NATO STANDARD

AOP-4518

SAFE DISPOSAL OF MUNITIONS, DESIGN PRINCIPLES AND REQUIREMENTS, AND SAFETY ASSESSMENT

Edition A Version 1
MAY 2018

NORTH ATLANTIC TREATY ORGANIZATION

ALLIED ORDNANCE PUBLICATION

Published by the
NATO STANDARDIZATION OFFICE (NSO)

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NORTH ATLANTIC TREATY ORGANIZATION (NATO)

NATO STANDARDIZATION OFFICE (NSO)

NATO LETTER OF PROMULGATION

24 May 2018

1. The enclosed Allied Ordnance Publication AOP-4518, Edition A, Version 1, SAFE DISPOSAL OF MUNITIONS, DESIGN PRINCIPLES AND REQUIREMENTS, AND SAFETY ASSESSMENT, which has been approved by the nations in the CNAD Ammunition Safety Group, is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 4518.

2. AOP-4518, Edition A, Version 1, is effective upon receipt.

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
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RECORD OF SPECIFIC RESERVATIONS

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CHAPTER 1 INTRODUCTION

1.1. AIM

1. The aim of this publication is to provide guidance on design safety principles, design safety requirements and the assessment process for the safe disposal of munitions.

1.2. SCOPE

1. Participating nations agree to consider the policies and principles of AOP-4518 (A)(1) and applicable related documents listed in AOP-4518 (A)(1) when designing and modifying munitions. This agreement is applicable to new developments; existing stores subject to major modification, rework, change, or addition of any hazardous component; replenishment purchases, and existing stores being used in a new role. Participating nations agree to procure for military use by NATO Forces munitions which have been designed, or will be modified, to comply with AOP-4518 (A)(1).

2. The nation developing a munition shall consider the design and assessment principles detailed in AOP-4518 (A)(1). Specifically, the nation developing a munition agrees to incorporate acceptable end-of-mission (EOM), end-of-operational-life (EOOL), or end-of-life (EOL) disposal capabilities; to assess the design for its adherence to the guidance provided here; and to document the EOM/EOL disposal processes to be used on the munition.

3. This AOP-4518 (A)(1) provides guidance on the methodology for carrying out an assessment process for the safe and environmentally acceptable disposal of munitions; the design principles to be applied during munitions development, procurement, acquisition; the available demilitarization and disposal techniques; and, the preparation of a demilitarization and disposal plan.

1.3. DEFINITIONS

1. In AOP-4518 (A)(1), the term “demilitarization” refers to the act of removing or otherwise neutralizing the original military potential of a munition. Such neutralization is to be carried out in a safe, cost effective, practical and environmentally acceptable manner. Demilitarization is a necessary step for military items prior to their release to a non-military setting.

2. The term “disposal” refers to EOL tasks and actions for residual materials resulting from demilitarization operations. Disposal encompasses the process of redistributing,

transferring, donating, selling, abandoning, or destroying military munitions. The Explosive Ordnance Disposal (EOD) activities are not included in this definition.

3. Other specific terms are defined in AAP-6, Annex A, and related documents listed in Annex D.

1.4. GENERAL

1. Munitions designers have traditionally focused their product development and design on performance, not on ease of demilitarization at the end of the munitions' life cycle. Design for demilitarization/disposal was not a significant issue when less complex disposal techniques, e.g. Open Burning/Open Detonation (OB/OD), or dumping were utilized.

2. Growing international awareness of ecological issues and the environmental impact of industrial waste disposal processes have caused member nations to examine programs and processes concerning the demilitarization and disposal of munitions. Contributors of this increased attention include more stringent international environmental legislation such as that listed in Annex C, public pressure on governments for sustainable methods of demilitarization, growing stockpiles of post-cold war surplus munitions, limited budgets, the desire to preserve natural resources, the desire to reduce waste, and limited space and locations for disposal. Because legislation is likely to become more stringent in the future, plans and processes used in the demilitarization and disposal of munitions will need to be carefully crafted and be reviewed continually in the light of new legislation and advances in technology. The focus of demilitarization and disposal is escalating from using techniques that are safe, efficient and cost effective to ones that are environmentally acceptable, physically safe, free of health hazards, practical, and cost effective. Nations are being urged to move from disposal processes that rely on destruction toward those that maximize the recovery and reuse of component materials. Consequently, demilitarization has moved towards recovery, reuse, recycling, with demilitarization requirements of conventional ammunition (including any item containing propellants, explosives, or pyrotechnics) being considered early during munitions system design.

3. New techniques have been developed to increase the use and benefits of Reuse, Recovery and Recycling (R3) methods. R3 methods break down the munitions into their basic, recyclable component parts and compounds, which can then be sold to offset processing costs and thus reduce the overall cost of demilitarization. However, not all munitions are suited to R3, and in some cases insufficient quantities exist to develop economically sustainable demilitarization solutions and operations.

4. The efficiency of these demilitarization operations is, among other factors such as the quantity and rate of demilitarization, significantly influenced by the original design of the ammunition. Yet the design of munitions does not always lend itself to the cost-

effective recovery of materials for recycling or reuse. Munitions designed and purchased today tend to be more complex than that currently being demilitarized. Munitions may incorporate embedded electronics, plastic-bonded explosives (PBX), and insensitive high explosives. These munitions designs may not efficiently accommodate current demilitarization processes, presenting additional difficulties during disassembly, and ultimately adding time and expense to demilitarization operations.

5. Design for Demilitarization (DFD) is the incorporation of demilitarization consideration throughout the life cycle. The objective is to produce munitions that can be demilitarized safely and more efficiently at a lower cost. This involves incorporating features into the munitions design with a systems engineering approach that facilitates demilitarization processing. Desired outcomes include ensuring:

a. Components can be disassembled easily
b. Energetic materials can be removed
c. Demilitarization processes can be used efficiently
d. Munitions are safe to handle by operators throughout demilitarization processing
e. Reusable or recyclable components/materials can be economically recovered
f. Minimal environmental impact
g. Ultimately, cost savings to future development programs may possibly be realized through the use of recovered components and materials in new production.

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CHAPTER 2 DETAIL OF THE PUBLICATION

2.1. REQUIREMENTS

1. The policies of national authorities and the international agreements in effect at the time of a munitions development will determine the extent of incorporation of demilitarization and disposal principles and plans into a munitions developmental life cycle. If the national ordnance safety authority of the developing nation approves munitions for service use (in keeping with national environmental legislation) even though a plan has not been developed that meets the intent of AOP-4518 (A)(1), that review authority shall clearly document the basis for its approval.

2. Demilitarization and disposal tasks and actions shall be applied to munitions designed for military use or taken into use by the military. Demilitarization does not include the resale of the store in an unchanged condition, other than remarking, but may include the resale of components in their original form following removal during demilitarization. It also excludes any operational task such as EOD and Battlefield Area Clearance, but does not preclude EOD personnel from participating in industrial demilitarization operations. EOD is the detection, identification, onsite evaluation, rendering safe, recovery and final disposal of unexploded explosive ordnance. Demilitarization of munitions is limited to stored items, which have become excess, obsolete or otherwise unneeded. The munitions items cannot have the explosive train functioned or partially functioned. Where all or part of a munition, whether the subject of a demilitarization and disposal plan in accordance with AOP-4518 (A)(1) or not, is used in the rework or development of another munition, the munition that emerges from the task shall be considered as a new design and shall be subject to the requirements of AOP-4518 (A)(1).

3. The process of demilitarization shall result in the removal or neutralization of the original military potential of a munition to prevent reuse, misrepresentation or misidentification of the residue for military or terrorist activities. Such actions shall make the item and all its components after disassembly incapable of full or partial functioning, reuse in other weapon systems (e.g., by replacement of fuzes), and shall make the item or its components unidentifiable as a munition.

2.2. DEMILITARIZATION AND DISPOSITION PROCESS

1. Figure 1 illustrates the demilitarization and disposal process typically followed. A brief description of each step follows Figure 1.

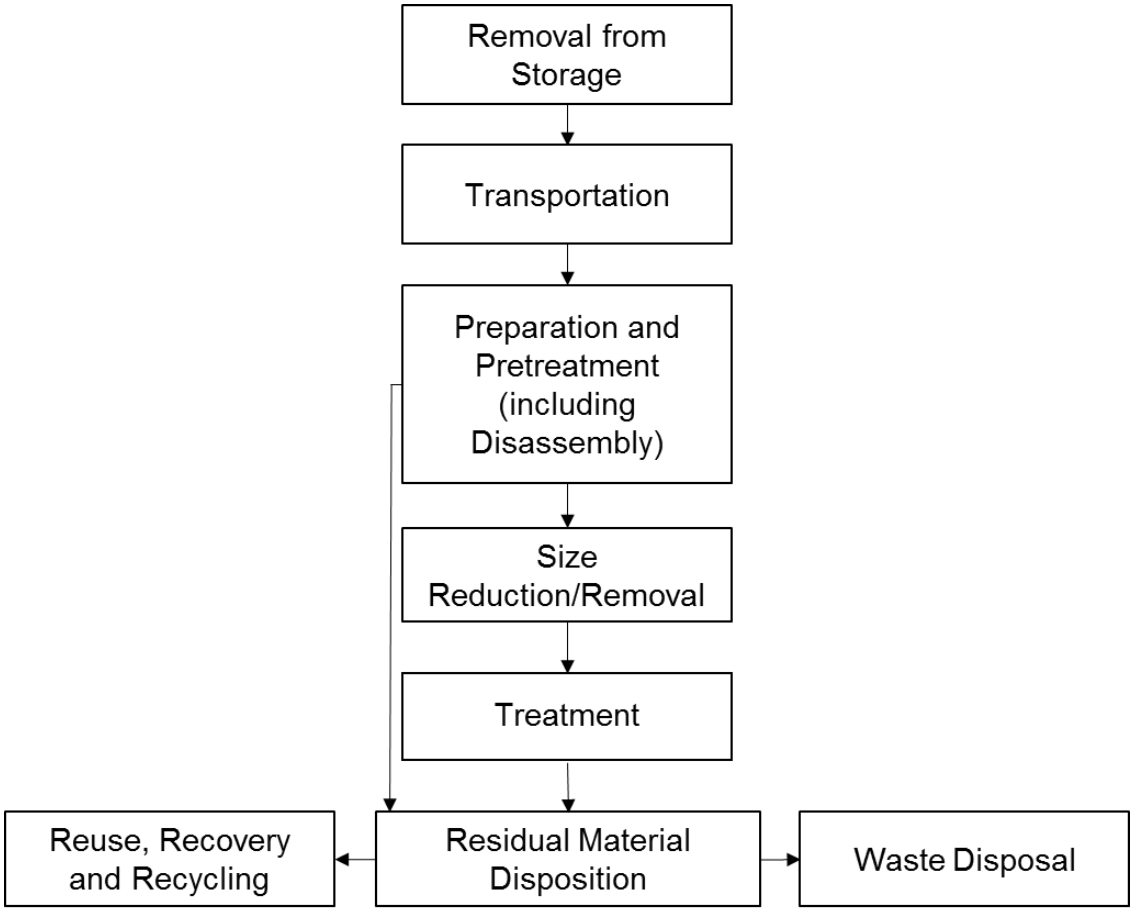

Figure 1. Demilitarization and Disposal Process

a. Removal from Storage: The demilitarization and disposal operation starts with collecting the munitions in suitable lots depending on the type and physical condition of munitions. The munitions must be labeled, controlled, and packaged as would be done for any other munitions of its type. The munitions may then be transported and shipped to the organization or contractor responsible for the demilitarization and disposal operation. If munitions are found to be in an unsafe physical condition and cannot be transported, further inspection must be done to determine if EOD should be involved. The plan of action for a situation with munitions in an unsafe physical condition is beyond the typical scope of demilitarization and a risk assessment may be needed to determine the appropriate emergency procedure required.

b. Transportation: Depending on the storage location of the munitions and the location of the demilitarization and disposal process site, various military or civilian regulations for transportation will need to be followed, especially if the transport involves crossing national or state borders.

c. Preparation and Pretreatment: Munitions to be removed from military service use often involve a variety of materials, some of which do not present an explosive hazard, such as packaging materials and steel casings, and other materials, such as explosives and fuels, which are hazardous. After separation and screening, packaging materials, wood, paper, and metals should be collected for recycling, or disposal according to the regulations for solid waste. Special attention must be paid to materials that require special treatment and disposal. The disassembly process will likely follow in reverse order the assembly procedures used in the production of the munitions. All hazardous materials should be identified for treatment by type. For example, igniters, fuzes, batteries, heavy metals such as lead, cadmium, mercury, asbestos containing materials, will all result being regulated at different levels depending on the final disposal process.

d. Size Reduction/Removal: The size and volume of a complete munition can usually be reduced by separating explosive warheads, rocket motors, and other large sections that contain hazardous materials by means of; mechanical sectioning, laser grooving/cutting, water jet cutting, and cryofracture. Washout or meltout processes are possible removal techniques. Whatever hazardous materials or hazardous components are remaining must be prepared and transported for treatment. The size reduction of explosive/pyrotechnic materials/components can lower the hazard from mass detonation to detonation of small parts.

e. Treatment: Any method or process designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize such waste, or so as to recover energy or material resources from the waste, or so as to render such waste non-hazardous; less hazardous; or safer to transport, store, or dispose of.

f. Reuse, Recovery and Recycling: Once the munitions have been separated from other inert materials, several options for recycling, reuse, and recovery of explosives, metals, and other materials exist. Options that provide the most advantageous cost benefit, such as recovery of explosives for industrial reuse, are selected. The demilitarization and disposal options resulting in the highest degree of reuse, recovery, recycling of the most valuable materials will usually be preferred. However, care should be taken to not saturate a particular reuse market segment.

g. Residual Material Disposition: The disposal of small quantities of original demilitarized constituents that are a byproduct of treatment.

h. Waste Disposal: After completing the preceding steps, paragraph 2.5 lists options for demilitarization and disposal of Waste Military Munitions and explosive hazardous waste. Hazardous material refers to material that may

pose a risk for the population, property, safety or the environment owing to its chemical or physical properties or the reactions that it may cause. Authorized and trained personnel and permitted (and/or licensed) facilities will dispose of any materials remaining that cannot be recycled or reused. Inert substances usually can be disposed of at solid waste landfills, but hazardous materials must be disposed of at controlled and permitted facilities.

2.3. DESIGN SAFETY PRINCIPLES TO BE APPLIED DURING MUNITIONS DEVELOPMENT

1. To the fullest extent possible, the following design safety principles should be applied during munitions development to facilitate demilitarization and disposal using processes that maximize safety and minimize health hazards, negative environmental impacts, and life cycle cost:

a. Select materials that are not inherently toxic and can either be reused, recycled or destroyed with minimum impact on health and the environment at the end of the munitions life.
b. Select materials and design features that will minimize the adverse impact of credible service-life environments and aging on demilitarization and disposal processes and by-products.
c. Select materials and design features that allow old operable stocks to be consumed in training.
d. Configure munitions for safe disassembly and ease of useful material recovery.
e. Configure munitions for ease of component and package reuse or recycling.
f. Design munitions to maximize service life.
g. Design munitions to permit significant life extension modifications and, consequently, reduce the need for demilitarization and disposal.
h. Design for ease of alternative munitions applications with limited remanufacturing.
i. Select materials and design features that allow the munitions to continue to be safe for handling, transportation and storage even after end-of-life.

2.4. DISPOSAL ASSESSMENT PROCESS

1. AOP-15 calls for the assessment of the disposal aspects of munitions as part of the overall safety assessment process. During munitions development procurement, acquisition, the following assessment principles shall be used to evaluate proposed demilitarization and disposal design features, processes and plans:

a. Compare the munitions design with the demilitarization and disposal design safety principles stated in Paragraph 2.3, above.
b. If conformity with those requirements is lacking, the risks involved shall be assessed. If those risks are unacceptable, the design should be changed or the acquisition process interrupted. Acceptability must be agreed upon by the national military safety authority. Testing may be required to gain adequate confidence in the assessment.
c. Confirm the effectiveness of selected processes by test and analysis.
d. Assess the chosen demilitarization and disposal procedures and EOL actions with regard to personnel safety, environmental consequences, and other substantial risks. The effects of exposure to credible life-cycle environments, of munitions degradation and aging, and of environmental factors and human errors during execution of the demilitarization and disposal processes shall be taken into account when making the assessment.
e. Assess the compatibility of the demilitarization and disposal procedures with national and international legislation regarding health, safety, and environmental protection.

2.5. DEMILITARIZATION AND DISPOSAL TECHNIQUES

1. This section provides representative techniques suggested by various nations. Their appearance here is not an endorsement of their use. National acceptance of any planned procedure is required.

2. While details of how demilitarization and disposal techniques are implemented are not included in AOP-4518 (A)(1), some possible size reduction techniques are mechanical sectioning, laser grooving/cutting, cryofracture, and water jet cutting. Some possible removal techniques include washout and meltout. Annex “A” gives a short description of each one.

3. All aspects of the demilitarization and disposal process must be carried out in a manner that meets the nations’ respective national and local environmental regulations on pollution, emission, and control of contaminated items. All proposals should be economically viable for any products intended for recycling. Because national policies will determine the acceptability of the selected method, a purchasing nation may require the use of a different method than the one accepted in the developing nation. Demilitarization

facilities, whether government or commercial, are responsible for following relevant laws, maintaining and documenting safety and compliance.

4. Methods of treatment might include OB/OD, incineration, oxidation, biochemical or chemical decontamination, photocatalytic neutralization, biodegradation, chemical conversion, electrochemical reduction, open burning, closed detonation, or other environmentally and safety-approved methods.

5. After treatment, the residual material must be recovered, reclaimed, reused, recycled, sold, or be treated as waste.

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2.6. DEMILITARIZATION AND DISPOSAL PLAN

1. Personnel for new and modified munitions development programs shall prepare an appropriate demilitarization and disposal plan. Uses of the related documents listed in AOP-4518 (A)(1) are recommended for consideration, when applicable, during the development of a plan. In general, a demilitarization and disposal plan should include the following information:

a. A functional and physical description of the munitions (including quantity), its packaging configuration, and the equipment, processes and procedures planned for safe and environmentally acceptable demilitarization and disposal.
b. A listing of all materials, including the hazardous materials contained in the munitions, and their associated hazards.
c. An indication of intent to conduct a hazards analysis on the demilitarization and disposal procedures and EOL actions in accordance with AOP-15 and to include a discussion of the safety and environmental impacts and their associated hazards.
d. Provisions to ensure that, after application of the selected processes, all sensitive materials and items will be neutralized or otherwise rendered inoffensive or be extracted for other uses.
e. The intended destination of liberated hazardous materials.

2. Annex D provides an example format for a demilitarization and disposal plan and the information that might be included.

CHAPTER 3 DEMILITARIZATION CONSIDERATIONS

3.1. DEMILITARIZATION PROCESS CONSIDERATIONS

1. The demilitarization and disposal process can be considered as the logical sequence of steps outlined in Figure 1. However, deviations from that sequence may be applicable to certain types of munitions, e.g. some Small Arms Ammunition (SAA) can be demilitarized without being disassembled.

2. The order of the different demilitarization and disposal process steps and the demilitarization techniques applied to munitions depend mainly on the following factors:

a. Available means.
b. Physical state.
c. Munitions quantities to facilitate economies of scale, i.e. the quantity that allows for the most economical method of destruction.
d. Demilitarization techniques available and their capacities.
e. Safety, security and environmental regulations.

3. There may be more than one technique to demilitarize similar munitions, and the focus of demilitarization should be according to the Best Available Techniques Not Entailing Excessive Costs (BATNEEC) principle.

a. 'Best' means most effective in achieving a high level of physical and environmental protection.
b. 'Technique' includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.
c. 'Available Technique' means those developed on a scale which allow economically and technically viable implementation.
d. 'Not Entailing Excessive Costs' implies where the benefits gained are worth more than the costs of obtaining those benefits.

3.2. DEMILITARIZATION TECHNIQUES

1. One should note that the complete demilitarization process, as shown in Figure 1, is likely a combination of different techniques, such as those described in Paragraph 2.5. A matrix of potential demilitarization techniques is given in Annex B. The matrix provides a brief description of the techniques, their usage and maturity and some notes on their advantages and disadvantages. The techniques are categorized by the stage of the demilitarization process that they apply to and are identified below:

a. Disassembly and Pretreatment: techniques providing access to the energetic material or size reduction prior to further treatment
b. Removal: techniques for removing energetic material from munitions
c. Destruction: techniques for destroying energetic material or converting it to less hazardous products
d. Reuse, Recovery and Recycling: techniques particularly related to R3 methods

2. As the characteristics and status of munitions vary, so do the hazards associated with their respective demilitarization activities. A risk analysis should be conducted to determine whether a technique is technically and economically feasible for the considered munitions and that the technique does not create a health or safety issue during the demilitarization process.

3. Demilitarization activities should be planned and prioritized according to the quantity, the type, the physical status and the difficulty of treatment. Grouping appropriate demilitarization activities may result in an economy of scale. Subsequently, economies of scale may offer a broader range of efficient and available demilitarization techniques.

3.3. BEST AVAILABLE DEMILITARIZATION TECHNIQUE

1. The demilitarization techniques enumerated in Annex B must be subjected to a multi-criteria analysis to determine whether the technique can be considered as the BATNEEC. Note that all munitions may not need a full multi-criteria analysis. For instance, small quantities of relatively benign munitions, munitions that are substantially the same as current designs with well understood demilitarization processes, etc. may not need a full multi-criteria analysis. The plans shall be proportionate to the hazard and risk. Those criteria should not only take into account environmental factors such as air, water, ground, material cycles, energy and noise, but also the technical availability and the economic aspects. Ideally, the production rate should also be taken into account, however the throughput depends mainly on the type of munitions.

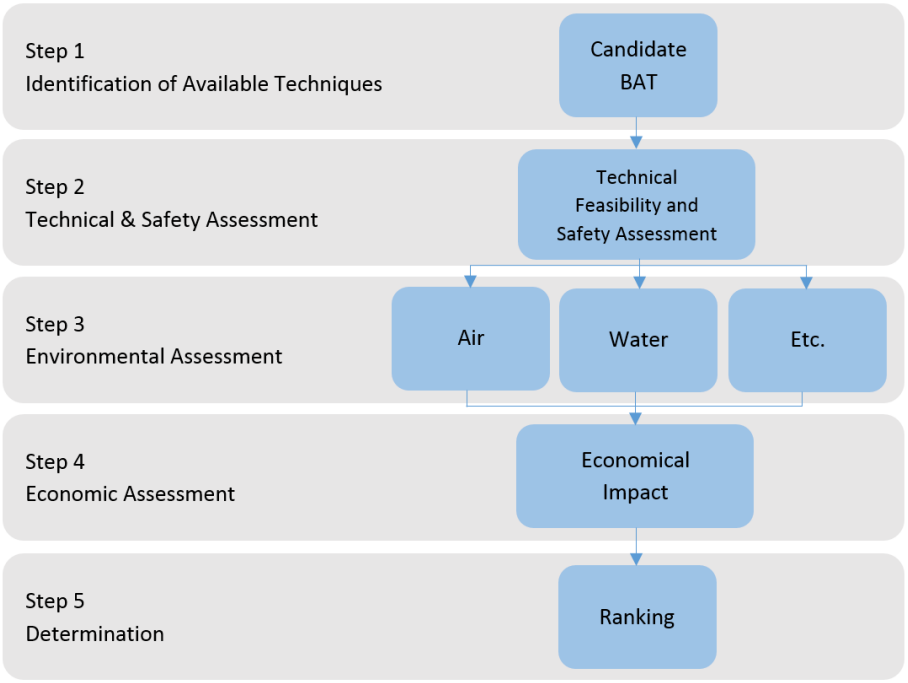

Figure 2. BATNEEC Determination Process

2. Figure 2 represents a useful multi-criteria analytic process to which candidate munitions could be subjected when determining the BATNEEC for demilitarization. Determination of the BATNEEC for the overall demilitarization process should take into consideration many different elements, e.g. environmental impacts, economic impacts and occupational health and safety risks and hazards. The steps of the BATNEEC Determination Process are described in more detail, below.

a. Step 1 – Identification of Available Techniques: Identify all potential and available techniques for the candidate munitions. These techniques shall be submitted to the multi-criteria analysis in order to determine which technique is the BATNEEC for the considered "BATNEEC" of munitions.

b. Step 2 –Technical & Safety Assessment: This first criterion should study whether the "candidate BATNEEC" is technically available and operationally safe, and the following elements should be considered:

i. Technical Maturity: the technique has been operationally proven successful in demilitarization (or industry) practice
ii. Safety: evidence to support whether the technique, when correctly used with suitable safety measures, mitigates or increases the risk for fire, explosion and other occupational safety incidents

iii. Quality: evidence to support whether the technique has an influence on the physical state of the end product or residual materials
iv. Summary Assessment: estimates the overall technical availability of the technique

c. Step 3 – Environmental Assessment: When the technique is available, the effect on the different environmental factors must be studied, and the following elements should be considered:

i. Waste Water
ii. Air Emissions
iii. Ground
iv. Material
v. Energy – candidate sources and possible reuse
vi. Noise
vii. Summary Assessment – the overall effect on the environment is estimated (i.e. negative impact, positive impact, no impact, both positive and negative impacts)

d. Step 4 – Economic Assessment: When the overall environmental impact is positive, an economic evaluation should be carried out to determine the additional costs for the implementation of the candidate BATNEEC and if these investments are reasonable compared to the achieved environmental benefits.

e. Step 5 – Determination/Decision: A technique is chosen a BATNEEC when it is technically available, the overall effect on the environment is positively evaluated, the technique is economically viable and there is no better candidate.

3.4. EXPLOSIVES SAFETY

1. Munitions demilitarization operations can be extremely hazardous and require a thorough knowledge of the activities involved, the hazards to be protected against, and the precautionary methods necessary for greatest protection to personnel, property, and the public.

2. NATO explosives safety guidelines and quantity-distances are given in Allied Ammunition Storage and Transport Publication (AASTP)-1 and shall apply to ammunition and explosives-related operations associated with demilitarization and disposal activities.

3. In the event OB or OD is selected as the method for munitions disposal, the requirements for such operations are given in AASTP-1, Part IV, Chapter 7.

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ANNEX A TERMS AND DEFINITIONS

A.1. TERMS AND DEFINITIONS

1. Terms defined in AAP-6 and referenced documents have been used. Terms specific to this document are defined as follows:

a. Biochemical: A general term referring to chemical reactions in living organisms.

b. Biodegradation: The process of breaking down a hazardous compound into innocuous products by the action of microorganisms or other living species.

c. Chemical Conversion: The changing of one compound into another via chemical reaction.

d. Chemical Decontamination: The process of making any contaminated object, person or area safe for unprotected personnel by chemically destroying, physically removing, sealing in, or otherwise making harmless the contaminating agent on or around it.

e. Closed Detonation: The process of placing munitions in a closed chamber and initiating it with an explosive charge or by using an external heating source. The evolved gases and solid residues can then be collected and treated in an environmentally acceptable manner.

f. Cryofracture: The process of cooling a munition usually in a bath of liquid nitrogen. At such a temperature, for example, a heavy steel projectile case would become brittle and could more easily be shattered to expose its contents. The munitions are then fractured in a hydraulic press to gain energetic access.

g. Demilitarization: The act of removing or otherwise nullifying the original military potential of a munition. Such action is to be carried out in a safe, cost effective, practicable, and environmentally acceptable manner. Demilitarization is a necessary step for military items prior to their release to a non-military setting.

h. Disassembly: The act of punching, crushing, unbolting, unscrewing or cutting apart munition items by robotic or manual means.

i. Disposal: The end-of-life (EOL) tasks and actions for residual materials resulting from demilitarization operations. Disposal encompasses the process of redistributing, transferring, donating, selling, abandoning, or destroying military munitions. The Explosive Ordnance Disposal (EOD) activities are not included in this definition.

j. Electrochemical Reduction: Treatment of organic wastes by generation of highly oxidizing species in an electrochemical cell and using them to oxidize the waste to carbon dioxide and water.

k. Explosive Ordnance Disposal (EOD): The detection, identification, onsite evaluation, rendering safe, recovery and final disposal of unexploded explosive ordnance.

l. Incineration: The controlled burning of solid, liquid, or gaseous combustion wastes to produce gases and solid residues containing little or no reactive material.

m. Laser Grooving/Cutting: Use of a laser to score a projectile case to a weakened grooved that, in combination with a tearing/breaking process, would bisect the case to expose the filler.

n. Mechanical Sectioning: The act of separating parts of a munition via with hand tooling or machining equipment.

o. Meltout: A process for removing energetic material in which the filler is heated sufficiently to cause it to melt and flow out. Three meltout technologies are autoclave, steam-out, and heating.

p. Neutralization: The process of making munitions ineffective in its intended application.

q. Open Burning (OB): The burning of explosives and munitions in a metal pan in the external environment, without the control of resulting emissions.

r. Open Detonation (OD): The detonation of explosives and munitions in an external environment without control of resulting emissions.

s. Oxidation: A treatment method that uses electron loss chemical processes. Such processes are widely used to treat cyanides, pesticides, phenol, and sulfur compounds. Common oxidants used are chlorine or hypochlorites, potassium permanganate, and hydrogen peroxide.

t. Photocatalytic Neutralization: The use of a light emitting source to render a material inactive or ineffective.

u. Recovery: The process of extracting serviceable and economically repairable components and material from excess or surplus munitions.

v. Recycling: The use in a different item of materials recovered from a munition.

w. Resale: The process of selling munitions to foreign governments.

x. Residual Materials: Small quantities of original demilitarized constituents that are a byproduct of treatment.

y. Reuse: The alternative use of a munitions or its components, e.g., change from operational to training use.

z. Washout: The use of an agent, such as pressurized hot water, solvent, or cryogenic dry wash, to remove energetic material in a munition without destruction of the case metal.

aa. Water Jet Cutting: A process of squeezing water through a nozzle to form a thin jet capable of cutting a variety of non-metallic materials. If an abrasive is entrained into the water jet, the method is called abrasive water jet cutting. Metallic or hard materials such as metal plates, ceramics, or glass can then be cut.

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ANNEX B DEMILITARIZATION TECHNIQUES

B.1. DEMILITARIZATION TECHNIQUES

1. A matrix of demilitarization techniques is given in Table 1, below. The table provides a brief description of the potentially available techniques, their usage and maturity and also some notes on their advantages and disadvantages. The techniques are categorized by the stage of the demilitarization process that they apply to. These are:

a. Disassembly and Pretreatment: techniques providing access to the energetic material or size reduction prior to further treatment
b. Removal: techniques for removing energetic material from munitions
c. Destruction: techniques for destroying energetic material or converting it to less hazardous products
d. Reuse, Recovery and Recycling: techniques particularly related to R3 methods

2. In Table 1, the usage column gives some indication of the types of munitions or waste streams that can be treated with this process. Secondary waste streams in this column should be taken to mean the waste streams of processes such as alkaline hydrolysis that have removed the explosive properties of the waste but require further treatment.

3. Maturity refers to the usage in a demilitarization context. A technique may be common in another industrial context but still at a research or prototype level in demilitarization. In particular, the phrases in this column indicate:

a. 'Widespread use' identifies those techniques which are the most common forms of demilitarization.
b. 'In use' identifies other techniques which are in use for demilitarization beyond pilot plants.
c. 'In development' identifies those techniques that are not yet in use.

Table 1. Matrix of Demilitarization Techniques

Technique	Description	Usage	Maturity	Notes
Disassembly and Pretreatment				
Disassembly, Manual	Disassembly, punching, crushing, unbolting, unscrewing or cutting by manual means	All munition types	Widespread use	Flexible – easy to adapt to different munitions; Low setup costs; Safety issues associated with manual disassembly of munition
Disassembly, Robotic	Disassembly, punching, crushing, unbolting, unscrewing or cutting remotely	All munition types	Widespread use	Reduces personnel exposure to munitions; Less flexible than manual disassembly
Cutting, Abrasive Water or Slurry Jet	Sectioning by a high pressure abrasive water or slurry jet	All munition types	In use	Flexible and quick; Generates waste water; Useful with UXO and MEC
Laser Grooving/Cutting	Use of a laser to score a projectile case	All munition types	In development	Bisects the case to expose the filler
Cryofracture	Liquid nitrogen bath embrittles munitions before mechanical pressing	Small detonable items	Widespread use	Ensures no high order event during incineration; An additional process that may not be necessary
Removal				
Machining, Mechanical	Dry machining of energetic materials by contour drilling	All munition types except small munitions	In use	No waste water; Typically only removes 95% of explosive so further treatment is necessary
Washout, HP Water	Ablation of energetic material by a high pressure water jet	All munition types except small munitions	Widespread use	Moderate pressures; Generates waste water; Difficult with small munitions
Meltout, Steam	Meltout of explosive by steam or hot water jets	Melt-cast explosives	Widespread use	Generates waste water; Moderate temperature and pressures
Meltout, Autoclave	Meltout of explosive by hot water in a pressurized vessel	Melt-cast explosives	Widespread use	Reduced waste water generation; Moderate temperature and pressure
Destruction				
Open Burning	Uncontained burning	Non-detonable items and waste	Widespread use	Simple process that does not require industrial plant; Potential environmental impact
Open Detonation	Uncontained detonation using a donor charge	Detonable items and waste	Widespread use	Simple process that does not require industrial plant; Potential environmental impact
Closed Detonation	Detonation by a donor charge in a contained chamber	Small detonable items	In use	Pollution control; Transportable;

Technique	Description	Usage	Maturity	Notes
				Small capacity batch process
Incineration, Static Kiln	Incineration in a sealed chamber. Items can burn or detonate	Munitions types except large detonable items after pretreatment	In use	Pollution control; Small capacity batch process; Items may require pre-treatment such as sectioning before incineration
Incineration, Rotary Kiln	Incineration with the items slowly moved through the kiln	Non-detonable items and small detonable items	Widespread use	Pollution control; Items may require pretreatment such as sectioning before incineration
Incineration, Car Bottom Furnace	Incineration using a moveable 'car' to insert the waste	All munition types except large detonable items	Widespread use	May have pollution control; Can handle unusual shapes; Small capacity batch process
Incineration, Plasma Arc	Molten slag is heated by a plasma arc and destroys munitions	Explosive waste slurry or granular solids	in use	Can deal with pyrotechnics; Slag encapsulates hazardous waste; Items may require pretreatment such as sectioning before incineration; Relatively expensive for bulk energetics
Biodegradation, Aqueous/Slurry	Biodegradation by microbes in a bioreactor	Explosive waste slurry or secondary waste stream	In use	In use for perchlorate treatment; Cheap and environmentally acceptable option
Reuse, Recovery and Recycling				
Resale	Sale of munitions to foreign governments	Serviceable munitions	In use	Limited by arms proliferation agreements; Munitions may be unsaleable by the time they are disposed of
Energy Recovery	Co-firing of slurries or use of waste heat boilers on incinerators		In use	
Scrap Metal Recovery	Resale of scrap metal from demilitarized munitions		Widespread use	Requires flashing or some method of removing contamination
Chemical Conversion	Conversion of energetic materials to saleable chemical products		In use	Typical applications include production of phosphoric acid
Energetics Recovery	Solvent based techniques to recover energetics from cross-linked binders	Rocket motors and PBXs	In use	As a precursor to reuse as commercial or military explosives

Technique	Description	Usage	Maturity	Notes
Reuse as Commercial explosive	Reuse of recovered energetics for commercial explosives	Recovered energetics	In use	

ANNEX C INTERNATIONAL ENVIRONMENTAL LEGISLATION

C.1 INTERNATIONAL ENVIRONMENTAL LEGISLATION

1. Relevant UK legislation:
   a. Control of Pollution Act

2. Relevant US legislation:
   a. DoD 5000.2R

3. Relevant EU legislation:
   a. Industrial Emissions Directive (Directive 2010/75/EU of the European Parliament and of the Council of on industrial emissions, dated 24 November 2010)

4. Relevant NATO legislation:
   a. MC 469/1 (NATO Military Principles and Policies for environmental protection (EP) dated 13 Oct 2011)

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ANNEX D EXAMPLE DEMILITARIZATION AND DISPOSAL PLAN

D.1 EXAMPLE OF DEMILITARIZATION AND DISPOSAL PLAN

1. This section shall state that the purpose of the plan is to identify the processes, procedures, and equipment necessary to accomplish the safe and environmentally acceptable demilitarization and disposal of munitions or its components. The plan must be proportionate to the hazard and risk.

    a. Give a brief overview of the process being used.

    b. Identify areas not covered by the plan, e.g., transportation, incinerator operations, washout operations. Also, identify subassemblies covered in other plans.

2. This section shall describe the physical and functional configuration of the complete item and major components with attached illustrations. The description is to list:

    a. All individual parts/components and filling (including explosive components) that are potentially recoverable; include quantities, compositions, and weights.
    b. All non-recoverable elements (including explosive components); provide reasons for being non-recoverable, and quantities, compositions and weights.
    c. All classified items and components; provide the minimum declassification requirements for each.
    d. All precious metals and materials; identify quantity of each.

3. This section shall list (and describe briefly) the preferred and alternative methods of demilitarization and disposal of the item(s) addressed by the plan. Descriptions should include step-by-step procedures, safety precautions, disassembly diagrams, declassification procedures, component and piece part tables, demilitarization operations, and disposal options. (NOTE: The National Authority shall provide information on available technology and equipment capability to the preparer. The preparer shall use that information in developing the demilitarization and disposal plan).

4. This section shall list special tools and equipment required to accomplish the procedure described for the preferred and alternative methods.

5. This section shall summarize safety hazards that are inherent in the munitions and the precautions and procedures that must be employed during the demilitarization

and disposal operation. This section shall also provide an overview of the safety requirements for storage and handling. A table shall be included in this section that identified all of the energetic and hazardous materials in the munitions item, the chemical composition of each material, and the material's products of combustion.

a. Primary risks: are those associated with the munitions, components and filling that might affect personnel, environment, or property during handling or exposure
b. Ingestion/Adsorption/Inhalation: List all materials that may have a physiological effect on personnel or may damage property or the environment (including flora and fauna). The list shall indicate the physical form of the material (solid, liquid or gaseous), the means of attack, the effect and the protection required.
c. Trauma Inducing: List all batteries, electrical and electromagnetic generating devices, capacitors, sources of electrical charge, and springs under tension or material under compression that can transfer kinetic energy upon release. The list shall indicate the likely energy output, the likely effect and the protection required.
d. Explosive or Filling Risk: List risks associated with the payload, propulsion system and any energetic (explosive) material. The list shall include any flammable or oxidizing material. Most nations have Explosive Hazard Data Sheets/Records and reference can be made to factors such as toxicity, reactivity and spark sensitivity. Where the filling is not an explosive energetic material, e.g., white phosphorus or CS/CAR/CN, then the criteria for the Ingestion/Absorption/Inhalation risk assessment would apply.
e. Radioactive or High Energy Emitters: List any risk related to the electromagnetic spectrum, whether from a natural or artificial source, e.g., radioactivity, bright light, coherent light (laser) and microwave. The list shall include details of the physical form of the source, output, effect on personnel, property, and environment and the protection required.
f. Secondary Risks: Secondary risks are those risks that exist during the process of demilitarization and disposal where the process changes the material; such risks are to be annotated using the same format as for the primary risk. A Secondary Risk will be specific to the disposal method selected and, therefore, there may be more than one Secondary Risk for a particular munitions, component or filling. A Secondary Risk may exist in material that was not considered to have a Primary Risk, e.g., a plastic that has no risk in its basic form but produces a toxic concentration of gases if burned. Additionally, risks associated with the waste stream of proposed breakdown or disposal equipment are to be included.

6. This section shall include an analysis describing the environmental significance and impact of each demilitarization and disposal alternative, including a brief overview of the regulations applicable to the preferred demilitarization process. This section shall also list all of the recyclable materials generated by the preferred demilitarization process and identify the waste streams produced by

the preferred demilitarization process. This will include the combustion products from the energetic and hazardous materials table.

7. Recognition that most stores, especially those used in training, may have a long storage life, must be addressed by identifying the need for some future review(s). Two situations that would induce the need for future reviews are:
    a. The stores undergo physical or chemical changes or minor modification. Even though this change with age is recognized and expected, the rate of change may be different than was originally anticipated. Therefore, a statement that the plan must be reviewed after (x) years or following modification should be considered for inclusion.
    b. Environmental or health and safety legislation may change so there is a need to state that the plan must be reviewed in the light of new legislation.

8. This section shall list the applicable reference documents such as safety, environmental, technical and other documents used to prepare the plan.

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ANNEX E APPLICABLE DOCUMENTS

E.1 APPLICABLE DOCUMENTS

Related Documents:

AAP-6	NATO Glossary of Terms and Definitions
AASTP-1	NATO Guidelines for the Storage of Military Ammunition and Explosives
AECTP-100	Environmental Testing - Guidelines on Management Planning
AECTP-200	Environmental Testing - Definitions of Environments
AECTP-230	Climatic Conditions
AECTP-240	Mechanical Conditions
AECTP-300	Climatic Environmental Tests
AECTP-400	Mechanical Environmental Test
AECTP-500	Electrical Environmental Test
AOP-7	Manual of Tests for the Qualification of Explosives for Military Use
AOP-8	NATO Fuze Characteristics Catalogue
AOP-15	Guidance on the Assessment of Safety and Suitability for Service of Munitions for NATO Armed Forces
AOP-16	Fuzing Systems: Design Guides
AOP-20	Manual of Tests for the Safety Qualification of Fuzing Systems
MC 469	NAO Military Principles and Policies for Environmental Protection (EP)
STANAG 4147	Chemical Compatibility of Ammunition Components with Explosives and Propellants (Non-Nuclear Applications)
STANAG 4157	Fuzing Systems: Test Requirements for the Assessment of Safety and Suitability for Service
STANAG 4170	Principles and Methodology for the Qualification of Explosive Materials for Military Use
STANAG 4187	Fuzing Systems - Safety Design Requirements
STANAG 4297	Guidance on the Assessment of the Safety and Suitability for Service of Non-Nuclear Munitions for NATO Armed Forces
STANAG 4315	The Scientific Basis for the Whole Life Assessment of Munitions
STANAG 4326	NATO Fuze Characteristics Data
STANAG 4440	NATO Guidelines for the Storage of Military Ammunition and Explosives

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