NATO STANDARD

AOP-4797

SAFETY REQUIREMENTS FOR HAZARD MITIGATION DEVICES (HMD) EMPLOYED TO ADDRESS FAST/SLOW HEATING THREATS TO MUNITIONS

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NORTH ATLANTIC TREATY ORGANIZATION

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NATO LETTER OF PROMULGATION

26 March 2019

1. The enclosed Allied Ordnance Publication AOP-4797, Edition A, Version 1, SAFETY REQUIREMENTS FOR HAZARD MITIGATION DEVICES (HMD) EMPLOYED TO ADDRESS FAST/SLOW HEATING THREATS TO MUNITIONS, which has been approved by the nations in the CNAD AMMUNITION SAFETY GROUP (CASG – AC/326), is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 4797.

2. AOP-4797, Edition A, Version 1, is effective upon receipt.

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4. This publication shall be handled in accordance with C-M(2002)60.

Zoltán GULYÁS
Brigadier General, HUNAF
Director, NATO Standardization Office

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS
Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.	

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RECORD OF SPECIFIC RESERVATIONS

[nation]	[detail of reservation]
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CHAPTER 1 INTRODUCTION

1.1. AIM

The aim of this allied publication is to establish safety guidance on application of Hazard Mitigation Devices (HMD) employed to address fast/slow heating threats (Cook-Off) to munitions, as defined in STANAG 4439, and to define safety design requirements for active and passive hazard mitigation devices if used in a munition or its associated logistic packaging.

1.2. GENERAL INTRODUCTION

To meet Insensitive Munitions (IM) requirements, developers recently have proposed the use of Active and Passive Hazard Mitigation Devices (AHMD & PHMD) that will mitigate the response of the munitions to STANAG 4439 thermal threats and cause the munition to react in such a way, that the IM classification is more favourable.

There are two types of Hazard Mitigation Devices: Active (AHMD) & Passive (PHMD). The HMD can be used to, e.g.:

1. initiate energetic material in the munition during Fast or Slow heating as a pre-emptive action to avoid a violent reaction such as detonation,

2. create venting in the payload/rocket motor case using such things as melt plugs or linear cutting charge which allow the energetic materials to react during Fast or Slow heating without detonating.

HMDs are considered safety critical items, therefore require careful evaluation prior to inclusion into a munition.

1.3. DEFINITIONS

Terms are defined in the NATOTerm database (see https://nso.nato.int/natoterm/content/nato/pages/home.html?lg=en). Other International sources may be used to compliment but not replace the NATO agreed definitions.

1.4. WORDING CONVENTIONS

1. “Shall” indicates the application of a procedure or specification is mandatory.

2. “Should” indicates the application of a procedure or specification is recommended.

CHAPTER 2 GENERAL

2.1. GENERAL CONSIDERATIONS

This document contributes to IM policy as defined by STANAG 4439 and to safety and suitability for service assessment of munitions as defined by STANAG 4297 and AOP-15.
This document is applicable to new or existing munitions that incorporate one or more HMD.
This document does not apply to nuclear weapon systems and associated training aids.
This document only addresses the specific thermal threats of fast and slow heating.
Fast/Slow Heating tests are described in detail in STANAGs 4240 and 4382.

2.2. SYSTEM SAFETY APPROACH

1. The IM requirements shall be established from a total system safety approach and include all life cycle configurations.

2. The behaviour of the energetic materials in the munition configuration shall be assessed as early as possible to determine the need for an HMD.

3. If the IM requirements cannot be met without use of an HMD, a system safety analysis considering the inclusion of an HMD over the life cycle of the munition shall be performed and presented to the National Safety Approving Authorities (NSAA) for review prior to the implementation of such device.

4. If it is determined that an HMD is required to improve IM response, the following steps shall be followed:

    a. A PHMD is a preferred solution wherever possible. If a PHMD does not provide a sufficient degree of system safety and/or does not meet IM requirements, an AHMD can be considered.

    b. If an AHMD is considered, obtain advice from Safety, Arming and Functioning (SAF) system experts and system safety experts on the intended AHMD design and its influence on total system safety.

c. Analyse the influence of the selected HMD(s) on munition safety over its life cycle:

(1) Establish the munition safety level without HMD.

(2) Establish the expected munition safety level with HMD(s), especially regarding the SAF systems.

(3) Establish the estimated probability that the HMD will function or fail without the IM threat being present and the consequences during the life cycle (e.g. unintended function on a warship, land-storage site, etc).

5. This system safety evaluation based approach will ensure that the inclusion of HMD will not only meet individual IM requirements but also maintain the total system safety.

6. In all cases, the NSAA shall review the HMD design and any applicable safety and risk analyses for compliance with this document. Early coordination and review with the NSAA regarding the HMD design in context with its use in a munition system is also recommended including the case of reuse of an existing HMD in a different munition, weapon system or life cycle.

2.3. GENERAL REQUIREMENTS

1. Verify that the PHMD meets the requirements of Annex B and any additional requirements as established by the NSAA and is qualified in accordance with STANAG 4157 and applicable STANAGs.

2. Verify that the AHMD meets the requirements of Annex C and any additional requirements as established by the NSAA and is qualified in accordance with applicable STANAGs.

3. HMD should only be used if all the following requirements are met:

a. Overall safety is not decreased below the required safety level.

b. The safety of SAF systems shall not be decreased below the levels required by STANAG 4187, STANAG 4497 and STANAG 4368 respectively.

c. The Program Office, the User and the NSAA have all agreed that the use of a HMD and its associated risk is acceptable.

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ANNEX A LIST OF NATIONAL SAFETY APPROVING AUTHORITIES (NSAA) OR POINT OF CONTACT

Country	Name/address
ALB - ALBANIA	
BEL - BELGIUM	Directorate General Material Resources Section Management – Risk – Ammunition Queen Elisabeth Barracks Eversestraat 1 1140 Brussels Belgium
BGR - BULGARIA	
CAN - CANADA	Directorate Ammunition & Explosive Management & Engineering (DAEME) National Defence Headquarters 101 Colonel By Drive Ottawa, Canada K1A 0K2
CZE – CZECH REPUBLIC	Military Technical Institute, s.e. Mladoboleslavska 944 197 06 Praha 9 – Kbely Czech Republic
DEU - GERMANY	Bundesamt für Ausruestung, Informationstechnologie und Nutzung der Bundeswehr K1.3 Ferdinand-Sauerbruch-Str. 1 56073 Koblenz Germany
DNK - DENMARK	Danish Defence Acquisition and Logistics Organisation Lautrupbjerg 1-5 DK-2750 Ballerup Denmark
ESP - SPAIN	
EST - ESTONIA	
FRA - FRANCE	DGA Techniques terrestre Rocade Est – échangeur de guerry 18021 Bourges Cedex DGA/INSP/IPE 60, boulevard du général Martial Valin 75509 Paris Cedex 15
GBR – THE UNITED KINGDOM	Defence Ordnance Safety Group Science and Technology Division Fir 3a #4304 MOD Abbey Wood South Bristol BS34 8JH
GRC - GREECE	
HRV - CROATIA	
HUN - HUNGARY	
ITA - ITALY	Ministero della Difesa Segretariato Generale della Difesa e DNA Direzione degli Armamenti Terrestri Via Marsala n. 104 00185 ROMA

LTU - LITHUANIA	
LUX - LUXEMBOURG	
LVA - LATVIA	
NLD - NETHERLANDS	Chairperson of the Defence Safety Board on Dangerous Goods PO-box 20701 2500 ES The Hague Netherlands
NOR - NORWAY	Norwegian Defence Material Agency Ammunition division P.O. Box 800, Postmottak N-2617 Lillehammer, Norway
POL - POLAND	
PRT - PORTUGAL	
ROU - ROMANIA	
SGP - SINGAPORE	Defence Science and Technology Agency 1 Depot Road Singapore 109679
SVK - SLOVAKIA	
SVN - SLOVENIA	
TUR - TURKEY	Ministry of National Defence of Republic of Turkey Department of Technical Services 06100 Bakanlıklar / Ankara / TURKEY
USA – THE UNITED STATES	Army Chairman, US Army Fuze Safety Review Board. Attn: RDAR-EIZ Picatinny Arsenal, NJ 07806-5000 United States of America Chairman, US Army Ignition system safety review board Attn. AMSAM-SFM Redstone Arsenal, AL 35898-5301 United States of America Naval Ordnance Safety & Security Activity Attn: WSESRB Chairman, C/O Code N00ED 3817 Strauss Avenue Bldg D323 Suite 108 Indian Head, MD 20640-5151 Air Force USAF, Non-Nuclear Munitions Safety Board Attn: AAC/SES 1001 N 2nd Street, Suite 366 Eglin Air Force Base FL 32542 - 6838 United States of America

ANNEX B SAFETY DESIGN REQUIREMENTS FOR A PHMD EMPLOYED TO ADDRESS THERMAL THREATS

B.1. SCOPE

1. The purpose of this annex is to establish specific design safety criteria for Passive Hazard Mitigation Device (PHMD) intended for use with munitions or their associated logistic packaging for reducing the severity of the munition’s response when subjected to specific thermal threat environments.

2. This annex has been developed to provide requirements for use by the design authority. This annex will be used by the NSAA to assess PHMD for an acceptable level of safety for service use.

3. This annex is applicable to PHMD in new or existing munitions. Application of this standard to modifications or new uses of an existing PHMD shall be determined by the NSAA.

B.2. REQUIREMENTS

When PHMD are being considered for use in munition system designs, including their logistical configuration, the following design safety requirements apply:

1. The design and implementation of PHMD in any munitions shall require review and acceptance by the NSAA.

2. The design of the PHMD shall not contain any energetic materials.

3. The PHMD shall not degrade the overall system safety below the required safety level.

4. The PHMD shall not degrade or circumvent the safety provided by SAF systems.

5. The PHMD design and operation shall be independent of SAF systems.

6. The following analyses shall be performed to identify hazardous conditions for their elimination or control. Safety hazard analyses must identify all PHMD failure modes with and without thermal threats in all its system configurations during its lifecycle. These analyses shall be used in the preparation of system design, test and evaluation requirements.

    a. A preliminary hazard analysis (PHA) shall be conducted to identify and classify hazards of all credible environments.

b. System hazard analyses and detailed analyses, such as fault tree analyses (FTA), and failure mode, effects, and criticality analyses (FMECA), shall be conducted.

c. Munition system level hazards associated with failure modes of the PHMD shall be evaluated for all phases of the life cycle. In addition, the hazards associated with an attempt to launch or deploy a munition with these failures shall be evaluated.

d. Launcher or munition system level hazards associated with the failure of the PHMD post launch shall be evaluated.

e. Use of the PHMD shall not increase the response severity to other IM tests.

7. The PHMD shall have reliability requirements specified.

8. The temperature at which the PHMD responds shall be characterized for each system with consideration of the temperature at which an unacceptable energetic reaction will occur. The temperature at which the PHMD intentionally responds should be as high as practicable to provide first responders with as much time as possible to fight fires or clear the affected area. Analysis and tests supporting the intended response temperature and safety margins shall be presented to the NSAA for concurrence.

9. The qualification test and analysis efforts to be conducted for the PHMD shall receive concurrence from the NSAA. In addition, testing of the PHMD shall be performed at the munition level as directed by the NSAA to assess any potentially hazardous effects throughout the munition's life cycle.

10. All materials used in the PHMD shall be chosen to be compatible and stable under all specified natural and induced environmental conditions in its life cycle.
If there is contact between the energetic materials used in the munition and the PHMD, assessment of compatibility shall be performed in compliance with STANAG 4147.

11. The PHMD shall be designed and documented to facilitate the application of effective quality control and inspection and test procedures in accordance with AQAP-2110. The design of the PHMD shall incorporate features that will facilitate the use of inspection procedures and test equipment to ensure that critical design characteristics have not been compromised. All critical design characteristics (for example: dimensions, material properties, heat treatments, and fabrication operations) shall be identified by the safety assessment and a method to ensure that these characteristics are within acceptable limits shall be incorporated during manufacturing and assembly of the PHMD.

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ANNEX C SAFETY DESIGN REQUIREMENTS FOR AN AHMD EMPLOYED TO ADDRESS THERMAL THREATS

C.1. SCOPE

1. The purpose of this annex is to establish specific design safety criteria for Active Hazard Mitigation Device (AHMD) intended for use with munitions or their associated logistic packaging for reducing the severity of the munition's response when subjected to STANAG 4439 thermal threat environments.

2. This annex has been developed to provide requirements for use by the design authority. This annex will be used by the NSAA to assess AHMD for an acceptable level of safety for service use.

3. This annex is applicable to AHMD in new or existing munitions. Application of this standard to modifications or new uses of an existing AHMD shall be determined by the NSAA.

C.2. REQUIREMENTS

When AHMD are being considered for use in munition system designs, including their logistical configuration, the following design safety requirements apply:

1. The design and implementation of AHMD in any munitions shall require review and acceptance by the NSAA.

2. The AHMD shall not degrade the overall system safety below the required safety level.

3. The AHMD shall not degrade or circumvent the safety provided by SAF systems.

4. The AHMD design and operation shall be independent of SAF systems.

5. The following analyses shall be performed to identify hazardous conditions for their elimination or control. Safety hazard analyses must consider the possibility of activation of the AHMD with and without thermal threats in all its system configurations during its lifecycle. These analyses shall be used in the preparation of system design, test and evaluation requirements.

   a. A preliminary hazard analysis (PHA) shall be conducted to identify and classify hazards of all credible environments.

b. System hazard analyses and detailed analyses, such as fault tree analyses (FTA), and failure mode, effects, and criticality analyses (FMECA), shall be conducted.

c. Munition system level hazards associated with the functioning of the AHMD shall be evaluated. In addition, the hazards associated with an attempt to launch or deploy a munition containing a previously functioned AHMD shall be evaluated.

d. Launcher or munition system level hazards associated with the functioning of the AHMD post launch shall be evaluated.

e. Use of the AHMD shall not increase the response severity to other IM tests.

6. The AHMD shall have reliability requirements specified.

7. The temperature at which the AHMD will intentionally function shall be characterized for each system with consideration of the temperature at which an unacceptable energetic reaction will occur. The temperature at which the AHMD intentionally functions should be as high as practicable to provide first responders with as much time as possible to fight fires or clear the affected area. Analysis and tests supporting the intended functioning temperature and safety margins shall be presented to the NSAA for concurrence

8. The AHMD shall provide a positive, direct and unambiguous indication that it has functioned.

9. Energetic materials shall be assessed and qualified for their intended role (e.g., primary explosive, booster explosive, high explosive, etc.) in accordance with the requirements of STANAG 4170.

10. The sensitiveness of the energetic materials shall not increase significantly during the entire service life of the AHMD beyond the level at which they were approved for service use, and shall not exceed the threshold values of STANAG 4170/AOP-7.

11. Qualification and Sensitiveness of Energetic Materials used for non-interrupted train. Only those energetic materials qualified in accordance with the requirements of STANAG 4170 and AOP-7 as an acceptable booster explosive are permitted to be in a position leading to the initiation of an explosive main charge without interruption. For other main charges, only those energetic materials qualified in accordance with the requirements of STANAG 4170, AOP-7 and approved by the NSAA for non-interrupted use are permitted to be in a position leading to the initiation of a main charge without interruption. The energetic material used in AHMD shall not be altered by any means likely to increase its sensitiveness beyond that at which the energetic material was qualified. If interruption is used, the interrupter shall comply with the following requirements:

   a. Interrupter lock. An interrupter(s) shall be directly locked or restrained mechanically in the interrupted position by at least one safety feature. The safety feature shall be removed only when an IM thermal threat environment is sensed and shall be as close as possible to the characterized AHMD functioning temperature.

   b. Interruption position: If safety is dependent upon the presence of an interrupter, the design shall prohibit assembly in an unsafe state. A single interrupter is acceptable if the omission of the interrupter will prohibit explosive train transfer.

   c. Interruption effectiveness: The effectiveness of the interrupter shall be numerically determined in accordance with AOP-20 Test D1 or by similar methodologies.

12. Non-interrupted detonating explosive components in AHMD systems shall be assessed in accordance with the requirements of, and pass, the tests specified in STANAG 4363.

13. The qualification test and analysis efforts to be conducted for the AHMD shall receive concurrence from the NSAA. The appropriate test selection and quantities to be tested shall be in accordance with STANAG-4157. In addition, testing of the AHMD shall be performed at the munition level as directed by the NSAA to assess any potentially hazardous effects throughout the munition's life cycle.

14. All materials used in the AHMD shall be chosen to be compatible and stable under all specified natural and induced environmental conditions in its life cycle. Assessment of compatibility shall be done in compliance with STANAG 4147. None of the following can occur in an unarmed AHMD:

    a. Premature arming or functioning.

    b. Hazardous ejection or exudation of material.

    c. Burning, deflagration or detonation of energetic materials.

    d. Materials which could contribute to the formation of more volatile or more sensitive compounds should not be used. If used, then the materials shall be treated, located or contained to prevent the formation of a hazardous compound.

    e. Production of unacceptable levels of toxic or other hazardous materials.

15. The AHMD shall be designed and documented to facilitate the application of effective quality control and inspection and test procedures in accordance with AQAP-2110. The design of the AHMD shall incorporate features that will facilitate the use of inspection procedures and test equipment to ensure that critical design characteristics have not been compromised. All critical design characteristics (for example: dimensions, material properties, heat treatments, and fabrication operations) shall be identified by the safety assessment and a method to ensure that these characteristics are within acceptable limits shall be incorporated during manufacturing and assembly of the AHMD.

16. All new or altered designs, or new applications of existing designs, or replacement or substitution of energetic materials, or power sources, shall be presented by the sponsor to the appropriate national Explosive Ordnance Disposal (EOD) research, development, test and evaluation authority for technical advice and assistance in determining viable design approaches or trade-offs for EOD requirements.

17. The AHMD’s design shall meet the disposal requirements of STANAG 4518.

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