WEST GERMAN RFI LAWS AND REGULATIONS

Understanding German laws and FTZ/FCC test differences helps manufacturers to ensure European RFI and safety compliance.

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INTRODUCTION

This article provides information on West German RFI laws and regulations and highlights differences between FCC and FTZ tests. At first glance, the mandatory RFI certification and compliance process in Germany appears complex, but the structure of the German RFI regulations, once understood, can be used to our advantage in marketing products in Germany and throughout Europe.

Product safety requirements are discussed briefly.

THE GERMAN RFI LAWS

FTZ is the governing body for RFI in Germany. Standards are written by VDE and become national requirements through government decrees (Vfg). According to the "Law on the Operation of High Frequency Equipment," it is compulsory for all electrical equipment/products likely to cause RFI to have an RFI permit prior to operation. As a consequence, the bulk of electrical products used in domestic and commercial markets, as well as in some industrial markets, requires RFI compliance. Manufacturers/importers of products generating radio frequencies (RF) between 10 kHz and 3,000 GHz must obtain an Individual Permit (Class A) or a General Permit (Class B).

German decree Vfg 523/1969 applies to Class A products. Vfg 1045 and 1046/1984 apply to Class B products. The RFI decrees refer primarily to VDE 0871/0875 for RFI requirements and to VDE 0877 for RFI measurement procedures.

For mass-produced products, manufacturers can select one of two classifications; Class A or Class B. The decision regarding class is usually based on a combination of two factors: (1) the product's inherent RFI emission level and (2) management awareness of Class B's advantages; namely, that Class B allows self-certification and unrestricted distribution. Class A requires a VDE test, FTZ certification, and registration of each product's location by the user. The applicable laws, standards and agencies are listed in Figures 1 and 2.

AGENCIES AND DEFINITIONS

HfrG	- Law on the Use of High Frequency Equipment Gesetz über den Betrieb von Hochfrequenz-geräten)	RFI Law of 1949 (10kHz - 3,000GHz)
BPM	- Federal Ministry of Post & Telecommunications (Bundesministerrium für das Postund Fernmeldewesen)	Issues RF Decrees
Vfg	- Decree (Verfügung)	Decrees issued by the BPM in the Official Gazette (Amtsblatt)
ZZF	- Central Office for Equipment Registration (Zentralamt für Zulassungenim Fernmeldewesen)	RFI registration for all products
FTZ	- Central Telecommunications Office (Fernmeldetechnische Zentralamt)	RFI administration & Class A certification (FTZ Number).
FA FuA	- Local Telecommunications & Radio Offices (Fernmeldeameter & Funkamter)	RFI enforcement , user registration of Class A products & site certifications Class C
PTB	- Federal Physical-Technical Institute (Physikalisch-Technische Bundesanstalt)	X-Ray Testing & Report RFI enforcement
DBP	- Federal German Post Office (Deutsche Bundespost)	
RPM	- Radio Protection Mark (Funkschutzelchen)	VDE RFI Mark
GSG	- The Equipment Safety Law (Geratesicherheitsagesetz)	Safety Law of 1968/80
VDE	- Association of German Electrical Engineers (Verband Deutscher Elektrotechniker)	Test Center, Issues standards
TUV	- Technical Supervision Society (Technischer Überwachungs-Verien)	Test Center
BG	- Injuries Insurance Institute (Berufsgenossenchaften)	Inspects equipment in use, issues ergonomic standards (ZH)
BMA	- Federal Ministry of Labor and Social Affairs (Bundesministerium für Arbeit und Sozialordnung)	Introduced GS mark and approves test centers
GWA	- Trade Supervision Office (Gewerbeaufsichtsmat)	Safety enforcement and accident prevention
IEC	- International Electrotechnical Commission (Commission Electrotechique Internationale)	Issues International standards
GS	- "Safety Tested" (Geprüfte Sicherheit)	German Product Safety Mark & EEC conformity mark

Figure 1. Agencies, Laws, and Definitions.

**See advertisement on page 340.*

CLASS A — THE INDIVIDUAL PERMIT

Products that meet the less stringent Class A limits must be tested by VDE. Once the product has passed the RFI test, VDE issues a certificate of conformity (Gutachten). The applicant submits the certificate to ZZF and an FTZ number is issued to the submitter. The manufacturer/importer labels the product with the FTZ number and supplies an FA (local telecommunications office) post card with each product. The user completes the post card and sends it to the local telecommunications office to register the product's location.

CLASS B — THE GENERAL PERMIT

Option 1

If a product meets the more stringent Class B limits, it can be submitted to VDE for testing and issuance of a Radio Protection Mark (RPM). Although not mandatory, some companies feel that the mark provides marketing advantages. RFI tests are performed by the VDE at Offenbach, Germany or at various U.S. RFI sites that are visited by VDE engineers.

Costs for a one-day VDE RFI test (Class A or B), performed in the U.S. on a typical personal computer can be high and the wait time can be substantial. Cost and wait time for the same test performed by VDE at Offenbach are considerably less.

Radio Protection Mark for Class B Certification

Option 2

Since January 1985, RFI testing by VDE for the general permit is no longer mandatory. The manufacturer can now self-certify and declare that the product meets Class B limits. Self-certification requirements for the general permit are met if the manufacturer/importer complies with the following:

- Ensures that the product meets VDE 0871 Class B requirements for Industrial, Scientific and Medical products (including EDP), or VDE 0875 for household appliances.
- Ensures that the product meets Vfg 1046 or 1045/1984 general permit according to the Law on the Operation of RF Equipment.
- Files an RFI declaration with ZZF in Germany (an RFI report is not submitted).
- Provides a German language declaration in one of three places: the user's manual, the product label, or on the warranty card (Figure 3).

IMPORTANT IEC, VDE AND FCC REGULATIONS

	Standard/Regulation	Description
GERMAN RFI	VDE 0871	RFI for Industrial, Scientific, Medical (ISM) & similar purposes (EDP, etc.)
	VDE 0875, Part 1	RFI for Household Appliances
	VDE 0875, Part 2	RFI for Fluorescent Lighting
	VDE 0875, Part 3 (Proposed)	RFI for Special Electrical Appliances (products with motors, etc.)
	VDE 0877	RFI Measurement Procedures
	Vfg 523/1969	Individual Permit for HF Equipment - Class A Decree
	Vfg 1046/1984	I,S,M and similar equipment (EDP, etc.) - Class B General Permit Decree (includes self-certification) [specifies VDE0871]
	Vfg 1045/1984	General Permit for Household Appliances [specifies VDE 0875]
	Vfg 1044/1984	EC Directives Implementation and Harmonization of Legislation [specifies 82/499/EEC and 82/500/EEC]
FCC	Part 15, Subpart J	Computing Devices Rules & Regulations
	OST 62	Understanding the FCC EDP Regulations
	OST 55	Open Field Sites for FCC Testing
	MP-4 (July 1987)	FCC Measurement Procedures for EDP
SAFETY	EN 60 950	Safety of Information Technology and Business Equipment
	IEC 380/VDE 0806	Safety of Office Equipment
	ZH 1/618	Ergonomic Requirements for Video Displays and Computers (Applies to products that generate or display video)
	IEC 601/VDE 0750	Safety of Medical Products
	IEC 204/VDE 0113	Safety of Industrial Equipment
	IEC 65/VDE 0860, IEC 335/VDE 0700	Safety of Household Appliances

Figure 2. Important IEC, VDE and FCC Regulations.

FTZ compliance is accepted throughout the European Community (EC) per directives 499/82/EEC and 500/82/EEC.

Many companies are selecting this option, even for products which qualify for the less stringent Class A category. They prefer to suppress their RF emissions below Class B limits for the compelling reason that self-certification saves time and money by reducing test cost and time-to-market. One example of a RFI self-certification mark is:

TUV RFI Mark for Class B Self-Certification

CLASS C — SITE CERTIFICATION

Vfg 523/1968 applies to equipment that requires RFI testing at the installation site. Site certification tests are conducted by the local telecommunications offices. Class C is primarily for large one-of-a-kind products. Class C certification requires an RFI test at each installation.

GERMAN RFI DECLARATION FOR CLASS B SELF-CERTIFICATION
Hiermit wird bescheinigt, dass der (product name and model number here) in Ubereinstimmung mit den Bestimmungen der Vfg 1046/1984 funk-entstort ist. Der Deutschen Bundespost wurde das inverkehrbringen dieses Gerates angezeigt und die Berechtigung zur Uberprüfung der Serie auf Einhaltung der Bestimmungen eingeraumt. (Company name and address here) English translation: We hereby certify that the ______________________ complies with the RFI suppression requirements of Vfg 1046/1984. The German Postal Service was notified that equipment is being marketed. The German Postal Service has the right to re-test the equipment and verify compliance. Note: Replace 1046 with 1045 for household appliances tested per VDE 0875.

Figure 3. German Declaration for Class B Self-Certification.

COMPARISON OF FTZ AND FCC TEST PROCEDURES

Many times a product that passes FCC tests fails FTZ tests in Germany. This often happens to the first-time submitter. One of the contributing factors to this problem is that test methodology differs between FCC and FTZ. The following points illustrate some of the main differences between the FCC and FTZ test requirements (Figure 4):

- VDE radiation test distances are 10 meters for Class B and 30 meters for Class A (Figure 5). Test distances of 3, 10, or 30 meters and others are allowed for FCC.
- CISPR EMI receivers are preferred test equipment for VDE measurements, although some spectrum analyzers using QP and pre-selectors are permitted. For FCC, spectrum analyzers are commonly used.
- Magnetic field strength (10 kHz - 30 MHz) is measured for VDE (Figure 6[1]). This test is not performed for FCC.
- VDE line-conducted limits cover 10 kHz to 30 MHz for Class B and 150 kHz to 30 MHz for Class A (Figure 7). The FCC line-conducted range is 450 kHz to 30 MHz for Class A or B. VDE also measures RF voltage on unshielded data cables (limit B plus 14 dB).
- Some domestic LISNs require correction factors for VDE conductive interference tests. LISNs designed for VDE testing, like Schwarzbeck or Rohde & Schwarz, need no correction and include a built-in "floating ground" switch. For Class B floating ground test is required when a conducted reading is within 5 dB of the limit. The floating ground test is not performed for FCC.
- VDE standards specify cable placement for the radiated test. Data cables are routed horizontally at a distance of 1.5 meters from the EUT, then vertically to the floor (Figure 8). FCC varies cable position to obtain maximum emission.

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	FCC	VDE
Class A	For commercial/office products. Manufacturer does RFI test for "self-verification" and labels product.	VDE RFI test and FTZ certification is mandatory by law, primarily for systems or low volume products. FTZ number must be on product and user registers device location.
Class B	For residential products only. Requires FCC authorization and FCC identifier number on device.	Can test at VDE for RMP or self-certify. Used for high volume and stand-alone products. German RFI Declaration and ZZF registration required for self-certification. A 2dB margin is required when one unit is tested.
Class C	Class A equipment can be tested at installation site for self-verification. The FCC does not perform this test.	Test is conducted by local postal authority at place of installation. Class C is for large "one-of-a-kind" systems installed in an industrial zone.
Radiated Test Distances	3 meters for Class B and 30 meters for Class A, preferred. Distances less than 30 meters allowed if data is correlatable.	10 meters for Class B, 30 meters for Class A (10 meters, 470-1000 MHz).
RFI Test Equipment	EMI Receivers are preferred but spectrum analyzers are allowed. Spectrum analyzers are widely used in the U.S.	EMI receivers with CISPR are highly preferred. Spectrum analyzers with Q.P. and preselection are sometimes permitted. Spectrum analyzers are rarely used in Germany.
Conducted Test	450 kHz - 30 Mhz, Class A and B.	10 kHz - 30 MHz, Class B. 150 kHz - 30 MHz, Class A. For Class B tests, when a reading is within 5dB of the B limit, then rerun test with floating ground.
Magnetic Field Test	N/A	Performed per VDE 0871 at 3 meters from 10 kHz to 30 MHz. If EUT fails at 3m then retest at 30m for class B.
Radiated Test - Antennas	Antenna height is varied from 1 to 4 meters for measurement distances up to and including 10 meters. For distances of 30 meters the antenna is varied from 2 to 6 meters.	Antenna height is fixed at 3m for up to 470 MHz and varied from 470 - 1000 MHz for class A (30m distance). Antenna height is varied from 1 to 4 meters for class B (10m distance).
Radiated Test - Cables	Interface cables are configured to discover maximum emission.	Interface cables are positioned at 1.5 meters out from EUT and parallel with ground (see VDE 0877).
Line Voltage	120V, 60 Hz	220 V, 50 Hz

Figure 4. Key FTZ and FCC Test Differences.

$Re = 353.6 + 10 \log(G / f^3 \mu r^2$
for E-Field,

$Rh = -17.3 - 10 \log(\mu / G)(1 / fr^2)$
for H-Field, and

$Rp = 168.2 + 10 \log(G / \mu f)$
for Plane Wave

where Re, Rh, and Rp are reflection terms for the electric, magnetic and plane wave fields in dB.

f = Frequency in Hz

μ = Relative permeability referred to space

r = Distance from the source to the shield in inches

From the above relations, it may be concluded that:

- As a general rule, above 10 kHz, reflection losses increase with an increase in conductivity and a decrease in permeability.
- E-Field reflection losses increase with a decrease in frequency and a decrease in distance between the source and shielding barrier.
- H-Field reflection losses increase with an increase in frequency and an increase in distance between the source and the shielding barrier.
- Plane wave reflection losses increase with a decrease in frequency.

The re-reflection losses for a thick metallic barrier are quite small and are generally ignored.

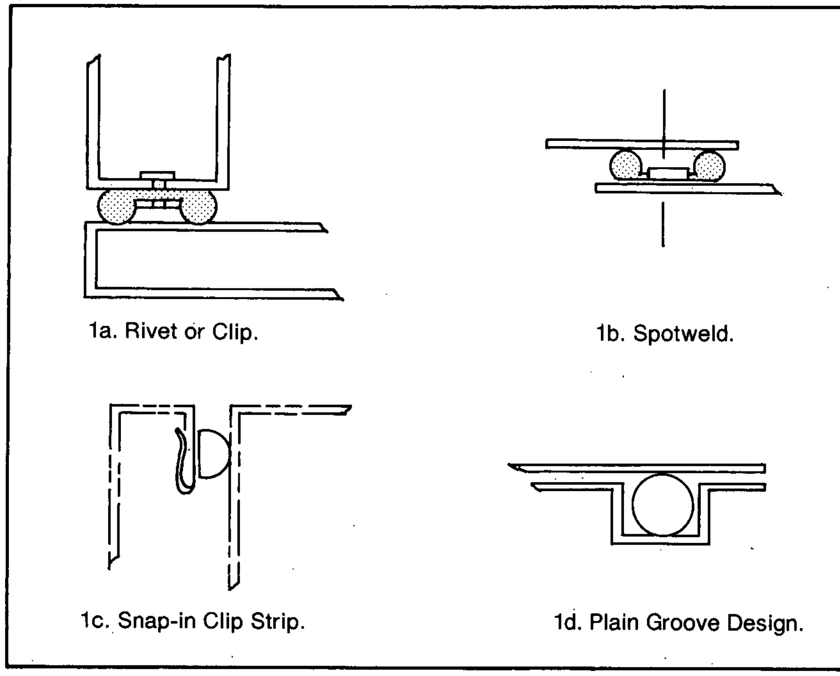


Figure 1. Gasket Mounting.

CONDUCTIVE GASKETS

Depending upon customer requirements, enclosures feature removable panels over apertures and doors for access and maintenance to the internally mounted electronics. To maintain the electrical continuity, conductive gaskets are used along all closure edges to provide a low impedance path across the gasketed joints. It is very important that the conductive gaskets are held in place and uniform pressure is exerted along the gaskets to guarantee the required seal.

Mechanical Considerations. Gaskets are held in place by the use of an adhesive on the elastomer. Gaskets with transfer adhesive backings are the simplest to install but the adhesive has a finite shelf life, and exposure to heat and other environmental stresses reduces the life of the adhesive. To overcome the problems associated with transfer adhesive backings, use of heat activated (or solvent activated) adhesive is recommended. This will have a longer adhesive life but its application is difficult and the solvents may attack the adhesive holding the conductive gasket to the elastomer.

Sometimes gaskets are installed with rivets or with spot-welded strips (Figure 1a and 1b). These will hold the gasket in place. These methods may increase the fabrication cost and replacement of gaskets becomes difficult. Doors and panels with return flanges may be fitted with a recently developed carbon-filled silicon rubber bulb gasket which is permanently affixed to a durable stainless steel clip-strip that can be snapped in place (Figure 1c). This gasket does not lend itself to application around a 90-degree bend. Carbon-filled silicon rubber is a conductive gasket available with clip-strip but may not be acceptable for all shielding applications.

Sometimes special grooves are incorporated in the enclosure design to hold the gasket in place (Figure 1d). This may result in higher fabrication costs of the enclosure. Also, tighter tolerances are required for groove dimensions and interchangeability among gaskets is very difficult.

Whenever a gasket is used around an aperture with a removable cover, the gasket is held in place by the same fasteners (screws) that are holding the cover in place. It is important that the adequate number of fasteners and an appropriately thick cover plate are used to ensure uniform gasket compression. A relationship has been developed between the fastener spacing and the material thickness for a given gasket (Figure 2).

$C = [480\ a/b\ Et^3H/(13\ F1 + 2\ F2)]$

where

C = Fastener spacing

a = Width of cover plate flange at seam

b = Width of gasket

E = Modulus of elasticity of cover plate

H = D2 − D1

D2 = Minimum gasket deflection

D1 = Maximum gasket deflection

F1 = Minimum gasket pressure

F2 = Maximum gasket pressure

t = Thickness of cover plate

The required maximum and minimum gasket deflection and corresponding maximum and minimum

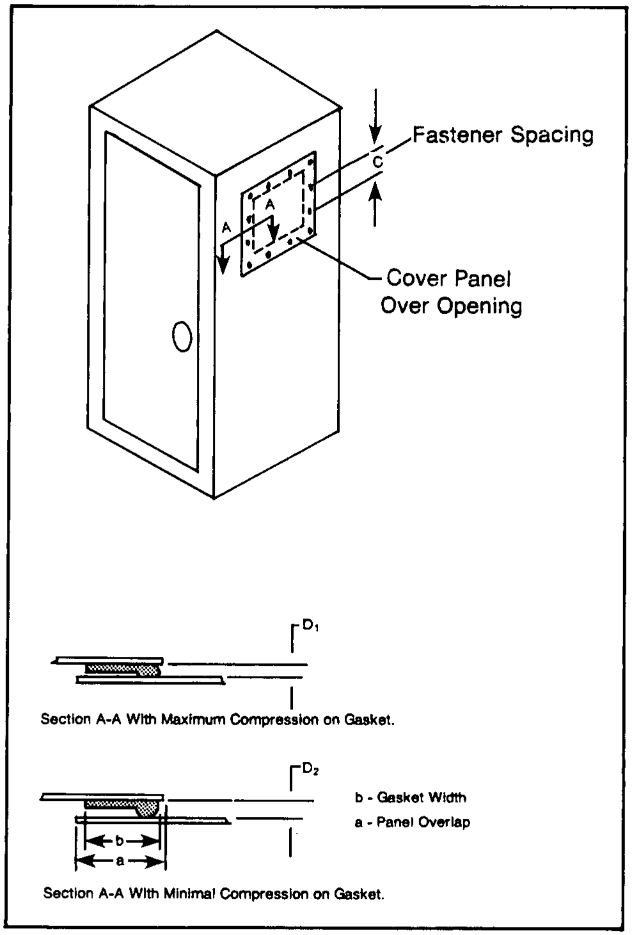


Figure 2. Fastener Spacing and Material Thickness.

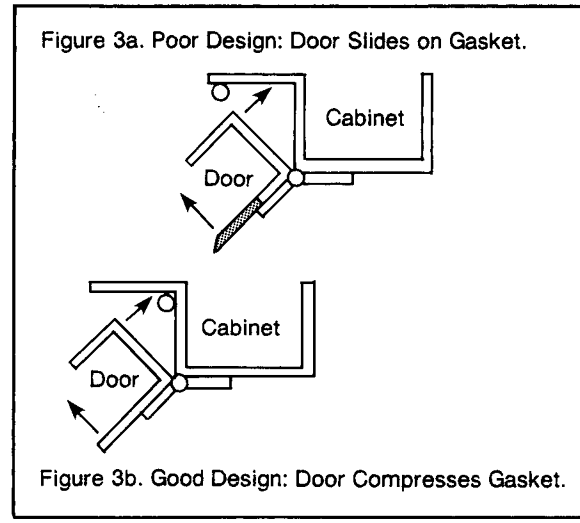


Figure 3. Doors.

gasket pressures are well established by gasket manufacturers. Thus, for a given gasket, and for a given cover plate, the bolt spacing can be determined using the above equation.

To maintain uniform pressure on a gasket between a door and the enclosure surface, an adequate number of latches are used. Three-point latching can be used to achieve uniform compression on gasketed doors. It should be emphasized that when hinged panels and doors are used, the hinges should be located such that the closing of the door compresses the gasket and does not slide on the gasket (Figure 3). The enclosure frame and the door must have structural integrity so that there is no deformation of the frame or door during the latching. It may be necessary to reinforce the door edges to minimize distortion during the latching.

Selection of Gaskets. Gasket selection is as important as the installation of the gaskets. A gasket must provide a low impedance path across the gasketed joint. A good gasket must not only meet shielding requirements but also must meet several mechanical and environmental criteria. An EMI gasket may be required to function as a environmental seal. A wide variety of gaskets with varying properties (conductivity, compression set, compressibility, temperature sensitivity, shelf life and corrosion resistance) are available. Depending upon the application, an adequate gasket may be selected. For example, a gasket with a higher compression set should be avoided for doors and panels that are frequently removed, opened or closed. Carbon-filled materials have higher resistance than silver-filled silicone.

One of the most important, and frequently overlooked considerations in the selection of gaskets is the degradation of gasket material over a period of time. Shielding quality of all gasketed joints degrades with time. The extent of degradation is caused by the oxidation of the gasket materials and the enclosure material at the mating surfaces. This type of degradation can be controlled by a periodic cleaning of the gasket and joint areas or by the use of dust and moisture seals to minimize the deteriorating effect of the environmental contaminates.

Corrosion due to the use of dissimilar materials in gasketed joints reduces the shielding effectiveness considerably. Thus gasketing material should be selected based on their compatibility with the joint material. Whenever a weather seal is provided with the conductive gasket, the weather seal should be installed on the exterior of the EMI seal to keep the moisture, dust and salt away from the joint. Neoprene and silicone rubbers are excellent for environmental sealing.

MATING SURFACES

All mating surfaces along openings must be clean, flat, paint-free and dirt-free to ensure the proper installation of gasket material. It is a common practice to protect and preserve the mating surfaces with the use of plating or conductive paints. Zinc, tin, nickel and cadmium are the most commonly used for plating steel enclosures. Iridite, nickel and tin are used on aluminum. One of the important considerations in selecting plating material is its chemical affinity with the gasketing material. For example, an aluminum chassis with a monel mesh gasket should be tinned or cadmium plated for the combination to be compatible. Also a beryllium-copper or monel gasket should not be used with zinc plated parts as, with time, they will develop a nonconductive layer and reduce the shielding effectiveness of joints. Anodized aluminum should never be used as it is electrically nonconductive.

Conductive paints, which have higher surface resistivities, can be applied instead of plating metallic enclosures. However, all enclosure manufacturers do not have plating capabilities, in which case they use conductive paints for protecting the mating surfaces. Conductive paints may be adequate for FCC shielding requirements, but for military applications, plating may be the only acceptable method to meet the desired shielding and environmental requirements.

While applying conductive paints, the paint container should be frequently agitated so that the metal content of the paint does not settle. The shielding effectiveness of a conductive paint depends upon the metallic content in the final coat.

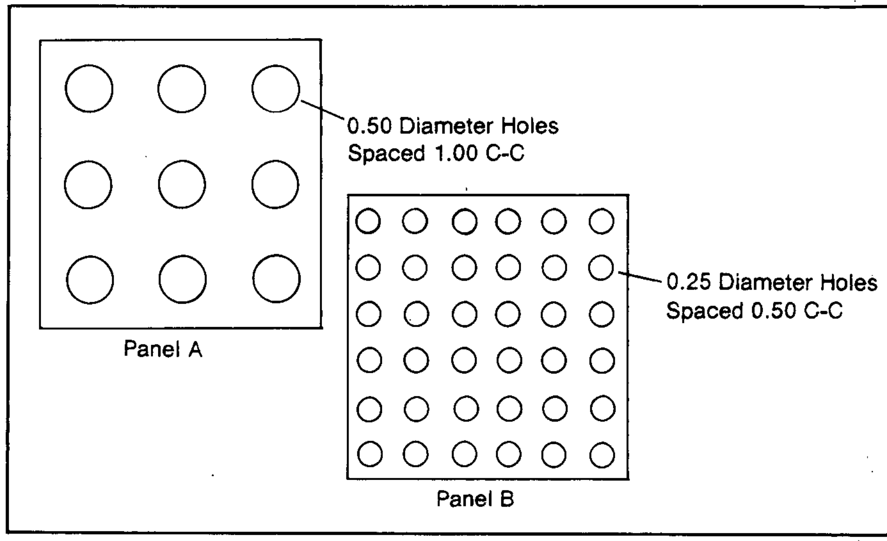
THERMAL CONSIDERATIONS

Cabinets are provided with apertures or openings for the introduction and exhaust of cooling air. Normally, a cutout with a filter is provided at the entrance and some type of louvers or slots are provided for the exhaust. However, these apertures and slots are detrimental to EMI shielding. Electromagnetic leakage through an aperture is dependent upon (1) the longest dimension, d, of the aperture and (2) the wave length, w, of the radiating field. The recommended longest dimension, d, of the aperture is:

$d \leq w/20$ for commercial systems, and

$d \leq w/50$ for military systems.

Whenever possible, the desired open area for air flow should be achieved by providing a perforated screen behind the aperture. It should be mentioned that the smaller the holes, the higher the shielding effectiveness (Figure 4). If the hole spacing and diameters are halved, the total open area remains constant. Hence, holes as small as practical should be used. It should be kept in mind that the smaller holes will increase the resistance to the flow of air and may require a larger blower.



Panel B has same opening area as Panel A. However the hole diameter and spacing are halved in Panel B compared to Panel A. Thus Panel B is identical for opening area to Panel A but has higher shielding effectiveness.

Figure 4. Air Holes.

Another method of achieving shielding at an aperture is to provide vent panels made of metal honeycomb materials. The honeycomb vent panels provide a higher degree of shielding (40 dB up to 100 dB) than a perforated screen. The only prohibitive factor is cost.

WINDOWS

Enclosure manufacturers often are requested to provide windows for viewing meters, digital read-outs, and print-outs inside a shielded enclosure. Commercially available glass and acrylic are non-conductors and do not provide the necessary shielding. In such instances, extremely thin conductive coatings are applied to the clear windows which can provide shielding effectiveness of better than 60 dB at 100 MHz and beyond. The shielding effectiveness and optical transparency are a function of the coating thickness and a tradeoff must be reached between the shielding effectiveness and optical transmission.

A number of gasket manufacturers have developed clear windows with fine knitted wire laminated between two layers of acrylic or glass. Transparent windows have not been standardized and, hence, have to be custom-made for each application. This makes the cost of such windows extremely high in comparison to the cost of the enclosure.

GROUNDING

Cabinets are provided with grounding points (threaded studs welded to the metal frame, bus bars and grounded straps) not only for safety but also for providing a reference potential or "signal common." Sheet metal cabinets, being highly conductive, are ideally suited as ground planes and provide minimum voltage drop in signal returns.

CONDUCTED EMI

A metal enclosure can help improve the shielding effectiveness against radiated EMI. Enclosures are adaptable to the installation of wire terminals, power-line filters, and shield-termination-adapters, proven devices which effectively control conducted interference.

COOPERATIVE EFFORTS REQUIRED

Some of the design considerations in the fabrication of a shielded cabinet have been discussed. It should be emphasized that a single unique solution to all EMI/RFI problems does not exist. Each and every electronic system is different and no one cabinet can meet the shielding requirements for all electronic systems.

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stantiate the credibility of a candidate. Current plans are that the candidate will provide endorsement from five persons (two of whom are themselves accredited) with whom the candidate has worked and who can attest to the validity of the candidate's work experience.

Examinations will be confined to the area of EMC fundamentals. The object for the fundamentals examination is to test for knowledge in certain specific areas. The examination is expected to take one day. The examination will be open book, and the candidate may bring any text or bound set of notes desired. The following areas will be covered:

• Bonding • Grounding • Shielding • Interface Control • Filtering • Materials • Intersystem Design • Intrasystem Design • Special Devices • Equipment Design • Conducted Interference • Antennas • Radiated Interference • Filter Theory • Terminology • EMI Prediction • EMI Analysis • ESD • Specifications • Standards • EMC Test Plan • Test Equipment • Test Facilities • Safety • Mathematics • Spectrum Analysis • Field Theory • EMP • Lightning Protection

Commercial training organizations are expected to provide refresher courses in EMC fundamentals to assist candidates in passing the examination.

CERTIFICATION AGENT

The National Association of Radio and Telecommunications Engineers (NARTE) is a nonprofit Association of engineers and technicians dedicated to advancing standards by donating their time, energy and expertise. NARTE advocates competence and professionalism in the field and serves as a certifying agent for engineers and technicians. NARTE was formed to fill the void created by the Federal Communications Commission's deregulation of licensing requirements for technicians and engineers. The NARTE program certifies, endorses and tests engineers and technicians who work with either non-RF-radiating or RF-radiating systems and equipment. The program establishes and administers qualification requirements for various certification classes and establishes new endorsement areas to reflect state of the art technology. It allows for the expansion of categories upon a showing of need.

NARTE is being considered as the Certification agent because it is independent, it has a certification program in operation and it has the resources needed to support Navy EMC certification requirements.

GRANDFATHERING

It is recognized that there are a lot of competent people currently providing direct EMC technical support. For a variety of reasons it may not be practical for these people to sit for an examination. As a consequence, there is a provision in the EMC certification process for certification by prior experience. This process will be available only for the first year after the requirement has been established. It will only be available to people who have a minimum number of years (probably nine) of experience and who have been actively engaged in the EMC technical support for the 12 preceding months.

SENSITIVITIES

While the need for certification and accreditation seems to be evident, the requirement is being implemented with the consideration for certain sensitivities. The implementation is proceeding at a slow and deliberate pace to ensure that the competitive process is not disturbed. Rapid implementation would create an artificial shortage of support personnel. To ensure that the concerns of industry are fully considered, the development process for accreditation is open for industry participation and involvement. Comments are invited and should be forwarded to Naval Air Systems Command, AIR-5161, Washington, DC 20361-5160. ■

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Some cooperative efforts will ease the design and manufacturing process. An enclosure should be considered at the outset of the system's design to eliminate potential packaging problems when the equipment is being introduced to the marketplace. The system designer must place equal emphasis on the design of the outer enclosures. Throughout the design process, the system designer should work closely with the enclosure designer so that all the system requirements (thermal, shielding, shock, vibration, ease of access, maintenance, appearance, finish) can be incorporated in the enclosure right from the beginning. This also allows an enclosure manufacturer to react to changes proposed by the system designer without adversely affecting the delivery.

CONCLUSION

Once a system is put together, it must be tested to determine whether it meets shielding requirements. All the commercial, consumer and military specifications governing EMI apply to *total* electronic systems and an enclosure manufacturer cannot guarantee meeting the emission requirements. However, an experienced enclosure manufacturer can help by making necessary changes to the enclosure after a system is tested for emissions. If electromagnetic leakage is found along a non-functional (but necessary for fabrication) seam, that seam can be welded solid. Similarly, the leakages around a panel or door can be eliminated by providing extra latches or fasteners and reinforcing the panels/doors.

An enclosure manufacturer should have the experience, knowledge, and manufacturing flexibility to modify products, the facilities to plate and apply different finishes, a strict quality control program, and a proven track record. But the most important requirement is that the enclosure manufacturer must have a strong desire to work and collaborate with clients to help design a cabinet that would adequately meet EMI/RFI and cooling needs, shock and vibration requirements, and provide ease of access and maintenance to the equipment in the enclosure. ■