MIL-STD-1399A(NAVY)
SECTION 408
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MILITARY STANDARD

INTERFACE STANDARD FOR SHIPBOARD SYSTEMS

SECTION 408

ELECTROMAGNETIC RADIATION HAZARDS TO PERSONNEL AND FUELS

FSC MISC

DEPARTMENT OF THE NAVY

WASHINGTON, D.C. 20362

Interface Standard for Shipboard Systems,
Electromagnetic Radiation Hazard to Personnel and Fuels

MIL-STD-1399A(NAVY)
SECTION 408

1. This Military Standard is approved for use by Commands of the Navy in the technical development plans, design, and procurement specifications for new ship acquisitions, ship modernizations or conversions, and systems/equipment for installation therein and into active fleet ships.

2. Recommended corrections, additions, or deletions should be addressed to the Naval Ship Engineering Center, Center Building, Prince Georges Center, Hyattsville, Maryland 20782.

FOREWORD

Purpose. This section defines the standard interface requirements for, and the constraints on, ship design and layout, and the installation of systems/equipment which radiate electromagnetic energy in order to control electromagnetic radiation hazards onboard ship.

Nature of the interface. Each ship, due to electromagnetic radiation (EM) existing on or about the ship, has an electromagnetic environment which varies with different ship configurations and which may, if of sufficient strength, adversely affect personnel or cause accidental fuel ignition.

Structure of this section. The technical content delineates the characteristics of this shipboard environment in terms of frequency and electromagnetic energy. The constraints necessary to afford protection to personnel and prevent accidental fuel ignition are then established.

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FIGURES

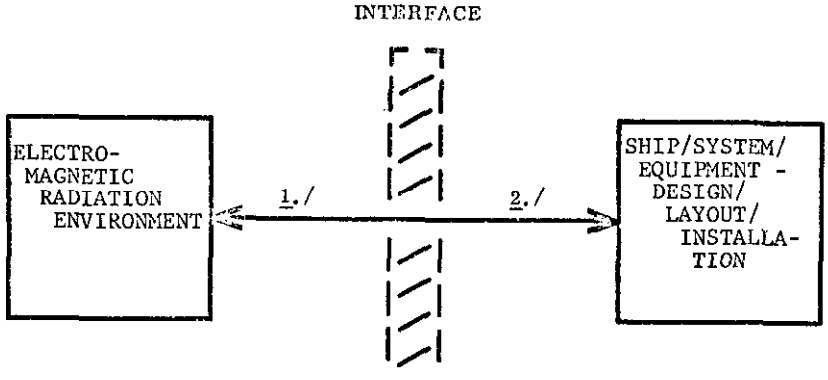
TABLES

1. GENERAL, SCOPE, INTERFACE AND APPLICABILITY

1.1 General. The policies and procedures established by MIL-STD-1399 are mandatory. This section and the basic standard are to be viewed as an integral single document.

1.2 Scope. This section establishes interface requirements to prevent injury to personnel and accidental ignition of flammable volatile fuels which could occur onboard ship as a result of electromagnetic radiation.

1.3 Interface. The basic characteristics and constraint categories concerned with this interface are shown symbolically on figure 1 (see paragraph "Definitions" of MIL-STD-1399):



1/ CHARACTERISTICS
- Physical
  - Frequency
  - Power density
- Induced
  - Rf burn
  - Ionization
  - Sparking

2/ CONSTRAINTS
- Compatibility
- Protection measures
- Equipment design

Figure 1 - Interface.

The particular interface characteristics and constraints pertinent to this section are described in 5.2 and 5.3.

1.4 Applicability. This section applies to electromagnetic radiation generated onboard a ship which may be hazardous to personnel exposed to such radiation, or which, under certain circumstances, can cause accidental ignition of flammable volatile fuels.

2. REFERENCED DOCUMENTS

2.1 The issues of the following documents in effect on the date of invitation for bids form a part of this standard to the extent specified herein.

GOVERNMENTAL

PUBLICATIONS

BUREAU OF MEDICINE AND SURGERY

BuMED P-5052-35 - Control of Hazard to Health from Laser Radiation (Army - TB MED 279).

BuMED P-5055 - Radiation Health Protection Manual.

PUBLICATIONS (cont'd.)
NAVAL SHIP SYSTEMS COMMAND
NAVSHIPS 0900-005-8000 - Technical Manual for Radio-Frequency Radiation Hazards.
NAVSHIPS 0967-317-7010 - Technical Manual - Radio Frequency Burn Hazards Reduction.

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

3. DEFINITIONS

3.1 Electromagnetic radiation. Electromagnetic radiation is the emission of energy in the form of electromagnetic waves.

3.1.1 Electromagnetic waves. Electromagnetic waves are waves characterized by variations of the electric and magnetic fields radiated by transmitting devices in the electromagnetic spectrum.

3.2 Electromagnetic radiation environment. The electromagnetic radiation environment of a ship, as used in this section, is the electromagnetic energy field which is present in any particular area of a ship.

4. REQUIREMENTS

4.1 The specific interface requirements and constraints established herein are mandatory and shall be adhered to by SYSCOMs, PMs, contractors and all others engaged in any aspect of shipboard electronic design to which these requirements and constraints apply including system/equipment design, production, and installation (see paragraph "Requirements" of MIL-STD-1399).

5. INTERFACE CHARACTERISTICS AND CONSTRAINTS

5.1 General considerations. Radiation hazards onboard ship are associated with the potential hazard to personnel and to flammable volatile fuels, created by radiated electromagnetic energy from high-powered communications, radar, and other electronic equipments. Hazards to personnel also exist from other radiation sources within the electromagnetic spectrum. These include ionizing radiation, laser radiation emitted by laser devices, and microwave radiation associated with microwave ovens when such radiation sources are present.

5.1.1 Hazards to personnel. The degree of hazard to personnel from radiated electromagnetic energy depends on factors such as transmitter frequency, power density, distance from the source and time of exposure. The physiological hazard to personnel is that of possible biological injury to sensitive organs as a result of radiation in the frequency range between 100 megahertz (MHz) and 100 gigahertz (GHz) absorbed by the body. An additional hazard to personnel from radio frequency (rf) radiation is indirect in nature and results from rf voltages induced in ship rigging or metallic items by radiation from nearby antennas. The hazard from this cause is that of possible rf energy burn to personnel coming in contact with such rf voltage source; in addition such contact could result in an involuntary body reaction causing a serious accident. Whenever laser devices are employed there exists the possibility of personnel exposure to injurious intensities of laser radiation. The directional intensity of the light generated by a laser results in concentrated light beam intensities at considerable distances. Because of the possible damaging effects of laser beams on body tissues, particularly the human eye, it is necessary that provisions be made in the design and operation of laser installations to protect personnel from this radiation hazard. Another device which is potentially hazardous is the microwave oven which, in utilizing microwave radiation to generate heat for cooking purposes, employs frequencies within the range which can be harmful to body tissues. A danger to personnel in the immediate vicinity of such ovens exists if radiation leakage occurs. Whenever radioactive substances or equipment capable of producing ionizing radiation are employed onboard ship, positive measures are required to protect personnel from such radiation, which can cause serious bodily damage.

5.1.2 Hazards to fuel. Increases in radiated rf energy from high-powered communications, radar, and other electronic equipment onboard ship have heightened the possibility of accidental ignition of flammable volatile fuel-air mixtures by sparks created by rf radiation. Flammable mixtures may be present close to aircraft fuel vents, open fuel inlets

during over-the-wing fueling or close to spilled fuels. Ignition of fuel vapors by rf induced arcs requires a combination of circumstances to occur simultaneously. Such occurrence is not probable under normal operating conditions but the hazard is constantly present and must be carefully guarded against. The hazard exists whenever a visible spark can be seen.

5.2 Interface characteristics. The interface characteristics of the ships electromagnetic radiation environment are specified in 5.2.1 through 5.2.4. Modern Naval ships are always equipped with sources which generate electromagnetic energy; therefore, an electromagnetic radiation environment will be present in varying degrees depending on the circumstances. The characteristics of this environment are described qualitatively in 5.2.1 and 5.2.2; quantitative values for particular situations must be determined by measurement or approximated by theoretical calculations. Personnel hazard exposure limits are given in 5.2.3.

5.2.1 Physical characteristics.

5.2.1.1 Frequency. The range of electromagnetic radiation frequencies which may be encountered onboard ship are shown on figure 2. The frequencies which are in most common use onboard ship and which present the broadest range of hazards are found in the radio, radar and microwave regions of the spectrum extending from approximately 0.3 MHz to 30,000 MHz. Ionizing radiation is associated with x- or gamma rays in the higher frequency region above 3×10^9 MHz. Laser radiation occurs in the "light" region of the spectrum including those frequencies associated with infrared, visible, and ultraviolet light rays.

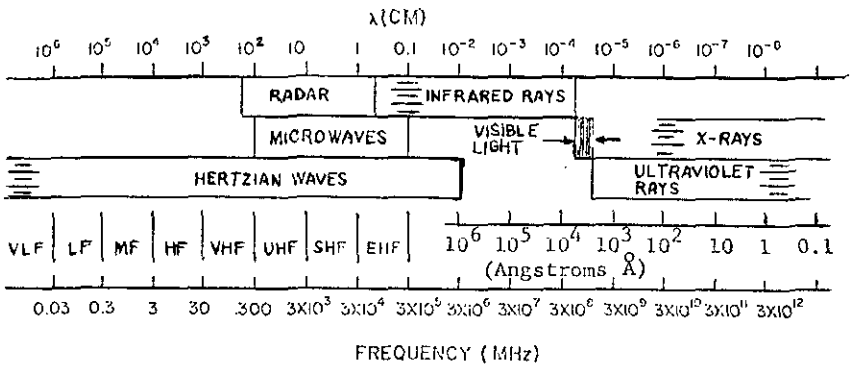


Figure 2 - Frequency spectrum.

5.2.1.2 Power density. The effects of electromagnetic radiation are dependent among other factors upon the amount of radiated energy present and the duration of exposure. Transmitted power outputs at communication frequencies may approach 10 kilowatts (kW); at radar frequencies the peak power output may exceed 5 megawatts (mW). The reference bases used as criteria for determining hazards to personnel are the power density expressed in milliwatts per square centimeter (mW/cm^2) for continuous exposure of personnel or the incident energy level expressed in millijoules per square centimeter per 30 second interval ($mJ/cm^2/30$ sec) for intermittent exposure of personnel. Laser radiations commonly have the properties of high power density, coherence of radiation, and monochromaticity of the light emitted. The energy associated with lasers may be 1000 joules/cm^2 or more at a distance of several miles with power densities exceeding 100 watts/cm^2. When the transmitted power or power of the source and other pertinent factors are known in a given situation, power density, incident energy level, etc., may be approximated to a satisfactory degree by theoretical calculation. In some cases direct measurement will be required.

5.2.1.3 Time variance. The shipboard electromagnetic radiation environment is time variant. Most radiation sources operate on an intermittent as needed basis or in a rotating or scanning mode.

5.2.2 Induced characteristics. The electromagnetic radiation environment of s ship will, under certain conditions, couple into metallic portions of the ship structure or appurtenances and generate a secondary, or induced, rf voltage which, upon contact, may be hazardous.

5.2.2.1 Radio frequency burn. Shipboard radio transmitters operating in the 2 through 30 MHz range are capable of inducing rf voltages in ship structure, rigging, appurtenances, and other metallic items. The magnitude of such induced rf voltage is directly related to:

(a) The resonance of the structure, in relation to the rf frequency.
(b) The proximity to the radiating antenna.
(c) The power being radiated.
(d) The orientation with respect to the polarization of the rf field.

When the induced rf voltage is greater than 140 volts, an rf burn hazard is deemed to exist.

5.2.2.2 Accidental fuel ignition. Rf fields may induce sufficient energy to generate a spart between an aircraft skin and a fueling hose nozzle which contains sufficient energy to ignite an optimum fuel-air mixture of flammable volatile fuel under the proper conditions (see NAVSHIPS 0900-005-8000, section 7).

5.2.3 Ionization. Electromagnetic radiations in the x- or gamma ray region (i.e. above 3 x 10^9 MHz) which have sufficient energy may induce ionization - the ejection of electrons from atoms. Such ionization cannot be seen or sensed by the human body; it can be detected only by radiac equipment designed to measure the amount of ionizing radiation present in a given area.

5.2.4 Hazard exposure limits. Safe upper limits for exposure of personnel to various types of electromagnetic radiation hazards have been established and are summarized in table I.

Table I - Exposure limits.

Hazard	Exposure limit		Remarks
Microwave radiation (100Mhz-100GHz)	10 mW/cm^2 - average power density		Exposure longer than 30 seconds
	300 mJ/cm^2/30 seconds incident energy level		Intermittent exposure up to 30 seconds
Rf burn	140 volts		See 5.2.2.1
Laser (eye exposure)	1 x 10^{-7} J/cm^2	0.4 - 1.4 micrometre range	Q-switched
	1 x 10^{-6} J/cm^2		Non Q-switched (approximately 1 millisecond pulse length)
	1 x 10^{-6} W/cm^2		Cw laser
	100 mW/cm^2	10.6 micrometre	CO^2 cw laser
Laser (skin exposure)	1 x 10^{-2} J/cm^2	0.4 - 1.4 micrometre range	Q-switched
	1 x 10^{-1} J/cm^2		Non Q-switched (approximately 1 millisecond pulse length)
	1 X 10^{-1} W/cm^2		Cw laser
	100 mW/cm^2	10.6 micrometre	CO^2 cw laser
Ionizing radiation	0.5R/year		Uncontrolled areas
	0.1R/week		Controlled areas

5.2.4.1 Radiation protection standards. The effect of ionizing radiation is harmful to the human body in a cumulative manner. The radiation protection standards for external exposure of a cumulative nature and special controls for areas controlled for radiation protection purposes are specified in BUMED P-5055.

5.3 Interface constraints. The interface characteristics of the ships electromagnetic radiation environment impose certain constraints on ship design and layout, radiating systems/equipment design and installation, and personnel exposure. These constraints are specified in 5.3.1 through 5.3.7.

5.3.1 Compatibility. The design and layout of the ship, including design and installation of systems/equipment and physical measures for the protection of personnel shall be directed toward compatibility of the electromagnetic radiation environment throughout the ship with the hazard exposure limits specified in 5.2.3. In cases where compliance would be impossible or unreasonable, the provisions of section 6 shall apply. Various specific constraints which may be required in specific situations are described in 5.3.2 through 5.3.7. Additional information and guidance including precautionary measures may be found in:

(a) NAVSHIPS 0900-005-8000.
(b) NAVSHIPS 0967-317-7010.
(c) BUMED P-5052-35.
(d) BUMED P-5055.

5.3.2 Rf fields. The following measures shall be utilized when appropriate to control the degree of hazard from the rf field level in the frequency range between 100 MHz and 100 GHz at various areas onboard ship where rf levels may exceed safe limits:

(a) Restrict the pointing arcs of highly directional radiating equipment, such as pencil beam radars etc., by physical cams, stops, or other suitable means.
(b) Provide a safe zone in which personnel may pass or work by installation of a suitable rf screen or shield.
(c) Provide fencing, chains, etc., in high hazard areas to restrict entry of personnel.
(d) Install appropriate standard radiation hazard warning signs and provide for installation portable signs to designate radiation areas.

5.3.3 Rf burn. When an rf burn hazard is deemed to exist, the hazard shall be reduced to an acceptable value. The following measures, as appropriate, may be considered:

(a) Installation of insulator links between the rigging and the hooks.
(b) The use of non-metallic materials if practicable.
(c) Antenna relocation.

5.3.4 Microwave ovens. Microwave ovens, particularly doors, hinges, seals, etc., are susceptible to progressive deterioration in operational use. Radiation leakage from microwave ovens onboard ship shall not exceed 5 mW/cm^2 at any oven surface. All microwave ovens shall be equipped with built-in door interlocks.

5.3.5 Lasers. Laser hazard to personnel shall be controlled when necessary by the use of physical barriers, interlocks, limitations of laser beam traverse, and installation of appropriate standard warning signs. Other control criteria applicable to particular circumstances may be derived from the guidance information contained in BUMED P-5052-35

5.3.6 X-rays. Spaces in which x-ray equipment with a capacity of 100 milliampere (mA) (or greater) is installed shall be provided with lead/steel shielding suitable for the protection of personnel. High voltage equipment with a similar capacity for producing x-rays shall also be suitable shielded (see 5.2.3.1).

5.3.7 Fueling hoses. Where a sparking hazard to flammable volatile fuels is deemed to exist the fueling nozzle shall be either non-conducting or equipped with a suitable insulating sleeve.

6. DEVIATIONS

6.1 Conditions. In achieving the purpose of this section it is recognized that there must be some flexibility of application. During the early stages of ship design, layout, and arrangement it may become apparent that strict compliance with the requirements of this section will result in an unreasonable or impossible situation. In such instance, the provisions of the "Deviations" paragraph of MIL-STD-1399 must be complied with.

6.1.1 Deviation procedure. Requests for deviations shall be submitted to NAVSHIPS with copies to:

(a) Program/Project manager.
(b) NAVSEC 6170.

Review activities:
EC, YD, MS
User activities:
AS, OS, CG

Preparing activity:
NAVY - SH
(Project MISC N816-5)

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