Changes to United Nations Test Series 7 for Hazard Division 1.6 Explosive Articles

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ABSTRACT

United Nations Test Series 7 (UN TS7) is used to classify explosive articles into Hazard Division 1.6 (HD 1.6). During the past two years, a UN Informal Working Group (IWG) chaired by the United Kingdom has been reviewing and proposing changes to TS 7 and to the UN hazard classification recommendations associated with such extremely insensitive articles. One aim of the UN endeavour has been to provide appropriate relief from the existing criteria that currently severely restricts the size of the explosive article population with the potential to qualify for assignment to HD 1.6, so TS 7 is more relevant and useable. Another aim has been to further harmonize TS 7 article testing with NATO Insensitive Munitions (IM) testing that military munitions are routinely subjected to. All this has to be accomplished without compromising the existing 'negligible' risk associated with HD 1.6 extremely insensitive articles.

This paper describes the issues identified within the UN IWG's activities and details the changes which have been made in the UN "Orange Book," along with the rationales for such modifications. The paper also includes some perspectives on the need to undertake further work within the UN to review, and potentially adjust, the extremely insensitive substance tests that are also a key component of UN TS 7.

BACKGROUND

The work to review UN TS7 began when issues were highlighted within the UK whilst undertaking the classification of a UK weapons system which had met the IM requirements. It was evident from discussion that the IM requirements and HD 1.6 criteria were developed to achieve similar goals with respect to explosive article safety. IM are those munitions which *'minimise the probability of inadvertent initiation and severity of subsequent collateral damage'* whereas HD 1.6 is for *'extremely insensitive explosive articles'* which *'demonstrate a negligible probability of accidental initiation or propagation (under normal conditions of transport)'*. However, despite similar definitions HD 1.6 was not available for the system in question primarily due to the explosive substances contained within not meeting the Extremely Insensitive Detonating Substance (EIDS) requirements which constitutes the first part of UN TS 7.

On reviewing munition classifications there are few articles transported today that can be classified HD 1.6 using existing UN TS 7 criteria. This is despite that the fact that there now exists a number of newer substances and articles which have HD 1.6 characteristics although some of their specific features and individual designs do not exactly align with the criteria. The overall insensitivity and safety in transportation of

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14. ABSTRACT
United Nations Test Series 7 (UN TS7) is used to classify explosive articles into Hazard Division 1.6 (HD 1.6). During the past two years, a UN Informal Working Group (IWG) chaired by the United Kingdom has been reviewing and proposing changes to TS 7 and to the UN hazard classification recommendations associated with such extremely insensitive articles. One aim of the UN endeavour has been to provide appropriate relief from the existing criteria that currently severely restricts the size of the explosive article population with the potential to qualify for assignment to HD 1.6, so TS 7 is more relevant and useable. Another aim has been to further harmonize TS 7 article testing with NATO Insensitive Munitions (IM) testing that military munitions are routinely subjected to. All this has to be accomplished without compromising the existing negligible risk associated with HD 1.6 extremely insensitive articles. This paper describes the issues identified within the UN IWG's activities and details the changes which have been made in the UN "Orange Book," along with the rationales for such modifications. The paper also includes some perspectives on the need to undertake further work within the UN to review, and potentially adjust, the extremely insensitive substance tests that are also a key component of UN TS 7.

15. SUBJECT TERMS

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those newer articles is believed to be equivalent with the intent of the originators of UN TS 7. To respond to concerns over the historic lack of articles assigned to HD 1.6 and the cause of that outcome, plus potential remedies aimed at mitigating the situation a UN TS 7 Informal Working Group (IWG) was established to address these. It was agreed from the start that a key guiding principle adopted by the (IWG) during their deliberations was that any potential remedy must maintain the current definition of 'negligible' risk.

These deliberations and the proposed changes which resulted were only possible through the contributions of many nations under the UN TS7 IWG meetings held over the last few years at:

- UK, Defence Academy, Shrivenham, 6th March 08
- UK, Bath 17th-18th March 2009
- UK, Bath 13th-14th October 2009

One should note that this paper was written and submitted prior to the UN ECOSOC Sub-Committee of Experts on the Transport of Dangerous Goods (37th Session, Geneva, 21-30th June 2010) at which the proposals detailed in this paper are due to be discussed. The presentation given at the DDESB seminar will be an opportunity to provide an update on the extent to which the proposed changes will be incorporated into the next version of the UN Recommendations on the Transport of Dangerous Goods (UN 'orange' book).

PROBLEM

The IWG, in deliberating the root cause of nearly nil explosive articles qualifying for assignment to HD 1.6, identified that the majority of today's munitions commodities are packaged and transported in configurations that integrally include initiating devices (e.g., fuzes) and/or boostering components necessary for producing a reliable explosive train. To perform their initiation functions, such components inherently contain explosives substances more sensitive than extremely insensitive detonating substance (EIDS). Thus, even when main explosive charges can be purposefully loaded with EIDS, by definition, the typical additional presence of any fuze and/or booster component within the article immediately negates the possibility of obtaining a HD 1.6 classification. So the IWG concluded the root cause behind only a few articles currently having achieved a HD 1.6 classification is the size of the basic population of articles being transported today with the potential of being classed HD 1.6 is very, very small.

Another important area raised in discussions is the nature and makeup of UN TS7 substance tests that define EIDS. Of particular issue is that the results of substance tests appear overly severe when compared to article response, particularly with respect to shock and the EIDS Gap Test criterion. This is an area for further deliberation and it is planned that NATO AC326 SG1 (energetic materials) will aid by being able to provide access to the necessary subject matter expertise to produce an improved set of substance tests. NATO AC326 SG5 experts (logistic storage and disposal) will also need to participate in such deliberations because the original intent of those severe substance tests was to ensure that negligible probability of initiation existed, instead of as screening tests correlating to the likelihood of passing or failing the article tests.

PROPOSED REMEDIES

Substance Tests

The opening step agreed by the IWG for increasing the population of candidates with potential for HD 1.6 classification was deleting the word “detonating” from the terms “extremely insensitive detonating articles” and “extremely insensitive detonating substance.” It was agreed that articles and substances should not have to first be detonable to subsequently be deemed extremely insensitive and not pose a mass explosion hazard in transport. Articles may contain multiple explosive substances some of which may detonate, such as warhead main explosive charges, and some may not, for example propellants, explosive actuators or pyromechanical devices. The latter group does not necessarily impact the probability of initiation and hence should not be the cause for exclusion from HD 1.6 because they are non-detonable. Furthermore, there are no tests included in UN TS7 designed to screen in substances capable of supporting a detonation. Therefore, it is proposed that energetic compositions contained in components which make up the article, upon passing UN TS 7 substance testing, should become known as “extremely insensitive substances” (EIS).

Realising that the initial step would not broaden the potential HD 1.6 population wide enough to resolve the matter; the IWG agreed that “extremely insensitive article” candidates could not exclude EIS-loaded articles containing certain fuzing and/or boostering components. It is recognised that the current position of requiring all energetic substances contained in candidate HD 1.6 articles to undergo UN TS7 (a) through (f) is not necessary for certain fuze and booster substances where explosive hazard can be controlled through design. It is also sometimes not possible or representative from a material form and quality perspective to take small fuze components and conduct substance tests on the explosive substances that they contain. However, it was agreed by the IWP that their inclusion into the candidate population must be appropriately controlled and a protocol was agreed to facilitate this.

The IWG decided that only fuzes with two or more independent effective protective features should be allowed in HD 1.6 articles. From a compatibility group definitional perspective, dual-protected fuzing arrangements are traditionally considered equivalent to the means of initiation not being present. Applying that convention and coupling it with any potentially sensitive fuze explosives components always being present during TS 7 article testing and even being specifically targeted in certain trials should sufficiently ensure the existing negligible probability of accidental initiation or propagation of a HD 1.6 article is maintained.

The IWG also agreed to a series of control measures for allowing the presence of boostering components in HD 1.6 articles. Boostering components within an article are defined as any other than EIS-loaded explosive component aiding explosive train reliability within a fuze or between a fuze’s output charge and an article’s main EIS-containing explosive charge (regardless of whether a fuze is present or not during transport). To maintain appropriate confidence that relative HD 1.6 article insensitivity remains, such boostering components should be required to contain only explosive substances that pass the UN TS 7(c)(ii) Friability test and 7(e) EIDS external fire test unless their maximum cross-sectional dimension (e.g., diameter) does not exceed 50 millimeters (mm). Smaller boostering components do not impact the response to the

same level and should be considered equivalent to smaller fuze output charges. In addition, all substances must be present and their role evaluated in determining the response obtained during article tests.

The logic behind the choice of boostering component tests is as follows:

- The UN TS 7 (c)(ii) Friability test is included as a test to determine propensity for deflagration to detonation transition (DDT) of a damaged and ignited booster. A pass gives confidence that a mechanical threat which disrupts and ignites the article is unlikely to result in a detonation (via the DDT mechanism).
- The UN TS 7 (e) EIDS External fire is included to characterise the likely response of embedded boosters when exposed to heating. A pass gives confidence that the booster will not influence the response of the main explosive fill (will not prompt a detonation response of the EIS main fill when the article is burning).

The IWG also agreed the percent volume by mass of boostering component explosive substances with respect to the EIS in the main explosive charges they initiate or ignite should be limited to five percent. This final control measure is meant to ensure other than EIS-loaded boosters cannot become too prevalent in size relative to main explosive charges containing EIS since such fills are the foundation on which HD 1.6 was established.

Explosive substances subjected to UN TS 7 (c)(ii) and 7 (e) should be in the form and quality in which they will be loaded into the boostering components of an article.

A final concession agreed by the IWG pertained to allowing other than EIS to be present in small isolated auxiliary explosive components, such as explosive actuators or pyromechanical devices, to be present within extremely insensitive articles. Assurance that ignition or initiation of such components does not cause any main explosive charge reaction would have to be established to conclude their presence will not affect existing accidental initiation or mass explosion risk during transportation.

A protocol, referred to above, was developed by the IWG and guides the application of the proposed rules is given at Figure 1 below.

Article Tests

The IWG deliberations identified a number of changes to article tests UN TS 7 (g) through to (l), linked to the changes mentioned above, which are proposed to attain confidence in the behaviour of more vulnerable, non EIS, substances upon accidental initiation or propagation of the article, which includes:

- Reinforcement of the need for all energetic substances to be present in article tests TS 7(g) through (l)
- Addition of a UN Test Type 7 (l) fragment impact: a test to determine the sensitivity of an article to shock directed at vulnerable components.
- Specific targeting of vulnerable areas often associated with fuze or boostering components, in UN TS 7 (j) bullet impact and 7 (l) (new) fragment impact tests.

UN TS 7(l) has been included to determine the response of an article in its transport configuration to a localised shock input representative of a fragment strike typical of

that produced from a nearby detonating article. The test has the benefit of being able to direct a shock stimulus at vulnerable components whilst taking into account the role of design in mitigating the severity of the threat. The test is necessary to thoroughly assess whether the presence of other than EIS-loaded components in articles might cause an adverse affect with regard to demonstrating a negligible probability of accidental initiation or propagation.

The IWG agreed that the fragment impact test would use a standardised 18.6 gram steel fragment in the shape of a right-circular cylinder body with a conical nose. The test is repeated in two different orientations, striking the test item in the most vulnerable areas as assessed by the competent national authority. These are areas for which an assessment of the explosive sensitivity (explosiveness and sensitiveness) combined with knowledge of the article design indicate the potential for producing the most violent response level. Typically, one test would be conducted targeting a non-EIS boostering component and the second test would target the centre of the main explosive load. The orientation of impact should generally be normal to the outer surface of the article. The fragment impact velocity should be 2530 ± 90 m/s. The criteria for 1.6 article fragment impact testing should parallel 1.6 article bullet impact, external fire, and slow cook-off test criteria in that a fragment impact reaction more severe than burning should be considered positive (failing).

A number of other changes to article tests were proposed to help achieve the following aims:

a. Provide improved guidance on test procedures drawing on best practice. Slight changes have been made to tests 7(g) – (k).
b. Develop consistency between article tests. Slight changes have been made to tests 7(g) – (k) to ensure consistency in measurement of response parameters and levels of acceptable response between article tests.
c. Introduce response descriptors developed under NATO AC326 SG3 now contained in AOP-39 Ed3

For the UN TS 7 Type 7 (j) 1.6 article bullet impact test, the IWG agreed that testing outcomes considered to be negative (passing) results should be limited to either no reaction or burning. Deflagration reactions, currently acceptable, should be considered positive (failing) outcomes. Such a modification would align Type 7 (j) criteria with the existing Type 7 (g) 1.6 article external fire test, Type 7 (h) 1.6 article slow cook-off test criteria and IM requirements as defined in NATO Standard STANAG 4439 Ed3. Table 1 below provides a summary of the acceptance criteria for UN TS7 Article tests 7(g) - (l).

Article Test	Before, Fail (+)	Proposed, Fail (+)	*STANAG 4439 Pass*
7(g) 1.6 Article or component level external fire test	a reaction more severe than burning	a response level more severe than burning	*No response more severe than Type V (Burning)*
7(h) 1.6 Article or component level slow cook-off test	a reaction more severe than burning	a response level more severe than burning	*No response more severe than Type V (Burning)*
7(j) 1.6 Article or component level bullet impact test	detonation	a response level more severe than burning	*No response more severe than Type V (Burning)*
7(k) 1.6 Article stack test	a response level more severe than burning or deflagration	a response level more severe than explosion	*No propagation of reaction more severe than Type III (Explosion)*
7(l) 1.6 Article or component level fragment impact test		a response level more severe than burning	*No response more severe than Type V (Burning)*
STANAG 4439 requirement - Shaped charge weapon attack Not included in UN TS7			*No response more severe than Type III (Explosion)*

Table 1. UN TS7 Article test acceptance criteria (response levels)
with NATO AC326 STANAG 4439 Ed3 requirements for comparison

One should note there exists only one significant difference between UN TS 7 article test proposals and IM requirements that being an assessment against Shaped Charge Weapon Attack. This requirement was considered by the IWG for inclusion into UN TS7 but was eventually rejected because it was decided that this did not represent a threat present during normal peacetime transportation.

The IWG noted that the bullet impact test apparatus and materials and procedures test prescription sections of UN TS 7 Type 7 (j) should be updated to appropriately reflect the details of how this bullet impact testing is typically conducted today. For example, rather than 3 to 20 meters, a range of approximately 10 to 30 meters between the guns and test item, sufficient to assure bullet stabilization, is currently preferred. Finally, as alluded to previously, the test is repeated in three different orientations, striking the test item in the most vulnerable areas as assessed by the competent national authority.

The IWG concluded that three 1.6 article stack test repetitions are excessive. Two repetitions, including one in a confined configuration like executed during TS 6 Type 6 (b) stack testing, should be more than adequate to assess the likelihood of propagation towards a mass explosion during transportation. Conducting one trial confined should provide practical assurance that the deletion of the third unconfined trial will not have a detrimental effect on whether articles qualify into HD 1.6.

This test should only be conducted on candidate Division 1.6 articles capable of supporting a detonation; the test 7 (k) article stack test is waived for non-detonable candidates for Division 1.6 (evidence must be available to demonstrate that the article cannot support a detonation). Where the article is designed to provide a detonation output, the article's own means of initiation or a stimulus of similar power shall be used to initiate the donor. If the detonable article is not designed to detonate, the donor shall be detonated using an initiation system selected to minimise the influence of its explosive effects on the acceptor article(s). Main explosive charges that are not

detonable (e.g., propellants in less than critical diameter configurations) should not undergo 1.6 article stack testing (i.e., testing should be waived) as only igniting the donor, perhaps even using its own means if present, serves no purpose relative to the detonation propagation criteria for assessing test results.

The changes agreed by the IWG also include a proposal on 'Response Descriptors' used to assign a level of response to TS7 article tests. A number of terms such as '*burn'* and *'detonation'* are referred to in the UN 'Orange book' but are not currently defined. Acceptance of response descriptors would address the need to improve guidance on assigning response levels and will facilitate international consistency in the analysis of test results. The proposed descriptors are detailed in Table 2 below and were developed under NATO AC326 SG3 for IM and contained in the NATO document AOP-39 Ed3 "Guidance on the Assessment and Development of Insensitive Munitions (MURAT)". To achieve this a number of definitions are proposed for the UN Model Regulations Volume I Appendix B Glossary of the terms. These refer to a new proposed Appendix 8 in the Manual of Test and Criteria which provides the detail needed to achieve this goal.

CONCLUSIONS

The IWG believes their efforts towards refining UN TS 7 to make it more relevant and therefore useful and valuable for the transport of today's munition commodities, should continue. Their array of notional definitional and testing modification proposals have been agreed with that end as their target, but also from a very keen perspective of maintaining the original integrity of HD 1.6 articles in terms of rigorously assuring their negligible probability of accidental initiation or propagation.

An additional benefit of this work was the opportunity to harmonise UN TS7 and IM testing which has been achieved to a greater extent. Table 1 indicates this with respect to article testing the only major difference being the shaped charge weapon attack assessment required for IM.

Some initial discussion has been held on the UN TS7 substance tests and as mentioned earlier there is some concern over the nature and makeup of the current tests particularly with respect to severity of the shock stimulus. Progress has been made in recent years on the role of small scale testing, often in combination with modelling, in increasing understanding of reaction mechanisms and enhancing confidence to munition vulnerability assessment. The IWG re-affirmed the importance of substance tests as part of UN TS7 but agreed that a review is now necessary to input our latest understanding. Given that the science of article/munition response to threat stimuli is common for UN HC and IM assessment there is an opportunity to agree a core set of substance screening tests at an international level that will benefit the community as a whole.

Finally, the UN Sub-Committee of Experts on the Transportation of Dangerous has been invited to consider these proposals for acceptance into the Recommendations on the Transportation of Dangerous Goods and an update on this process will be given in the presentation to accompany this paper.

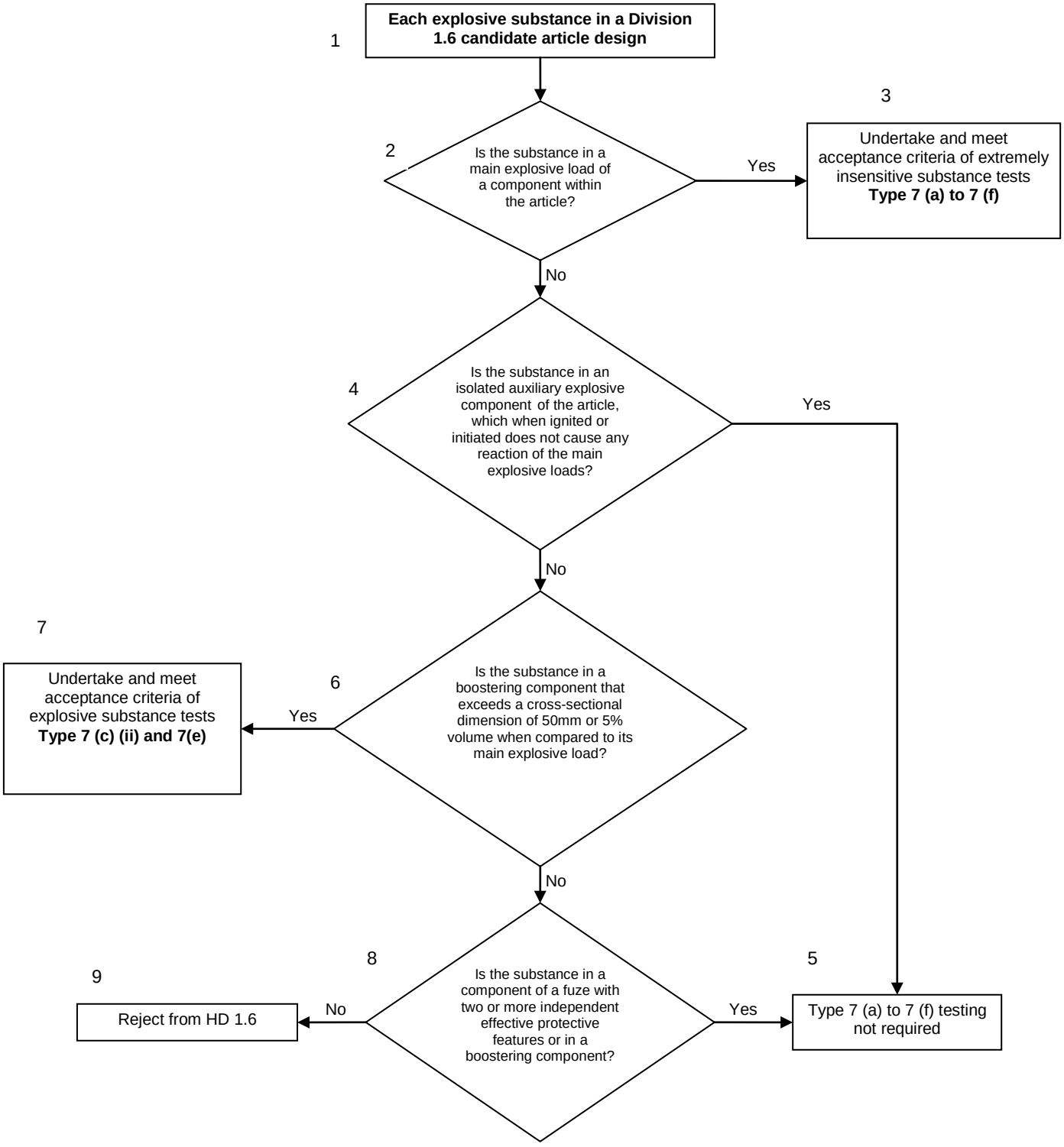

Figure 1. Procedure to Determine Required Substance Testing for Division 1.6

Table 2. New proposed APPENDIX 8 - RESPONSE DESCRIPTORS

These Response descriptors are to be used for the purposes of TS7 criteria and are designed to be used by the competent authority to determine the response type of articles. For example, articles vary greatly in size, type, packaging and explosive substances; these differences need to be taken into account. For a reaction to be judged a particular type, the Primary evidence (denoted P in the table below) for that type would need to be present. The entire (both primary and secondary) body of evidence must be weighed carefully and used in its entirety by the competent authority to assess the reaction. The secondary evidence provides other indicators that may be present.

Response level	Observed or measured effects				
	Explosive substances (ES)	Case	Blast	Fragment or ES projection	Other
Detonation	Prompt consumption of all ES once the reaction starts	(P) Rapid plastic deformation of the metal casing contacting the ES with extensive high shear rate fragmentation	(P) Shock wave with magnitude & timescale = to a calculated value or measured value from a calibration test	Perforation, fragmentation and/or plastic deformation of witness plates	Ground craters of a size corresponding to the amount of ES in the article
Partial detonation		(P) Rapid plastic deformation of some, but not all, of the metal casing contacting the ES with extensive high shear rate fragmentation	(P) Shock wave with magnitude & timescale < that of a calculated value or measured value from a calibration test Damage to neighboring structures	Perforation, plastic deformation and/or fragmentation of adjacent witness plates. Scattered burned or unburned ES.	Ground craters of a size corresponding to the amount of ES that detonated.
Explosion	(P) Rapid combustion of some or all of the ES once the article reaction starts	(P) Extensive fracture of metal casings with no evidence of high shear rate fragmentation resulting in larger and fewer fragments than observed from purposely detonated calibration tests	Observation or measurement of a pressure wave throughout the test arena with peak magnitude << and significantly longer duration that of a measured value from a calibration test	Witness plate damage. Significant long distance scattering of burning or unburned ES.	Ground craters.
Deflagration	(P) Combustion of some or all of the ES	(P) Rupture of casings resulting in a few large pieces that might include enclosures or attachments. *	Some evidence of pressure in the test arena which may vary in time or space.	(P) At least one piece (casing, enclosure or attachment) travels beyond 15m with an energy level > 20J based on the distance/mass relationship of Figure 16.6.1.1. Significant scattered burning or unburned ES, generally beyond 15 m.	(P) There is no primary evidence of a more severe reaction and there is evidence of thrust capable of propelling the article beyond 15m. Longer reaction time than would be expected in an explosion reaction.

Response level	Observed or measured effects				
	Explosive substances (ES)	Case	Blast	Fragment or ES projection	Other
Burn	(P) Low pressure burn of some or all of the ES	(P) The casing may rupture resulting in a few large pieces that might include enclosures or attachments. *	Some evidence of insignificant pressure in the test arena.	(P) No item (casing, enclosure, attachment or ES) travels beyond 15m with an energy level > 20J based on the distance/mass relationship detailed at Figure 16.6.1.1 . (P) A small amount of burning or unburned ES relative to the total amount in the article may be scattered, generally within 15m but no farther than 30m.	(P) No evidence of thrust capable of propelling the article beyond 15m. For a rocket motor a significantly longer reaction time than if initiated in its design mode.
No Reaction	(P) No reaction of the ES without a continued external stimulus. (P) Recovery of all or most of the unreacted ES with no indication of a sustained combustion.	(P) No fragmentation of the casing or packaging greater than that from a comparable inert test item. *	None	None	None

* Note: Mechanical threats will directly induce damage causing disruption of the article or even a pneumatic response resulting in parts, particularly closures, being projected. This evidence can be misinterpreted as being driven by the reaction of the explosive substances contained in the article, which may result in a more severe response descriptor being assigned. Comparison of observed evidence with that of a corresponding inert article can be useful in helping to determine the article's response.

MSIAC

Supporting Munitions Safety

Munitions Safety Information Analysis Center

Changes to United Nations Test Series 7 for Hazard Division 1.6 Explosive Articles

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Explosives Safety Board

DEPARTMENT OF DEFENSE

MINISTRY OF DEFENCE

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Introduction

The goal of this work is to modify UN test series 7 to better align with IM full scale tests but primarily to enable more opportunities for UN HD 1.6 hazard classification assignments where articles (munitions) continue to be deemed as posing a negligible probability of accidental initiation or propagation:

- Changes required to allow newly developed “extremely insensitive articles,” which do not exactly align with the current criteria, access to Division 1.6
- Current definition of HD 1.6 to be maintained, and HD 1.2.3 and HD 1.6 relative relationship important

Background

- Currently only a handful of articles classed HD 1.6

  Series of substance and article test criteria must be met

  – Fuzed munitions do not qualify because most initiating and boostering energetic materials do not pass substance tests

  – Energetic materials contained in explosive actuators or pyromechanical devices within complex munitions also typically fail substance testing, leading to disqualification

Contents

- Progress
- UN Proposal April 2010
- Proposed follow-on work

Progress

- United Nations (UN) Test Series (TS) 7 Intersessional Working Group (IWG) held 6th March 2008 meeting in Shrivenham, England
- MSIAC sponsored NATO AC-326 SG1 meeting to discuss EIDS tests
- United Nations (UN) Test Series (TS) 7 Intersessional Working Group (IWG) held 17th-18th March 2009 meeting in Bath, England
- Progress reported to the UN explosives Working Group 22nd-25th June 2009
- United Nations (UN) Test Series (TS) 7 Intersessional Working Group (IWG) held 13th-14th October 2009 meeting in Bath, England
- Progress reported at UN meeting December 2009
- Proposal submitted to UN April 2010

Progress

- **Phase 1 (accomplishable in current UN biennium)**

  Proposals focused on article tests and a methodology for applying substance tests

- **Phase 2 (next biennium)**

  To make proposals on Extremely Insensitive Substance Tests (EIS). Deferred; further progress depends on:

  - Acceptance of submitted proposal to the UN (June 2010)
    - Agreement to continue with IWG
  - Resource availability (AC/326 SG/1)

UN Proposal (Phase 1)

- Changes to definition; to cover “extremely insensitive substances and articles”
  - HD 1.6 not exclusively for articles containing substances which detonate
  - Result: EIDS becomes EIS

Proposed changes to EIS requirements

- Recognition that more sensitive energetics (not EIS) may be included in extremely insensitive articles. Risk managed by applying the following constraints:
  - Only fuzes including two or more independent effective protective features allowed
  - All boostering components with a cross sectional dimension of > 50mm or % volume > 5% relative to their main EM fill must pass:
    - UN TS 7 Type 7 (c) (ii) Friability test
    - UN TS 7 Type 7 (e) EIDS External Fire test
  - Allow other EM containing components, e.g., explosive actuators or pyromechanical devices, to be included provided their functioning is demonstrated to not cause any main EM fill reaction

Logic behind EIS requirement changes

- Negligible probability of accidental initiation or propagation maintained in extremely insensitive articles
  - UN treats munitions containing fuzes with two or more independent effective protective features as not having their own means of initiation
  - Current EIDS tests not appropriate for tiny energetic components in fuzes
    - Tests not representative in terms of confinement and geometry; results conflict with article behavior; difficult or impossible to manufacture samples suitable for testing

Logic behind EIS requirement changes (Continued)

- Munition designs shield typically embedded fuzing and boostering components from direct mechanical threats
  - Fuzing and boostering components to be present, however, during article testing and appropriately targeted in bullet and fragment impact article tests
- As larger embedded boostering components can influence article test outcomes, those are to be subjected to substance testing
  - 7(c)(ii) Friability test - determine propensity for deflagration-to-detonation transition (DDT) of a damaged and ignited booster
    - A pass gives confidence that a mechanical threat which disrupts and ignites the article is unlikely to result in a detonation (via the DDT mechanism).
  - 7(e) EIDS external fire test - to characterise the likely response of embedded boosters when exposed to heating.
    - A pass gives confidence that the booster will not influence the response of the main explosive fill (will not prompt a detonation response of the EIS main fill when the article is burning)

Article Test Proposals

- A number of changes to UN TS7 article tests were proposed to achieve the following objectives:
  - To improve confidence in the behaviour of more vulnerable non EIS:
    - Reinforcement of the need for all energetic substances to be present in article tests
    - Addition of a UN Test Type 7 (l) fragment impact: a test to determine the sensitivity of an article to shock directed at vulnerable components.
    - Specific targeting of vulnerable areas often associated with fuze or boostering components, in UN TS 7 (j) bullet impact and 7 (l) (new) fragment impact tests.
  - Provide improved guidance on test procedures
  - Develop consistency between article tests
  - Introduce response descriptors developed under NATO AC326 SG3 now contained in AOP-39 Ed3

Article Test Proposals

- UN TS 7 Type 7 (j) 1.6 article bullet impact test
  - Deflagration reactions should be considered positive (failing)
    - Previously detonation was considered a fail
- Addition of a fragment impact test
  - Shock stimulus can be directed at sensitive components (non EIS)
  - Gives an improved understanding of the response of the article to shock (taking into account the article's design)
  - 18.6g Conical tipped steel fragment velocity of 2530 ± 90ms^{-1} as per STANAG 4496

HC / IM HARMONISATION

Key Unaccepted Proposal

- Inclusion of 1.6 article shaped charge jet (SCJ) test
  - Requirement was considered by the IWG but was rejected because it was decided that this did not represent a threat present during normal peacetime transportation
  - Noted that test data may well be available from IM assessment
    - National military Competent Authorities may use SCJ data as part of the whole body of evidence on which well-informed decisions are based

HD 1.6 ASSIGNMENT = IM COMPLIANCE?

Inclusion of Response Descriptors

- Included the new AC/326 SG/3 Insensitive Munition Response descriptors
  - Recognised that *Detonation*, *Explosion*, *Burning* were poorly defined (with the exception of HD 1.4s)
  - Proposed as new annex to 'UN Manual of Tests and Criteria'
    - Only specifically referred to by UN TS 7, but also likely equally useful in UN TS 6 applications

HC / IM HARMONISATION

Latest News

- Proposed modification for Test Series 7 submitted to UN for consideration at the *Sub-Committee of Experts on the Transport of Dangerous Goods Thirty-seventh session Geneva, 21-30 June 2010*
  - Paper: ST/SG/AC.10/C.3/2010/40 (United Kingdom and United States of America) Proposed modifications to Test Series 7

http://www.unece.org/trans/doc/2010/ac10c3/ST-SG-AC10-C3-2010-40e.pdf

Proposals accepted June 24th 2010
Changes will be implemented in 2011

Proposed Follow-on Work

- UN IWG recognised need for a Phase 2 programme of work to develop proposals on substance tests for the next UN change opportunity in two years time (June 2012 proposals).

- Why is this needed?
  - EIDS tests are severe when compared to the article tests
    - UK position that the tests are too severe and screen out potentially viable substances because of the shock criteria
    - What level of risk are we trying to achieve?
  - EIS provide confidence in the article behaviour, but they need to be set at the right level
    - However, we need to maintain the confidence that the EIS is sufficiently insensitive such that the probability of accidental initiation or propagation of an article remains negligible.
  - It is agreed that EIS tests should continue to be used

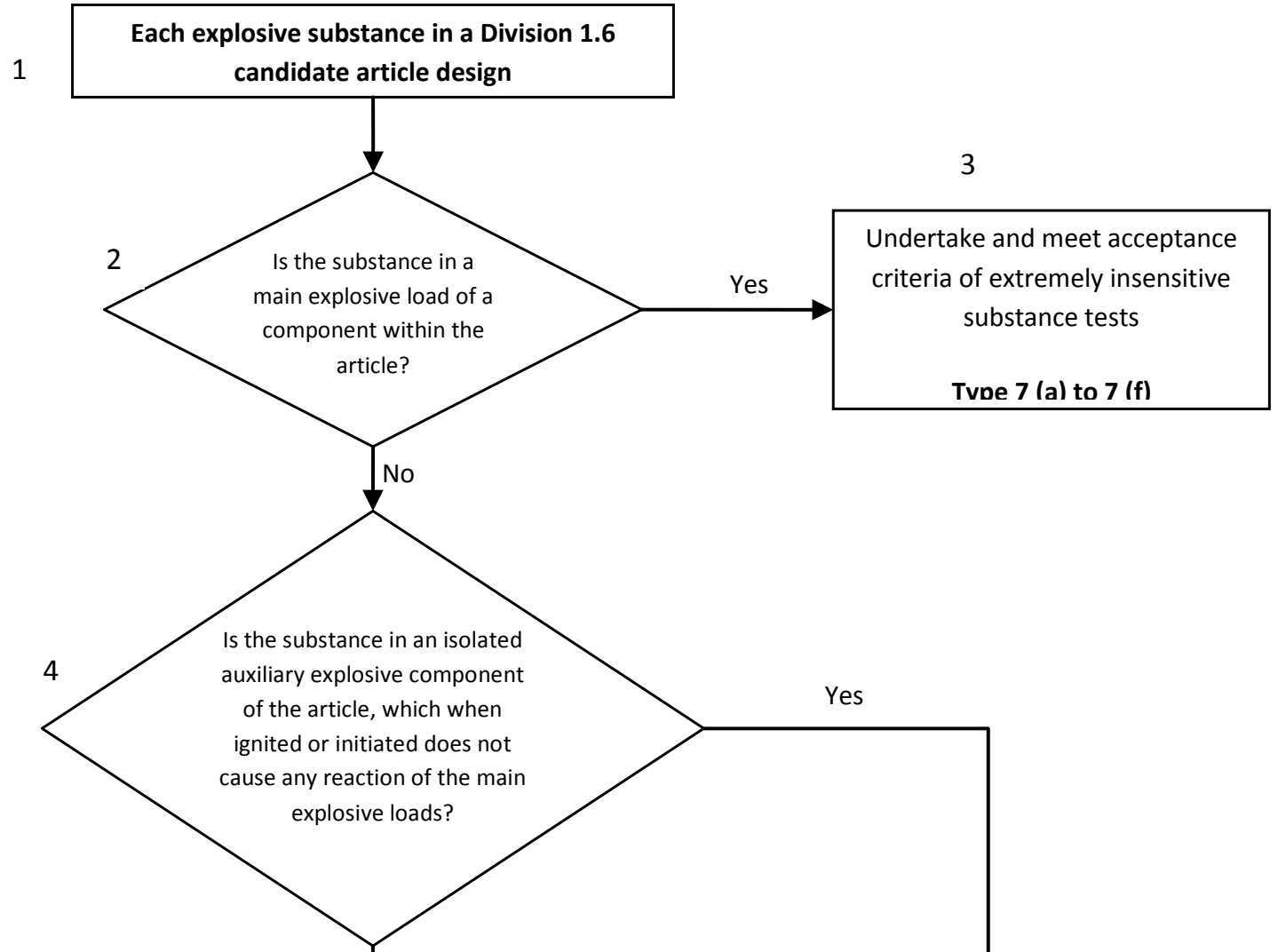
Benefits of UN TS7 Work

- Improved understanding of science
- Improved confidence in assessment of IM and HC
- Harmonisation of IM and HC small scale tests
  - Potential for agreed common set of screening tests for energetic materials in AOP-39 and UN orange book
- Reduce risk to the logisticians and Warfighters (users)

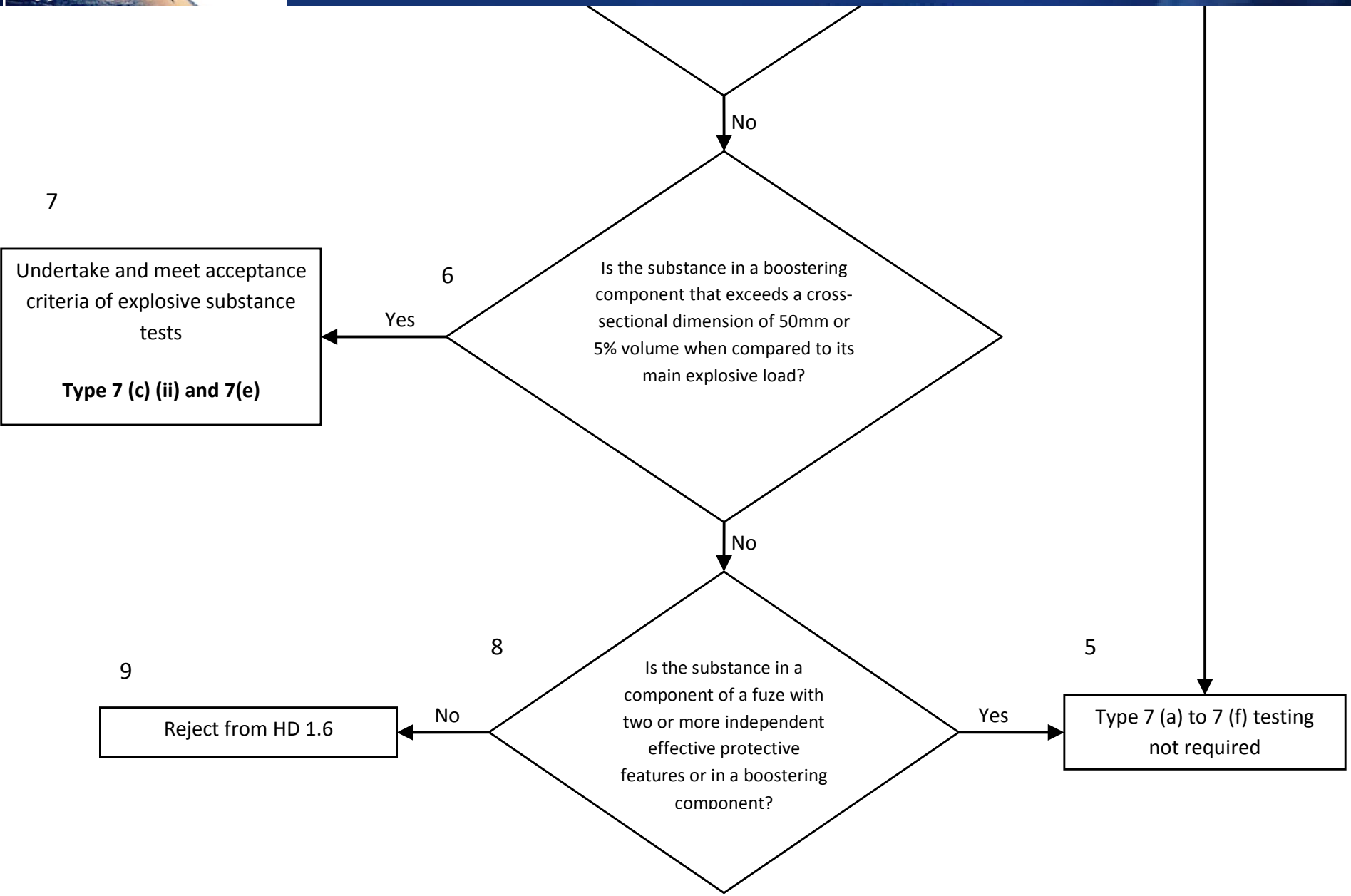
Summary

- Described proposals to change United Nations TS 7
  - New methodology and protocol for applying Extremely Insensitive Substance Tests
  - Changes to article tests proposed which bring HC and IM further together
- Discussed the need for follow on work to review EIS tests

New Protocol Captures the Requirements



New Protocol Captures the Requirements



MSIAC
Supporting Munitions Safety

Comparison of HD1.6, IM, HD SsD 1.2.3

UN HD 1.6			IM STANAG 4439 Pass	HD SsD 1.2.3 Pass
Article Test	**Before, Fail (+)**	**Proposed, Fail (+)**		
7(g) 1.6 Article or component level external fire test	a reaction more severe than burning	a response level more severe than burning	*Type V (Burning)*	*Type V (Burning)*
7(h) 1.6 Article or component level slow cook-off test	a reaction more severe than burning	a response level more severe than burning	*Type V (Burning)*	*Type V (Burning)*
7(j) 1.6 Article or component level bullet impact test	**detonation**	**a response level more severe than burning**	*Type V (Burning)*	*Type V (Burning)*
7(k) 1.6 Article stack test	**a response level more severe than burning or deflagration**	**a response level more severe than explosion**	*No propagation of reaction Type III (Explosion)*	*No propagation of reaction Type III (Explosion)*
7(l) 1.6 Article or component level fragment impact test	**X**	**a response level more severe than burning**	*Type V (Burning)*	*X*
STANAG 4439 requirement - Shaped charge weapon attack Not included in UN TS7	X	X	*Type III (Explosion)*	*X*