Allied Ammunition Storage and Transport Publication Number 4 (AASTP-4) – Status and Future Updates (21302)

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ABSTRACT

AASTP-4 Ed 1-Version 4 (2016) – Application of risk analysis to the storage and transport of military ammunition and explosives *lists the state of the art methodologies to establish risk based decision based on quantitative assessment of the consequence and probability of explosives accidents in storage and handling of ammunition stocks.*

Part I of the manual describes how to set up a risk based decision system, and present an adaption of the ISO standard specially aimed at assessing the risk from explosives accidents.

Part II of the manual lists models available for quantifying risk (the analysis part) by addressing probability of event, exposure of personnel, explosive effects and response to personnel following the effects.
The models described can be listed in three categoriesNATO agreed models.

- *Models with only one listed option.*
- *Multiple options listed as nationally approved methods.*

Future issue of AASTP-4 will focus on NATO agreed models. Nationally approved models will be listed as available references.

The goal for future work is:

- *Interoperable assessment of explosives safety*
- *Agreement on NATO agreed models used in analysis tools.*
- *Peer (NATO) review of models*
- *Implement RD as prompt as possible into available models.*

1. Introduction

1.1. **Purpose**

The purpose of the AASTP-4 manual is to aid establishment of a system able to make decisions based on the best possible knowledge of risk. The part I of the manual describe the elements (11-steps) that has to be in place for making the decisions. Part II of the manual lists methodology to perform the analysis. Both parts have examples describing how this are done in various nations approaches.

This description also sets a standard for the expectations NATO have to a risk based system, and accordingly make the nations able to base risk decisions on each-others assessments.

1.2. **History**

One of the first systematic analysis making prediction of risk for personnel from an explosive accident, known to the author, was the AMRAM 78 methodology (developed by FOI – Sweden).

Later came computerized methods from various national approaches, among them RISKNL, EXPLORISK, QRISK, SAFER, which to date is listed and described in AASTP-4 part I

The CASG (CNAD (Committee of national armament directors) ammunition safety group) storage subgroup (AC326) arranged annual workshops in the period 94-98 (Ad hoc technical working parties) on risk assessment and attempts to collect methodology for risk analysis on storage was made.

In 2000 the Risk Assessment Working Group (RAWG) was formed with 7 participants from 6 nations.

Quite many individuals have contributed to the manual available today. Some deserves to be mentioned explicitly (some are more equal than others).:

- Tom Pfitzer, said on a bus ride back to the hotel in Oberjettenberg in 1999: “lets do something about this that we have been talking about for quite a while, I can draft a straw-man for a manual for circulation”. He followed up by facilitating a number of productive meetings in Huntsville resulting in the first issue of AASTP-4 in 200x).
- Bengt Vretblad, was the chairman of AC/326 Subgroup 6 from 2003 to 2010, took responsibility for the custodianship of part I, and with his diplomatic background as a major of a Swedish local community he had the political skill to unite the interests of the nations involved.
- Peter Kummer with all his knowledge and expertise in the area taking custodianship for PART II and organized the technical input from the various nations.
- Meredith Hardwick organized all the rather unsystematic input and changing contributions from the parties made it technically consistent and created a manual.

2. Discussion

2.1. AASTP-4 part I

The AASTP -4 is written in accordance with the terminology in ISO 31 000. Accidents involving explosive articles are rare, but have potentially large consequences. This fact and other aspects of handling military ammunition is the reason for describing the specific area of explosive safety in detail. There is a hierarchy in risk terminology the terms;
risk governance, risk management, risk handling, risk assessment and risk analysis, which have a logical connection and interface. Risk governance as a term is most relevant at societal level (political) and will typically address third-party safety from military activity and safety level for service personnel. Risk management is setting up and running a system for taking decision on the basis of risk and includes the three remaining activities. Handling risk deals with the precautions and administering the risk that has been found necessary and acceptable. Assessing risk is to find the risk and addressing out whether the risk is acceptable, and finally, analyzing risk deals with finding the risk in a given scenario according to the chosen one and risk formulation.

The AASTP-4 deals with risk assessment and risk analysis and to some extent risk management. Risk assessment is described in the necessary context to take advantage of quantitative analysis methodologies and is not a complete description of every detail in the term. Risk management is addressed only to the extent of getting the two other elements working.

2.1.1. Necessary system to assess risk

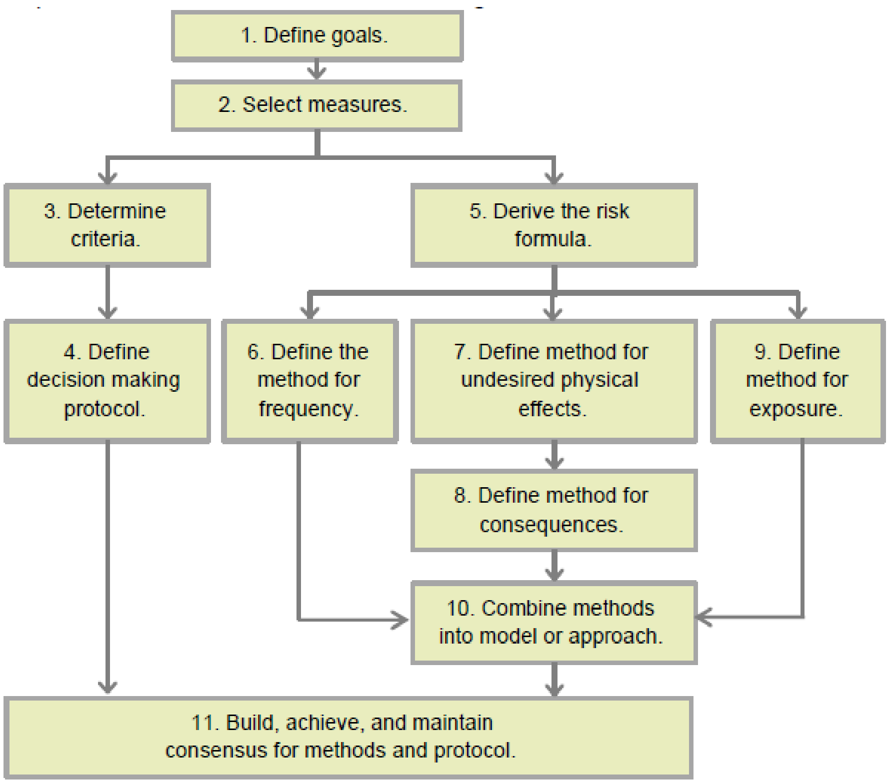

Figure 2. Developing a Risk-Based Decision Approach.

A key element in the manual is the figure 2, containing the 11 elements of risk based decisions.What might be included in the 11 steps is outlined in the manual and must be determined by the parties setting up the system but a few remakes could be tied to each step in the process:

- Goal, certainly a goal of a risk based decision is to take a decision based on the best possible knowledge of the risk, and to be able to document the basis of this decision.
- Measures, it is necessary to spent some time with measures to ensure the measures arcorrectly understood ant that the units coming out of the analysis matches those of the acceptance criteria.
- Determine the risk criteria, setting criteria is of course difficult but also often the difficulties are exaggerated. In most nations two criteria are found necessary. One to make sure the individual person is safe, and another to protect the general public. This of course has to do with duration of exposure, some live in a vicinity of an explosive storage a lifetime, A road passing by can expose millions of people for a very brief minute in the same period. The level of acceptable individual risk is often set by comparing other inherent risk of life, for example the risk of being struck by lightning. The societal risk or group risk is on the other hand determined by “the willingness to pay” or by a proportional part of the value of the activity to the gross national product, times the general accident rate.
- Decide protocol, to get things done authority has to be clear, but it is not evident that the man with the pen and authority to sign has the detail knowledge of what is signed. The way of doing this is to include the protocol in provisions and regulations, in a way

that all levels are aware of what exactly their signature upon and delegate authority to the appropriate skilled level.

- Derive the risk formula, it is quite clear which parameters and formulation the authors of the manual intend to include in the risk formula, but when it comes to the details the statements start to deviate a little among the nations. The basic demand is that the single model must be consistent.
- Frequency, the historic explosives storage accident frequency for various nations participating in this work is surprisingly consistent. One wish to think that historical data is conservative, that things are improving. To better prioritize resources for reducing accident frequencies it is favorable to take several factors into account and to ad granularity to event frequencies dependent on activities.
- Explosives effect, explosives effect is quite well quantified for intended, open detonations, with TNT. If different types of explosive material is introduced, structural properties of the PES, the amount of explosives actually contributing to the effects is unclear, - the description of the effect often ends up with quite conservative credible event.
- Response, response on explosive effects are quite well characterized.
- Exposure. Exposure could be described to the detail the resources allow, in principle in real-time.
- Combine the Frequency, Effect/response and exposure. Most nations calculate two risk parameters, the individual risk and collective risk.
- Build and maintain consensus. This is a often underestimated task. If this step fails the safety system gets vulnerable because of lack of understanding. People in general tend to mistrust things they know to little about, so also risk analysts. The approach has to be able to withstand the media test. When a journalist asks a risk specialist the wrong answer is:
  “I know very little about what they are doing, it is probably some ingrown routines in a small environment.”
  The right answer. “I have heard about what they are doing. To my understanding it is solid”.

2.1.2. Analysis model

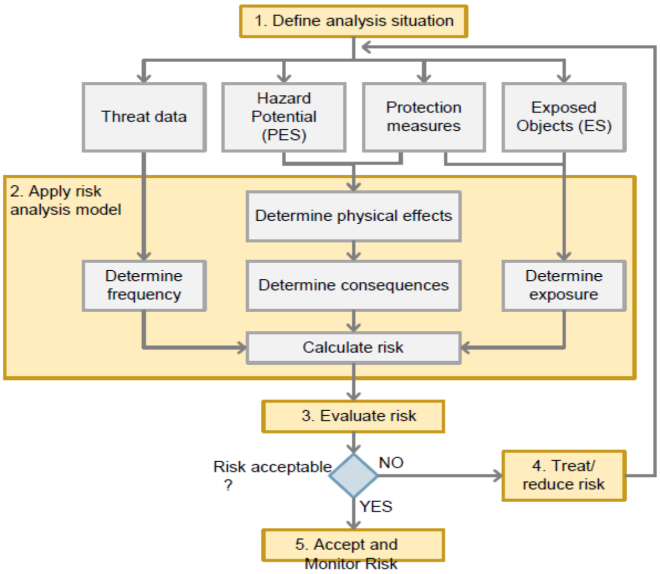

Figure 3. Practical Application of the Risk Based Method.

The figure above describes how to apply the model. The model is iterative. If the result (risk) is not good enough (not acceptable), parameters describing the situation has to be changed, for example harden the exposed objects, or put them at a further distance. The more the analysis model can be set up to make good decisions beneficial the better. In most circumstances it is not enough that the risk is acceptable as stated in the figure. It is also beneficial to have in the safety system two other principles:

- Unnecessary risk should be eliminated (if analysis show risk contribution from unnecessary risk handling it should be taken away)
- Cost effective measures of eliminating risk should be done. Reducing risk is a performance factor, adding solidity to an operation.

2.1.3. NATO and National approaches

The AASTP -4 cross-references AASTP-5 and ALP -15. There is still some adjustments to be made to explain better how this three documents work together. The various nations that has contributed to the AASTP-4 have listed some key elements in their implementation of the reccomendations.

Each nation have described the methods in use and the acceptance criteria in place for national models.

2.2. AASTP-4 part II

There are three categories of quantitative risk calculation models in AASTP-4 part II.

- What can be described as NATO agreed models
- Where there is only one model made available
- Where there are several national approaches available.

The goal of the Risk Assessment Working Group is to have as many as possible NATO agreed models. However it has been, and still is the policy not to hurry standardization at the

cost of granularity, quality and scientific basis. Where models are different there are reasons for it. They often have different range of validity and focus on special scenarios. The granularity is different, as simplicity of use increases the number of assumptions, and precision often increases the number of input variables. In some cases the models are based on different basis, trials results and scientific basis. It is important not to loose any qualities from the broad collective basis behind the models.
The streamlining work to compare the models and to understand and revisit all the reference work simply cannot be done in a few years, and must be focused at limited tasks.

2.2.1. **The NATO agreed models**

The following models has been agreed upon as NATO recommended models for explosives risks analysis:

- AASTP-4 part I (acceptance criteria for various nations are listed in separate chapter 3)
- Probability of event in operational storage
- Models for blast effects (whole of chapter 3)
- General description for debris and debris models for underground ammunition storage
- Ground-shock model for underground ammunition storage
- General models for lung injury from air blast
- Consequences from combined effect to personnel and assets applicable to operational storage situations.
- Relevant body areas for debris/fragment impact
- Comparison of glass breakage models

Acceptance criteria is an issue requiring some political decision and the RAWG has not been pushing any general agreement on this.

2.2.2. **Where only one model is described**

Some topic areas has only one referenced model:

- Lethality from direct blast inside buildings
- Asset damage assessment
- Lethality from ground shock in the open
- Lethality from ground shock in vehicles
- Structural consequences from ground shock

2.2.3. **Multiple models**

Multiple models exists for:

- Frequency methodology (US,NL, GE, CHE/NO/SW)
- Structural consequence from air blast(US, NL, CHE, SW)

- Structural consequence from debris(US, NL, CHE)
- Personnel consequences from air blast(GE, NL, US, UK, CHE)
- Personnel consequences from debris(NL, US, UK, CHE)
- Thermal effect (US, NL, CHE, NO/SW, UK)
- Consequences form thermal effect (NL, CHE, NO/SW, UK, US)

2.3. Layout next edition

Next edition of the AASTP-4 part II will be shortened in one respect since the national models will be referenced instead of being included in the manual. It is still desirable to have the different nations models easily available. It is probable that MSICAC will be asked to play a role in facilitating the documents.

As the content and scope of the future AASTP-4 will change it is assumed to be a ed 2 ver 1. This has not been discussed in the RAWG and it must be addressed in the upcoming meeting in October 2018.

2.4. Wish list

With numbers of manuals, textbooks, experts, consultants and working groups it is easy to get the impression that all knowledge are in place.

“QD's are presented as absolute numbers, and uncertainties are treated with the factor 1.2. “

There are still plenty of room for improvement, especially if the conservatism should be reduced. (Conservatism and distances cost performance and money).

The authors opinion is that the main overall uncertainty when performing quantitative analysis is within the effect of an accident. Explosives effects calculation are very high quality when it comes to predicting air blast from a hemispherical surface detonation of TNT. The methodology gradually increases in uncertainty when:

- Explosives are inside structures (Small NEQ in heavy structures in particular).
- Accidental initiation, how much of the explosives actually contribute in the reaction.
- The type of reaction (detonation, explosion, mass-fire, directional flame/jetting, single item serial reactions (1.2 events) or burn).

All types of structures /weapon platforms used in explosives handling cannot be tested an models, such as KG-ET (Klotz group engineering tool) need to be verified.

For reaction of energetic material more specific models need to be developed with some estimates of the likelihood of the respective reactions in the given scenario.

3. Conclusion

The AASTP -4 edition 1 version 4 is currently a complete reference of state of the art methodology to perform quantitative risk assessment for explosive storage. The methods are also useful in a wider range of handling of explosives and calculation of explosives effects and response. The models in AASTP-4 supports other related STANAGs as STANAG 4440 - AASTP-1 and 4657- AASTP-5.

There is still room for improvement of this basis for nearly all explosives safety regulations. It