CHAPTER 11

DESIGN AND SPECIFICATION PROCESS

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11-2. Introduction.

a. Shielding levels. The design of TEMPEST- and HEMP-shielded facilities begins with an evaluation of mission requirements, equipment susceptibility, and threat predictions. The threat is usually a given factor. Equipment susceptibility is usually derived by standard assumptions, with mission requirements the decisive issue in shielding design. There are two types of shielding for HEMP/TEMPEST--high-level and low-level. In general, these can be classified as 100-decibel and 50-decibel shields. Often, HEMP shielding is required in a facility that also requires TEMPEST shielding. TEMPEST and HEMP should be considered together, with HEMP requirements taking precedence.

b. Welded vs. mechanical seams. Although many manufacturers advertise mechanical seam structures (bolted, riveted, etc.), these structures are strongly discouraged for a HEMP-shielded facility. If a facility mission is critical enough to warrant HEMP shielding, it needs steel sheets welded by the metal inert gas (MIG) process. Mechanical seam structures have a well documented history of poor maintainability, high repair cost, and poor overall performance compared with welded structures. Although the relative low cost of mechanical seam structures is very enticing given manufacturer claims of performance, practical experience has proven that these structures do not meet attenuation requirements above 50 decibels and, in the end, cost more than welded structures due to high life-cycle maintenance costs. Mechanical seam structures are advised for laboratory clean rooms, calibration, and low-level TEMPEST structures (see chapter 6), but not for HEMP shielding. This chapter discusses design of HEMP-shielded facilities, which may include TEMPEST requirements, and presents a typical design process.

11-3. Design approach. In designing a HEMP/TEMPEST facility, the designer must first consider the mission requirements in answering two critical questions. First, does the mission warrant the expense of HEMP shielding? If so, is it possible to isolate mission-essential/TEMPEST equipment and shield it on a component basis, or is it more economical or realistic to shield the entire facility? Once these two questions are answered, the design process is relatively straightforward. In almost all cases where HEMP shielding is required, facility shielding is the more cost-effective and intelligent choice since it maximizes flexibility for future requirements. If either component or facility shielding is chosen, the steps are the same except that one process addresses the entire facility and the other addresses each critical component separately up to some interface.

a. Exterior shield performance. Determine exterior shield performance in terms of decibels of attenuation of outside environment (threat) to interior environment. Generally, the decibel level is as previously stated--100 decibels for high-level and 50 decibels for low-level shielding when equipment to be protected is robust. If the zonal concept is used (nested shield areas), this is an iterative process.

b. Shield material and thickness. Determine the shield material and its thickness to meet the attenuation requirements (usually 10 to 12 gauge steel). Develop seam-fastening methods (shall be by inert GMAW steel for facilities). Consideration should be given to fabrication difficulties, especially for thin metal sheets.

c. Necessary penetrations. Develop a list of necessary penetrations to the shield for personnel entry, power and utilities, ventilation, and communication and control lines. Once the list is compiled, it shall be checked carefully to minimize penetrations when possible.

d. Protecting penetrations. Develop a method for protecting each penetration to meet attenuation requirements. It is desirable to provide a penetration entry room (PER) or vault to consolidate all or most penetrations into one area (discussed in detail later).

e. Test requirements. Develop quality assurance (QA) and acceptance testing requirements for construction, and evaluate hardness maintenance/hardness surveillance (HM/HS) requirements for the testing devices emplaced.

f. Configuration control. Develop a method for configuration control of the design penetrations. Consider special problems such as shield expansion, uninterruptible power supply (UPS), backup generators, and other facility-specific items.

g. TEMPEST requirements. Ensure that the shield confines all potential compromising TEMPEST emanations and contains all RED equipment.

11-4. Typical design process. The design process consists of developing design drawings and specifications. These documents are meant to be complementary, but the specifications will always take precedence over drawings. To best define this process, an example design for a standard HEMP protection system will be developed step by step. The example is for a 100-decibel welded shield only. If TEMPEST protection is required, these specifications will require appropriate modification.

a. Specification development.

(1) Applicable documentation. Normally, several publications will apply to the project. The following are examples of those that might be included:

(a) American Society for Testing Materials (ASTM) standards on steel such as:

- A 36-81A, Structural Steel
- A 366-72, Steel
- A 569-72, Steel

(b) American Institute of Steel Construction (AISC) publications such as the Specification for Design, Fabrication, and Erection of Structural Steel for Buildings (November 1, 1978).

(c) American National Standards Institute (ANSI) publications such as Z49.1, 1973 Safety in Welding and Cutting.

(d) American Welding Society (AWS) publications such as:

- A2.4-79, Symbols for Welding
- A3.080, Welding Terms
- D1.1-83, Structural Welding Code - Sheet Steel
- AWS A5.18, Steel Carbon Filler Metals for Gas Shielded ARC Welding

(e) Military Standards are very important such as:

- MIL-STD-22, Weld Joint Design
- MIL-STD-188/124, Grounding, Bonding, and Shielding for Commo Systems
- MIL-STD-202, Test Methods
- MIL-STD-220, RF Filter Testing
- MIL-STD-248, Welder Qualification Test
- MIL-STD-285, Electromagnetic Shield Testing
- MIL-STD-454, Requirements for Electrical Equipment
- MIL-STD-461, Susceptibility and EMI Control
- MIL-STD-1261, Welding Procedures for Steel

(f) Military Specifications are also critical; for example:

- MIL-F-15733, Filters, RF Interference
- MIL-B-5087, Bonding Electrical Systems
- MIL-W-8611, Welding, Metal Arc
- MIL-T-10727, Tin Plating of Metal.

(g) Some Federal Specifications may be helpful such as QQ-C-533, which covers the copper strips used in grounding, and HW-C-581, which covers steel conduit. In addition, MIL-HDBK-419 could be referenced.

(h) The National Fire Protection Association (NFPA) Publication 70-1984, National Electric Code, is mandatory.

(i) Finally, Institute of Electrical and Electronic Engineers (IEEE) Standard No. 142-1972, Grounding Practices for Power Systems, is usually needed.

(2) HEMP protection system. The three vital requirements are--

(a) A brief discussion of what HEMP is, why it is critical, to what extent the QA portion is vital, and how the HEMP requirements take precedence over all others.

(b) The HEMP performance requirement for the facility.

(c) A statement that no penetrations will exist except those on the penetration schedule included in the drawings without written approval of the contracting officer (CO).

(3) HEMP system components.

(a) Shield. The shield thickness, the ASTM Standard (usually A36), and the fact that the welding procedures shall conform to this section are given.

(b) Penetration. This paragraph usually discusses the fact that all penetrations will be treated and that no penetrations are allowed other than those listed on the penetration schedule without written CO approval. This paragraph also explains how penetrations will be highlighted on the drawings (stars) and that any accidental penetrations will be repaired at no expense to the Government.

(c) Doors. This paragraph briefly covers the doors, usually stating that they will be complete assemblies including frame and hardware. It is also usually mentioned that doors will be welded in place in conformance with this section, and any interlocking doors are covered here as well. Since a separate paragraph covers doors in detail, it is usually referenced here.

(d) Waveguide-beyond-cutoff (WBC) penetrations. This paragraph defines the maximum length-to-diameter ratio (5 to 1 for 100 decibels and the maximum allowable diameter (6 inches for 500 megahertz) (10 centimeters for 1 gigahertz and 1 centimeter for 10 gigahertz when there is a TEMPEST requirement). It generally mentions that all WBC penetrations for utilities will conform to requirements and references the paragraph that discusses WBC penetrations in detail.

(e) Pipe penetrations. This paragraph usually says that all pipe penetrations will be welded to the shield at the circumference as shown in drawings and not exceed the maximum allowable diameter (6 inches for 500 megahertz) (10 centimeters for 1 gigahertz and 1 centimeter for 10 gigahertz when there is a TEMPEST requirement).

(f) Electrical filters. This paragraph usually says that all power, communication, and control/signal lines other than fiber optic penetrating the shield will be provided with filters. The paragraph that discusses these lines in detail is referenced.

(g) Surge arresters. This paragraph generally states that the arresters must be installed according to manufacturer specifications and that they must have short leads (to form a low impedance path to ground) to work best. It references the paragraph detailing this component.

(h) Grounding system. This paragraph basically states the importance of the grounding system to the proper function of the system and notes that it is critical to follow the drawing during installation.

(4) General requirements. This section generally covers areas that are not directly applicable to specific system components such as QA and coordination.

(a) Usually a standard products paragraph is included which basically says that the equipment will be new and produced by a manufacturer regularly engaged in this type of work. It states that strict conformance to this section will be required.

(b) Usually a standard compliance paragraph is included to state that Underwriters Laboratories (UL) and other accepted labels will be accepted as proof of meeting standards already described. Otherwise, equipment not so labeled will be tested by an authorized agency and a written letter of certification provided.

(c) Another paragraph will state the contractor is responsible for integrating the shield system into the overall facility as shown on the drawings and for meeting this section of the specification exactly.

(d) A critical statement usually is included which is vital in avoiding the selection of unqualified AEs. It states that the system shall be provided by a firm regularly employed in this type of construction on an equal scale which has successfully completed several similar facilities. The CO may reject any proposed supplier or installer who cannot show documented evidence of these qualifications to the COs satisfaction. Finally, all work on the shield shall be under the supervision of competent, experienced HEMP shielding personnel.

(e) Another critical paragraph is that of coordination, which basically states that the contractor is responsible for ensuring that all disciplines realize the importance of the shielding and do not cause unauthorized penetrations to the shield. It also states that the contractor is responsible for repair of any compromise to the shield and must coordinate and submit in writing to the CO any changes to the HEMP system design.

(f) The next paragraph usually addresses the protection of materials from weather and corrosion.

(g) The last paragraph of this subsection states that the contractor is responsible for all testing--both QA and acceptance--and references the paragraphs that describe them in detail.

(5) Submittals. This section details the submittals required on a HEMP project.

(a) Manufacturer certificate. This paragraph generally states that the contractor shall submit certificates of compliance for all materials. Specifically included are--

- Shield: all steel and weld materials.
- Doors: certified test results, materials, and O&M data.
- WBCs: certified test results.
- Filters and surge arresters: certified test results.

(b) Shop drawings. This requirement is vital since it requires a complete list of equipment and materials, including manufacturers' literature, catalog cuts, and installation details. Shop drawings should show the sequence of shield construction; sizes, arrangement, and method of fabrication and installation; equipment layout; and details that prove the integrity of the shield as a complete system. Typical details will be provided that clearly show how the shielding effectiveness is maintained. Examples are--

- Shield. Details will be provided that display the locations of floor anchors, elevations, joint connections, types of welds, assembly and erection structural ties between shielding and building structure, connection to shield supports, and anchorage.
- Ground system. Connection details of the grounding system and shield will be given.
- Shielded doors. Manufacturer drawings showing the method of construction, attachment to shield, and control systems will be provided.
- WBCs. The size of opening, welding method, length of WBC, and attachment to shield will be shown.
- Filters and surge arresters. Manufacturer's drawings for enclosure, closure gaskets, and installation of components will be provided. Shop drawings will depict the location of the enclosure, method of attachment to the shield, conduit, manufacturer's data, and specifications for filters and surge arresters.

(c) Quality assurance (QA) plan. This section normally includes as a minimum--

- The contractor's organization plan showing how QA integrates with job-site management.
- Names, positions, and qualifications of all QA personnel and their responsibilities.

- Written proof of the authority vested in each individual or agency, including testing laboratories hired for the QA. A copy shall be included in the contractor's plan.
- The methods to be employed in daily inspection and testing.
- A sample format of the contractor's daily QA report. Specific test report forms shall be submitted for approval at least 10 days before the first use. Legible copies of the daily inspection reports shall be maintained by the contractor onsite at all times. The original copies of the "construction QA report" shall be submitted to the CO on the work day following the date of the report period, along with other items as required to assure adequate QC. Results of all inspections and tests performed by the contractor in accordance with the technical provisions shall be attached to the daily construction QA report.
- The location and description of all testing facilities and equipment to be used onsite.
- Procedures for control, submittal, and checking of contractor documents as required.

(d) Test procedure. A detailed test plan/procedure must be approved by the CO for in-progress and final acceptance testing. Included should be identification of personnel, test equipment, test schedule, methods, specific test points, and frequencies. The test procedure should detail the method of implementation and application of the procedures to be performed as part of the in-progress and final acceptance testing to verify compliance with the specifications. Testing should not commence without the CO's approval of the test procedure. The test plan should include--

- Introduction and scope. (Statement of purpose and relation to shielding. List of all tests to be performed.)
- Applicable documents. (Military, company, other.)
- General. (Description of in-progress testing and when used. Description of MIL-STD-285 acceptance testing and when used. Calibration method for equipment.)
- Test procedure. (Block diagram of each setup. Equipment used in each test. Detailed test procedure showing placement and orientation of antennas or probes, test frequencies, test points, data to be recorded, units of measure, and success criteria.)
- Outline of test report.

(e) Qualification of welders. The contracting welders' qualifications must be defined. Welding should be performed only by welders certified in the required process (MIG for the shield). Prior to assigning welders for HEMP shield work, the contractor should provide names of candidates to be employed together in the process specified in AWS D1.1 and D1.3 as required by the CO. It is vital that this paragraph state that the contractor shall submit identifying stenciled test specimens made by an operator whose workmanship is subject to question. Further, it will note that the welder must be retested and recertified at no cost to the Government. It is also critical for this paragraph to state that any defective weld that compromises shielding effectiveness shall be ground out and properly rewelded. Other measurements and tests of welder capability are also recommended for inclusion here.

(6) Quality assurance. This section should state that the contractor is responsible for all in-progress testing of shield welds and HEMP protection devices as required and that all deficiencies will be corrected at no cost to the Government.

(7) Delivery and storage of materials. These requirements should be described briefly in terms of ensuring no damage to components, areas not approved for storage, and repair at no cost to the Government.

(8) Materials and equipment. These requirements should be covered in detail as a major part of the specification in a breakdown similar to that below.

(a) Shielding materials. The shield plate shall comply with ASTM A36 and be uncoated, degreased, and cleaned prior to installation. All sheets shall be flat or formed into appropriate shapes with no bends, kinks, or other deformities except those required by plans. Rusted or dirty steel shall not be installed. Steel sheets shall be sized for optimal fabrication and installation, and shall be a minimum of 3/16 inches thick.

(b) Weld filler material. This shall conform to AWS A5.18.

(c) Miscellaneous materials and parts. All materials necessary to complete each item, even though work is not definitely shown or specified, shall be included.

(d) Miscellaneous metal members. These shall conform to ASTM A36.

(e) Grounding. Any departures from the grounding system shown in contract drawings shall be submitted to the CO for approval. Grounding methods will comply with NFPA 7D, IEEE 142, and MIL-STD-188/124. Grounding guidance can be obtained from MIL-HBK-419.

(f) Material adjacencies. No materials shall be used in a combination that causes an electrolytic couple which creates unacceptable corrosion.

(g) Conductors. These shall be copper of a grade equal to standard commercial installation designated as being 98 percent conductive when annealed. Ground conductors for grids will be bare-sized as shown in drawings.

(h) Ground rods. The ground rods shall be copper-clad steel at least 3/4 inch in diameter and 10 feet long, exothermically welded to the grounding conductors and shield.

(i) Bonding of facility metal. Any metal that contacts the shield shall be bonded in accordance with MIL-B-5087, Class R System requirements and applicable safety practices.

(j) Penetrations. The contractor shall carefully determine all penetrations required in the shield. All electrical conduit penetrating the shield and within the PER and utility entry vault (UEV) shall be zinc-coated steel conduit (heavy metal rigid conduit all welded at points) as specified in Fed-Spec WW-C-581. Since zinc coating must be removed before welding, non-zinc coated conduit can be used where it will not be exposed to weather or corrosion. This section also should--

- Provide all WBC filters and penetration protection devices necessary to meet the specified attenuation.
- State that interfaces between trades (electrical, mechanical, plumbing, etc.) such as penetrations of the shield shall be coordinated to precisely match and maintain shield integrity.
- State that the finished facility shall not contain any unauthorized penetrations to the shield not shown on the approved drawings and penetration list. The contractor shall be responsible for warning all trades against unauthorized penetrations. Any repair or modification necessary as a result of unauthorized penetrations will be the responsibility of the contractor at no cost to the Government.

(k) RF shielded doors. This section shall state that--

- Doors should have attenuation of at least 10dB higher than the facility because doors degrade quickly.
- Doors shall be furnished by a firm regularly employed in the successful manufacture of similar products and shall duplicate assemblies that have had a proven satisfactory use over 2 years.
- The contractor shall submit test results proving that the doors shall meet the attenuation requirements over their life expectancy. However, these documents shall not relieve the contractor of onsite and acceptance testing. Shielding attenuation shall meet the requirements of NSA 65-6.
- RF seals, gaskets, and compact surfaces shall be permanently protected against physical damage by the shape of the jamb. They shall be readily replaceable without special tools.
- Frequency of operation shall be continuous. All components and assembly of door shall be of strength and size to function properly through 50,000 cycles of usage.
- Door material, including all components and assembly, shall conform to ASTM A 366 or A 569 for steel and be stretcher-leveled. Minimum thickness is 10 gauge.
- RF fingerstock for shielded doors shall be double-row conforming to Fed-Spec QQ-C-533 and installed around the periphery of the door and/or frame. The fingerstock shall use an extruded channel containing a recess into which two sets of beryllium copper contact fingers are fitted. The fingerstock shall be easily removable without special tools. The door

edge shall use a knife edge to mate to the fingerstock in such a way that optimal conductivity is obtained and attenuation requirements are met.

- All doors shall have suitable three-point latching mechanisms that provide proper compressive force for the RF seal through fingerstock. All latching shall be by roller bar system. All doors shall have three well balanced ball bearing or adjustable radial thrust bearing hinges.
- Threshold protectors shall be provided as ramps covering the knife edge for moving heavy equipment through RFI doors.
- Door interlocks shall be developed so that only one door can open at once.

(l) Waveguide-beyond-cutoff. Vents and panels shall provide the specified attenuation when installed in the shield configuration. Construction of WBC shall be according to drawings, with no WBC entry exceeding 6 inches (10 centimeters or 1 centimeter if there is a TEMPEST requirement) in diameter and a ratio of 5 length to 1 diameter. The WBC 5-to-1 length shall not be broken by drill holes, joints, or other openings from the point at which it enters the shield. Honeycomb vents (stacked WBC) shall be used for large airflow areas. A maximum of 4 inch squares brazed or soldered into a 1/4-inch metal frame by brazing or welding is permitted with a flange plate at least 6 inches wide. The flange plate serves as an insulator to weld the WBC to the shield without melting the solder or brazing the panel. Such WBC panels will be covered to protect against insect or bird invasion as required.

(m) Electrical filters and surge arresters. These devices shall be installed on all power, communication, signal, and control hardware penetrating the shield. Many manufacturers offer these devices. A minimum set of specifications to be met will follow in this section. Ground lengths shall be minimized for all filter/surge arrester installations. Also state that--

- Each filter unit shall be capable of being installed individually and shall include one filter for each phase and neutral wire for power lines or one filter for each conductive line or pair for communications and control lines.
- Filter units shall be provided in RF-modified NEMA type 1 enclosures made of not less than 14-gauge steel with welded seams. The enclosures shall be galvanized or electroplated after fabrication and welding, or the enclosure shall be finished with a corrosion-inhibiting primer and two coats of enamel. The enclosure will be RF-tight, 100 decibels from 14 kilohertz to 500 megahertz (both compartments). For TEMPEST protection, frequency requirement is 14 kilohertz to 1 gigahertz or 10 gigahertz.
- The power or control/signal input terminal compartment shall be separated from the power or control/signal output compartment by a solid steel barrier plate of the same gauge as the filter unit enclosure compartment extending across the width of the enclosure to form a 100-decibel barrier from 14 kilohertz to 500 megahertz. For TEMPEST protection, frequency requirement is 14 kilohertz to 1 gigahertz or 10 gigahertz. The output

compartment shall house the individual power line filters and the output terminals of the filter.

- The input terminal end of the individual filter case shall be attached to the RF barrier plate between two compartments to provide attenuation in accordance with NSA 65-6. The input terminals of the filters shall project through openings in the RF barrier into the input terminal compartment. The case of each filter shall be attached to the enclosure to prevent stress from being applied to the RF seal between the case and the RF barrier plate.

- The output and input compartments shall have no knockouts; weld conduits shall be welded to enclosures at the circumference.

- Access shall be from the front of the enclosure. The access opening for the load terminal compartment shall provide clear access to the filter input specified herein. The power output compartment opening shall provide clear access to the filter output terminals and the stand-off insulator terminals or insulated terminal blocks. It shall also allow easy removal of the individual filters from the enclosure. Two access cover plates shall be provided. One plate shall cover the access opening to the power input terminal compartment only and when secured in place shall provide an RF-tight seal with the compartment it covers. The second access cover plate shall cover the power output compartment only. RF gaskets shall be provided for both terminal compartment cover plates. The cover plates shall be secured with bolts having a maximum spacing of 3 inches. Access cover plates shall be made of not less than 14-gauge steel and the finish, except for bare-metal mating surfaces, shall be the same as specified for the enclosure. Plates shall be attached so as to be easily removed and replaced. Access cover plates should have folded edges to reduce uneven compression of the cover gaskets. Access panel retaining bolt torque shall provide 25 percent compression of the gasket over its entire contact surface (approximately 30 pounds per linear inch of gasket). Alternately, 0.094-inch-thick spacers may be used to provide proper gasket compression. All gasket contact areas shall be tin-plated per MIL-T-10727.

- Both terminal compartments shall provide an attenuation of not less than 100 decibels to radiated RF energy from 14 kilohertz to 500 megahertz with the individual filters mounted and the access cover plates attached.

- Individual filters shall be sealed in a steel case. The filter shall be sealed with an impregnating or potting compound meeting the requirements of MIL-F-15733 and having a flashpoint for operating temperature range B as defined in Table VIII of MIL-F-15733. After the filter is filled with an impregnating or encapsulating compound, the seams shall be welded. When a solid potting compound is used to fill the filters, the filters may be mechanically secured and sealed with solder. Hermetically sealed, impregnated capacitors shall be used, or the complete filter assembly shall be vacuum-impregnated. Individual power filter cases shall be made of not less than 14-gauge steel and corrosion-resistant primer and two coats of finish enamel. When enamel finishes are used, clean and free grounding surfaces of paint and/or insulating material.

- Provide the manufacturer's nameplate on each filter enclosure stating the filter's rated current, rated voltage, operating frequency, number of phases, lines or pairs for which it is designed, manufacturer's name, total filter unit weight, and model number. The nameplate shall be mounted on the filter enclosure to be visible after installation without removing cover plates or disturbing the interior parts or wiring. Each individual filter case shall be marked with the rated current, rated voltage, manufacturer's name, type of impregnating or potting compound, operating frequency, and model number. In addition, individual filter cases and the filter enclosure shall be durably marked by the manufacturer with the following statement: "Warning: Before working on filters, terminals must be grounded to ensure discharge of capacitors." Nameplates and warning labels shall be attached with epoxy. Each filter enclosure and each filter within the enclosure shall be numbered and recorded on the drawings for ease of location.

(n) Penetrator vault treatments. These are usually covered as follows--

- All conductive penetrators such as pipes and shielded cable must be treated as per MIL-STD-188/124 in the entry vault area. All conductive cable shields/sheaths must be grounded or be circumferentially bonded to the PER entry panel in the vault area as they enter the PER area.
- Where shielded cables are terminated in connectors on the PER entry panel, the cable shield must terminate at the connector and not be carried through the entry panel via a connector pin.

(o) Waveguides. Waveguide penetrations shall enter the facility at the PER entry panel. Waveguides will be peripherally welded or brazed to the communication vault side of the entry panel. All mechanical fasteners that penetrate the entry panel shall be circumferentially welded or brazed.

(p) Fiber optic cables. Fiber optic cables shall have no conductive strength members or vapor barriers. They shall enter the facility through the PER via conduit or pipe that is circumferentially welded to the entry panel and the back shield, thus effecting a WBC. The fiber optic conduits shall be identified at the shield and backshield penetrations and marked with notices prohibiting their use for anything other than fiber optic cables.

(9) Construction of the shield. This section usually covers the actual construction as follows:

(a) Workmanship. Metal work for the shield shall be formed to the correct shapes with sharp lines, angles and curves, and finished in accordance with approved shop drawings and samples. Welding of shielding liner shall conform to the requirements of this section. The mating surfaces of materials to be welded shall be clean and free of rust, scales, oil, and other deleterious materials. All exposed surfaces shall have a smooth finish. Steel plates shall be placed in a straight line with true level and joints.

(b) Sequence of installation. The basic design of this project assumes installation of the floor shield prior to erection of the structural system. The contractor may, as an option, choose to erect the structure first and install the floor shield later in the project. Should this option be selected, the contractor will so indicate to the Government and ensure that the required shop drawings and erection details clearly indicate the methods to be used to ensure shield integrity under all column and other structural members. All shielding components must be installed and approved in final inspection prior to construction of any features that would limit access for repairs to the shield.

(c) Placement of floor shield. Floor shield placement shall not begin until at least 14 days after the floor slab is poured and the Government has approved all required submittals.

(d) Placement of overslab. Approval of the CO's representative is required prior to pouring slab over any portion of the floor shield. Both visual and shielded-enclosure-leak-detection-system (SELDS) testing of shielded area to be covered must be completed, any defects repaired and retested, and full test results supplied to the CO prior to pouring the overslab.

(e) Penetration entry rooms. The PERs for the terminal equipment building and generator building provide a location for treatment of penetrations of driven conductors and for placement of in-vault treatments. The outer wall and floor surfaces of the PERs serve as the entry panel. The entry panel shall be constructed of 1/4-inch-thick ASTM A 36 steel plate welded in the same manner as the facility shield. The backs, or inner, walls of the PERs (backshields) shall be constructed of the same material as the facility shield. Filter enclosures for treatment of electrical penetrations shall be circumferentially welded to the inner surface of the entry panel. RFI-tight construction practices as described in this section must be exercised in the PERs--particularly for conduit and piping runs. This treatment requires heavy metal rigid welded conduit.

(f) Control of warping. Warping of steel shielding plates during installation and welding shall be kept to a minimum. Embeds and drive pins may be employed to hold plates in place during welding. Other techniques also may be employed to reduce warpage such as skip welding. However, when welding is complete, full penetration welds shall be used and drive pins shall be circumferentially welded.

(g) Repair of warped floor shield. With the exception of floor shield plates under concrete block walls, all steel floor shield plates that have a warp with an amplitude greater than 3/4 inch or a void longer than 3 feet between the underside of the plate and the concrete slab shall be cut out and replaced with new steel plate which will lie flat within these tolerances after all welding has been completed. The floor shield plates must lie flat and bear continuously on the concrete leveling slab under all concrete block walls.

(10) Shielded door installation. This part is generally defined as follows. Door assemblies shall be welded to the shield in accordance with the manufacturer's installation instructions and approved shop drawings. Care shall be taken during installation to prevent damage, especially to fingerstock and RF gaskets. Doors, frames, thresholds, and associated hardware shall be furnished as preassembled matched units, each of which is to remain sealed until the installation has been accepted by the manufacturer's erection engineer and the CO. Each unit shall be installed in its respective door opening in accordance with the door manufacturer's instructions. Alignment shall be maintained within the tolerances established by the door manufacturer.

(a) Supervision. The door manufacturer's representative shall supervise the installation and checking of door assemblies.

(b) Post-installation protection. During the construction phase, the opening and closing of doors shall be kept to a minimum in order to limit wear on the door components, particularly the contact surfaces. The contractor shall plan his operations to keep the doors in a permanently open position with protection over sensitive components during all construction activities. When construction in the affected rooms has been completed, doors shall be locked in the closed position. All components that sustained damage during the construction phase shall be replaced at no cost to the Government. Temporary covers of not less than 5/8-inch plywood shall be secured to protect exposed RF barrier contactors from physical damage. Easily removable masking or strippable coatings shall be applied over contact surfaces to prevent soiling and corrosion.

(11) Shield welding and brazing. These skills are vital in attaining good attenuation in shielding. This section should be addressed similar to the following example.

(a) Location and types of welds. Weldments critical to the achievement of shielding effectiveness for the facility are shown in the drawings (see para b below). Shield welds shall be performed in the manner shown in the drawings using a GMAW (sometimes referred to as MIG) process in accordance with MIL-W-8611 and MIL-STD-1261. However, it should be noted that the term "critical" shall be used as defined above. The welding procedure and welding operator performance shall be qualified using MIL-STD-248 and shall comply with the Structural Welding Code of the American Welding Society. Where both structural integrity and shielding quality are required for a given weldment, both criteria shall be met simultaneously. Where not otherwise specified in this document, welded joint design shall follow MIL-STD-22. These joint design restrictions may be relaxed if it can be shown that shielding quality will not be degraded. All brazing shall conform to the above documents, where practical, and shall also conform to requirement 59 of MIL-STD-454.

(b) Weld quality. The general quality of weldments shall be such that no gaps, burn-throughs, holes, cracks, bubbles, wormholes, undercuts inclusions or porosity is present. Fillet welds shall be heavy and oversized with a weldment thickness of not less than 3/16 inch and width of not less than 3/8 inch. Unless otherwise specified, all shield welds shall be continuous (or circumferential or peripheral) with no metal discontinuities allowed.

(12) Welding procedure qualification. This section should read substantially as follows:

(a) General. Each contractor to perform welding shall record in detail and shall qualify the welding procedure specification for any welding procedure that will be followed in making weldments. Qualification of welding procedures shall be in conformance with the applicable requirements of AWS D1.1, AWS D1.3, and as specified herein.

(b) Approval. Copies of the welding procedure specification and procedure qualification test results for each type of welding that requires procedure qualification shall be submitted for approval. Approval of any procedure, however, will not relieve the contractor of the sole responsibility for producing a finished structure meeting all requirements of these specifications. Welding procedure specifications shall be identified individually and shall be referenced on the shop drawings and erection drawings.

(c) Retests. If procedure qualification tests fail to meet the requirements of AWS D1.1, the welding procedure will not be approved, and the procedure specification shall be revised and requalified; or, at the contractor's option, retesting may be performed. If the welding procedure is qualified through retesting, all test results, including those of test welds that failed to meet the requirements, shall be submitted with the welding procedure.

(13) Other welding qualifications. This section usually includes the following requirements:

(a) General. Each welder, welding operator, and tacker assigned to work on this contract shall be qualified in accordance with the applicable requirements of AWS D1.1, AWS D1.3, and as specified herein. Welders, welding operators, and tackers who make acceptable procedure qualification test welds will be considered qualified for the welding procedure used.

(b) Certificates. Prior to assigning any welder, welding operator, or tacker to work under this contract, the contractor shall provide the CO with the names of the welders, welding operators, and tackers to be employed on the work, together with certification that each individual is qualified as specified herein. The certification shall state the type of welding and positions for which the worker is qualified, the code and procedure under which he or she is qualified, the date qualified, and the firm and individual certifying the qualification tests. The certification shall be kept on file and three copies shall be furnished to the CO. The certification shall be kept current for the duration of the contract.

(c) Identification. Each welder, welding operator, or tacker shall be assigned an identifying number, letter, or symbol which shall be used to identify all welds made by that person. For identification of welds, each welder, welding operator, or tacker shall apply his or her symbol adjacent to the weld using a rubber stamp or felt-tipped marker with waterproof ink or other methods that do not result in an indentation in the metal. Records shall be maintained indicating these locations. In the case of seam welds, the identifying mark shall be adjacent to the weld at 3-foot intervals. Identification using die stamps or electric etchers shall not be allowed.

(d) Renewal of qualification. Requalification of a welder or welding operator shall be required under any of the following conditions:

- The welder or welding operator has not used the specific welding process for which he or she is qualified for a period exceeding 6 months.
- There is a specific reason to question the welder's ability to make welds that meet the requirements of these specifications.
- The welder or welding operator was qualified by an employer other than those firms performing work under this contract and a qualification test has not been taken within the preceding 12 months. A tacker who passes the qualification test shall be considered eligible to perform tack welding indefinitely in the positions and with the processes for which he or she is qualified unless there is some specific reason to question this individual's ability. In the latter case, the tacker shall be required to pass the prescribed tack welding test.

(14) Welding materials. These requirements may be addressed in a single paragraph as follows: All items of equipment for welding, electrodes, welding wire, and fluxes shall be capable of producing satisfactory welds when used by a qualified welder or welding operator using qualified welding procedures. All welding materials shall comply with the applicable requirements of AWS D1.1 and AWS D1.3.

(15) Welding operations. Likewise, workmanship may be covered in a brief paragraph: Workmanship and techniques for welded construction shall be in conformance with the applicable requirements of the AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, and of AWS D1.1 and AWS D1.3. In case of conflict between AWS D1.1/D1.3 and the AISC specification, the requirements of AWS publications shall govern.

(16) Government inspection and tests. This paragraph gives the Government the right to test as it feels necessary: In addition to the inspection and tests performed by the contractor for quality control, the Government may perform inspection and testing for acceptance to the extent determined by the CO. The costs of such inspection and testing will be borne by the Government and the work may be performed by its own forces or under a separate contract for inspection and testing. The Government reserves the right to perform supplemental nondestructive and destructive tests to determine compliance with this section. The welding shall be subject to inspection and tests in the mill, shop, and field. Inspection and tests in the mill or shop will not relieve the contractor of the responsibility to furnish weldments of satisfactory quality. When material or workmanship does not conform to the requirements of this section, the Government reserves the right to reject either or both at any time before final acceptance of the structure containing the weldment.

(17) In-process weld inspections. These inspections are critical and should be defined similar to the following:

(a) Visual inspections. The welds shall be inspected visually. Defects uncovered shall be repaired and the area reinspected. All welds shall be 100 percent inspected.

(b) Weld test requirement. During construction, electromagnetic "sniffer" type tests shall be employed to inspect and ultimately assure quality welds. The test method to be employed is the shielded-enclosure-leak-detection-system (SELDS) or equivalent. This test measures normal magnetic fields resulting from an electromagnetic discontinuity or anomaly. The magnetic field probe will locate these anomalies by indicating a change in the meter reading accompanied by an audible tone or an increase in sound level as the probe passes over the discontinuity. The SELDS is to be used on all welds, including seams, patches, wall joints, and door frames. Testing, repair, and retesting shall continue until no anomalies are noted. Discontinuities found shall be marked for repair. All repaired areas shall be pretested for acceptability. Other information to include is--

- SELDS consists of two units, a generator and a small hand-held detector. The generator is connected directly to two opposite corners of the shielded area under test and the outer surface is excited with an RF current. When the sheath of RF current encounters a discontinuity such as a defective weld, a strong magnetic field is set up at right angles to the shield wall. The discontinuity is detected by a speaker, earphones, and/or an indicating meter.
- All welds in the total shielding system shall be 100 percent tested by the SELDS technique and all defects repaired prior to conducting the final acceptance tests. The CO shall be notified 3 days prior to SELDS testing so that Government witnesses can attend if desired.
- The floor shield shall be thoroughly SELDS tested and accepted by the CO prior to pouring the overslab. All penetrations shall be

in place and thoroughly SELDS tested. The CO shall be notified before the SELDS test is conducted on the floor.

(c) Corrections and repairs. When inspection or testing indicates defects in the weld joints, the welds shall be repaired by the shielding contractor using a qualified welder or welding operator. Corrections shall be in accordance with the applicable requirements of AWS D1.1, AWS D1.3, and as specified herein. All defects shall be marked clearly and conspicuously. Defects shall be repaired in accordance with approved procedures. Defects discovered between passes shall be repaired before additional weld material is deposited. Workmanship in the affected area shall be blended into the surrounding surface so as to avoid sharp notches, crevices, or corners. After a defect is thought to have been removed, and prior to rewelding, the area shall be examined by suitable methods to ensure that the defect has been eliminated. Repair welds shall be inspected and retested to the requirements for the original welds. Any indication of a defect shall be regarded as a defect unless reevaluation by nondestructive methods and/or by surface conditioning shows that no unacceptable defect is present.

(d) Covering of shielded work. In addition to the contractor's QA performance in terms of materials and workmanship, the contractor shall notify the CO 3 working days prior to covering or enclosing any shielding work. This notice will allow for any inspection of systems that the CO may wish to conduct and for adequate time to witness any covering or enclosing of the shielding work.

(e) Reports. Reports of daily testing shall be submitted to the CO within 3 working days. Each report shall include the method of testing, the equipment used, the location of the test, and results. A final report detailing in-progress testing shall be submitted in accordance with the format shown in (19)(h) below.

(18) Factory acceptance. Factory acceptance may be detailed as follows:

(a) General. All manufactured HEMP protection components shall successfully pass factory acceptance prior to their shipment to the site. These components include shielded doors, filters, ESAs, and WBC panels.

(b) Shielded doors. All RF-shielded doors shall be tested to show compliance with the requirements of this section, including attenuation. In addition, the following mechanical tests shall be performed--

- Swinging and sliding door static load test. The swinging leaf door shall be mounted and latched to its frame, then set down in a horizontal position so that the door will open downward and only the frame is rigidly and continuously supported from the bottom. A load of 40 pounds per square foot shall be applied uniformly over the entire surface of the door for at least 10 minutes. The door will not be acceptable if this test causes any breakage, failure, or permanent deformation that makes the clearance between door leaf and stops vary more than 1/16 inch.

Swinging door sag tests. The door and its frame shall be installed normally and opened 90 degrees. Two 50-pound weights, one on each side of the door, shall be suspended from the door within 5 inches of the outer edge for at least 10 minutes. The door will not be acceptable if this test causes any breakage, failure, or permanent deformation that makes the clearance between the door leaf and door frame vary more than 1/16 inch from its original dimension.

- Swinging and sliding door closure test. The door shall be operated for 100 complete open-close cycles. The door will not be acceptable if this test causes any breakage, failure, or permanent deformation that makes the clearance between door and door frame vary more than 1/16 inch from its original dimension.

(c) Filter insertion loss tests. All filters shall be tested at the factory for insertion loss in accordance with MIL-STD-220 under full load using modified buffer networks and shall provide 100 decibels of insertion loss under full load from 14 kilohertz to 500 megahertz (for TEMPEST requirement, frequency is 14 kilohertz to 1 gigahertz or 10 gigahertz). All power line filters shall also be tested for voltage drop not to exceed 2 percent under full load. Power filters must be operated under full load for 10 hours before testing. The increase in temperature of the outer case during this period must not exceed 40 degrees centigrade above the ambient temperature of the room. Filters shall be shipped after successful testing per above. Prior to installation, evidence that the filters being used were tested successfully shall be presented to the CO's representative. Furthermore, prior to installation, filters shall be examined to determine if any obvious damage occurred during shipment. Any damage that affects the filter's function shall be grounds for rejection of the filter. All filters must be installed prior to beginning the facility final acceptance testing.

(d) Filter enclosure tests. All installed filter enclosures shall be tested for 100 decibels attenuation from 14 kilohertz to 500 megahertz (for TEMPEST requirements, frequency is 14 kilohertz to 1 gigahertz or 10 gigahertz) in accordance with MIL-STD-285. Isolation from the filtered to the unfiltered side of the enclosure also shall be verified.

(e) Panels. Attenuation of premanufactured WBC panels shall be verified by factory test to be 100 decibels from 14 kilohertz to 500 megahertz (for TEMPEST requirements frequency is 14 kilohertz to 1 gigahertz or 10 gigahertz).

(f) Electrical surge arresters. All ESAs shall be factory-tested to show compliance with requirements of this section.

(19) Final acceptance. Requirements other than factory testing may be stated as follows.

(a) Acceptance test requirements. Upon completion of construction, including installation of all penetrations, penetration protection devices, and successful in-progress testing of welds, the shielding system shall be tested to assure compliance with performance requirements of the contract specifications. Shielding effectiveness testing shall be in accordance with MIL-STD-285, modified as appropriate to accomplish the required tests. The purpose of this test is to ascertain the continuity and electromagnetic tightness of the shielding after construction. The measurements are designed to show that an electromagnetic defect-free enclosure is achieved.

(b) Test contractor requirements. Tests shall be performed by a qualified firm regularly engaged in the testing of welded shield enclosures. "Regularly engaged" is defined to mean that the testing firm has successfully performed MIL-STD-285 and "seam-sniffing" tests on similarly sized facilities at least twice in the 3-year period preceding award of the contract. All costs of tests are the responsibility of the contractor. Qualifications of the firm selected and the test methodology shall be submitted to the CO for approval within 30 days after receipt of notice to proceed.

(c) Test plan. The contractor shall provide a test plan for the CO's approval. The test plan shall include the qualifications of the firm proposed to perform the test as required in paragraph (b) above. The test plan shall also identify the test equipment to be used and its proposed configuration; the special-purpose support equipment required (scaffolds, cherry-pickers, etc.); and the safety approach that will be employed. Furthermore, the test grid shall be identified and the plan for correlating that grid to the structure shall be provided. In addition, a schedule of test events to include equipment delivery, calibration, layout of test points, and the testing activities, including plans for corrective action and retesting, shall be provided.

(d) Notice of tests. The CO shall be notified in writing 10 working days prior to test initiation.

(e) In-process testing. In-process testing and certification shall not demonstrate conformance to the specified attenuation levels. This conformance shall be demonstrated by final acceptance testing as specified below.

(f) Final acceptance testing. Final acceptance testing shall be conducted by the shielding contractor or independent testing laboratory in conformance with the procedures in MIL-STD-285. The test shall be witnessed by a CO representative. All necessary personnel and test equipment for performing tests required by this section shall be furnished by the contractor. Where structural conditions prohibit use of MIL-STD-285 procedures, testing shall be provided by use of the SELDS as described above. This procedure shall be used only as authorized and directed by the CO. Performance of the shielding system shall meet the requirements of NSA 65-6. Final acceptance tests shall be conducted around all doors and mechanical, electrical, and communications penetrations, in addition to weak points previously identified by SELDS and repaired under interim testing requirements. The final acceptance test instrumentation shall have the necessary sensitivity, power output, and quality for the required tests so that the combination of source gain and receive sensitivity will permit attenuation measurements at least 6 decibels greater than the limits specified in NSA 65-6. Also included in this section are--

- Test methodology. Antennas shall be oriented for maximum signal pickup. Each test point shall be probed for area of maximum leakage, such as all around door frames, accessible joints, filters, pipes, and air ducts. The magnitude and location of maximum signal levels emanating from the enclosure shall be determined for each accessible wall in at least two locations per wall, around the door, all penetrations, and all seams in the facility. Attenuation shall be measured in accordance with the guidance provided in NSA 65-6.
- Magnetic field tests. Attenuation of low-impedance (magnetic) fields shall be measured at 14 kilohertz, 250 kilohertz, and 5.0 megahertz.
- Plane wave tests. Attenuation of 377-ohm plane waves shall be measured at 100, 200, and 500 megahertz. For TEMPEST, also test at 1 gigahertz or 10 gigahertz.

(g) Corrections and repairs. Any defect in any part of the HEMP protective system discovered during final acceptance testing shall be corrected at contractor expense in accordance with the techniques and practices specified in this section. All costs to repair the shield and return the facility to finished design condition shall be borne by the contractor. Pretesting shall be accomplished as necessary to ensure that the complete structure meets the attenuation requirements of NSA 65-6 from 14 kilohertz to 500 megahertz (for TEMPEST requirements, frequency is 14 kilohertz to 1 gigahertz).

(h) Reports. Reports of final testing shall be submitted in triplicate to the CO. Each report shall describe the method of testing, equipment used, and location of tests. The report of final acceptance testing shall include--

- Cover page.
- Administrative data. This includes test performer, contract number, date of test, and authentication (contractor personnel responsible for performing the tests and any witnesses).
- Technical contents. This includes shielded facility description, nomenclature of measurement equipment, serial numbers of measurement equipment, date of last calibration of measurement equipment, type of test performed, measured level of reference measurements and ambient level at each frequency and test point, measured level of attenuation in decibels at each frequency and test point, limits at each test frequency and test point, frequencies of test, and location on the shielded enclosure of each test point.
- Conclusions. This section shall include the results of the tests in brief narrative form.

- Daily reports. Daily reports of the results of each individual test performed on each portion of the shielding system shall be submitted. The location of the area tested shall be identified clearly. Leaks detected during testing shall be identified with enough accuracy to permit relocation for testing in accordance with the final acceptance test procedures. Reports of daily testing and of final acceptance testing shall be submitted to the CO with the required certification by the testing agency representative or consultant.

(20) Quality control. This section is usually addressed with a standard paragraph as follows: "The contractor shall establish and maintain quality control to assure compliance with contract requirements and shall maintain records of his quality control for all construction operations required under this section. A copy of these records, as well as the records of corrective action taken, shall be furnished the Government as required in this specification."

(21) Supplemental data. Tables 11-1 through 11-6 and figure 11-1 are examples of supplemental data that could be included in the specifications.

b. Design drawings. The second part of a complete facility design package is the design drawings. Though the specifications take precedence, the drawings tend to be used much more often by contractors. The one critical element that the drawings must show is a completely sealed shield. Ideally, one would like to build a perfect shield without seams or penetrations. This is not possible. As a result, the drawings must show clearly how each type of seam and each penetration is protected. This level of illustration can only be accomplished with details that are of small enough scale to show singular protection devices. The checklist in figure 11-2 is provided as a recommended test for all HEMP drawings to pass.

11-5. General shield design problem areas. HEMP shield is a steel box welded at the seams. If holes must be drilled into it to use its inner space, some type of seal must be placed around the hole. The steel is usually 3/16 inch or thicker because it is very difficult to weld thinner material. There are only three types of penetrations allowed in a shield: WBC, electrical filters, and RF doors.

a. Waveguide-beyond-cutoff (WBC) penetrations. A WBC is basically a solid steel tube that dampens electromagnetic waves as they reflect off its sides. The tube must be unbroken for the proper length to dampen the required amount, such as 5 times the diameter for 100 decibels. Thus, a 2-inch hole must have an unbroken tube 10 inches long welded circumferentially (all around the pipe) to the shield. Also, to ensure that the WBC functions correctly, it cannot be more than a certain diameter or the electromagnetic waves will simply pass through it without rebounding and no dampening will occur. This maximum diameter is determined by the required frequency cutoff (usually 500 megahertz). A simple approximation to calculate this diameter is that it must be no greater than 6000/2 divided by the upper protection frequency in megahertz. Thus, for 500 megahertz, no diameter greater than 6 inches is allowed and no more than 3 inches for 1 gigahertz. WBCs encompass ventilation, exhausts, water/fuel pipes, fiber optic entries, and all other nonconductive openings. The typical problems found with WBCs are described below.

(1) Large diameter openings. The utility entry or exhaust is too large to meet maximum diameter rules and it is not feasible to use multiple WBCs due to possible backpressure or clogging. The solution is to use a 1/4-inch wire mesh and keep the pipe RFI tight for as long a length as possible. This solution should be used only where a solid argument can be made for not using the standard WBC arrangement.

(2) Welding honeycomb metal. The second problem is the welding emplacement of honeycomb WBC for ventilation. Since the honeycomb is brazed or soldered together, it may melt under welding. A heat sink consisting of 6 inches of steel frame should be enough to handle this problem.

b. Electrical filters. A filter consists of capacitors and inductors in a configuration that bleeds out EMP currents at unwanted frequencies. Generally, small communication and signal filters are well made and have no problems. Power-line filters are entirely different, however, and have many problems--especially the high-power type. High-power filters tend to have the problems described below.

(1) Unbalanced loads. Overheating due to unbalanced loads between phases which causes single filters to fail and can cascade power onto the remaining filters to cause complete destruction of the filter. The solution is to specify a load balance within 5 percent and have the filter designed so that any failure of one filter element causes the filter to short to ground and to drop offline, thus saving the remaining filters. This will not work with filters in parallel.

(2) Insulation breakdown. Insulation breakdown which causes a short to the filter casing and burns up the filter. The only solution to this problem is to rely on reputable filter manufacturers who understand complexities such as corona effects and other high-power phenomena.

(3) Improper placement. Installation of filters such that they are placed in the circuit backwards, causing failure of the filter and misplacement of the MOV behind the filter. The construction inspector therefore must have knowledge of proper filter emplacement. Also, symmetrical filters that will operate in any configuration should be used.

(4) Oil insulation leakage. Leakage of oil insulation into the filter case, causing filter failure. In general, it is best to avoid oil-filled filters or to carefully inspect them for leaks.

(5) Improper sizing. Failure to meet specified attenuation requirements.

c. Radio-frequency (RF) doors. There are two types of RF doors--fingerstock and pneumatic. RF doors are the single weakest link in the shielding system. They degrade faster and are abused and misused more than any other item. It is highly recommended that the major entry and exit for any HEMP facility use two interlocking RF fingerstock doors with a waveguide entry between them. This design prevents compromise when one door is open and provides dampening to make up for the degradation that is natural in RF doors. Other entry points should be used as infrequently as possible. Waveguide entry tunnels should be all-welded steel hallways approximately 50 feet long with no conductors in them. Lighting can be provided through WBCs in the tunnel ceiling. Doors should have regular O&M service to curtail degradation.

(1) Fingerstock doors. Double knife-edge RF fingerstock doors are the most dependable type on the market. They are recommended for all 100-decibel facilities as the main points of entry and other personnel access. Their main drawback is fingerstock damage. Good O&M and occasional testing are necessary to keep these doors in operation at the proper decibel level.

(2) Pneumatic doors. Pneumatic sliding doors are the second best entry method. When this type of door is working correctly, it surpasses the fingerstock door in attenuation. The problem with the pneumatic door is that it is composed of a complex mechanism of air bladders, pneumatic piping, and sensitive contact surfaces. These doors are subject to many breakdowns and long downtime because specially trained individuals and specialty parts are required for repair. Because of the likelihood of breakdown, this type of door is recommended only for seldom used cargo or other large entries. If it is used at the main entry point, a double door with waveguide tunnel between doors is required to provide protection when one door is down for repair.

Table 11-1. Power line surge arrester criteria.

Parameter	Requirement
	277/480-V, 3-Phase, 4-Wire System
Clamp voltage	Less than 1200 V with kV/nsec pulse slope
Power consumption	Less than 600 MW per phase (device only)
Extreme duty discharge capability	Greater than 65 kA (8x20 microsec* pulse, 0.65 Coulomb)
	120/128-V, 3-Phase, 4-Wire System
Clamping voltage	Less than 750 V with 10 kV/nsec pulse slope
Power consumption	Less than 200 MW per phase (device only)
Exreme duty discharge capability**	Greater than 25 kA (8x20 microsec* pulse, 0.25 (Coulomb)
	Common to Both Systems
Minimum operational life	200 operations with 10 kA, 8 x 20 microsec pulse
Operating temperature	-40 F to =140 F
Self-restoration time	Less than 10 msec

*The first figure in the waveform is the 10 percent to 90 percent risetime. The second figure is the time to fall from peak value to 1/e, (approximately 0.368) times the peak value (e-fold time).
**Where a lightning threat is applied, the extreme duty discharge capability should be increased to 65 kA, 0.65 Coulomb.

Table 11-2. Power line filter criteria.

Parameter	Requirement
Insertion loss	100 dB from 14 kHz to 500 MHz measured per MIL-STD-220A
Minimum life	15 years (150,000 hours)
Current overload capability	140% of rated current for 15 minutes, 200% for 1 minute, and 500% for 1 second per MIL-F-15733
Operating temperature range	Continuous operation from -55 C to +65 C per MIL-STD-202, method 108A, test condition H. Shall also withstand temperatures cycling as specified in MIL-STD-202, method 102, test condition D
Temperature rise	Less than 40 C for individual filters suspended in ambient air at 20 C
Inductor linearity	Better than +3% from no load to full load
Voltage drop (at operating frequency)	Not to exceed 2% of rated line voltage when fully loaded (resistive load)
Dielectric withstanding voltage	200% of rated voltage for 2 minutes as specified in MIL-STD-202, method 301
Terminal resistance to ground	Greater than 1.5 megaohm when measured per MIL-STD-202, method 302, test condition B
DC resistance	No greater than 5 milliohms as measured per MIL-STD-202, method 303
Maintainability	Individual filters shall be replaceable units and like filters shall be interchangeable

Table 11-3. Signal and control line protection: coaxial penetrations.

Data: 2 Mb/sec, 75 ohm	
	Surge Arrester
Parameter	Requirement
Clamp voltage	7 V +/- 0.5V
Maximum insertion loss	< 3 dB
Maximum peak pulse current; I_{pp}	139 A
Minimum operational life	2000 operations at I_{pp}
	Filter
Impedance (in-band)	75 ohm +/- 1 ohm
Insertion loss (out of band)	100 dB 14 KHz - 500 MHz
Bandwidth (40 dB BW)/center	15%/2 MHz
Insertion loss (in-band)	< 3 dB

Data: RF 70 to 700 MHz, 50 ohm	
Parameter	Requirement
DC breakdown voltage	200 +/- 50 V
Impulse current (max), I_c	10,000 A (8x20microsec waveform)
Impulse breakdown (max)	1000 V 1 kV/nsec)
Impedance	50 ohm +/- 1 ohm
Insertion loss	< .25 dB
Minimum operational life	10 pulse at 1/2 I_c
	Filter
Double band pass may be required. Further information is needed.	

Table 11-4. Twisted shielded pair criteria.

Balanced Surge Arrester for All Twisted Pairs*	
Parameter	Requirement
DC breakdown voltage	300 V +/-50 V
Impulse current (max), I_c**	25 kA (8x20 microsec pulse shape)
Impulse breakdown (max)**	700 V (20 kV/microsec)
Balance (max)	10 ns firing
Minimum operation life	>50 pulse at 20 kA
Data: 10 Kb/sec and Voice Low-Pass Filter	
Insertion loss (out of band)	100 dB (14 kHz - 500 MHz)
Data: 10 Kb/s < Rate < 56 Kb/s* **	
Parameter	Requirement
Impedance (in-band)	100 ohms + 1 ohm
Insertion loss (out of band)	100 dB 14 kHZ - 500 MHz
Bandwidth (40 dB BW)/center frequency (of)	15% of or as required
Insertion loss (in-band)	<3 dB

Twisted shielded pairs will have a 5-ohm 1-watt carbon composition resistor in series with each filter input, placed between the surge arrester and the filter input.

*Recommended Joslyn TRIGUARD Model 2022-24 or equivalent.
**To ground.
***Comment: specific line data rates must be defined. Custom filters may be required.

Table 11-5. Terminal protection device.

Parameter	Requirement	Type No.
Reverse standoff voltage	6 V 12 V	IN6036A IN6043A
Peak pulse power dissipation	1500 W	
Polarity	Bidirectional	
General semiconductors		TransZorb or equivalent.

Table 11-6. Shielding effectiveness check points.

Joints between steel panels (roof and walls)	-Test every 3 feet for small facilities
Corner seams (walls to floor surfaces)	- Test every 3 feet for small facilities
Corners (intersection of 3 surfaces)	- Test all corners
Single doors (hinged)	- Test at each corner and midpoint of each side longer than 4 feet and at center
Sliding doors	- Test each separately at same test points as with single hinged doors
WBC vents and vent panels	- Test in center (on axis) for all sizes (including single), and at all four corners if 1 x 1 feet or larger, and at the midpoint of each side longer than 4 feet
All treated penetrations of shield (and entry panel and backshield)	- Test as close to "on-axis" as possible or orient for maximum signal
All other shield joints, seams or corners	- Test every 3 feet

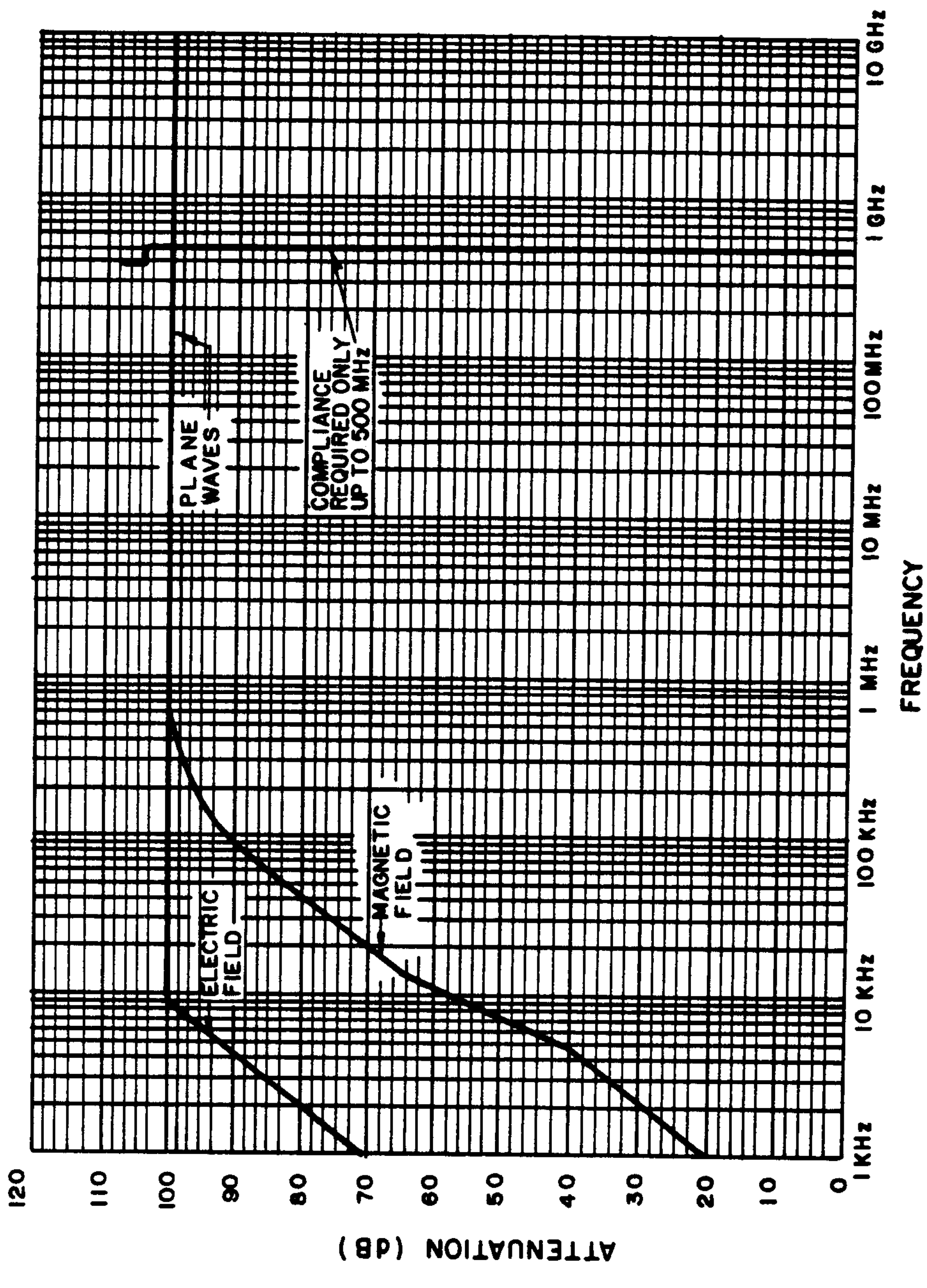

Figure 11-1. Required electromagnetic attenuation.

A. Specifications and Review

1. Shield

---- a. The level of shielding required is clearly stated in terms of decibels.

---- b. The shield material is clearly identified and meets the proper ASTM or equal qualifications.

---- c. The proper EMP hardness test is noted (MIL-STD-285, sniffer, and dipenetrant).

---- d. The methods of making seams and attaching the roof to walls and walls to floor are clearly defined.

---- e. The method of attachment for shield to structure is clearly defined.

---- f. QC and acceptance test procedures are required from the contractor as submittals to the Government.

---- g. The welding method is clearly defined and welding material and welder certification are identified.

2. Penetration protection

---- a. RF filters are clearly defined in terms of decibel protection and rating.

---- b. Electric surge arrester devices are clearly defined and properly specified for application.

---- c. Waveguide-below-cutoff devices are clearly defined and properly specified.

---- d. Utility penetrations are defined and treated properly.

---- e. RF doors are properly designed to provide the required protection.

---- f. Personnel entryways are defined properly in terms of interlocked doors and entryway waveguide.

---- g. Access covers/doors are proper.

Figure 11-2. Checklist for HEMP drawings. (sheet 1 of 3)

---- h. The fiber optic entering the shield is protected by WBS and completely devoid of conductive strengthening wire.

---- i. Conduits are clearly defined and properly joined.

---- j. Filter enclosures are clearly defined and proper.

---- k. Utility entry vault is clearly defined and proper.

---- l. A statement is included covering the protection for doors/WBC/filters/and shield materials during construction.

---- m. Any special certification required is noted.

---- n. Grounding method is clearly defined and proper.

---- o. A note covering construction changes and the care which must be taken to ensure no compromise in shield is included.

B. Drawings and Plans

1. General

---- a. A table listing filters is included in drawings giving size, type, rating, location, and other pertinent details.

---- b. A table listing penetrations, their locations, and their usage (ventilation, power, water, etc.) is included in the drawings. The table will reference penetration details.

---- c. A wiring diagram is included in the drawings which includes location of filters and filter identification noted on the filter table referenced.

2. Details

---- a. Details of filter attachment/mounting to shield are included showing all views.

---- b. Details of filter enclosures are included.

---- c. Details of shield seams and wall cuts showing the shield attachment to structural beams/support are included.

---- d. Details of the grounding method are included.

Figure 11-2. Checklist for HEMP drawings. (sheet 2 of 3)

---- e. All penetrations should reference a detail showing exactly how the penetration is treated.

---- f. Attachment to the floor and roof to the wall shield is shown in detail.

---- g. Expansion devices are shown in detail.

---- h. Doors are shown in detail. Subdetails such as frame, closure, handle mechanism, threshold and others are shown clearly.

3. Penetrations

---- a. Filters are shown clearly by some notation system (F1, F2, etc.).

---- b. The RF shield is shown clearly on all drawings.

---- c. A method for filter repair bypass is available (breakers) where applicable.

---- d. The grounding system is shown clearly and is proper for the protection method.

---- e. Conduits are identified and specified properly for the protection system.

---- f. All access panels to shield are shown in detail and clearly identified.

---- g. Where applicable, a built-in testing system is shown clearly on the drawings, including the proper details of attachment.

Figure 11-2. Checklist for HEMP drawings. (sheet 3 of 3)