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MILITARY HANDBOOK

ELECTROMAGNETIC (RADIATED) ENVIRONMENT CONSIDERATIONS FOR DESIGN AND PROCUREMENT OF ELECTRICAL AND ELECTRONIC EQUIPMENT, SUBSYSTEMS AND SYSTEMS

PART-1B

GENERAL GUIDANCE

AMSC N/A

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DEPARTMENT OF DEFENSE
WASHINGTON D.C. 20360

ELECTROMAGNETIC (RADIATED) ENVIRONMENT CONSIDERATIONS FOR DESIGN AND PROCUREMENT OF ELECTRICAL AND ELECTRONIC EQUIPMENT, SUBSYSTEMS AND SYSTEMS

MIL-HDBK-235-1B

1. This Military Handbook is approved for use by all Departments and Agencies of the Department of Defense.

2. Every effort has been made to reflect the latest information on the electromagnetic environment. It is the intent to review this handbook periodically to insure its completeness and currency. However, several factors dictate that the document be revised periodically. The factors include advances in emitter state-of-the-art, increased knowledge of hostile emitter characteristics or revised definitions of emitter and missile deployments. The document can be updated on a bi-annual basis.

3. Procedures for the release of Part 2, 3, 4, and 5 of MIL-HDBK-235 to Industry. Other parts of MIL-HDBK-235 may be released to private industry, when necessary, for the performance of a Department of Defense contract, or to bidders, if required for the preparation of response to an invitation-for-bid, in accordance with the following procedures:

a. Releasing Service or Command. The following activities are authorized to release other parts of this handbook.

- For Air Force contracts and bids - ASD/ENES
- For Army contracts and bids - U.S. Army Communication Research and Development Command
- For Navy and other DoD agencies contracts and bids - Space and Naval Warfare Systems Command

Prior to releasing other parts of the handbook, the above activities shall:

(1) Ensure that the conditions of paragraph 7-106d of DoD Dir 5200.1-R (Information Security Program Regulation) are met.

(2) Critically review existing and proposed contract requirements to ensure that all data being requested are actually required (based on system or platform type, function, intended installation and expected electromagnetic environment). When all data are not required, the handbook shall be tailored by the releasing command or service so that only applicable portions of the classified parts of the handbook are sent to bidders or contractors. Reference to the levels in Part 1, TABLE II,

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may be adequate for bid purposes.

(3) Keep a record of all releases to contractors and bidders.

b. Contracting officers and security managers. Contracting Officers and Security Managers will ensure that the following requirements are specifically included in the contract itself, invitation-for-bid or in the Contract Security Classification Specification (DD Form 254);

(1) The material does not become the property of the bidder or contractor and may be withdrawn at any time. Upon close of bid or expiration of the contract, Classified parts of MIL-HDBK-235, and any material using data from the handbook shall be returned to the contracting officer or authorized representative for final disposition.

(2) Bidders and Contractors shall not release classified parts of MIL-HDBK-235 to any activity or person of the contractor's organization not directly engaged in providing services under the contract or to another contractor (including subcontractors), government agency, private individual, or organization.

(3) Classified parts of MIL-HDBK-235 shall not be released to foreign nationals or immigrant aliens who may be employed by the contractor, regardless of their security clearance level.

(4) Classified parts of MIL-HDBK-235, shall not be reproduced.

(5) The bidder and contractor shall maintain such records as will permit them to furnish, on demand, the names of individuals who have access to foreign intelligence material in their custody.

4. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to:

COMMANDER
SPAWAR 2243
SPACE AND NAVAL WARFARE SYSTEMS COMMAND
2451 CRYSTAL PARK 5
WASHINGTON D.C. 20363-5200

by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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FOREWORD

Department of Defense activities have experienced increasingly serious problems of damage and performance degradation to electrical and electronic equipments, subsystems and systems due to inadequate consideration of the intended operational electromagnetic environment in their initial design. To correct this, general design requirements and limits in existing electromagnetic compatibility (EMC) and interference (EMI) standards must be analyzed to determine their suitability and applicability for a given development and procurement. The standards are to be tailored by the Procuring Activity to the peculiarities of the specific equipment, its mission and operational concepts, the probabilities of achieving intra- and intersystem EMC, program cost objectives and the anticipated operational electromagnetic environment. Definitive postulations of the total intended environment are required at various stages during the system design, as well as requirements to demonstrate operation and survivability in those environments. An initial postulation of the environment should be included in the specification. This postulation may be based on the assumption that the emitters with the largest radiated levels represent the greatest threat. From this, the extreme electromagnetic environment parameters which can be encountered during the system's life cycle may be documented. Subsequent analyses may show that the initial assumptions yielded extremely high environment levels thus necessitating revisions of the initially postulated environment. The revised environment levels could then be used by the designer or testing organization.

This document provides information and guidance to the project manager, acquisition manager and others responsible for the design, test and procurement of electrical and electronic components, equipments, subsystems and systems on the representative maximum electromagnetic environment which may be encountered at various stages of their life cycle. The intent of this document is not to provide detailed electromagnetic environment specifications since each equipment and procurement is somewhat unique, but rather, to provide guidance and information which must be weighed during design and procurement. Use of this document will require engineering judgment. Therefore, it is advisable to search out the additional electromagnetic environment data in the referenced publications when more precise or detailed environmental information is required.

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SECTION 1: INTRODUCTION

1 1 Scope. The intent of this handbook is to provide and establish a uniform approach for the protection of military electronics from the adverse effects of the electromagnetic environment. The handbook is applicable to any electrical and electronic equipment, subsystem or system which may be exposed to an electromagnetic environment during its life cycle, including the following:

a. Aerospace and weapons systems and associated subsystems and equipments.
b. Ordnance.
c. Support and checkout equipment and instruments for (a) and (b) above.

1.2 Purpose. This handbook provides:

a. Information on the electromagnetic environment for consideration in the design and procurement of new systems, subsystems and equipments which may be exposed to electromagnetic radiation environment levels during their life cycle.

b. Information for use in tailoring the radiated susceptibility requirement RS03 of MIL-STD-461 and the requirements of MIL-E-6051, and to supplement the requirements of MIL-STD-1385 and MIL-STD-1512 to ensure adequate consideration of the electromagnetic environment during equipment and system design.

1.3 Use. The information contained herein will be valuable in implementing the military departments' policies on tailoring of requirements. Tailoring of susceptibility requirements must not violate International agreements. In the event that there are essential reasons for non-conformance with such an agreement, the signatory Nations must be consulted, as required by the agreement. Care should be taken to ensure that tailoring does not restrict an equipment for use in only one system or installation; therefore susceptibility levels less stringent than the applicable levels in MIL-STD-461 should not be used. Contractors shall not use this handbook as justification for changing any contractual provision based on MIL-STD-461 or MIL-E-6051 or any EMC or EMI control or test plan, as may be required by the contract.

1.4 Format. This handbook is issued in five parts. Part 1 gives general information and approximate electromagnetic environment levels; Parts 2 and 3 describe the electromagnetic levels which may be encountered from friendly and hostile emitters, respectively, as well as emitter characteristics; Part 4 describes the electromagnetic environment levels which may be encountered in specific Army installations; and Part 5 describes the predicted typical electromagnetic environment levels which may be encountered by platforms operating in four US Naval Battle Force scenarios. Table I is an index of the tables in other parts of this handbook.

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SECTION 2: REFERENCED DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids, request for proposal, form a part of this handbook to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-E-6051	- Electromagnetic Compatibility Requirements, Systems.

STANDARDS

MILITARY

MIL-STD-461	- Electromagnetic Interference Characteristics, Requirements for Equipments.
MIL-STD-1385	- Preclusion of Ordnance Hazards in Electromagnetic Fields, General Requirements for
MIL-STD-1512	- Electroexplosive Subsystems, Electrically Initiated, Design Requirements and Test Methods

HANDBOOKS

MILITARY

MIL-HDBK-235 Part 2	- Electromagnetic Radiation Environment fromFriendly or Own Force Emitters.
MIL-HDBK-235 Part 3	- Electromagnetic Radiation Environment from Hostile Force Emitters
MIL-HDBK-235 Part 4	- Electromagnetic Radiation Environment, Army Installations
MIL-HDBK-235 Part 5	- Predicted Electromagnetic Environments forFour Selected Battle Force Scenarios
MIL-HDBK-237	- Electromagnetic Compatibility/ Interference Program Requirements
MIL-HDBK-253	- Guidance for the Design and Test of Systems Protected against the Effects of Electromagnetic Energy

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AIR FORCE

AFSC DH1-4	-	Air Force Systems Command Design Handbook, Electromagnetic Compatibility
AFSC DH2-7	-	Air Force Systems Command Design Handbook, "System Survivability"

(Copies of specifications, standards, handbooks, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Non-Government Publications. The following document forms a part of this document to the extent specified herein. Unless otherwise specified, the issues of the document which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the document cited in the solicitation.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C63.14	-	Standard dictionary for Technologies of Electromagnetic Compatibility (EMC), Electromagnetic Pulse (EMP), and Electrostatic Discharge (ESD).

(Applications for copies should be addressed to the IEEE Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.)

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SECTION 3: DEFINITIONS

3. Definitions. The terms used in this handbook are defined in ANSI C63.14.

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SECTION 4: DEFINING REQUIREMENTS

4.1 General. One of the basic objectives of the Department of Defense is to provide equipments and systems whose performance will not be adversely affected by the electromagnetic environment during all phases of the equipment or system life cycle. The effects may be either permanent, in which case the system will not operate until the damage has been repaired, or temporary, in which case the system will operate when the emissions causing the degradation are reduced or removed. Different effects can be produced, depending on the victim. Examples are:

a. Burnout or voltage breakdown of components, antennas, and so forth.
b. Performance degradation of receiver signal processing circuits.
c. Erroneous or inadvertent operation of electromechanical equipments, electronic circuits, components, ordnance, and so forth.
d. Unintentional detonation or ignition of electro-explosive devices, Flammable materials, and so forth.
e. Personnel injuries.

The effects on a given victim in a specific electromagnetic environment depend on the victim susceptibility characteristics, amplitude, frequency and time-characteristics of the environment, response time and frequency response of victim, and so forth. To prevent these problems, it is imperative that the possible effects of the electromagnetic environment on each new system be considered by the designer. A requirement to demonstrate satisfactory performance in a defined environment should be included in the equipment, subsystem or system (see 4.4) specification. MIL-HDBK-253 provides guidelines on the use of the electromagnetic environment data contained in this handbook as well as general information on the design and test of equipment, systems and platforms.

4.2 Developing the performance requirement. In developing the performance requirement for equipments, subsystems, and systems that may be exposed to the electromagnetic environment, various aspects should be considered as described in 4.2.1 through 4.2.5.

4.2.1 Environment profile. Each equipment, subsystem and system will be exposed to several different electromagnetic environments during its life cycle. The tables in the other parts of this handbook are intended for use in defining representative environment levels (see 4.3) to which each may be exposed. It is necessary to define each distinct environment. For example, a missile will be exposed to different environments during shipment, storage, checkout, launch, and during approach to a target.

4.2.2 Configuration. The configuration of each equipment, subsystem and system will vary depending on its location with the result that its susceptibility to the electromagnetic environment may also vary. Therefore, in developing the performance requirement the modes of operation, shielding, and so forth, in each of the environments defined should be identified.

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4.2.3 Operate vs. survive. It is important to distinguish between the conditions of operate and survive. There is usually a significant difference between the environment levels that will degrade performance and the levels that will permanently damage. In addition, there are many precautions that can be taken to protect an equipment from damage when it is not operating that are not feasible when it is operating.

4.2.4 Susceptibility. The susceptibility characteristics of the equipment, subsystem or system may be different depending on the design characteristics. The equipment may be frequency selective or may respond to a broad frequency range. Certain victims have response times in milliseconds and are affected by short-term, peak levels in the environment, whereas others are affected by heating and may respond slowly to average signal levels. All of these characteristics as well as the shielding integrity, choice of components and use of filtering must be considered when evaluating the effect of the electromagnetic environment on the equipment, subsystem or system. Furthermore, non-metallic materials are being considered for use on new platforms. Since these non-metallics provide little or no shielding, the installed system, subsystem or equipment can be exposed to environmental levels much higher than would be encountered on a platform with conventional metallic materials.

4.2.5 Future considerations. The definition of the electromagnetic environment which an equipment, subsystem or system may encounter should also include consideration of any possible future applications of the equipment, subsystem, or system and changes in the environment. Equipments designed to operate in one environment may be installed in another, or used to perform functions and missions that were not planned when the equipments were originally designed. Therefore, it is important to realize that although the cost of an equipment, subsystem, or system may increase when a severe electromagnetic environment is predicted, the increase may be justified in terms of adaptability for future applications.

4.3 Environment levels. The electromagnetic environment levels provided in Parts 2, 3, 4, and 5 are based on actual measurements, or predictions where measurements were not feasible. They are representative maximum values for each of the frequency bands. Approximate levels are given in TABLE II of this handbook for general information. However, care should be exercised if these values are to be used for anything other than general information.

4.3.1 Modification of environmental levels. The electromagnetic environmental levels are given in terms of peak and average power density and field strength. However, there are many other parameters which could influence the effect of the environment on a system, including:

Antenna scan rates	Pulse width
Antenna patterns	Pulse repetition frequency
Antenna polarization	Pulse rise and decay time
Antenna aperture	Spectrum coverage

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Relative location and proximity to other emitters, both friendly and hostile.

All known information concerning the environment within which an equipment, subsystem, or system must operate should be considered when evaluating its operation in its intended electromagnetic environment During development it is advisable to search out additional environmental data to ensure successful operation of the completed system, subsystem or equipment. Additional information concerning the sources of the environment levels in this document can be obtained from the preparing activity or the departmental custodians, as appropriate.

4.3.2 Conditions precluding exposure. When defining the electromagnetic environment within which an equipment, subsystem or system will be required to survive and operate during its life cycle, any operational or installation conditions that can preclude exposure to these levels and any additional information concerning the environment that may affect the impact of these levels should be considered. For example, the complement of intentional emitters on a platform or site will provide an indication of those frequency bands where high environment levels can probably be encountered. Furthermore, dimensional restrictions and intervening structures may exist thereby causing a system, subsystem or equipment to operate in the near or induction field region of an antenna. Other factors which must be considered are given below:

a. Limited platform usage. Many electronic equipments, subsystems, and systems are procured for installation on specified hulls, aircraft, ship types or land facilities. Definition of the electromagnetic environment to which the equipments and systems may be exposed should include consideration of the actual radiation levels based on the actual emitters installed or planned for installation on the specific site or platform rather than the general radiation levels.

b. Known location. Many electronic systems, subsystems, and equipments will be permanently installed at known locations. Definition of the electromagnetic environment to which they may be exposed should include consideration of the possibility that exposure to certain of the general radiation levels is unlikely because of the location of the new system, subsystem, or equipment relative to the sources of the radiation levels.

c. Operational usage. There are certain electronic systems which, because of their functions, may not be exposed to the general radiation levels. For example, backup equipment may not be exposed to radiation from primary equipment, and systems used when entering port normally will not be exposed to radiation from the fire control radars. Definition of the electromagnetic environment to which the systems may be exposed should include consideration of operational procedures which may preclude exposure to some of the environmental levels.

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TABLE II. Approximate EM Environment Levels.

LOCATION	FREQ. RANGE (MHz)	APPROXIMATE NEAR FIELD EM LEVELS			
		Pwr Dens (mW/cm^2)		Fld Stgth (V/m)	
		Peak	Avg	Peak	Avg
MIL-HDBK-235 Part 2 (Partial)					
Table I - Factory-to-Depot	< 35 35-2000 > 2000	- - -	- - -	- - -	10 5 20
Table II - Depot-to-Checkout	< 35 35-2000 > 2000	- - -	- - -	- - -	10 5 20
Table III - Checkout Areas Aboard Ship	< 30 30-2000 > 2000	- - -	- - -	1 32 1	1 1 1
Table IV - Hangar Deck (CV's and CVN's)	< 30 30-2000 > 2000	- - -	- - -	32 250 234	10 55 10
Table V(a) - Flight Deck of Aircraft Carriers (CV's and CVN's)	< 30 30-2000 > 2000	- - -	- - -	200 5,100 9,700	100 183 183
Table V(b) - Weather Decks, Missile Launching Ships (CG, CGN, DDG, FFG & FF's)	< 30 30-2000 > 2000	- - -	- - -	200 5,100 9,700	100 183 183
Table V(c) - Weather Decks, Non-Missile Combat Ships	> 30 30-2000 < 2000	- - -	- - -	200 5,100 7,220	100 183 183
Table VI(a) - Landbased Installations (Inside Xmtr Bldg and Outside all other structures)	< 30 30-2000 > 2000	- - -	- - -	20 40 1,500	10 5 40
Table VI(b) - Landbased Installations (Inside all other structures)	> 30 30-2000 > 2000	- - -	- - -	10 40 40	1 1 1
Table VII - Envelope of Maximum EM Environment Levels in Main Beam of US Shipboard Emitters	< 30 30-2000 > 2000	1 5,000 205,000	1 60 3,100	55 4,250 31,000	55 460 3,500
Table VIII - Envelope of Maximum EM Environment &2 Levels in Main Beam of US Airborne Emitters	< 30 30-2000 > 2000	10 5,500 45,000	10 25 800	185 4,500 31,000	185 285 1,750
Table IX - Envelope of Maximum EM Environment Levels in Main Beam of US Landbased Emitters	< 30 30-2000 > 2000	0.3 55,000 210,000	0.3 250 450	30 15,000 28,000	30 950 1,300

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TABLE II. Approximate EM Environment Levels. (Continued)

LOCATION	FREQ. RANGE (MHz)	APPROXIMATE NEAR FIELD EM LEVELS			
		Pwr Dens (mW/cm^2)		Fld Stgth (V/m)	
		Peak	Avg	Peak	Avg
MIL-HDBK-235 Part 3 (Partial)					
Table I - Maximum EM Environmental Levels for Hostile Shipboard Emitters	< 30 30-2000 > 2000	0.4 14,500 250,000	0.4 90 450	40 7,300 30,000	40 600 1,400
Table II - Maximum EM Environment Levels for Hostile Airborne Emitters	< 30 30-2000 > 2000	- 2,510 50,000	- 4 65	- 3,100 14,000	- 125 500
Table III - Maximum EM Environment Levels for Hostile Landbased Emitters	< 30 30-2000 > 2000	4 700,000 800,000	4 7,000 275,000	120 55,000 850,000	120 5,500 33,000
Table X - Actual Hostile Jammers	< 2000 > 2000	25 35	2 30	300 360	85 320
Table XI - Postulated Hostile Jammers	< 2000 > 2000	4,500 35,000	25 350	4,100 12,000	300 1,200
MIL-HDBK-235 Part 4 (Army only)					
Table I - Land Environment (Pulsed & Non-Pulsed Transmitters)	< 50 50-1000 > 1000	- - -	- - -	- - -	300 800 800
Table II - Land Environment (Pulsed Transmitters)	> 50 50-1000 > 1000	- - -	- - -	10 20,000 25,000	- - -

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4.4 Evaluation guidance. A requirement to demonstrate satisfactory operation in the defined environment should be included in the specific equipment, subsystem or system specification. Compliance with MIL-E-6051, MIL-STD-461 or MIL-STD-1385 would provide for a testing requirement, but only to lower levels of electromagnetic radiation. The electromagnetic environment levels in this handbook are substantially higher than those in MIL-E-6051, MIL-STD-461 and MIL-STD-1385; however, it should be noted that they are more difficult to generate and require careful consideration of the availability of test equipment and the type of testing laboratory, that is, military or civilian. Numerous alternatives are available for performing the evaluation, including the following:

a. Laboratory simulation. Prior to finalization of the design specification, a model of the platform, system, subsystem or equipment being procured may be developed and its performance evaluated in a model of the anticipated operational electromagnetic environment. The environment model should include all anticipated friendly and hostile, intentional and unintentional electromagnetic emissions. The objective of this effort is to validate the proposed design parameters and make necessary modifications prior to hardware development. The models can then be updated and re-used throughout the life cycle of the platform, system, subsystem or equipment to evaluate proposed hardware design changes and engineering change proposals (ECP's) as well as to reduce the need for costly field testing.

b. Anechoic chamber simulation. The performance of the Advanced Development and Engineering Development Models may be evaluated by a series of tests in an anechoic chamber wherein the anticipated electromagnetic environment developed as in (a) above is scaled down and simulated by limiting the electromagnetic environment levels, frequency ranges and test sample shielding.

c. Full-Scale field testing. The performance of this type of test may necessitate use of a military test facility in lieu of contractor's due to the difficulty in generating the high level electromagnetic environment levels. Such tests are usually quite costly since they may require installation of the system, subsystem or equipment on the intended platform. It is noted that data obtained from (a) and (b) above may reduce the requirement for field performance data.

4 5 Documentation. Provisions should be included in the procurement documentation to verify that the environment is considered throughout the contract. This can be accomplished by requiring the contractor to provide documentation similar to or an expansion of that described in MIL-STD-461 or MIL-E-6051 as indicated in 4.5.1 through 4.5.3.

4.5.1 Control plan. The techniques and procedures that will be used to enhance compliance with the performance requirements in the specified

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electromagnetic environment should be described. This may be accomplished by requiring the contractor to expand the contents of the control plans which may be required by the contract, such as those described in MIL-E-6051 or MIL-STD-461.

4.5.2 Test plan. The test methods and equipment that will be used to demonstrate compliance with the performance requirements in the specified electromagnetic environment should be described. This may be accomplished by requiring the contractor or testing activity to expand the contents of the test plans which may be required by the contract, such as those described in MIL-STD-461 or MIL-E-6051.

4.5.3 Test report. The results performed to demonstrate compliance with the performance requirements in the specified electromagnetic environment should be documented and reviewed by the procuring activity. This may be accomplished by requiring the contractor or test activity to expand the contents of the test reports which may be required by the contract, such as those in MIL-STD-461 or MIL-E-6051.

Custodians:

Army - CR
Air Force - 11
Navy - EC

Review Activities:
Army - ER, AV, MI, AR
Navy - SH, AS, MC
Air Force - 10, 15, 17, 18, 19

User Activities:
Army - TE

Preparing Activity:

Navy - EC
(Project EMCS-N128)

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