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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MSIAC - Reflection on 25 Years Supporting Munitions Safety Community

Over the years MSIAC has played a central role in facilitating member nation's efforts to design, develop, procure, and use safer munitions.

MSIAC was created after a number of horrific munition accidents in the 1960s and 70s, particularly those aboard USS Forestal and USS Enterprise, exposed the need for munitions with reduced vulnerability to so-called "unplanned stimuli" such as fire, exploding bombs, or impacts from other weapons (bullets, fragments, etc.) There was an understanding that munitions are inherently dangerous, but that safety precepts and principles applied at the time had failed to provide an acceptable level of protection to those exposed to risk. Indeed, there became a strong desire within some national policy makers and safety organizations to drive down this risk, and create munitions that were *insensitive* to any external forces, and would only function when used in their intended mode. Hence the history of MSIAC is linked to the history of the insensitive munitions, or IM, effort. Beauregard (*The History of Insensitive Munitions" By RL Beauregard, http://www.insensitivemunitions.org/*) has put together an excellent history of IM which is available on the Internet.

MSIAC was first known as NIMIC, the NATO IM Information Centre. NIMIC was notionally conceived as early as 1984 from discussions within the NATO AC/310 group, responsible for policy on safety and suitability for service of conventional munitions. This group reported to the Conference of National Armament Directors (CNAD). In order to progress development of IM, it was agreed to pull together the capabilities and knowledge of various countries to address the technical challenges. Further, as this was an issue facing many NATO nations, it would impact interoperability, an over-arching goal of the NATO Alliance. These discussions culminated in an AC/310-sponsored workshop held in 1986 at which seventy representatives from various governments discussed and agreed the need to establish an IM information centre under NATO.

As noted by Beauregard, US Navy leadership recognised this need and were a key player in efforts to establish NIMIC. Indeed, the US Navy took responsibility for drafting the MOU establishing NIMIC as a pilot back in 1988.

"The NIMIC will enhance the ability to achieve the U.S. desire for equality of conventional munitions within the alliance in the area of insensitive munitions program requirements, thus improving their inter-operability potential, and overall safety concerns in transportation and storage. …The Navy agrees to provide funding…for the establishment of the NIMIC…" [1]

*1. OPNAV ltr Ser. 35/*OU587461 of 17 May 1990; Subject: NATO Insensitive Munitions Information Center.

Initially only six NATO members were interested in participating. France, the Netherlands, Norway, the United Kingdom, and the United States initially signed the MOU with Canada joining slightly later in 1989. Participating nations contributed funds and technical personnel for the project and an office was established at the Johns Hopkins Applied Physics Laboratory, in Columbia, Maryland, USA. Governance was provided directly by the member nations via a steering committee headed by an elected chairperson.

Pilot NIMIC was a success and in 1991 it transitioned to its current home at NATO Headquarters in Brussels. NIMIC grew in membership adding five more nations: Australia, Italy, Norway, Sweden, and Finland.

In 2003, member nations realised that the development and fielding of IM was maturing and becoming part of the safety design and management process. It was agreed to broaden the project office's scope to cover lifecycle ammunition safety. The transition was managed over a two year period establishing MSIAC in 2005. The scope matched well with the objectives of the newly formed CNAD Ammunition Safety Group (CASG, also called AC/326) and a closer working relationship developed between the two groups with MSIAC able to provide support on a case by case basis (as agreed by MSIAC's steering committee).

MSIAC has expanded its membership further with Germany (2005) and Belgium (2015), and Poland is currently in the process of joining with membership ratification expected in 2017.

Technical Mission

The MSIAC project operates today in a very similar manner to how it did 25 years ago. Its scope is to collate, review, and analyse munitions safety-related information across the whole life cycle of munitions. IM is a key focus, with IM technologies continuing to be key drivers to enhanced weapons safety.

The MSIAC steering committee and project manager use the strategic plan to define the scope of the yearly work plan. This is then approved through the steering committee with individual work elements developed for the following enabling activities:

- **Requirements**. Capture and analyse MSIAC member nations' and relevant stakeholders' munitions safety requirements;
- **Knowledge**. Develop, synthesize, and maintain knowledge and understanding to enhance munitions safety;
- **Policy**. Define, harmonize, improve, and promote policies for munitions safety;
- **Delivery**. Promote munitions safety and execute MSIAC's mission.

MSIAC's products and services are available in a number of different ways. Some are engaged via national practitioners through the secure web environment, some are collaborative engagements of many experts, and others are focused, targeted engagements at the organisational level. The schematic provides a summary of these, all centred about the fundamental MSIAC goal to support munitions safety.

I will highlight the history of just two of these areas here: answering technical questions, and hosting technical workshops.

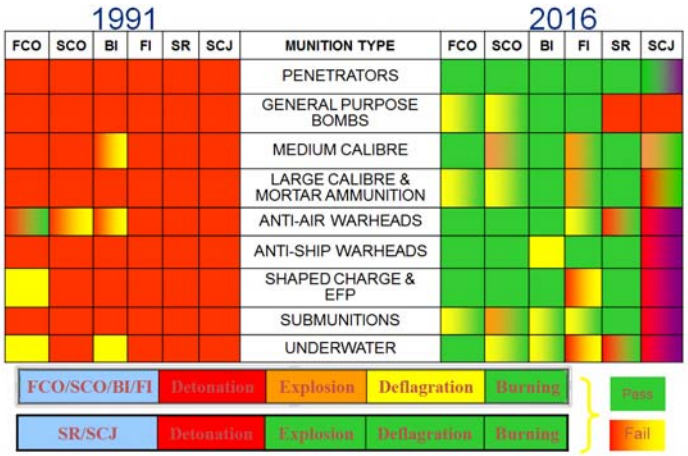
Technical Questions

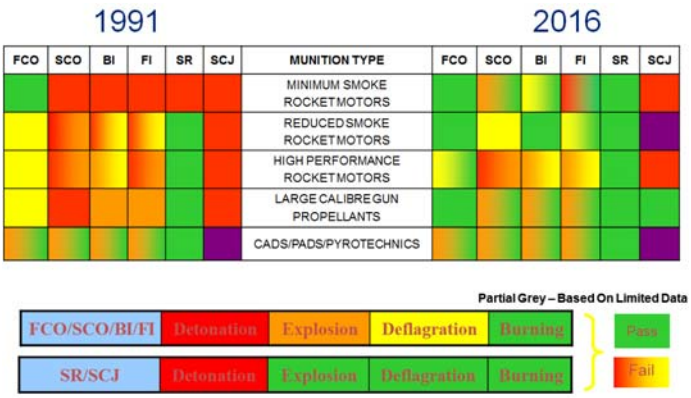
Answering technical questions continues to be one of MSIAC's most visible means of supporting the munitions community in our member nations. Over the years NIMIC and MSIAC have answered more than 2600 questions which cover a wide range of subjects and complexities.

The first question asked of NIMIC in October 1989 requested information on: National IM requirements, the IM tests used, components critical in meeting IM requirements, and the efforts currently underway to address IM deficiencies. That answer reveals how much progress has been made by the community:

- Only the US had an IM policy.
- On IM testing – Only national procedures existed and there were few systems which had been tested at that time (perhaps with the exception of the US as detailed in a later question).
- Many of the concepts to improve IM response were known in 1989 but remained just that; few examples of where the concepts had been applied were known.

A quick review of the situation today reveals a very different picture: NATO IM policy and tests standards are mature, and MSIAC tools and databases contain many IM success stories. Many of the concepts known in 1989 have been successfully implemented and fielded and the benefits have been realised. To illustrate this point we have put together two stop light charts to indicate progress from 1991. This is an MSIAC TSO consensus assessment based on fielded systems in 2016 for warheads and propulsion/pyrotechnics.





Technical Workshops

MSIAC facilitates the advancement of knowledge and policy though organising meetings, workshops, and seminars on IM and munition safety related issues. Workshops constitute a major effort for MSIAC as, in addition to organizing the venue and logistics, the MSIAC technical team prepares much of the technical background on which to base the discussions before the event, as well as thorough documentation and analysis afterward.

There have been more than 25 workshops or major technical meetings since NIMIC began in 1991. The workshops have been within three topical areas: IM reaction mechanisms and testing, IM technology and insertion, and general munitions safety. A trend becomes evident in that early workshops focused on individual threat stimuli. These meetings served to increase our understanding of the reaction mechanisms so that we could design munitions with reduced vulnerability to threats giving lower levels of reaction violence. More recent workshops have focused on topics relevant to IM implementation, and are linked to the increasing availability of IM technology.

The Future

MSIAC is preparing for the move the new NATO headquarters building in early 2017. Efforts will be taken to minimise the impact to MSIAC users, however, given that our data centre will be moving, we expect some down time for the secure web environment.

MSIAC is currently updating its founding MOU. Since 1991, changes in the project's scope and addition of new members have been enacted through amendments. The Steering Committee agreed last year to update the MOU and bring it in line with current objectives, language, and policy. This provides member nations with an opportunity to review the current scope of MSIAC and introduce changes where necessary. Three areas were identified where support should be expanded:

- Range safety. There is a gap in expertise that should be addressed in the near future. Range safety specialists will be engaged to explore possibilities for working more closely with this community.
- Actual environmental exposure. A better understanding and characterization of the actual exposure of munitions during their lifecycle. This is linked to the NATO Integrated Munitions Health Management (IMHM) Smart Defence Initiative (SDI) which MSIAC has been requested to support.
- Supporting modeling and simulation efforts in general, and combustion modeling in particular was noted as an area requiring attention.

In Closing

Over the last 25 years, significant progress has been made with respect to munitions safety aims, particularly with IM development and fielding. MSIAC's role in assisting nations with their munition safety requirements and goals has given rise to a diverse range of products and services which continue to be developed and exploited.

It is important to realise that MSIAC facilitates munition safety improvements and this works because of a successful partnership with our member nations who have a strong safety culture, and requirements to build and continually improve munition safety.

The efforts of the munitions safety community are ultimately directed toward keeping the warfighter and others handling explosives and munitions safe. For MSIAC member nations this equates to almost five million uniformed service members throughout our 13 member nations. That is no small challenge, and unfortunately accidents and incidents still occur which serve to remind us why the community takes this responsibility seriously.

Dr Michael Sharp
MSIAC Project Manager

2016 Insensitive Munitions & Energetic Materials Technology Symposium Review

This year the Insensitive Munitions & Energetic Materials Technology Symposium (IMEMTS) was held in Nashville, Tennessee at the vast Gaylord Opryland Hotel. The topic of the three-day symposium was "Advanced IM/EM Solutions: Minimizing Risk to our Warfighters and Delivering Needed Performance, Security, and Readiness to Address Evolving Threats in our World." More than 250 people were registered for the symposium, representing 21 nations. In total 86 presentations were delivered and 21 posters were available for attendees.

MSIAC was represented by four TSO's (Warhead, Propulsion, Energetic Materials and Material Technology) and the Project Manager. MSIAC personnel chaired three sessions, delivered four session papers, one plenary paper and one keynote address and were also involved in a total of seven papers. When not presenting papers, the MSIAC staff could be found by the MSIAC booth providing information, flyers and pens to the attendees.

The keynote address was given by Dr. Baker, covering his lifetime of energetics experiences. He is the MSIAC Warheads TSO since June 2016 and is recently retired from the US Army ARDEC. He discussed his youthful energetic experiences including fun with chemistry, reloading powder, and explosives avalanche control; his benefiting from broad technical community interaction including the US Army, US DoD, US DOE, industry, academia and international; and outlined the differences in national energetics policies and approaches observed while at MSIAC. The presentation ended with a recounting of his worst day (death of colleagues) and best day (lives saved due to insensitive munitions). He stressed the importance of the work done by the international safety and insensitive munitions community, as well as the required maintenance of technical excellence.

The plenary session provided a good introduction to the symposium by covering a number of IM and EM topics. Mr. Di Stasio (ARDEC) covered the progress that the US Joint Insensitive Munitions Technology Program (JIMTP) has made on promoting development and delivery of solutions to a range of munitions. This work includes the promotion of new materials through the "Molecule of the Year", new technologies that has seen a 300 % increase in funding, and updating the program requirements to include performance as well as IM goals.

Dr. Sharp (MSIAC) reflected on the past 25 years of how both NATO Insensitive Munitions Information Center (NIMIC) and MSIAC had evolved and were actively engaged with the development of munitions safety. For further information see the 25th anniversary article in this newsletter.

This was followed by Dr. Price (BAe Systems) who provided an overview of the **Gr**een **I**nsensitive **M**unitions **Ex**plosive (GrIMEx) program. The aim of the program was to develop novel IM replacements for RDX and TNT to formulate a greener "Composition B." It has been a multi-year collaborative effort with the Strategic Environmental Research and Development Program (SERDP) and United States Army Public Health Command (USAPHC). Progression of the work has shown that, with respect to toxicity, 2-bromo-4-methoxy-1,3,5-trinitrobenzene (TNBA) and 3,4-dinitropyrazole (DNP) are both viable TNT replacements and that 2,6-diamino-3,5-dinitropyrazine-1-oxide (LLM-105), 2,6-dinitro-2,4,6,8-tetraazabicyclo[3.3.0]octan-3,7-dione (DNGU) and fluid energy milled 1,3,5,7-tetranitro-1,3,5,7-tetraazacyclooctane (FEM-HMX) can be used as a replacement for RDX.

Lastly Mr. Guengant (Airbus) provided the European industry's Insensitive Munitions and Explosive Materials Group (IMEMG) perspective on potential improvements to IM-related STANAGs and AOPs. The review focused on AOP-39 analysis by the Hazard Assessment & Classification Expert Working Group of IMEMG.

MSIAC Awards

This year's career achievement awards were given to Mr. Bruno Nougez (France, not present) and Mr. Steve Struck (US Air Force). The IM Team Achievement award was given to the Brimstone 2 Project which consisted of a multinational team from Roxel UK, MBDA UK, TDW Gmbh DEU and UK MoD. A Steering Committee recognition award was given to Mr. Ronald Derr (US) for his outstanding contribution and support to NIMIC & MSIAC. For further details see the PM's Perspective.

Highlights

The following section contains only material, process & system highlights from the symposium.

Energetic Materials

Continued work and scale up on 3,4-dinitropyrazole (DNP) was presented by three authors: Dr. Price (BAe), Dr. Morris (BAe) and Dr. Ritums (FOI). This melt cast explosive has good performance properties (*c.f.* TNT) and an accessible melting temperature (88°C) for processing using steam and current melt cast facilities. Improvements to the synthetic route and scale up have been carried out by BAe Holston at the pilot plant scale. Some reported issues with DNP include long cooling times and low viscosity of the molten-phase leading to potential sedimentation with solid fills. According to Ritums, DNP is more shock-sensitive (using French Mini Gap Test) than TNT.

A one-pot synthesis (Samuels, ARDEC) and pilot plant scale up (Velarde, Orbital-ATK) for DEMN, a eutectic salt comprising of **D**iethylenetriamine trinitrate, **E**thylenediamine dinitrate, **M**ethyl nitroguanidine and **N**itroguanidine, was discussed. The material, as a melt cast, has an achievable melting temperature, good compatibility with potential solid energetic fills, low vapour pressure and reasonable performance.

Dinitromelamine (DNAM) was presented by Mr. Samuels (ARDEC) as a potential RDX booster replacement. Despite being hydrolysable formulations were made using inert, non-aqueous processing liquids during granulation.

Processing

Fluid Energy Milled (FEM) HMX was discussed a number of times during the symposium and work by Mr.

Alexander (BAe) replaced part of the HMX fill with FEM-HMX to reduce the shock sensitivity of LX-14. The program of work highlighted which particle size fraction of HMX required replacing to achieve a less-sensitive formulation.

Formulations

Mr. Johanson (Chemring) presented a series of melt cast formulations based on DNAN and TNT matrices that contained NTO, RDX and/or HMX. MCX-6002 (NTO/TNT/RDX) performed like Composition B but was less shock sensitive and had a larger critical diameter; reaction to fast and slow cook off was not presented for this formulation. MCX-6100 (NTO/DNAN/RDX), similar in composition to IMX-104, performed well across the qualification trials and was similar to IMX-104 data. The FCO & SCO Tube Test results were good with low reaction levels reported for both tests.

A new booster formulation based on HMX, LLM-105 and Viton (ARLX-4201) was presented by Dr. Piehler (ARL). The formulation was designed to replace PBXW-14; TATB/HMX/Viton formulation. The reported IHE Gap Test results showed that ARLX-4201 was less sensitive than PBXW-14, and that the response to the VCCT was less violent at high confinement.

Propellants

Nitroisobutanetrinitrate (NIBTN), a potential NG replacement plasticizer (Paraskos) was designated the molecule of the year by JIMTP.

An overview of ARDEC activities was provided by Mr. Caravaca (ARDEC). This covers areas like 3-D printing of gun propellant, novel ingredients, sub-scale SCO screening tools, venting technologies for cartridge case, co-extrusion and new ignition systems.

BAE systems (Dr. Penny) presented LOVA formulations using thermoplastic elastomer (TPE) for high energy 120 mm tank application as well as lower energy for artillery application.

Green stabilisers were presented by Eurenco PB Clermont (Dr. Dobson) to replace conventional stabiliser.

The Nammo GAP propellant was presented as the first GAP propellant formulation qualified by the UK MOD, for use in the LMM missile. It is based on GAP, RS-RDX and Bu-NENA.

Research on parameters influencing the shock reaction mechanisms of rocket motor (e.g. SDT, XDT) was presented by both the US and the UK.

Testing

AOP-39 projection criteria was the subject of two papers of particular interest related to IM testing. Mr. Pudlak (ARDEC) discussed IM Type IV lethal fragment projection energy threshold calculations and potential paths forward for updated IM assessment criteria. Dr. Baker (MSIAC) presented similar work done by Mr. van der Voort (MSIAC) on projection criteria for IM and Hazard Classification. Both presentations showed that the current 20J mass-distance relationships are based on launch energy rather than impact energy as commonly believed.

Among a number of presentations on alternative heating methods for fast and slow cook off testing and examining the dynamics within the fast cook off heating environment, Dr. Washburn (NSWC-CL) provided particular insights on calibrating a propane-fuelled burner used for fast cook-off testing. This correlates nicely with an on-going update to NATO STANAG 4240 for fast heating test procedures. Dr. Washburn's presentation provided quantitative data supporting such an update, as well as methodology for testing calibration. There were a number of other interesting presentations within this same topic area, including a radiative panel alternative heating method (Moriceau, Herakles), examination of the environmental impact of the fuel fire (Hubble, Dahlgren), and the blockage effects from packaging items within the fire (Yagla, Dahlgren).

A presentation on the MSIAC audit procedure missile testing was provided by Mr. Pechoux (DGA) from the French MoD/DGA Test Centre. This comprehensive presentation detailed the methodology and application of the testing audit procedure to the DGA missile testing and capabilities. This procedure helps to verify and validate that the testing is complete, detailed and uniform in order to provide for assured comprehensive results that are comparable between different test centres.

Dr Matt Andrews, Dr Ernie Baker, Emmanuel Schultz, Wade Babcock & Dr Michael Sharp

MSIAC Technical Specialist Officers and Project Manager

11TH Intern. Armament Conf. on Scientific Aspects of Armament & Safety Technology

The 11th International Armament Conference on Scientific Aspects of Armament & Safety Technology was held on 19-22 September 2016 at the beautiful and historic Castle Ryn in Poland.

This well attended conference covered the areas of mechanics, optics, optoelectronics, electronics, control and robotics, technical equipment operation, chemistry and technology of explosives. The specific conference topics included: systems of weapon, ammunition and rocket; armour, personal and infrastructure protection; targets detection and tracking; camouflage; anti-aircraft and air defence systems; command and fire control systems; interior, exterior, terminal and wound ballistics; launch dynamics; modern propellants and explosives; warhead mechanics; aviation's armament technology; counterterrorism measures; and safety engineering.

Dr. Ernest Baker, Warheads TSO (USA) represented MSIAC and provided an overview presentation entitled "Supporting the Munitions Safety Community". The presentation was well received with several questions related to the availability of MSIAC tools. It is anticipated that Poland will become the 14th MSIAC member nation near the end of 2016. The conference included many safety and Insensitive Munitions oriented papers and

presentations. More information on the conference may be found at:
http://www.wml.wat.edu.pl/index.php/konferencje-wml/miedzynarodowa-konferencja-uzbrojeniowa/iac.html

Dr Ernest Baker
MSIAC Warhead Specialist

PM'S PERSPECTIVE

MSIAC attended the 2016 Insensitive Munitions and Energetic Materials Symposium in Tennessee, 13-15th September. The meeting is organised by the National Defense Industrial Association (NDIA), with MSIAC also providing support. This again proved to be a productive meeting with two and a half days of interesting papers and discussion opportunities.
MSIAC sent 4 technical specialists, as well as myself, and the team presented or contributed to seven papers. These are all available on the MSIAC secure web environment; topics presented and corresponding report numbers are as follows:

- O-168 Projection Criteria for Insensitive Munitions and Hazard Classification – Martijn van der Voort et al.
- O-169 Benefits of Insensitive Munitions on Storage and Operation – Ben Keefe et al.
- O-170 MSIAC - Reflection on 25 Years Supporting the Munitions Safety Community - Dr Michael Sharp et al. (synopsis provided as part of this newsletter)
- O-171 Changes to NATO IM Policy and Full-Scale Testing Documents – Martin Pope et al.
- O-172 Turning up the Heat: Science of Cookoff Workshop Findings – Dr Matt Andrews et al.
- O-173 MTM-Mitigation Techniques for Munitions – Easy Access Online – Emmanuel Schultz
- O-175 Consolidated Guide to Material Parameters Needed for IM Modeling and Simulation Efforts - Progress Update - Wade G. Babcock

The meeting also provided the opportunity to recognise excellence in Munitions Safety (MS) with MSIAC awards for Technical and Career achievements being given. MSIAC has been presenting Awards at NDIA IM/EM Technology Symposia since 1997. The winners are chosen by the Steering Committee on the basis of proposals made by MSIAC and by Steering Committee Members, NFPOs, or any other interested parties.

A reminder on the two award types
MSIAC MS Award for Technical Achievements - Individuals or teams who have made significant contributions in research and/or engineering related to the field of munitions safety.
MSIAC MS Award for Career Achievements - Individuals who have made consistent contributions in research, engineering, production, procurement, fielding, standardisation, policy, etc. related to MS, over an extended period.

This year I had the honour to present one Technical Achievement award, two Career Achievement awards, as well as a special recognition.

The first award was presented to the **Brimstone 2 Missile Team (ROXEL UK, MBDA, TDW, UK MOD DOSG and LMAS PT)**, for developing new insensitive rocket motor and warhead technologies, and integrating them into the Brimstone 2 missile. There are a number of notable achievements that were recognised:

- Vastly improved IM signature compared to legacy systems - world first for this class of weapon, delivering significant reductions in risk to users (has already been fielded)
- Very successful long term collaborative effort between Government and international industrial partners
- Motor was major technical issue – team found an acceptable solution giving significantly improved IM signature
- The system was subjected to a rigorous test and evaluation programme.

Brimstone is an important component of the UK munitions inventory, providing a precision, low-collateral damage capability against static and moving targets. Brimstone 2 introduces a warhead and motor incorporating state of the art IM technologies. The missile's IM signature is as good as current technology allows and better than any comparable system yet fielded by any nation.

IM Threat	Warhead	Motor
Fast Cook-Off	Type V Burning	Type V Burning
Slow Cook-Off	Type V Burning	Type III Explosion
Bullet Impact	Type V Burning	Type V Burning
Fragment Impact @1860 ms^{-1}	Type V Burning	Type V Burning
Sympathetic Reaction	Type V Burning (missile in logistic packaging)	

The award was presented at IMEMTS and accepted by representatives from UK MOD DOSG and TDW. An opportunity arose in October to meet other representatives from the team at the UK MOD Defence Equipment and Support site in Abbey Wood, Bristol. MSIAC staff were pleased to be able to congratulate those team members present in person.

Accepting the Award: ***Nathan White*** *(UK MOD DOSG- S&T),* ***Michael Sharp*** *(MSIAC Project Manager),* ***Ulrich Störchle*** *(Managing Director of TDW GmbH)*

In the picture below, UK MOD ceremony in October 2016: ***Phil Cheese*** *(DOSG Chief Technologist),* ***Richard Smart*** *(Director Weapons),* ***Andrew Strickland*** *(Roxel UK),* ***Tony Bates*** *(LMAS Brimstone 2 Project Manager),* ***Ray Gibson*** *(DOSG Science and Technology),* ***Michael Sharp*** *(MSIAC Project Manager),* ***Ian Carr*** *(DOSG Team Leader),* ***Holly Pennington*** *(DOSG Science and Technology),* ***Colin Lapsley*** *(MBDA Brimstone 2 Chief Engineer) and* ***Chris Roberts*** *(DOSG*

Science and Technology).

The two Career Achievement awards were presented to:

Mr Steven Struck, US Air force, who has dedicated his career to technology development and transition providing the war fighters with safer munitions. Steven Struck is well know in the community for his deep involvement and technical expertise over many years in the fields of insensitive munitions (IM), energetic materials (EM), and testing. Steve has been a key individual for the Air Force's IM research and development efforts since he first arrived in 1986, 30 years ago, and began formulating IM explosive fills. He was instrumental in the development of six explosive IM-compliant fills, most notably AFX-757 - the USAF's state-of-the-art fill for all penetrator weapons. Steve is now the Munitions Directorate's preeminent IM expert and has worked to advance IM technologies, processes, doctrine, and implementation across all levels including Air Force, DoD, and the international community.

Dr. Michael Sharp *(MSIAC Project Manager),* ***Steven Struck*** *(US Airforce)*

M. Bruno Nouguez, EURENCO France, has more than 35 years of achievement in energetic materials, addressing performance as well as safety, vulnerability, and insensitiveness of high explosives and rocket propellants. He has contributed to 11 patent families and more than 50 published papers (IMEMTS, EuroPyro, Kishem, Parari or ICT Symposia). Bruno is a recognized expert who has chaired numerous sessions during IMEMT Symposia and contributed to various international workshops, technology panels, and development efforts. As a testament to his collaborative nature and abilities, he now serves in the R&D Division of Eurenco, managing a diverse group of energetic material experts and leading innovation activities. In addition to contributions with the Ageing Expert Working Group, he is currently Eurenco's deputy to IMEMG and is responsible for two EUROSAE continuous education courses related to IM and high explosives.
Unfortunately, Bruno Nouguez was unable at the last minute to attend IMEMTS meeting but a colleague, Ms. Genevieve Eck, was able to accept the award on his behalf. We very much hope to be able to meet with Bruno in the near future to congratulate him on receiving the award.

On the occasion of the 25th Anniversary of MSIAC, the Steering Committee (SC) wanted to recognise the outstanding contribution of **Dr Ronald Derr**, US Navy (retired), as a founder of NIMIC/MSIAC and the lasting impact of his efforts. Dr Derr played a key role in the AC/310-sponsored workshop held back in 1986 at which the need to establish an Insensitive Munitions Information Centre was agreed. He contributed to the success of pilot NIMIC at John Hopkins University, and was key in facilitating the transition to a NATO project in 1991. He continued to support the project over the next 20 years, first as chair of the SC, and subsequently as assistant to the chair. During this time, Dr Derr provided valuable direction, continuity, and unerring advice to all involved in the project. His dedication, knowledge and interest in Insensitive Munitions technologies proved to be a great motivation to others and have made a lasting impact on the munitions safety community. Having worked at NIMIC when Ron was the SC chair, it gave me great pleasure to be able to present the award in person.

Dr. Michael Sharp *(MSIAC Project Manager),* ***Dr. Ronald Derr*** *(US Navy Retired)*

Finally, I would like to congratulate each of the winners again for the important work that they have undertaken over the years to support Munition Safety efforts. Further, MSIAC and the Steering Committee would like to thank all those that took the effort to recognize the hard work and commitment of others by submitting nominations, and in particular all those who were the subject of a nomination.

Dr Michael Sharp
MSIAC Project Manage

Energetic Materials Compendium (EMC) v5.0

Over the course of this year the infrastructure to EMC has been upgraded to the current web standards. The upgrades have been carried out to allow greater flexibility in the future. It now has the same look and feel as our other online tools such as AIMS and MTM.

https://portal.msiac.nato.int/emc

After a period of beta testing EMC v5.0 was launched on our servers at the end of September. The overhaul of EMC allows for easier upgrades and smoother operation of functionality, navigation, searching and finding information. We have added some new sub-tabs to the main menu including News and Help for ease of use.

During the year we have also added more data from the open literature resulting in more information within our 1300 Formulations and 690 Components.

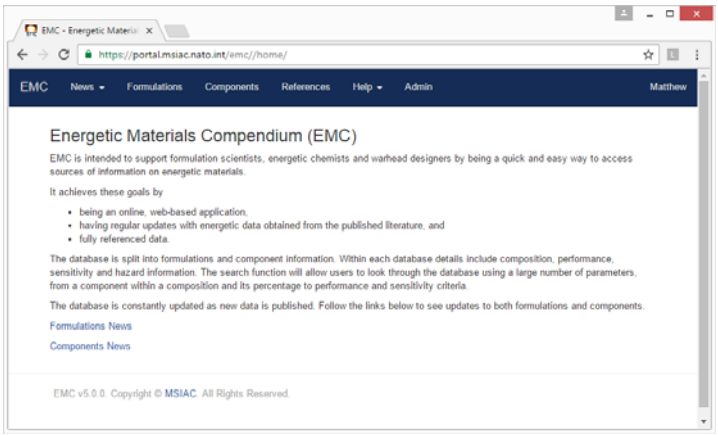
Due to the infrastructure upgrade we will now be able to implement some new features. At the start of 2017 a new side-by-side comparison tool (for both formulations and components) will be launched (v.5.2), greater search capability for the components and an environmental specific search.

If you have any thoughts or comments on the current version of EMC please let us know and provide us with your feedback by emailing me: m.andrews@msiac.nato.int

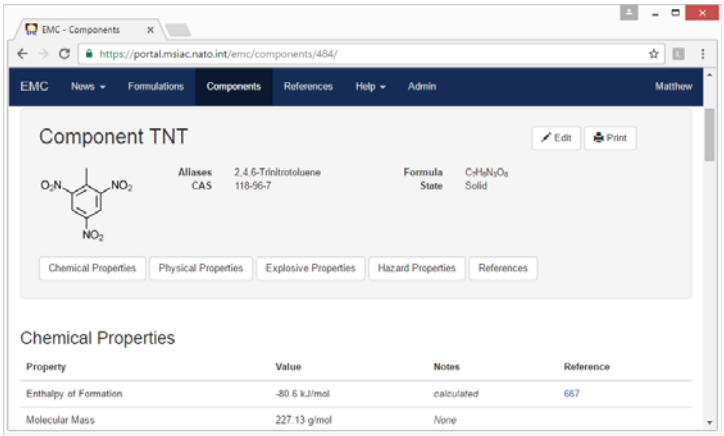
Would you like access to EMC?

Fill out the access request form on our website using the link below. After completing the form, your country's National Focal Point Officer (NFPO) will review your submission. If approved, MSIAC will then provide you with a username and password to access EMC and any other authorised tool.

https://www.msiac.nato.int/contact-access/access-request-form-for-members-of-msiac-nations



EMC v5.0 Home Page

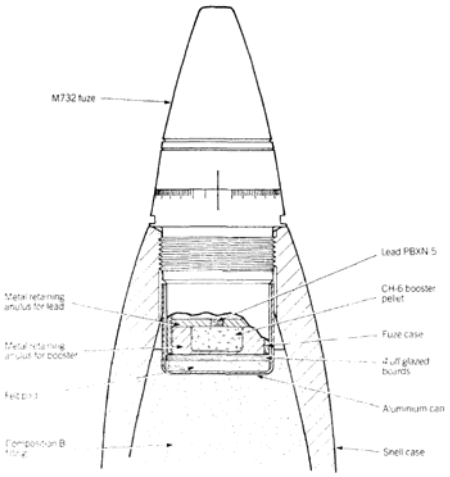


Component Fiche Layout

Dr Matthew Andrews
MSIAC Energetic Material Specialist

Finding Data from Unexpected Sources

Recently MSIAC received a question about wool felt. At first this seems to be an inquiry best suited to our Scandinavian colleagues, whose knowledge of wool is probably much greater than those of us from southern climates. The inquiry, however, was targeted specifically at the shock and high-rate mechanical properties of woolen felt used extensively in munition fuze assemblies.



Upon receiving the question I did a quick review of MSIAC's database of more than 130,000 insensitive munitions and munitions safety related documents, and found plenty of items that mentioned felt, and only a few with any material properties. Many of these referred to felt simply as a component in a system, like a "felt pad" or "felt disk", and did not provide any properties beyond dimensions and sometimes density. We had a fairly large number of documents that discussed tensile and impact properties of non-woven, aramid-based felts, but these were exclusively armor applications, and neither the materials nor the mechanical behaviors were relevant to the inquiry.

What fascinated me immediately was the simple fact that so many munition devices include wool felt as a component. A review of the general properties of wool revealed some interesting characteristics. First, wool fibers are very environmentally stable, absorb little moisture, and resist dimensional or flexibility changes with temperature excursions. Second, *felted* (randomly fluffed and packed fibrous meshes) wool pads have very predictable mechanical properties, have predictably hysteretic compression and release behaviors, resist relaxation when compressed for long periods, and rebound well when loads are released. Further, it has proven very difficult to create man-made fibers and felts that can replicate many of these properties. All of this helps to explain why wool felt has been such a seemingly invisible but important part of so many munition systems.

That being said, the goal of the inquiry was to understand the mechanical properties better, and perhaps find data or a behavior model that could be used for high-rate loading and shock simulations.

It appears that the most relevant material science evaluation of woolen felts is in the study of piano hammers. In this application, a thin layer of wool felt is

adhered to a smooth wooden mallet, which is then struck on a tightly strung metal wire. As the felt's mechanical behavior (compression densification, rebound, mechanical damping, etc.) plays a critical role in the resultant sound quality of the instrument, this is a crucial area of research and study. Attempts to create man-made materials which reproduce the mechanical behavior of the woolen felt have fallen short.

There has also been a significant body of work attempting to create better mechanical models to describe the mechanical response of piano hammers in computational simulations. In addition, there have been efforts to create more detailed test devices that can better capture the mechanical response of piano hammers.

Of particular note is the work of Anatoli Stulov, et. al. in Estonia, whose dynamic evaluation of felt indicates strongly non-linear force-compression behavior, strong rate-dependency of the slope of the loading curve, and significant hysteresis between loading and unloading behaviors.

There are so many variations of engineering materials and uses of uncommon materials in specific applications, it would be unusual to find exact data on a specific material of interest. It is rare that a specific material has been characterized in exactly the conditions that are needed. It does seem unusual however, that such a common component of so many munition systems has apparently not been characterized for its shock behavior.

The mechanical characterization and resultant descriptive models created for felt used in piano hammers, while not at the specific strain rates of interest, can still be used as a reasonable surrogate until more appropriate characterization is done. Leveraging data and research from a completely disparate industry in this fashion is a very cost effective means of meeting immediate technical needs, and in some cases might completely alleviate the need for re-characterization.

Wade Babcock
MSIAC Material Technology Specialist

AASTP-1 and AASTP-5 Lecture Series

Another successful AASTP-1 and AASTP-5 Lectures Series was held at the Ce FLI (Centro per la Formazione Logistica Interforze) in Rome, 24 to 28 October. The week was well organized by T.Col. Massimo Marsella, and started with a warm welcome from Adm. Martina and colleagues. Positive student feedback was received at the end of the week.

https://www.msiac.nato.int/about-msiac/member-nations/italy

Italy Country Visit

22 to 24 November 2016

MSIAC visited Rome once more in November (or should we call it Movember with these four bearded men!). Michael Sharp, Martijn van der Voort, Matt Andrews and Ernie Baker contributed to a symposium about Ammunition Safety and Risk Analysis. The three day symposium program was defined in a good cooperation with T.Col. Dario Porfidia. There were close to 200 participants from military, universities, industry, and fire-fighters. There was a good exchange of information in the many presentations and discussions. On the first day, safety of ammunition storage and transport and Explosives Safety Munitions Risk Management (ESMRM) received much attention. On day two and three the theme shifted to accidents, hazards associated with propellants, IM design and testing, and ageing. Also fireworks and risk analysis of industrial hazards were discussed.

The symposium program and more pictures can be found here: https://www.msiac.nato.int/about-msiac/member-nations/italy.

MSIAC TEAM RAISE MONEY FOR MEN'S HEALTH

The month of November, sorry, Movember saw the MSIAC staff abandon their razors in an effort to raise money and awareness of men's health.

The beginning of the month saw the office full of fresh faced TSO's, not a usual sight. As the month grew on so the moustaches and beards flourished. We battled through the itch and marital issues to finish the month with some fine looking beards, police inspector moustaches and …. For those of us with light hair the associated picture doesn't quite highlight the growth, but be assured we were all sporting a beard or moustache. Importantly we did raise money and hopefully some discussion on men's health.

This year we raised a total of **€401** with kind donations coming from colleagues, family and friends. A special thanks to the Steering Committee for taking part in an auction for a limited edition tie. So a big THANK YOU to all.

The website will stay open until the **9th December** so should you wish to donate towards the project please follow this link:

http://moteam.co/my-stache-is-against-cancer?mc=1

The projects that were supported in Belgium include research into Testicular and Prostate cancer. You can find out more information at the following site (http://be.movember.com/report-cards/) including how much money was raised in your country and the types of projects being supported.

All ***PUBLICATIONS*** *on can be found in the Technical Reports section on our Secure Web-environment via this* ***hyperlink*** *.*

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