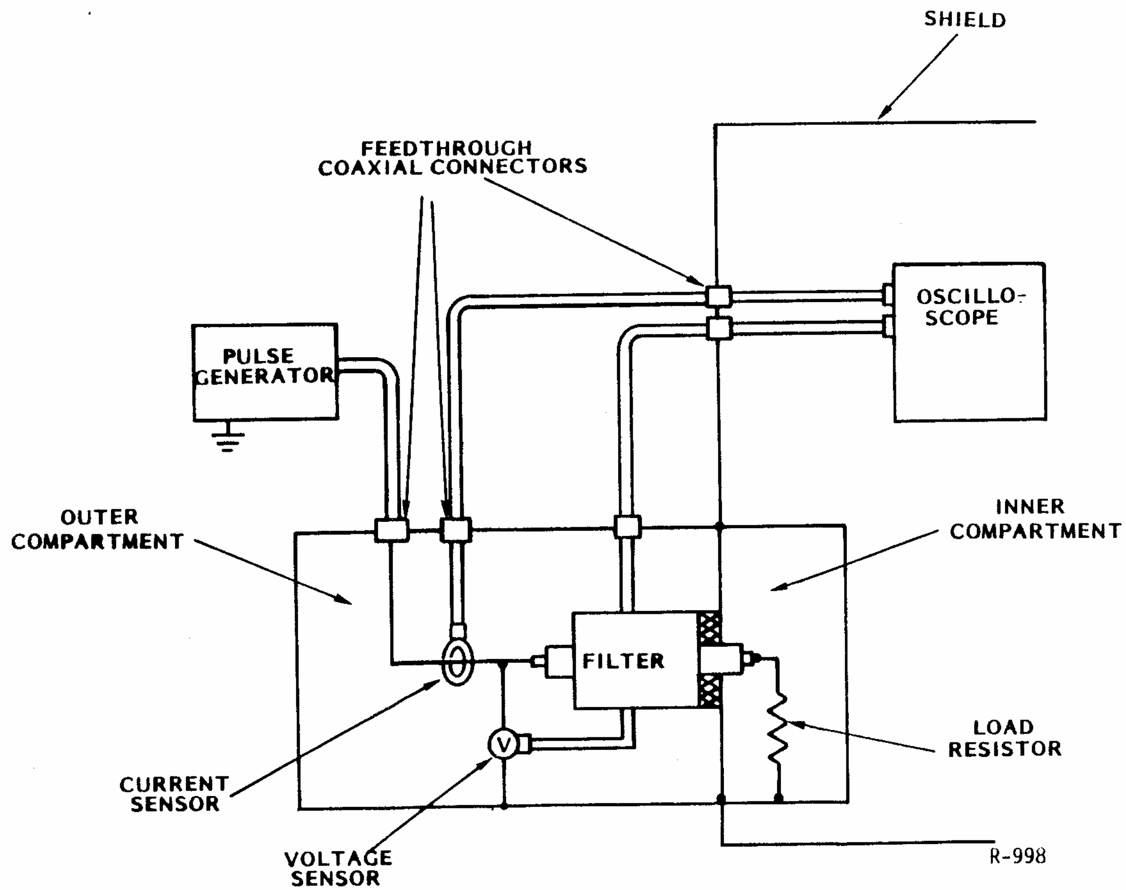


Figure 7. Possible configuration for filter pulsed withstanding voltage test.

5.2.1.8 Voltage Drop--The voltage drop across the filters at rated voltage and frequency and at any current from no-load through full-load current shall not exceed 1 percent, when tested in accordance with procedures of paragraph 7.5 of this specification.

The sample specification language is for a.c. filters. For d.c. filters, a maximum terminal-to-terminal d.c. resistance (DCR) is specified. The typical value is much less than 1 percent of rated voltage divided by rated current.

5.2.1.9 Current Overload--The filters shall withstand 5 times the rated current for a period of 1 second, twice the rated current for 1 minute, and 1.4 times the rated current for 15 minutes without degradation or damage, when tested in accordance with procedures of paragraph 7.6 of this specification.

5.2.1.10 Reactive Current--The maximum reactive shunt current drawn by the filters operating at rated voltage and frequency shall not exceed ______ amperes, when tested in accordance with procedures of paragraph 7.7 of this specification.

A large reactive current can be shunted through the filter capacitance-to-ground. This leakage affects the power factor of the circuit and can overload current-limited sources, causing circuit breakers to trip or burning out fuses or components. In a 120-V a.c./400-Hz circuit, the reactive current leakage is about 0.3 A/μF and a typical 100 dB power filter may contain several tens of μFs. Power factor correction methods can be used to "tune-out" the reactive leakage.

The designer may use 35 percent of the full-load rated current as the maximum reactive shunt current, when other information for defining the requirement is not available.

5.2.1.11 Current Sharing among Parallel Filters--Filters which are electrically tied in parallel shall share the load current approximately equally, when tested in accordance with procedures of paragraph 7.8 of this specification.

Filters may be paralleled to achieve rated currents in excess of 400 A (see note for paragraph 5.2.1.4).

5.2.1.12 Bleeder Resistor--The filters shall have a bleeder resistor installed external to the filter case. The bleeder resistor shall reduce filter voltage to less than 10 percent of its initial value in less than 1 minute, when tested in accordance with procedures of paragraph 7.9 of this specification.

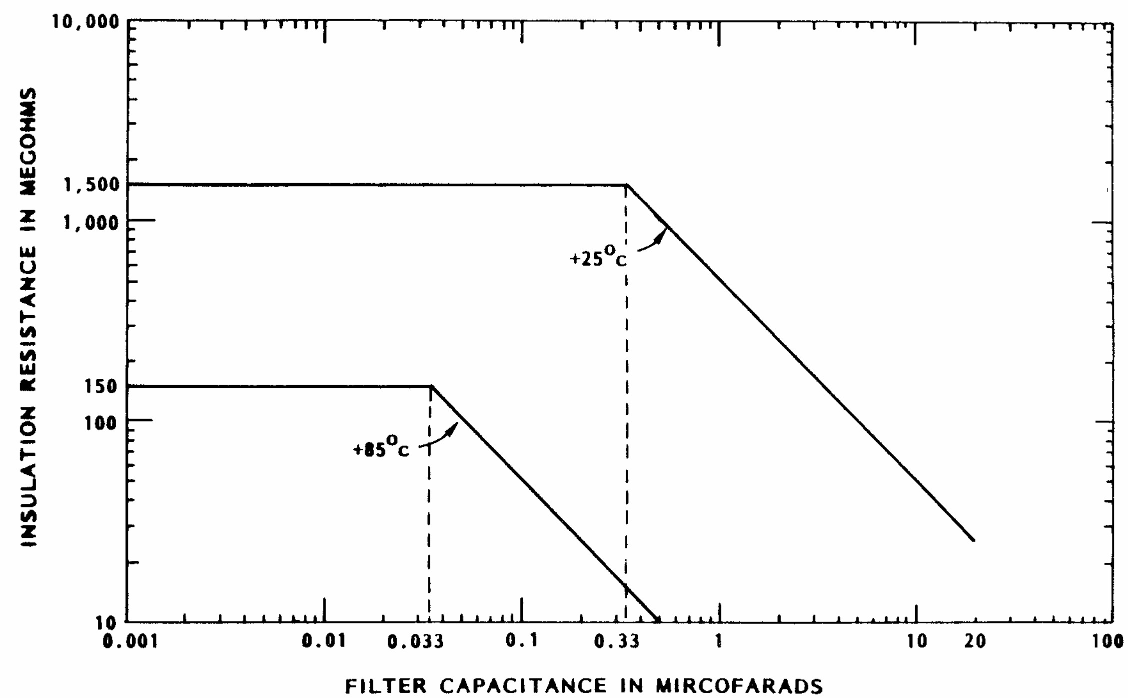
Stored charge on capacitors in the filters can create a high-voltage shock hazard for personnel. This requirement should be imposed on all filters with operating voltages in excess of 50-V a.c. or 50-V d.c.

An external bleeder resistor is preferred for two reasons: it can be disconnected for insulation resistance measurements, and it can be visually inspected.

5.2.1.13 Insulation Resistance--Insulation resistance (R_I) of the filters shall be at least the minimum applicable value shown in Figure 8, when tested in accordance with procedures of paragraph 7.10 of this specification.

Oil-impregnated electrostatic film capacitors are recommended to be used in power filters. Electrolytic capacitors have larger d.c. leakage currents and greater dissipation factors and will not meet these insulation resistance requirements.

If a bleeder resistor is to be installed within the filter case, R_I measurements must be made by the manufacturer, before the case is sealed.



R-998

Figure 8. Insulation resistance requirements.

SAMPLE ELECTRICAL FILTER/ ESA ASSEMBLY SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
5.2.1.14 <u>Operating Temperature</u>--The filters shall be rated for continuous operation at rated voltage and full-load current in ambient temperatures from -25°C to +85°C (measured inside the RF filter cabinet).	The filter operating environment is that within the assembly enclosure, and this requirement must be coordinated with the assembly operating temperature specification (see note for paragraph 5.2.5.5). This performance will be evaluated as part of the filter/ESA assembly thermal test, to the extent considered necessary. Operating temperature range is only one of many environmental requirements which may apply. Others include: • Humidity • Barometric pressure or altitude • Moisture, salt-spray, or immersion resistance • Sand and dust resistance • Shock and vibration The designer must evaluate which of these conditions are applicable and specify them appropriately. MIL-F-15733 and MIL-STD-202 are useful references when specifying environmental requirements.

5.2.1.15 Temperature Rise--The temperature rise of the filters when operating at rated voltage and frequency and rated full-load current shall not exceed 25°C, when tested in accordance with procedures of paragraph 7.11 of this specification.

If forced circulation of ambient air through the assembly enclosure is necessary to satisfy this requirement, appropriate provisions should be included among the configuration requirements for the enclosure.

Some manufacturers suggest that filter reliability will increase significantly if the temperature rise is limited to 20°C or even 10°C.

5.2.1.16 Filter Life--The filters shall be warranted for a minimum service life of 3 years.

Enforceability of warranties, in a practical sense, at least, is questionable for low-cost devices such as low-voltage filters. Nevertheless, some life requirement is recommended.

5.2.2 Communication/Signal Line Filters

5.2.2.1 Application--The filters specified herein are designed for use in a ________ circuit.

The category of communication and signal line filters covers a broad spectrum of devices; a few examples are as follows:

- Control circuit filters (on-off, digital, and analog)
- Energy Monitoring and Control System
- Data circuit filters at various data rates

5.2.2.2 General--Communication and signal line filters shall satisfy the requirements of MIL-F-15733. In the event of conflict between MIL-F-15733 and this specification, this specification shall take precedence.

5.2.2.3 Operating Voltage--The filters shall be rated for continuous operation at ________, as shown in the drawings.

5.2.2.4 Operating Current--The filters shall be rated for continuous operation at _______, as shown in the drawings.

- Fire Alarm (Coded)
- Security instrusion alarm ("supervised" signal)
- RF transmit and receive circuit filters

Characteristics of the operating signals and design of the associated equipments must be analyzed and carefully considered in the specification development process. Many filter manufacturers are more experienced with this process than the facility electrical designers and, by identifying the application, the value of their experience can be realized.

Specify the maximum a.c. and/or d.c. operating voltage.

Specify the maximum operating current.

An operating power specification may be more useful than an operating current requirement for some applications, such as RF transmit circuits.

SAMPLE ELECTRICAL FILTER/ ESA ASSEMBLY SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
5.2.2.5 Passband Requirements--(Specify)	The passband requirements are highly application-dependent and cannot be comprehensively addressed here. They usually include some or all of the following performance characteristics: • Frequency range • Image impedance • Maximum attenuation or voltage standing wave ratio (VSWR) • Phase shift or harmonic distortion limits
5.2.2.6 Stopband Attenuation--The filters shall provide at least the minimum stopband attenuation requirements shown in Figure 5, when tested in accordance with procedures of paragraph 7.3 of this specification.	See note for paragraph 5.2.1.5. Some communication/signal line applications will have passband frequencies which lie between 14 kHz and 10 GHz, and the attenuation versus frequency characteristics will have to be modified accordingly. When this occurs, the passband should be as narrow as practical, and the skirts of the attenuation curve should be as steep as practical. Supplementary protective measures must be implemented to account for the partial loss of filter attenuation. Examples of such measures include:

SAMPLE ELECTRICAL FILTER/ ESA ASSEMBLY SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
	• In HEMP facilities, voltage-clipping diodes may be required in the inner compartment of the assembly. • Special TEMPEST tests may be required to ensure that other undesired signals are not leaking through the filter notch.
5.2.2.7 Dielectric Withstanding Voltage--The filters shall withstand twice the rated operating voltage for a period of 1 minute without degradation or damage, when tested in accordance with procedures of paragraph 7.4 of this specification.	See note for paragraph 5.2.1.6.
5.2.2.8 Pulsed Withstanding Voltage--The filters shall withstand a 40-kV, 10-ns x 100-ns pulse applied at the filter outer compartment terminals without degradation or damage.	See notes for paragraph 5.2.1.7.
5.2.2.9 Voltage Drop--The voltage drop across the filters at rated voltage and frequency and at any current from no-load through full-load current shall not exceed 1 percent, when tested in accordance with procedures of paragraph 7.5 of this specification.	See note for paragraph 5.2.1.8.
5.2.2.10 Current Overload--The filter shall withstand 5 times the rated current for a period of 1 second, twice the rated current for 1 minute, and 1.4 times the rated current for 15 minutes without degradation or damage, when tested in accordance with procedures of paragraph 7.6 of this specification.	Current overload specifications may be unnecessary for some communication/signal line filters.

SAMPLE ELECTRICAL FILTER/ ESA ASSEMBLY SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
5.2.2.11 Reactive Current--The maximum reactive shunt current drawn by the filter operating at rated voltage and frequency shall not exceed _______ amperes, when tested in accordance with procedures of paragraph 7.7 of this specification.	See notes for paragraph 5.2.1.10. Reactive current specifications may be unnecessary for some communication/signal line filters.
5.2.2.12 Bleeder Resistor--The filters shall have a bleeder resistor installed external to the filter case. The bleeder resistor shall reduce filter voltage to less than 10 percent of its initial value in less than 1 minute, when tested in accordance with procedures of paragraph 7.9 of this specification.	See notes for paragraph 5.2.1.12.
5.2.2.13 Insulation Resistance--Insulation resistance (R_I) of the filters shall be at least the minimum applicable value shown in Figure 8, when tested in accordance with procedures of paragraph 7.10 of this specification.	
5.2.2.14 Operating Temperature--The filters shall be rated for continuous operation at rated voltage and full-load current in ambient temperatures from -25°C to +85°C (measured inside the RF filter cabinet).	See notes for paragraph 5.2.1.14.
5.2.2.15 Temperature Rise--The temperature rise of the filters when operating at rated voltage and frequency and rated full-load current shall not exceed 25°C, when tested in accordance with procedures of paragraph 7.11 of this specification.	See notes of paragraph 5.2.1.15.
5.2.2.16 Filter Life--The filters shall be warranted for a minimum service life of 3 years.	See notes of paragraph 5.2.1.16.
5.2.3 Power Line Surge Arresters	Common power line surge arresters for high-current transients are of two types--spark gaps and metal oxide

varistors (MOVs). Both types have been used for lightning and HEMP protection; neither is clearly superior.

A spark gap is a controlled discharge through the gas within the device. Even the fastest spark gaps take a few nanoseconds to "turn on." Thus, the impulse sparkover voltage (voltage across the gap at breakdown) on a fast transient will be significantly greater than the d.c. breakdown voltage. (Voltage overshoot also occurs because of the wiring inductance in series with the spark gap.) The clamping voltage, voltage across the gap after it is in full breakdown, is much less than the d.c. breakdown voltage (and often less than the operating voltage). Clamping voltage is only weakly dependent on the discharge current. Except in a spark gap with special provisions such as a resistor in series, line voltage must approach zero (zero crossing in an a.c. power circuit or power off in a d.c. or high-frequency circuit) in order to extinguish the arc.

An MOV is essentially a voltage-dependent resistance and operates almost instantaneously. Voltage overshoot is, therefore, primarily due to the series inductance, and sparkover voltage is not usually specified as an MOV requirement. The clamping voltage increases with increasing current and is greater than the operating voltage. After the transient passes, the device returns to its high-resistance state without necessity for line voltage to approach zero.

5.2.3.1 ESA Application--The ESAs specified herein are intended for use in a ______ circuit.

For a.c. power circuits, specify the voltage (peak or rms and phase-to-phase or phase-to-ground), current (per phase), frequency, single or three phase, wye or delta connected, and use. For d.c. power circuits, specify voltage, maximum current capabilities of source, and use. See note for paragraph 5.2.2.1.

5.2.3.2 ESA D.C. Breakdown Voltage--The d.c. breakdown voltage of the ESAs shall be at least ____ volts and shall not be greater than ____ volts, when tested in accordance with procedures of paragraph 7.12 of this specification.

The sample language is for a spark gap; the equivalent parameter for an MOV is voltage at 1-mA d.c. current.

Specified d.c. breakdown voltage (or MOV voltage at 1-mA d.c. current) for d.c. and single phase a.c. 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 ESAs on the other two phases.

5.2.3.3 <u>ESA Impulse Sparkover Voltage</u>--Impulse sparkover voltage of the ESAs shall be less than 4000 volts on a voltage surge of either polarity having a rate of rise of 1000 V/ns, when tested in accordance with procedures of paragraph 7.13 of this specification.

The sample language is for a spark gap. Impulse sparkover voltage is not usually specified for an MOV.

An equivalent requirement is: "Response time of the ESAs, from the time of application of voltage to the time of gap firing, shall be less than 4 ns on a voltage surge of either polarity and having a rate of rise of 1000 V/ns."

This 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.

5.2.3.4 <u>ESA Clamping Voltage</u>--Clamping voltage of the ESAs shall be less than 900 volts at a current of 10 kA, on an 8 μs x 20 μs waveshape, when tested in accordance with procedures of paragraph 7.14 of this specification.

This requirement is intended to ensure that the ESA does not have excessive series resistance. Again, the specific value is not critical and should be chosen after reviewing manufacturers' data.

SAMPLE ELECTRICAL FILTER/ ESA ASSEMBLY SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
5.2.3.5 ESA Extinguishing Characteristics--The ESAs shall extinguish and shall be self-restoring to the normal nonconductive state within one-half cycle at the operating frequency, when tested in accordance with procedures of paragraph 7.15 of this specification.	The sample language is for an a.c. spark gap. For d.c. spark gaps, specify the extinguishing voltage or extinguishing time. An extinguishing requirement for an MOV is unnecessary.
5.2.3.6 ESA Extreme Duty Discharge Current--The ESAs shall be rated for an extreme duty discharge current of a least 65 kA, on an 8 μs x 20 μs waveshape, when tested in accordance with procedures of paragraph 7.16 of this specification.	The 65 kA is a lightning specification, adequate for the 90th percentile strike. For HEMP, a 20-kA extreme duty discharge rating is adequate.
5.2.3.7 ESA Surge Life--The ESAs shall have a surge life of at least 1000 surges at 2000 A, on a 10 μs × 1000 μs waveshape, when tested in accordance with procedures of paragraph 7.17 of this specification.	The 2000-A specification is an estimate of the lightning requirement (based upon charge contained in a lightning stroke and the fraction of that charge which must be discharged through the ESA). For HEMP-only, the amplitude can be reduced to 500 A.
5.2.3.8 ESA Operating Temperature--The ESAs shall be rated for continuous operation in ambient temperatures from -25°C to +85°C (measured inside the RF filter cabinet).	See notes for paragraph 5.2.1.14.
5.2.3.9 ESA Life--The ESAs shall be warranted for a minimum service life of 3 years, provided that surge life and other ratings are not exceeded.	See notes for paragraph 5.2.1.15.
5.2.3.10 ESA Self-Monitoring--The ESAs shall have a self-monitoring system which lights a red light if fuse protectors are blown.	Fusing of ESAs is not recommended, because it becomes possible to lose protection without the operator's knowledge. If the designer chooses to employ fuses, a

self-monitoring capability is strongly recommended.

5.2.4 Communication/Signal Line ESAs

Both spark gaps and MOVs are also used in communication/signal line applications. (Low-current surge arresters, such as Zener diodes and TranZorbs, may be used at the inner compartment terminals of the filter, but are not robust enough for the outer compartment requirements.)

5.2.4.1 ESA Application--The ESAs specified herein are intended for use in a _______ circuit.

See note for paragraph 5.2.2.1.

5.2.4.2 Operating Signal Requirements--(Specify)

Communication/signal line ESA operating signal requirements, like the passband requirements for communication/signal line filters, vary greatly from application to application. Many of the same characteristics (image impedance for coaxial ESAs, attenuation or VSWR, etc.) are important. It may be necessary to limit device capacitance so that operational signals are not distorted.

5.2.4.3 ESA D.C. Breakdown Voltage--The d.c. breakdown voltage of the ESAs shall be at least ____ volts and shall not be greater than ___ volts, when tested in accordance with procedures of paragraph 7.12 of this specification.

No significant differences from power line ESAs; see notes for paragraph 5.2.3.2.

SAMPLE ELECTRICAL FILTER/ ESA ASSEMBLY SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
5.2.4.4 ESA Impulse Sparkover Voltage--Impulse sparkover voltage of the ESAs shall be less than 4000 volts on a voltage surge of either polarity, having a rise rate of 1000 V/ns, when tested in accordance with procedures of paragraph 7.13 of this specification.	No significant differences from power line ESAs; see note for paragraph 5.2.3.4.
5.2.4.5 ESA Clamping Voltage--Clamping voltage of the ESAs shall be less than 900 volts at a current of 10 kA, on an 8 μs × 20 μs waveshape, when tested in accordance with procedures of paragraph 7.14 of this specification.	No significant differences from power line ESAs; see note for paragraph 5.2.3.4.
5.2.4.6 ESA Extinguishing Characteristics--(Specify)	See note for paragraph 5.2.3.5.
5.2.4.7 ESA Extreme Duty Discharge Current--The ESAs shall be rated for an extreme duty discharge current of at least 10 kA, on an 8 μs × 20 μs waveshape, when tested in accordance with procedures of paragraph 7.16 of this specification.	See note for paragraph 5.2.3.6. Increase the requirement to 20 kA if a large follow-on current is possible. If a lightning threat exists for the circuit, increase this requirement appropriately.
5.2.4.8 ESA Surge Life--The ESAs shall have a surge life of at least 1000 surges at 500 A, on a 10 μs × 1000 μs waveshape, when tested in accordance with procedures of paragraph 7.17 of this specification.	See note for paragraph 5.2.3.7. If a lightning threat to the circuit exists, increase the requirement appropriately. It may be possible to reduce the current and or duration requirement, based upon HEMP coupling analysis.

SAMPLE ELECTRICAL FILTER/ ESA ASSEMBLY SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
5.2.4.9 ESA Operating Temperature--The ESAs shall be rated for continuous operation in ambient temperatures from -25°C to +85°C (measured inside the RF filter cabinet).	See notes for paragraph 5.2.1.14.
5.2.4.10 ESA Life--The ESAs shall be warranted for a minimum service life of 3 years, provided that the surge life and other ratings are not exceeded.	See note for paragraph 5.2.1.15.
5.2.5 Filter/ESA Assembly	
5.2.5.1 Stopband Attenuation--When assembled and installed, the filter/ESA assembly shall provide at least the minimum stopband attenuation specified for the filters (see 5.2.1.5 and 5.2.2.6), when tested in accordance with procedures of paragraph 7.18 of this specification.	This is a final test of the linear electromagnetic performance of the assembly. In-place testing is preferred, but not essential.
5.2.5.2 Dielectric Withstanding Voltage--When assembled and installed, the filter/ESA assembly shall withstand twice the rated operating voltage of the filters (see 5.2.1.6 and 5.2.2.7) for a period of 1 minute, without degradation or damage, when tested in accordance with procedures of paragraph 7.19 of this specification.	This dielectric withstanding voltage test verifies the standoff of the assembly wiring. In-place testing is preferred, but not essential.
5.2.5.3 Pulsed Withstanding Voltage--When assembled and installed, the filter/ESA assembly shall withstand a 2.5 kA, 10 ns x 1.5 μs pulse applied at the assembly outer compartment terminals, without damage or degradation, when tested in accordance with procedures of paragraph 7.20 of this specification.	This is the final HEMP functional demonstration of the combination of linear and nonlinear protection elements. If a a lightning protection functional demonstration is also required, specify the applicable threat pulse. In-place testing is preferred, but not essential.
5.2.5.4 Insulation Resistance--When assembled and installed, insulation resistance of the filter/ESA assembly shall	This test verifies the R_I of the assembly wiring. In-place

be at least the minimum applicable value for the filters (see 5.2.1.13 and 5.2.2.13), when tested in accordance with procedures of paragraph 7.21 of this specification.

Note: testing is preferred, but not essential.

5.2.5.5 Operating Temperature--The filter/ESA assembly shall be rated for continuous operation, with all filters at rated voltage and full-load currents, in ambient temperatures from -25°C to +60°C (measured outside the RF filter cabinet).

Note: See notes for paragraph 5.2.1.14.

Experience indicates that the reliability of a filter/ESA assembly will be greatly improved, when operating in an environmentally controlled space. Ambient temperature should be maintained in the range of 24 + 14°C (75 + 25°F), and the assembly should be sheltered from direct exposure to the elements (sunlight, rain, etc.).

5.2.5.6 Temperature Rise--When assembled and installed, temperature rise of components in the filter/ESA assembly, with all filters at rated voltage and full-load currents shall not exceed 25 degrees C. Thermal performance shall be demonstrated in accordance with procedures of paragraph 7.22 of this specification.

Note: In-place testing is highly recommended, as a final check that the installation is proper.

5.2.5.7 Shielding Effectiveness--When the filter/ESA assembly is installed and operational, the HEMP/TEMPEST shielding effectiveness in the area of the installation shall be measured in accordance with procedures in Section _______ : SHIELDING AND PENETRATION PROTECTION SUBSYSTEM REQUIREMENTS. The presence of the protected penetration shall not degrade the shield performance below specified values.

5.2.5.8 Filter/ESA Assembly Life--The filter/ESA assembly shall be warranted for a minimum of 3 years, provided

Note: See note for paragraph 5.2.1.16.

that specified ratings have not been exceeded and prescribed maintenance has been performed (see 3.5).

6.0 INSTALLATION

Installation of the filter/ESA assembly shall be the responsibility of the contractor. The work may be subcontracted to the RF shielding specialist or the filter/ESA supplier. The installation shall be in accordance with the manufacturer's recommendations and as shown in the shop drawings.

7.0 QUALITY CONTROL

7.1 General

7.1.1 Test Procedures and Test Results--All required quality assurance testing shall be documented with test procedures and test reports, as required by Section 3 of this specification. It is emphasized that tests must be performed on actual units which will be delivered and installed and that actual test data shall be supplied to the Contracting Officer. Certifications of specification compliance, without the supporting data, will not satisfy these requirements.

The contractor should be permitted to make minor modifications to these procedures to improve accuracy, to reduce testing costs, and for his convenience. The modifications must be described in his test procedures and approved by the Contracting Officer.

7.1.2 Notification--The contractor shall notify the Contracting Officer at least 2 weeks prior to the performance of these tests. The Government reserves the right to witness all required testing.

7.1.3 Additional Government Testing--At its discretion, the Government may conduct additional testing to verify compliance with specification requirements. Such tests will be performed without interference with contractor activities and will not subject components or assemblies to stresses which exceed specified limits. The Government will notify the contractor of the

This provision attempts to ensure that products are designed to meet the performance requirements, rather than being designed to pass the quality control tests.

nature and planned time of conduct of these tests and the contractor may witness them.

7.1.4 Remedial Action--If any component or assembly fails to meet the specified requirements, as shown by required quality assurance tests or additional tests by the contractor or Government, the contractor shall replace the defective item, repair the defective installation, or take other actions necessary to achieve acceptable performance. These remedial actions shall be taken at no additional cost to the Government.

7.2 Terminal Strength Test (Filters and ESAs)--All filters and ESAs shall be tested to demonstrate compliance with terminal strength requirements. Tests shall be performed in accordance with MIL-STD-202, Method 211A, Test Condition A, modified as follows:

a. Testing shall be performed with the components mounted in the filter/ESA assembly enclosure or mounted on a plate by the same holding method which will be used for mounting in the enclosure.

b. The applied force shall be as specified in this document (see 5.1.2.2 and 5.1.3.2) and shall not be limited to values listed in MIL-STD-202.

Once again, it is emphasized that standardized procedures should be carefully reviewed and tailored to the particular character of the specific item being procured. Modifications a. and b. illustrate this point.

This provision requires every filter and surge arrester to be terminal strength-tested. When a large number of identical items are being procured, sample testing should be considered. The cost of performing the test versus the risk and system impact of noncompliance if it is not performed should be considered.

7.3 Filter Stopband Attenuation Test

7.3.1 Power Filters--All power filters shall be tested to demonstrate compliance with stopband attenuation requirements (see 5.2.1.5). Tests shall be performed as illustrated in Fig. 9 and in accordance with the following procedures:

The commonly used, filter insertion loss measurement procedures of MIL-STD-220 have several deficiencies, which make the measured

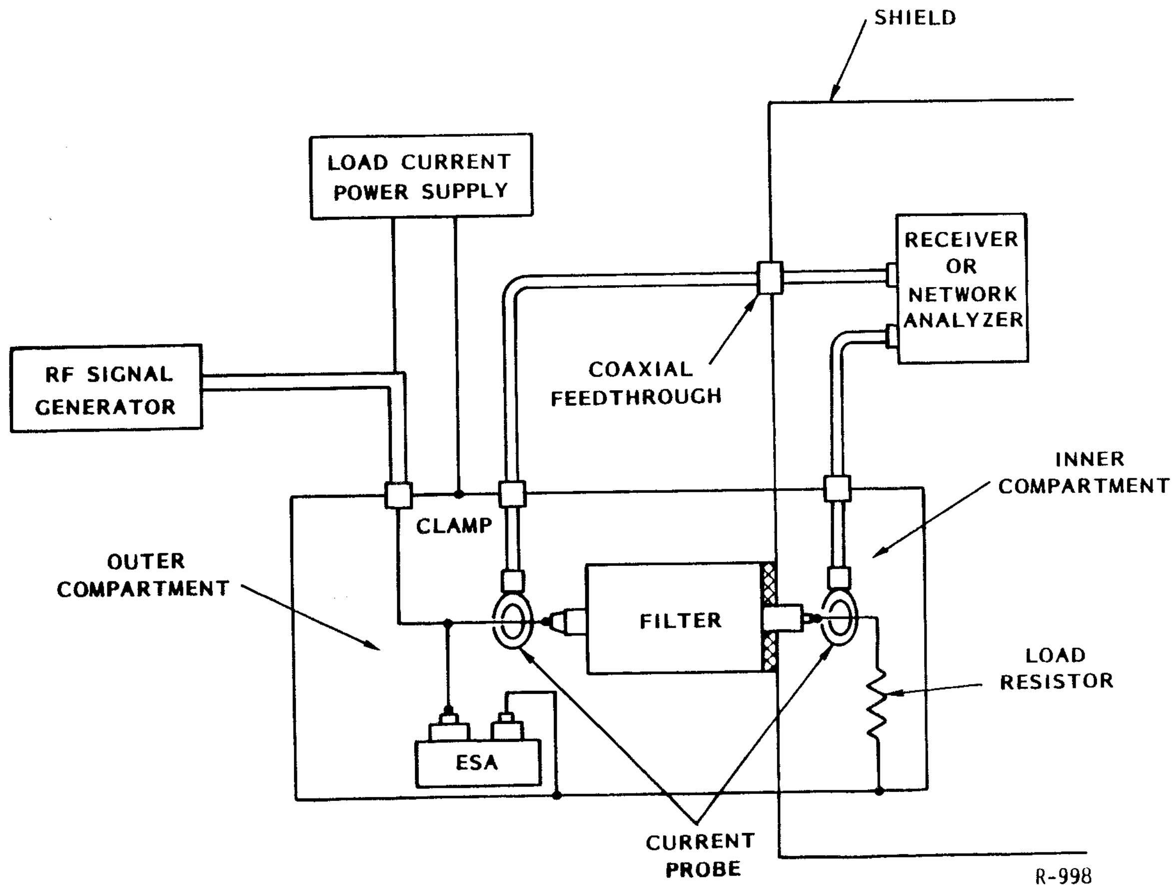


Figure **9**. Possible configuration for stopband attenuation test.

results unrepresentative of the in-place performance:

- The specified 50-Ω termination impedance does not simulate actual load characteristics.
- Frequency sampling can be too sparse, allowing stopband resonances with poor attenuation to be overlooked.
- MIL-STD-220 allows no-load testing only and full-load testing over a limited frequency range.

This procedure attempts to correct these deficiencies.

Other improved test procedures can also be devised. This method measures current attenuation; an equivalent voltage attenuation test procedure could be written. Additional variations could include:

- Discrete frequency testing, at two or three test frequencies per decade (instead of swept CW).

- Testing could be performed after installation, using facility power as the load current source.

a. The filters shall be installed in the filter/ESA assembly enclosure.

b. The load current power supply shall operate at the rated voltage of the filters and shall be capable of providing any current from no-load through rated full-load current.

This test could also be done with d.c. current, even if the filter is an a.c. device, and could be done with a source which does not operate at rated filter voltage. Arc welders and automotive batteries are convenient, low-voltage, high-current sources, if the requirement to operate at rated voltage is removed.

c. The RF signal generator shall be a swept continuous wave (CW) source, capable of operation over the entire frequency band on which attenuation requirements are specified (see Fig. 5). The CW source shall be capacitively coupled to the outer compartment terminal, to protect the signal generator from the load current power supply.

For TEMPEST-only facilities, the signal generator should be connected at the inner compartment terminal. Several signal generators, each operating over a portion of the spectrum, may be necessary.

d. Calibrated current probes shall be installed to monitor the inner and outer compartment RF currents. The probes must not saturate under full-load conditions.

e. The receiver or network analyzer shall be capable of operating over the entire frequency band on which attenuation requirements are specified. It shall be capacitively coupled to the inner compartment terminal, for protection from the load current power supply. Sensitivity shall be adequate to provide a measurement dynamic range at least 10 dB greater than the stopband attenuation requirement.

f. The load impedances shall be resistive and shall be capable of dissipating the rated full-load filter current.

g. Attenuation measurements shall be made at 20 percent, 50 percent, and 100 percent of the filter full-load operating current.

It is recommended that attenuation measurements be performed on every filter unit. When a large number of identical devices is being procured, sample testing should be considered--samples tested under all specified conditions and the remaining units tested at a subset of the specified conditions.

7.3.2 Communication/Signal Line Filters--Stopband attenuation measurements on communication/signal line filter shall be performed as described in paragraph 7.3.1, modified as follows:

a. Attenuation measurements are required at a load impedance equal to the image impedance of the filter and with zero voltage applied and a short-circuit termination.

Generally, communication/signal line filters operate at low current and inductor saturation is not an issue of concern. The measurements should be made with impedances which simulate actual loads during normal operation. This needs to be tailored to the specific application.

7.4 Filter Dielectric Withstanding Voltage Test--All filters shall be tested to demonstrate compliance with dielectric withstanding voltage requirements (see 5.2.1.6 and 5.2.2.7). Tests shall be performed in accordance with MIL-STD-202, Method 301, modified as follows:

a. Testing shall be performed with the components mounted in the filter/ESA assembly

When large numbers of identical items are being procured, sample testing should be considered.

enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure.

b. A.C. filters shall be tested with an a.c. source.

> Because of the reactive current leakage, the dielectric withstanding voltage source may draw quite high currents during the filter tests. A tunable inductor in parallel with the filter capacitance can be used to produce a parallel-resonant load, as seen in Fig. 10, thereby reducing the primary circuit and transformer current requirements.
>
> If it is absolutely necessary to perform the dielectric withstanding voltage test of an a.c. filter using a d.c. source, the test voltage shall be 4.2 times the rated a.c. (rms) operating voltage.

c. D.C. filters shall be tested with a d.c. source.

d. In addition to the physical examination, insulation resistance measurements shall be made (or repeated) after the dielectric withstanding voltage test.

7.5 Filter Voltage Drop/D.C. Resistance Test

7.5.1 A.C. Filters. All a.c. filters shall be tested to demonstrate compliance with voltage drop requirements (see 5.2.1.8 and 5.2.2.9). Tests shall be performed in accordance with paragraph 4.6.8.1 of MIL-F-15733, modified as follows:

> This test may be performed in combination with the filter/ESA assembly thermal test (see 7.22).

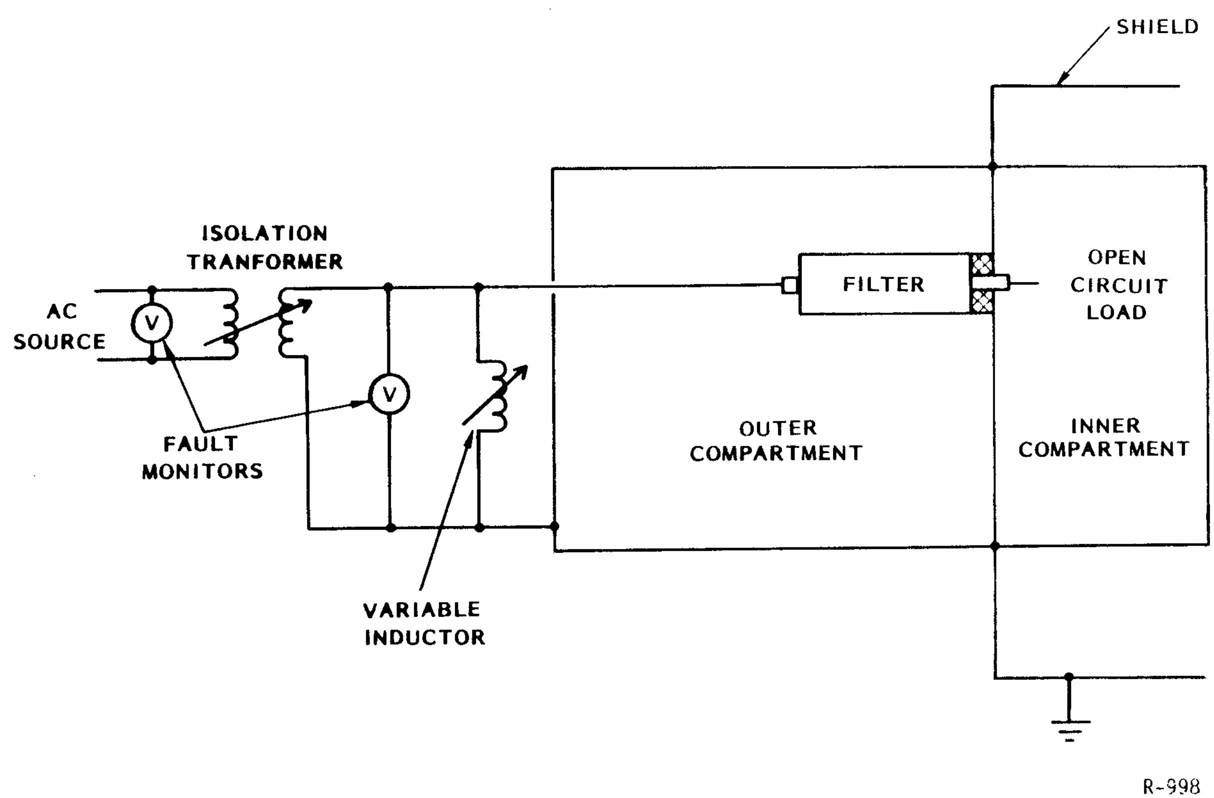


Figure 10. Possible configuration for dielectric withstanding voltage test.

SAMPLE ELECTRICAL FILTER/ ESA ASSEMBLY SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
a. Testing shall be performed with the components mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure.	When a large number of identical filters is being procured, sample testing should be considered.
7.6 <u>Filter Current Overload Test</u>--All filters shall be tested to demonstrate compliance with the current overload requirements (see 5.2.1.9 and 5.2.2.10). Tests shall be performed in accordance with paragraph 4.6.10 of MIL-F-15733, modified as follows:	The designer should consider requiring conduct of the 200 percent current and 500 percent current demonstrations, after the 140 percent current overload test.
a. Testing shall be performed with the filters mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure.	When a large number of identical filters is being procured, sample testing should be considered.
7.7 <u>Filter Reactive Shunt Current Test</u>--All a.c. filters shall be tested to demonstrate compliance with reactive shunt current requirements (see 5.2.1.10 and 5.2.2.11). Tests shall be performed in accordance with the following procedures:	This test configuration is identical, except for test voltage and the requirement for current monitoring, to the configuration for dielectric withstanding voltage testing. When a large number of identical filters is being procured, sample testing should be considered.
a. Testing shall be performed with the filters mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure.	This test may be performed in combination with the filter/ESA assembly thermal test (see 7.22).
b. The filter shall be terminated in the inner compartment in an open circuit.	
c. Rated a.c. voltage shall be applied between the filter outer compartment terminal and the enclosure (or metal plate).	See note for paragraph 7.4.b.

d. The a.c. current into the outer compartment terminal shall be monitored. This current is equal to the filter reactive shunt current.

7.8 <u>Power Filter Current Sharing Test</u>--All circuits consisting of two or more power filters in parallel shall be tested to demonstrate compliance with the current sharing requirements (see 5.2.1.11). Tests shall be performed as shown in Figure 11 and in accordance with the following procedures:

Note: This test may be performed in combination with the filter/ESA assembly thermal test (see 7.222).

a. Testing shall be performed with the filters mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure.

b. The filter inner compartment terminals shall be loaded with a resistor equal in value to the rated operating voltage divided by the sum of the current ratings of the devices in parallel. The resistor shall be capable of dissipating the total current.

c. Rated operating voltage shall be applied at the filter outer compartment terminals.

Note: See note for paragraph 7.4.b.

d. The current into each filter outer compartment terminal shall be monitored. Filters are considered to share the load equally when all measured currents are within 5 percent of the average current per filter.

7.9 <u>Filter Bleeder Resistor Discharge Test</u>--All filters operating at voltages in excess of 50 V shall be tested to demonstrate compliance with bleeder resistor discharge requirements (see 5.2.1.12 and 5.2.2.12). Tests shall be performed as shown in Figure 12 and in accordance with the following procedures:

Note: This test may be performed on a sample of each type of filter.

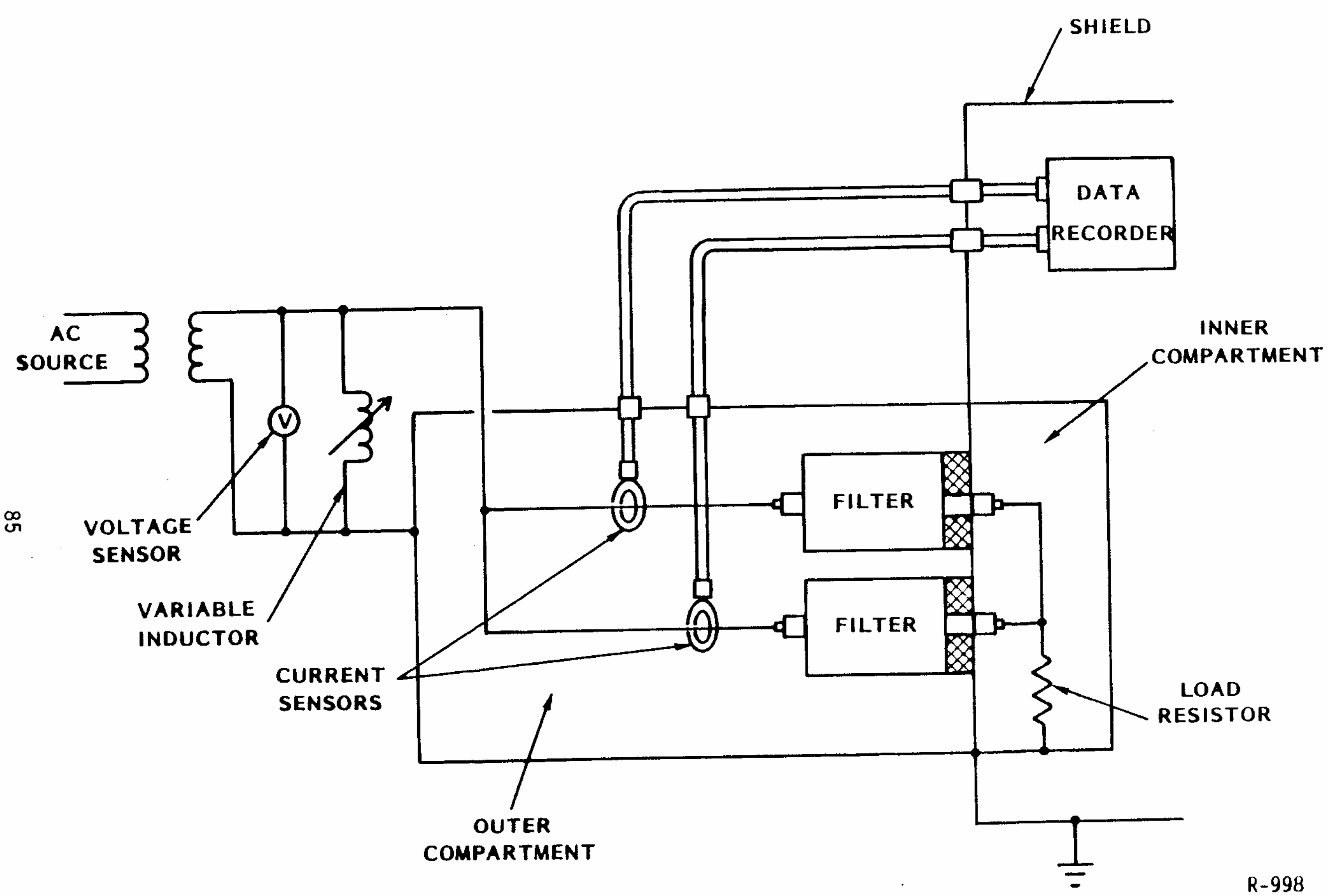


Figure 11. Possible configuration for power filter current sharing test.

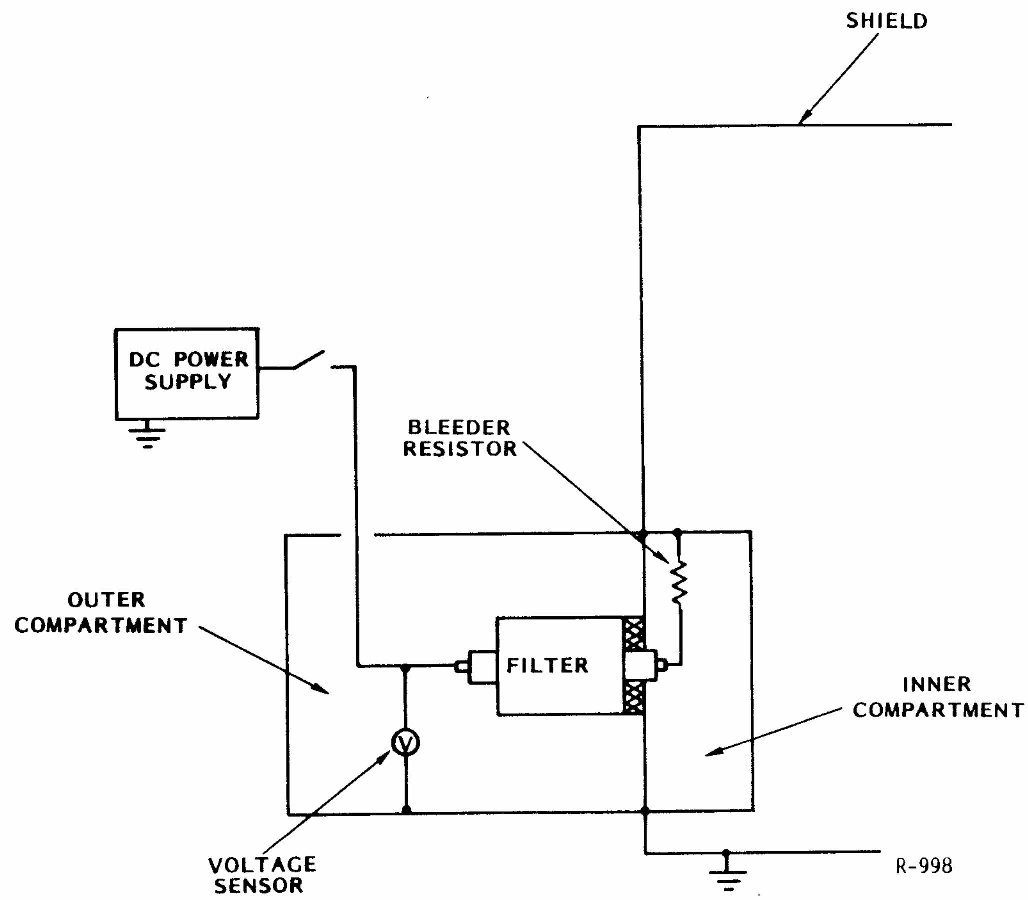


Figure 12. Bleeder resistor discharge test configuration.

a. Testing shall be performed with the filters mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure. The bleeder resistor shall be connected between the filter inner compartment terminal and the enclosure (or plate).

b. Using a d.c. power supply, the filter shall be charged to the rated peak a.c. voltage or rated d.c. voltage with respect to the enclosure (or plate).

c. Filter voltage shall be monitored. Discharge time is the time from opening the power supply output switch until voltage has decayed to 10 percent of its initial value.

7.10 Filter Insulation Resistance Test--All filters shall be tested to demonstrate compliance with insulation resistance requirements (see 5.2.1.13 and 5.2.2.13). Tests shall be performed in accordance with MIL-STD-202, Method 302, modified as follows:

An R_I measurement is inexpensive and a fair indicator of the overall condition of a filter. An R_I measurement on every filter, even among a large number of identical devices, is recommended.

a. Testing shall be performed with the filters mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure. The bleeder resistor shall be disconnected.

b. The test shall be conducted at the largest test condition voltage (100 V, 500 V, or 1000 V) which does not exceed the rated peak a.c. voltage or the rated d.c. voltage.

c. A separate d.c. power supply may be used to charge the filters to the test voltage, as shown in Fig. 13.

d. After switching to the megohm meter, the insulation resistance value shall be recorded after the reading has stabilized (rather than at a specified time).

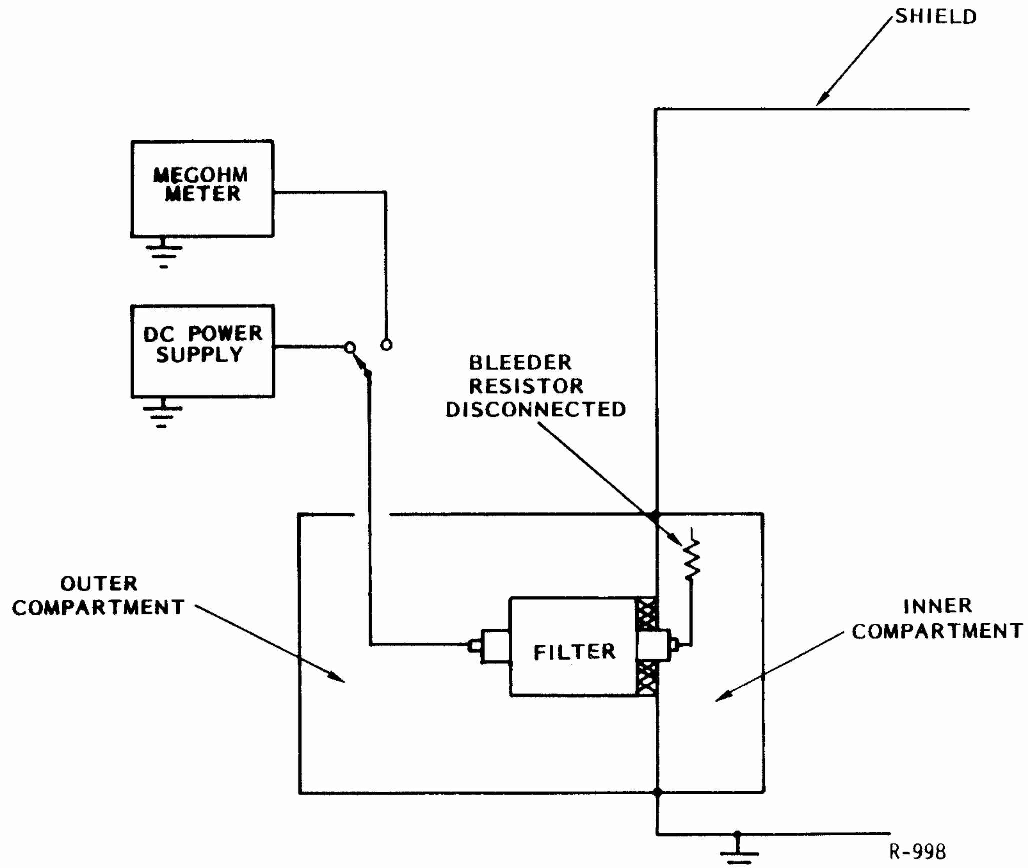


Figure 13. Filter insulation resistance test configuration.

7.11 <u>Filter Temperature Rise Test</u>--All filters shall be tested to demonstrate compliance with temperature rise requirements (see 5.2.1.15 and 5.2.5.15). Tests shall be performed in accordance with procedures of paragraph 4.6.4 of MIL-F-15733, modified as follows:

When a large number of identical filters is being procured, sample testing should be considered.

This test is also being used as a demonstration of operation at rated voltage and current. The period, 24 hours, is long enough that devices with very serious design flaws should fail.

a. Testing shall be performed with the filters mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure.

b. The period during which the filter is at rated voltage and full-load current shall be until temperature equilibrium is reached or 24 hours, whichever is longer.

7.12 <u>ESA D.C. Breakdown Voltage Test</u>--All ESAs shall be tested to demonstrate compliance with d.c. breakdown voltage requirements (see 5.2.3.2 and 5.2.4.3). Tests shall be performed in accordance with teh following procedures:

When testing an MOV, current through the ESA must be monitored and voltage should be increased in discrete steps. The applied voltage, when a steady state current of 1 mA is observed, is the parameter to be measured.

When a large number of identical ESAs is being procured, sample testing should be considered.

a. Testing shall be performed with the ESAs mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure.

b. A variable d.c. power supply shall be connected between the ESA terminal and the enclosure (or plate).

c. The applied voltage shall be increased at a rate not to exceed 10 percent of the rated d.c. breakdown voltage per second.

d. The d.c. breakdown voltage is the applied voltage just prior to breakdown (indicated by a rapid decrease in the voltage across the device). Deenergize the power supply immediately after breakdown occurs.

7.13 <u>ESA Impulse Sparkover Voltage Test</u>--All spark gaps shall be tested to demonstrate compliance with impulse sparkover voltage requirements (see 5.2.3.3 and 5.2.4.4). Tests shall be performed in accordance with the following procedures:

Impulse sparkover measurements are not usually performed on MOVs.

When a large number of identical ESAs is being procured, sample testing should be considered.

a. Testing shall be performed with the spark gaps mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure.

b. The pulse generator shall be connected between the spark gap terminal and the enclosure (or plate) with a minimum inductance connection. The pulse generator shall be capable of providing a ramp voltage of 1 kV/ns to a peak voltage which is at least twice the expected impulse sparkover voltage (into an open-circuit load).

c. Voltage across the spark gap shall be monitored 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.

A permanent record of the measured waveform data must be made. A copy of the raw data, as well as results corrected for probe and instrumentation factors

Notes: and converted into engineering units, is to be submitted as part of the test report.

7.14 <u>ESA Clamping Voltage Test</u>--All ESAs shall be tested to demonstrate compliance with clamping voltage requirements (see 5.2.3.4 and 5.2.4.5). Tests shall be performed in accordance with the following procedures:

Notes: When a large number of identical ESAs is being procured, sample testing should be considered.

a. Testing shall be performed with the ESAs mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure.

b. The pulse generator shall be connected between the ESA terminal and the enclosure (or plate) with a minimum inductance connection. The pulse generator shall be capable of providing a 10-kA current pulse, on an 8 μs x 20 μs waveshape, into a short-circuit load.

Notes: IEEE Standard 587-1980, "IEEE Guide for Surge Voltages in Low-Voltage AC Power Circuits," provides schematic diagrams for various pulse generators.

c. Current through the ESA and voltage across the ESA shall be monitored on oscilloscopes or transient digitizing recorders. The asymptotic voltage during the 10-kA portion of the pulse is the clamping voltage.

Notes: Preserve measured waveform data.

7.15 <u>ESA Extinguishing Test</u>--All a.c. power spark gaps shall be tested to demonstrate that the arc extinguishes within one-half cycle after passage of the transient, when operating at rated voltage and frequency. Tests shall be performed as shown in Figure 14 and in accordance with the following procedures:

Notes: This test may be performed on a sample of each type of spark gap.

a. Testing shall be performed with the spark gaps mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure.

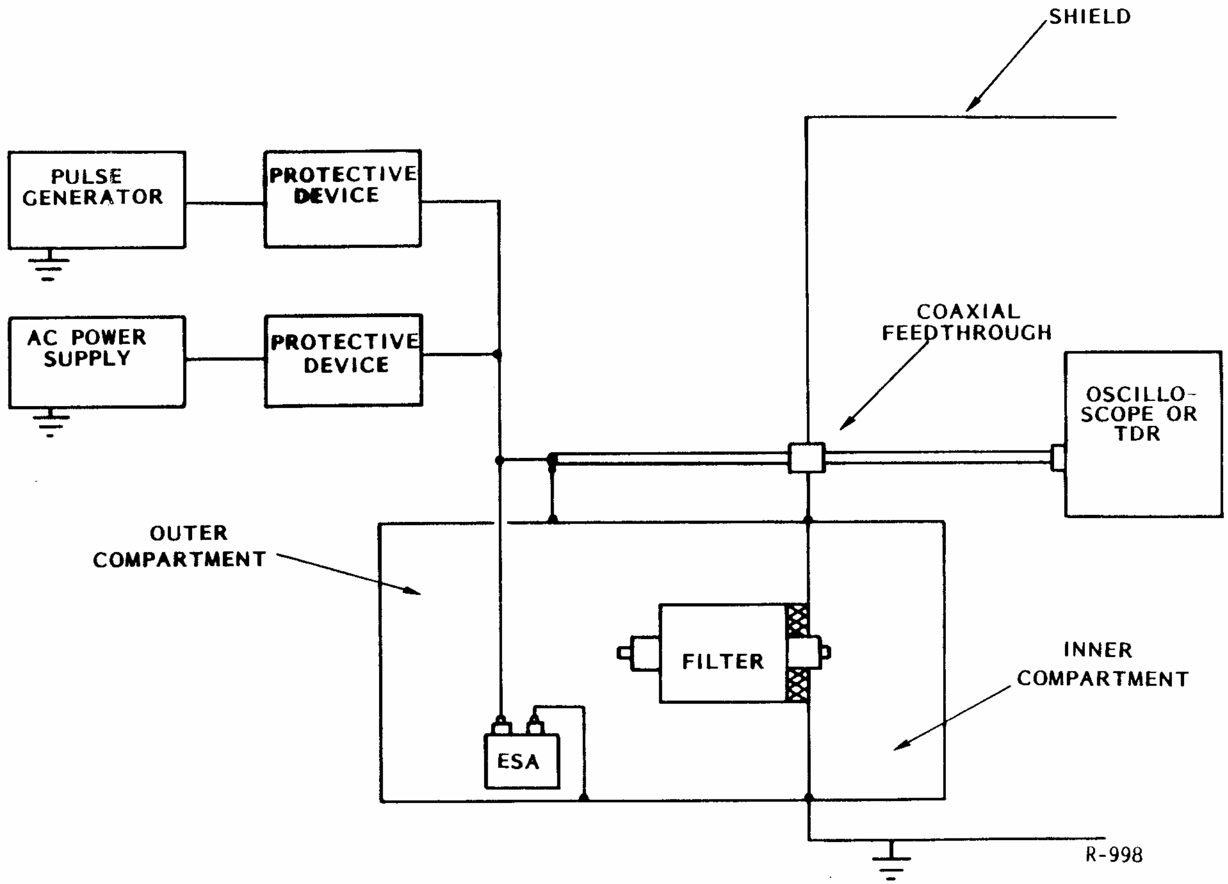


Figure 14. ESA extinguishing test configuration.

b. A power source at the rated operating voltage and frequency, capable of providing at least 25 A into a short-circuit load, shall be connected between the spark gap terminal and the enclosure (or plate). A pulse generator, capable of providing a short pulse which will fire the spark gap (amplitude and waveshape are not critical), shall also be connected across the spark gap.

Protection of the a.c. source from the pulse generator output and protection of the pulse generator from the a.c. power must be provided.

For d.c. spark gaps, a d.c. power supply at the operating voltage should be used. Appropriate provision should be made so that the test source simulates the characteristics (current limiting, fault behavior, etc.) of the circuit to be serviced by the spark gap. This test is not usually performed when the ESA is an MOV.

c. Voltage across the spark gap shall be monitored on an oscilloscope or transient digitizing recorder. A series of ten pulses shall be injected. Performance of the ESA is satisfactory if the arc extinguishes (indicated by reoccurrence of the sinusoidal waveform) within 8.5 ms after the start of each pulse.

Preserve measured waveform data.

7.16 <u>ESA Extreme Duty Discharge Test.</u> All ESAs shall be tested to demonstrate compliance with extreme duty discharge current requirements (see 5.2.3.6 and 5.2.4.7). Tests shall be performed in accordance with the following procedures:

The designer should consider performing this test only on a sample of each type of ESA.

a. Testing shall be performed with the ESAs mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure.

b. The pulse generator shall be connected between the ESA terminal and the enclosure (or plate) with a minimum inductance connection. The pulse generator shall

SAMPLE ELECTRICAL FILTER/ ESA ASSEMBLY SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
be capable of providing a current pulse of the prescribed amplitude, on an 8 μs × 20 μs waveshape, into a short-circuit load.	
c. Only a single pulse is required. Current through the ESA and voltage across the ESA shall be monitored on oscilloscopes or transient digitizing recorders. The ESA shall be visually monitored during the pulse for indications of external breakdown.	Preserve measured waveform data.
d. After the pulse, the ESA shall be carefully inspected for charring, cracks, or other signs of degradation of damage. The ESA d.c. breakdown voltage test shall be performed (or repeated) after the extreme duty discharge test.	
7.17 <u>ESA Surge Life Test</u>--All ESAs shall be tested to demonstrate compliance with surge life requirements (see 5.2.3.6 and 5.2.4.7). Tests shall be performed in accordance with the following procedures:	The designer should consider requiring one sample to be destructively tested to its specified number of pulses. When a large number of identical ESAs is being procured, sample testing in the ten-pulse series should also be considered.
a. Testing shall be performed with the ESAs mounted in the filter/ESA assembly enclosure or mounted on a metal plate by the same holding method which will be used for mounting in the enclosure.	
b. The pulse generator shall be connected between the ESA terminal and the enclosure (or plate) with a minimum induction connection. The pulse generator shall be capable of providing repetitive current pulses of the prescribed amplitude, with a 10 μs x 1000 μs waveshape, into a short-circuit load.	
c. A series of ten pulses is required. Current through the ESA and voltage across the ESA shall be monitored on oscilloscopes or transient digitizing recorders. The ESA	Preserve measured waveform data.

shall be visually monitored during the series of pulses for indications of external breakdown.

d. After the series of pulses, the ESA shall be carefully inspected for charring, cracks, or other signs of degradation or damage. The ESA d.c. breakdown voltage test shall be performed (or repeated) after the surge life test.

7.18 Filter/ESA Assembly Stopband Attenuation Test--The filter/ESA assembly shall be tested to demonstrate compliance with stopband attenuation requirements (see 5.2.5.1). Measurements shall be made on each conductor which penetrates the shield through the assembly. Tests shall be performed as described in paragraph 7.3, except that the filter/ESA assembly shall be complete and installed (except for connections to the external and internal circuits).

Notes: See notes for paragraph 7.3.

The individual filter tests (para. 7.3) check the filter components. This procedure is more thorough, since it checks quality of the installation, as well as the components. Since it cannot be done in the laboratory, it is also more expensive. The designer should trade-off the amount of laboratory testing done under paragraph 7.3 and the amount of in-place testing under this article.

7.19 Filter/ESA Dielectric Withstanding Voltage Test--The filter/ESA assembly shall be tested to demonstrate compliance with dielectric withstanding voltage requirements (see 5.2.5.2). Measurements shall be made on each conductor which penetrates the shield through the assembly. Tests shall be performed as described in paragraph 7.4, with the following exceptions:

Notes: See notes for paragraph 7.4.

This procedure checks the wiring and connections, as well as the filters. The designer should trade-off the amount of laboratory testing done under paragraph 7.4 and the amount of in-place testing done under this article.

a. The filter/ESA assembly shall be complete and installed (except for connections to the external and internal circuits).

b. When spark gap surge arresters with a d.c. breakdown voltage less than twice the rated operating voltage are used, the test voltage shall be 90 percent of the d.c. breakdown voltage.

7.20 Filter/ESA Assembly Pulsed Current Injection Test. The filter/ESA assembly shall be tested to demonstrate compliance with pulsed withstanding voltage requirements (see 5.2.5.3). Measurements shall be made on each conductor which penetrates the shield through the assembly. Tests shall be performed as illustrated in Figure 15 and in accordance with the following procedures:

This procedure is a realistic simulation of the required performance in a HEMP event and provides valuable information needed for survivability assessment. Its conduct is highly recommended, but sampling should be considered when there are a large number of identically protected penetrations.

a. The filter/ESA assembly shall be complete and installed (except for connections to the external and internal circuits).

b. The assembly inner compartment terminal (where the internal circuit will be connected) shall be terminated in a short circuit connection. The length of wiring providing the termination shall not exceed 0.3 m (12 inches) in length.

c. The pulse generator shall be connected between the assembly outer compartment terminal (where the external circuit will be connected) and the HEMP/TEMPEST shield with a low-inductance connection. The pulse generator shall be capable of providing a 2.5-kA current pulse, on a 10 μs x 1.5 μs waveshape, into a short-circuit load.

d. Three pulses are required, with peak amplitudes of approximately 400 A, 1000 A, and 2500 A. Current injected at the outer

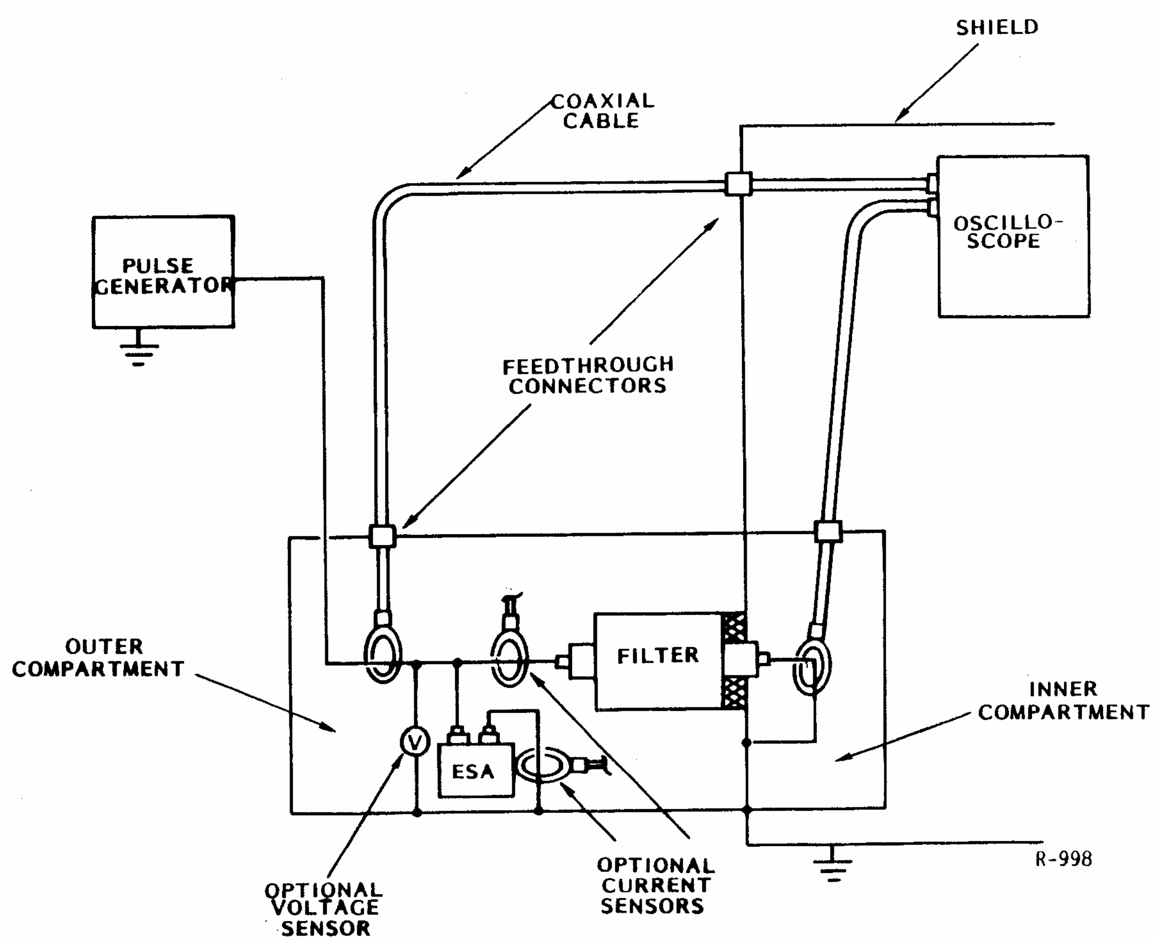


Figure 15. Filter/ESA assembly pulsed current injection test configuration.

compartment terminal and short-circuit current at the inner compartment terminal shall be monitored on oscilloscopes or transient digitizing recorders. Other optional sensor locations are indicated in Figure 15. The assembly shall be visually monitored during the pulses for indications of external breakdown.

e. After the series of pulses, the filter/ESA assembly shall be carefully inspected for charring, cracks, or other signs of degradation or damage. The assembly stopband attenuation test shall be performed (or repeated) after this pulsed current-injection test.

7.21 Filter/ESA Assembly Insulation Resistance Test--The filter/ESA assembly shall be tested to demonstrate compliance with insulation resistance requirements (see 5.2.5.4). Measurements shall be made on each conductor which penetrates the shield through the assembly. Tests shall be performed as described in paragraph 7.10, except that the assembly shall be complete and installed (except for connections to the external and internal circuits).

See note for paragraph 7.10.

This procedure checks the wiring and connections, as well as the filters. The designer should trade-off the amount of laboratory testing performed under paragraph 7.10 and the amount of in-place testing under this article.

7.22 Filter/ESA Assembly Thermal Test--The filter/ESA assembly shall be tested to demonstrate compliance with thermal performance requirements (see 5.2.5.6). Tests shall be performed in accordance with the following procedures:

See notes for paragraph 7.11.

This procedure checks the thermal behavior in the actual configuration and under the actual circulation conditions which will exist during normal operation. It is far superior to the component temperature rise tests described in paragraph 7.11. The designer should trade-off the amount of

a. The filter/ESA assembly shall be complete and installed.

b. The assembly inner compartment terminals shall be terminated in resistive loads. The value of the resistors shall be rated voltage divided by rated current. The load shall be capable of operating continuously at rated voltage, frequency, and current.

c. Thermocouples shall be placed at selected locations on components and surfaces within the filter/ESA enclosure. All expected "hot spots" shall be monitored.

d. Sources operating at the rated voltage and frequency and capable of supplying full-load current shall be connected at the assembly outer compartment terminals. All conductors which penetrate the shield through the assembly shall be simultaneously energized during this test.

e. All access covers shall be secured in place.

f. The duration of the test shall be until temperature equilibrium is reached or 24 hours, whichever is greater. Temperature equilibrium exists when the temperature

laboratory testing performed under paragraph 7.11 and the amount of in-place testing under this article.

Other tests at rated voltage and full-load current (voltage drop, reactive shunt current measurements, parallel filter current sharing) can be performed in combination with this procedure.

differential (monitored temperature minus ambient temperature) at the hottest spot and the average temperature differential for all monitored points remains constant within ±0.2 degrees C for a period of 2 hours.

g. Voltages and currents on all conductors and temperatures at monitored points shall be recorded at 15-minute intervals during the first 6 hours and at 30-minute intervals thereafter.

SAMPLE POWER, SIGNAL, FIBER OPTIC, VENTILATION DUCTS, AND PIPING PENETRATION PROTECTION SPECIFICATION

CONTENTS

FOREWORD

The integral shielding approach to HEMP/TEMPEST protection provides a metal box which encloses all equipment requiring electromagnetic emissions security and nearly all of the mission-essential equipment to be HEMP-protected. Clearly, however, a system which is totally isolated from the external environment is useless in a command and control network. Penetrations of the shield are required for many purposes, including:

- Personnel and equipment entry and exit
- Ventilation
- Utility piping connections
- Utility electrical service
- Communications to and from the facility

Unless properly treated, shield penetrations can completely negate the isolation characteristics of the metal box.

Each penetration is a potential source of electromagnetic leakage and requires special attention during design and construction, as well as periodic maintenance and inspection. This sample specification presents requirements for HEMP/TEMPEST protection of RF shield penetrations by electrical power, signal and communication circuits, fiber optic cables, ventilation ducts, and piping. Other guide specifications in this series discuss similar requirements for shielded doors and filter/electrical surge arrester assemblies.

SAMPLE POWER, SIGNAL, FIBER OPTIC, VENTILATION DUCTS, AND PIPING PENETRATION PROTECTION SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION

1.0 GENERAL

1.1 Purpose--This specification defines requirements for design, construction, installation, testing, and quality assurance related to the electromagnetic performance of penetration protection devices in HEMP/TEMPEST shielded facilities. Electrical power, signal, and communication circuit, fiber optic cable, ventilation, and piping penetrations are addressed. Other criteria related to the submittals and components specified herein appear in other sections of this document, as follows:

- Section _____: General Requirements for Contractor Submittals
- Section _____: Shielding and Penetration Protection Subsystem Requirements
- Section _____: General Mechanical Requirements
- Section _____: General Electrical Requirements
- Section _____: Electrical Filter/ESA Assembly Requirements

Notes: Delete HEMP or TEMPEST if only one of these requirements apply.

The other sections listed are for illustrative purposes only. Appropriate entries should be made for each project.

1.2 Coordination--All work under this section shall be coordinated with shield construction activities under Section __: SHIELDING AND PENETRATION PROTECTION SUBSYSTEM REQUIREMENTS.

2.0 APPLICABLE DOCUMENTS

The publications listed below form a part of this specification to the extent specified. In the event of a conflict between a referenced document and this specification, the specification shall take precedence.

2.1 Government Documents

2.1.1 Military Standards

MIL-STD-285 Attenuation Measurements for Enclosures, Electromagnetic Shielding, for Electronic Test Purposes, Measurement of

2.1.2 Military Handbooks

MIL-HDBK-419 Grounding, Bonding and Shielding for Electronic Equipment and Facilities

2.1.3 Other Government Documents

USAF Handbook for the Design and Construction of HEMP/TEMPEST Shielded Facilities (Revised, July 1986)

(Applicable TEMPEST documents)

3.0 SUBMITTALS

3.1 Shop Drawings--Drawings showing the location of filter/ESA assemblies, signal and communication penetrations, fiber optic cable penetrations, ventilation duct penetrations, and piping penetrations of the shield and fabrication and installation of their penetration protection devices shall be included in the drawing package (see Section __: SHIELDING AND PENETRATION PROTECTION SUBSYSTEM REQUIREMENTS). The drawings shall show that lengths and diameters of waveguides meet requirements specified herein. These drawings shall also show that the utility entrance vault (UEV) has been implemented, to the maximum practical extent.

3.2 Test Reports--Certified test results of the in-progress penetration weld inspections and final shield acceptance measurements at penetrations shall be submitted to the Contracting Officer. These results shall be included with the shield test results (see Section __: SHIELDING AND PENETRATION PROTECTION SUBSYSTEM REQUIREMENTS).

4.0 GENERAL REQUIREMENTS

All power, signal, and communication circuits entering the shielded volume shall be protected with filter/electrical surge arrester (ESA) assemblies which satisfy the requirements of Section __: ELECTRICAL FILTER/ESA ASSEMBLY REQUIREMENTS. All circuits entering a double door shielded waveguide or vestibule from outside or inside the shielded volume shall also be protected with filter/ESA assemblies. When the filter/ESA assembly is installed in the inside or outside configuration, the conduit connecting the filter enclosure's RF-tight compartment and the shield shall be circumferentially welded at the points of entry into the filter enclosure and into the shielded volume.

All dielectric lines (fiber optic cables, pneumatic hoses, etc.) entering the shielded volume shall penetrate through metal waveguide sleeves, which are electrically bonded to the shield. Any conducting element of the line (metal strength member, conducting jacket, etc.) shall be terminated to the shield and shall not enter the waveguide.

Ventilation ducts entering the shield shall be protected with honeycomb waveguide panels.

All metallic piping penetrations of the RF shield shall be circumferentially welded to the shield at the point of entry and shall be configured to provide waveguide protection.

Filter/ESA assemblies installed in the imbedded configuration do not require an RF-tight compartment or welded conduit.

For TEMPEST-only shielded facilities, a nonconducting conduit, duct, or pipe section approximately 15 cm (6 in) in length is required for dielectric isolation. The nonconducting insert is placed outside the shielded volume, beyond the filter/ESA assembly, waveguide sleeve, or other penetration protection device. These dielectric inserts are not required for HEMP/TEMPEST shielded facilities.

SAMPLE POWER, SIGNAL, FIBER OPTIC, VENTILATION DUCTS, AND PIPING PENETRATION PROTECTION SPECIFICATION	NOTES ON THE SAMPLE SPECIFICATION
Electrical, dielectric line, and piping penetrations shall be located at the utility entrance vault (UEV). The shield shall be grounded to the earth electrode subsystem at the UEV in accordance with MIL-HDBK-419.	In the event of a shield fault, the ground connection provides a low-impedance path to ground for external shield surface currents.
5.0 DETAILED REQUIREMENTS	
5.1 <u>Electrical Penetrations</u>--All electrical wiring penetrations of the shield shall be protected with filter/ESA assemblies. See Section __: ELECTRICAL FILTER/ESA ASSEMBLY REQUIREMENTS for detailed specifications on these protection devices.	
When the filter/ESA assembly is installed in the inside or outside configuration, the conduit from the RF compartment of the filter enclosure to the primary shield shall be an RF conduit. The RF conduit shall be rigid steel, circumferentially welded at all joints and seams and at penetrations of the shield and filter enclosure. These circumferential welds are primary shield welds and shall be inspected as required by paragraph 7.1.	
5.2 <u>Waveguide Penetrations</u>--Penetrations for dielectric fibers or hoses shall be protected with waveguides beyond cutoff. The waveguides shall have a minimum cutoff frequency of ___ GHz [inside diameter less than __ cm (_ in)] and shall have an unbroken length of at least five times the inside diameter. The waveguide shall be circumferentially welded at all joints and seams on the required unbroken length and at the penetration of the shield. These circumferential welds are primary shield welds and shall be inspected as required by paragraph 7.1 No conductors (wires, fiber cable strength members, etc.) shall pass through the waveguide opening.	See Table 1 for waveguide dimensional requirements. Some colored sheaths may be partially conducting. Conductive sheaths must be avoided.
5.3 <u>Ventilation Penetrations</u>--Ventilation penetrations of the shield shall be	See Table 1 for waveguide dimensional requirements.

TABLE 1. WAVEGUIDE REQUIREMENTS

Functional Requirements	Shielding Effectiveness (Nominal)* / Frequency Range*	Maximum Rectangular Waveguide Dimension (a)** / Minimum Waveguide Length (ℓ)
Low-Risk EMP	100 dB / 14 kHz - 500 MHz	a < 20 cm (7.9 in) / ℓ/a > 5
TEMPEST (per NSA 73-2A)	50 dB / 1 kHz - 1 GHz	a < 10 cm (3.9 in) / ℓ/a > 3
TEMPEST (per NSA 65-6)	100 dB / 1 kHz - 10 GHz	a < 1 cm (0.4 in) / ℓ/a > 5
Low-Risk HEMP + TEMPEST (per NSA 73-2A)	100 dB / 1 kHz - 1 GHz	a < 10 cm (3.9 in) / ℓ/a > 5
Low-Risk HEMP + TEMPEST (per NSA 65-6)	100 dB / 1 kHz - 10 GHz	a < 1 cm (0.4 in) / ℓ/a > 5

*TEMPEST attenuation requirements and frequency range vary with function, configuration, and location of the facility and are not restricted to those in the three common NSA specifications. When shielding and filtering are necessary, typical attenuation requirements are 50 dB to 120 dB. The highest frequency of interest will normally be from 1-10 GHz. The illustrated requirements are provided as examples and must be site-adapted in consultation with the major command TEMPEST OPR and AFCSC/SRV.

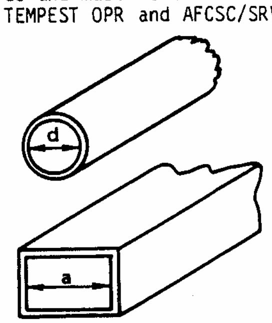
**Waveguide Dimensional Requirements

a. Round waveguide

$$d_{max} = \frac{17.6}{f_{co_{min}}} \text{ cm} = \frac{11.7}{f_u} \text{ cm} = \frac{4.61}{f_u} \text{ in.}$$

b. Rectangular waveguide

$$a_{max} = \frac{15.0}{f_{co_{min}}} \text{ cm} = \frac{10.0}{f_u} \text{ cm} = \frac{3.93}{f_u} \text{ in.}$$



where $f_{co_{min}}$ is the minimum waveguide cutoff frequency and f_u is the highest frequency of the shielding effectiveness requirement in GHz. Waveguide cutoff frequency must be at least 1.5 times f_u.

protected with honeycomb waveguide panels. Honeycomb cells shall have a minimum cutoff frequency of ___ GHz [maximum transverse dimension less than __ cm (_ in)] and shall have an unbroken length of at least five times the maximum transverse dimension. The frame of the honeycomb panel shall be circumferentially welded into the RF shield. The circumferential weld is a primary shield weld and shall be inspected as required by paragraph 7.1.

The honeycomb designation implies that the total cross-section of the opening is subdivided into a number of cells, each of which has smaller transverse dimensions than the ventilation duct and which do meet the waveguide size limit. The grid structure must be metallic and all joints must be continuously bonded.

Large areas of honeycomb, properly fabricated, can be used without fear of loss of shielding. Electrical generator air intakes, for example, may require large areas for adequate ventilation.

Honeycomb is also recommended for lighting a double-door RF vestibule, in place of filtered electrical power.

5.4 Piping Penetrations--All piping penetrations of the RF shield shall be protected with waveguide beyond cutoff stubs. The penetrating stub shall form a waveguide beyond cutoff with a minimum cutoff frequency of ___ GHz [inside diameter less than __ cm (_ in)] and shall have an unbroken length of at least five times the inside diameter. The waveguide stub shall be circumferentially welded at all joints and seams on the required unbroken length and shall be circumferentially welded to the shield at the penetration. These circumferential welds are primary shield welds and shall be inspected as required by paragraph 7.1. Dielectric linings (glass, plastic, etc.) are not permitted in the penetrating stub.

If adequate fluid flow cannot be achieved with a pipe of the maximum allowable diameter, the preferred approach is to use several parallel pipes which comply with this dimensional requirement. If a pipe with an inside diameter larger than the allowed size must penetrate the shield, a honeycomb waveguide section should be used for penetration protection. See Table 1 for waveguide dimensional requirements.

5.5 RF Conduits--All conduits designated in the drawings as RF conduits (in addition to those specified in paragraph 5.1) shall be rigid steel conduit, circumferentially welded at all joints and seams and at the shield penetration. These circumferential welds are primary shield welds and shall be inspected as required by paragraph 7.1.

RF conduits are used to protect wiring which runs between two shielded volumes.

Conduit penetrations may be made by welding the conduit to a flange and then welding the flange to the shield.

6.0 INSTALLATION

All penetrations specified in the drawing package shall be installed during construction of the RF shield and work shall be coordinated with the shielding specialist. No additional shield penetrations shall be made without approval of the Contracting Officer.

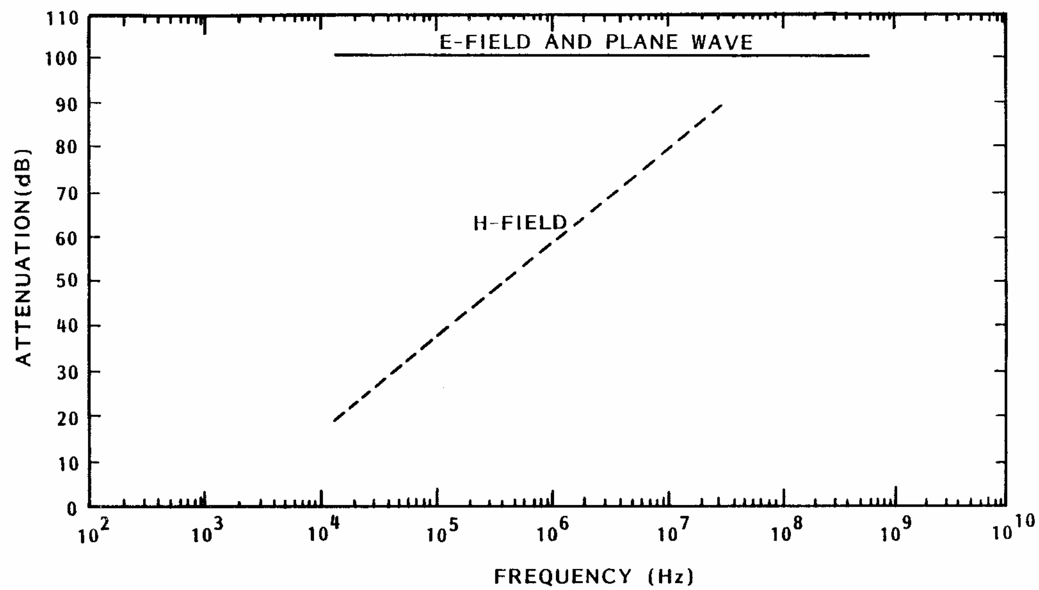
Associated primary shield welds must be included in the RF shield in-progress inspection program and shall be tested in the final shield acceptance test.

7.0 QUALITY CONTROL

7.1 In-Progress Weld Inspection--All seam, joint, frame, piping, and conduit welds which are primary shield welds used for penetration protection shall be included in the in-progress weld inspection program. Requirements for the in-progress inspection program are established in Section __: SHIELDING AND PENETRATION SUBSYSTEM REQUIREMENTS. The contractor shall maintain appropriate records to ensure that all primary shield penetration welds are checked and to record results. All unsatisfactory welds shall be repaired and retested.

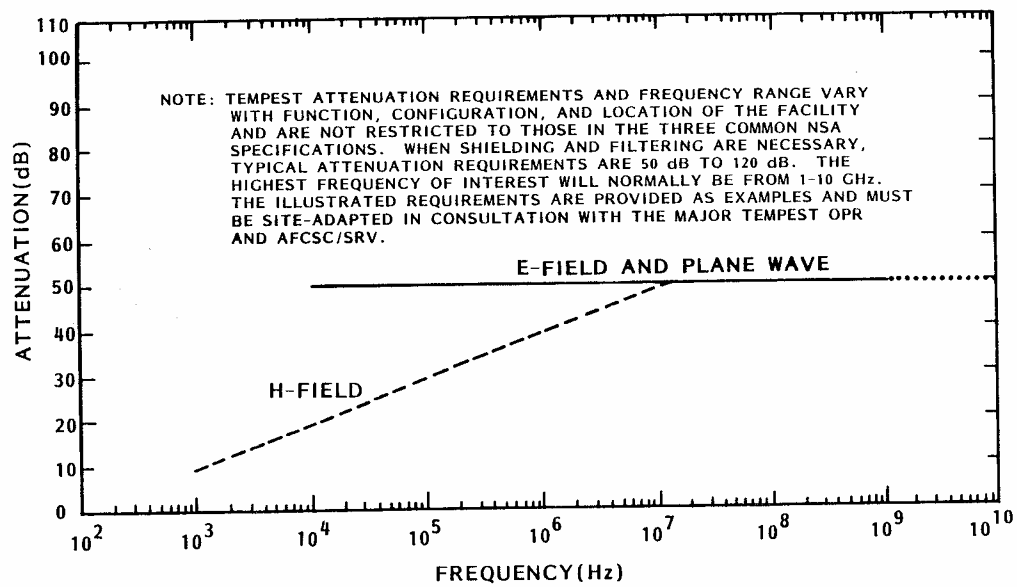
7.2 Final Shield Acceptance Testing--During final shield acceptance testing, measurements shall be taken in the vicinity of all shield penetrations (see Section __: SHIELD AND PENETRATION PROTECTION SUBSYSTEM

See the Sample RF Shield Door Specification for discussion of the three versions of Fig. 1.



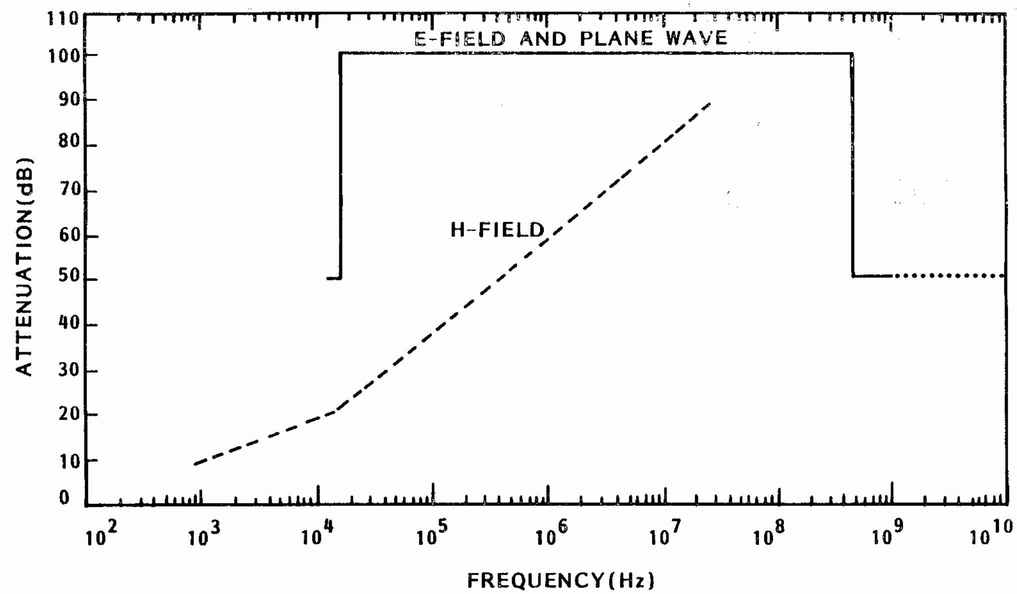
a. HEMP-only installations.

Figure 1. Shielding effectiveness requirements (use MIL-STD-285 test methods).



b. TEMPEST-only installations.

Figure 1. Shielding effectiveness requirements (use MIL-STD-285 test methods) (continued).



c. HEMP/TEMPEST installations.

Figure 1. Shielding effectiveness requirements (use MIL-STD-285 test methods) (concluded).

REQUIREMENTS). The presence of conduit and waveguide penetrations shall not degrade performance of the shield below requirements shown in Fig. 1.

Minimally, the test plan should call for MIL-STD-285-type testing at penetration locations at frequencies across the specified performance band (see Fig. 1). The contractor-prepared test plan should require measurements at the same frequencies used in testing the remainder of the shield room. Minimally, the measurements should be made at 14 kHz (magnetic), 100 kHz (magnetic), 1 MHz (magnetic), 20 MHz (magnetic), 100 MHz (plane wave), 500 MHz (plane wave), and 1-10 GHz (plane wave). If desired, the electric tests of MIL-STD-285 may be added; in the past, these tests have not shown any leakage that the other tests do not already indicate.