An update on STANAG 4439 and AOP-39 Edition 2

AC-326 SG3 (experts working group)

Abstract

The NATO policy document covering the introduction and assessment of insensitive munitions (IM), STANAG 4439, and the supporting guidance document, AOP-39, are currently being reviewed and updated by an experts working group under AC-326 SG3 (the NATO Cadre Group responsible for munition systems). The purpose of this paper is to present some of the improvements and changes in methodology which will be implemented in the new editions. One of the main changes is to move away from IM assessments based solely on statistically insignificant all-up-round (AUR) tests towards the adoption of a whole body of evidence approach as a means of increasing confidence in IM assessments. The guidance provides details on how such a methodology can be implemented as well as identifying some of the tools which can be used. The importance of linking the munition configuration to the IM signature is also recognised.

Introduction

The first draft of STANAG 4439 was issued in March 1995 and was ratified and promulgated in November 1998. Since then much work has been undertaken to advance IM efforts through the development and insertion of IM technology, through improved understanding of munition response mechanisms and IM assessment methodologies, and through efforts to understand implementation issues. Proposals for improvements in the IM assessment area have been forthcoming from a series of NIMIC (now MSIAC) workshops including;

- Small Scale Testing and Modelling, Fort Walton Beach, FL, US, January 24-28, 2000.
- IM Assessment Methodology, Nettuno (near Rome), Italy, 4-8 March 2002.

A number of these proposals have been implemented on an ad hoc basis by various nations and as a consequence it was realised that the NATO policy and guidance required updating in order to reflect this. The driving force for change is the need improve confidence in IM assessments which will be low if based solely on a few full scale test results (small statistical samples). To address this problem, it is proposed that a detailed understanding of the reactive behaviour of energetic materials is required along with an understanding of their interaction with hazard stimuli in conjunction with hardware characteristics and full-scale configurations. The evidence required to support response predictions can be determined by analysing the initiation and reaction mechanisms that the various stimuli are known to induce in the energetic materials.

This paper highlights some of the changes which have been developed and are being recommended by the AC-326 experts working group.

Proposed Changes to STANAG 4439

The first edition of the STANAG is brief and to the point and deals with the following key points:

a. The Agreement - what ratifying nations accept to undertake
b. Definitions – what an Insensitive Munition is
c. General – brief background information on IM
d. Details of the agreement – expanded details on the principle agreement
e. Insensitive munitions requirement goals and tests – identification of the threats with identified standard test methods

It is important to note that the overall thrust of Edition 1 of STANAG 4439 has not changed; the proposed changes which are described below are designed to make the STANAG clearer and more explicit.

Starting with changes to the agreement, Edition 1 defines the agreement as being that ratifying nations agree that:

a. Whenever it is feasible to do so, Insensitive Munitions shall be developed and introduced into service.
b. The result of threat hazard assessments, assessment of test results, assessments and tests to evaluate IM (MURAT) performed in accordance with STANAG 4439 and AOP-39 developed to define the methodology for these and other matters, will be provided by the developing nation.

In the new version of the STANAG this has been changed to the following clearer statement that ratifying nations agree to:

a. Develop and /or introduce munitions which are as insensitive as reasonable practicable.
b. Apply the guidance of AOP-39 for the development and assessment of insensitive munitions.

The word ‘practicable’ has been adopted which more strongly defines the requirements for IM. The second agreement of sharing data between nations, now addressed in the AOP, has been replaced by the requirement for nations to apply the AOP.

A change is proposed to the definition of insensitive munitions in the new edition of the STANAG, which is that in order for a munition to be classified as an insensitive munition it must meet the IM requirements as detailed in Table 1. The change here is that the ‘ultimate/ideal’ requirement goals from edition 1 have been replaced by explicit requirements. This clarifies the issue of what level of response a munition must meet in order to be an Insensitive Munition. To aid this definition more details on the threat stimuli are given in the AOP, see Table 2 below. One should note that it is acceptable to assess against threats which deviate from the baseline threat range, detailed at Table 2, provided this can be justified by a munition threat analysis.

Threat	Requirement
Magazine/store fire or aircraft/vehicle fuel fire	No response more severe than Type V (Burning)
Fire in an adjacent magazine, store or vehicle	No response more severe than Type V (Burning)
Small arms attack	No response more severe than Type V (Burning)
Fragmenting munitions attack	No response more severe than Type V (Burning)
Shaped charge weapon attack	No response more severe than Type III (Explosion)
Most severe reaction of same munition in magazine, store, aircraft or vehicle	No propagation of reaction more severe than Type III (Explosion)

Table 1: Insensitive munitions threats and requirements.

Two other important definitions, which are used by the community, have now been introduced into the STANAG, which are:

1. IM assessment. A process to determine the compliance of a munition with the IM requirements.
2. IM Signature. A representation of the IM level of the munition, i.e. the response level to the various IM threats.

Concerning the later definition, the IM signature is now identified as being specific to a particular configuration. Therefore, a new requirement, which has been written into edition 2, is to generate signatures for the various configurations in which a munition is likely to exist (ie packaged as an individual item, packaged as part of a palletised load, or as an unpackaged, bare munition) during its life cycle. A munition can only be considered to meet the IM requirements (be called IM) if it meets the requirements for each particular configuration (or the worst credible) for each considered threat.

Also emphasised is the role of small scale testing and modelling as part of the IM assessment methodology, which is in line with the need to improve confidence in assessments though using the whole body of evidence. To make this clear, where edition 1 had a table linking threats to requirement goals and standard AUR tests, the latter link has now been dropped (see Table 1 above).

A further addition is that there are a number of references in the text of the STANAG to AOP-39 and the guidance contained therein, which is in line with the change in the agreement.

<u>Proposed Changes to AOP-39</u>

It was recognised early on in the programme of work to update the STANAG and the AOP that most of the work would be directed at the latter, which now contains guidance on the following topics:

1. Methodology of IM assessment
2. Identifying the threats
3. Munition configurations
4. Assessing the response of a munition to the threats
5. IM signature
6. Reporting of IM assessment
7. IM design and guidance

Methodology of IM Assessment

The methodology of IM assessment is defined as the process of evaluating how a munition is likely to respond to the IM threats. This process involves identifying the threats, identifying the munition configurations, assessing the response of the munition to the threats and finally generating an IM signature for the identified configurations. The importance of not conducting IM assessment in isolation is highlighted as a means to optimise test and evaluation requirements.

Identifying the Threats

Details are now given in the AOP identifying the baseline threat range. Table 2 below indicates the threats, the IM requirement and the baseline threat stimuli characteristics. It is proposed that an analysis of the lifecycle is conducted to determine credible threats which may require additional analysis against or may allow one to reduce or discount the threats identified.

THREAT	REQUIREMENT	BASELINE THREAT RANGE
Magazine/store fire or aircraft/vehicle fuel fire (Fast Heating)	No response more severe than Type V (Burning)	Average temperature between 550ºC and 850ºC until all munitions reactions completed. 550ºC reached within 30s from ignition.
Fire in an adjacent magazine, store or vehicle (Slow Heating)	No response more severe than Type V (Burning)	Between 1ºC and 30ºC per hour heating rate from ambient temperature.
Small arms attack (Bullet Impact)	No response more severe than Type V (Burning)	12,7mm AP round, velocity from 400 m/s to 850m/s.
Fragmenting munitions attack (Fragment Impact)	No response more severe than Type V (Burning)	Steel fragment from 15 g with velocity up to 2600m/s and 65 g with velocity up to 2200m/s.
Shaped charge weapon attack (Shaped Charge Jet Impact)	No response more severe than Type III (Explosion)	Shaped charge calibre up to 85 mm.
Most severe reaction of same munition in magazine, store, aircraft or vehicle (Sympathetic Reaction)	No propagation of reaction more severe than Type III (Explosion)	Detonation of donor in appropriate configuration.

Table 2: Threat and Baseline Threat Range

Munition Configurations.

Edition 2 of the STANAG stipulates the requirement to assess different munition configurations and assign an IM signature to each. Brief guidance is now proposed for aiding in the identification of the various munition configurations. In this it is stated that if it is not feasible to assess each configuration then the most pertinent configuration should be assessed based on probability of threat exposure and consequences to the surroundings.

Assessing the Response of a Munition to the Threats

Edition 2 of the STANAG stresses the role of building an assessment for each configuration of interest and for each IM threat using all the available supporting evidence in order to increase the confidence in the result. As part of the assessment process it is now recognised that the following factors should be considered:

a. Type and magnitude of the stimulus associated with the threat range.
b. Explosiveness and sensitiveness of the energetic materials used in the munition.
c. Design of the munition.
d. Component interactions.
e. Selected Configuration.

Information that can be used to perform this assessment includes but may not be limited to:

a. Read across from similar designs.

b. Modelling and analysis.
c. Energetic materials characterisation.
d. Laboratory scale test results.
e. Small scale and component level test results.
f. Full scale test results.

The hazard assessment protocols which were developed in the NIMIC Workshops on IM Assessment Methodology are suggested as tools for determining the response level. It is recognised that compared to AUR testing in isolation, use of the protocols can increase the level of confidence and range of validity of the IM assessment. Protocols are ordered procedures described by a flow chart, through which modelling, small scale testing, generic testing, data on similar munitions or munitions using the same or similar EM and expert analysis can be used. Confidence in the validity of the result is directly linked to the level of detail provided. The protocols may be used in an iterative manner to establish the sensitivity of the assessment to variations in threat stimulus level, EM formulation, munition design, packaging and storage /transport configuration. Guidance on the application of protocols is given along with those developed by the international community for each of the IM threats.

For each of the protocols there are lists of small scale tests and models identified that can be used to provide data to aid decisions. It is expected that the protocols and supporting lists will updated as necessary to reflect advances in our understanding of munition response and as new techniques and models are developed.

It is recognised that full scale tests on the AUR will often still need to be conducted as part of the assessment process and a new section is proposed to provide guidance here. This takes the form of an annex which has the aim of providing detailed guidance on the best practices for designing, conducting and reporting full-scale IM tests. It is hoped that if nations adopt and apply this guidance then there will be improved consistency in the conducting and reporting of tests which could reduce the testing burden particularly for international projects.

IM signature

There are no changes to the format of the existing IM signature other than the requirement to indicate the configuration which the munition is assessed in. Therefore, in future it is expected that multiple signatures will be reported for systems as appropriate.

Reporting of IM assessment

The importance of producing a comprehensive assessment report is realised in the new edition. It is important that the assessment report captures all the data used in order to arrive at the IM signature, such as explosive characterisation data, generic testing modelling and use of protocols. The agreed format is as follows:

a. An executive summary
b. Munition system information.
c. The assessed configuration(s) and the threat ranges
d. The supporting information.
e. The IM signature (s)

IM design and guidance

Guidance is also offered on IM design which is included as an Annex. This is not intended to be a comprehensive compendium of design techniques but serves to indicate generic solutions which have been developed.

The AOP makes the point that IM should be considered at the earliest stages of system design and development in order to reduce the risk that the IM requirements will not be met. To achieve this, the design of the munition needs to include appropriate energetic materials and/or to make use of applicable IM design techniques. The hazard assessment protocols can be used during the development of a munition to anticipate potential hazards, identify design solutions and help mitigate hazards of existing munitions.

It is emphasised that the application of design techniques need not be limited to the development of new munitions but can be applied to in-service munitions for product improvement when IM insertion opportunities arise such as refurbishment, replenishment and mid-life update.

Conclusions

Changes to STANAG 4439 and AOP-39 have been proposed by the experts working group which are in line with the direction that the international community is taking.

Of particular importance is the move away from reliance solely on AUR tests towards adopting a whole body of evidence based assessment which will provide improved confidence. It is also hoped that the new proposed definition of IM, which links the definition to response levels to for the various threats, will also remove confusion over what is an IM.