MSIAC Munitions Safety Information Analysis Center
Supporting Member Nations in the Enhancement of their Munitions Life Cycle Safety

Bulletin

In this issue

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Data Loggers Providing Insight Into Actual Field Conditions

"What have my munitions been exposed to?" -- often during life extension efforts, safety assessments, or accident investigations, this is the first question asked. Yet there is typically only very limited information available to build the answer. This ignorance forces caution and conservative assumptions with respect to ageing conditions to limit user risk. There are many examples where this has led to the destruction of products that could have been used for a few more years in a safe and efficient manner.

Even though National authorities spend millions qualifying and purchasing munitions systems, very little is often spent on tracking the real environment these items are exposed to during their service life. Recently MSIAC set out to determine how this situation was changing, and help identify some of the efforts going on among our member nations to deploy and evaluate data logging technology. We also wanted to see how useful the collected data might be, and how member nations might be using that information to change their procedures.

MSIAC has compiled a comprehensive limited report (L-193) summarizing:

- the results of a survey sent to representatives in its member nations,
- documents from the NATO science and technology exchange groups dealing with this topic, and
- other literature found in its database and other sources.

The report illustrates environmental data logger use, and how the data collected by loggers is being used. The types of sensors and their physical and technical characteristics are presented, and examples are provided showing where and on which munitions they have been deployed.
In various cases, different geographic deployment examples are provided, as well as different types of installations on the munition items themselves.

The examples also show how the logger systems provide access to the real environment the munitions are exposed to, and the effect of that environment on some select energetic systems. Some examples are also provided of data optimization methods to make data more useful in surveillance programs, life-extension decisions, detection of "out-of-specification" environments, combination with aging models to determine the current condition, and accident analysis.

Moreover, data collected in some of these programs has allowed better understanding of the ammunition storage and deployment conditions in recent military operations such as Afghanistan and Iraq, as well as counter-piracy operations

(Continued on page 2)

in the Gulf of Aden and in the Mediterranean Sea.

Some highlights of the report include:

Previous NATO Activities

The NATO Science and Technology Organization Applied Vehicle Technology Panel (STO/AVT) has had a series of efforts in the area of health monitoring and management of munitions. Significant information on the use of data loggers as well as research and demonstrator programs has been collected from the following STO/AVT activities:

- AVT-119: Health Monitoring of Munitions (2003–2007)
- AVT-160: Health Management of Munitions (2007-2009)
- AVT-176: Advances in Service Life Determination and Health Monitoring of Munitions (2010)
- AVT-208: Technical advances and Changes in Tactical Missile Propulsion for Air, Sea and Land Application (2012)
- AVT-228: Lecture series on Munitions Health Management (2013)
- AVT-212: Application of Integrated Munition Health Management – Developing Methodologies for Implementation (2011– 2015)

The reports from these activities may be downloaded from NATO STO/AVT. Additionally, the report from the AVT-212 cooperative demonstration of technologies will be accessible on the MSIAC secure website under the reference L-192.

Questionnaire

A questionnaire was sent to the MSIAC member nations to get an overview of their involvement in this technology area. Australia, Belgium, Canada, Finland, Germany, Norway, Sweden and the UK provided direct responses to the inquiry, and The Netherlands asked MSIAC to refer to its published papers in this area as a basis for their work.

Environmental Data Loggers

Environmental data logger (EDL) is the title given to any device that will provide data about the environment surrounding it. The term is mostly associated with independent electronic devices that record and store temperature and humidity data, however, it should be taken as a more generic term covering all devices that improve knowledge of the environments experienced by an item. This can range from simple chemical devices that change colour at certain temperatures, to health and usage monitoring systems (HUMS) that can record temperature, humidity, shock, vibration, and pressure over many years.

As EDL technology advances, it should be incorporated into complementary in-service surveillance plans. The more that is known about the environment actually experienced by items in service, the more testing can be focused into areas of concern. A fully monitored fleet of missiles or munitions would allow *fleet leaders,* those that have seen the *worst* conditions, to be easily identified and tested.

An example provided by users in the report is that flight hours were much higher than expected in Afghanistan and Libya engagements, which could help better define technical requirements in future acquisitions.

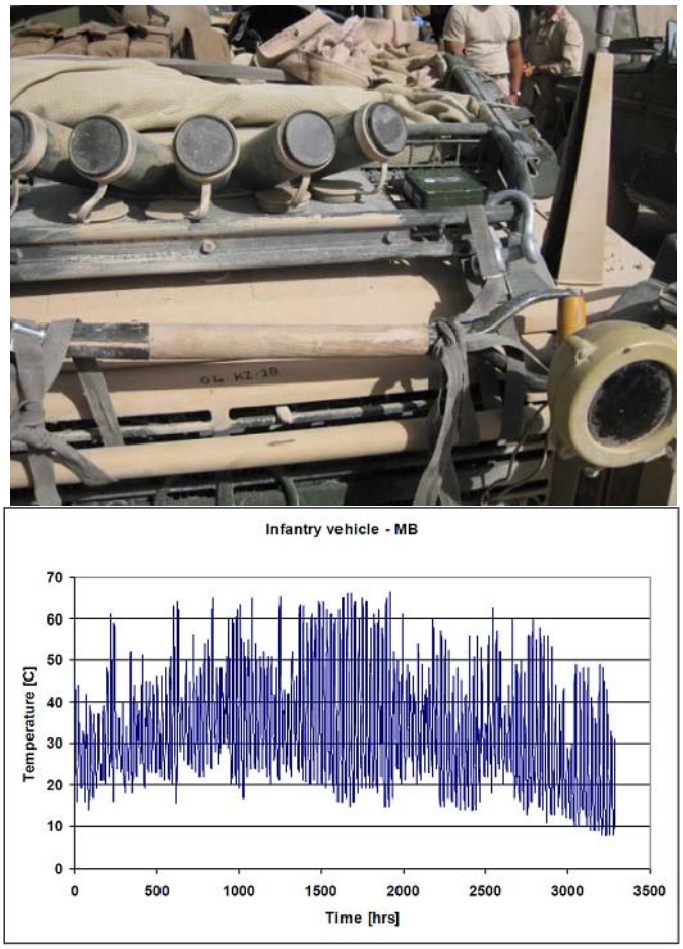


Figure 1:
EDL next to a 66 mm smoke launcher and corresponding data (courtesy of TNO)

NATO Policy

The use of data loggers for health monitoring or health management of munitions is linked with in-service surveillance activities and life assessment. NATO has recently drafted STANAG 4675 dealing with in-service surveillance of ammunition.

This STANAG covers:

- Methods of test and assessment
- Selection of surveillance assets
- Methods for determining life

It assumes that safety is the primary criterion for limiting a munitions' life. Ratifying nations agree to follow the guidance given in the three AOPs and provide on-demand the relevant safety and reliability data indicated in them when transferring munitions to other NATO nations. STANAG 4675 has the following structure:

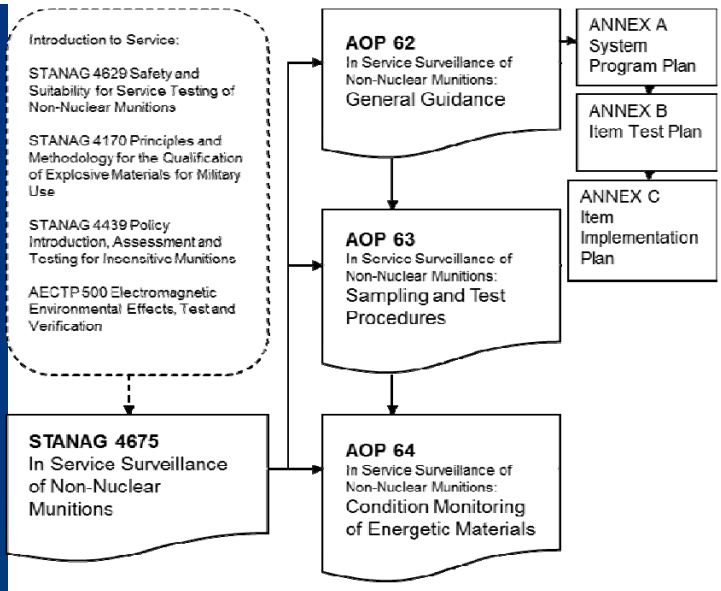


Figure 2: STANAG 4675 document structure

Munition Health Management

The idea of health management is to increase reliability and confidence in in-service surveillance decisions to better manage the stockpile, e.g.:

- to avoid disposing of munitions that are still reliable and safe,
- to avoid keeping in service munitions that are no longer reliable and/or safe,
- to adjust surveillance testing and inspection of munitions as a function of what they have actually experienced.

This could help save costs by reducing the number of destructive tests during surveillance and by extending the life of weapon systems. A potential additional feature includes tracking of munitions, which could be useful in order to track the stockpile and to get access to the main principles of MHM: condition, safe remaining life, and location of assets. The overarching goal would be a move to condition-based maintenance, where items that need attention get it, and ones that are still safe and fit-for-purpose are kept in the fleet:

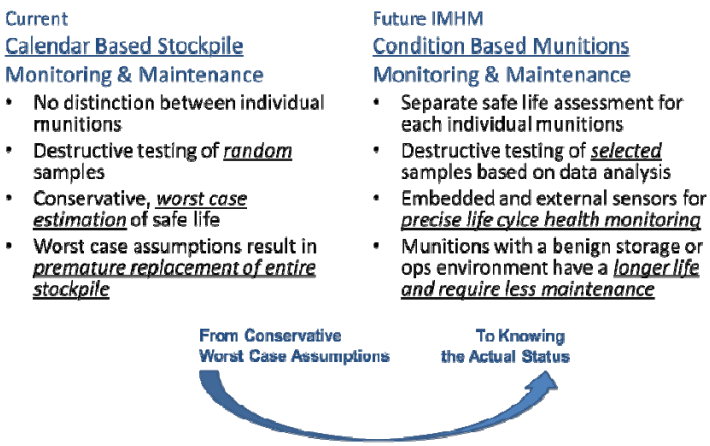
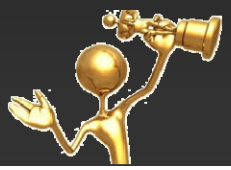


Figure 3: Calendar based maintenance vs. Condition based maintenance

Emmanuel Schultz
MSIAC Propulsion Specialist

Announcing The MSIAC Munition Safety Award Call for Nominations 2016

To acknowledge and encourage progress and achievements in munitions safety and insensitive munitions technology, MSIAC will present awards for MS and IM excellence at the 2016 IM/EM Technology Symposium.
The call for nominations is now open through **20 May 2016**.
Submission guidelines may be found at **www.msiac.nato.int/news/ms-awards**!



MSIAC in Australia: PARARI & Country Visit

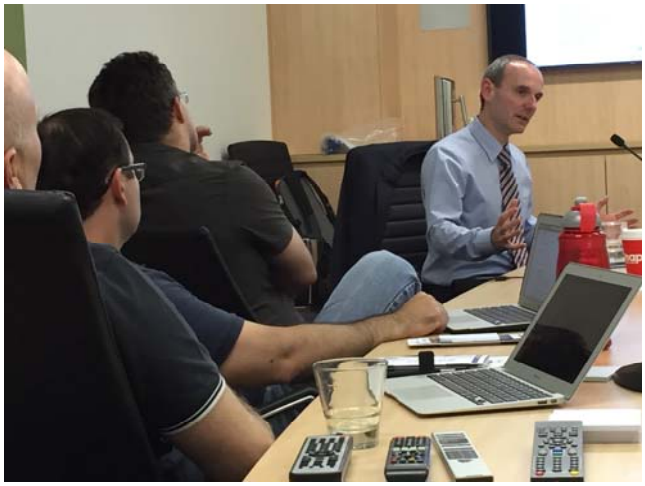
Three members of the MSIAC team traveled to Australia in mid-November to participate in the Parari explosive ordnance symposium and engage with Australian Defence Force (ADF) members. Dr. Michael Sharp, MSIAC Project Manager, Mr. Martin Pope, Munition Systems Technical Specialist Officer (TSO), and Mr. Wade Babcock, Munition Materials Technology TSO, gathered critical needs facing Australian government explosive ordnance practitioners, exchanged technical information, and presented MSIAC capabilities.

The two-week visit began with a visit to the Garden Island Royal Australian Navy (RAN) base in Sydney, led by LCDR Grant Wing, RAN. LCDR Wing is Australia's National Focal Point Officer to MSIAC, and in addition to hosting and organizing many of the details of the team's visit, was also tasked by ADF's Director of Ordnance Safety to communicate some of the most pressing munitions safety issues that are facing the ADF today. Chief among these are challenges with loading munitions on the newest RAN fleet vessels, *HMAS Canberra* and *HMAS Adelaide*, which were both alongside at Garden

Island. These vessels have some unique capabilities when it comes to munition load-out, but they also have a deck height that is well above the nominal 12 meter drop height testing that is routinely undertaken during munition qualification. LCDR Wing also talked about some of the issues facing Australia, as they routinely find themselves in multiple roles when it comes to munitions: as developer, purchaser, integrator, modifier, maintainer, and disposer. And all of these roles are performed by a small team on an inventory of munitions and systems that are sourced domestically and from around the world.

MSIAC then spent three days participating in the Parari conference in Sydney. This bi-annual event brings together around 300 participants from around the globe and is the only event of its kind in the southern hemisphere. This year's theme was "Challenges for explosive ordnance safety in a constantly changing environment" and focused on complexity in weapon systems and promises of improved performance and safety. MSIAC presented four papers and attended almost every presentation given during the three days.

On Friday, MSIAC visited the ADF staff working for both Munitions and Guided Weapons Branches at Penrith, New South Wales. About 25 personnel heard focused briefs from the MSIAC team on both current and critical munitions safety issues. This visit to Penrith is illustrative of one of the tasks MSIAC undertakes when engaging in a country visit. In the weeks prior to the visit, MSIAC seeks input from the NFPO, Steering Committee member, and other national contacts to find out what issues are pressing in their community right now and on the immediate horizon. This is used to create specific technical exchange which is tailored to each venue and their needs.



Following the visit to Penrith, the team spent three days in Canberra, with sessions at ADF Director of Ordnance Safety (DOS) and additional engagement with the Guided Weapons Branch personnel based in Canberra. Available personnel from DOS and the Explosives Storage and Transport Committee were engaged in several small groups, again focusing the technical exchange to the specific needs of each participant. Group Captain Wade Evans RAAF and Captain Nigel Smith RAN, the former and current Director DOS respectively, participated in these meetings, emphasizing the importance of re-energizing the DOS activity and its role in ADF munition procurement and lifecycle management.
At GWB more than 30 personnel participated in exchange briefings, driving home the problems they are facing as purchasers of munitions and munition systems from other nations. Key challenges with respect to munitions safety were the importance of managing lifecycle ageing and surveillance and evaluating remaining life.

Also in Canberra, MSIAC visited the Australian Forces Defense Academy, where the staff are looking to create an ordnance engineering program for ADF members on appropriate career paths. Possible collaborative, training, and data exchange opportunities were identified and will be reviewed by the ADF in the near future.

The final stop for the MSIAC team was to the Defense Science and Technology Group installation just outside Adelaide. A full day of technical exchange, including presentations from DST Group personnel as well as requested presentations from MSIAC, was incorporated with a short visit to a new gas gun facility just being brought online. Dr. Ian Lochert organized the exchange, which included discussion topics on the use of data loggers, ageing of double-base compositions, small-

scale fragment impact testing, and new technology trends in formulations and ingredients.

The country visit to Australia and resultant technical exchange was very informative and has already produced a significant number of new technical inquiries. MSIAC gleaned a number of explosives safety challenges facing the ADF and will endeavor to incorporate these as appropriate into future MSIAC work elements.

MSIAC would like to extend our appreciation to LCDR Wing, Dr. Lochert, and CAPT Smith RAN for their efforts to make the trip productive and engaging.

Wade Babcock
MSIAC Material Technology Specialist

Benefits of IM: Stokes Fellow Project

On the 29th of February we will welcome **Ben Keefe** from the UK as the new Stokes fellow.

After obtaining his master degree in Explosives Ordnance Engineering from Cranfield University, Ben was involved in various projects for the UK MoD (Explosives Safety Cell, Strategic Weapons Project Team, Defence Ordnance Safety Group – Risk Assessment). His last project was at Roxel, where he assisted with the development of multiple rocket motors whilst also undertaking research into Resonant Acoustic Mixing of inert propellants.

At MSIAC, Ben will work with Martijn van der Voort (TSO Safety of Ammunition Storage and Transport) on the benefits of IM. For the introduction of IM it is important to explore the impact over all phases of the ammunition life cycle. A literature study will reveal available experimental data on IM response in various threat scenarios.
Next, the project will focus on modeling the reduced explosion effects in scenarios with IM as compared to conventional ammunition.
For this purpose state of the art explosion effects models and software will be employed for blast, fragmentation and structural debris.

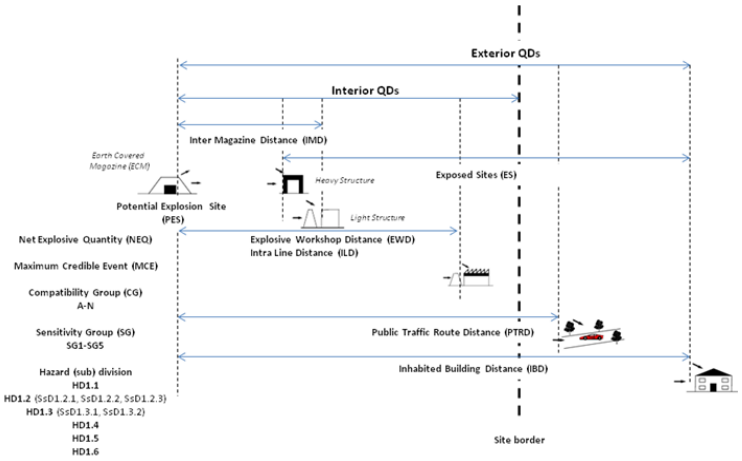
We are thankful that the Klotz Group Engineering Tool was made available for the analysis of the break-up behavior of storage structures within this project. Further attention will be given to the operational impact of IM.

After this 6 month project, the aim is to present the work at relevant meetings and symposia.

Martijn van der Voort
MSIAC Safety, Storage & Transport Specialist

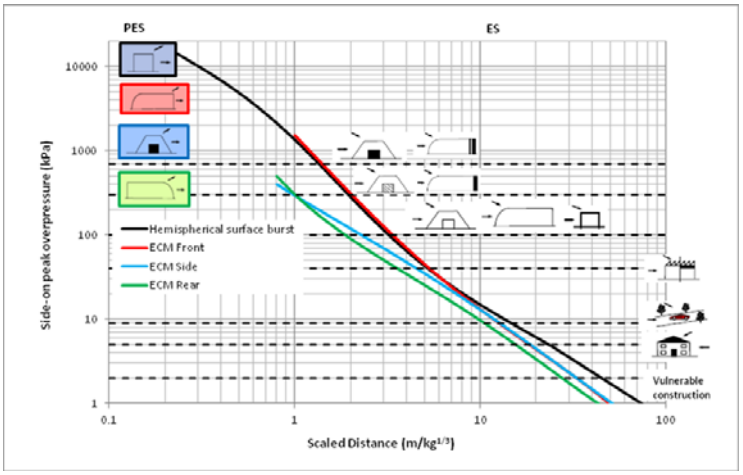
Experimental and Theoretical basis of current NATO standards for safe ammunition storage

NATO safety standards for storage of ammunition and explosives contain tables with so-called Quantity Distances (QD). These distances, which are to be kept between Potential Explosion Sites (PES) and Exposed Site (ES), provide a specified level of protection.
The figure below gives an overview of different types of QDs and the parameters that influence them.

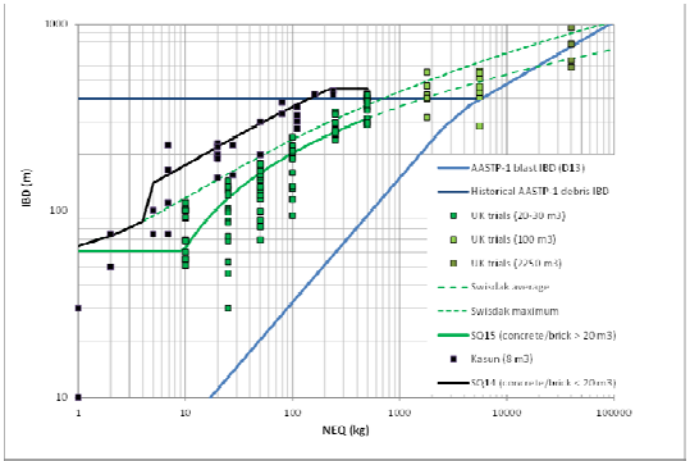


The QDs are based on an analysis of a large amount of explosives test- and accident data. The development of the standards took place over many decades by explosives safety experts within AC/326 SGC. At MSIAC a work element was defined with the aim to provide a comprehensive and transparent overview of the experimental and theoretical basis of the QDs.

As a preliminary result various references relevant for NATO standards AASTP-1 and AASTP-5 have been collected and analyzed.
QDs have been compared to state of the art prediction models for blast wave propagation and throw of structural debris. The figure below gives a comparison between blast overpressures from above ground and earth covered magazines and various exposed sites.
Checking the consistency between the models and the QDs is ongoing working. Blast loads have been compared to observed building damage.

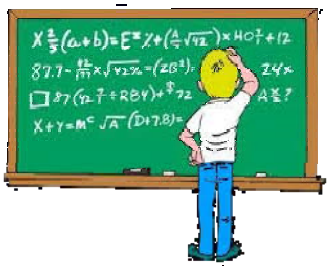


To make the study more future proof, planned changes to the standards were also taken into account. An example is the implementation of QDs for small quantities of explosives (SQQD). In this regime the structural response and as a result the details of the PES construction become very important. The figure below gives the Inhabited Building Distance (IBD) based on debris hazard (1% hit probability by a hazardous piece of debris), observed in a large number of tests. This figure shows that for small NEQ in the order of 10s or 100s of kg the observed IBD is much smaller than the historical minimum 400m which has to be respected according to the current version of AASTP-1. The minimum will be replaced by the plotted new QD relations in the years to come.



In this work element we will also define knowledge gaps, and make recommendations for long term development. The aim is to present the results at relevant meetings and symposia.

Martijn van der Voort
MSIAC Safety, Storage & Transport Specialist



Training to NATO Standards

MSIAC has facilitated the 5th training session in 2015 on the NATO Ammunition Storage Standards AASTP-1 and AASTP-5. The training was conducted in Club Prince Albert in Brussels, from 7-11 December.

The course lectures and exercises continue to evolve based on feedback received and changes in the standard thereby remaining current. The presentations thoroughly cover all aspects of the standards, but most popular according to the feedback received are the practical exercises on Hazard Class/Division, Barricades, Quantity Distance and Explosive Safety Munitions Risk Management.

MSIAC's Mr. Martijn van der Voort is the course manager and Mr Thomas Taylor and former Belgian MOD Ammunition Technical Officer, Mr. Johan De Roos, are the instructors.

The course slide presentations, exercises and instructor notes are also posted on the MSIAC website for downloading by Member Nations.

In 2016 three training events are already planned: Wiesbaden (US army Europe, 7-11 March), Versailles (4 -8 April) and Rome (24-28 October).

Martijn van der Voort
MSIAC Safety, Storage & Transport Specialist

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LIMITED PUBLICATIONS

L-193:
Munition Health Monitoring, Feedback from the use of data loggers

L-194:
Science Cook Off Workshop — Information Package