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A DISCUSSION ON INTERNATIONAL HARMONISATION OF THE SAFETY AND SUITABILITY FOR SERVICE ASSESSMENT

by

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ABSTRACT

This paper presents some of the current issues inhibiting the accepting of other nations, or services, qualification data as part of the Safety and Suitability for Service (S3) assessment process. The elusive goal of 'qualify once' has been on the agendas of various national safety authorities for some time and is a clear objective for AC/326 dealing with standardisation of munitions S3 assessment and yet nations still duplicate the qualification on common weapons systems to fulfil own national requirements. The paper discusses the challenges and opportunities for achieving agreement on a core set of test/data that could be acceptable at the international level to help alleviate this issue. The role of MSIAC in helping facilitate this process is discussed with the intention of gaining comment and support for this effort from MSIAC member nations.

Keywords: Munitions, Safety, Qualification, International, MSIAC, NATO

1. BACKGROUND

The purpose of this paper is to present some of the current issues inhibiting the accepting of other nations, or services, qualification data as part of the Safety and Suitability for Service (S3) assessment process. The paper covers this topic by first providing some background data on the current standardisation process under CNAD Ammunition Safety Group (CASG) (AC/326) before identifying some of the issues and progress with respect to achieving the goal of transferability of S3 information.

A major enabler in being able to accept other nations, or services, qualification data* is standardisation of the Safety and Suitability for Service (S3) assessment process. At an

* NATO AOP-38 Definitions for Qualification
Qualification (also known as Final or Type qualification): Assessment and statement by an accredited authority that the subject materiel possesses and will maintain the properties which are acceptable with regard to safety and suitability for service in a specified role, a specified environment, during its specified life cycle, and that the associated risks are acceptable.
NATO AC/326 Sub-Group 1 develops standards intended to ensure that the energetic materials used in munitions and explosives serve their intended purpose and that they do not deteriorate and become liable to spontaneous explosion during the life time of the parent munitions or explosive device. Note: Qualification of a munition includes all configurations and situations, likely to exist during its life cycle.
Energetic Material Qualification: Explosive materials: The assessment of an explosive material by the accredited authority to determine whether it possesses properties which make it safe and suitable for consideration for use in its intended role. Note: Qualification is an intermediate risk reduction stage prior to final (or type) qualification.

international level the most important body working in the S3 arena is the CNAD Ammunition Safety Group (CASG) (AC/326) established under the Conference of National Armament Directors (CNAD) at NATO. Through its sub-groups, it provides the "forum for NATO, Partner and Mediterranean Dialogue Nations, and Contact Countries to develop common standards and procedural guidance on munitions and explosive safety in order to foster interoperability in NATO led operations, the potential for interchangeability of ammunition and a basis for coordinated procurement of munitions and explosives"[1]. The realisation of these goals for nations, though agreeing on common definitions, requirements and measure of munitions safety level, delivers confidence that during joint operations personnel and defence material are not exposed to unknown or undue risk from ammunition deployed by own, other services, or other nations forces.

Achieving such a state also implies that any qualification data to support an S3 assessment should be applicable or transferable to other nations. If nations adopt common requirements and common measurements for safety qualification data they should be acceptable for use by other nations, thus achieving the goal of 'qualify once'. However, as the paper explains below this is not routinely achieved.

Financial and project time penalties are also major drivers pushing the 'qualify once' goal. The cost and time for qualification of an energetic material and weapon systems is facing increasing scrutiny in these times of austerity and is prompting review of S3 procedures in some counties.

2. STANDARDS AND STANDARDISATION

The application of safety standards to munitions depends on many factors; the nation applying the standards, munition type, environmental life cycle profile, and phase of the lifecycle. The latter being whether the munition is; in development, an off-the-shelf procurement, being assessed for changes to the environmental lifecycle profile, being reviewed for life extension etc. The most comprehensive application of standards is generally during munition development when the requirements and standards are first applied. It is the data that is generated during this phase that will form the basis of any information pack made available to other services or nations and hence principally relevant to the goal of 'qualify once'.

When developing a list of safety requirements for a new munition the first decision that the national authority must take is whether to impose national or international standards or a mix. In the past nations developed and used their own standards but in recent years many of these have been incorporated into international standards. As a consequence, it is now currently the policy for many nations to adopt International standards whenever possible, which is the stated situation for the US, UK and France:

US Department of Defense Instruction Number 2010.06. July 29, 2009:

> *Equipment procured for U.S. forces employed in North Atlantic Treaty Organization (NATO), other allied, and coalition operations be standardized or at least interoperable with the equipment of allies and coalition partners.*

UK JSP 520 UK Mod's Ordnance, Munitions and Explosives Safety and Environmental Management. Part 1 – Policy Issue 3.0

> *To comply with SofS's [Secretary of State] policy, the MOD requires evidence within the Safety and Environmental Case that the management and technical standards adopted by the Duty Holder are consistent with best civil and international best-practice as a minimum. To achieve maximum harmonisation it is current MOD policy*

to utilise civil standards where appropriate and an agreed order of preference is as follows:

1. *European standards*
2. *International standards.*
3. *UK civil standards.*
4. *Commercial standards widely recognised by industry.*
5. *International Military Alliance standards.*
6. *UK MOD Defence standards.*
7. *UK MOD Departmental standards and specifications.*
8. *Other Nation's military standards.*
9. *Recognised industry/partnership/consortium standards.*

French hierarchy is reported as follows:

1. *International.*
2. *Civilian Standards.*
3. *Military International.*
4. *National Civil.*
5. *National Military.*

One will note above that the US directive gives preference to NATO standards whilst for the UK, NATO standards appears as a 5th priority. This would appear to be at odds to the commonality goal but in reality many of the standards dealing with munitions S3 under the AC/326 arena. Therefore, as a first recommendation with respect to achieving the goals, an agreed hierarchy between allies should be developed to promote transfer, development, and use of same standards whenever possible. At the moment the standards exist under different bodies and there must be some flexibility to allow implementation of best practice. Specific pointers in NATO documents should be included to identify these. There would also appear to be a requirement for nations to document which standards they implement to encourage further discussion and development of consensus.

An effort under the European Commission, CEN workshop 10, is seeking to identify best practice in S3 assessment by reviewing relevant standards, which goes some way towards addressing the point above. One of the groups that is relevant is Expert Group 8 on environmental engineering. The output[2] is a review of 250 test procedures with recommendation on best practice for environmental test procedures being made using factors such as; technical innovation, currency, reproducibility, strength of reference (contractual), and interoperability. How this impacts NATO standardisation activities has yet to be determined.

Standard hierarchy is likely to remain a challenge because of the myriad of documentation, recommendations and guidance which are produced by a range of organisations including: NATO Committee for Standardization (NCS), United Nations (mainly on) Recommendations on the Transportation of Dangerous goods; European Committee for Standardisation (CEN) sponsored by the European Commission; and International Test Operations Procedure (ITOP) (status unknown). The situation is set to become more complex as a recent NATO policy, February 2010, 'the NATO Standardization Organization (NSO) Civil Standards Campaign', dictates that whenever possible standards should be transitioned or developed under civil organisations such as: ISO, IEC, ETSI, CEN, CENELEC, ANSI, ASTM, GS1, SAE, and IEEE. Following the first round of this process the author does not believe that any S3 standards were volunteered for transition but this situation could change.

There are benefits foreseen from adopting such an approach, not the least of which would be an easing of the financial and resource commitments for nations in supporting AC/326. However, from the point of view of increasing the transferability of the data the following points are made on two standards; an explosive ingredient standard (STANAG 4022), and the main standard dealing with the safety assessment process for munitions (STANAG 4297). One could consider these as being at the extremes of munition safety standardisation:

- Explosive Ingredient Standard: STANAG 4022 - Explosives, Specification for RDX (Hexogene), Ed. 4.

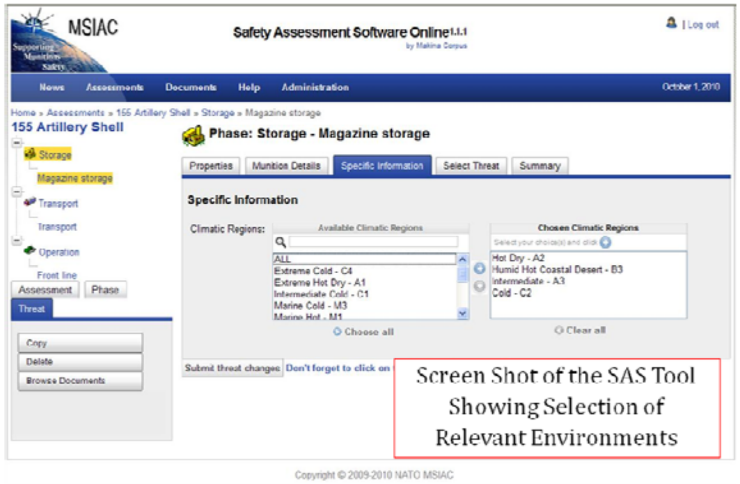
  'The aim of this agreement is to ensure that RDX (cyclotrimethylenetrinitramine) shall possess properties that make it suitable for military use and to provide, within NATO, an acceptable basis for procurement and certification of RDX.'

  The standard covers the required chemical and physical properties and details acceptable techniques for measuring these. It is agreed by most that these standards are important in managing safety and programme risk and hence should continue to be supported. However, recent informal discussion raised questioned over where such standards should be developed; should they be developed by AC/326 or by an industry led forum. National authorities do consult industry in the development and review of STANAGS where appropriate but there could be some merit in adopting an industry led approach when they are the predominant end user, which would result in a civil standard. Anecdotally, it is reported that industry finds that they require more detailed specifications when procuring explosive ingredients from other companies, which perhaps gives some weight to the 'Civil Standards Campaign'. In terms of our goal on commonality, having the end user intimately involved and leading the standardisation process encourages ownership, should improve relevance and encourage use, and result superior transferable standards.

- STANAG 4297 (Edition 2) & Guidance document AOP-15 - Guidance on the Assessment of the Safety and Suitability for Service of Non-Nuclear Munitions for NATO Armed Forces. Provides a uniform guide for the assessment of the safety and suitability of a nonnuclear munition for use by NATO armed forces. This standard is applied by the National Authority and there would be no benefit in a transition to a civil standard. Such a move would likely damage participation and be detrimental to the goals of developing common requirements and safety levels.

Clearly, transfer of standards to civil bodies would require a willingness to first accept ownership and for industry to be willing to accept a lead role, for which they would need to identify appropriate benefit.

To help MSIAC member nations grasp the extent and applicability of the international, national and civil standards MSIAC has developed a number of tools for safety specialists.



Screen Shot of the SAS Tool Showing Selection of Relevant Environments

Munitions Safety and Standardisation database (MSAS) and its online version are designed to enable instant access to the latest S3 relevant international standards. A more intelligent tool Safety Assessment Software tool (SASO) has been developed to help the safety assessor identify relevant munition safety requirements and standards using a simple process. The user first selects the munition type and inputs the expected environmental profile for the munition. The tool then displays potentially relevant threats and requirements based on the user inputs. Benefits include the identification and easy access to latest standards and help in developing a consistent approach. Both tools contain both national and international standards which can help in developing an understanding of the S3 approach employed for an off the shelf procurement where another nations national standards have been implemented.

3. TRANSFERABILITY OF QUALIFICATION DATA

Nations adopting and implementing same standards is the first step in moving towards the goal of ‘qualify once’. On more detailed investigation of the munition S3 process there are other factors which impact the transferability of qualification data goal. This is explored in more detail under Energetic Material Qualification and Qualification (Final or Type qualification).

When procuring an already qualified munition system the procuring nation has a duty of care to ensure that the munition meets their S3 requirements. In performing this duty the national authority will typically ask for information relevant for both the energetic material and munition qualification, which would include details of the design, Safety design requirements, environmental lifecycle profile, test and evaluation plan, tests results and sentencing criteria.

Gaining access to this information can be challenging and typical issues to be overcome in this process are:

- Ownership of the data, the nation responsible for development is likely to have paid for the data.
- Intellectual Property Rights (IPR) may limit the availability of the data.
- Export controls. Examples include US ITAR, Consolidated EU and National Arms Export Licensing Criteria.
- Knowing what data is available to request prior to contract.

An important enabler here is use of national channels to engage with the national authority responsible for developing the S3 assessment for the munition. It is implied or stated in both AOP-7 and AOP-15 that information should be supplied to the requesting nation.

4. ENERGETIC MATERIAL QUALIFICATION

Much progress has been made to standardise the qualification process under NATO and Nations have agreed standards dealing with energetic material ingredients, stability and reactivity, hazard testing and mechanical properties. Overarching standards responsible for governing the implementation of the various standards relevant to energetic materials are:

- STANAG 4170 and AOP-7; Principles and Methodology for the Qualification of Explosive Materials for Military Use.
- STANAG 4397 and AOP-26; NATO Catalogue Of Qualified Explosives
- STANAG 4147 Chemical Compatibility of Ammunition Components with Explosives
- STANAG 4675 In Service Surveillance

Of particular importance is the table of 'Mandatory Qualification Data (Properties), Data and Associated STANAGS', which appears in STANAG 4170. This table contains a list of the required properties by intended role (primary explosive, booster explosive, high explosive, solid gun propellant, solid rocket propellant, liquid propellant, pyrotechnic composition) with the tests required to measure them being called up in additional STANAGs. Since the energetic material is qualified for a generic role it is not normally relevant only for a specific munition, which should imply that the qualification data can be transferred to another application provided the role stays the same.

This would appear to indicate that the nations have harmonised their approach to energetic material qualification. However, on closer analysis there are a number of remaining issues.

- Many of the STANAGS called up by this agreement contain multiple tests used by different nations and services. For example, STANAG 4489 on 'Explosives Impact Sensitivity Tests' contains the following test methods:

    - ERL/Bruceton Machine with Type 12 Tools;
    - Rotter-Type Impact Machine;
    - BAM Impact Machine.

- A recent study on Reduced Sensitivity RDX which involved multiple laboratories using the same test methods on same RDX samples resulted in varying results.

- Explosives manufactured by different facilities or same facility using different sourced materials often exhibit differing physical, chemical and hazard properties.

With respect to nations implementing different test methods there are a number of things which can be done to alleviate this situation. Complete harmonisation of the energetic material qualification process would mean that all the nations are using the same tests. However, this has not and is not likely to be achieved in the short-or even long-term. Nations and companies have invested in expensive test facilities over decades and have large databases to support analysis of results which cannot be replaced overnight. One must ask whether harmonisation at the test level is a requirement when what is important is whether the energetic material has acceptable chemical, physical and hazard properties. Being able to accept an impact sensitivity value should not depend upon which test has been conducted but rather an assessment of suitability based on knowledge of what the value means relative to other materials. One should note that for many of the tests there are no agreed acceptance criteria and acceptability of a formulation is based on review of the properties as a whole. Therefore, the main issue here is confidence in the assessment that the tests performed by other nations or laboratories have been completed in an acceptable manner and that the values are acceptable for the intended role.

STANAG 4397 and AOP-26 list the explosives which have been qualified by nations but are limited in the information to help address the ‘qualify once’ issue. The document lists the energetic materials that have been qualified by nations with some information on the formulations and point of contact details. The author believes that the initial intention was to publish qualification data on the formulations but the document stopped short of this goal, which would have aided the goal. However, nations signing up to this standard do agree to share qualification data but this is not always straight forward, see comments above.

There are a number of tools available or could be developed further to help. For example, MSIAC has developed an energetic materials database which contains data on the chemical, physical and hazard properties of high explosives, gun propellants and rocket propellants. This is not a complete listing of qualification results but goes some way towards understanding; what are typical and acceptable properties for different types of energetic materials.

A recent effort by the US Navy, Ken Tomasello et al., on the origin of qualification tests for high explosives presented at the IMEMTS[3] and further work presented here on primary and booster explosive qualification[4] helps explain the rational of the US explosives qualification requirements. Such an effort will help develop other nations understanding and confidence in US energetic materials qualification.

A further facilitator could be an enhancement to AOP-7 where additional cross correlation between tests conducted by different nations and services was provided. For example, typical values of impact sensitivity for same energetic materials, ingredients, for the different impact tests allow nations which receive data on energetic materials tested on a different impact machine to better understand the hazard. An expansion of this to include typical newer formulations and expansion to cover all the other mandatory tests could aid more wide scale acceptance of qualification data.

The recent study on RS RDX, referred to above remains a concern to AC/326 SG1 and impacts the goal of being able to accept qualification data from other nations. Why did different laboratories conducting the same tests on same energetic materials end up with results out with the accepted accuracy or precision of the test methods? SG1 on energetic materials is still working on this issue but the robustness of the procedures and competence of the test houses have been called into question. One potential route to tackle this, which has been loosely debated, is a test house accreditation scheme.

A supporting precursor to a test house accreditation scheme would be adoption of the process presented at several symposiums, lastly at the 2008 DDESB Seminar, by the US Navy, Roger Swanson and Steve Tanner, on DC3 - Document, Calibrate, Certify, & Correlate. This process would allow for and facilitate the correlation of test results between different laboratories or test houses/facilities. In addition, this maybe a necessary first step due to the legal issues (specifically legal liability) involved with creating and chartering an international accreditation organisation.

In summary, the ideal long term solution may be harmonised tests with agreed acceptance criteria performed by accredited test facilities. However, full harmonisation may not be required if confidence can be gained in other nations assessment methodologies and testing procedures. Indeed, the UK and France have achieved this situation and now formally agree to accept each other’s energetic material qualification data without the need for duplicate testing.

5. QUALIFICATION (FINAL OR TYPE QUALIFICATION)

The overarching document dealing with the final or type qualification is STANAG 4297 and AOP-15 which provide 'Guidance on The Assessment of the Safety and Suitability for Service of Non-Nuclear Munitions for NATO Armed Forces'. The purpose of the document is to:

- Provide guidance on the assessment of S3.
- Recommend system safety design and development criteria.
- Present a methodology to identify and to reduce risks related to munitions and refer to analysis and test methods to demonstrate that the risks related to a munition are acceptable.

Very briefly, AOP-15 contains the detail of the standard and calls up other STANAGs dealing with Safety Design Principles for generic classes of munition systems. This document also provides guidance on defining the predicted service environment, which drives much of the test and evaluation requirements. A first problem encountered with respect to the goal 'qualify once' is that guidance can be interpreted differently and consistency in considering marginal or low risks can be a problem.

A major issue impacting the wider applicability of an S3 assessment is that the predicted service environment is likely to vary between nations or services (and may even vary when predicted by different individuals in a safety organisation). Nations use and deploy munitions in different ways, they transport and carry munitions on different platforms, and hence the requirement for munitions to survive environments is varied between nations. It is not the case that an S3 assessment will prove a munition as being S3 for all possible service environments, such an approach would likely be prohibitively expensive and increase programme technical risk through subjecting munitions to extremes increasing the chance of failure in testing. In addition, it is often the case that the user will assess S3 for a limited service environment only to discover later that this is insufficient resulting in further test and evaluation.

To highlight some of the issues in more detail comments are given below on environments that are considered during the S3 assessment process:

- Natural environments – The munition will be assessed to determine S3 to natural environments dependent on geography and logistic and tactical configurations. Nations may deploy munitions to different part of the world and use them in different configurations which can impact the test and evaluation programme. The more extensive the natural environment test programme the more likely the data will be transferrable to other services or nations.
- Induced environments associated with handling or transportation – In particular, vibration conditions associated with handling or transportation will likely be different between nations due to transportation of different platforms. Conservative sets of vibration curves consistent with a wide range of potential transport vehicles encountered in NATO service are available in AECTP 400. However, the more severe the vibration environment the more likely the test programme will be tailored to a particular platform.
- Induced environments associated with carriage - Vibration conditions associated with munition carriage will likely be different between nations due to use of different platforms. See comments above regarding vibration and tailoring.
- Induced environments associated with projection, launch or ejection and free flight – Data is more likely to be transferrable between nations as it linked to designed operation of the munition.

- Induced electromagnetic, electrostatic and nuclear environments – Hazards of Electromagnetic radiation; RF environment likely to vary between nations.

It should be possible to define a core set of qualification data that could be transferred between nations, which could help reduce duplication of testing. Complicating this is the use of sequential testing, subjecting munitions to a sequence of environmental stresses which simulate extremes of the lifecycle environmental profile, which can increases the specificity of test and evaluation data to the nation or service conducting the S3 assessment.

It is the case that some munitions types will see a similar service environment between nations and services such as general purpose munitions e.g. small arms, grenades etc. For more complex munitions the S3 assessment may be linked more to carriage on a particular platform and hence only limited data may be applicable to another nation or service using a different platform. This is more commonly the case for complex weapons where technical risk means that the test and evaluation will be more tailored to the service environment.

Another area which could perhaps be explored in more detail, or guidance developed, is the extrapolation of test and evaluation data generated for different service environments. There is a role for modelling here which does not currently appear as part of the S3 process; it is mentioned briefly in AOP-15 and not at all in AAS3P1 (see below).

A current programme of work which should help is the development of STANAG 4629 on S3 testing. The goal of this work is to develop munition type specific design and S3 test and assessment standards (AAS3Ps), see figure 1 below.

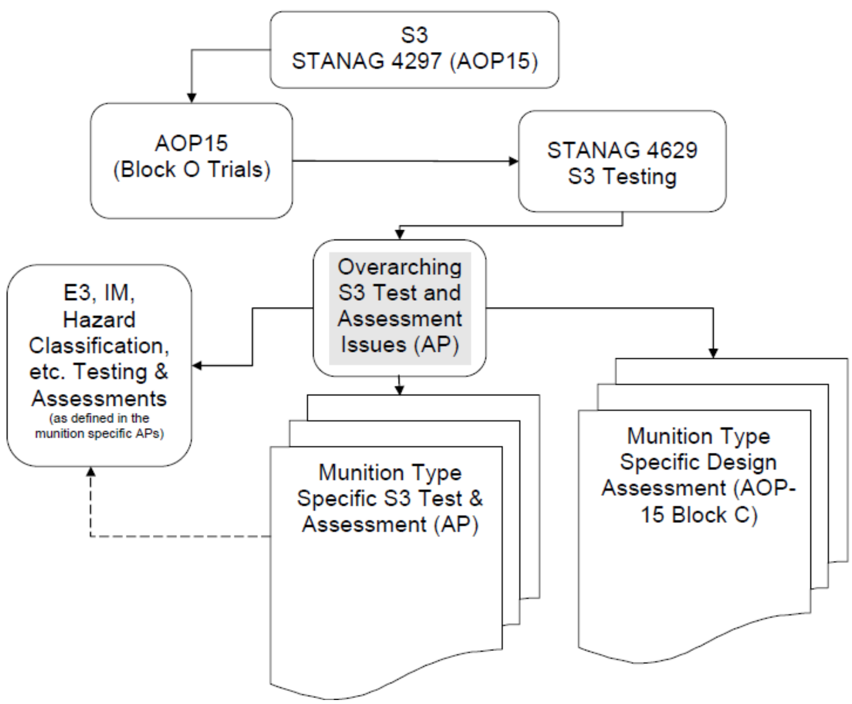


Figure 1. S3 document family structure.

The stated purpose of the AAS3P munition type documents is 'to act as a munition type specific document dealing with the necessary safety testing and assessments'. So far a relatively small number of AAS3P have been produced; the overarching S3 testing guidance document, AAS3P-1, is complete along with a munition specific document, AAS3P-10, covering shoulder launched missiles, rockets and projectiles. This effort will help develop consistency and best practice in how the S3 testing is conducted which should help aide the efforts of ‘qualify once’ and improve confidence in other nation’s qualification programmes.

In summary, there remain significant challenges in achieving the goal of ‘qualify once’ at the munition qualification level. The principal issue being that national requirements with respect to service environment vary which impacts the test and evaluation S3 programme resulting in national or service S3 specificity. However, progress is being made and, in particular, development of a more consistent approach to S3 though development of the AAS3P standards will help.

6. CONCLUSIONS

There is on-going work in a number of areas which will help move forward the ‘qualify once’ goal. Of particular importance would be an agreed standard hierarchy at the international level so that efforts can be focussed.

It is clear that significant progress has been made on qualification of energetic materials through NATO standardisation activities. In order to accept qualification data directly from other nations there is a need to develop confidence in the other nation’s tests and acceptance criteria. This can be achieved as evidenced by the UK French agreement.

Qualification at the munition level poses more of a challenge with respect to the goal of this paper due to tailoring of the test and evaluation programme to the national service environment. The development of AAS3P standards on testing will go some way towards addressing consistency issues in the S3 assessment between nations.

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