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DEFENCE STANDARD

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FRENCH TITLE: Evaluation et emploi des systèmes d'armes et munitions équipés de dispositifs électro-pyrotechniques soumis aux effets des rayonnements électromagnétiques non ionisants

Partie n° 1: Exigences relatives à l'évaluation des dispositifs électro-pyrotechniques et de leur intégration dans les systèmes d'armes et munitions

ENGLISH TITLE Evaluation and use of munitions and weapon systems embodying electrically initiated devices against the effects of non-ionizing electromagnetic radiations

Part 1: General specifications for evaluation of electrically initiated devices and for their integration in munitions and weapon systems

ANALYSIS:

This document defines the requirements for electrically initiated devices and their integration in munitions and weapon systems, when they are exposed to the effects of non-ionizing electromagnetic radiations.
It also describes the different sources of electromagnetic radiation that can pose a risk to electrically initiated devices and defines the evaluation procedures specific to these devices.
The aim of this information is to obtain "DRAM" qualification for the stability of weapon programmes against electromagnetic radiation.

KEYWORDS:

DRAM - Electromagnetic radiation - Electrically initiated device - EID - Munitions Weapons system - Initiators - Evaluation - Qualification

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INTRODUCTION

Most weapon systems and munitions contain electrically initiated devices (EIDs) that can be accidentally initiated by electromagnetic radiation generated by radio and radar transmitters. Accidental firing can also be caused by phenomena of electrostatic discharge (ESD), lightning bolt, high-altitude electromagnetic pulse of nuclear origin (HEMP) and more generally by high-power electrical systems (degausser coils, electromagnetic catapults etc.). This problem is referred to in France by the acronym “DRAM”, standing for “Dommages dus aux Rayonnements électromagnétiques sur les systèmes d’Armes et les Munitions” (Damage to Weapon Systems and Munitions by Electromagnetic Radiation).

Under the effects of electromagnetic radiation, an EID can:

- either be actuated prematurely, causing problems of safety and reliability for both personnel and equipment,
- or undergo an alteration, causing essential problems of reliability.

These risks can be eliminated by

- making the munitions less sensitive to the electromagnetic environment with the aid of secured devices built into the systems from the design stage,
- or by implementing safety instructions, so that sensitive munitions are not exposed to an electromagnetic field greater than they can withstand.

To draw up these safety instructions, the first necessary step is to evaluate the electromagnetic vulnerability of the munition concerned (“DRAM evaluation”). The rules to be followed for this evaluation are defined in the first part of French Defence Standard NORMDEF 0301-1 (Part 1) - General specifications for evaluation of electrically initiated devices and their integration in weapon systems and munitions against the effects of electromagnetic radiation.

Subsequently, when the sensitivity of the munition exposed to electromagnetic environments has been determined, in other words when its permissible exposure level is known, it is possible to define the associated safety instructions. The definition of these safety instructions is the object of the second part of the standard, NORMDEF 0301-2 (Part 2) - Definition of safety instructions concerning the conditions for the use of weapon systems and munitions equipped with electrically initiated devices in radio-radar electromagnetic environments.

French Defence Standard NORMDEF 0301, Parts 1 and 2, cancels and replaces standards GAM DRAM 01 and GAM DRAM 02 ([BIBLIO1] and [BIBLIO2]). The procedures for the evaluation of munitions are based on the broad principles of the cancelled standard GAM DRAM 01 and also draw largely on STANAG 4370 ([DR01]) as fundamental reference, with the aim of resolving problems of interoperability and facilitating export of weapons and munitions.

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1.

1. AIM

This standard describes the general specifications for evaluation of electrically initiated devices (EIDs) and their integration in munitions and weapon systems against the effects of electromagnetic environments deriving from the following sources:

- Radio-radar transmitters.
- Electrostatic discharge (ESD).
- Lightning.
- High-altitude electromagnetic pulses of nuclear origin (HEMP).
- Other environments (on-board transmitters and portable transmitters, power electronics, etc.)

In this context, the present standard lays down the procedures for the qualification of these devices. The aim of the standard is to determine the level of electromagnetic aggressions that weapons systems and munitions can withstand without compromising their safety of use and their reliability.

This standard concerns the evaluation of munitions and weapon systems intended for use by the armed forces. It is designed to serve as reference for the offices of the French State (programme management departments and technical authorities) in charge of the development, acquisition and evaluation of these systems. It can also be used in the context of export of weapons programmes.

Note:
In the remainder of this document, for reasons of simplicity and consistency with [DR01], the term "munition(s)" is used for all systems equipped with EIDs (such as missiles, decoy flares, short-life safety flare systems etc.). In certain phases of the life-profile of a weapon system or munition, this term can also designate sub-modules comprising at least one EID.

2. FIELD OF APPLICATION

This standard, which is dedicated to the evaluation of electrically initiated devices (EIDs) and their integration in weapon systems and munitions exposed to the effects of electromagnetic environments, excludes the evaluation of pyrotechnic substances. However, it is important to note that an EID can be degraded by alteration of the initiator characteristics due to ageing phenomena resulting from exposure to electromagnetic environments. This question must be evaluated on a case-by-case basis.

The present standard focuses exclusively on the unreliability caused by accidental actuation of an electrically initiated device.

In particular, this standard applies to the following phases of the life-profile:

- Storage and transport of the munition (ST/TR):
  - Munition alone
  - Munition in logistic packaging
  - Munition in tactical packaging,
- Implementation of the munition:
  - Deployment of the munition (on carrier, launcher etc.).
  - Connection/disconnection of the munition.
  - Programming of the deployed missile etc.
- Deployed munition (on carrier, launch pad, powered, non-powered etc.)
- Munition in launching and flight phase

Note:
The above list of operating configurations is not exhaustive and depends on the specific weapons programme.

3. REFERENCE STANDARDS

The reference standards listed below are those that should be taken into account for the application of the present document:

Reference	Standard document	Edition / date
[DR01]	**STANAG 4370:** *Environmental testing*	**Edition 5 — December 2014**
[DR02]	**NORMDEF 0301-2:** *Evaluation and use of munitions and weapon systems embodying electrically initiated devices against the effects of non-ionizing electromagnetic radiations - Part 2: Definition of safety instructions concerning the different conditions of use of the weapon systems and munitions embodying electrically initiated devices in electromagnetic environment*	**Edition 1 - October 2016**
[DR03]	**STANAG 1380 :** *NATO naval radio and radar radiation hazards manual - AECP-2(D) AND MECP-2(D)*	**Edition 5 — August 2015**
[DR04]	**Technical Notice No. 312 CAD/NUC5/CD dated 18/07/1991:** *Justification and presentation of the new High-Altitude EMP specifications* **(classified document)**	**July 1991**
[DR05]	**Technical Notice No. 314 CAD/NUC5/CD dated 30/07/1991:** *Digital data on the changes to the HEMP standard (annex to Notice 312)* **(classified document)**	**July 1991**
[DR06]	**STANAG 4145:** *Nuclear Survivability Criteria for Armed Forces Material and Installations - AEP-4* **(classified document)**	**Edition 2 — January 1991**
[DR07]	**STANAG 4560:** *Electroexplosive devices, assessment and test methods for characterization*	**Edition 2 — December 2006**

Reference	Notices concerning STANAG 4145	Edition / date
[DR14]	**AEP-04:** *Nuclear Survivability Criteria for Armed Forces Material and Installations* **(classified document)**	**Edition 1 - April 1975**
[DR15]	**AEP-04 - Annex A:** *Nuclear Hardening Criteria for Armed Forces Material and Installations* **(classified document)**	**Edition 4 - July 1990**
[DR16]	**AEP-04 - Annex B:** *Nuclear Survivability Criteria for Naval Forces Material and Installations* **(classified document)**	**Edition 2 — January 1999**
[DR17]	**AEP-04 - Annex C:** *Nuclear Survivability Criteria for Air Forces Material and Installations* **(classified document)**	**Edition 1 — December 1987**

Reference	Notices concerning STANAG 4370	Edition / date
[DR08]	**AECTP 250:** *Electrical and Electromagnetic Environmental Conditions:*	Edition C December 2014
[DR09]	**Leaflet 253:** *Electrostatic Charging, Discharge and Precipitation Static*	
[DR10]	**Leaflet 254:** *Atmospheric Electricity and Lightning*	
[DR11]	**Leaflet 255:** *Direct Current (DC) Magnetic and Low Frequency (LF) Fields*	
[DR12]	**Leaflet 256:** *Nuclear Electromagnetic Pulse (NEMP/EMP)*	
[DR13]	**Leaflet 258:** *RF Electromagnetic Environments (EMEs)*	
[DR18]	**AECTP 500:** *Electromagnetic Environmental Effects Tests and Verifications*	Edition 4 — January 2011
[DR19]	**AECTP 500 - Category 501:** *Equipment and sub systems tests*	
[DR20]	**AECTP 500 - Category 508:** *Electromagnetic Environmental Effects Test and Verification - Introduction to Test Ordnance and Verification Procedures*	
[DR21]	**Category 508 leaflet 1:** *Guidance for Testing the Electromagnetic Vulnerability of Ordnance and Weapon Systems*	
[DR22]	**Category 508 leaflet 2:** *Electrostatic Discharge*	
[DR23]	**Category 508 leaflet 3:** *Electromagnetic Radiation*	
[DR24]	**Category 508 leaflet 4:** *Lightning, Munition Assessment and Test Procedures*	
[DR25]	**Category 508 leaflet 5:** *Nuclear Electromagnetic Pulse*	

4. ACRONYMS AND TERMINOLOGY

a) Acronyms :

A/C: Aircraft

AECTP: Allied Environmental Conditions and Test Procedures

A/m: Amps/metre

ASDVL: Artifice de Sécurité à Durée de Vie Limitée (Limited-life Safety Pyrotechnical Device)

BCI: Bulk Cable Injection

CD: Confidential Defence

CND: Centre de Normalisation de la Defence (Defence Standardization Centre)

dB: Decibels

EID: Electrically initiated device

ESD: Electrostatic discharge

HESD: "Helicopter" electrostatic discharge

PESD: "Personnel" electrostatic discharge

DGA: Direction Générale de l' Armement (Directorate General of Armaments)

DIRISI: Direction Interarmées des Réseaux d'infrastructure et des Systèmes d'information de la défense (Joint Forces Directorate for Defence Infrastructure Networks and Information Systems)

Ead: Admissible energy

EBW: Exploding Bridge-Wire

EFI : Exploding Foiled Initiator

EMA: Etat-Major des Armées (French Joint Forces Command)

EME: Electromagnetic Environment

E_{NF} : No-fire energy

GHz : Gigahertz

H/C : Helicopter

I_{AD} Admissible current

I_{NF}: No-fire current

HEMP: High-altitude electromagnetic pulse

kHz: Kilohertz

m: Metre

HPM High Power Microwave

MHz: Megahertz

NATO: North Atlantic Treaty Organization

Ne: Number of EIDs

Np: Minimum number of strikes per sequence

Nl: Minimum number of threat levels

OTAN: French acronym for NATO

P_{ad} : Admissible power

EIRP: Equivalent Isotropic Radiated Power

PTC: Pin-to-Case

PTP: Pin-To-Pin

P_{NF} : No-fire power

RF: Radiofrequency

SGA: Secrétariat Général pour l'Administration (Secretary General for Administration)

SRAD: Susceptibility RADHAZ Designator

SSA: Service de Santé des Armées (French Defence Health Service)

STANAG: Standardization NATO Agreement

ST/TR: Storage/Transport

V/m: Volts per metre

VBF: “Vérification de Bon Fonctionnement” (Operational Acceptance Verification)

W/m^2: Watts per square metre

b) Terminology:

National Authority:
State department in charge of exercising the technical authority necessary to guarantee the safety of persons and property.

Direct lightning strike
Lightning discharge that directly strikes the weapon system (or munition) and that causes the circulation of lighting current in a part of the weapon system (or munition) or even in the entire weapon system (or munition).

Close-proximity lightning strike
Lightning discharge that does not directly strike the weapon system (or munition) but, due to its proximity, can induce current inside the weapon system (or munition) by electromagnetic coupling or ground current.

Electrically initiated device (EID):
Electrical device that, in its entirety, can perform a specific explosive function.

Note:
An active EID has an active initiator (see definition of “active mock-up”)

Indirect effects of lightning:
Effects due to coupling of the weapon system (or munition) with the electromagnetic field generated by lightning. These effects can be the consequence of a direct or close-proximity lightning strike. The transient voltages induced in wiring are one example of indirect effects.

On-board transmitters (or internal transmitters):
Set of transmitters such as on-board radio, proximity detector, radar, radar jammer, etc. They can also be called internal transmitters.

Radio-radar transmitters (or external transmitters):
Set of transmitters used for radio, radar, satellite jammer etc. and likely to be encountered by a munition or weapon system during its life-profile. These systems are not part of the munition or weapon system. They can also be termed external transmitters.

Environment:
At any given moment, the combination of physical, chemical, biological etc. agents liable to have a direct or indirect effect on living beings, human activities and on the systems or their operation (definition from NF X 50-144-1).

Initiator:
Pyrotechnic component actuated by means of a non-pyrotechnic phenomenon (e.g. electric initiator)

Active (or semi-active) mock-up:
Mock-up containing active substances, in other word containing pyrotechnic substances. This type of mock-up is termed semi-active because it is representative of the industrially produced munition, with the exception of the military charges and fuels, which have been removed. Only the initiators of this type of mock-up are active.

Munition:
A complete device charged with explosives, propellants, pyrotechnics, initiating composition or chemical, biological, radiological or nuclear material, for use in military operations, including demolitions. (NATO/NTMS definition)

Life-profile of the weapon system or munition:
Chronological description presenting the detailed scenarios of use of the weapon system or munition, considered from the moment it leaves the factory to its withdrawal from service (including dismantling). (Definition adapted from NF X 50-144-1)

Qualification:
Combination of tasks contributing to providing proof, based on theoretical and experimental evidence and justifications, that the defined weapon system or munition corresponds to the specified needs and is producible (definition adapted from NF EN 9200, 4.51).

Weapon(s) system:
A combination of one or more weapons with all related equipment, materials, services, personnel and means of delivery and deployment (if applicable) required for self-sufficiency (NATO/NTMS definition)

5. DEFINITION OF ELECTROMAGNETIC ENVIRONMENTS

5.1 General

This chapter describes the sources of electromagnetic environments that, due to the risks that they can generate, have an influence on the design and use of munitions.

The different electromagnetic environments defined below, in combination with the assessment procedures described in section 6, permit the establishment of:

- appropriate test configurations, specially adapted to the technical problems and cost constraints,
- tests satisfying the specified qualification requirements defined for each weapons programme. Specific adaptations ("customizations") of the requirements, where applicable, are defined by the National Authority.

Note:
It is not necessary to assess a munition against every electromagnetic environment. Only the environments likely to be encountered, with a sufficient probability of occurrence, during the various phases of the life-profile of the munitions must be considered. For example, helicopter ESD (in the case of helihoisting) does not concern all munitions. The consideration of unjustified environments can lead to excessive costs of weapons programmes (design and evaluation of munitions).

5.2 Radio-radar transmitters.

Radio-radar-type transmitters external to the munition are also termed external transmitters.

Given the diversity of their characteristics, including transmission frequency, waveform and the radiated power level, radio-radar environments are defined after establishing the life-profile of the munitions.

To assist in the specification of weapons programmes for the armed forces, different environments have been defined for the different operating spheres, i.e. land, fleet-air, sea. The sole aim of these defined environments is to provide a foundation for defining the requirements of immunity to electromagnetic radiation and can be customized by the National Authority if necessary.

The aim of evaluating a munition against this type of environment is to establish safety instructions (monitoring of radio-radar emissions, positioning of munitions etc.). These instructions are drawn up by the armed forces with the aid of the following information, defined by [DR02] and [DR03]:

- classification by colour-coding (procedure specific to France),
- an SRAD code.

The aim of a "DRAM" evaluation is to provide this classification and code to the armed forces for the different use configurations concerned. In addition to these data, the DGA also draws up a Munition-Environment Specification (classed CD), which specifies the levels of immunity permissible per munition in narrower frequency ranges than for the SRAD code.

5.2.1. "Land" Environment

Table 1 defines the permissible environments, to be specified as a function of their use configuration, for munitions dedicated to the land operations of the armed forces.

Configuration of use		**Permissible environment of "Land" munitions**
ST/TR (logistic, tactical, stand-alone)		"Land" Environment (see Annex A - Table A1)
Transport by air	By helicopter	"Rotary-wing Aircraft" Environment (see Annex A - Table A5)
	By aeroplane	"Fixed-wing Aircraft" Environment (see Annex A - Table A4)
Implementation ("MEO")		"Land" Environment (see Annex A - Table A1)
In position		"Land" Environment (see Annex A - Table A1)
In free flight		"Free flight" Environment (see Annex A - Table A9)

Table 1: Permissible environment of "Land" munitions

5.2.2. "Air" Environment

Table 2 defines the permissible environments, to be specified as a function of their use configuration, for munitions dedicated to the airborne operations of the armed forces (except for fleet air arm operations).

Note:
The "Air" environment does not include the aircraft launched from a surface vessel. These aircraft are considered under the "Fleet Air" Environment.

Configuration of use			**Permissible environment of "Air" munitions**
ST/TR (logistic, tactical, stand-alone)			"Land" Environment (see Annex A - Table A1)
Implementation ("MEO")			"Land" Environment (see Annex A - Table A1)
In position	On aeroplane	On ground	"Land" Environment (see Annex A - Table A1)
		In flight(1)	"Fixed-wing Aircraft" Environment (see Annex A - Table A4)
	On helicopter	On ground	"Land" Environment (see Annex A - Table A1)
		In flight(1)	"Rotary-wing Aircraft" Environment (see Annex A - Table A5)
In free flight			"Free flight" Environment (see Annex A - Table A9)

Table 2: Permissible environment of "Air" munitions

(1) This configuration includes transport of the munitions by air.

5.2.3. “Fleet Air” Environment

Table 3 defines the permissible environments, to be specified as a function of their use configuration, for munitions dedicated to the fleet air operations of the armed forces.

<table>
<tr><th colspan="3">Configuration of use</th><th>Permissible environment of “Fleet Air” munitions</th></tr>
<tr><td colspan="3">ST/TR (logistic, tactical, stand-alone)</td><td>“Flight deck” Environment (see Annex A - Table A8)</td></tr>
<tr><td colspan="3">Implementation (“MEO”)</td><td>“Flight deck” Environment (see Annex A - Table A8)</td></tr>
<tr><td rowspan="4">In position</td><td rowspan="2">On aeroplane</td><td>On flight deck</td><td>“Flight deck” Environment (see Annex A - Table A8)</td></tr>
<tr><td>In flight</td><td>“Fixed-wing fleet air arm aircraft” Environment (see Annex A - Table A6)</td></tr>
<tr><td rowspan="2">On helicopter</td><td>On flight deck</td><td>“Flight deck” Environment (see Annex A - Table A8)</td></tr>
<tr><td>In flight(1)</td><td>“Rotary-wing fleet air arm aircraft” Environment (see Annex A - Table A7)</td></tr>
<tr><td colspan="3">In free flight (munition fired, beyond the safety distance)</td><td>“Free flight” Environment (see Annex A - Table A9)</td></tr>
</table>

Table 3: Permissible environment of “Fleet Air” munitions

(1) This configuration includes transport of the munitions by air.

5.2.4. “Sea” *Environment*

Table 4 defines the permissible environments, to be specified as a function of their use configuration, for munitions dedicated to the naval operations of the armed forces.

Configuration of use	Permissible environment of “Sea” munitions
ST/TR (logistic, tactical, stand-alone)	“Marine - All decks” Environment (see Annex A - Table A2)
Munitions transported by air	“Rotary-wing Aircraft” Environment (see Annex A - Table A7)
Implementation (“MEO”)	“Marine - All decks” Environment (see Annex A - Table A2)
Post-launch (immediately after firing, beyond the safety distance)	“Marine - Main beam” Environment (see Annex A - Table A3)
In free flight (munition fired, beyond the safety distance)	“Free flight” Environment (see Annex A - Table A9)

Table 4: Permissible environment of “Sea” munitions

5.3 Lightning

The lightning environment can present a risk for munitions.

The various types of lightning environment, and their associated characteristics, are defined in [DR10]. The environmental parameters to be considered for the DRAM assessment are determined as a function of the munition (characteristics of the EIDs and control electronics) and of its life-profile (type of carrier, positioning of the munition etc.)

From the electromagnetic vulnerability (“DRAM”) point of view, the indirect effects of lightning must be examined, whether for direct lighting strike or close-proximity lightning bolt.

5.4 ESD

The phenomena of electrostatic discharge (ESD) can constitute a risk for munitions. The various types of ESD are described in [DR09] and are summarized below:

- Electrostatic discharge originating from “personnel” (PESD): Table 253-1 of [DR09] describes the PESD parameters.
- Electrostatic discharge originating from “helicopter” (HESD): this results from the phenomenon of charging or discharge following contact between a helicopter and the ground during helihoisting operations; HESD is a major risk during the transport of helihoisted munitions. Table 253-2 of [DR09] describes the HESD parameters.

5.5 HEMP

The electromagnetic pulse generated by a nuclear explosion at high altitude (HEMP) can constitute a risk to munitions.

The incident waveform and ground coverage vary as a function of many different parameters (altitude of explosion, weapon technology etc.). HEMP, which must be taken into account for certain weapons programmes, is a pulse-form electromagnetic field envelope. It is described in various documents.

- Technical Notices CAD 312 [DR04] and CAD 314 [DR05].
- STANAG 4370 [DR01] via AECTP 256 [DR12], STANAG 4145 [DR06] via AEP-04 [DR14] and its annexes [DR15], [DR16] et [DR17].

The choice of standard to be applied for a DRAM assessment is the responsibility of the National Authority.

5.6 Other environments

This chapter describes different electromagnetic environments that can constitute a risk for munitions.

Given their specific characteristics, the evaluation of a munition in these environments is customized by the National Authority, as a function of:

- The occurrence of electromagnetic disturbance
- The occurrence of accidental initiation of an EID by these environments.

These environments can be produced by the following sources:

- Transmitters specific to the munition or weapon system, also termed “internal transmitters”. These transmitters consist of equipment built into the munition or weapon system (on-board radios, radars, proximity detectors etc.).
- Portable low-power transmitters (EIRP less than 5W): GSM telephone, Wi-Fi networks, walkie-talkies etc.).
- Degausser coils and low-frequency magnetic fields ([DR11]).
- Electromagnetic catapults and cannons.
- High-power microwave (HPM).
- Miscellaneous industrial equipment powered with alternating current (50 Hz, 400 Hz etc.) and liable to radiate or cause disturbance.
- Rotating electrical machinery.
- Inverters, converters etc.
- Actuating and cut-off systems (relays, contacts, switches etc.)
- Non-linear electronic components (thyristors, diodes, rectifiers etc.)
- Commutation systems; accidental source categories, such as cut-outs or tripping of high-voltage lines can be included in this category.

6. MUNITION EVALUATION PROCEDURES

6.1. General

The specific procedures and requirements for evaluating munitions are described with respect to the different electromagnetic environments defined in section 5.

These procedure and requirements are largely based on STANAG 4370 [DR01] and more particularly on the AECTP 500 [DR18] series, which has the following aims:

- To define the requirements for the development of test programmes and the choice of test type that must be performed.
- To explain the aim and principle of the different methodologies.

A "DRAM" electromagnetic vulnerability evaluation does not always require tests to be performed. The evaluation can sometimes be performed by analytical methods, in particular in the case of less complex systems.

It is important to note that regardless of the type of tests or analyses required for the DRAM evaluation of a munition, a pyrotechnic characterization is necessary. Although this characterization represents a significant source of costs during the evaluation process, particular attention must be paid to it, and it must be performed with due regard to the safety objectives of the weapons programme concerned. The pyrotechnic characterization can relate to:

- The active initiators.
- The active EIDs.
- An active mock-up of the munition.

The type of characterization to be conducted is defined for each procedure (see section 6.2).

6.1.1. Adaptation of evaluation t procedures to the electromagnetic environment

Each electromagnetic environment has specific characteristics and therefore requires specific evaluation procedures. This is because the characteristics of the electromagnetic environment for which a munition must be evaluated have a major influence on the evaluation procedure.

- Simulation of the electromagnetic environment during tests.
- Types of electromagnetic coupling:
  - "Differential-mode" coupling, also called *pin-to-pin* (PTP) in the literature on the subject, corresponds to the energy induced between the pins of the EID initiator.
  - "Common-mode" coupling: also known as *pin-to-case* (PTC), corresponds to the energy applied between one or more pins of the EID initiator and its electrical reference ground (generally the case of the initiator).
- Type of tests:
  - Tests on instrumented mock-up
  - Statistical tests.
- Instrumentation type.
- Margin levels to be applied.
-

6.1.2. *"*Safety/reliability*"* classification

The EIDs on munitions are classed into two categories:

- "Safety class" if their accidental initiation compromises the safety of persons or property.
- "Reliability class" if their accidental initiation diminishes the effectiveness of the munition or renders it inoperative, without compromising safety

Note:

It is important to note that the classification of an EID depends on:

- The system in which it is integrated.
- The phase of its life-profile for a given system.

This classification must be validated by the National Authority.

6.1.3. Go / No Go tests

In case of difficulties concerning the instrumentation of a munition, statistical tests of the "go/no go" type must be conducted. This type of test consists in exposing a defined number of mock-ups, equipped with active EIDs, to an electromagnetic environment and determining a probability of no-fire and the associated level of confidence.

The number of mock-ups depends on the no-fire probability and the desired confidence level. This can be determined with the aid of Table 5 from [DR09].

No-fire probability (%)	Confidence level (%)						
	50	60	70	80	90	95	99
99	69	92	120	160	229	298	459
95	14	18	24	31	45	58	90
90	7	9	12	15	22	29	44
85	5	6	8	10	15	19	29
80	3	4	6	7	11	14	21
75	3	4	5	6	8	11	16
70	2	3	4	5	7	9	13
65	2	2	3	4	6	7	11
60	2	2	3	4	5	6	9
50	1	2	2	3	4	5	7

Table 5 - Number of samples without accidental initiation, to demonstrate a no-fire probability and the associated confidence levels.

The recourse to this type of test is limited, due to its cost.

Note:
To avoid conducting a large number of tests, it is sometimes possible to apply a safety margin to the electromagnetic environment to be demonstrated, instead of applying the margin to the no-fire characteristics.
This method is only valid for radio-radar transmitters if the munition has been verified to have a linear reaction function. However, this method imposes levels of electromagnetic environment that are often difficult to generate.

6.2. Radio-radar transmitters.

6.2.1. General

The DRAM evaluation of a munition in electromagnetic environments of the "radio-radar transmitter" type must be conducted in compliance with [DR23].

6.2.2. Description of the test methodology

The test methodology consists in exposing the munition to the radio-radar environment for which it must be evaluated. The parameters to be measured are:

- The levels of the electrical parameters (power, current and voltage) induced in the EIDs. These levels are compared to the no-fire thresholds of the electrical parameter concerned (no-fire current I_{NF}, no-fire power P_{NF} or no-fire energy E_{NF}), in each case reduced by a safety/reliability margin.
  The no-fire thresholds are defined by STANAG 4560 [DR07] concerning the pyrotechnic characterization of the initiators. With rare exceptions, the no-fire values are determined with an accidental initiation probability of 10^{-3} and a confidence level of 95%, as defined in [DR07].
  The no-fire thresholds, reduced by a safety/reliability margin, define the notion of acceptable levels (admissible current I_{ad}, admissible power P_{ad} and admissible energy E_{ad}) that the induced disturbances must not exceed.
- The environment level causing a malfunction or switching of the electronic control system or weapon safety systems of the EID and liable to affect safety or reliability. Since these systems can have non-linear response, the munition must, when possible, be subjected during testing to the electromagnetic environment to be demonstrated.
  This type of characterization is particularly important for initiators of the slapper- detonator type (EFI) or explosive bridgewire type (EBW), since their sensitivity depends essentially on the sensitivity of the electronic controls and safety systems.

6.2.3. Acceptance criteria

Unless otherwise specified by the National Authority, the safety/reliability margins to be taken into account for this type of evaluation are defined in Table 6 from [DR23]:

Required margin	EID, without electronic systems		Electronic control systems of the EIDs or weapon safety systems (2)	
	EIDs with no-fire thresholds validated by national authorities	*EIDs with no-fire thresholds not validated by national authorities*	*BCI-type methodology[1] based on a transfer function*	*Go - No go methodology (1)*
Safety	16.5 dB	20 dB	10 dB	6 dB
Reliability	6 dB	10 dB	0 dB	0 dB

Table 6 - Acceptance criteria with regard to radio radar-type transmitters

(1) These margins are applicable when the electromagnetic field level generated during the tests attains or exceeds the electromagnetic field at which the munition must be evaluated.
(2) The failure criterion of these tests is the accidental initiation of the EID concerned.

In case of difficulties during the generation of the electromagnetic field levels, the electromagnetic environment to be generated is customized by the National Authority as a function of the life-profile of the munition.

Note:

[1] BCI tests must be carried out in accordance with the NC807 procedure defined by [DR19] in the frequency band 100 kHz-200 MHz

For EFI or EBW-type initiators, different margins can be applied as a function of the phase of the life-profile of the weapon system.

- For the phases where the EID is not powered during the relevant phase of the life-profile, the tests are carried out on unpowered mock-ups, and the initiators constituting the EIDs are classified in reliability class, regardless of their function, so that a margin of 6 dB or 10 dB must be applied, depending on their no-fire characteristics.
- For the phases where the EID is powered during the relevant phase of the life-profile, the tests are carried out on powered mock-ups, and the initiators constituting the EIDs are classified in safety or reliability class, depending on their function. In this case, the tests will be operating tests of the Go / No Go type, so that the applied margin will be 6 dB or 10 dB, depending on the classification of the initiator.

6.2.4. Supplements

For hot-wire initiators, the electrical parameter to be considered is either the power, if the disturbance phenomenon is permanent or can be assimilated to a permanent disturbance (radio transmission, radar transmission with high recurrence frequency), or energy, if the phenomenon is of pulse type (connector plugging, electrostatic discharge, lightning bolt etc.).

For conductive composition initiators or dielectric structure initiators, the most significant parameters are the induced energy and the heating of the pyrotechnic substance. For this type of initiator, the test methodology described above is often supplemented by Go / No go statistical tests (see section 6.1.3) on the active EIDs. The margins to be applied for this type of test, and the desired no-fire probability and associated confidence level must be defined as a function of the safety objectives of the weapon system.

For high-energy EFI or EBW-type initiators, the level of the aggressions of radio/radar transmitter type described in this standard are not sufficient to produce actuation by direct effect (actuation by induction of energy in the wiring). Excessive energy can potentially degrade their characteristics (or render them inoperative), but without leading to accidental initiation. The sensitivity of these initiators to electromagnetic radiation is based mainly on the sensitivity of their electronic control systems. These systems must be subjected to customized tests to ensure the safety and reliability objectives of the weapon system.

6.3. Lightning

6.3.1. General

The DRAM evaluation of a munition in the lightning environment must be conducted in compliance with [DR24]. However, given their pyrotechnic character, this standard provides additional details relating to the specific characteristics of the EIDs, in particular the test methodology (adapted, solely from the point of view of the test procedures flow chart, from the HEMP test method - figure 508/5-1 of [DR25] and the associated acceptance criteria).

6.3.2. Description of the test methodology

The test methodology consists in applying the test logic defined in Figure 1, which implements 5 different procedures as a function of the types of system (electronic or pyrotechnic) and coupling (differential-mode or common-mode) concerned.

[Flow chart]

Analysis

Electrical/electronic system associated with the EID?
Yes /No

Test Procedure E
Operating tests

Instrumentation of munition possible?
Yes / No

Common-mode testing necessary?
Yes / No

Influence of explosive on coupling
Yes / No

Test procedure A	Test procedure D	Test procedure C	Test procedure B
Common-mode current measurement	*Common-mode voltage measurement*	*Differential-mode tests (PTP)* *Ne = 1* *Np = 3* *NI = 2*	**Go / No go tests)* *Ne = 8* *Np = 15* *NI = 2*

Test procedure A1	Test procedure D1
Test on complete munition with instrumented active EID *Ne = 1* *Np = 5* *NI = 3*	*Test on complete munition with EID removed* *Ne = 0* *Np = 5* *NI = 2*

Test procedure A2	Test procedure D2
Test on subsystem active EID *Ne = 5* *Np = 10* *NI = 2*	*Test on subsystem active EID* *Ne = 5* *Np = 10* *NI = 2*

End of testing

Figure 1 - Lighting tests flow chart

(1) : Procedure D2 only applies if a common-mode voltage greater than 1 kV is measured during procedure D1.

These procedures are summarized below.

6.3.2.1. Procedure A - Common-mode current measurement

This procedure takes place in two stages:

Procedure A1 (tests on munition):
Procedure A1 consists in determining the common-mode current (I_{MC}) between the pins and the ground reference of the EID when the munition is subjected to the lightning environment. During this procedure, the EID is active, in order to take into account the influence of the pyrotechnic substance on the electromagnetic coupling effects.

Procedure A2 (tests on EID alone):
Procedure A2 consists in determining the admissible level of the common-mode current of the EID ($I_{MC\ ad}$), by injecting current I_{MC} determined above, plus a safety margin, across the active EID. The admissible level ($I_{MC\ ad}$) will therefore correspond to the injection level for which none of the following events occurs:

- accidental initiation
- modification of the pin-to-pin resistance of the initiator,
- modification of the pin-to-case impedance of the EID.

This operation must be performed on several samples. The safety margins and the number of samples necessary are defined in Tables 7 and 8.

Note:
After a current injection, in the event of any modification of the electrical characteristics of the EID, an expert assessment must be conducted to determine its impact on the operation and reliability of the EID. This assessment must be validated by the National Authority.

6.3.2.2. Procedure B - Tests on active mock-up

This procedure consists in applying the lightning environment to a mock-up of the munition fitted with active EIDs and then analyzing the EIDs to verify that none of the following events have occurred:

- accidental initiation
- modification of the pin-to-pin resistance of the initiator,
- modification of the pin-to-case impedance of the EID.

Note:
In the case of tests on a sub-assembly of the munition, the corresponding transfer function must be taken into account.

This operation must be performed on several samples. The precise number is defined in Table 8.

6.3.2.3. Procedure C - Measurement of induced energy

The test methodology consists in exposing the munition to the lightning environment for which it must be evaluated. The parameters to be measured are:

- The level of energy induced inside the EID. This induced energy must be less than the no-fire energy of the EID (E_{nf}), minus a safety/reliability margin.
  The no-fire thresholds are defined by STANAG 4560 [DR07] concerning the pyrotechnic characterization of the initiators. With rare exceptions, the no-fire values are determined with an accidental initiation probability of 10^{-3} and a confidence level of 95%, as defined in [DR07].
  The no-fire energy, reduced by safety/reliability margin, defines the notion of admissible energy (Ead) that the induced disturbances must not exceed.
  The safety/reliability margin to be applied is defined using Table 7.

Note:
The safety/reliability margins to be applied are higher if the level or waveform of the lighting environment defined by [DR01] cannot be identically reproduced and if the measurement results require extrapolation.

- The environment level causing malfunction or switching of the electronic control system or of the weapon safety systems of the EIDs, which may have an effect on safety or reliability.
  This type of characterization is particularly important for initiators of the slapper detonator type (EFI) or explosive bridgewire type (EBW), since their sensitivity depends essentially on the sensitivity of the electronic controls and safety systems.

6.3.2.4. Procedure D - Common-mode voltage measurement

This procedure comprises two stages:

Procedure D1 (tests on munition):
Procedure D1 consists in determining the common-mode voltage (V_{MC}) between the location of the pins and the ground reference of the EID when the munition is subjected to the lightning environment. During this procedure, the EID is removed from the munition, due to the lack of influence of the pyrotechnic substance on the electromagnetic coupling effects.
If voltage V_{MC} is less than 1 kV, it is possible to conclude that there is no risk for the EID concerned. If not, procedure D2 must be applied.

Note:
The criterion of 1 kV for the admissible common-mode voltage is derived from [DR22].

Procedure D2 (tests on EID alone):
Procedure D2 consists in determining the admissible common-mode voltage level of the EID (VMC ad). This is done by applying the VMC determined above, plus a safety margin, to an active EID. The admissible level ($V_{MC\ ad}$) will therefore correspond to the level for which none of the following events occurs:

- accidental initiation
- modification of the pin-to-pin resistance of the initiator,
- modification of the pin-to-case impedance of the EID.

This operation must be performed on several samples. The safety margins and the number of samples necessary are defined in Tables 7 and 8.

Note:
After a voltage application, if there is any modification of the electrical characteristics of the EID, an expert assessment must be conducted to determine its impact on the operation and reliability of the EID. This assessment must be validated by the National Authority.

6.3.2.5. Procedure E - Operating tests

This procedure consists in conducting operational acceptance verifications before and after each test sequence or at the beginning and end of the tests. These checks apply to the electronic systems connected to the EIDs (initiation control and safety and arming systems).

6.3.3 Acceptance criteria

The safety/reliability margins and other acceptance criteria that must be applied for this type of test are defined in Tables 7 and 8.

Test procedure	Safety / reliability margin to be applied
A1	0 dB
A2	Safety 10.5 dB Reliability 2 dB
B	0 dB
C	Safety 10.5 dB(1) Reliability 2 dB(1)
D1	0 dB
D2	Safety 10.5 dB(121) Reliability 2 dB(121)
E	Not applicable.

Table 7 - Acceptance criteria for the lightning environment

(1) : The lightning test equipment cannot always generate a lightning aggression with the levels and waveforms defined by [DR10] and require extrapolation of the measured values for the energy induced in the EIDs. Given the various uncertainties involved in extrapolation (calculation method, technology used for EID instrumentation etc.), higher safety/reliability margins must be applied. These margins must be defined as a function of the test equipment used (generators and measurement sensors) and the safety objectives of the weapons system. In the case of a particularly unfavourable test configuration, the application of a 16.5 dB safety margin and 6 dB reliability margin may be advisable.

(2) : 0 dB if an acceptable common mode voltage of 1 kV is considered (extreme case).

Test procedure	Number of EIDS (Ne)		Minimum number of strikes per sequence (Np)
	active	*instrumented*	
A1	1	-	1
A2	5(1)	-	10
B	8PI	-	15
C	-	1	3
D1	-	0(3)	1
D2	5(1)	-	10
E	1		Not applicable141

Table 8 - Number of EIDs and lightning test parameters

(1) : The number of EIDs depends on the result of the tests

(2) : This number of EIDs is able to demonstrate a no-fire probability of 75%, with a confidence level of 90%.

(3) : No EID is present during procedure D1; however, a voltage measurement system is used at the EID location to measure the common-mode voltage from the point of view of the EID.

(4) : Procedure E must be conducted after each test sequence or at the end of testing

6.4. ESD

6.4.1. General

The DRAM evaluation of a munition in conditions of electrostatic discharge must be conducted in compliance with [DR22].

If the ESD immunity of the initiators of the munition is demonstrated in accordance with [DR22], no testing on a munition mock-up is required. However, if the ESD immunity is unknown, tests on an instrumented inert mock-up may be required. This procedure is generally adopted when a mock-up has already been instrumented for the radio-radar transmitter tests. This avoids the costs and delays involved in pyrotechnic tests to demonstrate ESD immunity.

Note:
The procedures applied by initiator manufacturers generally differ from the procedures defined by [DR22]. If the number of samples tests by the manufacturer is judged to be insufficient in view of the safety objectives of the weapons programme, a new evaluation in conformity with [DR22] will be necessary.

6.4.2. Description of the test methodology

This methodology consists in exposing a certain number of active initiators to varying levels of ESD, as defined by [DR22]. The number of samples depends on the safety objectives of the weapons programme concerned.

In certain cases, the tests on active initiators can be replaced by tests on inert instrumented mock-up. In this case, the procedure involves subjecting the instrumented mock-up to different ESD levels, and the number of test sequences and the levels must be defined as a function of the safety objectives of the weapons programme. The parameters to be measured are:

- The level of energy induced inside the EID. This induced energy must be less than the no-fire energy of the EID (E_{nf}), minus a safety/reliability margin.
  The no-fire thresholds are defined by STANAG 4560 [DR07] concerning the pyrotechnic characterization of the initiators. With rare exceptions, the no-fire values are determined with an accidental initiation probability of 10^{-3} and a confidence level of 95%, as defined in [DR07].
  The no-fire energy, minus a safety/reliability margin, defines the notion of admissible energy (Ead) that the induced disturbances must not exceed.

  The safety/reliability margin to be applied is defined using Table 9.

- The environment level causing malfunction or switching of the electronic control system or of the weapon safety systems of the EIDs, which may have an effect on safety or reliability.
  This type of characterization is particularly important for initiators of the slapper-detonator type (EFI) or explosive bridgewire type (EBW), since their sensitivity depends essentially on the sensitivity of the electronic controls and safety systems.

6.4.3. Acceptance criteria

The safety/reliability margins and other acceptance criteria that must be applied for this type of test are defined in Tables 9 and 10.

Test procedure	**Safety/reliability margin to be applied[(1)]**
Tests on active initiators	0 dB
Tests on instrumented initiators	Safety 10.5 dB Reliability 2 dB

Table 9 - Acceptance criteria for ESD

Test procedure	Number of EIDS		Minimum number of strikes per sequence (Np)	Minimum number of threat levels (Nl)
	Active	*instrumented*		
Tests on active initiators	PESD 22[1] HESD: 10[2]	-	To be defined for each weapons programme	
Tests on instrumented initiators	-	1		

Table 10 - Number of EIDs and ESD test parameters

[1] : This number of EIDs is able to demonstrate a no-fire probability of 90%, with a confidence level of 90%.

[2] : This number of EIDs is able to demonstrate a no-fire probability of 85%, with a confidence level of 80%.

6.5. HEMP

6.5.1. General

The DRAM evaluation of a munition in HEMP environment must be conducted in compliance with [DR25].

Note:
The various polarizations and incidences of the electromagnetic field must be considered.

6.5.2. Description of the test methodology

The flow chart defined in Figure 508/5-1 of [DR25] is reproduced in Figure 2. This figure implements 5 different procedures, as a function of the types of system (electronic or pyrotechnic) and coupling (differential-mode or common-mode) concerned.

[Flow chart]

Analysis

Electrical/electronic system associated with the EID?
Yes /No

Test Procedure E
Operating tests

Instrumentation of munition possible?
Yes / No

Common-mode testing necessary?
Yes / No

Influence of explosive on coupling
Yes / No

Test procedure A *Common-mode current measurement*	Test procedure D *Common-mode voltage measurement*	Test procedure C *Differential-mode tests (PTP)* *Ne = 1* *Np = 3* *Nl = 2*	Test procedure B **Go / No go tests)* *Ne = 8* *Np = 15* *Nl = 2*

Test procedure A1 *Test on complete munition with instrumented active EID* *Ne = 1* *Np = 5* *Nl = 3*	Test procedure D1 *Test on complete munition with EID removed* *Ne = 0* *Np = 5* *Nl = 2*

Test procedure A2 *Test on subsystem active EID* *Ne = 5* *Np = 10* *Nl = 2*	Test procedure D2 *Test on subsystem active EID* *Ne = 5* *Np = 10* *Nl = 2*

End of testing

Figure 2 - Flow chart for HEMP tests

(1): Contrary to [DR25], procedure D2 only applies if a common-mode voltage greater than 1 kV is measured during procedure D1.

These procedures, which apply for each polarization and incidence of the electromagnetic field, are summarized below.

6.5.2.1. Procedure A - Measurement of common-mode current

This procedure comprises two stages:
Procedure A1 (tests on munition):
Procedure A1 consists in determining, by tests, the common-mode current (I_{MC}) between the pins and the ground reference of the EID when the munition is subjected to the HEMP environment. During this procedure, the EID is active, in order to take into account the influence of the pyrotechnic substance on the electromagnetic coupling effects.

Procedure A2 (tests on EID alone):
Procedure A2 consists in determining the admissible level of the common-mode current of the EID ($I_{MC\ ad}$), by injecting current I_{MC} determined above, plus a safety margin, across an active EID. The admissible level ($I_{MC\ ad}$) will therefore correspond to the injection level for which none of the following events occurs:

- accidental initiation
- modification of the pin-to-pin resistance of the initiator,
- modification of the pin-to-case impedance of the EID.

This operation must be performed on several samples. The safety margins and the number of samples necessary are defined in Tables 11 and 12.

Note:
After a current injection, in the event of any modification of the electrical characteristics of the EID, an expert assessment must be conducted to determine its impact on the operation and reliability of the EID. This assessment must be validated by the National Authority.

6.5.2.2. Procedure B - Tests on active mock-up

This procedure consists in applying the external environment corresponding to HEMP to a mock-up of the munition fitted with active EIDs and then analyzing the EIDs to verify that none of the following events have occurred:

- accidental initiation
- modification of the pin-to-pin resistance of the initiator,
- modification of the pin-to-case impedance of the EID.

This operation must be performed on several samples. The precise number is defined in Table 12.

6.5.2.3. Procedure C - Measurement of induced energy

The test methodology consists in exposing the munition to the external environment corresponding to HEMP for which it must be evaluated. The parameters to be measured are:

- The level of energy induced inside the EID. This induced energy must be less than the no-fire energy of the EID (E_{nf}), minus a safety/reliability margin.
  The no-fire thresholds are defined by STANAG 4560 [DR07] concerning the pyrotechnic characterization of the initiators. With rare exceptions, the no-fire values are determined with an accidental initiation probability of 10^{-3} and a confidence level of 95%, as defined in [DR07].
  The no-fire energy, minus a safety/reliability margin, defines the notion of admissible energy (Ead) that the induced disturbances must not exceed.
  The safety/reliability margin to be applied is defined using Table 11.

- The environment level causing malfunction or switching of the electronic control system or of the weapon safety systems of the EIDs, which may have an effect on safety or reliability.
  This type of characterization is particularly important for initiators of the slapper- detonator type (EFI) or explosive bridgewire type (EBW), since their sensitivity depends essentially on the sensitivity of the electronic controls and safety systems.

6.5.2.4. Procedure D - Common-mode voltage measurement

This procedure comprises two stages:

Procedure D1 (tests on munition):

Procedure D1 consists in determining, by tests or simulations, the common-mode voltage (V_{MC}) between the location of the pins and the ground reference of the EID when the munition is subjected to the HEMP environment. During this procedure, the EID is removed from the munition, due to the lack of influence of the pyrotechnic substance on the electromagnetic coupling effects.

If voltage V_{MC} is less than 1 kV, it is possible to conclude that there is no risk for the EID concerned. If not, procedure D2 must be applied.

Note:

The criterion of 1 kV for the admissible common-mode voltage is derived from [DR22].

Procedure D2 (tests on EID alone):

Procedure D2 consists in determining the admissible common-mode voltage level of the EID (VMC ad). This is done by applying the VMC determined above, plus a safety margin, to an active EID. The admissible level ($V_{MC\ ad}$) will therefore correspond to the level for which none of the following events occurs:

- accidental initiation
- modification of the pin-to-pin resistance of the initiator,
- modification of the pin-to-case impedance of the EID.

This operation must be performed on several samples. The safety margins and the number of samples necessary are defined in Tables 11 and 12.

Note:

After a voltage application, if there is any modification of the electrical characteristics of the EID, an expert assessment must be conducted to determine its impact on the operation and reliability of the EID. This assessment must be validated by the National Authority.

6.5.2.5. Procedure E - Operating tests

This procedure consists in conducting operational acceptance verifications before and after each test sequence or at the beginning and end of the tests. These checks apply to the electronic systems connected to the EIDs (initiation control and safety and arming systems).

6.5.3. Acceptance criteria

The safety/reliability margins and other acceptance criteria that must be applied for this type of test are defined in Tables 11 and 12.

Test procedure	**Safety / reliability margin to be applied**
A1	0 dB on the external environment
A2	20 dB on I_{MC}
B	0 dB
C	16.5 dB
D1	0 dB on the external environment
D2	20 dB on VMC[111]
E	Not applicable.

Table 11 - Acceptance criteria for the HEMP environment

Test procedure	Number of EIDS (Ne)		Minimum number of strikes per sequence (Np)	Minimum number of threat levels per polarization (Nl)
	active	*instrumented*		
A1	1	-	5	3
A2	5(n	-	10	2
B	8Pi	-	15	2
C	-	1	3	2
D1	-	0(3)	5	2
D2	5(1)	-	10	2
E	1		Not applicable[4]	Not applicable[4]

Table 12 - Number of EIDs and HEMP test parameters

(1) : The number of EIDs depends on the test results (see table 508/5-1 in [DR25]).

(2) : This number of EIDs is able to demonstrate a no-fire probability of 75%, with a confidence level of 90%.

(3) : No EID is present during procedure D1; however, a voltage metering system is instrumented at the location of the EID to measure the common-mode voltage at the EID.

(4) : Procedure E must be conducted after each test sequence or at the end of testing

6.6. Other environments

The evaluation criteria for the electromagnetic environments described in section 5.6 must be defined on a case-by-case basis and must be validated by the National Authority.

Note:
Contrary to the munition evaluation procedures for radio-radar transmitters (external transmitters), the evaluation procedures for on-board transmitters (internal transmitters) and low-power portable transmitters are more representative in terms of reproduction of the electromagnetic environment to which the munition is subjected.

- The characteristics of the transmitter to which the munition is subjected are known (transmission frequencies, waveforms, transmission power, antenna gain etc.).
- The position of the munition in relation to the transmitter enables the real electromagnetic coupling effects to be reproduced (incidence, electromagnetic field polarization and level etc.).

Perfect control of the above parameters can help to reduce the safety and reliability margins of Table 6 within a limit of 6 dB.

7. BIBLIOGRAPHY

The following documents are provided for information:

Reference	Document title	Edition / date
[BIBLIO1]	**GAM DRAM 01:** *General specification concerning electrically initiated devices and their integration in weapon systems and munitions against the effects of non-ionizing electromagnetic radiation [French]*	**December 1992**
[BIBLIO2]	**GAM DRAM 02:** *Safety instructions to be established in different conditions of use of the systems and munitions equipped with electrically initiated devices in electromagnetic environment [French]*	**December 1992**

The present Annex describes the radio-radar environments recommended by the National Authority for the specification of weapons programmes for the armed forces.

These environments have been determined on the basis of the environment levels specified in [DR13], customized with the aid of the calculated radiation of French transmitters, under conditions of use representative of the use of the munitions.

All the phases of the life-profile and of the different operating environments of the munitions are covered by the following environments defined in Tables A1 to A9:

- “Land” Environment
- “Naval - All decks” Environment
- “Naval - Main beam” Environment
- “Fixed-wing aircraft” Environment
- “Rotary-wing aircraft” Environment
- “Fleet-Air fixed-wing aircraft” Environment
- “Fleet-Air rotary-wing aircraft” Environment
- “Flight deck” Environment
- “Free flight” Environment

"Land" Environment		
Frequencies (MHz)	Average electric field (V/m)	Peak electric field (V/m)
0,01 - 2	200	200
2 - 30	200	200
30 - 150	100	100
150 - 225	100	100
225 - 400	100	1500
400 - 700	50	1500
700 - 790	50	1500
790 - 1000	50	1500
1000 - 2000	50	2500
2000 - 2700	50	2500
2700 - 3600	50	2500
3600 - 4000	50	2500
4000 - 5400	50	2500
5400 - 5900	50	2500
5900 - 6000	50	2500
6000 - 7900	50	2500
7900 - 8000	50	2500
8000 - 8400	50	2500
8400 - 8500	50	2500
8500 - 11000	60	2500
11000 - 14000	60	1500
14000 - 18000	60	1500
18000 - 40000	50	1500
40000 - 45000	--	--

Table A1 **"**Land**"** Environment

The "Land" environment has been determined on the basis of 258-2 "NATO Ground EME Field Strength Levels" in [DR13].

"Naval- All decks" Environment		
Frequencies (MHz)	Average electric field (V/m)	Peak electric field (V/m)
0.01 - 2	--	--
2 - 30	200	200
30 - 150	60	60
150 - 225	60	60
225 - 400	60	60
400 - 700	70	410
700 - 790	100	160
790 - 1000	240	1300
1000 - 2000	180	550
2000 - 2700	160	180
2700 - 3600	180	2030
3600 - 4000	200	1860
4000 - 5400	200	290
5400 - 5900	240	710
5900 - 6000	240	350
6000 - 7900	240	350
7900 - 8000	200	350
8000 - 8400	200	350
8400 - 8500	200	480
8500 - 11000	200	1130
11000 - 14000	200	830
14000 - 18000	200	830
18000 - 40000	200	200
40000 - 45000	200	200

Table A2 **"**Naval - All decks**"** Environment

The "Naval - All decks" environment has been determined on the basis of a synthesis of the *Weather Deck* and *Flight Deck* columns of Table 258-1A "NATO Ship Operation EME Field Strength Levels (Flight Deck and Weather Deck)" in [DR13].

Naval – Main Beam Environment

Frequencies (MHz)	Average electric field (V/m)	Peak electric field (V/m)
0,01 - 2	200	200
2 - 30	200	200
30 - 150	60	60
150 - 225	60	60
225 - 400	60	60
400 - 700	70	410
700 - 790	100	160
790 - 1000	490	2530
1000 - 2000	332	1387
2000 - 2700	160	180
2700 - 3600	1700	5500
3600 - 4000	200	1860
4000 - 5400	657	2541
5400 - 5900	657	2541
5900 - 6000	650	650
6000 - 7900	650	650
7900 - 8000	960	960
8000 - 8400	960	960
8400 - 8500	494	494
8500 - 11000	776	3800
11000 - 14000	494	1000
14000 - 18000	494	494
18000 - 40000	200	200
40000 - 45000	200	200

Table A3 – Naval Main Beam" Environment

The "Naval - Extreme case" environment has been determined from:

- the *Main Beam* column of Table 258-1B "NATO Ship Operation EME Field Strength Levels for Rotary and Fixed Wing Aircraft Landing Aboard a Ship (Main Beam Worst-Case, 152 and 305 meters)" in [DR13],
- the *Weather Deck* column of Table 258-1A "NATO Ship Operation EME Field Strength Levels (Flight Deck and Weather Deck)" in [DR13],
- the calculation of the electromagnetic environment produced by transmitters of the French Navy, under the conditions of use of the munitions.

Fixed-wing aircraft environment		
Frequencies (MHz)	**Average electric field (V/m)**	**Peak electric field (V/m)**
0,01 - 2	70	70
2 - 30	200	200
30 - 150	50	50
150 - 225	100	100
225 - 400	100	100
400 - 700	80	730
700 - 790	240	1400
790 - 1000	240	1400
1000 - 2000	200	3300
2000 - 2700	490	4500
2700 - 3600	490	4500
3600 - 4000	490	4500
4000 - 5400	300	7200
5400 - 5900	300	7200
5900 - 6000	300	7200
6000 - 7900	200	1100
7900 - 8000	200	1100
8000 - 8400	330	3000
8400 - 8500	330	3000
8500 - 11000	330	3000
11000 - 14000	330	2000
14000 - 18000	330	2000
18000 - 40000	420	1000
40000 - 45000	--	--

Table A4 – Fixed-wing aircraft Environment

The “Air - A/C” environment was determined on the basis of the *Fixed Wing Aircraft Non-Ship Operations* column of Table 258-3B “NATO Air operations EME Field Strength Levels” in [DR13].

Rotary-wing aircraft Environment		
Frequencies (MHz)	**Average electric field (V/m)**	**Peak electric field (V/m)**
0,01 - 2	200	200
2 - 30	200	200
30 - 150	200	200
150 - 225	200	200
225 - 400	200	200
400 - 700	200	730
700 - 790	240	1400
790 - 1000	240	1400
1000 - 2000	250	5000
2000 - 2700	490	6000
2700 - 3600	490	6000
3600 - 4000	490	6000
4000 - 5400	400	7200
5400 - 5900	400	7200
5900 - 6000	400	7200
6000 - 7900	170	1100
7900 - 8000	170	1100
8000 - 8400	330	5000
8400 - 8500	330	5000
8500 - 11000	330	5000
11000 - 14000	330	2000
14000 - 18000	330	2000
18000 - 40000	420	1000
40000 - 45000	-	-

Table A5 – Rotary-wing aircraft Environment

The “Air - H/C” environment was determined on the basis of the *Rotary Wing Aircraft Non-Ship Operations* column of Table 258-3B “NATO Air Operations EME Field Strength Levels” in [DR13].

Fleet-Air fixed-wing aircraft Environment»

Frequencies (MHz)	Average electric field (V/m)	Peak electric field (V/m)
0,01 - 2	200	200
2 - 30	200	200
30 - 150	50	50
150 - 225	100	100
225 - 400	100	100
400 - 700	80	730
700 - 790	240	1400
790 - 1000	240	1400
1000 - 2000	600	3300
2000 - 2700	490	4500
2700 - 3600	1500	4500
3600 - 4000	490	4500
4000 - 5400	400	7200
5400 - 5900	350	7200
5900 - 6000	400	7200
6000 - 7900	400	1100
7900 - 8000	400	1100
8000 - 8400	750	3210
8400 - 8500	400	3000
8500 - 11000	1940	10000
11000 - 14000	680	3630
14000 - 18000	330	2000
18000 - 40000	420	1000
40000 – 45000	--	--

Table A6 Fleet-Air fixed-wing Environment

The “Fleet-Air A/C” environment was determined from:

- the *Main Beam* column of Table 258-1B “NATO Ship Operation EME Field Strength Levels for Rotary and Fixed Wing Aircraft Landing Aboard a Ship (Main Beam Worst-Case, 152 and 305 meters)”,
- the *Fixed Wing Aircraft Non-Ship Operations* column of Table 258-3B “NATO Air operations EME Field Strength Levels” in [DR13],
- the calculation of the electromagnetic environment produced by transmitters of the French Navy, under the conditions of use of the munitions.

"Fleet-Air rotary-wing aircraft" environment

"Fleet-Air rotary-wing aircraft" environment		
Frequencies (MHz)	Average electric field (V/m)	Peak electric field (V/m)
0,01 - 2	200	200
2 - 30	200	200
30 - 150	200	200
150 - 225	200	200
225 - 400	200	200
400 - 700	200	730
700 - 790	240	1400
790 - 1000	240	1400
1000 - 2000	600	5000
2000 - 2700	490	6000
2700 - 3600	1500	6000
3600 - 4000	490	6000
4000 - 5400	400	7200
5400 - 5900	400	7200
5900 - 6000	400	7200
6000 - 7900	400	1100
7900 - 8000	400	1100
8000 - 8400	750	5000
8400 - 8500	400	5000
8500 - 11000	1940	10000
11000 - 14000	680	3630
14000 - 18000	330	2000
18000 - 40000	420	1000
40000 - 45000	--	--

Table A7 **"**Fleet-Air rotary-wing aircraft**"** environment

The "Fleet-Air H/C" environment was determined from:

- the *Main Beam* column of Table 258-1B "NATO Ship Operation EME Field Strength Levels for Rotary and Fixed Wing Aircraft Landing Aboard a Ship (Main Beam Worst-Case, 152 and 305 meters)",
- the *Rotary Wing Aircraft Non-Ship Operations* column of Table 258-3B "NATO Air operations EME Field Strength Levels" in [DR13],
- the calculation of the electromagnetic environment produced by transmitters of the French Navy, under the conditions of use of the munitions.

"Flight deck" Environment		
Frequencies (MHz)	**Average electric field (V/m)**	**Peak electric field (V/m)**
0,01 - 2	--	--
2 - 30	160	160
30 - 150	60	60
150 - 225	60	60
225 - 400	60	60
400 - 700	70	180
700 - 790	100	160
790 - 1000	100	1130
1000 - 2000	110	550
2000 - 2700	160	180
2700 - 3600	180	2030
3600 - 4000	200	300
4000 - 5400	200	290
5400 - 5900	210	450
5900 - 6000	210	350
6000 - 7900	210	350
7900 - 8000	200	350
8000 - 8400	200	350
8400 - 8500	200	480
8500 - 11000	200	510
11000 - 14000	200	790
14000 - 18000	200	790
18000 - 40000	200	200
40000 - 45000	200	200

Table A8 **"**Flight deck**"** Environment

The "Flight deck" environment was determined on the basis of the *Flight Deck* column of Table 258-1A "NATO Ship Operation EME Field Strength Levels (Flight Deck and Weather Deck)" in [DR13].

“Free flight” Environment		
Frequencies (MHz)	Average electric field (V/m)	Peak electric field (V/m)
0.01 - 2	200	200
2 - 30	200	200
30 - 150	200	200
150 - 225	200	200
225 - 400	200	200
400 - 700	200	730
700 - 790	240	1400
790 - 1000	240	1400
1000 - 2000	250	5000
2000 - 2700	490	6000
2700 - 3600	490	6000
3600 - 4000	490	6000
4000 - 5400	400	7200
5400 - 5900	400	7200
5900 - 6000	400	7200
6000 - 7900	200	1100
7900 - 8000	200	1100
8000 - 8400	330	5000
8400 - 8500	330	5000
8500 - 11000	330	5000
11000 - 14000	330	2000
14000 - 18000	330	2000
18000 - 40000	420	1000
40000 - 45000	--	--

Table A9 **“**Free flight**”** Environment

The “Free flight” environment was determined on the basis of the *Rotary Wing* column of Table 258-3B “NATO Air Operations EME Field Strength Levels” in [DR13].
This environment represents an extreme case that can be used in the absence of information on this particular phase of the life-profile of the munition, due to

- The diversity of munitions
- The diversity of transmission sources.
- The diversity of use scenarios.
- Etc.

However, to adjust the specification and design of the munitions to operational needs, a study of their life-profile would be of major benefit, since this information would enable customization of this environment table. Any customization of this environment table must be validated by the National Authority.