MSIAC
Munitions Safety Information Analysis Center

Supporting Munitions Safety

April 2021

Bulletin

In This Issue

In Memoriam
Thomas Nicholas Taylor

(°15.07.1956 – †27.02.2021)

We received the sad news that our former MSIAC colleague and friend Tom Taylor has passed away.

After a career with USAREUR, Tom was the TSO for Munitions Transport and Storage Safety between 2008 and 2015. His achievements include developing a shared accident database and setting up a course for teaching NATO ammunition storage standards. He was also a well-respected member of the AC/326 SGC. During his years at MSIAC, Tom worked with Michael Sharp, Angeline Liekens, Valerie Cousens, Diane Vanoverstraeten, Fred Becker, Pierre-Francois Peron, Ernst-Christian Koch, Emmanuel Schultz, Martin Pope, Matt Andrews, Johnny de Roos, Eric Deschambault, and Martijn van der Voort.

After retiring, Tom moved to Speyer, Germany. Unfortunately, he has been struggling with health issues and lost his tiring battle on 27 February this year. Tom leaves behind his loving wife Nellie, and his daughter Marianne.

His colleagues and friends describe him as a very pleasant, charming and attentive character to work with, flamboyant at times loose, and with a lot of humour. We have collected impressions and pictures from various colleagues **here**.

Farewell Tom, we will miss you!

MSIAC Workshop:

Virtual Plenary Session 9th – 11th March 2021

In March 2021 MSIAC hosted the latest in our ongoing series of technical workshops, this time focussing on defects in energetic materials and munition systems, and the ways in which we can assess their significance.

Although our technical workshops are usually held in-person, global events forced us to take a different approach; instead, we hosted virtual plenary sessions over three days using the GoToMeeting platform. During these sessions, we were delighted to welcome over 100 delegates from across the MSIAC member nations; 24 technical presentations were delivered considering topics over the following Focus Areas:

- Origin of defects
- Detection of defects
- Consequences of defects
- Criticality of defects

All presentations delivered during the workshop have since been uploaded to the MSIAC Secure Website and can be accessed by registered users: https://www.msiac.nato.int/weblink.

Supporting technical reports, including the list of abstracts, can also be found here. Video recordings of each session will also soon be uploaded to this location.

MSIAC staff will now begin development of a series of technical reports discussing each of the four Focus Areas. These reports will include not only a review of the presentations delivered during the virtual plenary sessions, but also the responses provided by the presenters to questions asked, as well as delegate contributions from the post-workshop survey. The goal of these reports is to make recommendations for areas of further investigation or discussion.

These recommendations will form the basis of proposed follow-on in-person technical meetings, which will seek to explore specific areas or themes in more detail. The scope and format of these meetings will become clearer later in the year, and are primarily dependent on the resumption of international business travel by MSIAC member nations. We will keep you informed as the situation develops.

We would like to thank all those involved in the workshop so far, and look forward to your ongoing contributions as we progress with this work.

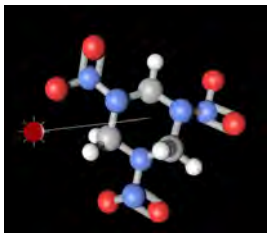
Matt Ferran
TSO Munition Systems

Machine Learning & EMC

The MSIAC Energetic Materials Compendium is a database containing properties of different energetic materials and associated formulations. The database holds information on performance, sensitivity, chemical and physical properties as well as hazard information. Currently, EMC contains 580 separate component materials including molecular explosives, oxidisers, binders and other additives; additionally 1311 different formulations are stored within the database covering gun and rocket propellants, explosives and pyrotechnics.

Recently there has been an increased interest in the use of Machine Learning algorithms for energetic materials and formulation development. However these algorithms require a data set to facilitate their development. With a large collection of information available to all MSIAC member nation nations, could EMC be used?

Are you interested in Machine Learning? If you are and think EMC could be of help / use, please contact a member of the MSIAC team.



Christopher Hollands
TSO Energetic Materials

You can find all Technical PUBLICATIONS via this hyperlink .

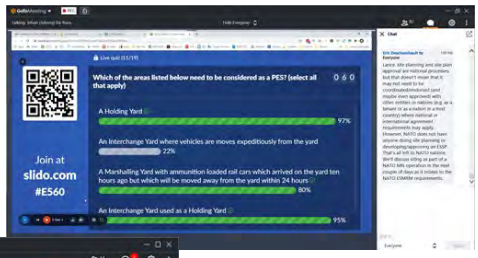
Check out the updated reported ACCIDENTS via this hyperlink and our series of ACCIDENT POSTERS on our website.

Do you want to know what's going on in AC/326 and its SUB-GROUPS? Check it out here!

MSIAC Courses

In 2020, MSIAC developed webinar versions of the AASTP-1 and -5 lecture series and the ESMRM course. The course material was also updated to reflect the upcoming changes to NATO standards, most notably the AASTP-1 Ed C V1. Whereas a few in-person courses had to be cancelled, the last quarter of the year was used to catch up with three webinars: a world-wide one in October and two webinars for Germany and Belgium in November and December respectively.

The pictures below show that quizzes, feedback and interaction are still possible using the SLIDO app and chat functionality in GOTOMEETING. During the Brussels course it was even possible to propose a toast at the end!



Webinars continued in 2021 with an AASTP-1 and -5 lecture series for a Canadian, US, and German audience (22-26 February) with in total 85 participants. Thanks to Maj. Paul Walsh (Canada) for the organization from their side, and thanks to Johnny de Roos and Eric Deschambault for their continued support to deliver this course together with MSIAC. We will also work with them to develop a "QD User Manual" which is planned to become a Standard Related Document (SRD) to AASTP-1 in parallel with the new edition.

Unfortunately, courses planned this year in Versailles (France) and Picatinny Arsenal (US) had to be cancelled. We notice that our members are looking forward to in-person courses again! Before this is possible, we plan to conduct another webinar in the early fall of 2021. Please let us know if you or colleagues are interested.

As always, the most recent course materials are available for download on the MSIAC secure website. This time, video recordings have also been included.

Martijn van der Voort
TSO Ammunition Transport and Storage Safety

IMEMTS 2021

On the 7th and 8th of April, the IM & EM Technology Symposium was held for the first time in a now world renowned location: a virtual platform! Despite the lack of personal interactions, the event was a success: a total of 38 briefings were provided over two days and 216 registrations from 15 nations were recorded by the meeting organiser, NDIA.

As usual, MSIAC strongly contributed to this unmissable event which has gathered the international IM community every 18 months since 1990. The technical MSIAC team participated in the event by presenting a number of recent activities: "TNT Exudation and Crystal Growth" by Ernie Baker, "Harmonisation of NATO Insensitive Munitions & Hazard Classification Standards and Practices" by Matt Ferran, "Application of Herd Immunity to Munitions Safety" by Martijn van der Voort, "Nanomaterials as Energetic Fillers" by Chris Hollands, "Influence of Mechanical Properties on the Explosiveness of Energetic Materials" by Morgan Bolton (2020 MSIAC Stokes Fellow), and "A Review of Mitigation Techniques for Small Calibre Munitions and Flares" by Christelle Collet, just to mention a few of them. And, if you want to have an exhaustive overview of our current and future highlights, we can only recommend that you look at Chuck's introductory presentation of Day 2 titled "MSIAC – Highlights and Future Priorities".

Thanks to this event, it was possible to get an updated overview on the recent work done by the IM community. We encourage you to keep an eye on Weblink (https://www.msiac.nato.int/node/854), where the shareable presentations will be soon made available to the MSIAC users.

In the meantime, here is a selection of contributions particularly relevant to current MSIAC topics of interest: "Influence of Ageing on the IM Signature of an Anti-Aircraft Missile Propulsion Unit" by Quentin Weisse and Hervé Bénard (spoiler: there is no influence), the use of FEM HMX in LX-14 and PBXN-9 (presented by John Latwinas and Daniel Iwaniuk) and the IM Upgrade of the Italian Army's 155 mm Artillery Projectiles (by James Padfield).

Christelle Collet
TSO Propulsion Technology

MUNITIONS SAFETY AWARDS 2021

The MSIAC Awards for Technical Achievement or Career Achievement are an opportunity to recognise excellence in Munitions Safety (MS). The winners are chosen by the MSIAC Steering Committee on the basis of proposals made by MSIAC staff, Steering Committee members, NFPOs, or any other interested parties. MSIAC has been presenting awards at NDIA IM/EM Technology Symposia since 1997 and a long list of deserving individuals and teams can be seen on the MSIAC website here.

This is a short reminder of the two award types:

MSIAC MS Award for Technical Achievement: Individuals or teams who have made significant contributions in research and/or engineering related to the field of MS.

MSIAC MS Award for Career Achievement: Individuals who have made consistent contributions in research, engineering, production, procurement, fielding, standardisation, policy, etc. related to MS, over an extended period.

This year Chuck Denham had the honour to present one Career Achievement Award and one Technical Achievement Award.

The Career Achievement Award: Patrick Lamy

A lot has already been said about Patrick Lamy and his outstanding contribution to the IM community (see previous MSIAC newsletter, Issue 3 of 2020). Let's revisit the main milestones of his impressive career devoted to munitions safety:

- In the first half of his carrier, Patrick was involved and took the lead of nearly all the French MOD projects regarding the development of new ingredients and explosives with reduced sensitivity. He contributed to the first IM doctrine in France and extended his role in the field of standardization.
- In 2001, he was appointed Head of the Munition Safety Office within the Inspectorate of Propellant and Explosives. His role was to provide a mandatory independent explosive safety assessment to munitions project managers and French armed forces within the Safety and Suitability for Service process.
- From a NATO perspective, he has significantly contributed to the Conference of National Armaments Directors (CNAD) AC/310 and Ammunition Safety Group AC/326 in the area of standardization and harmonization efforts and the development of STANAGs in support of munitions safety.
- Overall, from the mid-1990s, as Chairman of AC/310 and throughout his leadership role of AC/326, he has provided an impressive contribution to the development, ratification, promulgation and review of publications and documents totaling 140 STANAGs and 76 standards.
- Patrick has been the French Steering Committee Representative for MSIAC since 1999, where he has also served as the National Focal Point Officer. His continued leadership over the years has provided valuable direction for numerous MSIAC Project Managers and he has certainly been instrumental in MSIAC's continued success.
- In November 2020, Patrick Lamy retired from DGA, the French MOD, after 42 years of service.

Patrick giving a thank you speech during the Awards Ceremony at IMEMTS 2021:

Technical Achievement – Efforts in the assessment of HD 1.3 (Team)

The current weight-based siting methods are inadequate for determining safe-separation distances from mass fire HD 1.3. To address this concern a team was formed by the US Department of Defense Explosives Safety Board (DDESB) composed of 10 safety experts from different agencies in the US. A series of experiments were designed that would examine the response of a reinforced concrete structure with varying loading densities of HD 1.3 materials, differing propellant surface areas, and vent areas. The work of this group will lead to policy for safer and more effective storage of HD1.3 and HD1.4 materials

Members of the US team who contributed to this effort include:

Aubrey Farmer (NAWCWD), **Nathaniel Davis** (NAWCWD), **Cynthia Romo** (NAWCWD), **Kevin P. Ford** (NAWCWD), **Brian Bojko** (NAWCWD), **Austin Bons** (NAWCWD), **Clint Guymon** (SMS, Inc.), **Jon Chrostowski** (ARCTOS), **Alice I. Atwood** (Engility, Inc.), **Thomas L. Boggs** (SATECH), **Jo Covino** (DDESB), **Ming Liu** (NAVFAC EXWC), **Michael Oesterle** (NAVFAC EXWC)

On behalf of the MSIAC team and the MSIAC steering

committee, we congratulate each of the winners again for the important work that they have undertaken over the years to support Munition Safety efforts. The awards and certificates will be sent soon to each winner, and we strongly encourage the winners to take a picture of them with their trophies, for inclusion in a future edition of the MSIAC newsletter!

If you wish to make a nomination for the next session of the Munition Safety Awards, please take notice of the full requirements and instructions at the link: https://www.msiac.nato.int/news/ms-awards. We look forward to your nominations.

Christelle Collet
TSO Propulsion Technology

The Application of Herd Immunity to Munitions Safety

Over the course of last year and the beginning of 2021, we have become well aware of the concept of herd immunity. Herd immunity helps restrain the spread of contagious disease within a population if a sufficiently high proportion of individuals are immune to the disease, especially through vaccination.

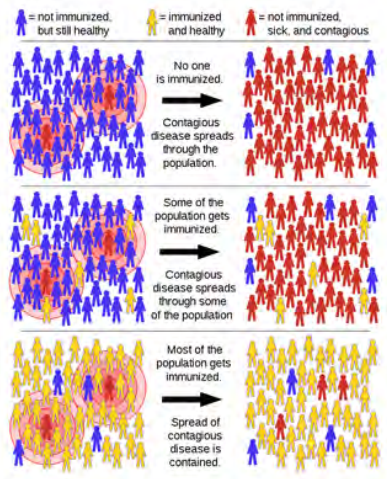


Illustration of Herd Immunity

At MSIAC, we started to explore the analogy between herd immunity and munitions safety which is relevant in situations with a co-existence of IM and conventional munitions. This may be the case in ammunition workshops; during loading and unloading activities in ports, airfields, staging areas, marshalling-, interchange- and holding yards; and at forward operation bases and firing points. An accidental munition response may be regarded as a disease, whereas the introduction of IM can be compared with vaccination.

When conventional munitions are replaced by IM, this often takes place partially and in phases. It has been theorized that the overall aggregate reaction of stockpiles of munitions in accident scenarios might be lessened with the introduction of IM rounds, even when these only represent a portion of the stockpile.

Two mathematical approaches have been developed to determine the effective reproduction number and herd immunity threshold in munitions safety problems. The first approach describes the propagation of detonation in a 2D random distribution of munitions. A second approach considers munition responses in more detail in a 1D configuration. The models illustrate the importance of careful planning and design of storage, including buffered storage and other mitigation options.

The findings will soon be published in an MSIAC report that presents a theoretical basis which may help national authorities assess the interim benefits of IM investments, during the period when inventories are only partially converted. Further, the report helps form a framework to more accurately estimate the safety benefits for military personnel, infrastructure, and equipment. The results of this study are also aimed at informing mixing rules and risk assessments.

We would like to request input from the community about the coexistence of IM and conventional munitions. In particular, we are interested in the type of activities and under which conditions this coexistence takes place.

Martijn van der Voort
Munitions Transport and Storage Safety TSO

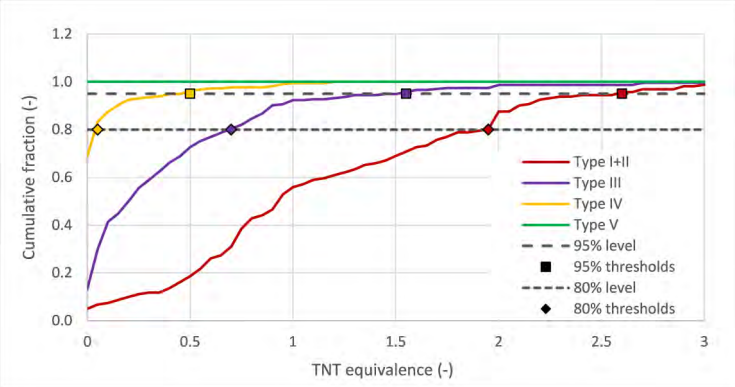
Institute of Explosives Engineers (IExpE) Virtual Event 2021

Dr Baker represented MSIAC at the IExpE Virtual Event 2021 held on 16 March 2021. This was the first virtual IExpE event, replacing the IExpE Fulmination Conference, which was cancelled in 2020 and 2021. He provided a briefing entitled “NATO Munitions Safety Information and Analysis Center: Supporting Munitions Safety”. This presentation provided an overview of MSIAC and MSIAC’s recent achievements in advancing munition safety efforts on behalf of its member nations. It highlighted the ongoing support of MSIAC to its member nations through a variety of products and services, including the MSIAC tools developed over 30 years. Examples of current work activities were given which included the recent emphasis on the role of defects on safety.

Ernie Baker
TSO Warheads

IM TNT TOOL AVAILABLE

Within the project “Collation and Analysis of IM test data”, we have analyzed a large number of blast measurements from IM tests conducted by the US Navy and the French DGA. This led to a correlation between the assigned response type and TNT equivalence. The findings were reported in MSIAC report L-248, and also recently presented at IMEMTS.



Correlation between response type and TNT equivalence

In order to derive TNT equivalence from blast measurement data, MSIAC developed the IM TNT tool. This tool calculates a TNT equivalence, including a measure of uncertainty, based on a least squares data fit to peak overpressures and positive phase impulses measured in the test arena. The tool is available for MSIAC members as a stand-alone Excel application. We would welcome any user feedback and suggestions for further development.

Another request we would like to make is to share your IM test data with MSIAC, so we can continue our meta-analysis of world-wide IM test data! Thanks in advance!

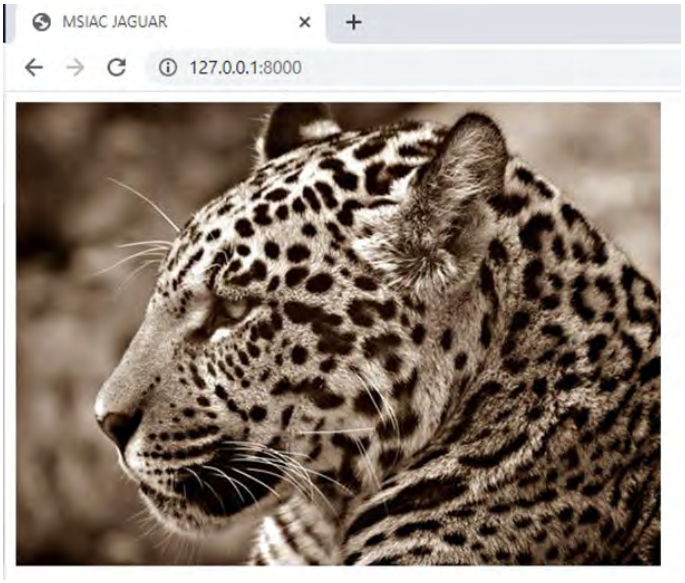
Martijn van der Voort
Munitions Transport and Storage Safety TSO

JAGUAR MSIAC APPLICATION

MSIAC has been working with the US Army Combat Capabilities Development Center Armaments Center (CCDC AC) for the use of the JAGUAR thermochemical equation of state (EOS) computer program by the MSIAC nations. A Cooperative Research and Development Agreement (CRADA) between MSIAC and the US Army for the joint development of JAGUAR was finalized in December 2020.

JAGUAR is a computer program developed by CCDC AC that provides explosive performance estimates that can be used in safety calculations. In particular, thermodynamic EOS, such as Jones-Wilkins-Lee (JWL) parameters, can be produced for use in modeling. MSIAC is working with CCDC AC to collaboratively improve JAGUAR and provide a Graphic User Interface (GUI) for an online tool. The initial version of the JAGUAR MSIAC tool is anticipated during 2021.

A formal announcement and access process will be published when the application becomes available.



JAGUAR MSIAC Application Development

Ernie Baker
TSO Warheads

THE FRENCH CHRONICLE

The MSIAC workplace is obviously a very polite and respectful environment. However, as a French individual in this team, this could be hard to believe when you first hear that we will soon get the support of “trainees”. First, let me clarify what “trainee” means in French language, with the extra challenge of using polite words. A “traînée” is actually a girl who offers her favors quite often and without being very discriminating, in other words, it is an easy girl, if you see what I mean… Hence, certainly not the kind of person you expect to see in this respectful place which is the MSIAC office. Of course, once you notice the missing accents on top of the “i” and the first “e” in the English word “trainee” (as opposed to “traînée” in French), it all makes sense! Indeed, it is always good to have the support of skilled and motivated young students every year at MSIAC and unless these “trainees” turn out to be “traînées” (the case has never happened so far and hopefully, it will never happen in the future), MSIAC will remain a polite and respectful place… well… until you hear people in the office talking about their bitches, which is a different story!!

Christelle Collet
TSO Propulsion Technology

What's in a Name: Tetrazene or Tetracene?

There is some confusion about the chemical compound used as a primer ingredient: Is it spelled tetrazene or tetracene? When looking up the chemical structure, there are at least two different possibilities, so which one is correct? MSIAC was approached to help sort out the history.

The original term for the compound, first reported by Hofmann et al in 1910, was tetrazene and this spelling continues to the present day in the NATO, UN, and in the UK literature. Unfortunately, this term is not unique as it also describes a rocket propellant with the formula N_4H_4. The American literature used the spelling tetracene, but this word too is not unique. Tetracene is the IUPAC recognized name for an aromatic compound otherwise called naphthacene; a polycyclic aromatic hydrocarbon ($C_{18}H_{22}$). As the term tetrazene originates from the last part of guanylnitrosoaminoguanyltetrazene, the use of the unique abbreviation GNGT, already used in some literature, is recommended.

The structural formula of GNGT took several years and several attempts to determine. The first linear structure was suggested in 1910, Figure 1, and was assigned CAS# 109-27-3. This number has associated with it a large amount of safety information and remains in use to the present day.

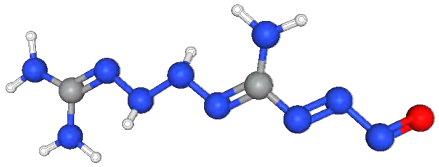


Figure 1: First Suggested Structure of GNGT, CAS# 109-27-3 (from PubChem, CID 9571005).

But this is the incorrect structure! This structure of GNGT was published by Duke in 1971, Figure 2, and was assigned CAS# 31330-63-9.

Figure 2: Structure of GNGT, CAS# 31330-63-9 (from PubChem, CID 3035399)

If the tetrazene was produced from the reaction between an aminoguanadine salt and nitrite ions in a slightly acidic environment, which is the typical and economical synthesis route, the compound has the structure in Figure 2. This is clear in Matyas and Pachman's book, Primary Explosives (2013), and also confirmed in correspondence with Dr. Michael Williams from Pacific Northwest. The confirmation of the chemical structure some 60 years after the first report of GNGT has resulted in the situation of two different numbers for notionally the same compound. So not only is the compound known by different names, but categorized by different structures!

Unfortunately, these different designations are also associated with different safety information. For example, CAS# 109-27-3 is referenced in the UN Transport of Dangerous Goods (UN0114) and many safety data sheets for tetrazene, where CAS# 31330-63-9 is not. Of course, tetrazene the ingredient in the primers is meant, not the rocket propellant nor the aromatic compound naphthacene.

So in summary, GNGT is recommended instead of tetrazene or tetracene. The correct chemical structure is in CAS# 31330-63-9 and, for safety data, see CAS# 109-27-0.

Kevin Jaansalu
TSO Materials Technology